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## **GIS-ALAS: The Integration and Analysis of Highway Crash Data in a GIS Environment**

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### **Abstract**

The Center for Transportation Research and Education and the Iowa Department of Transportation are developing a GIS-based Accident Location and Analysis System (GIS-ALAS). This system, an extension of Iowa's DOS-based PC-ALAS, includes the location of all crashes on all roads in the state for the last ten years, about 700,000 records. It provides spatial display, query, and analysis capabilities for users in highway safety, law enforcement, and health services. This paper covers the history and status of GIS-ALAS development and methodologies for data assimilation and system design. Issues covered include software selection, crash data and location, integration of background data and other applications, and distribution/security methods.

## **INTRODUCTION**

### **Need for Crash Analysis Systems**

Every day, on average, more than 100 persons are killed in highway crashes in the United States. In 1996, the National Highway Traffic Safety Administration (NHTSA) reported 6.8 million motor vehicle traffic crashes. That year, there were 37,351 crash-related fatalities and 2.3 million injuries.<sup>2</sup> Due to the high number of deaths and injuries, state and federal agencies continually seek to improve the safety of highways and reduce the number of crashes. A useful tool for highway agencies in the campaign to make roadways safer is a crash location and analysis system, a database query tool that provides a method for storing and analyzing information about crashes and, particularly, for identifying and mitigating high-crash locations and situations. The objective of this paper is to report on the development of a GIS-based crash analysis system for Iowa.

Crash analysis requires information on the characteristics of crashes and potential contributing circumstances. This includes data on the crashes themselves (number of crashes, severity of crashes, and number of vehicles and fixed objects struck), as well as highway features (geographic locations, roadway classifications, surface type, and traffic control devices), vehicle

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<sup>2</sup> National Highway Traffic Safety Administration. Traffic Safety Facts 1996: A Compilation of Motor Vehicle Crash Data from the Fatal Accident Reporting System and General Estimates System. U.S. Department of Transportation 1997

characteristics (type, size, and age of vehicle), human factors (age, gender, license status), and environmental conditions (weather and light conditions)<sup>3</sup>.

Crash data are used in statistical analyses to identify high crash locations and determine what solutions would make crash-prone segments safer. From this process, severity reduction factors can be related to proposed safety improvements including: removing utility poles, straightening curves, reducing speed limits, widening lanes, adding turn bays, and widening shoulders.

### **Crash Analysis Systems in Iowa**

*PC-ALAS:* The Iowa Department of Transportation (Iowa DOT) has developed one of the most comprehensive computerized crash location and analysis systems in the country, PC-ALAS. This system is used by transportation and enforcement agencies throughout Iowa—cities, counties, metropolitan planning organizations, and regional planning affiliations. PC-ALAS is more portable than its mainframe predecessor, and, with its pull-down menus, more user friendly. Queries can be narrowly defined. For instance, can query the database for crashes of specific type, at certain times or by drivers with characteristics of interest. The results (outputs, statistics) can be viewed on-screen, saved to a file, or printed using predefined formats. The database behind PC-ALAS includes up to 10 years of crash data (700,000 records) for all of Iowa's road system (110,000 miles). Data are distributed on a county-by-county or city basis.

*Limitations of PC ALAS:* Still, PC-ALAS can be improved. For example, to request information for a particular location, a user must specify an ALAS node number comprised of a county number, a congressional township number, and a unique node specification (e.g., 85141347 is Story County (85), township 14, node 1347). Currently, node maps (paper or CAD) must be consulted to determine these node numbers (literal descriptions are available for nodes along primary highway and interstate routes). For corridor analysis, each node in a node string must be identified and, at times, it is difficult determine intermediate node numbers from the paper node maps. Consequently, identification of a large number of nodes is cumbersome and time consuming.

The use of maps or tables to determine node numbers limits the performance and utility of the PC-ALAS system. In addition, the presence of a node does not necessarily indicate the existence of historical data (a node representing a bridge constructed in 1994 will have no data for years prior to 1994). Adjacent nodes may not represent adjacent nodes along a link (e.g., nodes representing grade separation may be mistakenly associated with a link).

Most importantly, although PC-ALAS enables the user to access crash statistics for a given node, segment or area, it does not readily support the spatial analysis of crash patterns or promote the integration of additional data. It is difficult or impossible to properly and efficiently identify crash “hot spots” or their causes. Further, the system is DOS based, which hinders data integration.

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<sup>3</sup> Brackett, R. Brackett & Associates. Basic Highway Safety Analytical Procedures. Proceedings from the Joint 21st International Forum on Traffic Records and Highway Information Systems at the 4th NHTSA Conference on the Analysis of State Highway Safety Data. National Safety Council, National Highway Traffic Safety Administration, and the Federal Highway Administration, Milwaukee, Wisconsin, 1995. pg. 106-110

## Related Projects

Other ongoing projects at the Iowa DOT and elsewhere in the state are relevant to, and are being conducted in coordination with, the Department's crash location and analysis efforts. These projects include:

- developing a program for assessing the potential benefits of safety improvements to roadways;
- using software to develop collision diagrams for intersections or short sections of roadway;
- analyzing the relationship of crashes to roadside features such as guardrails;
- developing statewide transportation management systems, especially safety and intermodal systems, but also maintenance, pavement, bridge, and congestion management systems; and
- automating reporting methods used by law enforcement officers (e.g., the Mobile Accident Reporting System (MARS) being implemented across Iowa for crash reporting and crash data interfacing, which is pioneering the application of global positioning systems (GPS) and GIS technologies for such systems).

To enhance PC-ALAS's capabilities for the Iowa DOT, while making it compatible with related efforts in Iowa, Iowa State University's Center for Transportation Research and Education is developing a GIS-based Accident Location and Analysis System: GIS-ALAS<sup>4</sup>.

## OBJECTIVES

A primary project objective in GIS-ALAS is to make use of GIS technology to manage the crash retrieval and analysis system. Within GIS, various queries can be performed. Instead of referring to a paper node map for a node number, a user could locate the desired node, link, or interchange through a map-based GUI. Parameters for refining a search could be added before querying or reporting from the database through a GIS SQL capability. GIS can then easily create tables or maps displaying query results.

