

Implementation of the AASHTO Highway Safety Manual

For the Alabama Department of Transportation

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Executive Summary

This report outlines a cost-effective and thoughtful way to implement the Highway Safety Manual (HSM) in Alabama.

The HSM was published by the American Association of State Highway and Transportation Officials, and it was prepared by the Transportation Research Board over a ten-year period using more 100 volunteers. The team included a broad cross section of safety scientists, academic researchers, transportation practitioners, and others, and this was reflected in the content of the HSM. The resulting document was comprehensive (over 1,000 pages); and it significantly enhanced the science of roadway safety and introduced new terminology, procedures, and protocols.

Due to the size of the document, the new terminology, the new concepts, and many other issues, moving the HSM off the shelf and into practice is an exceedingly difficult task. It helps to have an implementation roadmap from the beginning. The volunteers who developed the HSM did not realize the need for implementation assistance until after the HSM was prepared. At that time several agencies and organizations realized that a roadmap was needed, and several good implementation outlines became available. But the implementation task is still overwhelming for those who did not participate in the preparation of the HSM and find themselves leading the transition of state departments of transportation from their previous safety programs into a completely new and complex HSM-based program. For example, the decision is difficult (and expensive) about whether to acquire, develop, or ignore software to support the HSM. Likewise, the amount and level of training, the need for new data, and other issues require time and study to make implementation cost effective yet successful.

The Alabama Department of Transportation decided that it would be best to study the key implementation issues and choose a course of action that best fit the needs, existing programs, and resources of the state and of ALDOT. This report presents the results of such a study.

The research team that conducted this project gleaned information from ongoing efforts, identified users of the HSM in Alabama and what they needed from it, evaluated the capabilities of several tools and software to perform the analytical aspects of the HSM, investigated the implementation of existing major software (*SafetyAnalyst* and *IHSDM*), assessed data needs and gaps in Alabama data, mapped the capabilities of Alabama's existing safety software *CARE* to *SafetyAnalyst*, developed Safety Performance Functions for Alabama roads, and performed other investigations.

Based on these findings, the research staff developed implementation steps and actions on three bases: by the ALDOT Office of Safety Operations; by ALDOT Divisions, Sections, and other work units; and by implementation component or activity. These three lists are intended to provide guidance for a flexible implementation over three time periods: short term, mid term, and long term.

Chapter 1

Introduction and Background

This report summarizes the current status of ongoing research conducted for the Alabama Department of Transportation (ALDOT) to customize the implementation of the *Highway Safety Manual* (HSM) published in July 2010 by the American Association of State Highway and Transportation Officials (AASHTO). This research is being conducted by the University Transportation Center for Alabama (UTCA) and the Center for Advanced Public Safety (CAPS) through ALDOT contracts awarded to The University of Alabama.

There are three major components to this report:

- (1) A description of the Highway Safety Manual; its embedded definitions, methodologies, and procedures; and supporting software, publications, organizations, and assistance networks.
- (2) An overview of the Scoping Study conducted by The University of Alabama to identify the most efficient and cost-effective way to implement the HSM in Alabama and to customize the HSM for Alabama's state and local governments.
- (3) A review of a plan proposing key implementation strategies and a general implementation configuration based on key findings of the scoping study, the results of implementation in other states (e.g., Lead State project), and additional information that has become available since the HSM was published two years ago.

This report includes separate parts for each of the three major topics introduced in the preceding paragraphs, plus appendices containing key documents produced during the scoping study, ongoing and planned research that supports HSM implementation and ALDOT safety programs, and similar relevant documents.

Chapter 2

The AASHTO *Highway Safety Manual*

The first edition of the HSM was designed and developed through a mammoth effort by more than 100 expert road safety volunteers over a 10-year period. The effort was guided by a 35-person volunteer task force of the Transportation Research Board (TRB). AASHTO appointed an 18-person subcommittee to work with the TRB task force to enhance the transition of the new document into the workplace. Development of the HSM was supported by more than \$6 million in research projects selected by AASHTO and conducted through TRB's National Cooperative Highway Research Program (NCHRP).

Upon completion and a series of stakeholder reviews of the draft document, it was turned over to AASHTO for formatting and publishing. In the summer of 2010, the completed manual was published in three volumes, consisting of 4 parts, 17 chapters, and almost 1,000 pages.

Not only is the HSM a very large document; it is radically different from the myriad of smaller documents and procedures that it replaced. It is based on the constructs of modern science, which will significantly enhance the long-term effectiveness of safety policies and safety treatments. It uses data beyond that currently used by ALDOT or for that matter any other state DOT. In many other ways it promises to be a substantial improvement to the way safety processes and analysis are conducted, but this cannot be confirmed through research because the new methodologies have not been installed for a sufficient amount of time to be evaluated.

The following HSM characteristics and issues illustrate some of the major considerations in designing the implementation plan for the HSM in Alabama:

- The HSM introduces new terminology, procedures, and protocols.
- Significant training is necessary to employ the HSM procedures, which are tailored to meet the needs of safety professionals at different levels of transportation agencies.
- There is no pro forma for training across an entire state DOT, although AASHTO and FHWA have developed multiple training courses since the HSM was published.
- Computations are conducted using the Empirical Bayes (EB) method, which is rigorous and provides statistical results that are more reliable and repeatable than current procedures.
- HSM methodologies are data hungry in that they utilize more extensive data than current procedures to make more accurate estimates of safety effectiveness.
- Virtually all state DOTs will have to conduct thorough analyses of their data for roadway geometry, crashes, traffic control, traffic operations, and related projects and will find that

they need to collect additional, high-quality data to implement all of the features of the HSM.

- The user compares existing crash records and crash patterns against those predicted by Safety Performance Functions (SPFs) for the type of facility being investigated as a means of selecting sites and cost-effective situations.
- SPFs derived from national data are provided in the HSM, but they must be calibrated to match Alabama conditions or research must be conducted to prepare SPFs from Alabama data.
- No new software was developed specifically for the HSM.
- Two pieces of software long under development, *SafetyAnalyst* and IHSDM, were adapted to implement portions of the HSM methodologies.
- FHWA designed the *SafetyAnalyst* (SA) software for safety screening of sites, identifying crash patterns, analyzing the cost effectiveness of countermeasures, and conducting similar activities. It is a robust model that can require extensive effort to input and edit data during start up, but it delivers multiple types of output that can be tailored to fit the needs of an agency. FHWA transferred the software to AASHTO, which maintains it and markets it through its *AASHTOWare* suite of software.
- FHWA prepared the *Interactive Highway Safety Design Module* (IHSDM) software to provide safety analyses of alternative designs to allow use of crash costs during design decisions. Following publication of the HSM, the IHSDM crash prediction module was expanded to include several additional types of roadways.
- The CARE software (developed for Alabama and now used for virtually all Alabama safety studies and safety programs) is an issue of great concern for ALDOT. It may or may not be compatible with *SafetyAnalyst*/IHSDM. It is linked to numerous databases useful in Alabama safety studies, and it has extensive data-handling and data-analysis capabilities. A compatibility/mapping research effort will be needed to determine how CARE might be used as part of the HSM effort.
- Given a location or a situation where safety enhancement is desired, the user can estimate the effectiveness of the application of various safety countermeasures using Crash Modification Factors (CMFs).
- Many CMFs of high quality were prepared as part of the HSM. In addition, the Federal Highway Administration (FHWA) reviewed research reports to assemble a CMF Clearinghouse that contains thousands of CMFs of various levels of quality.
- For any particular future Alabama safety analysis, CMFs may or may not be available, and where they are available, they might not be high quality. It is probable that ALDOT will need to develop its own CMFs for situations specific to Alabama.
- The primary basis for selecting one countermeasure above another is safety-cost effectiveness.
- The new procedures can estimate the cost to the public for crashes that will accrue without safety treatments, and the reduction in crash costs that will occur with safety treatments.
- DOTs have found implementation of the HSM to be a major, long-term process.
- There is no plan for national implementation, nor is there a pro forma for implementation by state DOTs.

- The lack of a systematic, proven plan for implementation has delayed the use of the new safety procedures.
- The lack of a systematic, proven plan has also produced wide variety in implementation among state DOTs, especially in the amount accomplished since the HSM was published. But there is also great variety in the degree of acceptance of HSM methodologies by DOT managers, the funding and staff available to implement and administer the HSM procedures, the implementation actions that are undertaken first, and many other aspects.
- No DOTs have used the HSM and evaluated its methodologies and processes.
- An NCHRP “Lead State” project is following implementation efforts of 12 to 18 state DOTs and has found some general patterns, but in general the states are following unique paths toward implementation.
- In Alabama, local governments have less expertise and less funding than ALDOT, so special consideration will be needed in their implementation efforts.
- Preparation of the second edition of the HSM is now underway. Completion is anticipated to take three to five years, and it appears that some existing methodologies will be revisited. So the Alabama implementation should allow for future alterations and enhancements.
- It will likely take state DOTs at least five years to complete full implementation of the HSM methodology, and for many it could take ten years.

This partial list of key implementation issues illustrates the complexity of planning the implementation program and the lack of a clear direction to follow. For these reasons, ALDOT chose to conduct a scoping project to investigate the best way to conduct implementation prior to jumping headfirst into the process. The next part of this report gives an overview of the scoping study.

Chapter 3

Overview of Key Findings from Scoping Project

Due to the many uncertainties associated with the implementation of the HSM in Alabama, the best path appeared to be to investigate, test, and evaluate the overall HSM process on a limited basis to develop a least-cost/highly efficient path for implementation. Although this would postpone full-scale implementation and possibly place Alabama behind other states, such a project would most likely save time during the implementation, minimize the chance of taking the wrong steps (and wasting funding), and produce an implementation tailored to Alabama.

