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COMPUTER PROGRAMS FOR SAFETY ANALYSIS

Research, Development, and Technology
Turner-Fairbank Highway Research Center
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McLean, Virginia 22101-2296

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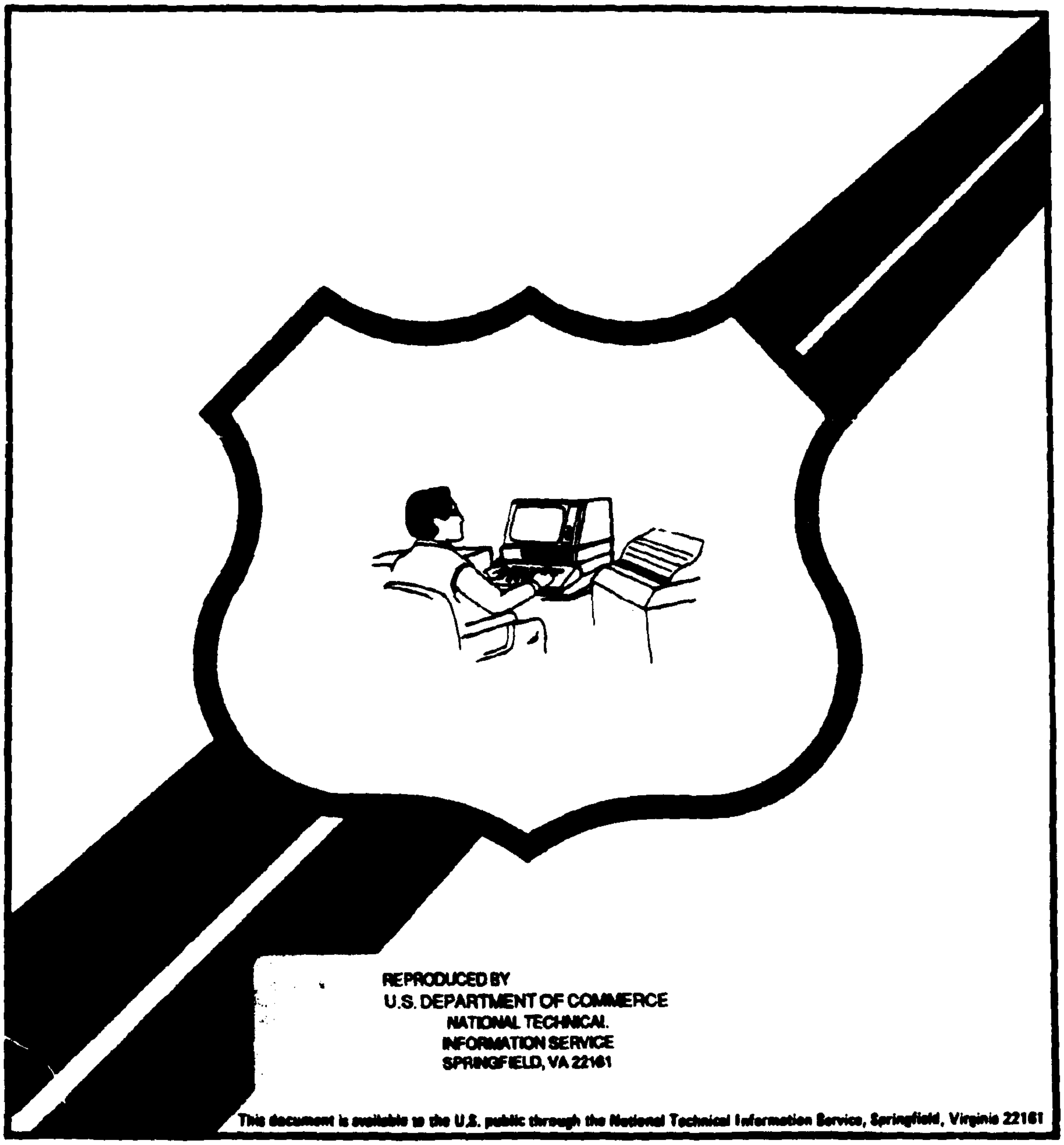

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16. Abstract
This report summarizes the results of a study to assess the needs of transportation agencies for computer software to aid in the analysis of accident data. Two computer programs were developed to meet the identified needs of local (city, county, regional) transportation agencies. The programs will operate on microcomputers and are user friendly, thus requiring minimal user training.

The first program, "Highway Safety Analysis and Monitoring" (HISAM), is used to enter, edit, and maintain accident records, street inventory data, and traffic volume data. It also contains subroutines for identifying high-accident locations, analyzing accident characteristics, and producing standard accident analysis reports.

The second program, "Highway Safety Evaluation" (HISAFE), is used to perform safety evaluations of completed safety projects. The program contains subroutines to aid the user in selecting the appropriate experimental design for the evaluation, computing the accident rates and percent changes resulting from the safety improvements being evaluated, performing statistical significance testing, and conducting an economic evaluation of the effects of the safety improvement.

These programs are fully documented in their respective Users Manuals and Operators Guides:

HISAM Users Manual FHWA/RD-87/073
HISAFE Users Manual FHWA/RD-87/074

The computer software and its documentation are available on IBM-compatible 5 1/4" diskettes from the Center for Microcomputers in Transportation (McTrans Center), 512 Weil Hall, University of Florida, Gainesville, Florida 32611. Their telephone number is (904) 392-0378.

17. Key Words
Accident data analysis, Microcomputer analysis, High-accident location identification, Highway safety evaluations

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METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

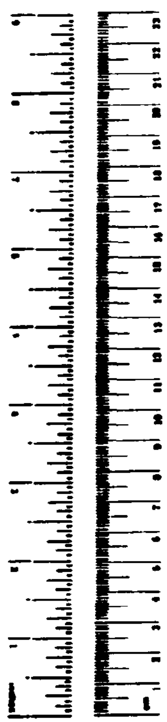
Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	2.54	millimetres	mm
ft	feet	0.3048	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
		AREA		
in^2	square inches	645.2	millimetres squared	mm^2
ft^2	square feet	0.0929	metres squared	m^2
yd^2	square yards	0.836	metres squared	m^2
mi^2	square miles	2.59	kilometres squared	km^2
ac	acres	0.395	hectares	ha
		MASS (weight)		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		VOLUME		
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft^3	cubic feet	0.0328	metres cubed	m^3
yd^3	cubic yards	0.0765	metres cubed	m^3

NOTE: Volumes greater than 1000 L shall be shown in m^3.