Other data that have been used (road characteristics) or might be used (demographic and socioeconomic data) to enhance highway safety analysis can be integrated in the analysis environment. As location is the key to transportation data integration, GIS can effectively provide this function. Since crash and related data are spatially oriented, it makes sense to manage the data using a GIS.

In addition to replicating the functionality of PC-ALAS, GIS-ALAS is intended to satisfy other design requirements:

- **Maintainability:** The system is to be easily updated to accommodate new and improved data and cartography and easily adjusted for changes in the format of the crash database.

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<sup>4</sup> The use of the GIS-ALAS acronym predates the current preference for the term "crash" over the term "accident".

- **Compatibility:** The system must have import/export options that are compatible with other systems and efforts (as described above).
- **Enhanced logical query capabilities:** Users should be able to use standard queries or define their own queries based on any field(s) in the database.
- **Spatial query capabilities:** Users should be able to query actual crash locations, while retaining the ability to use the old node system to reference non-crash information like roadside features (at least for the time being while nodes remain in popular use).
- **Maps and crash diagrams:** The system will provide diagrams of specific crashes, maps of crashes in a given city or county, pie diagrams of crashes at nodes (e.g., by cause, number of vehicles, etc.), and intersection maps (when used in conjunction with collision diagram software).
- **Accessibility:** The system is to be accessible statewide, eventually via the Internet, with queries possible via a secure, interactive Web session, (the data and program are currently only accessible via CD).
- **Performance:** The system should respond quickly and efficiently.
- **User friendliness:** The program should have a short learning curve and an interface familiar to current users of PC-ALAS.
- **Report generation:** Users should be able to select predefined report formats or define their own.

The GIS-ALAS project follows a three-year timeline. In the first year (CY 1997), GIS-ALAS was constructed to reproduce the current functionality of PC-ALAS and incorporate improved spatial query and display capabilities. The graphical interface of GIS-ALAS allows the viewer to see on-screen maps of crash locations and to select specific nodes and links of interest with the click of a mouse. Paper maps and tables of node numbers are now unnecessary, as is the manual typing of node numbers to do queries. The results of GIS-ALAS queries can be displayed, not only in tabular form but also in maps. Subsequent phases of development are described below.

## **SYSTEM DEVELOPMENT**

### **Software Criteria and Selection**

The development platform for GIS-ALAS was chosen through the following process. First, the GIS World Sourcebook was consulted to identify the universe of potential software platforms. This publication, produced annually by GIS World, Inc., provides detailed lists and descriptions of hundreds of software products, services, and vendors. Searches on the Internet World Wide Web were also performed to identify additional candidates.

After examining the resulting list, the project team decided to narrow the list of candidates using several fundamental criteria. The chosen platform would be a desktop package suitable for distribution to a wide community of end users, with a development language to support necessary customization, and provided by a vendor with marketplace stability (to ensure that the selected platform would continue to be available in the future, preferably with enhanced functionality). The

list of candidates was thus narrowed to three desktop GIS packages: MapInfo (MapInfo), Maptitude (Caliper Corp), and ArcView (ESRI).<sup>5</sup>

The project team then prepared detailed criteria for the final selected platform to support GIS-ALAS. Two developmental levels were considered, "minimum functionality" and "enhanced functionality" (see Table 1).

Crash reference nodes for Dallas County, Iowa, were imported into each GIS package, along with five years of ALAS location and attribute data. The performance of all three packages was similar in many respects. ESRI's ArcView was selected due to its dynamic segmentation and network analysis capabilities that make it a particularly useful package for the management and analysis of transportation data. The software was also found to best meet project criteria as outlined in Table 1.

For users who do not wish to purchase and learn a GIS package, the project team chose ESRI's ArcExplorer, currently available at no cost from ESRI's World Wide Web site. Although this program does not include the full query and reporting capabilities of ALAS, it reads the same data format as ArcView, and can be distributed freely along with the data on CD-ROM.

ESRI's Internet Mapper and Map Objects are also being considered for further GIS-ALAS development in Phase II of the project.

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<sup>5</sup> Software selection for GIS-ALAS was completed prior to the release of Intergraph's GeoMedia, which has been chosen as the DOT's preferred desktop GIS platform for end-users. Phase II of the project allows for reconsideration of the development platform.

**Table 1: Criteria and functionality considered in GIS-ALAS software evaluation**

<b>Criteria</b>	<b>Minimum and Enhanced Functionality</b>
General functionality	Minimum: ability to reproduce PC-ALAS capabilities (existing and updated), cost of distribution, ease of training end users.
Data updates/ data integration	Minimum: functionality in updating data and cartography (existing and future), import/export capabilities. Enhanced: ability to tie in to videolog/GPS, overlay "other" data (e.g., land use, road features, health care facilities, FRA data, aerial photos/DOQs/DEMs, weather, location of maintenance and emergency equipment, major infrastructure changes, intersections).
Queries	Minimum: ability to perform logical queries (e.g., high crash locations, alcohol related crashes, subset of crashes based on any field in the database at the state, county, and city levels), and spatial queries (e.g., beat/area request, graphical selection of a single node/link or a set of nodes/links, graphical selection of nodes within a user-defined area), and to support an appropriate interface for queries.
Analysis	Minimum: implications for analytical/statistical programming. Enhanced: interdisciplinary applications identify historical trends, analysis of relationships in crash causation, e.g., volumes, v/c (LOS), road conditions, weather, lighting.
Output	Minimum: ability to support reports (e.g., local area report, reports on frequency/location of any crash report form element, ability to select format of report, ability to create and save user-defined report formats), ability to support maps/diagrams (e.g., crash diagrams, maps of crashes in a given city or county, pie-diagram maps of crashes at nodes by cause, number of vehicles, etc.). Enhanced: intersection maps.
Maintenance	Minimum: ability to support system maintenance, and to easily adjust for changes in the format of the crash database.