The University Transportation Center for Alabama (UTCA) and the Center for Advanced Public Safety (CAPS) at The University of Alabama (UA) have extensive experience with ALDOT roadway safety studies and crash analyses. Researchers at these two centers joined forces and proposed to conduct a scoping study and prepare an implementation plan for HSM implementation. ALDOT accepted the proposal and funded the study, with research beginning in late 2010.

The Scoping Project closes with the delivery of this draft implementation plan. The following narrative describes the individual project research tasks and the pertinent findings from each task. The findings typically involve research actions that identified preferred implementation steps and general time frames. Where available, the project identified optimum implementation steps.

Project Research Tasks

The heart of the project is contained in ten work tasks, each addressing a major aspect of the implementation planning. Many of the tasks will be conducted in parallel, saving time and allowing better coordination. The final task will be the development of a proposed work plan and schedule for implementation. Each of the tasks is described in the following portions of this proposal.

Task 1 – Learn from Implementation Efforts of Others

The UA research team has taken advantage of ongoing efforts of others, learning from them and swapping information with them. This project has benefited from four key sources of information about HSM development and implementation:

- TRB Task Force to Develop the HSM (now the TRB Highway Safety Performance Committee)

- AASHTO Safety Management Subcommittee, Task Committee to oversee technical documents (including the HSM)
- AASHTO Lead State initiative for implementing the HSM (NCHRP project 17-50)
- HSM coordinating committee (HSM leaders and experts from FHWA, AASHTO, and TRB)

The principal investigator for this project has been a member of all four of these groups, and the ALDOT state safety operations engineer has been a member of two of them. This allowed first-hand access to virtually all sources of up-to-date information regarding implementation of the HSM. In addition, the PI has participated in the following groups:

- Panel member for NCHRP project 17-45, which developed a freeway/interchange SPF (model) and prepared a chapter for the second edition of the HSM.
- Panel member for NCHRP project 17-48.
- Member of the task committee that developed a strategic plan for expanding the HSM for the Safety Management Task Group on Technical Documents.

The national HSM involvement of the PI and the ALDOT state safety operations engineer provided opportunities for phone and personal conversations with key representatives of FHWA, AASHTO, TRB, and other safety agencies and organizations. The experiences of those interviewed were very helpful and often revealed insights into the successes or failures of implementation attempts by others and made the UA-ALDOT team aware of unintended consequences from some actions.

Task 2 – Identification of Users and User Needs

The ideal situation would be to incorporate HSM concepts and methodologies into daily practice throughout the transportation and safety professions in Alabama. This cannot be achieved immediately, so it must be approached by determining those elements most essential to the success of the HSM implementation and designing information, training, and application programs for them. After that, other elements and other organizations can be brought under the HSM umbrella as funding and personnel are available.

The first step in this process was conducted by the project principal investigator and the ALDOT safety operations engineer, who reviewed prior and ongoing safety programs and developed the following list of potential HSM users by discipline, agency, and level of involvement:

GROUP 1: Extensive HSM Involvement by ALDOT Bureaus

- Construction
- County Transportation
- Design: Consultant Management, Environmental Technical Section, Location Section, Roadway Design Section, Traffic Design Section
- Maintenance: Traffic Operations, Access Management, Resurfacing
- Modal Programs: Safety Section, Special Programs Section, Rail Safety Section

- Transportation Planning Bureau
- Office of Safety Operations

GROUP 2: Routine or Occasional HSM Involvement by ALDOT Bureaus

- Administrative
- Bridge
- Computer Services
- Legal
- Materials and Tests
- Media and Community Relations
- Research and Development
- Training

GROUP 3: Division Extensive HSM Involvement (all 9 divisions)

- Division Pre-construction Section
- Division Maintenance Section
- Division Traffic Engineering Section

GROUP 4: Division Routine or Occasional HSM Involvement (all 9 divisions)

- Division Engineer
- Division Permitting Engineer
- Division Construction Engineer

GROUP 5: Agencies with HSM Involvement or Duties

- County Engineers
- City Engineers/Public Works Directors/Traffic Engineers
- Metropolitan Planning Offices
- Regional Planning Offices
- Federal Highway Administration Division Office
- Alabama Department of Public Safety
- Alabama Department of Economic and Community Affairs, Governors Highway Safety Representative
- Alabama Department of Public Safety
- Alabama Department of Public Health, EMS and Trauma Director
- Federal Motor Carriers Safety Administration

GROUP 6: Organizations with Occasional HSM Involvement

- SHSP Steering Committee
- Alabama Legislature, State Safety Coordinating Committee
- Auburn LTAP program
- UTCA, CAPS, and other university based research centers
- UAB and University of South Alabama research programs on emergency medical services and trauma treatment

- Industries and organizations with roadway safety interests

Other than overview training, only a limited number of these entities have been brought into HSM implementation planning or activities to date. As the implementation unfolds, additional engagement will begin with those most involved in roadway safety and those most important to the success of HSM implementation.

Task 3 – Evaluate Capabilities and Deployment Experiences of SafetyAnalyst (SA)

SA software was conceived and prepared by FHWA through a series of projects that built the basic model and expanded its capabilities to fit most of the steps of roadway safety analyses. During the development of the HSM, SA was adapted to conduct the “Part B – Roadway Safety Management Process” portion of the HSM methodology. Upon completion, FHWA passed the software to AASHTO to become part of its highly successful suite of *AASHTOWare* software. This has many advantages, including a direct link to state DOT users, addressing training and feedback from users, and ensuring long-term maintenance and upgrade capabilities. In 2010, SA was placed in the *AASHTOWare* software catalog for licensing by state DOTs (<http://www.AASHTOWare.org/Pages/SafetyAnalyst.aspx>).

The software is intended for use by state and local agencies as a safety-management tool. It can be used to evaluate the safety effectiveness of site-specific countermeasures and treatments, but it is not intended for evaluation of system-wide or programmatic safety initiatives such as increased enforcement or driver education/licensing requirements. It functions through four primary modules:

- Network screening
- Diagnosis and countermeasure selection
- Economic appraisal and priority ranking
- Countermeasure evaluation

and three additional modules:

- Administration tool
- Data Manager
- Implemented Countermeasures Tool

The software handles the basic computational tasks for the four safety diagnoses outlined in the previous paragraph for virtually any size of system, from a statewide system to a simple intersection. In addition, output can be arranged to tabulate and display data for any size system, especially if the user translates the output into a GIS system.

SA is quite involved, and there are many steps necessary to conduct accurate studies using any of the four primary modules. Unless the analyst is knowledgeable of the roadway system under study and the associated crash data, data errors or erroneous input assumptions might cloud the

accuracy of the output. The *SafetyAnalyst* software user guide addresses this issue by advising that,

Until the analyst becomes used to navigating through the SafetyAnalyst to answer particular problems, analysts should begin the process of addressing every particular problem by asking two general questions:

- *Which SafetyAnalyst module(s) should be used for this analysis?*
- *What type of analysis is needed to answer the question of interest?*

In addition, SA requires an extensive amount of data from multiple types of data files. The safety analyst must work intensively while executing the software and must have an excellent understanding of the roadway system (geometrics, traffic, traffic crashes, etc.) to ensure the data and SA output are realistic and fit the needs of the user. To assist users in implementation, there are specialized training courses, SA user groups, and chat rooms where novices can obtain advice and assistance from experienced and expert users.

During the scoping project, UA researchers and the ALDOT state safety operations engineer took multiple opportunities to attend conferences and hear presentations by state DOT representatives who were using SA. In addition, discussions were held with AASHTOWare representatives and FHWA managers involved in development of SA. UA also installed a copy of SA. A limited number of tests were run to get a feel for its capabilities. As a result of these research actions, several general conclusions were drawn:

- State DOT users and representatives of FHWA and AASHTO were confident and optimistic about the ability of *SafetyAnalyst* to function as intended.
- The model produces excellent output quality and can provide the specific output needed for a particular study.
- The software can handle many of the tedious portions of HSM-type safety studies.
- It can be time consuming and at times frustrating to install the software, proof test its components, obtain the right data in the right format, link files to build the input data file, or transfer output to another medium for display and analysis.
- The individual in charge of the software will be extremely busy during the installation and testing period and while performing studies of large systems. Institutional memory is important in preventing logic errors in assembling data, checking output for errors, and tabulating/displaying results in a user-friendly manner.
- For a large system, say statewide, the software may run on a robust desktop computer from several hours to several days.
- Even with the drawbacks of dealing with large, cumbersome data sets and complex models, SA produces terrific results.
- State DOTs that are leading in the implementation and use of SA have a high-level, dedicated staff member in charge of the overall effort. This person provides institutional memory and stability to the program.

The University of Alabama research team included the ITIS Corporation as a subcontractor due to its extensive experience in assisting state DOTs with safety programs and particularly in installing SA and similar software. One of the major tasks ITIS performed on this project was to provide background information through a nationwide survey on the status of SA implementation among state DOTs. The ITIS survey was completed in November of 2011, and pertinent findings are reflected in Exhibits 1-3. A copy of the report was provided to the ALDOT Office of Safety Operations, and the reference list at the end of this report contains a full citation of the source.