TEMPERATURE (exact)

Symbol	When You Know	Multiply By	To Find	Symbol
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

* SI is the symbol for the International System of Measurements



APPROXIMATE CONVERSIONS TO SI UNITS

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		LENGTH		
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
		AREA		
mm^2	millimetres squared	0.0016	square inches	in^2
m^2	metres squared	10.764	square feet	ft^2
km^2	kilometres squared	0.39	square miles	mi^2
ha	hectares (10 000 m^2)	2.53	acres	ac
		MASS (weight)		
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T
		VOLUME		
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m^3	metres cubed	35.315	cubic feet	ft^3
m^3	metres cubed	1.308	cubic yards	yd^3

TEMPERATURE (exact)

Symbol	When You Know	Multiply By	To Find	Symbol
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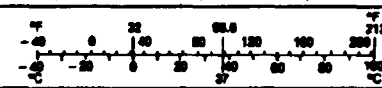

These factors conform to the requirement of FHWA Order 5190.1A.

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INTRODUCTION

Highway safety professionals are faced with the responsibilities for reducing the number and severity of accidents and the potential for accidents. Addressing these responsibilities in an effective, systematic manner requires a well-organized highway safety improvement program that includes planning, implementation, and evaluation components. Associated with each of these components are a series of processes that involve decisionmaking efforts. These processes include:

- Developing accident/traffic/highway data bases.
- Summarizing accident data.
- Identifying hazardous locations.
- Analyzing accident data.
- Selecting alternative countermeasures.
- Assessing the cost-effectiveness of alternative countermeasures.
- Prioritizing projects.
- Evaluating the effectiveness of safety improvements.

The extent and sophistication of efforts associated with these processes vary considerably with the resources (equipment, manpower, budget, computer facilities) available to an agency. Computer facilities are particularly important in the process since most agencies deal with thousands of accidents, extensive roadway networks, and widely differing traffic conditions. This implies that a considerable amount of information must be processed as part of highway safety improvement efforts.

Functional Aspects of Highway Safety Analysis

Highway safety analysis efforts can be subdivided into five distinct functional areas. These areas are:

1. Collect and maintain data: The ability to conduct any rigorous highway safety analysis depends on the existence of a well-organized and well-maintained data base. The development of such a data base requires effective management and timely input of collected data, monitoring of data integrity, integration of different data files,

maintenance of a viable location reference system, and generation of useful reports.

2. Identify hazardous locations: A systematic procedure for reviewing the entire highway system on a periodic basis is necessary to identify those locations within the system that have experienced unusually high numbers of accidents or levels of severity, or have the potential for major safety problems. Undertaking this function requires a well-defined description of the highway system and a data base that provides accurate accident location data. In addition, information describing the features of the roadway system is useful in identifying potentially hazardous locations.

3. Investigate hazardous locations: It is necessary to carry out a systematic review of hazardous locations to determine the causes of safety problems. This function requires information on the characteristics of a location to determine safety, design, or control deficiencies that may exist. It is also necessary to determine the expected accident-reduction potential and cost-effectiveness of various remedies or countermeasures.

4. Establish project priorities: Once possible improvement projects have been selected for a given location, it is necessary to determine the relative priority of various locations for improvement. A rational means to set priorities is valuable in achieving the greatest number of benefits while satisfying established public policies.

5. Highway safety evaluation: It is imperative to evaluate the effectiveness of completed highway safety projects and programs to determine if they meet their intended objectives. The information gained in this process serves as feedback, which helps in future decisionmaking.

These functions represent the key elements promulgated by the Federal Government for highway safety improvement programs. The hierarchy of these activities provides for a systematic approach to address safety problems while the feedback mechanisms provide a means to continually improve the process and enhance highway safety.

Levels of Application

The above highway safety functions are undertaken at various levels of government. Federal agencies have responsibilities to set policies that ensure uniform design and control of roadways, establish funding programs, provide for highway construction and improvement, conduct research related to national concerns, and maintain the safety and efficiency of roadways under their direct jurisdiction. State agencies have responsibilities to plan, design, analyze, build, and maintain a system of roads to meet the transportation needs of the State. The State also has the responsibility to set standards, administer funds to local agencies, and provide other resources to local agencies. Local agencies, namely counties and cities, have direct responsibility to plan, design, build, operate, and maintain a system of roads and streets to provide for the movement of people and goods within their respective jurisdictions.

At each level, however, there exists the need to undertake various highway safety analysis functions. For example, Federal agencies need to collect and maintain data that relates to the performance of the highway system on a national scale. This information provides the basis for identifying common problems that warrant research. Information also is needed for specific locations on a sample basis to evaluate the effectiveness of various standards, programs, and policies.

At the State and local levels, similar needs exist; but generally the data bases must be more detailed and include all incidents and/or segments of the system. These detailed data are necessary to meet the daily information needs for undertaking operations, safety, planning, design, and maintenance activities for specific locations. At the local level, detailed data on each accident are needed to identify problem locations, analyze accident causes, and select appropriate safety improvements. Accident and other data also play important roles in monitoring safety and planning daily activities to maintain a high level of safety.

Applications of Computers

Computers have been used for quite some time for highway safety analyses at all governmental levels. Computers provide the capabilities to:

- Store and retrieve large amounts of data.
- Manipulate data readily for planning, design, and analysis efforts.
- Generate analyses and management reports using the data.
- Carry out tedious computations in minimal time with high levels of accuracy.
- Allow the integration of information from different data files.

These capabilities are considered essential to the management of accident, highway features, and traffic operations data. Advances in computer technology have led to improvements in hardware and software capabilities as well as reductions in cost. As a result, the feasibility of using computers for highway safety analyses has become more attractive. Increasing numbers of agencies are implementing or upgrading their computer systems.

Despite successes in using computers for highway safety analyses and demonstrated experience in system implementation, many agencies are seriously lacking in their financial ability to provide hardware, software, or manpower for computerized highway safety analysis.

Project Objectives

The primary objectives of this project were to:

- Determine the current state of the art in computer software for use in highway safety analysis.
- Identify existing software for highway safety analysis and summarize by functional area.
- Determine the needs for improved highway safety analysis software for the various functional areas and levels of application.
- Establish a work plan that defines the priorities and considers the difficulties associated with new software development.
- Develop, test, document, and deliver computer program(s) that address the highest priority needs.

Project Scope

This project has generated general computer software that will aid local jurisdictions in developing, monitoring, and evaluating their highway safety programs. The computer software has been written to run on microcomputers. Commercially available computer packages have not been duplicated. The products of this research are intended for use by city/county/regional transportation agencies to effectively analyze highway accident data and evaluate safety improvements.