## **Database Development**

### Crash Data - Location

Crash data are currently obtained from paper copies of officer and driver reports submitted to the Department of Transportation, Motor Vehicle Division. While the process is being automated in the field through the MARS project, currently crash data are entered and located in the central office. To support PC-ALAS, crashes are referenced to a node or set of nodes (distance from a reference node to a direction node).

The first step in the development of GIS-ALAS was to determine and import crash locations. The first version of GIS-ALAS generates x-y coordinates for crashes based on straight line interpolation between node x-y locations which were available in a Microstation CAD format. Node locations were exported from Microstation in DXF format, then imported into MapInfo. A

text file containing crash reference information was then read into a MapBasic program (Mapinfo's programming language), which calculated the crash locations. Located crashes were then exported to ArcView via MIF (MapInfo Interchange Format). MapInfo was used to facilitate the process as the project team was originally more familiar with its programming language and had previously developed a program similar to the location routine in MapBasic for another project.

Obviously, the straight-line location process may result in some errors in crash location (especially on curved roads). The Iowa DOT Office of Cartography has subsequently developed a Microstation MDL program to tie nodes to underlying road cartography and "walk a line" to a more accurate crash location. The Office then provides x-y coordinates for crashes that can be directly read by the GIS.

### Crash Data - Integration

From the officer and driver reports, the Motor Vehicle Division inputs three types of crash information: 1) information about the crash in general, known as A-records, 2) information about each driver involved, known as B-records, and 3) information about each injured person, known as C-records. For a given crash, there is only one A-record, one B-record for each involved driver, and zero, one, or more C-records, depending on the incidence of injury. One C-record can accommodate information for up to three injuries. All these records contain a common, unique crash identifier and are made available to the GIS-ALAS team in text format. Therefore, it is a straightforward process to join A, B, or C records to crash locations in the GIS. However, the current system generates a point for each record, so, for a given crash, there may be as few as two coincident points (one A-record and one B-record) or, in rare cases as many as seven or eight (with several B and C records).

Using ArcView and its programming language, Avenue, a one-to-many relationship is established between crash locations and data records upon execution of predefined queries. One-to-many user-defined queries are slightly more complicated, requiring manual database joins or spatial queries. As ArcExplorer has limited query capability and no programming language, one point for each A, B, and C record is currently provided. This makes crash analysis difficult. Therefore, A, B and C records will be joined for each crash prior to inclusion on the CD ROM in an ABBBC format. "Extra" B and C records will not be provided, as very few (<1%) crashes have more than three driver (B) records or more than one C-record (i.e., more than three injuries). Although a small amount of crash information will not be available to ArcExplorer users, at a minimum the A-records contain information on the number of vehicles involved (number of B records) and total number of injuries. While in-depth study of a particular, severe crash might not be possible with the freeware version, the ability of the program to facilitate statistical and spatial analysis is not compromised.

### Reference Data

To provide a more powerful, convenient and practical analysis system, several additional layers of data were needed. In order to determine exposure levels, highway information (e.g., traffic, geometry) is required. Since the crash database covers all roads in the state, highway data were incorporated for municipal, county and state highways. These "base record" data from the DOT are provided to the project team along with text descriptions of underlying cartography

(coordinates of vertices). A MapBasic program was written that reads these data and creates a GIS layer. The layer is then exported to ArcView via MIF. MapInfo is used to facilitate the process as it has superior projection processing (ArcView will not properly import the DOT's coordinate projection system). Also included as reference layers are rail data from the National Transportation Atlas Database (NTAD) and reference nodes and hydrology from the Iowa DOT (see Table 2).

**Table 2: Databases provided with GIS-ALAS**

<b>Coverage</b>	<b>Source</b>	<b>Current as of</b>
Primary (State) Highways	Iowa DOT Records Section	7/1/97
Secondary (County) Highways	Iowa DOT Records Section	7/1/97
Municipal Roads	Iowa DOT Records Section	7/1/97
Rail	National Transportation Atlas Database	1997
Crash Reference Nodes	Iowa DOT Cartography Section	7/1/97
Hydrology	Iowa DOT Cartography Section	1/1/96
A Crash Records	Iowa DOT Office of Transportation Safety	12/31/95
B Crash Records	Iowa DOT Office of Transportation Safety	12/31/95
C Crash Records	Iowa DOT Office of Transportation Safety	12/31/95

Estimates of the time required to import these databases into ArcView format are provided in Table 3.

**Table 3: Time estimates for creating GIS-ALAS coverages**

<b>Coverage</b>	<b>Time Required to Create</b>
Attributed Primary, Secondary, and Municipal Roads	3 days
Crash Nodes	1 day
Crash Data	3 days
Hydrological Data	1 day
<b>Total Time</b>	<b>8 days*</b>

\*Note: The amount of personnel time is approximately 3 days. Computer running time is 5 days.

