GIS-BASED ACCIDENT LOCATION AND ANALYSIS SYSTEM (GIS-ALAS)

PROJECT REPORT: PHASE 1

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I. Introduction

This report summarizes progress made in Phase 1 of the GIS-based Accident Location and Analysis System (GIS-ALAS) project. The GIS-ALAS project builds on several longstanding efforts by the Iowa Department of Transportation (DOT), law enforcement agencies, Iowa State University, and several other entities to create a locationally-referenced highway accident database for Iowa. Most notable of these efforts is the Iowa DOT's development of a PC-based accident location and analysis system (PC-ALAS), a system that has been well received by users since it was introduced in 1989. With its pull-down menu structure, PC-ALAS is more portable and user-friendly than its mainframe predecessor. Users can obtain accident statistics for locations during specified time periods. Searches may be refined to identify accidents of specific types or involving drivers with certain characteristics. Output can be viewed on a computer screen, sent to a file, or printed using pre-defined formats.

Despite its many benefits, PC-ALAS can be rather difficult to use. Location "node numbers" -- corresponding to intersections, bridges, highway/rail crossings, etc. -- must be identified from cumbersome node tables or paper/CAD maps. Further, as a text-based system, PC-ALAS does not utilize recent developments in computer graphics and spatial analysis methods such as geographic information systems (GIS).

In Phase I of this project, the first version of the GIS-based Accident Location and Analysis System (GIS-ALAS) has been developed in response to these concerns. GIS-ALAS reproduces most of the query and reporting functions of PC-ALAS, but in a graphical environment which facilitates advanced spatial query and display capabilities. Customized data requests are available as before, but GIS-ALAS provides graphical data access, enabling the user to view and select desired locations on the network, eliminating the need for node tables and paper maps. Query results can be displayed in both map and tabular form, thereby creating more easily interpreted query results and promoting the analysis of accident patterns and causal relationships.

Specifically, two products have been developed, after having been chosen through an extensive steering committee process, to serve two types of users. The first product, Explorer ALAS, combines a free GIS viewing tool and an extensive database of accident locations and characteristics. This allows users, at little or no cost, to view accident data in a GIS environment. The second product is GIS-ALAS itself, perhaps more accurately called "ArcView ALAS." ArcView is a GIS software package that allows customization using a dedicated programming language, Avenue. The query functionality of PC-ALAS has been reproduced in a GIS environment using this language. Both products, Explorer ALAS and ArcView ALAS, access the same database, thus allowing one set of data to be maintained for both types of uses.

This report documents several aspects of Phase 1 of the GIS-ALAS effort. First, a literature review and a description of the state of the art and practice are provided. Second, the development and distribution of GIS-ALAS, in both its Explorer ALAS and ArcView ALAS forms, are outlined; this section, the bulk of this report, covers several topics, including the selection of the software platforms, the characteristics of Explorer ALAS, the characteristics of ArcView ALAS, distribution procedures, and database development. In addition, this section refers the reader to several appendices where more detailed information is provided. Third, an update is provided on technology transfer activities, including beta testing and training. Finally, current and future project efforts are outlined.

II. Literature Review, State of the Art, and State of the Practice

Literature Review

Literature abounds on accident analysis, traffic records, and statistical methods used to perform accident analysis. Included within this literature are numerous articles submitted to Transportation Research Record (TRR) and numerous United States Department of Transportation (U.S. DOT)/Federal Highway Administration (FHWA)/National Highway Traffic Safety Administration (NHTSA) reports.

Statistical methods articles covered a variety of techniques to analyze accident records and road safety. One article described the use of the Classification and Regression Tree (CART) method of nonparametric regression-type statistical procedure applied as a classifier and a regression model to highway safety analyses [1]. Another evaluates the use of R^2 to evaluate goodness of fit of accident prediction models [2]. One article focuses on statistical hypotheses testing and its use to analyze whether the expected accident frequency is beyond what might be explained by changes in traffic and similar influences [3]. Another article used logistic regression analysis to determine whether age and gender were factors that influenced severity of injuries suffered in head-on automobile crashes on rural highways [4]. Yet another analyzed the reliability of statistical road accident injury severity models [5], while others focused on statistical methods to identify hazardous sites [6, 7, 8, 9]. The first of these utilized a statistical test of significance to test the difference in means between two Poisson random variables [6]. The second describes the development of the rate-quality control method and use of this method in hazardous roadway location identification [7]. The third uses regression models to estimate expected number of crashes [8] and the last covers the historical and conceptual development of procedures for identification of hazardous locations for safety improvement [9]. Additional articles focus on causal factors, one considering the relationship between volume-to-capacity ratios and accident rates [10] and the other examines the relationship between prior incidents and additional incidents on urban arterial roadways [11]. Other articles focused on roadside object effects on accident severity with one focusing on guardrail end-types, vehicle weights, and accident severities [12], a second on median treatments on urban arterial safety [13], a third on the effects of air bags on severity of roadside object crashes [14], a fourth studying the feasibility of utilizing accident data to derive unintentional roadside encroachment rates [15], and a fifth source, containing 7 articles, which concerns the finite element modeling of vehicle impact with a variety of safety structures [16].

Additionally, compilations of various state and federal accident statistics are available. The state of Iowa, much like other states, is required to publish a compilation of the motor vehicle crash statistics each year [17]. The federal government compiles the various state crash statistics obtained through the Fatal Accident Reporting System (FARS) and the General Estimates System (GES) in a book each year as well [18].