Two software packages were developed as a result of this project. The first, Highway Safety Analysis and Monitoring (HISAM), is designed to facilitate the analysis and monitoring of highway safety by local agencies. The second package, Highway Safety Evaluation (HISAFE), will allow local agencies to perform evaluations of completed highway safety projects.

SYNTHESIS OF PRACTICES AND NEEDS

This project was initiated to determine how and where computers were being used for highway safety analyses. The approach involved an indepth review of available literature, formal contacts with agencies, and informal discussions with professionals in the field. In the process, a significant amount of information was obtained, but it varied significantly in its level of detail.

The synthesis effort was initiated with a literature review (see source list) compiled from two bibliographic searches and from the personal libraries of project team members. In many cases it was found that the readily available literature failed to provide sufficiently detailed descriptions of the safety software or that software documentation was limited or nonexistent. This fact made it difficult to gather detailed information about the software from the literature alone. Therefore a list of prospective agency contacts was derived from the findings of the literature review. From this list, transportation agencies in the following six States were contacted for detailed information on the highway safety software used:

- Texas.
- Oregon.
- Virginia.
- Minnesota
- New York.
- Arizona.

The objectives of the contacts were to:

- Gather information on relatively unknown software systems currently being used or developed.
- Identify needs for new software based on the experiences of persons involved in highway safety analysis.
- Establish contacts for follow-on efforts to implement and test new software.

In each case, additional literature was requested to provide a means of thoroughly understanding the features and functions of the highway safety software used.

Informal discussions were held with various highway safety professionals. These discussions helped to identify the software capabilities of other agencies and/or efforts currently underway to develop new software. Several private sector firms active in software marketing also were contacted to determine if innovative programs were under development.

The findings from these efforts were compiled to provide the basis for the synthesis of practices and needs. The following sections present summaries of the current software available and the needs for additional software.

Summary of Current Safety Software

A summary of the software reviewed in this project is presented by functional area in table 1. This table shows that computer software for the collection and maintenance of data and the identification of hazardous locations is the most prevalent. These aspects of a highway safety improvement program are the most data intense and, therefore, the most obvious candidates for computerization. (It should be noted that the existence of software does not imply adequate computer capabilities.)

The software classified under the investigation of hazardous locations function is not as extensive as it may appear. Much of the software indicated is primarily related to the management of accident information. This information is the starting point for the investigation of hazardous locations, but additional analysis capabilities are needed. Computer software for the other functional areas, including evaluation of safety projects and establishment of project priorities, has been developed, but it is clearly not as common. The reasons for this are:

- Agencies have placed more importance upon developing and upgrading the software for data base development and hazardous location identification.
- The nature of the processes for investigating hazardous locations involves a great deal of engineering judgment to determine correctable/noncorrectable accidents and identify specific accident causes.
- Limited safety funds reduce the number of annual projects that can be undertaken to a manageable few. This implies that the selection process can be handled manually.
- Some agencies have not conducted evaluations of highway safety projects and programs.

Table 1. Summary of software by functional area.

Agency	Collect and Maintain Data	Identify Hazardous Locations	Investigate Hazardous Locations	Establish Project Priorities	Evaluate Safety Projects
Michigan DOT	MIDAS, MALI	MALI	MALI, MIDAS		
Florida DOT	HSIS, SAS	HSIS, SAS	SAS		
Auburn University		CARE	CARE		
Alabama DOT	MTRS	RAPID, AIM CORRECT	RAPID CORRECT	DPM CORRECT	ACE CORRECT
Ohio DOT	TSP	HSP			
Federal Highway Administration	MACTOP		MACTOP, UPACE COMEP, GRAIL	DYNPROC, HIAP INTPROC, INCBEN	
Kentucky DOT				KyDPM	
North Carolina DOT	MERGE II	MERGE II	MERGE II		
Texas Transp. Institute			ISAP		
Montana DOT	HIS	HIS	HIS		
Rhode Island DOT	RIARS				
Hagerstown, MD	McTARS	McTARS	McTARS		
Minneapolis, MN	TACT		TACT		
Goodell-Grivas, Inc.			ACDS		
Fulton County, GA	CTRMS	CTRMS			
Washington State DOT	TRIPS		TRIPS		
Pennsylvania DOT	ARS	ARS			

Table 1. Summary of software by functional area (continued).

Agency	Collect and Maintain Data	Identify Hazardous Locations	Investigate Hazardous Locations	Establish Project Priorities	Evaluate Safety Projects
National Highway Traffic Safety Administration	DART		DART		
New York DOT	CLASS	CLASS	CLASS		FIES
Indiana DOT	INTRACS	INTRACS	INTRACS		
Seattle, WA	SAFTI		SAFTI		
Texas DOT		WINDOW	CASESTUDY, TAP	SAVE/CITY-COUNTY	
Maryland DOT	MAARS		MAARS	MDPM	
Utah DOT	HISIS		HISIS		
Tennessee DOT	TRIMS	TRIMS	TRIMS		
West Virginia DOT	TRIS	TRIS	TRIS		
Oakland County (MI) TIA	TIA	TIA	TIA		
Missouri DOT	STARS		STARS		
Colorado DOT	IRIS	IRIS	IRIS	IRIS	IRIS
Phoenix, AZ	MAIP				
Nebraska DOT	ARI	HALA	ARI		
Hennepin County, MN	HCHIS	HCHIS	HCHIS		
Kansas DOT	HYSIS		HYSIS		
Claremont, CA	TARP	TARP	TARP		
Maine DOT	TINIS		TINIS		
Arizona DOT	ALISS	ALISS	ALISS		

Despite the limited existing software for the last three functional areas, it is believed that computer applications in these areas would be advantageous.

A general observation from the information in table 1 is that most of the highway safety software capabilities exist at the State level. The size of the State road network has provided the impetus for State agencies to implement computers and computer systems. The State, in many cases, acts as a central information depository and provides information to local agencies. While there are certain efficiencies in the centralization of computer facilities and resources, problems are often encountered at the local level. These problems include:

- Failure to obtain information and/or analysis reports in a timely manner.
- Local roads often are not included in the State data system.
- Lack of understanding of local streets and traffic patterns leads to miscoded data and/or unusable analyses.
- Centralized systems often lack the capabilities to provide the types of reports needed at the local level.

It must be recognized that addressing these problems will not necessarily lead to more emphasis upon safety at the local level. Some agencies do not have the staff, the expertise, or the time to put more emphasis on safety. Even when they do, efforts to identify and analyze safety problems may be in vain, since the money necessary to make the improvements is unavailable.