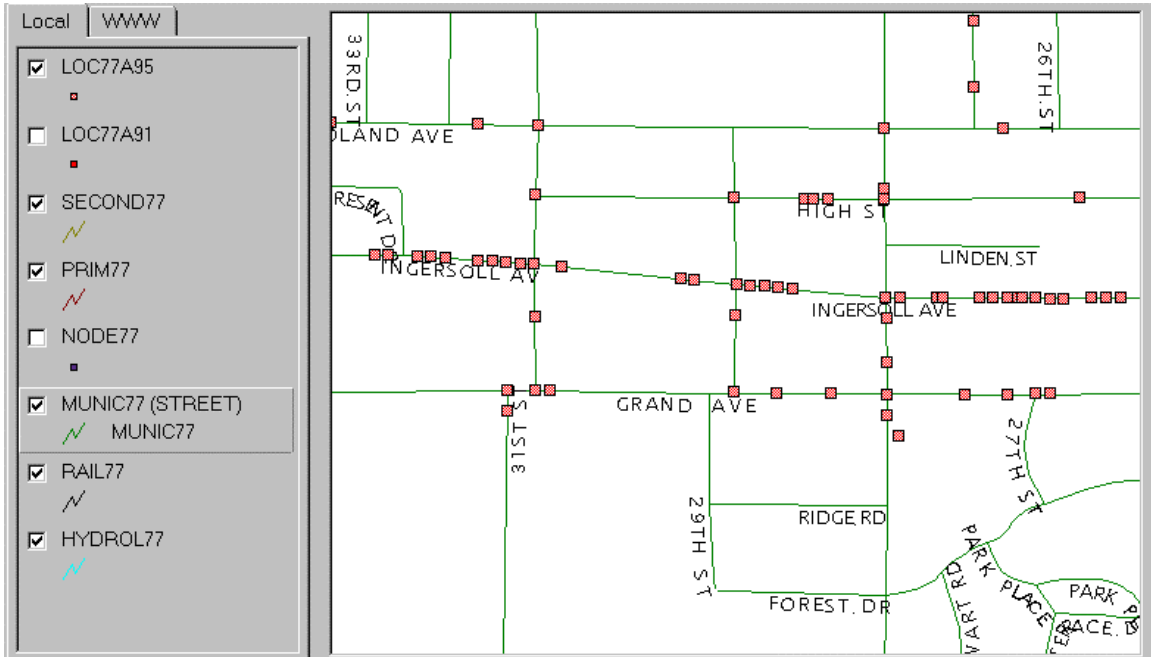
## **Products**

Two products have been developed to serve two types of users. The first product, Explorer-ALAS, combines a free GIS viewing tool and an extensive database of crash locations and characteristics. The second product, ArcView-ALAS replicates the functionality of PC-ALAS in a GIS environment. Both products access the same database, minimizing data maintenance requirements.

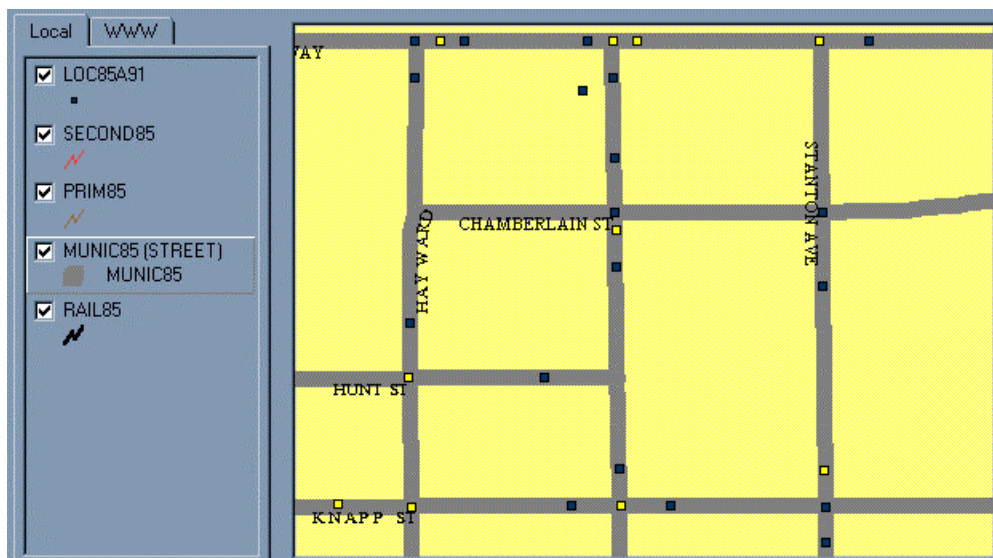
### Explorer-ALAS

ArcExplorer is a GIS viewing tool provided by ESRI at no cost. This system allows users to simultaneously view crash data and background layers but does not have the mapping and spatial query functions of the ArcView-based system (see Figure 1). Based on ArcExplorer, Explorer-ALAS is provided on a CD and includes data to display the primary roads, secondary roads, municipal roads, as well as crash records and locations.

The database can be queried to select specific crashes based on their characteristics. These results will appear highlighted on the screen (Figure 2). Thematic mapping, which allows additional visual analysis of data, is also available using ArcExplorer.



**Figure 1: Crash data for a Des Moines neighborhood, 1995**



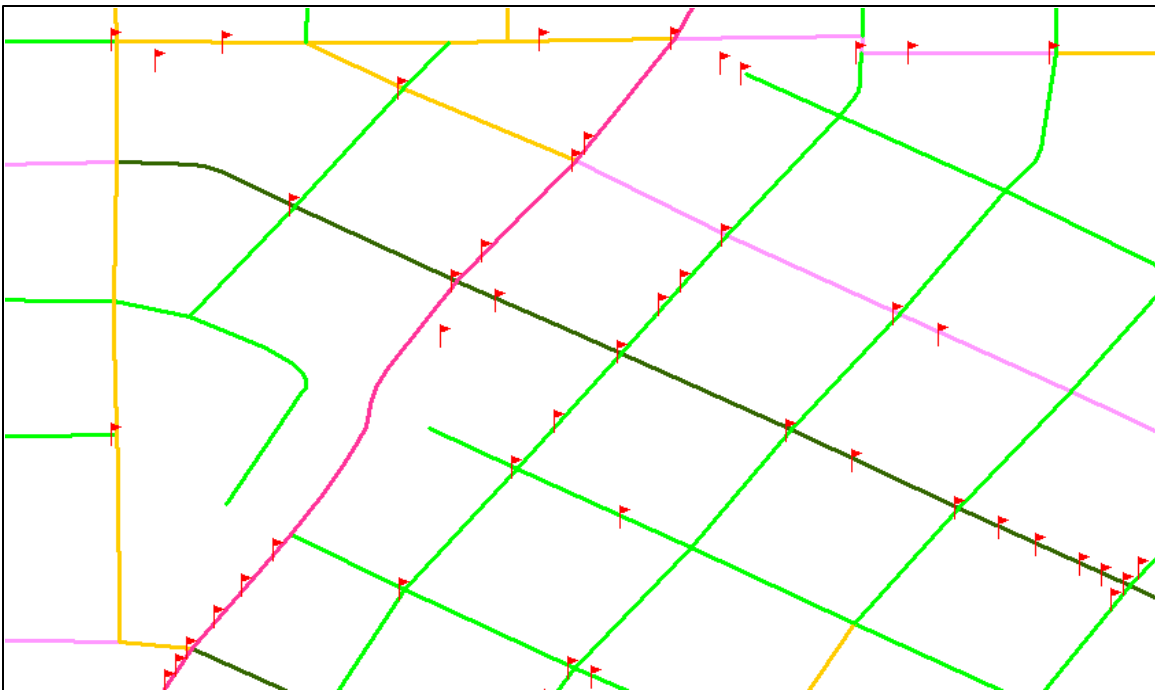
**Figure 2: Injury crashes (white squares) and property-damage-only crashes**