Also, national efforts have been made recently to improve data quality, data collection techniques, and data analysis techniques. The U.S. DOT/FHWA published a report a few years ago (1993) which summarizes a study which identified and examined technologies and current processes related to the collection and management of motor vehicle traffic accident data [19]. The report focused on identification of technologies that are most promising in terms of improving quality, accuracy, completeness, and timeliness of accident data and/or reducing the demands on police officers, accident investigators, data coders, and data entry personnel. Technologies examined included: form readers/optical scanners, laptop and notebook computers, pen-based portable computers, identification technologies including magnetic stripe, bar codes, “smart” cards, Automatic Vehicle Identification (AVI), the Global Positioning System (GPS), and location technologies. A more recent (1998) U.S. DOT/FHWA publication reports on the evaluation performed to determine the effect of emerging technologies on traffic accident reporting [20]. The technologies evaluated included standard laptop and pen-based portable computers, Global Positioning Systems (GPS), Geographic Information Systems (GIS), computer-based accident diagramming, and various forms of computer-based data entry. Technologies were evaluated for their effect on accuracy and completeness of data, speed of data entry, practicality (e.g., ease of learning, ease of use), and sturdiness of equipment. Costs of hardware and software used is also provided. One of four sites examined in this publication is Des Moines/West Des Moines, Iowa. Two U.S. DOT/NHTSA publications report on two current national data quality/data linkage efforts. The first reports on the current efforts of the Crash Outcome Data Evaluation System (CODES) [21]. Discussion includes data resources and case selection and issues related to “as reported” data and the linkage process. The second discusses the Minimum Uniform Crash Criteria (MUCC) development process and initial efforts to develop a uniform guideline for data element collection [22].

However, implementing these various technologies, systems, and criteria will require allocation of funds. A U.S. DOT/FHWA publication which summarizes a project conducted by Northwestern University Traffic Institute addresses this issue [23]. The project objectives were: determine the costs of collecting and managing safety data, determine the quality of safety data, and recommend strategies for reducing cost and/or improving quality. Two related reports that are available as of the end of 1997 are listed.

With the efforts made to analyze and collect accident data, it is vital that quality, complete data is collected. A U.S. DOT/NHTSA technical report reviews and lists some desired characteristics of data quality to be considered when building and maintaining statistical data systems [24]. Included are discussions of possible conflicts between different characteristics. Additionally, a U.S. DOT/FHWA publication summarizes existing and emerging sources of highway safety analysis exposure data [25]. Sources reviewed include: Highway Performance Monitoring System (HPMS), Highway Safety Information System (HSIS), Long-Term Pavement Performance (LTPP) Monitoring System, Nationwide Personal Transportation Survey (NPTS), National Truck Trip Information Survey (NTTIS), Operational Exposure Data Sources, Residential Transportation Energy Consumption Survey, Truck Inventory and Use Survey (TIUS), and Weigh-in-Motion (WIM) devices. Areas reviewed for possible emerging exposure data include: Intelligent Transportation Systems (ITS), transportation planning surveys, and traffic volume data collected by the States. These data sources should allow for better causal factor determination and statistical analysis.

One other national effort to mention is the development of the Interactive Highway Safety Design Model (IHSDM). Two U.S. DOT/FHWA publications [26, 27] concerning the IHSDM are currently available. The IHSDM is a suite of CADD-compatible programs that highway designers can use to evaluate the safety effects of various design alternatives and will include the following modules: Policy Review, Design Consistency, Driver/Vehicle, Traffic Analysis, and Accident Analysis. Current plans for the Accident Analysis Module consist of models to estimate the number and severity of accidents on specified roadway segments, a benefit/cost analysis model to evaluate alternate roadside designs, and an expert system that can evaluate a design alternative and identify geometric deficiencies that may impact safety. The first report [26] presents the results of a workshop on the development of the IHSDM Accident Analysis Module. Results of the workshop included a recommendation that statistical models providing both point and interval estimates of safety measures be included. Statistical techniques that could be included are: linear regression; generalized linear models; Classification and Regression Tree (CART) analysis; Bayesian approximation; multivariate analysis; jackknifing, bootstrapping, and subsampling techniques; and nonparametric methods. A recommendation for combining formal statistical models with an expert systems approach for identifying potential safety problems associated with geometric design features also resulted. Another result was that a diagnostic approach to accident analysis module development be pursued. This diagnostic approach would combine accident reconstruction from hard-copy police accident reports and on-scene accident investigation. Identification of the sequence of events leading to particular accidents and the causal or contributing role of specific features in that sequence of events is key. The second report [27] presents the results of a feasibility study of alternative methods for developing the knowledge base for the Diagnostic Review Component (DRC) of the IHSDM.

Also, sources related to specific crash analysis programs/softwares were collected. The first of these is the user's guide for Iowa's PC-ALAS system [28], which was discussed in the introduction. The second is a CTRE report submitted to the Iowa DOT as part of the Collision Diagrams Software Evaluation project [29]. The third is the user's guide for Intersection Magic, one of the collision diagram softwares evaluated in the previously mentioned CTRE/Iowa DOT project [30]. The last is a user's manual for Alabama's Comprehensive Accident Rapid Evaluation (CARE) system [31]. Although both PC-ALAS and CARE are both excellent accident analysis and location systems, neither involves the use of a GIS for spatial referencing of the data.

Finally, only a few articles were found that utilized GIS for traffic accident analysis or modeling. One such article describes a prototype computer-based indexing model to store and retrieve the massive amounts of state transportation data, including accident data [32]. The article does not focus specifically on accident data. Another article describes a GIS-based accident risk model developed for the Ontario highway network [33]. The model described provides estimates of accident risk at four levels of spatial aggregation as specified by the user: networkwide, route-specific, route-section-specific, and site-specific. Neither of these articles reports on the development of a system, much less a system that can be utilized state- or nationwide. An additional article reported on early efforts to develop a GIS-based ALAS for the state of Iowa [34]. The system described was an early pilot project of the Iowa DOT Geographic Information Systems Coordinating Committee (GISCC). This initial pilot project effort resulted in further investigation of a GIS-ALAS system for the state of Iowa.

With all the literature existing related to accident analysis, traffic records, statistical methods, and related fields, it is clear there is a strong interest in these topics. However, of all the literature collected, only a small fraction of the literature [32, 33, 34] mentioned the use of GIS. This reflects not only the relative infancy of GIS, especially for use by transportation researchers, but also the fact that GIS is not used frequently for accident location and analysis. However, clearly interest is growing, both in GIS for accident location and analysis and in other non-GIS methods of accounting for the importance of traffic safety throughout the transportation community.