The conclusions drawn from a synthesis of current software for highway safety analyses are summarized below by functional area:

1. Collect and maintain data.

    - Most State agencies have implemented computer systems for the storage, editing, and retrieval of accident, highway, and traffic data. Other agencies (i.e., cities, counties) have also undertaken efforts to implement software for improved information management.
    - Accident, highway, and traffic information systems have been developed using both custom programming and commercially available Data Base Management System (DBMS) software.

- Various amounts of detail may be noted in data base systems.

- Data linkages are critical to comprehensive highway safety analyses, but a considerable amount of work generally is associated with establishing appropriate linkages.

- Considerable data overlap and redundancy is common with unlimited data systems.

- Relatively few agencies have established the necessary linkages for the full integration of their data bases.

- Most of the existing software for information management is oriented to large computers. Only limited efforts have been made to develop microcomputer-level systems.

2. Identify hazardous locations.

   - Many different methods are used to rank locations relative to their level of hazard, with the accident frequency and rate methods being the most common.

   - Many State agencies have implemented software for the identification of hazardous locations on a periodic basis. The extent of roadway networks has provided the impetus for the computerization of this process.

   - The transferability of software has been limited by the unique features of each State's data base.

3. Investigate hazardous locations.

   - Limited software is available to facilitate the process of investigating identified hazardous locations.

   - Some software is available for the assessment of specific types of countermeasures, but only limited software is available for the assessment of general treatments.

   - Some efforts have been made toward computer generation of collision diagrams. Recent advances in computer graphics capabilities offer new opportunities for safety software.

4. <u>Establish project priorities</u>.

   - Limited efforts have been made by State agencies to implement decisionmaking tools for project prioritization.

   - Several pieces of software--INCBEN, DYNPROG, and INTPROG--were recently developed by TTI under a Federal research grant for the analysis of the viability of the incremental benefit-cost ratio, dynamic programming, and integer programming methods of project prioritization. It is not known if these programs can be readily implemented by a highway agency.

   - Existing software for project prioritization is oriented toward large mainframe computers.

5. <u>Evaluate safety projects</u>.

   - Only a limited effort has focused on the evaluation of highway safety projects and programs. Consequently, relatively little software is available for this function.

Highway Safety Software Needs

The findings of this project indicate there are a number of "needs" for new or improved software for highway safety analysis purposes. A summary of these needs is presented below by functional area:

1. <u>Collect and maintain data</u>.

   - Improved methods are needed to get accident data into the computer. Equipment has been developed to automate the process of developing highway and traffic data bases but the need to facilitate accident data acquisition and compilation remains.

   - Information management tools are needed by local agencies to facilitate highway safety efforts. Local agencies have limited facilities for the management of accident, highway, and traffic information. This information is critical for local agencies to deal with daily problems.

   - A microcomputer-oriented, integrated information management system would represent a valuable tool to local agencies. None of the currently available software meets this specification.

- State-maintained data bases are often inaccessible to county and municipal agencies. The need exists for better means to download information.

2. Identify hazardous locations.

    - Software is needed that makes use of more sophisticated methods of ranking hazardous locations, e.g., equivalent property damage only (EPDO) method.

    - Generalized routines for the identification of hazardous locations by various methods are needed to eliminate redundant software development efforts.

3. Investigate hazardous locations.

    - Generalized software for the plotting of collision diagrams for various situations needs to be developed.

    - Microcomputer software for preparing detailed cross tabulations of accident characteristics is needed to improve the identification of possible accident causes.

    - Generalized software for the assessment of alternative accident countermeasures is needed to assure that accident reduction factors and cost-effectiveness measures are considered in the selection process.

4. Establish project priorities.

    - There is a need to provide generalized software for the prioritization of projects using any one of the presently known methods.

    - Priority analysis software needs to be developed for microcomputers to provide greater access to this type of decision tool.

5. Evaluate highway projects.

    - Microcomputer software applicable for conducting various types of highway safety evaluation is needed at all levels to provide the basis for establishing accident reduction factors.

- Evaluation software is needed to facilitate and standardize the highway safety evaluation process to encourage more evaluations and to allow greater use of the results.

In determining critical needs it was necessary to consider the level of application and frequency of software use. Table 2 provides a summary of software needs by level of application. It is apparent that the greatest needs for highway safety software exist with the local agencies. Many local agencies are deficient in their software capabilities across all functional areas. State agencies have the greatest needs in steps 3 to 5 of the Highway Safety Improvement Program (HSIP), which are to investigate hazardous locations, establish project priorities, and evaluate safety projects. The nature of these steps is such that any software developed to address these needs may also be applicable at the local level. Finally, one need that cuts across all levels relates to highway safety evaluations. A software system could be developed to encourage more evaluation efforts, standardize the process, and provide inputs to a national data base that could serve as the basis for developing accident reduction factors or conducting research.

The importance to be placed upon addressing needs also depends on the frequency of application. It is obvious that the implementation of a tool that will facilitate daily highway safety analysis efforts will be more advantageous than one that is used only on an annual basis. Table 3 provides a summary of the general frequency of application of the various types of highway safety analysis software. This table indicates that addressing software needs associated with collecting and maintaining data and investigating hazardous locations offers the greatest return. These and other considerations were used in developing the recommended software described in the remainder of this report.

Table 2. Summary of highway safety analysis software needs.

	Level of Application		
Functional Area	**Federal**	**State**	**Local**
Collect & Maintain Data	o Establish data base for safety analysis	o Data uploading capabilities o Improved data linkages	o Improved information management tools o Integrated data systems o Improved access to state data bases o Data uploading capabilities
Identify Hazardous Locations	N/A	o Upgraded software incorporating new methods o Integrated safety analysis systems	o Upgraded software incorporating new methods o Integrated safety analysis systems
Investigate Hazardous Locations	o Development of ARF/costs data base	o Improved accident analysis tools o Development of ARF/costs data base o Integrated safety analysis systems	o Improved accident analysis tools o Integrated safety analysis systems o Microlevel tools for countermeasure assessment
Establish Project Priorities	N/A	o Implementation of priority analysis software o Microlevel tools for priority analysis	o Implementation of priority analysis software o Microlevel tools for priority analysis
Evaluate Safety Projects	o Development of data base for safety evaluation	o Development of data base for safety evaluation o Tools for conducting evaluations	o Development of data base for safety evaluation o Tools for conducting evaluations

Table 3. Frequency of software use at various levels.