Exhibit 1. State decisions to implement/not implement SA

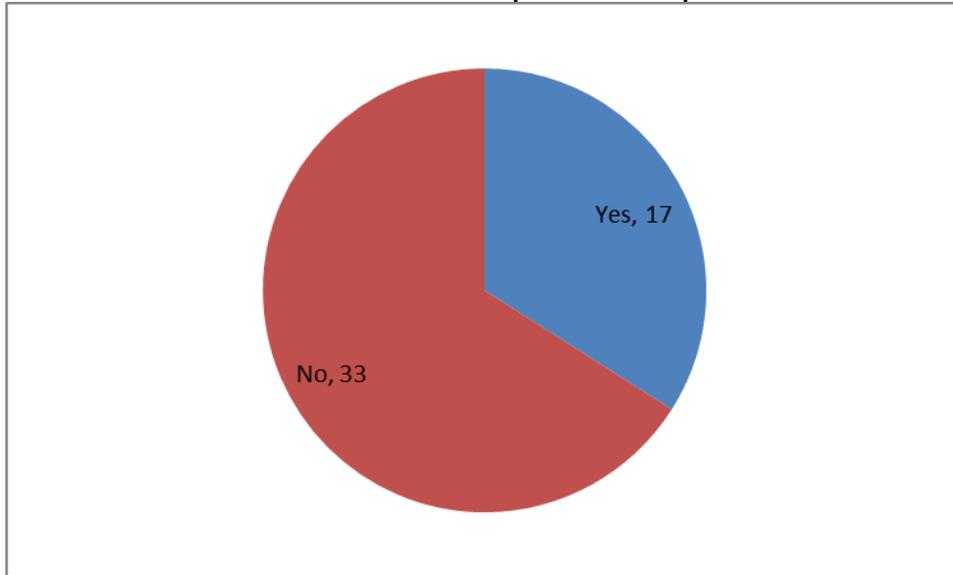
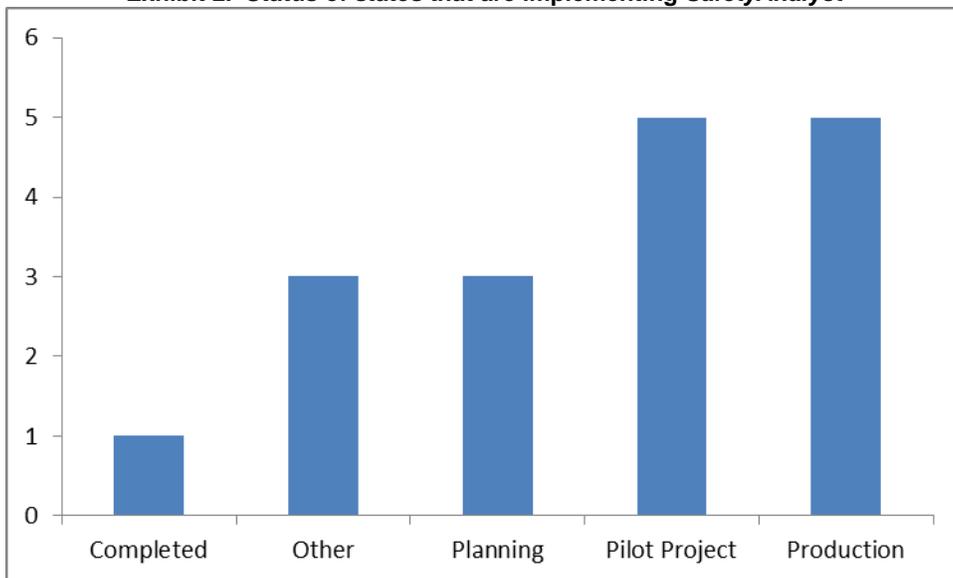


Exhibit 2. Status of states that are implementing *SafetyAnalyst*



Several conclusions may be drawn from Exhibits 1, 2, and 3. First, about a third of state DOTs were implementing or planning to implement SA. The other two-thirds indicated that they did not intend to use SA in their implementation program. Of the states that were implementing SA, one had finished its implementation and progress among the other 16 varied widely. During implementation most of the state DOTs had encountered problems or issues, some of which were substantial, as shown in Exhibit 3.

Exhibit 3. Issues identified by states implementing/planning to implement SA

7%	Construction Data
7%	Diagnosis too Strict
13%	Milepost Transformation
13%	Resolution of Data
20%	Changing Thinking from Crash Rates to Crash "Counts"
20%	General Data Migration
20%	Processing Performance

Most of the states (14) were using only the Screening Module. Two states were using the Screening, Diagnosis, and Countermeasure Modules; and one was using those three modules plus the Evaluation Module. No states were installing the Economic Appraisal Module. There are many additional findings from the survey not reported here due to space limitations. In general, the survey confirmed that installation is a major task. It requires committed staff members and serious work to acquire the needed data, to transform the data to fit SA, and to build and test the data/SA system.

Installation of SA appears to be a daunting task, given the magnitude of effort described by current users of SA and the fact that two-thirds of state DOTs do not plan to use it. Implementing SA could have a significant impact on the Office of Safety Operations and its total workload. This new work group is starting and staffing a new office, planning statewide programs, initiating and managing these programs, and simultaneously implementing all aspects of the HSM. Both UA researchers and the state safety operations engineer are concerned about the total workload if SA selected as the most appropriate tool for HSM computations.

SafetyAnalyst will be discussed again under the review of “Task 6 – Potential Integration of CARE/CORRECT with *SafetyAnalyst*.”

Task 4 – Evaluate Capabilities and Deployment Experiences of IHSDM

The Interactive Highway Safety Design Model (IHSDM) software was developed by the FHWA Research and Development Program over an extended period of time. The predictive module was based on research findings and expert opinion, and it evaluated the safety performance of roadway geometry for existing and proposed two-lane rural roads. The initial version of the software was a visionary step that was far beyond the practice of its day, and it provided a foundation for highway safety predictive-modeling efforts that came to fruition in the first edition of the HSM.

Since the initial model was prepared, a series of research projects has expanded the predictive capability of the IHSDM. The 2010 version contains crash prediction modules for two-lane rural roads, multilane highways, and urban/suburban arterials. NCHRP Project 17-45 is nearing completion and will add freeways and interchange models to the IHSDM, and additional models are planned for the future.

IHSDM is available online for free download at <http://www.ihsdm.org>. The site <http://www.ihsdm.org/wiki/welcome> includes information on current IHSDM events, downloading the software, technical support, web conferences, user applications, and more.

IHSDM's current analytical capabilities include the following evaluation modules:

- Policy Review
- Crash Prediction
- Design Contingency
- Intersection Review
- Traffic Analysis
- Driver/Vehicle Evaluation

As implied by the name of the software, IHSDM was created to assist roadway designers in predicting the safety effects of their designs. In the long term this is highly cost-effective because it may later be very expensive to alter in-place roadway geometry (e.g., horizontal curves, deep excavations) to mitigate traffic crashes. The software is an especially useful tool in evaluating the safety effects of alternative designs at a specific location or with alternative design criteria. Currently designers have incomplete guidance of safety effects of alternatives, and IHSDM can be a valid decision-making tool for traffic safety professionals in Alabama.

It must be recognized that, like any sophisticated software-based analytical tool, it requires significant training and expertise to be used effectively. Additionally, IHSDM can be data intensive. In addition to traditional traffic data such as traffic volumes and speeds, IHSDM requires detailed geometric data for roadways and intersections, information on traffic control, historical crash data, etc.

The early versions of IHSDM software were criticized by busy designers as labor intensive because of the time required to upload data for each highway-design situation, and ALDOT designers disliked use of the software because of the time and effort involved in data transfer. This requires a multi-step process for designers who are using CADD systems. They export the CADD design as an XML file, run IHSDM to identify cost-effective safety changes, and manually make the changes in the CADD design file.

IHSDM data entry is now much better than the initial versions, but the variety of types of design software makes it impossible to automatically upload every type of roadway design file.

At this time, IHSDM does not appear to be the most viable option for HSM computations for design purposes due to data input issues and the lack of automatic transfer of IHSDM design

recommendations (once approved by the designer) into existing roadway design CADD files. An alternative option might be use of HSM spreadsheets developed for ALDOT and the Virginia Department of Transportation during extensive HSM training and manual procedures.

Task 5 – Data-Needs Assessment, Inventory and Gap Analysis

As previously discussed, the HSM procedures and their related analysis tools are data intensive and require various geometric, operational (e.g., traffic control, ADT, etc.), and crash-history data. The safety-performance functions (SPFs, discussed further in Task 6) provided in the HSM were constructed from national data. They will need to be calibrated using Alabama statewide data, or new SPFs must be created using Alabama data.

It is clear from review of HSM methodologies, SPFs, and Crash Modification Factors (CMFs) that new data elements must be obtained to reach the full potential of the HSM. In addition, it is likely that some existing ALDOT data has been collected in an incompatible format or with non-HSM variables. Overall, collecting new data items and supplementing/correcting existing data files can be a costly and time-consuming exercise. In 2011, studies were underway in at least four ALDOT bureaus to expand the collection of data to allow optimal use of existing funding. Data collection for the HSM will coordinate with those ongoing efforts.

ALDOT does not necessarily have to collect the data on its own. There is a State Traffic Records Coordinating Committee (TRCC) with authority funding for collecting road-safety data. Most of its effort is aimed at agencies with less funding than ALDOT, but where ALDOT needs the same data as other agencies, there is the possibility that TRCC could provide funding or ensure intra-agency cooperation in collecting the new data.

The starting point in collecting new data is NCHRP Research Results Digest 329, *Highway Safety Manual Data Needs Guide*, which was initially prepared to define the data needed to run the full spectrum of SA analyses. Additional data items will be identified during the design of new software or modification of existing software (see Tasks 6, 7, and 8). This makes it important to begin the design of such software as soon as feasible to allow time to collect enough data to operate the software effectively.

The following are the tasks necessary to satisfy the goals of this stem of the project:

- Obtain NCHRP Research Results Digest 329.
- Identify and list data required for operation of HSM, SA, and IHSDM.
- Using these lists to compare data needs with the data available.
- For the data elements that remain, develop a list of needs and survey the various bureaus within ALDOT to see if these remaining data elements are available.
- Survey the bureaus and at the same time validate that the data that has been used and is still accessible. From this, create a source list for all available data. This will include the contact information for the custodians of the various data element groups.
- Determine those data elements that are not available and develop a plan to collect the information.

- Prioritize the data elements according to their cost and criticality based on the sensitivity analysis.
- Establish a data-development plan for data accumulation and data enrichment over the next five years recognizing the need to obtain the most critical data elements first.

ALDOT has already begun data-planning projects and in some cases data-production projects to acquire data already known to be important to HSM methodologies. More about this data may be found in the “Ongoing and Planned Research and Operations Projects” portion of this report. But additional work will be necessary as implementation proceeds to identify needed data and begin collecting it.