State of the Practice

Currently in the state of Iowa, four different systems for accident location and analysis exist or are underway. The original mainframe system, ALAS, has existed since the inception of computerized accident records assessment in Iowa. The successor to ALAS, the personal computer-based ALAS (PC-ALAS) [28], began in 1989 as an effort to enable various transportation agencies around the state of Iowa to access statewide or countywide accident data and alleviate the burden on the Iowa DOT main office of having to process accident information requests for these various agencies. The agencies that currently use PC-ALAS include county engineering offices, law enforcement offices, the Iowa DOT Transportation Centers, the Governor’s Traffic Safety Bureau (GTSB), and the Iowa Department of Public Safety (DPS). Two efforts that are currently underway include this project, Geographic Information System-based ALAS (GIS-ALAS), and the Microsoft Access-based ALAS (Access ALAS) project of the Iowa DOT Office of Data Services. In addition, other ongoing or recently completed projects in Iowa related to accident data include the Officer Information Manager/Mobile Accident Reporting System (OIM/MARS) project of the Iowa DOT Motor Vehicle Division, the Collision Diagram Software project for the Iowa DOT completed by CTRE, the Access Management project for the Iowa DOT completed by CTRE, and various other projects at CTRE that utilize accident data extensively.

Nationwide, only a handful of states seem to have a recent update to their mainframe systems. Of these, only Alabama’s CARE (Comprehensive Accident Rapid Evaluation) [31] system seems to be widespread. Through an email listserver maintained by the University of Alabama, information concerning CARE is sent to transportation safety personnel nationwide. According to the list, CARE is already established in both Alabama and Tennessee, and Michigan, North Carolina, and the Federal Aviation Administration (FAA) have recently decided to use CARE as well.

State of the Art

Only a few GIS-related programs/softwares exist nationwide that perform functions similar to Iowa’s PC-ALAS. Three such softwares include the Accident Information Management System: Geographic Information System (AIMS:GIS) (JMW Engineering, Inc.), Collision Database System (Crossroads Software), and AcciMap (CalGIS).

One source provides the following information on Accident Information Management System: Geographic Information System (AIMS:GIS):

> AIMS:GIS is a GIS-based program originally developed for the City of San Francisco by JMW Engineering, Inc. The program runs on Windows 95, and uses MapInfo 4.1 to operate the GIS portion of the program. The program allows the user to select intersections or links by manual input or point and click selection from the map. Once an intersection or link is selected, a collision diagram can be generated. Other features of AIMS:GIS are the ability to plot worst accident locations, provide annual reports, and perform queries. AIMS:GIS prints collision diagrams to most printers or plotters. [29]

Another source provides additional information on AIMS:GIS. AIMS:GIS runs on all Windows operating systems, runs under MapInfo, costs $4000 for the first copy of the software, 30 percent off that price for the second copy, 20 percent off that price for the third through fifth copies, and 10 percent off that price for the sixth through tenth copies. With the purchase one receives one-half year of free technical support (phone, faxes) and maintenance updates. After that, technical support and maintenance cost $750 per year. None of this covers the cost of configuring the systems. AIMS:GIS needs to be configured to work for the accident database for each jurisdiction. In the case of the Iowa DOT, the system would need to be configured to work with the statewide accident database produced by the Office of Driver Services. For a city of 1 million, it could be configured for $19,000. For state highways only, estimates range from $40,000 - $50,000 for the whole state. Additional functionality can be added by writing MapBasic code. This really is not an off-the-shelf product. It cannot just be bought, loaded, and expected to work. The location format that the software relies upon is strictly based on intersections (e.g., Main St. & 1st St.). Another component that needs to be purchased is an Address Geocoding database. The software cannot use Reference Points, Global Positioning Systems, or any other location format. To use data in other formats, a conversion program must be written as part of the configuration. It will convert the location of our data to an offset from an intersection. This includes rural areas. Handling of rural interstates and changes in the real world are vague. All of the software query and reporting functions are based on intersections. The software seems to be designed for use in urban areas. This is substantiated by the city population pricing structure. Along with the relative low costs (as compared with comparable software) comes low functionality. Most of the points made in the advertisement have to do with displaying data, not analyzing it. [35]

Also, a recent AIMS:GIS informational sheet lists the AIMS price as $2,468, for up to 20,000 accidents. For additional accidents, the price rises by $1,000 for each additional 20,000 accidents. The informational sheet mentions that AIMS:GIS doesn’t require a GIS per se, it only requires a GIS map of your jurisdiction.

The source for the first AIMS:GIS information listed also provides some information on Collision Database System by Crossroads Software. This information follows:

> Collision Database System (Crossroads Software) software runs under MS Windows and uses city street layout data to verify the location of every collision

> in the database. The Collision Database System also uses a full relational database engine to store, query, and edit collision records and an operational GIS mapping module. The Collision Database System produces reports, collision diagrams, and maps of collision information. Presentation quality color collision diagrams can be created by specifying the location, date range, and any other collision parameters desired such as collision type, distances, conditions, and primary collision factors. This software also supports color printers and plotters. [29]

Collision Database System is priced similarly to AIMS:GIS.

AcciMap (CalGIS) runs on WindowsNT 3.51 or higher, Windows95 and Win3.11, uses ArcView and Arc/Info, and costs from $15,000 - $20,000 for software (includes ArcView or Arc/Info license). The cost without the ArcView or Arc/Info license is uncertain. Additional license prices vary. This includes one year of technical phone support and maintenance. This does not cover configuration or customization costs. Since they customize the software based on individual situations, they won't estimate a total price. They did indicate that one place that had little configuration and customization paid $100,000, and one that did a medium amount paid $180,000. Maintenance costs are based on the number of computers the software is loaded on and are approximately 8 percent per year of initial costs. Any enhancements they make, they will support. They will train you to program enhancements, but will not support any enhancements you make. AcciMap seems to have a lot more functionality than AIMS:GIS, but with it comes a price. CalGIS, the creator of the software, seems to be very flexible in what they can do. That is partly why it is difficult for them to estimate a price. Part of it has to do with the quality of Iowa's data, where it resides, and how much functionality is desired. CalGIS is willing to visit and demonstrate their software. They also have a white paper with more information and a demo CD available. [35]

As a result of the Collision Diagram Software project, another collision diagram software, Intersection Magic by Pd' Programming Inc [30], was recommended to, and subsequently approved and implemented by, the Iowa DOT. Within the project evaluation report it is stated that part of the evaluation process would be considered in the GIS-ALAS development.