	Level		
Functional Area	Federal	State	Local
Collect & Maintain Data	Occasionally	Daily	Daily
Identify Hazardous Locations	Rarely	Annually	Annually, Monthly
Investigate Hazardous Locations	Occasionally	Daily	Daily
Establish Project Priorities	Rarely	Annually	Annually
Evaluate Projects	Occasionally	Periodically	Periodically

COMPUTER SOFTWARE DEVELOPMENT

The review and critique of existing software for highway safety analysis led to the identification of many areas of need. Many options existed for the development of software to address these needs. These options include:

- Mainframe-to-microcomputer linkages to increase the accessibility of State-maintained accident data files for local agency use.
- Micro/minicomputer software package for local agency safety monitoring and analysis. Functions would include accident data entry, identification of hazardous locations, and the analysis of problem locations.
- Improved software for the identification of hazardous locations that will incorporate state-of-the-art algorithms.
- Software for computer-generated collision diagrams to facilitate accident analysis (possibly using interactive graphics software).
- An accident countermeasure effectiveness analysis package to assess accident reduction factors and costs/benefits for candidate improvements.
- Improved software for accident trends analysis that will provide better summaries or use advanced statistics (i.e., time series analysis).
- Software for recording and monitoring safety-related complaints.
- Software for the analysis and targeting of safety-problem-prone groups (i.e., drinking drivers, young drivers).
- Software to facilitate the application of statistical analysis and simulation programs to increase safety research capabilities (possibly a generalization of some of the CRASH software used for NASS).
- Develop software to determine State/local agency norms for comparative analysis.
- Develop templates and/or external subroutines for use of commercially available micro/minicomputer data base management programs for keeping accident records, maintaining

a highway and traffic data base, and/or providing management/analysis reports.

- Develop a micro-oriented system for safety evaluation processes following the Highway Safety Evaluation (HSE) model.

- Develop graphics tools for use with safety studies (e.g., summary charts, monitoring reports, and trend analysis).

The selection of those options to be the focus of software development efforts in this project was made on the basis of the following assumptions:

- Software development would attempt to address common needs (i.e., software meeting the unique needs of a single agency would not be pursued).

- A critical need exists at the local level for better information management and tools for highway safety analysis.

- The applicability of the software developed in this project would be maximized by focusing upon microcomputer systems.

- The scope and resources of this project would limit software development options.

Based on the needs and options summarized above and the scope and resources of this project, two software packages were developed. The first package, Highway Safety Analysis and Monitoring (HISAM), is designed to facilitate the analysis and monitoring of highway safety by local agencies. The second package, Highway Safety Evaluation (HISAFE), will allow these local agencies to perform evaluations of completed highway safety projects.

When software is developed for scientific and engineering uses, its design must be carefully planned and rigorously tested before it can be used on a widespread basis. It is also important to consider who will use the software. The intended users of these packages include:

- City or county engineers who may have little or no formal highway safety background, yet require a data management tool to conduct accident analyses.

- City or county police officers who are familiar with traffic enforcement, but may have little scientific knowledge about highway safety analysis.

Therefore, the characteristics of both packages are as follows:

- Requires no additional field data to what are commonly collected.
- Involves very few human decisions.
- Requires simple input and produces simple output.
- Can be operated on an IBM or IBM-compatible microcomputer.
- Does not require users to have a computer programming background.
- System is user friendly.

HIGHWAY SAFETY ANALYSIS AND MONITORING (HISAM) SOFTWARE

The HISAM software was developed to meet information management needs and to aid local agencies with data base development and accident analysis. The software developed has the following characteristics:

- The system is modular in design to allow additional future routines to increase program capabilities.
- Programs are menu driven to facilitate their use.
- Programs allow for the integration of accident and inventory data bases.
- Data entry programs have standardized formatted screens to facilitate the data input process.
- Data entry programs have internal validity checks for alpha-numerical characters of all data fields.
- Programs provide error messages and interpretation information to facilitate the use of the system.
- Complete documentation provides user with instructions to facilitate system use.

These features allow the software to be used by many agencies. It is particularly important to provide linkages between files for the integration of data. For example, the length of a link and the average annual daily traffic volume from the link data base can be combined with the number of accidents on the link from the accident data base to determine the accident rate for the link. This feature is currently limited or nonexistent in available microcomputer software.

System Hardware/Software Requirements

The HISAM software is designed to run on the IBM PC, PC-XT, PC-AT, and 100 percent IBM-compatible microcomputers. The system must have the following:

- DOS, version 2.0 or higher.
- 640K of main memory.
- A 5.25-inch floppy disk drive.
- A hard-disk drive with a minimum of 10M bytes.

- A monochrome or color monitor.
- A printer that is compatible with the computer and operating system listed above.

This system is also adequate for the Highway Safety Evaluation (HISAFE) software which does not require the amount of memory or storage space listed above (refer to page 28).

Fundamental Structure and Design

The HISAM software package has a modular design. The fundamental structure is shown in figure 1 and includes:

- Main program module.
- Data base module.
- Analysis module.
- System utilities module.
- System information module.

This modular structure allows for the future addition of other analysis programs and data base developments.

The main module serves as the primary operating system for HISAM and links the other modules together. It is entered each time the system is initiated and provides a means for the user to request information about the various subsystems included in HISAM. Once the program is accessed, the user can call up the main menu for the entire software system on the screen by pressing the carriage return key (found on the right side of the computer keyboard). This main menu provides the user with options, each corresponding to the four system modules. By pressing an appropriate function key (found on the left side of the keyboard), these system modules can be accessed.

The data base module of HISAM is used to store, view, modify, and remove data from the data base. There are three files incorporated into the data base module: an accident report file, a link description file, and a node description file.

The analysis module contains several programs to perform a number of analyses and produce reports useful in highway safety management. Among the reports generated are high-accident location reports, accident rate reports, and equivalent property damage only (EPDO) reports.