**(black squares) in the Campustown area of Ames, 1991**

Advanced analysis tools are not provided with ArcExplorer. Query capabilities are limited compared to ArcView's query capabilities. For instance, it is not possible to determine the number of people injured (A records) in crashes that had male drivers (B records) using Explorer-ALAS if separate tables are provided for these two record types. Moreover, ArcExplorer has no programming language that can be used to customize its interface or functionality. ArcExplorer also cannot perform several types of spatial queries (e.g., selecting crashes within a user-defined box or within 0.25 miles of a given intersection). In addition, the results of queries cannot be exported from ArcExplorer to other formats for use in other software packages.

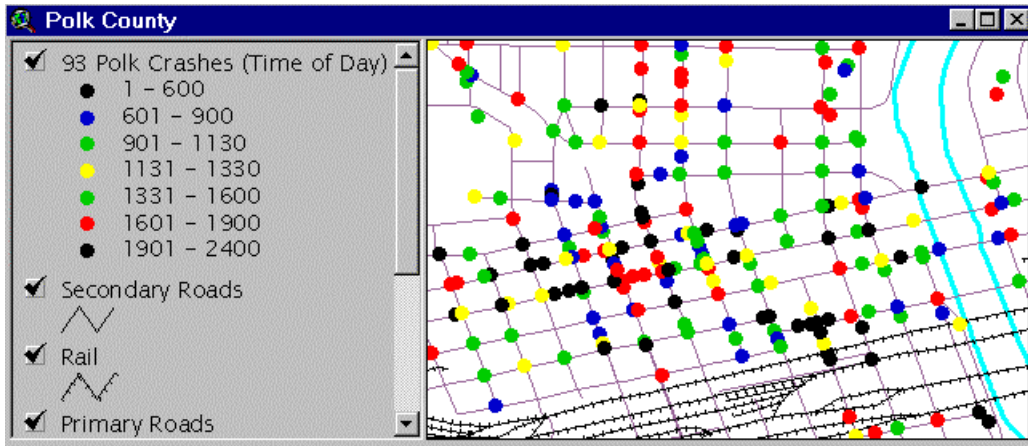
ArcView-ALAS

Spatial queries and analyses of multiple databases are possible with ArcView. This enables users to obtain results to more complex queries than are possible using ArcExplorer. Through the



**Figure 3: Thematic map of a neighborhood in Sioux City, Iowa. Traffic volumes are reflected in the shading of the roads. Crashes are displayed as flag symbols on the road network. This kind of graphical representation of data was not readily available before GIS-ALAS.**

customization of ArcView developed during Phase 1 of the GIS-ALAS project, ArcView ALAS has the general functionality of PC-ALAS within a visual interface designed to improve data query and analysis (see Figures 3 and 4). ArcView ALAS is also designed to have the “look and feel” of PC-ALAS, through identical menus and querying processes, in order to provide a shorter learning curve for users.



**Figure 4: The spatial pattern of crashes by time of day can be easily displayed using the power of a GIS.**

ArcView GIS-ALAS is being designed to work with a commercial collision diagram software already selected for use by the Iowa DOT through another CTRE-managed project. Care was taken to avoid inefficient file structures, duplicate and orphan databases, etc., because ultimately the GIS-ALAS may be integrated with MARS and other law enforcement applications, as well as other safety and engineering applications outside the current scope of ALAS. Throughout the programming process, Internet distribution and access has been considered.

## **GIS-ALAS Usability**

### "Look and Feel"

The GIS-ALAS team made a special effort to duplicate the Graphical User Interface (GUI) from PC-ALAS into the development of GIS-ALAS. This similarity provides an approach to data access familiar to users who have been exposed to PC-ALAS. The similarity between the two systems in performing a typical query (in this case, crash severity) is illustrated in the following three figures (Figures 5-7).

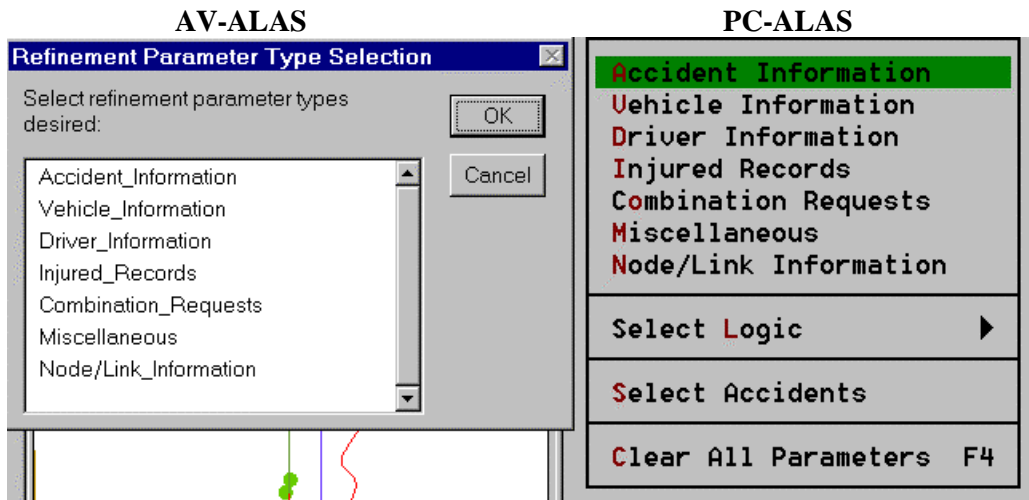


Figure 5: Selection of Refinement Parameters.