In conclusion, though many efforts have been made to analyze accident data through various statistical means and models, very few efforts have been made to utilize the power of a GIS environment to analyze the data utilizing its spatial nature. In addition, of the efforts that have utilized a GIS, few have developed a system to do so. The softwares that were developed utilizing a GIS environment either are not designed to analyze crash data or are prohibitively expensive. Some have both features. The recent efforts in Iowa are an initial step towards developing a low-cost, statewide system for distribution to transportation agencies for locating and analyzing hazardous roadway locations.

III. The Development of GIS-ALAS

This section outlines the development of GIS-ALAS. It covers several topics, including the selection of software platforms, the characteristics of two products developed in Phase 1 (Explorer ALAS and ArcView ALAS), and database development. Explorer ALAS is used to facilitate the simple, inexpensive viewing of accident data, and ArcView ALAS provides the query functionality of PC-ALAS in a GIS environment. In addition, this section refers the reader to several appendices where more detailed information is provided.

A. Selection of the Development Platform for GIS-ALAS

ArcView was selected to be the development platform for GIS-ALAS 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 major desktop GIS packages: MapInfo (MapInfo), Maptitude (Caliper Corp), and ArcView (ESRI). Intergraph's GeoMedia, now resident at the Iowa DOT, was not considered as it was not in existence at the time of our software evaluation process. An advantage of GeoMedia is that it can utilize data from several GIS packages in their native format. GeoMedia will be reviewed during Phase II of the GIS-ALAS project.

The project team then prepared an outline of criteria which focused on the required functionality of the selected platform to support GIS-ALAS, both within its current scope ("minimum functionality" items), and for its future development ("enhanced functionality" items). Each category of functionality was further subdivided into several types, listed in Table 1 with typical criteria used in the evaluation.

The performance of all three options was similar in most respects. ESRI's ArcView was selected due to a combination of several factors. It has dynamic segmentation and network analysis capabilities that make it a particularly useful package for the management and analysis of transportation data. Technical support is available from ISU's GIS facility, which uses ESRI's suite of products extensively, from the high-end Arc/Info to the user-oriented ArcView. In addition, the selection of ArcView also provides an opportunity to more readily make use of software upgrades and other improvement in technology. For instance, the feasibility of providing the display and query functionality of GIS-ALAS via the World Wide Web using ArcView Internet Map Objects with Visual Basic is currently being investigated.

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

Criteria	Minimum and Enhanced Functionality
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 (regular and improved), 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 accident locations, alcohol related accidents, subset of accidents 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 including capability for customizable analysis
	Enhanced: interdisciplinary applications, identify historical trends, analysis of relationships in accident 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 accident 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., accident diagrams, maps of accidents in a given city or county, pie-diagram maps of accidents 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 accident database.

The Iowa DOT’s system of collecting, managing, and analyzing crash data is likely to change over time along with technologies and user needs. Although ArcView best suits the needs of the current system, it is possible that GIS-ALAS will make a transition to another platform at a later date. It is also possible that storage platforms and database management procedures will change. Currently, accident data are stored in DB2 and exported to text files for use by ArcView in GIS-ALAS. In the future, it is possible that data will be stored in DB2, as before, and transferred to Oracle as a central server for use by GIS-ALAS, including an Internet version, and Access ALAS.

The data are also available for use in a simple GIS viewer, ArcExplorer, currently available at no cost from ESRI’s World Wide Web site, although this does not include the full query and reporting capabilities of ALAS. Improvements in software functionality, increased computer operating speeds, and the continued development of the Internet likely will provide new opportunities to improve Iowa's crash data system. The next two sections describe the two products currently available through the GIS-ALAS project, Explorer ALAS and ArcView ALAS.

B. Explorer ALAS (See Appendix A for the Explorer ALAS User's Guide and Appendix H for the ArcExplorer User's Guide)

ArcExplorer is a GIS viewing tool provided by ESRI at no cost to users. This allows users to display accident data and perform limited data analyses (see Figure 1). Explorer ALAS is provided on a CD and includes data to display the primary roads, secondary roads, municipal roads, as well as accident records and locations. The CD currently has separate A, B, and C tables for the accident records, but future versions will combine these tables into a single "ABBBC" format. (A tables contain information about the accident, B tables contain information about the vehicles and drivers involved, and the C records contain information about any person injured.) Rail lines and hydrology are provided as reference layers but contain no attribute information.

Accident and roadway data can be queried to obtain results about specific information. These results will appear highlighted on the screen (Figure 2). Thematic mapping, which allows additional visual analysis of data, is also available using ArcExplorer.