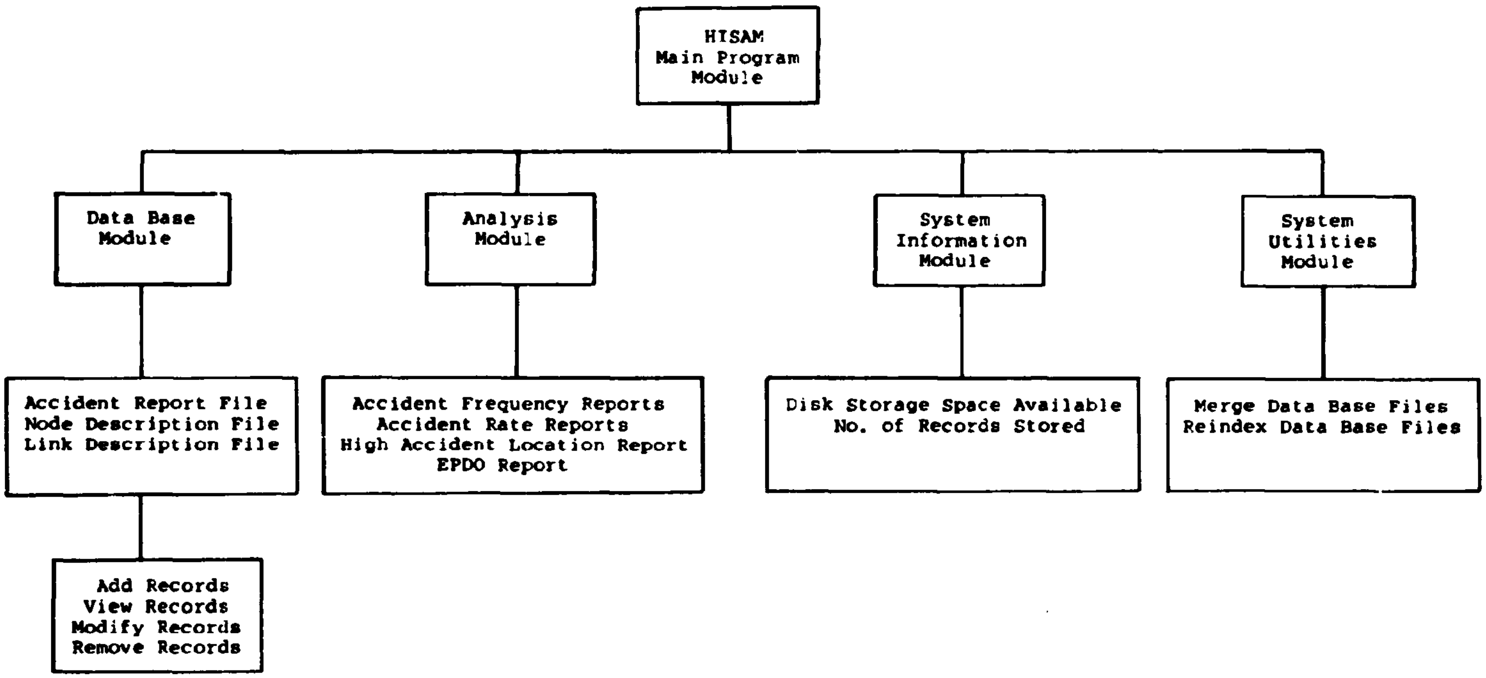

Figure 1. HISAM fundamental structure.

The system utilities module contains programs to merge data base files that may have been entered on separate computers. This module also allows the user to reindex files which may have been damaged as a result of operating errors such as turning off the computer during data entry.

The system information module of HISAM is accessed to determine the amount of space available on the hard disk and the number of records stored in the HISAM program.

Program Features

One of the functional classifications in highway safety analysis is the collection and maintenance of a well-organized and well-maintained data base. The HISAM software data bases are structured to allow for the effective management and monitoring of collected data as well as integration between data files.

The three HISAM data bases--accident report, link description, and node description--are menu driven for easy access by the user. The functional capabilities of each data base consist of the following:

F1: Add a report.

F2: View an existing report.

F3: Modify an existing report.

F4: Remove an existing report.

F5: Data base information.

F9: Return to master menu.

These functions allow for the efficient storage and retrieval of data while minimizing the chance of operation errors by using menu-driven operations.

The accident report file is used to maintain the accident recording system. Each accident that occurs within the specified system of links and nodes is recorded under a separate report number and entered in the format shown in figure 2. The variables entered in this report include:

- Accident location (link or node).
- Location code (up to 9 characters).
- Reference code (up to 9 characters).

```
Move Forward: Tab    | Move Backward: Ctrl-E    | Save: Ctrl-Z Aftr Rsp Rq Fs
Clear Field: Ctrl-Y  | Clear to left: BackSpace | Clear to right: Ctrl-G
 ----------A C C I D E N T   D A T A   E N T R Y----Report No.: ------
| Accident Location:      Location Code:          Reference Code:          |
| Accident Date:          Day of Week:            Time of Accident:        |
| Distance:               Accident Type:          Total Prsns Invl:        |
| No. Injured:            No. Killed:             Accident Severity:       |
|--------------------------------------------------------------------------|
|              Vehicle No. 1         Vehicle No. 2         Vehicle No. 3   |
|            Driver   Passenger    Driver   Passenger    Driver   Passenger|
|--------------------------------------------------------------------------|
| Inj. Class |                                                             |
| Belt Use   |                                                             |
|--------------------------------------------------------------------------|
|            | Dr   Dr   Veh   Veh/Ped  Drink  Travel  Veh   Driv   Vio     |
|            | Age  Sex  Type  Manvr    Cond   Speed   Dir   Fault  Ind     |
|--------------------------------------------------------------------------|
| Vehicle #1 |                                                             |
| Vehicle #2 |                                                             |
| Vehicle #3 |                                                             |
|--------------------------------------------------------------------------|
| Alignment:       Surface Cond:       Light Cond:       Weather Cond:     |
 --------------------------------------------------------------------------

Press "Esc" twice to Return to Acc. Main Menu; "Ins" to Enter an Accident.:
```

Figure 2. Accident data base entry screen.

- Accident date.
- Day of week.
- Time of accident.
- Distance (from the reference point).
- Accident type (rear-end, left-turn, etc.).
- Accident severity (fatality, injury, property-damage-only).
- Total persons involved.
- Number of persons injured.
- Number of persons killed.
- Surface condition (wet, dry, ice, etc.).
- Light condition (dawn, dusk, etc.).
- Weather condition (rain, snow, etc.).
- Alignment of the roadway.

In addition, the following information can be entered for 1 to 3 vehicles in any accident.

- Injury class and belt usage information for the driver and passenger(s).
- Driver age.
- Driver sex.
- Vehicle type.
- Vehicle or pedestrian maneuver.
- Drinking condition.
- Travel speed (just prior to the accident).
- Vehicle direction prior to the accident.
- Driver fault.
- Type of violation indicated.

Contained in the link and node description files is information describing the physical and operational characteristics of the system including:

- Link and node location codes.
- Street name.
- Length of link.
- Highway type (divided, undivided, etc.).
- Administrative class (State, Federal, etc.).
- Number of lanes.
- Speed limit.
- Type of traffic control (signs, signal, etc.).
- Level of service.
- Parking.
- Roadway width.
- Curb, median, and shoulder characteristics.