Task 6 – Potential Integration of CARE/CORRECT with SafetyAnalyst (SA)

Alabama has been fortunate for the past 30 years to have the versatile CARE software. It provides data analysis and decision statistics for almost all roadway safety activities. One of CARE’s key capabilities is system-wide screening or screening of smaller units like geographic areas or specific roadways, defined portions of a road, or individual locations to find critical locations in need of improvement. It also generates standardized reports from crash/ADT/other data to support site investigations. It can also receive the results of investigations and produce an optimum set of roadway improvements based on the data provided from the divisions.

CARE is user friendly, with screen commands and icons to lead a user through an investigation of circumstances or locations of interest for possible safety improvement. The software is intuitive, providing prompts about the next step in an analysis. The user uses filters to build a data set specifically for a study. It takes only a few minutes to create a data file, such as alcohol-involved crashes on Friday night with drivers under age 19 in a specific city. This file can be examined for characteristics and trends, and the CARE “Impact” includes a data-mining routine to find statistically significant relationships and trends. Over 200 ALDOT employees, county engineers, and law-enforcement officers use this versatile tool for safety programs.

The companion software, Cost/benefit Optimization for the Reduction of Roadway Caused Tragedies (CORRECT), has been employed by ALDOT since the early 1980s. CORRECT encompasses the entire process of field investigation of hot spots using data generated during the CARE hotspot-determination procedure; it includes the data generated by crash location investigations from which costs and benefits of recommended improvements are determined, and it includes methods for assuring that the maximum benefits are obtained given the funds allocated to an overall program. It now takes the critical locations obtained by CARE along with the standardized reports of specific crash information for each location and synthesizes the results into an optimal set of roadway improvements. It does this by maximizing the number of lives saved and injuries reduced within the total budget available for a given program.

CARE has been refined almost continuously over the past 30 years as new safety programs emerged or as ALDOT identified a need for better safety data analyses. It fully supports ALDOT’s normal safety programs, and it possesses capabilities to conduct extensive analyses and customized data assessment. CARE addresses almost all of the methodologies of the HSM.

The present question for ALDOT is whether to invest additional resources in switching to *SafetyAnalyst* and acquiring/warehousing additional data, adding EB and similar capabilities to CARE and acquiring/warehousing additional data, or developing hybrid CARE-*SafetyAnalyst* software. ALDOT desires a robust future analytical support system that optimizes safety decisions, and it specifically requested that this project investigate these options and recommend which of the three options (CARE, SA, or CARE/SA) appears most promising.

When the project began, ALDOT and the UA research team knew a great deal about the capabilities of CARE and had a general understanding of SA. But a deeper understanding of SA was needed to select the software that best fit ALDOT’s needs and resources. ITIS Corporation was subcontracted to examine the capabilities of CARE/Correct and SA and to perform a gap analysis to compare the two major safety analysis packages. Both software programs perform network screening, with the major difference being that SA uses Empirical Bayesian methodology while CARE uses a less structured, user-defined process for the screening. So the gap analysis was aimed primarily at crash-type diagnosis, countermeasure-diagnosis, and selection and economic analysis.

Exhibit 4 provides a direct comparison, using subjective ratings across 16 categories of common elements of these two major roadway-safety-analysis software packages. The following tabulation shows that the ratings in Exhibit 4 are fairly balanced; however, CARE ranked “none” or “weak” for 25% of the elements evaluated, which indicates features that may be candidates for modification to enhance their capabilities to conduct HSM type analyses.

Score	SA Occurrences	CARE Occurrences
Very Good	6	6
Good	8	6
None or Weak	2	4

Exhibit 5 displays highly useful information from the ITIS study: a listing of general positive and negative characteristics of the two software packages. Scanning the exhibit provides a good overview of the two pieces of software and allows a general comparison.

A simple conclusion that can be drawn from Exhibits 4 and 5 is that SA is very good at network screening, integrated database, countermeasure diagnosis, and economic appraisal. It has more structured analysis methods and additional data that CARE does not possess. On the other hand, CARE is easy to use and flexible. It is very good at data filtering, crash-pattern identification, overall crash interrogation, “what if” analyses, and visualization.

The key considerations that play into ALDOT’s software selection might be those mentioned earlier in this report during the discussion of Task 3. First, there are already 200 happy and satisfied CARE users in Alabama. Second, the workload in starting the new Office of Safety Operations might be too intense to allow it to install and operate SA at this time.

A final set of considerations can be taken from the national survey regarding state DOT use of *SafetyAnalyst*. There are 17 states using SA or planning to use SA, but 14 of them are using only

the screening module. Two others are using two modules, and one state is using three modules. No state is currently using all SA modules. The most probable reason lies at the intersection of the latest analytical safety science and current, hands-on practice. The new screening methodology is scientifically robust and is handled automatically by the software. It offers peace of mind to *SafetyAnalyst* who learned from the HSM about standing weaknesses (like regression to the mean) in prior safety analyses. An additional reason is that current practice depends heavily on engineering judgment to identify crash patterns, crash causes, and candidate countermeasures but SA is weak in accident-pattern identification, data filtering, and rapid analysis of crashes.

Considering the design and capabilities of the two software programs, noting incomplete usage of SA by state DOTs as revealed by the national survey, and netting out the differences between economic approaches, there are actually only small differences between the two. The major and significant difference is the network screening approach, i.e., the Empirical Bayes methodology and significant additional data. When economic approaches are considered, CARE is much less versatile than SA.

Exhibit 4. Summary Comparison of Features of CARE/Correct and SafetyAnalyst

Feature Name	CARE/Correct	SafetyAnalyst
Accident Pattern Identification	Very Good	Weak
Accident Pattern Diagnosis	None	Very Good
Site Database	None	Very Good
Counter Measure Recommendation	None	Good
Countermeasure Select / De-select	Good	Very Good
Site Benefit Costs	Good	Good
Countermeasure economics	Weak	Good
Economic Appraisal Methods	Good	Very Good
Countermeasure Ranking	Good	Good
Economic Optimization	Good	Very Good
Overall Reporting	Good	Very Good
Collision Diagram	Very Good	Good
Site Creation and Management	Very Good	Good
Site Review and Access	Very Good	Good
GIS Integration	Very Good	None
Site Statistics	Very Good	Good

The two software packages are not competitors; they are complimentary methods of accomplishing roadway safety studies. In an ideal world, the best features of each could be combined into a simple and superior tool for roadway safety.

Conclusion: Based upon the foregoing analysis, the options available to ALDOT include: (1) retain CARE in its present form; (2) replace CARE with SA; (3) develop a CARE-SA hybrid, which would be an optimum tool; (4) modify CARE to provide the SA features of EB screening and enhanced economic analyses; and (5) modify SA to provide the CARE features of filtering data, interrogating data (what if analyses), user friendliness, and visualization.

Exhibit 5. General Characteristics of SafetyAnalyst and CARE

SAFETYANALYST – STRENGTHS AND WEAKNESSES
Complete turnkey software solution for all of safety engineering data lifecycle (assess, diagnose, treatment alternatives, program, evaluations). A key strength of is a common overall database for the entire lifecycle.
Sequential processing of data through overall safety engineering process, less flexible/less interactive than CARE
Restrictive in nature and has heavy specific data input requirements, provides extensibility in adding data, but only within predefined elements
More advanced network screening techniques eliminate problems from the "regression to the mean" effect
Network screening is complicated to use and not intuitive to obtain valid results.
Strong tools for diagnosing accident patterns and assisting in selecting countermeasures
Integrates the steps of diagnosing patterns, selecting countermeasures, and performing economic analysis.
Approach to identifying accident patterns is limited, and tools supporting this process are limited
Approach to diagnosing countermeasures is good, but needs to be greatly expanded.
Approach to selecting and de-selecting countermeasures is very good and allows the user to exercise engineering judgment or get assistance through diagnosis.
Reporting capabilities are very good.
Approach to identifying accident patterns can be time consuming and somewhat ineffective
Provides only very simple filtering capability.
Difficult within SA to interrogate detailed crash information.
Does not intuitively provide access to site data.
Not open and not easy to interface with.
Appeared to have bugs, none fatal, but a large number were displayed in the message area during operation.
Data management (setup and importing) within SA is difficult and not very intuitive.
Data management within a SA project is very good.
Provides a good ability to add data to the database once it has been set up.
Provides multiple approaches to economic analysis.
CARE AND CARE/CORRECT – STRENGTH AND WEAKNESSES
Highly interactive, rapid response and easy-to-use approach over the lifecycle of safety engineering data analysis. A key strength is its extremely powerful filtering and data interrogation techniques.
Ability to filter and interrogate general data to obtain significant data is extremely effective.
Ability to integrate with GIS provides a powerful data visualization tool
Integration of Intersection Magic provides a powerful collision diagram tool.
Operation appears to be much smoother overall as compared to SA.
CARE Correct is easy-to-use and provides much of the same information as SA.
CARE Correct does not maintain economic information on safety countermeasures.
CARE Correct does not appear to have an integrated database with CARE desktop
Over 200 trained CARE users in Alabama, who are comfortable and happy with CARE's performance
CARE already interfaces with a myriad of sources of safety data in Alabama and 10 other states.

Task 7 – Preliminary Analysis of the Safety Performance Functions for Alabama

The HSM provides a predictive method to estimate the expected total number of crashes per year for certain types of facilities. The method relies largely on safety performance functions (SPFs), crash modification factors (CMFs), and calibration factors.

Overview The HSM provides a predictive method to estimate the total number of crashes per year for certain types of facilities. The method relies largely on safety performance functions (SPFs), crash modification factors (CMFs), and calibration factors. The HSM contains default

SPFs and CMFs developed using data from selected states, so they might not apply universally. The HSM recommends that each state using the default models calibrate them to fit the unique situation in that state or develop new SPFs specific to local jurisdictions before actual implementation.