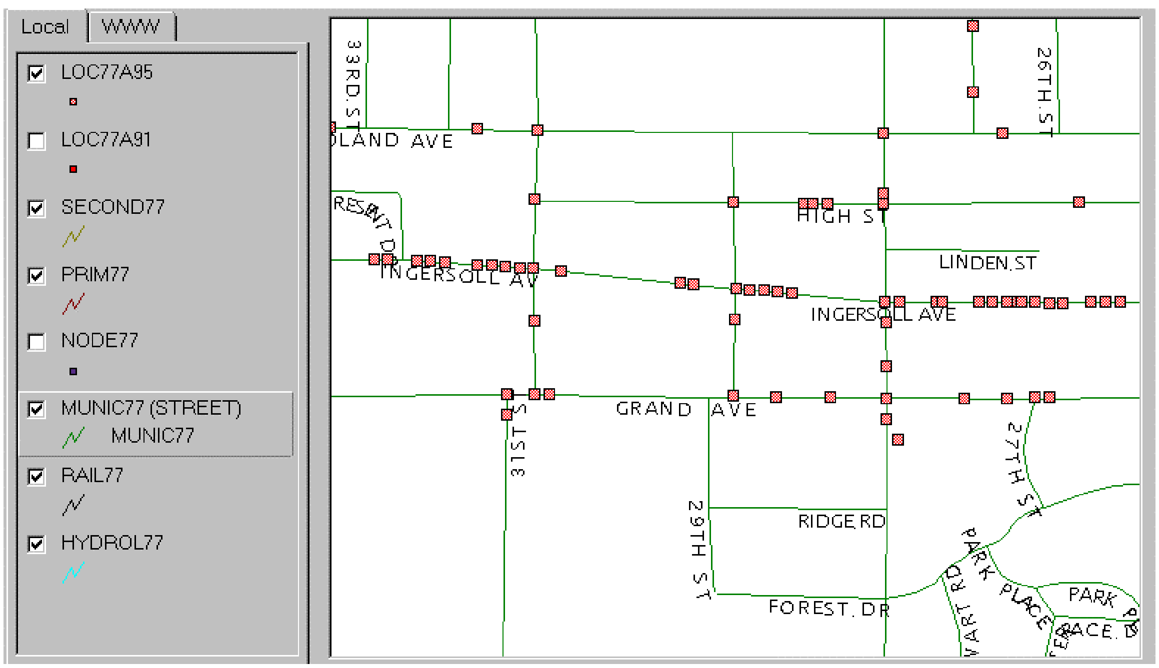

Figure 1: Accident data for a Des Moines neighborhood, 1995

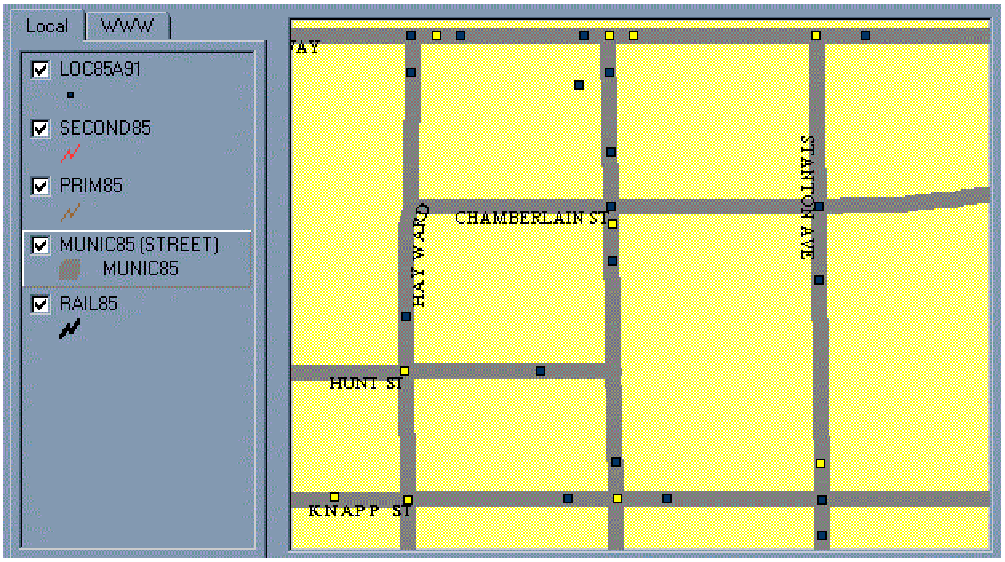

Figure 2: Injury accidents (white squares) and property-damage-only accidents (black squares) in the Campustown area of Ames, 1991

Advanced analysis tools are not provided with ArcExplorer. Query capabilities are limited compared to ArcView's query capabilities. Attempts to query two separate tables will not produce the desired result; for example, it is not possible to determine the number of people injured (A records) in crashes that had male drivers (B records) using Explorer-ALAS. 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 accidents 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. To perform these more advanced analyses, the user must have a commercial GIS package.

C. ArcView ALAS (See Appendix B for the User's Guide and Appendix C for the Developer's Guide)

ArcView is a GIS product sold by ESRI. This software provides advanced analysis capabilities, along with customization tools using ArcView's programming language, Avenue. Spatial queries and analyses of multiple databases are possible using the advanced functionality of the software. This enables users to obtain results to more complex queries than are possible using ArcExplorer.

Through the 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, by creating identical menus and querying processes, in order to provide a shorter learning curve for users. Not every function that was present in PC-ALAS is available in the first release of GIS-ALAS. However, the major functions are present. Future enhancements will be considered and addressed as feedback is received from various beta testers of the current GIS-ALAS.