Also listed in these files are traffic volumes, which are used to determine accident rates. All of these data are entered in the same format and on a similar screen as was shown for the accident report file in figure 2.

The analysis module contains programs that generate reports used in highway safety analysis. They are as follows:

- Link Accident Location Report.
- Node Accident Location Report.
- Total Accident Frequency Report.
- Accident Frequency by Accident Type Report.
- Link Accident Rate Report.
- Node Accident Rate Report.

- Equivalent Property Damage Only (EPDO) Report.

- Accident Report List.

The Link Accident Location Report is used to determine the distances (in feet) at which accidents occurred along a given highway segment during a specified time period. The Node Accident Location Report is used to determine the distances at which accidents occurred within varying radii from a referenced intersection during a specified time period. The Total Accident Frequency Report is used to rank the links and nodes in descending order of total number of accidents occurring at each location during the specified time period. The Accident Frequency by Accident Type Report allows the user to specify up to three accident types. The program will then rank the links and nodes in descending order of frequency by the accident types specified.

The Link and Node Accident Rate Reports rank accidents in descending order of accident rates. The accident rate for links is calculated as follows:

$$R = \frac{N \times 1,000,000}{L \times AADT \times 365 \times n} \qquad (1)$$

where: R = accident rate per million-vehicle-miles (MVM) traveled,

N = number of accidents on the link during the year,

L = length of the link in miles, and

AADT = annual average daily traffic on the link, and

n = number of years of accident data being considered.

The calculation for the node accident rate is as follows:

$$R = \frac{N \times 1,000,000}{AAEDT \times 365 \times n} \qquad (2)$$

where: R = accident rate per million-entering vehicles (MEV),

N = number of accidents at the node during the year, and

AAEDT = annual average daily entering volume at the node.

n = number of years or accident data being considered.

It is important to note that the accident rates for nodes and links cannot be directly compared since the calculations do not use the same variables.

The Equivalent Property Damage Only (EPDO) Report calculates the EPDO index for accidents and ranks accident locations (links and nodes) based on this index. The EPDO index for a given location (link or node) is calculated as follows:

$$\text{EPDO index} = F(C1) + A(C2) + B(C3) + C(C4) + PDO$$

where: F = number of fatality accidents,

A = number of class A accidents,

B = number of class B accidents,

C = number of class C accidents,

PDO = number of property damage only accidents, and

C1, C2, C3, C4 = constants by which the accident totals are multiplied (input by the user).

The report also calculates an EPDO rate using this equation:

$$R = \frac{\text{EPDO index} \times 1{,}000{,}000}{ADT \times 365 \times n} \qquad (3)$$

where: R = EPDO accident rate per MVM (links) or per MEV (nodes),

ADT = annual average daily traffic (links) or total annual average daily entering volume (nodes), and

n = number of years of accident data being considered.

The final report, Accident Report List, lists all accidents at a given link or node along with selected data on each accident (e.g., time and date of accident, severity, distance of the accident from the point of reference, etc.).

HIGHWAY SAFETY EVALUATION (HISAFE) SOFTWARE

The Highway Safety Evaluation (HISAFE) Software was developed to evaluate the effectiveness of accident countermeasures following implementation. The software developed has the following characteristics:

- The system is modular in design to allow additional future routines to increase program capabilities.
- Programs are menu driven to facilitate their use.
- Programs provide error messages and interpretation information to facilitate the use of the system.
- Complete documentation provides the user with instructions to facilitate system use.

System Hardware/Software Requirements

The HISAFE software is designed to run on the IBM PC, PC-XT, PC-AT, and 100 percent IBM-compatible microcomputers. The system must have the following:

- DOS, version 2.0 or higher.
- 64K of main memory.
- A 5.25-inch floppy disk drive (preferably two).
- An IBM monochrome or color monitor.
- A printer that is compatible with the computer and operating system listed above.

This system will not satisfy the storage requirements or the memory capabilities required for the operation of the HISAM software (refer to page 19).

Fundamental Structure And Design

The HISAFE software package has a modular design. The modules in HISAFE operate independently of each other and may be accessed from DOS by typing the name of the module or by selecting the appropriate option on the HISAFE main menu. There are six program modules that make up the HISAFE package as shown in figure 3 including:

- Menu - The HISAFE system menu and utilities.