This study calibrates the HSM default SPFs and developed state-specific SPFs for three types of roadway facilities: two-lane two-way rural roads, four-lane divided highways, and two-lane urban and sub-urban arterial roads. The final calibration factors and newly developed SPFs recommended for each type of facility along with statistical soundness measures are presented in the following pages. The technical details regarding preparation of the SPFs, CMFs, and calibration factors are contained in a separate report, along with their testing and adaptation to Alabama-specific roadways.

Methodologies Used This section of the report reviews methods to create Alabama SPFs, CMFs, and calibration factors. These methodologies are all accepted or recommended for studies of this type.

Data Cleaning The data used for the analysis were obtained from CARE. The CARE database contains roadway geometry and crash data for all the roads in the Alabama state and interstate road system in 0.01-mile roadway segments. Relevant data for the three types of facilities were extracted and cleaned. These segments were then transformed into homogeneous sites so that the geometric and traffic characteristics remained the same within a particular site. Different variables were used to create homogeneous sites for different facility types. Two subsets were sampled from the set of homogeneous sites for each facility type using stratified sampling. One of the subsets was used to develop calibration factor and new SPFs, and the other was used as a validation set.

Negative Binomial Regression Count regression models were adopted to quantify the relationship between the expected number of crashes and various explanatory variables. Because traffic crashes are random events, the number of observed crashes is commonly assumed to follow an over-dispersed Poisson distribution, and maximum likelihood estimation is widely used to fit a regression model. In this study, an extension of the Poisson regression model, called Poisson-Gamma (a special type of Negative Binomial or NB) regression, was employed to allow over-dispersion in the data. Several parameterizations of NB regression models exist in the literature. This study applied both NB1 and NB2 parameterizations, and has found that NB2 models outperformed NB1 models for our data. Two goodness-of-fit measures, the log likelihood (LL) value and the Akaike's Information Criteria (AIC), were used in this study.

Calibration Factor The calibration factor is a multiplicative factor used to adjust the HSM base SPF for the unaccounted differences in weather, driving behaviors of people, etc. from region to region. Two methods are used to estimate the calibration factor. In the first method, a NB regression model is developed, with the unadjusted base SPF as part of the model with an additional variable for calibration factor. This method can be considered as a special case of SPF estimation. The second method is the HSM-recommended approach. The calibration factor is

calculated as the ratio of the sum of the observed number of crashes over the predicted average number of crashes.

Model Validation The prediction capability of an estimated model was further evaluated using the validation dataset based for five performance measures: mean absolute deviance (MAD), mean prediction bias (MPB), mean prediction squared error (MPSE), LL, and AIC.

Results For SPF development, a range of model specifications was examined using different explanatory variables such as speed limit, lane width, shoulder type and width, and median type. The models were estimated using Nlogit software. After analyzing the results, one particular model specification was recommended for all three types of facilities. It fit the data well and yielded good prediction performances on the validation datasets. The final model specification was

$$\hat{\mu}_i = \exp(\beta_0 + \beta_1 \ln AADT_i + \beta_2 \ln SL_i + \beta_3 LW_i + \beta_4 S_i + \beta_5 DY_i)$$

where for each site i , $\hat{\mu}_i$ is the estimated average number of crashes per year, $AADT_i$ is the average annual daily traffic, SL_i is the segment length, LW_i is the lane width, S_i is the speed limit, and DY_i is a dummy variable for the year. DY_i serves as a proxy variable to account for other unobserved factors that may vary from year to year. The estimated final models are summarized in Exhibit 6.

For calibration factor estimation, the two methods discussed earlier produced similar results. The calibration factor estimated using the HSM-recommended method performed slightly better in terms of MAD, MPB, and MPSE in most of the cases. Moreover, the HSM-recommended method was easier. Therefore, the research team recommended adoption of the HSM method for estimating the calibration factor in practice. The recommended calibration factors and their prediction performances for the three types of facilities are shown in Exhibit 6.

It can be observed from Exhibit 6 that the newly developed SPFs outperformed the (calibrated) HSM-default SPFs for all three types of facilities. The MPB and MPSE for the newly estimated SPF model were lower than for the calibrated model indicating a lower prediction error and lower prediction bias. The variation in the prediction accounted for using MAD was also lower for the newly developed SPFs. The LL and AIC also corroborated the findings of the other performance measures.

Task 8 – Supplementary Software/Supporting Items to Implement the HSM in Alabama

This task addresses design and development of two types of software: (1) some form of SA-CARE-CORRECT as the major software to implement and conduct HSM methodologies and (2) supporting software that simplifies the overall safety process and draws all components of statewide roadway-safety programs together.

Exhibit 6. Parameter Estimates for the SPF Best Fit Model

		Facility Type		
		Two-Lane Two-Way Rural Roads	Four-Lane Divided Rural Highway	Two-Lane Undivided Urban and Suburban
Recommended SPFs				
	β_0	-7.971 (0.3610)	-7.784 (0.6019)	-9.991 (0.5544)
	β_1	0.775 (0.0351)	0.759 (0.0562)	1.035 (0.0563)
	β_2	0.694 (0.0268)	0.354 (0.0213)	0.336 (0.0283)
	β_3	0.0552 (0.0415)	0.099 (0.0637)	-0.113 (0.0509)
	β_4	0.1641 (0.0229)	0.049 (0.0165)	0.1324(0.0207)
	β_5	0.0388 (0.0213)	0.081 (0.0280)	0.0871 (0.0301)
Dispersion Parameter		0.9814	2.077	2.817
Goodness-of-Fit	LL	-5069.970	-4966.408	-4585.238
	AIC	1.694	2.484	1.837
Prediction Capability	MAD	0.525	1.1120	1.123
	MPB	0.008	-0.0373	-0.355
	MPSE	0.702	3.4352	4.056
	LL	-2343.780	-2537.793	-3188.423
	AIC	1.567	1.697	2.130
Recommended Calibration Factors				
Value		1.392	1.103	0.885
Prediction Capability	MAD	0.523	1.0927	1.044
	MPB	0.011	-0.0547	-0.594
	MPSE	0.768	4.0633	4.213
	LL	-2428.337	-2774.984	-4164.626
	AIC	1.621	1.852	2.778

Summary of Scoping Project Work Tasks

This portion of the report presents the key findings from 1.5 years of investigation, comparison, and testing pertinent to implementation of the HSM in Alabama. Particular attention was given to the resources and operating mode of ALDOT because it will lead the implementation effort and will provide much of the funding.

As with many projects of this nature, the best-fit implementation was deduced through a series of decisions that build on prior decisions and new information. It was not until near the end of the research effort that the best implementation configuration became clear. The implementation plan is described in skeleton form in Part V of this report. As this plan is reviewed and discussed by ALDOT, it will be possible to prioritize the elements and place them on a timeline. In turn, it will be possible to budget for individual components and assign them to units of ALDOT or to contract them to others for completion.

Chapter 4

Activities Related to the Scoping Project

During the year and a half that the Scoping project was underway, external activities occurred that directly influence the implementation plan. Several of them are identified and discussed in the following paragraphs.

National Activities and Issues

Roadway Safety as a National Emphasis Area Safety is a prominent topic in our nation's capital, and federal transportation agencies are embracing it. For example, federal legislation requires Strategic Highway Safety Plans (SHSPs) of all states, which has created a cooperative culture among state transportation and safety organizations. This is the driving reason that fatalities are falling on our nation's highways.

Growing Endorsement of the HSM Nationally, there has been a clear wave of support for the HSM and its methodologies. The HSM is discussed in positive terms in technical publications, organizational newsletters, trade publications, and other documents. At TRB, AASHTO, and FHWA meetings the questions are no longer "Do we have to use it?" but rather "How are you using it?" and "How is your HSM implementation coming along?" This positive momentum is a good thing and helps ALDOT with implementation because ALDOT managers are reading and hearing about HSM successes from their friends in technical organizations.

Growing Support for HSM Implementers and Users TRB, AASHTO, FHWA, GHSA, and other organizations are working hard to assist with HSM implementation and operation for state DOTs and local governments. State DOT managers leading HSM implementation have many publications, specialized training, and other sources to consult. Even better, if a difficult question comes up most of them can pick up their phones and call friends to ask how to handle it. Clearly the pendulum is swinging in a positive direction for HSM implementation, and that is good for ALDOT and for Alabama.

Alabama Activities and Issues

Office of Safety Operations The most apparent change in Alabama has been the rapid creation and staffing of ALDOT's new Office of Safety Operations. In less than two years, OSO was created and staffed with experts in roadway safety, GIS, and other related fields, and it planned a creative program of safety activities largely based upon implementing and using HSM methodologies. OSO is intended to be the focal point for infrastructure safety programs in ALDOT, and it is rapidly moving toward that status.

Change in the Chief Engineer's Office A potential issue that could affect OSO is the recent retirement of Chief Engineer Don Vaughn, who, as chair of the AASHTO Safety Management Subcommittee, was a national roadway safety advocate. Mr. Vaughn created OSO and was a strong advocate for both the OSO and the safety operations engineer. While it is probable that the new chief engineer will also support OSO, it may not be the same level of advocacy as Mr. Vaughn. Additionally, it will take time for the new chief engineer to learn about OSO operations and to absorb the new technical aspects of HSM methodologies.

Alabama Strategic Highway Safety Plan Builds Safety Coalition The SHSP 2nd Edition was developed during 2010–2011, and it underscored the strong roadway safety partnerships in the state. The completed report adopted a “Toward Zero Death” goal and was signed by the governor and the leaders of seven state and federal agencies that operate in Alabama. The associated Safe Home Alabama Traffic Safety Summit provided a boost to safety efforts in late 2011. There is strong road safety momentum, and agency-to-agency cooperation on roadway safety issues is on a first-name-basis. The positive, cooperative attitude of so many roadway-safety managers and advocates provides a fertile climate for HSM implementation.