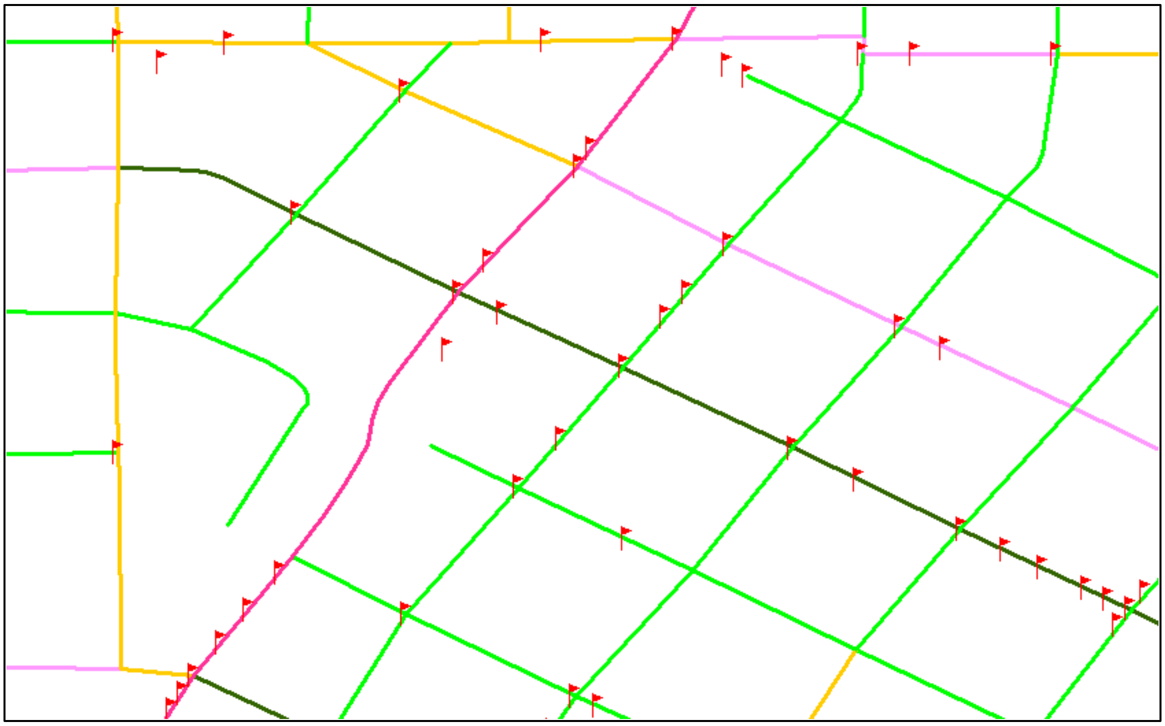

Figure 3: Thematic map of a neighborhood in Sioux City, Iowa. Traffic volumes are reflected in the shading of the roads. Accidents are displayed as flag symbols on the road network. This kind of graphical representation of data was not readily available before GIS-ALAS.

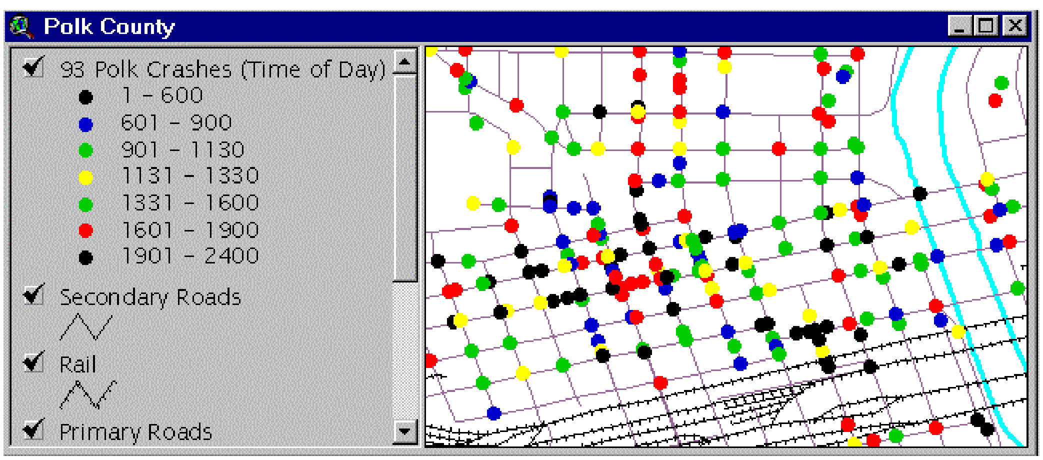

Figure 4: The spatial pattern of accidents by time of day can be easily displayed using the power of a GIS.

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, accident severity) is illustrated in the following three figures (Figures 5-7)

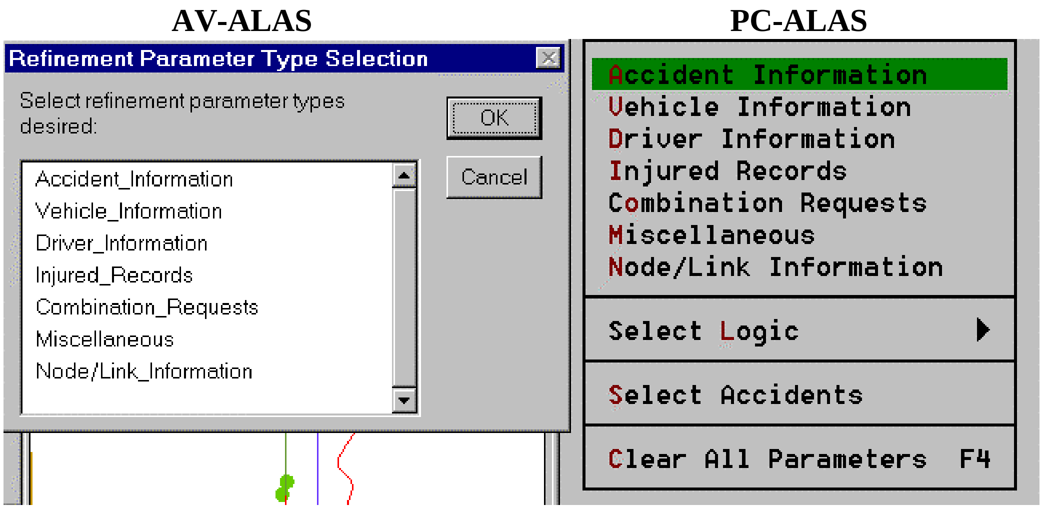

Figure 5: Selection of Refinement Parameters.

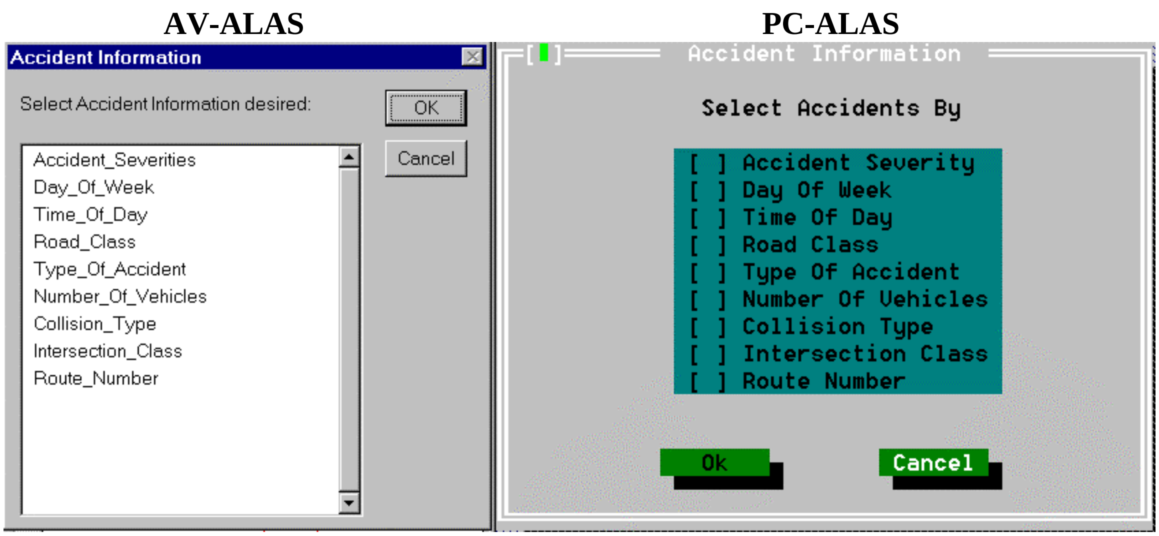

Figure 6. Selection of Accident Information Parameters.