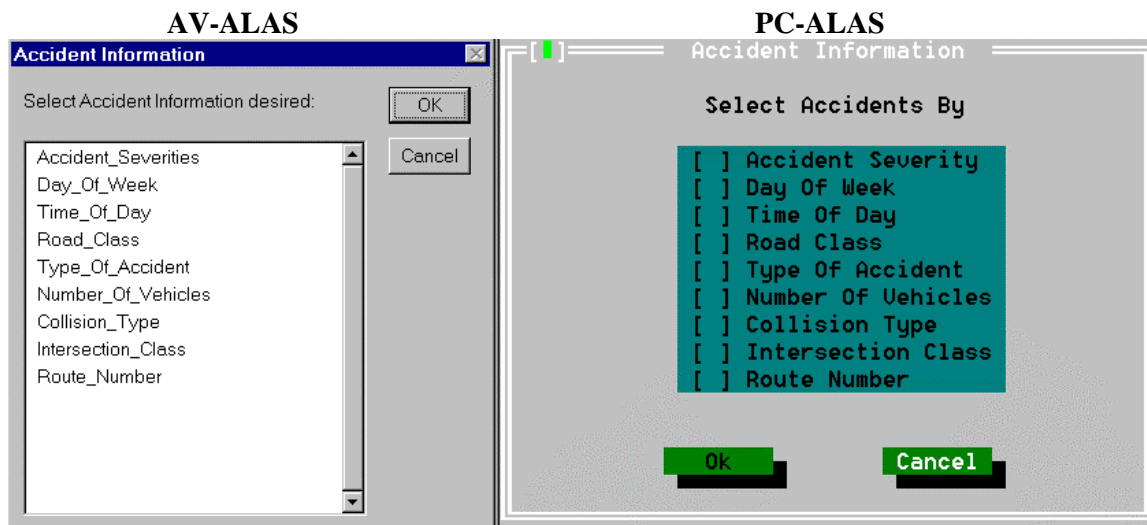


Figure 6: Selection of Crash Information Parameters.

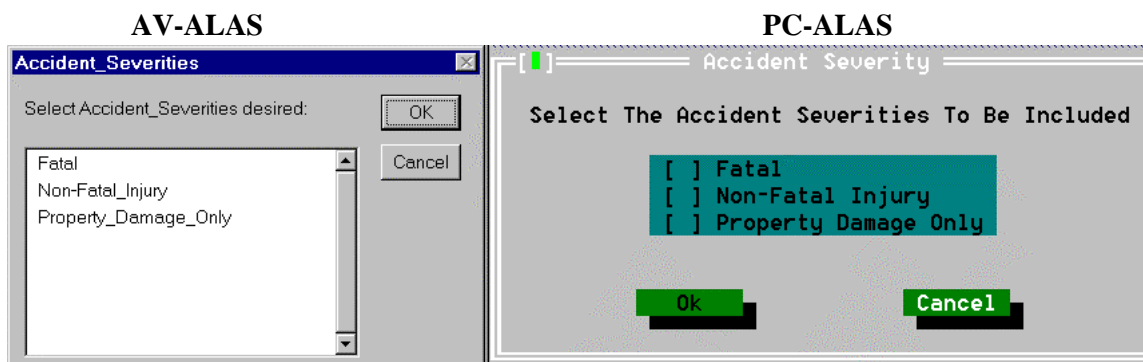


Figure 7: Selection of Crash Severities.

## Usability Study

A usability and implementation study is being conducted in cooperation with ISU's Department of English to evaluate the GIS-ALAS menus and toolbars, query and report options, and online documentation and to test for bugs or potential technical problems. Specifically, this research will include an assessment of GIS-ALAS's purpose as seen by its designers and users, a period of observing and interviewing the users of GIS-ALAS in order to identify difficulties, and the preparation of design recommendations to improve the usability of the system. The products of this research will include:

- a summary of differences between users' and designers' perceptions of the system (often a source of problems);
- a report that categorizes and details difficulties that users have with the system;
- a prototype revision of the system that corrects some of the problems; and
- a report on an experiment to determine whether the revision was successful.

This component of the project is currently being conducted and will be completed during the summer of 1998. After improvements suggested by the usability study have been incorporated, both the ArcView and Explorer versions will be distributed to transportation agencies throughout Iowa via CD-ROM or secure Internet access.

## **EXAMPLE APPLICATIONS**

GIS-ALAS is designed largely as an enhanced tool to provide quick and easy data access and query capabilities to end users. However, during the system development phase the project team has learned that the data integration and spatial analysis capabilities of GIS create a variety of new opportunities for using crash data. These opportunities have been discovered largely through continual interaction with individuals in the user community, including traffic engineers and law enforcement personnel, as well as individuals from the emergency services, public health, and academic communities. In this mutually beneficial process, end users have learned about the capabilities of GIS and the project team has learned of new applications areas and issues to address. Through a focus group, presentations/demonstrations at several professional conferences and committee meetings, and on-going contacts, several applications have been selected for further development. One such area is the analysis of implications of crash location characteristics for emergency response services

## High Crash Locations: Implications for Emergency Response

Response time is critical for crashes that involve an injury.<sup>6,7</sup> Emergency medical services (EMS), such as intravenous drip, trauma care, and basic life support, can make the difference between life and death. Conversely, injuries may unnecessarily become fatalities if such care is not provided in a timely fashion. GIS can be used to analyze the relationship between the distribution of emergency response services and the spatial pattern of crashes, a crucial determinant of the final outcome of highway crashes.

For example, (Figure 8) shows travel time areas around emergency medical service facilities in Cedar Rapids, Iowa, shown in rings around the facilities that represent five, seven, and ten minute increments (in this case, the road network depicted contains gaps which illustrate the impact of roadway obstacles). In urban areas, the level of service sought by EMS planners is that 95% of the daily demand be reached within 10 minutes.<sup>8</sup> Travel time area analysis can provide data on the number and types of crashes that can be reached within this threshold, given the pattern of response facilities and crashes.