Ongoing and Planned Research and Operations Projects The vigorous initial activity of the OSO has been discussed. Evidence of the rapid startup of the new office may be found in Appendix B, which contains a list of more than 20 planned or ongoing research and service projects that advance the implementation of the HSM or provide support to other OSO programs that support HSM implementation.

The projects have been loosely grouped into the following categories:

- HSM implementation and HSM software
- Safety performance functions/crash modification factors
- Data acquisition and use
- Safety evaluations/safety assessments
- Development of manuals and guides
- Safety program coordination and development

The fact that top-level ALDOT managers have allocated significant funding for OSO research and implementation efforts is strong evidence of the support for implementing the HSM and for conducting the strongest possible safety program.

Chapter 5

Draft Implementation Plan Recommendations

This portion of the report provides a list of activities associated with implementation of the HSM. General recommendations on activities, timing, and priorities are included where appropriate. The plan is broken into three general time spans: immediate/startup, midterm, and long term. Some of the intermediate activities are already underway (including this scoping study), and others are scheduled.

This is a flexible plan intended primarily to guide the first three to five years of implementation activities. Further work will be necessary to fine tune the initial activities and to optimize implementation of the remainder of planned activities. Once the plan is approved and in operation, it should be periodically reviewed and adjusted to maximize accomplishments.

The structure of the implementation plan is intentionally flexible to respond to changes in the identified top needs, available resources, stakeholder participation and support, and the potential for saving lives and preventing serious injuries. The plan is described in three broad methods: (1) activities of the ALDOT Office of Safety Operations, (2) implementation actions by Bureaus, Sections and other units, and 3) implementation activities by task of component.

Implementation Activities of the Office of Safety Operations

The OSO is a relatively new organization. One reason that it was created was to implement the HSM, and it has done an excellent job of actively leading that effort. The following actions are recommended for OSO for the remainder of implementation.

- Concentrate all HSM actions in the OSO to the extent possible. All system-wide and most division-wide safety studies should initially be housed in the OSO. This will require a designated group within the OSO to manage and perform the HSM analyses for proposed and existing projects. As training and implementation experience increases, shift responsibilities to divisions and bureaus.
- In implementing the HSM, utilize a flexible approach and a flexible time frame. Do not depend on a rigid schedule or rigid plan.
- Continue to extend the reach of the relatively small OSO by utilizing the resources of on-call consultants to provide support of road-safety assessments.
- Develop a management system to track, evaluate, and manage research and implementation projects.

- Extend the reach of the OSO by coordinating with the State Traffic Records Coordination Committee and the agency representatives involved in the production of the SHSP 2nd Edition.
- Continue the aggressive posture of staffing the OSO, promoting roadway safety at every possibility, and aggressive budgeting.
- Utilize training for general education of ALDOT employees and others associated with HSM implementation, and utilize specialized training as components of the HSM are activated.

Implementation Actions by Bureaus, Sections and Other Units

This portion of the plan lays out envisioned activities, methodologies and programs to implement the HSM throughout ALDOT and its partner transportation agencies and organizations.

GROUP 1: ALDOT Bureaus with Extensive HSM Involvement

- Construction Bureau – overview training, implement results of research project investigating work zone crashes to develop WZTC guidance, decrease duration of projects to minimize crash exposure, detailed training as appropriate for implementation
- County Transportation Bureau
 - COUNTY ENGINEERS – overview training, require selection of state-funded projects via HSM-methodology, use spreadsheets or develop tools to conduct analyses, detailed training as needed, ALDOT will convert historic link-node crash location data to coordinate data to allow historical crash locations to be merged with current data; LONG TERM develop a version of RISE for county analyses.
 - A-TRIP PROJECTS – use implementation steps similar to county engineers
- Design Bureau: Overview training for all
 - CONSULTANT MANAGEMENT SECTION – general awareness training, be aware when consultants should be making a full HSM type analysis
 - ENVIRONMENTAL TECHNICAL SECTION – awareness training only
 - LOCATION SECTION – Use HSM methodologies initially via spreadsheets and long term via IHSDM
 - ROADWAY DESIGN SECTION – Use HSM methodologies initially via spreadsheets and long term via IHSDM
 - TRAFFIC DESIGN SECTION – general awareness training, coordinate with traffic engineering section (Maintenance Bureau), use HSM methodologies for lighting, ITS, etc. specialized training as needed
- Maintenance Bureau
 - TRAFFIC OPERATIONS – general training, need knowledge of HSM methodologies for incident management, coordinate with Traffic Design Section (Design Bureau)
 - ACCESS MANAGEMENT – general training, need knowledge of HSM methodologies when evaluating access management projects and when approving permits
 - RESURFACING PROGRAMS – general training, implement the RISE software including specific training in use of the software
- Modal Programs

- SAFETY SECTION – coordinate enforcement efforts (special blitzes, work zone programs), and conduct public education programs
- SPECIAL PROGRAMS SECTION – coordinate with program manager
- Transportation Planning Bureau – *general awareness training*
- Office of Safety Operations – plan and coordinate overall HSM implementation effort, plan and oversee research and implementation projects, organize training, and otherwise facilitate implementation efforts

GROUP 2: ALDOT Bureaus with Routine or Occasional HSM Involvement

- Administrative Bureau – general awareness training, endorse program, support and fund implementation
- Bridge Bureau – general awareness training
- Computer Services Bureau – general awareness training, support for GIS applications and data storage/access
- Legal Bureau – general awareness training
- Materials and Tests Bureau – general awareness training, data acquisition and sharing
- Media and Community Relations Bureau – general awareness training, develop public education programs
- Research and Development Bureau – general awareness training, oversee and manage HSM/safety research and implementation projects
- Training Bureau – general awareness training, develop and coordinate training for HSM implementation and for development of a professional safety workforce

GROUP 3: Division Extensive HSM Involvement (all 9 Divisions) - general awareness training, mimic training of their counterparts in the Construction and Maintenance Bureaus (including Traffic Engineering Section) as needed, and LONG TERM utilization of RISE software

- Division Pre-construction Section
- Division Maintenance Section
- Division Traffic Engineering Section

GROUP 4: Division Routine or Occasional HSM Involvement (all 9 divisions) – general awareness training

- Division Engineer
- Division Permitting Engineer
- Division Construction Engineer

GROUP 5: Other Agencies with HSM Involvement or Duties

- County Engineers – *full treatment (see County Transportation Bureau above)*
- City Engineers/Public Works Directors/Traffic Engineers – *general awareness training, and some treatment similar to county engineers*
- Metropolitan Planning Offices – *general awareness training, use of PlanSafe software to be required*

- Regional Planning Offices – *general awareness training, encourage use of PlanSafe software to be required*
- Federal Highway Administration Division Office – *general awareness training, specific training if requested, review of entire implementation program*
- Alabama Department of Public Safety – *very general training, enhanced enforcement blitzes, develop CMF for increased safety with increased officers on the road, work zone traffic management program*
- Alabama Department of Economic and Community Affairs, Governors Highway Safety Representative – *very general training*
- Alabama Department of Public Health, EMS and Trauma Director – *very general training, develop FIRST software, best routing program for emergency vehicles, incident management*
- Federal Motor Carriers Safety Administration – *very general training, mimic other bureau and section actions as needed*

GROUP 6: Organizations with Occasional HSM Involvement – *general awareness training, and additional actions as shown below:*

- SHSP Steering Committee
- Alabama Legislature, State Safety Coordinating Committee
- Auburn LTAP program – *administer HSM training at all levels, possibly administer training and certification for development of professional traffic safety workforce*
- UTCA, CAPS and other university based research centers – *conduct software development and implementation, implementation projects, training projects and research projects, assist in managing the entire implementation program*
- UAB and University of South Alabama research programs on emergency medical services and trauma treatment – *very general training, selection of best route of emergency vehicles to appropriate trauma treatment*
- Industries and organizations with roadway safety interests – *very general training, engage as needed and incorporate innovations and products as appropriate*

Implementation by Component or Activity

This portion of the plan reviews major plan components and individual activities that must be planned and put into place during the implementation of the Highway Safety Manual in Alabama. As these components or activities are accomplished, additional supporting activities will be identified and included in the plan.

Advocacy

The success of the implementation effort can be enhanced considerably by support from the highest levels of ALDOT leadership.

- This has already been accomplished by making the Chief Engineer aware of the capabilities of the HSM process and gaining his full support. A second step was 2-hour HSM training

for all Bureau Chiefs and Division Engineers and two-day training of District Engineers, county engineers, Alabama Division FHWA managers, and others who will be using the process.

- A program will be developed to continue promoting the positive aspects of the HSM methodology to build a group of advocates to push the HSM implementation forward.
- Possibilities for building advocacy include newsletters, a HSM website with chat room, and user groups.

Analytical Tools/Software

These tools are necessary for efficient system screening, site analysis, pattern analysis, countermeasure selection, economic analysis, and other components of roadway safety programs. The enhanced safety science embraced by the HSM enhanced the reliability and repeatability of these activities. Supporting software is needed, as it is almost impossible for a state DOT to analyze large projects by hand calculations. Some analytical tools are currently available to perform the calculations, and ALDOT will develop another one as outlined below.