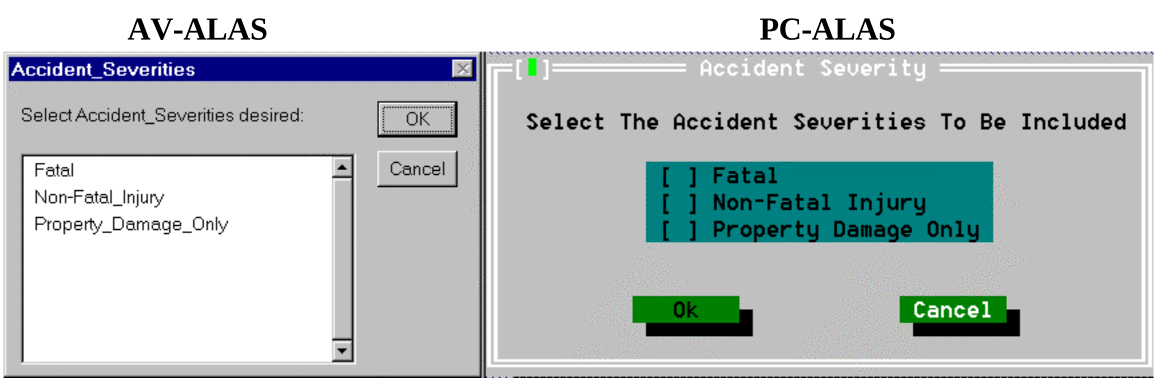

Figure 7: Selection of Accident Severities.

D. Database Development (See Appendices D, E, and F for information on variable names and value labels in the accident database)

Several data layers were needed to create a complete database that could be used with GIS-ALAS. These include road, rail, node, accident, and hydrology data layers. The rail data came via the National Transportation Atlas Database (NTAD) from the Bureau of Transportation Statistics (BTS). The remaining data layers were obtained from the Iowa DOT (see Table 2).

Table 2: Databases provided with GIS-ALAS

Coverage	Source	Current as of
Primary	Iowa DOT Office Of Transportation data	7/1/97
Secondary	Iowa DOT Office Of Transportation data	7/1/97
Municipal	Iowa DOT Office Of Transportation data	7/1/97
Rail	National Transportation Atlas Database	1997
Nodes	Iowa DOT Office of Cartography	7/1/97
Hydrology	Iowa DOT Office Of Cartography	1/1/96
A Accident Records	Iowa DOT Office of Transportation Safety	12/31/95
B Accident Records	Iowa DOT Office of Transportation Safety	12/31/95
C Accident Records	Iowa DOT Office of Transportation Safety	12/31/95

Estimates of the time required to create these databases in ArcView format are provided in Table 3. The time listed is the time required to generate the coverage from the design files obtained from the Iowa DOT Office of Transportation Data. The PC-ALAS data files, MPT files, were obtained from the Iowa DOT Office of Transportation Safety.

Table 3: Time estimates for creating GIS-ALAS coverages

Coverage	Time Required to Create
Attributed Primary, Secondary, and Municipal Roads	3 days
Accident Nodes	1 day
Accident Data	3 days
Hydrological Data	1 day
Total Time	**8 days***

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

The data obtained had to be converted for use within the GIS. The accident locations were derived from the node locations. Each accident location is determined from the distance from the reference node to the direction node. The current process determines the accident location based on the straight line distance between the nodes. Using this process may provide a location of an accident that is not on the roadway. The Iowa DOT Office of Cartography recently developed a solution to this problem. In the future, accident locations will be tied to the base records.

Roadway and hydrological data layers were provided from the Iowa DOT Office of Cartography. This information was converted to ArcView format by using another GIS, MapInfo. The MPT files were generated from PC-ALAS. This provided an ASCII file of all the information associated with the accident records. A MapBasic program was created to take the ASCII format data and create the tabular data for each accident within the state of Iowa. The accident locations are generated by using another MapBasic program. Once the accident locations are determined, a final MapBasic program was used to export the file into a MapInfo Interchange Format (MIF). ArcView can convert MIF files into ArcView format. A batch file was created to convert the data from MIF format to an ArcView format. Whenever possible, data from the Iowa DOT Office of Cartography was used. A similar process is involved in creating the other data layers in ArcView. This process was performed as illustrated in Figure 8.