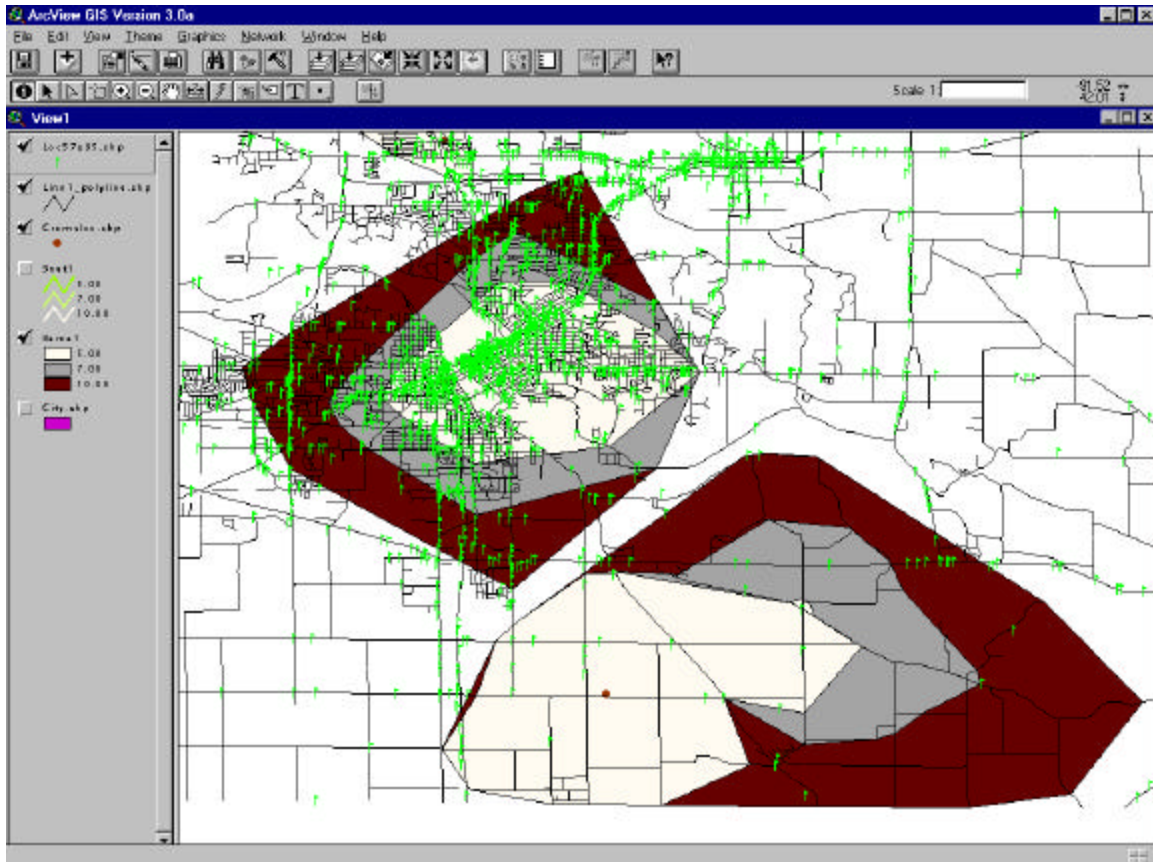
The results of this analysis can be used to assess service areas, to detect high-crash zones with insufficient response times, and, if necessary, to allocate additional facilities. In certain cases, the results can be also used to assess the possibility of pre-deploying emergency vehicles in areas with high crash likelihoods at certain times of the day. Specifically, the network analysis capabilities of GIS can be used to estimate the response times of strategically placed emergency vehicles and compare them to the actual response times of fixed facilities.

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<sup>6</sup> Repede, John, and Bernardo, John J., Developing and validating a decision support system for locating emergency vehicles in Louisville, Kentucky, *European Journal of Operations Research*, V. 75(3).

<sup>7</sup> Williams, F.L.R., Lloyd, O.L.I., and Dundar, J.A., Deaths from road traffic accidents in Scotland: 1979-1988, Does it matter where you live? *Public Health*, 1991, 39-326.

<sup>8</sup> Scott, D.W., Factor, L.E., and Gorry, G.A., Predicting response time of an urban ambulance system, *Health Services Research*, Winter 1978, 404-417.



**Figure 8: Travel time areas around emergency service facilities in Cedar Rapids, Iowa, and the pattern of crashes.**

## **NEXT STEPS**

Phase 1 activities have been completed and the GIS-ALAS project is beginning its second phase. Phase 2 will build on this first version of GIS-ALAS by incorporating additional refinements and enhancements and by improving its data integration and analytical capabilities. The interface will be improved and specific functionality will be added in response to input from users. This input will be gathered both during technology training sessions/workshops and after the users have had time to work with ArcView-ALAS or Explorer-ALAS in their own offices. Typical improvements might include changes to the menus and/or toolbars, additional query and report options, clarifications in the on-line and/or hardcopy documentation, and the removal of bugs and other potential technical problems.

Analytical capabilities will be developed to: 1) facilitate more in-depth assessments of crash pattern and causation, such as the development of tools to analyze trends and identify discontinuities in trends, 2) the incorporation of causal statistical analysis, and 3) the creation of automated systems to assist the user in identifying problem areas and crash characteristics.

Using Black Hawk County (Waterloo) as a pilot area, the research team is working with the University of Northern Iowa to experiment with incorporating additional kinds of information. These include road features, health care facilities, geographic borders (e.g., counties, census tracts), emergency response service districts, highway/rail grade crossings, aerial photos/digital ortho quads/digital elevation models, and maintenance and emergency facilities.

The project team is also assisting Iowa State University's Fire Services Institute with its pilot project to assess the emergency response impacts of Iowa's Highway 218 corridor relocation and expansion into the "Avenue of the Saints."