- Spreadsheets – As part of the NCHRP two-day training course developed for the HSM, spreadsheets were prepared for HSM methodologies. The Virginia DOT and ALDOT engaged CH2M Hill to customize the spreadsheets, and they are now in use by ALDOT.
 - The spreadsheets are recommended for use by OSO and the Design Bureau.
 - The safety prediction functions embedded within the spreadsheets should be replaced by the SPFs developed for Alabama roads.
 - The user instructions manual should be further developed and further customized for the ALDOT Design Bureau.
- IHSDM – This tool was designed by FHWA to help roadway designers assess the safety effects of their design decisions. Its use will be deferred until the future, when it will be evaluated for installation in the Design Bureau.
- PLANSAFE – NCHRP developed this safety software to help forecast the safety impacts of engineering and behavioral changes associated with socio-demographics and safety investments. This information can be of great use to planners in helping to estimate the impacts of proposed projects. ALDOT will adapt PLANSAFE to Alabama situations, pilot test its use with a MPO, and make it available to MPOs and RPOs across the state.
- SafetyAnalyst – This tool was prepared by FHWA to conduct the full suite of road safety analyses, using the Empirical Bayes methodology. Its use will be deferred until the future, when it will be evaluated for inclusion in the OSO suite of safety software as a high end tool to compliment and expand the analyses of RISE and CARE+.
- RISE – The RISE software will be developed to combine the best aspects of CARE and *SafetyAnalyst*. The initial version will have a limited set of functions so that it can be placed into operation relatively soon. It will be directed toward crash assessments for pavement overlay or pavement rehabilitation projects, for which there are normally a limited number of crash types. After the pilot version is in operation, more complex versions will be developed to cover other types of crash analyses and treatments.

- CARE+ – The CARE software has been a mainstay of ALDOT’s safety program and has evolved to meet ALDOT’s specific needs. It is anticipated that additional enhancements will be made to CARE to support HSM methodologies, to produce a “CARE+” model.
- Dashboard/Introductory Screen – Implementation will expand over time and many groups will be using the software, so there will be a need to gather all users under a single umbrella. This will make it easier to monitor use of the software, inform users, update software or protocols, etc. This could be as simple as using a single portal for all users.
- Other Software – As implementation progresses, needs for additional software will arise and will be addressed by the HSM implementation team.

CMFs and SPFs

Crash Modification Factors (CMFs) predict the change in safety following implementation of a safety countermeasure. Safety Predictive Functions are models that estimate the number and types of crashes associated with certain roadway types or certain roadway situations.

- CMFs – ALDOT will utilize CMFs from the HSM and from the FHWA Clearinghouse. Training will be needed to help users learn to select appropriate CMFs for the situations in their studies. Research is planned or underway to develop CMFs for Alabama-specific situations, and to periodically refresh the pool of acceptable CMFs as new ones are added by FHWA.
- SPFs – SPFs have been completed for three Alabama roadway types, as discussed earlier in this report. Research projects are planned or underway to develop SPFs for additional roadway types and for special situations like rail-highway grade crossings.

Data

The HSM and its associated software are data hungry. More data items; more detailed data; and integrated, accessible data banks are needed to reach the full potential of HSM Methodologies.

- ALDOT has already begun a program to identify and acquire additional data, as reflected by some of the research projects in Appendix B of this document.
- This program will be continued and expanded in the future. These activities should be coordinated through the State Traffic Records Coordinating Committee for possible use by other safety-related agencies, and for possible funding by that Committee.

General

Complete and efficient implementation requires that the overall effort be monitored and steered, that guidance documents and support manuals be prepared, that users and stakeholder groups be engaged, and that budgets and timeframes be met. The following are representative of such general, supportive activities:

- Policies and Guide to Operations – As safety work processes, designs, maintenance practices and other activities are identified, they should be incorporated into the ADLOT Guide to Operations. A good way to start this might be a research project to scan the Guide to Operations and other policy and guidance documents for potential safety enhancements.
- Engage User Groups – Both internal and external user groups need to be aware of the safety potential and implementation progress of the HSM. This can be accomplished through a newsletter, periodic meetings, a website dedicated to the HSM and ALDOT's overall safety program, and similar means.
- Develop Manuals, for users, new forms, new guides

Non-ALDOT Implementation

There are many agencies and organizations that address traffic safety in Alabama. Activities appropriate for several of them are shown in the following list:

- Counties – Provide county engineers overall training and specialized training as they are introduced to HSM analytical tools. Require use of HSM methodologies to receive ALDOT safety funding. Work with County Transportation Bureau to support county safety projects.
- Cities – Treat similar to counties, except there is a greater range in sizes of organizations and capabilities of transportation program directors.
- Governor's Highway Safety Representative – Offer training, fully coordinate, provide frequent information on the HSM and the implementation, and ask for suggestions.
- MPOs, RPOs – Provide overview training. Obtain and modify (if needed) PLANSAFE software for Alabama conditions; and offer the software including specialized training to both MPOs and RPOs. Eventually require PLANSAFE use by MPOs.
- Alabama Division FHWA – Keep them informed about HSM capabilities and progress toward implementation. Meet with them periodically for detailed review of the overall program.
- Steering Team for Strategic Highway Safety Plan – Provide general training and periodic updates on HSM implementation, including HSM successes.
- Other Agencies and Groups – As they are identified during implementation, engage them and design implementation steps to address their needs.

Research

An extensive research and training program has already been initiated by the OSO, and an overview of these efforts is shown in Appendix B. The projects address implementation, data, development of SPFs/CMFs, production of guidelines and manuals, safety evaluations and assessments, program coordination and development, and policies. Implementation leaders will continue to monitor research programs, scheduling to deploy research results as available, and creating additional research projects as needed.

Training

The HSM introduced major changes in methodologies and terminology, which require extensive training. This training must apply to multiple types of users and different levels of expertise.

- Initial Wave of Overview Training/Education – This is important to show why the HSM is needed, how it estimates changes in safety and how it conducts cost effectiveness studies. Users also need to know the implementation schedule and how/when it will affect them. Training has already been completed for more than 100 ALDOT, county, MPO, FHWA and other managers.
- Specialized Training as Each Component Comes on Line – ALDOT intends to provide specialized Training as HSM tools and programs are introduced.
- Train the Trainer– With extensive training planned, it may be beneficial for the OSO to develop training expertise within ALDOT, or at designated academic institutions, or in the private sector. Training the trainers will require time, and should begin well before the implementation of a specific component.

Workforce Development

The expansion of safety activities and the size of the HSM implementation effort require that the burden be shared by many managers and employees. ALDOT has initiated a project to define the training needed by safety managers and employees. That project is creating a workforce development plan.

Appendix A

Preliminary Outline of Capabilities of the Roadway Improvement Safety Evaluation (RISE) Software

The RISE tool will be designed and created as a pilot project to enhance ALDOT efforts to implement AASHTO Highway Safety Manual (HSM) methodologies through software. This will be a simplified pilot project, with the intent of broadening the tool to accomplish multiple types of safety studies and safety enhancement evaluations.

PURPOSE 1: Develop a simple safety tool for use by ALDOT managers who design roadway overlay and rehabilitation projects to help them review and analyze safety data, and select cost-effective countermeasures where appropriate.

PURPOSE 2: Modify CARE in two ways: incorporate the Empirical Bayes methodology from the Highway Safety Manual, and develop a more general and more versatile economic analysis module.

SIMPLISTIC FOR USER: The overriding goal is to make safety analyses simple for designers so that a minimum of training will be needed, a reasonably small amount of their time will be needed, and so that they feel like their decisions are making a difference in road safety.

SIMPLIFIED ANALYSIS: The tool will be deliberately constrained to the types and severities of traffic crashes that are most often associated with severe crashes. Likewise, the geometric situations handled by the tool and the number of countermeasures available may be constrained to a reasonable number of options. After the tool is in operation, it will be evaluated for effectiveness and expanded to other situations and crash types as appropriate.

OPERATION: The tool will perform the following steps:

- User establishes the route and end points for the study.
- CARE screens the study area for locations and situations where crashes, especially severe crashes, are overrepresented.
- CARE reviews crash patterns and other information for each identified location or situation.
- CARE identifies appropriate countermeasures where patterns are found.
- CARE performs economic analysis of individual countermeasures and combinations of countermeasures.
- User receives a tabulation of crashes by severity and other characteristics.

- User receives a visualization of the crash situation to assist her or him in understanding the causes of the crashes.
- User receives cost effectiveness information for countermeasures.
- User selects countermeasures that appear most appropriate, at a designated minimum level of cost effectiveness or cost benefit ratio.
- User forwards her or his analysis and selected countermeasures to the ALDOT Office of Safety Operations (OSO) for review.
- Upon review and approval, OSO provides safety funding for countermeasure implementation. This means that maintenance funds are not diverted to safety countermeasures, and makes the program even more attractive to ALDOT design and maintenance personnel.

DATA: The data will be automatically populated from CARE software files.

DESIGN OF COUNTERMEASURES: OSO will assemble a “plan set ready” file of standard countermeasures, which can be adapted by the designer and inserted in the plan set or incorporated by reference in the plan set.

ANALYSIS LOGIC AND SEQUENCE: The designers of CARE and CORRECT (the current cost effectiveness module associated with CARE) are traffic safety leaders and thoroughly understand roadway, crash and traffic data. They will carefully evaluate the options available as they design the initial, simplified version of RISE.

LONG TERM GOAL 1: Within 10 years, the RISE tool will have automatically analyzed the majority of the State road system and much of the Interstate system. Cost-effective treatments will be in place to address the most prevalent and most severe current crashes.

LONG TERM GOAL 2: Within 5 years the success of RISE will be evaluated, and the software will be expanded to cover more types of safety screening, crash analysis, countermeasure selection, and cost effectiveness studies. It will be the primary ALDOT safety tool.

LAYOUT DESIGN FOR RISE (TASKS AND TIMELINE): The project is expected to require 22 months for complete development, training and deployment. It is expected that the first 10 months will be an evolutionary process with heavy interaction ALDOT Safety and select Division Engineers (referred to as Beta Group below). The final 12 months will include continued interaction with ALDOT Safety and will incorporate a larger user base to eventually include the deployment and training to ALDOT Divisions. Exhibit 7, on the following page, provides a comprehensive breakdown of dates and tasks.