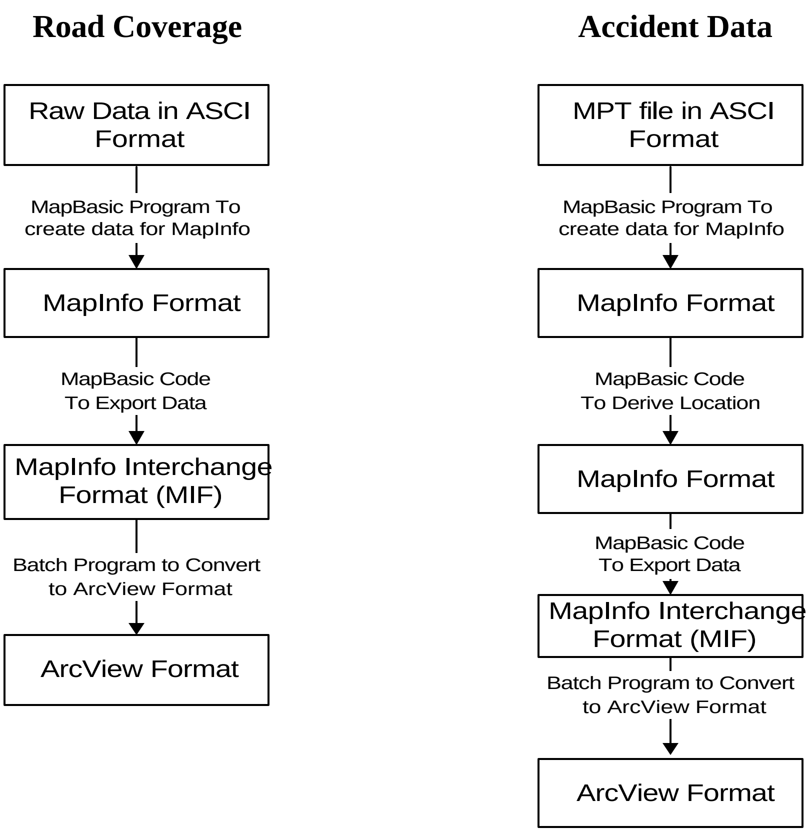

Figure 8: Database Development Process

IV. Technology Transfer

A. Distribution of GIS-ALAS Products and Data

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 accident 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 accident data along with roadway graphics to the beta test users.

The use of the World Wide Web 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 accident data via the World Wide Web, especially for data on a single accident or a specific node number. Password protection of the World Wide Web application or some of its components can easily be accomplished. Other measures may also be taken to ensure the protection of the data, including: stripping off the last four digits of the node number and creating thematic maps (e.g., to show the number of accidents at particular location). An assessment needs to be made of potential uses and users of the product to determine specific functionality implementation requirements once the World Wide Web option becomes available.

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

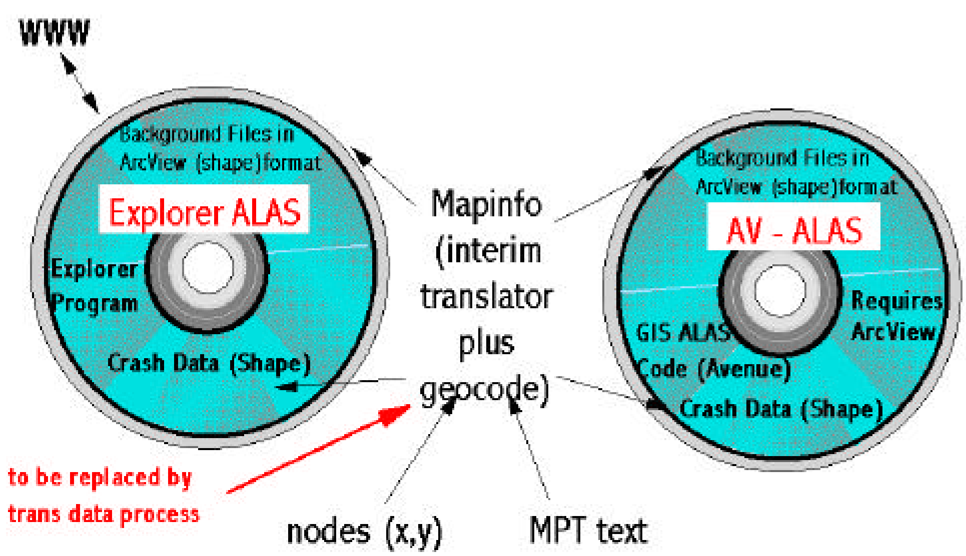

Figure 9: Summary of Database Development and Distribution

B. Training, Beta-Testing, and Feedback

On December 18, 1997, the GIS-ALAS project team provided a demonstration and training session for the GIS-ALAS Steering Committee and other interested individuals. Tutorials were provided for both Explorer ALAS and a prototype version of ArcView ALAS. Useful feedback was provided by the participants and this information 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. The project team's responses to this list are provided in Appendix G.

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. Feedback from the beta test group will be incorporated into future enhancements of the product. The following people are beta testers:

- Joyce Emery, Iowa DOT
- Jack Latterell, FHWA
- Becky Hiatt, FHWA
- Peggi Knight, Iowa DOT
- Bill Schuman, Iowa DOT
- Jaime Reyes, Iowa DOT
- John Nervig, Iowa DOT
- Jon Ranney, Iowa DOT
- Harold Jensen, Story County
- Alicia Caton, Des Moines MPO
- Sergeant R. L. Miller, Council Bluffs Police Dept
- Steve Mattke, City of Fort Dodge
- Major Larry Noble, State Patrol
- Robert Schultz, PC-ALAS Trainer
- Terry Dillinger, Iowa Department of Motor Vehicles
- Rich Rothart, Iowa Department of Motor Vehicles

Future beta testing activities and training sessions for ArcView ALAS are being planned.

In addition, the project team is working with a Ph.D. student at Iowa State University conducting dissertation research on usability testing and the implementation of information systems. The research is expected to identify possible usability problems of GIS-ALAS, explain their origin, and suggest ways to fix them. 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 research is currently being conducted and will be completed during the summer of 1998.

V. 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. The interface will be improved and specific functionality will be added in response to input from users. This input will be gathered both during the technology training sessions/workshops and after the users have had time to work with AV-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.

Additional data incorporation will be investigated in cooperation with the Black Hawk County pilot project team. This investigation will consider incorporating several different kinds of data, such as 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 (DOQs)/digital elevation models (DEMs), and maintenance and emergency facilities. In addition, this task will assess a tie-in to GPS and links to weather and other real-time information.

Phase 2 also includes exploring the following tasks:

1) Assess methods to identify accident rates for highway sections or intersections based on specific accident locations and traffic counts.

2) Develop enhanced procedures for link-node/latitude-longitude conversions.

3) Investigating the changes in emergency response patterns due to the construction of the “Avenue of the Saints.”

4) Conduct technology transfer and training.

For more information on past, current, or future efforts on the GIS-ALAS project, please contact Reg Souleyrette at 515-294-5453 (reg@ctre.iastate.edu).

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