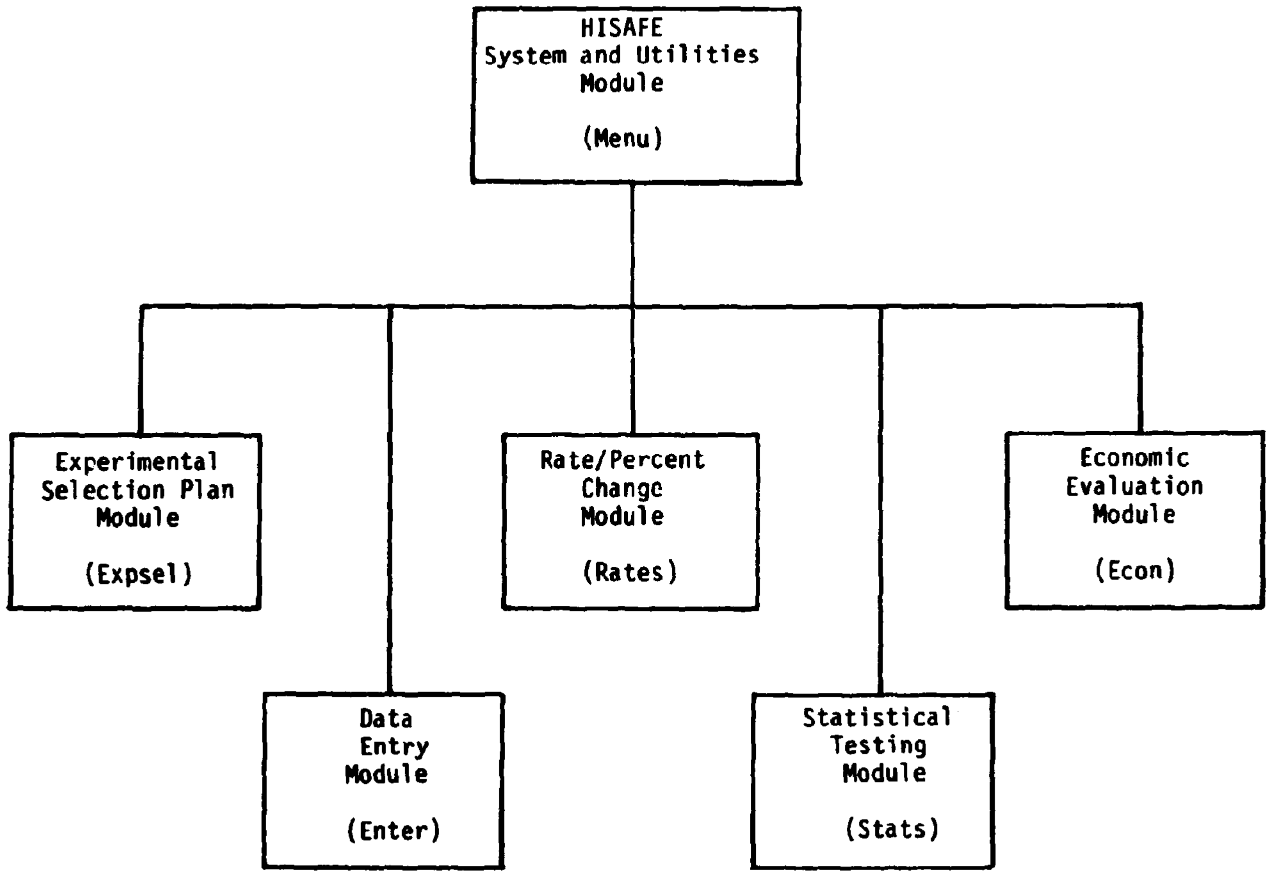

Figure 3. HISAFE fundamental structure.

- Expsel - The experimental selection plan determination module.

- Enter - The data editor/file creation module.

- Rates - Accident expected rate/percent change calculations module.

- Stats - Statistical significance testing module.

- Econ - Economic evaluation module.

The Menu module serves as the primary operating system for HISAFE. It is entered each time the system is initiated and provides the means for the user to interact with the software. The main menu in this module provides the user with options, each referring to one of the five other system modules.

The Expsel module is an interacting program used to select the data analysis techniques. The Enter module is an interactive program used for data entry. The Rates module is a program used to perform various rate/percent change analyses. The Stats module is a program used to perform statistical significance testing. The Econ module is a program used to perform economic evaluation.

Program Features

The experimental plan selection program module (Expsel) is an interactive program to aid in the selection of data analysis techniques for the HISAFE program. The Expsel module will ask the user various Yes/No questions regarding what data are available for a particular study. These questions are:

- Is "before data" available?

- Is the project of a temporary nature?

- Are similar sites available?

- Are multiyear accident data available?

- Is control of independent variables critical?

The program will terminate as soon as enough information is input into the system to determine which study is the most effective for a particular set of data. Upon termination, the program will display which type of study should be used. The five types of studies considered include:

- Comparative parallel study.
- Before-during-after study.
- Before-after with control group.
- Before-after study.
- Before-after trend analysis.

The rate/percent change computations that are available in the Rates module are taken from the "Highway Safety Evaluation Procedural Guide (FHWA-TS-81-219)." The Rates module will perform a number of different types of analyses and will flag analyses that will result in erroneous data.

Statistical significance testing is used in the Stats module to test the validity of the changes in accident rates that were found by using the Rates module. Testing can be done at four levels of confidence (80, 90, 95, and 99 percent). If the user does not specify a level of confidence, a default value of 95 percent will be used. The Stats program examines the percent change to determine whether or not the observed change in accident frequency is large enough to be attributed to changes in the project site within a given confidence level.

HISAFE will also perform an economic evaluation. The method used to perform this evaluation is the benefit/cost ratio technique documented in the "Highway Safety Evaluation Procedural Guide." To perform the evaluation, the following information must be entered:

- Initial implementation cost of the project.
- Annual operating and maintenance cost before and after project implementation.
- Salvage value of the project.
- Service life of the project.
- Discount rate.

If no discount rate is entered, a default value of 5 percent will be used. Also, the default values for accident costs shown below will be used unless modified by the user:

Fatality - $1,305,116.

Injury - $ 9,783.

Property Damage Only - $1,830.

For an explanation of these values refer to the article "Accident Costs for Highway Safety Decisionmaking," Public Roads, June 1986. After all data have been entered, the system will perform the evaluation based on equivalent uniform annual benefits and costs and display the results.

SUMMARY/CONCLUSION

Based on a thorough needs assessment, two computer software programs were developed and documented. These programs are designed to meet the highest priority needs of local transportation agencies with respect to the maintenance of accident data bases, the analysis of accident data to identify high-accident locations and accident characteristics and patterns, and the performance of safety evaluations. The programs will operate on microcomputers and are user friendly, thus requiring minimal user training.

The programs developed are designed for municipalities that range in population from 15,000 to 500,000 and average less than 30,000 accidents per year. While HISAFE can be run on a floppy disk drive, the operation of HISAM depends directly on the amount of storage available on the computer system. A minimum of a 10 megabyte hard disk is recommended for this software. Shown in table 4 are the storage capabilities of various hard disk configurations based on the number of records to be entered. It is important to remember that each record in the three data bases (accident report, link description, and node description) requires the same amount of disk space (approximately 200 bytes including the data file and the index files). Therefore, the larger the street network, the fewer will be the number of accident reports that can be accommodated by the system.

Table 4. Hard disk storage capabilities.

Hard Disk Size (Magabytes)	Storage Capabilities* (No. of Records)
10	40,000
20	80,000
30	120,000
40	160,000

*Each accident, link, or node record requires the same amount of disk space.

Here is an example of how one may determine the required amount of storage space. A municipality wants to be able to analyze 3 years of accident data with HISAM. If they experience about 20,000 accidents per year, the system would require space for 60,000 accident records alone. If the municipality was made up of 250 intersections and 1,100 links, a total storage space of 61,350 records would be required (the sum of the number of accidents, links, and nodes). Thus, a total 12.3 megabytes would be required to accomodate the municipality's needs. Table 4 indicates that a 20 megabyte system would have the storage capabilities required for this municipality.

The development phase reported here is being followed by a test phase that began in February 1986 in which both software packages are undergoing testing in a medium-sized city (Charlotte, NC). The test will consist of entering one year of accident data (approximately 18,000 reports) as well as roadway and traffic data on the locations where these accidents occur. Both programs will then be exercised to the full extent of their designed analytical capability. The test will be performed by a team of city and contractor personnel under the overall supervision of the Federal Highway Administration. At the conclusion of the test, in November 1986, a technology sharing report will be prepared that summarizes the procedures, requirements, costs, and problems experienced in implementing the software.