### **Data Input (conversions, location)**

Two issues found to be relevant during the development of GIS-ALAS included: a) the location of crashes on curved line segments; and b) missing links. This phase is already beginning to address these problems. Also, as future crash location collection is likely to include only geographic coordinates, the existing procedure that converts link-node locations to latitude-longitude will be reversed. (i.e., to convert latitude-longitude to a link-node specification). As long as node-based referencing is required or desired, this procedure will allow the crash records to be populated with both reference designations.

In addition, ArcView-ALAS and Explorer-ALAS will be reviewed for their potential to assist in DMV traffic crash location efforts. Preliminary discussions with DMV on integrating GIS-ALAS tools into their OIM (Officer Information Manager) will be conducted.

### **High Crash Locations, Links and Intersections**

Other activities of Phase 2 include an assessment of methods to estimate crash rates for highway sections/intersections based on specific crash locations and traffic counts and a definition of requirements for a database to support detailed intersection analysis.

The calculation of segment-based crash rates can conceal patterns of specific crash locations within, or even between, these segments. For instance, crashes may be clustered in one part of a segment, or clustered near the endpoints of two consecutive segments. Moreover, the traffic counts used to calculate these rates may vary as one travels along a single segment. Other relevant roadway characteristics may also vary. The end result is that analyses of segments may miss important factors in the identification of crash problems, causes, and solutions. This task will assess the usefulness of the crash point locations of GIS-ALAS, and estimates of ADT variations along a segment, in providing finer-scale analyses of crashes.

### **Technology transfer**

Training and documentation will be provided for the Phase 2 enhanced version of GIS-ALAS. In addition, the project team will outline the system requirements for maintaining the application once the project is completed. (A final set of requirements and recommendations will be provided at the end of Phase 3.)

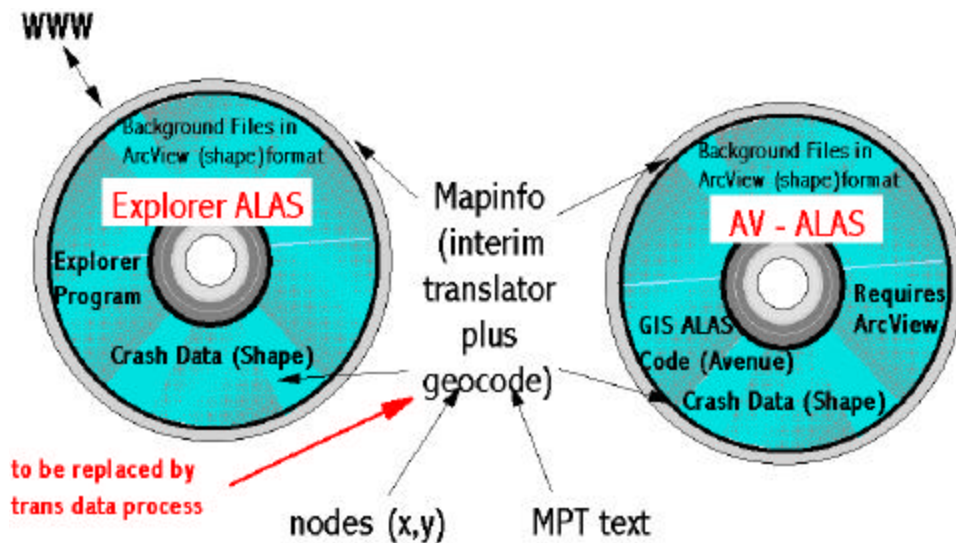
## System Distribution

GIS-ALAS products and data will be distributed on compact disc (CD). The CD for Explorer-ALAS will include the file with which users can install a free version of ArcExplorer, as well as the crash data and related information outlined above. The CD for ArcView-ALAS will include an ArcView project file, which contains the customization programs that provide its interface and analytical capabilities, as well as the databases outlined above. Currently, users who want to use ArcView-ALAS will need to purchase ArcView. CTRE on has already begun distributing five years of crash data along with roadway graphics to test users.

The use of the Internet for distribution has been explored but was not implemented in Phase 1. Concerns were expressed about confidentiality and other issues related to public access to crash data via the Internet, especially for data on a single crash or at a specific node number. Measures may be taken to ensure the security of the data, such as stripping off the last four digits of the node number and creating thematic maps (e.g., to show the number of crashes at particular locations).

Finally, VisualBasic and MapObjects are being explored to see if a fully functional, freeware GIS-ALAS can be developed. In addition, the data from ArcView-ALAS will tested for use in GeoMedia, as per the Iowa DOT's enterprise GIS implementation strategy.

Figure 9 summarizes the current status of development and distribution of the GIS-ALAS database and its related products.



**Figure 9: Summary of Database Development and Distribution**

## Training, Beta-Testing, and Feedback

In December 1997, the GIS-ALAS project team provided a demonstration and training session for the GIS-ALAS Steering Committee and other interested individuals<sup>9</sup>. Tutorials were provided for both Explorer-ALAS and a prototype version of ArcView-ALAS. This feedback was incorporated into the subsequent development of GIS-ALAS. Participants also generated a list of questions and issues for the project team to answer and address.

## **SUMMARY**

This paper has described the need for and development of a GIS-based crash location and analysis system for the State of Iowa. A rich database existed even before the start of this project in the form of a comprehensive set of crash records referenced to a statewide node system. Some 70,000 crashes per year were already keyed into the system for 110,000 miles of road. While the database and the efforts on the part of the DOT and its partners was impressive, the system currently being used to access and analyze the data, PC-ALAS, had limitations and did not make use of GIS technology.

By importing and combining graphic and non-graphic databases in ESRI software, two systems were developed (ArcView-ALAS and Explorer-ALAS). ArcView-ALAS replicates the functionality of PC-ALAS and allows GIS queries, management, overlay and presentation of the data. Explorer-ALAS provides users with an excellent viewing and query tool for the data and is distributed at no cost.

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<sup>9</sup> Several individuals, many of whom attended the training session, are currently testing Explorer-ALAS. These include Iowa DOT employees, city employees, Federal Highway Administration personnel, city and state law enforcement agencies, metropolitan planning associations, and county engineers.

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