Exhibit 7: RISE Datelines, Tasks, and Deliverables

Dates	Tasks
Aug – Dec 2012	<ul style="list-style-type: none"> • Interact with ALDOT Safety to identify Crash Types and Potential Countermeasures • Adopt Crash Types and Safety Countermeasures into RISE tool • Enhancements to CARE to extract the needed attributes to be consumed by RISE • Integrate crash data with RISE tool
Jan – June 2013	<ul style="list-style-type: none"> • Define initial output screens and reports • Deploy RISE tool to ALDOT Safety • Work with ALDOT Safety to revise tool interface, data needs, and output reports • Deployment of RISE to Beta Group
June – Aug 2013	<ul style="list-style-type: none"> • Site visits to Beta Group • Collect feedback on tool interface and technical accuracy • Modify tool and iterate with Beta Group based on feedback • Development of training materials
Sep – Dec 2013	<ul style="list-style-type: none"> • Development of training material • Testing of training materials by Beta group • Deployment to ALDOT Divisions • Training Session(s)
Jan – May 2014	<ul style="list-style-type: none"> • Assist ALDOT Divisions and ALDOT Safety in tool usage • Modify and iterate with ALDOT Safety to reconcile usage issues

Appendix B

Abbreviated List of Planned and Ongoing Research Projects, Office of Safety Operations, Alabama DOT

HSM Implementation and HSM Software

Implementation of the AASHTO HSM (master contract)	2012-16
Roadway Safety Improvement Evaluation (RISE software)	2012-16
Pilot Implementation of PLANSafe software	2013-15
First Responder Solution Technique (FIRST) System	2012-15
HSM Implementation Technical and Management Assistance	2012-16

Safety Performance Functions/Crash Modification Factors

Bridge Rail Retrofit SPF Analysis and CMF Preparation	2012-13
SPF Development – Freeways	2013-15
Enhanced Enforcement CMF	2014-15

Data Acquisition and Use

Convert Link-Node Crash Locations to GPS	2012-13
Non-signalized Intersection Inventory, State Highways	2013-16
Traffic Signal Inventory and Safety Analysis, State Highways	2013-16
Speed Management Program Data Collection	2014-16
Rural Local Road AADT Estimation via GIS	2014-16

Safety Evaluations/Safety Assessments

Safety and Operations Evaluation of Adaptive Signal Control	2012-15
Wet Weather Safety Analysis and Site Identification Methods	2012-14
Work Zone Mobility and Safety Assessment	2012-14

Development of Manuals/Guides

Alabama Roundabout Design Guidelines	2012-14
Guidance for Performing Road Safety Assessments Manual	2012-14
Traffic Signing and Marking Application Guide	2012-13
Update of ALDOT Traffic Signal Design/Timing Guide	2012-13
Speed Management Program	2013-14
Highway Safety Improvement Program Manual	2013-14

Safety Program Coordination and Development

Safety Workforce Development Guidance	2012-13
Pedestrian/Bicycle Safety Coordination	2012-14
Integrating Safety and Operations in Planning, Design, Construction and Post Construction Operations	2012-13
GIS Safety Tools Evaluation and Development	2013-14

Policy Statements

Red Light Running Camera Warranting Criteria and Safety Evaluation Requirements	2012-13
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Appendix C



Draft Gap Analysis of
CARE/Correct Software
and SafetyAnalyst Software

Gerald Dildine
June 2011

Introduction

The State of Alabama Department of Transportation (ALDOT) is making plans with how best to implement those recommendations contained in the Highway Safety Manual (HSM). Part of their planning is to consider how the HSM impacts their current and planned safety computing systems. To better understand how it should proceed, ALDOT has determined it would be best to evaluate how tools like SafetyAnalyst (SA) and/or the Interactive Highway Safety Design (IHSDM) should be used, whether or not to integrate them with existing safety computing tools, or whether to adopt existing tools to accomplish the goals of HSM.

The "Gap Analysis Study" involves a comparison between elements of two major safety analysis software packages (SafetyAnalyst and CARE/Correct).

This study has been conducted under the general guidance of the University of Alabama (UA), and more specifically Dr. Daniel Turner, and Dr. Dave Brown.

The Gap Analysis takes advantage of some of the findings of the "sister" project, the "Best Practices Study" in performing the analysis of the data.

The study spends more energy focusing upon SafetyAnalyst rather than CARE, as it is believed that ALDOT is more familiar with the capabilities of CARE. We believed that it was worthwhile to perform a detailed review and comprehensive compilation of the SA software in the cases that (a)ALDOT decided to replicate some of the SA functions, or (b) the case that ALDOT would consider replacing CARE software.

It is hoped that the results of this study would provide some helpful recommendations to ALDOT and suggested next steps for moving forward safety analysis computing efforts in support of HSM.

I. Approach

This study is a gap analysis between SafetyAnalyst and CARE (and primarily CARE Correct) software solutions. The main focus of the gap analysis is between those elements of the two software packages which are intended to assist in countermeasure diagnosis, countermeasure selection, and economic analysis.

The organization of the documentation is based upon the following:

- A synopsis of each software's operation as related to countermeasure diagnosis, countermeasure selection, and economic analysis.
- Analysis of the differences between to two software packages.
- Recommendations on how to move forward in considering the strengths and weaknesses of each package.

We utilized the following basic approach in accumulating the information for the study:

- we obtained both software packages and installed them on a local system,
- then we processed data from both software packages to generate data results for comparison,
- we extracted information(including screen shots) from the software and from the software documentation, and
- utilized input from the previous Best Practices Survey.

II. System Reviews

This section consists of performing software reviews of the two software package: SafetyAnalyst, and CARE Correct. The reviews for SafetyAnalyst only deal with the modules related to Countermeasure Diagnostics and Economic Appraisal. The CARE software review is limited to the CARE Correct software.

A. SafetyAnalyst



The SafetyAnalyst (SA) software was created by the Federal Highway Administration in 2007. The software has since (2010) been transferred to AASHTO ownership. The software was actually written by ITT, and functionally specified by MRIGlobal. A technical working group of approximately fifteen states participated in the initial development review.

SA runs as desktop software, and is written primarily in Java programming language. The software is designed to work in several configurations, but primarily in a desktop configuration

connected to "Derby" database software, or in a client server configuration. In the recent State of the Practice Survey, several states suggested that the software ran most efficiently in a desktop configuration with considerable memory. Ohio DOT noted, that it ran the software with the most recent cpu personal computer running Windows 7 with sixteen gigabytes of ram. This high-end configuration appeared to provide the best performance of those interviewed.

The SA software contains four primary analysis modules and some several other modules. The primary modules are as follows:

- Network Screening
- Diagnoses and Countermeasure Selection
- Economic Appraisal and Priority Ranking
- Countermeasure Evaluation

In addition to the primary modules, SA contains the following additional modules:

- Data Manager
- Administrator
- Implemented Countermeasures

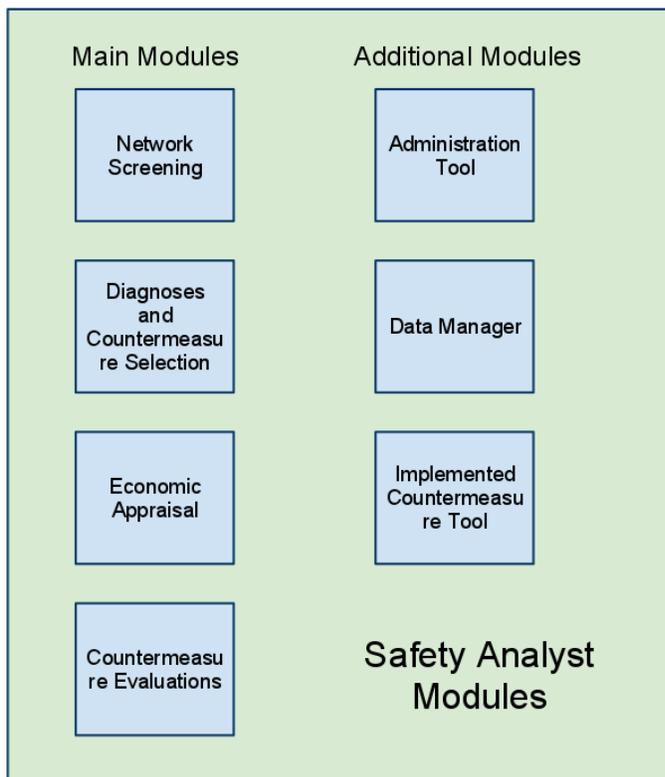


Figure 0: SafetyAnalyst Modules

The *Network Screening Module* identifies sites with potential for safety improvements.

The *Diagnosis and Countermeasure Selection Module* assists users in the selection of countermeasures to reduce accident frequency and severity at specific sites, and performs an economic appraisal of a specific countermeasure.

The *Economic Appraisal and Priority Ranking Module* performs an economic appraisal of several alternative countermeasures for a specific site, and provides a priority ranking of sites and proposed improvement projects based on the benefit and cost estimates.

The *Countermeasure Evaluation Module* provides the capability to conduct before/after evaluations of implemented safety improvements.

1. SafetyAnalyst Diagnosis and Countermeasure Selection

As stated above, SA provides a module for performing diagnosis and countermeasure selection.

This tool divides the process into several steps as follows:

- Determining patterns of interest
- Performing safety diagnosis
- Selecting countermeasures
- Performing countermeasure cost benefit analysis

Diagnostics is started by selecting "Diagnosis" from the main menu of the SA Analytical Tool. Next, the user is provided with a listing of sites contained in the current "Workbook". Each site is represented by an ID, narrative site subtype, route name, county, start location, end location, accident count, screening ranking, and currently recommended countermeasure. The site information is provided in a datagrid which can be sorted using any of the columns.

It is expected that the typical operator approach would be to sort by screening ranking, and then to start working through the sites with the lowest ranking (lowest being the most probable location for improvement). This approach would be modified if the system has a limited number of countermeasures from which to select. A sample screenshot follows.

a) Accident Patterns of Interest

The software does not provide any specific tools for automatically determining accident patterns, but rather provides supporting tools to empirically determining evidences of accident patterns. The supporting tools include:

- The ability to generate summary statistics about a site
- The ability to create collision diagrams
- The ability to perform statistical tests on specific sites

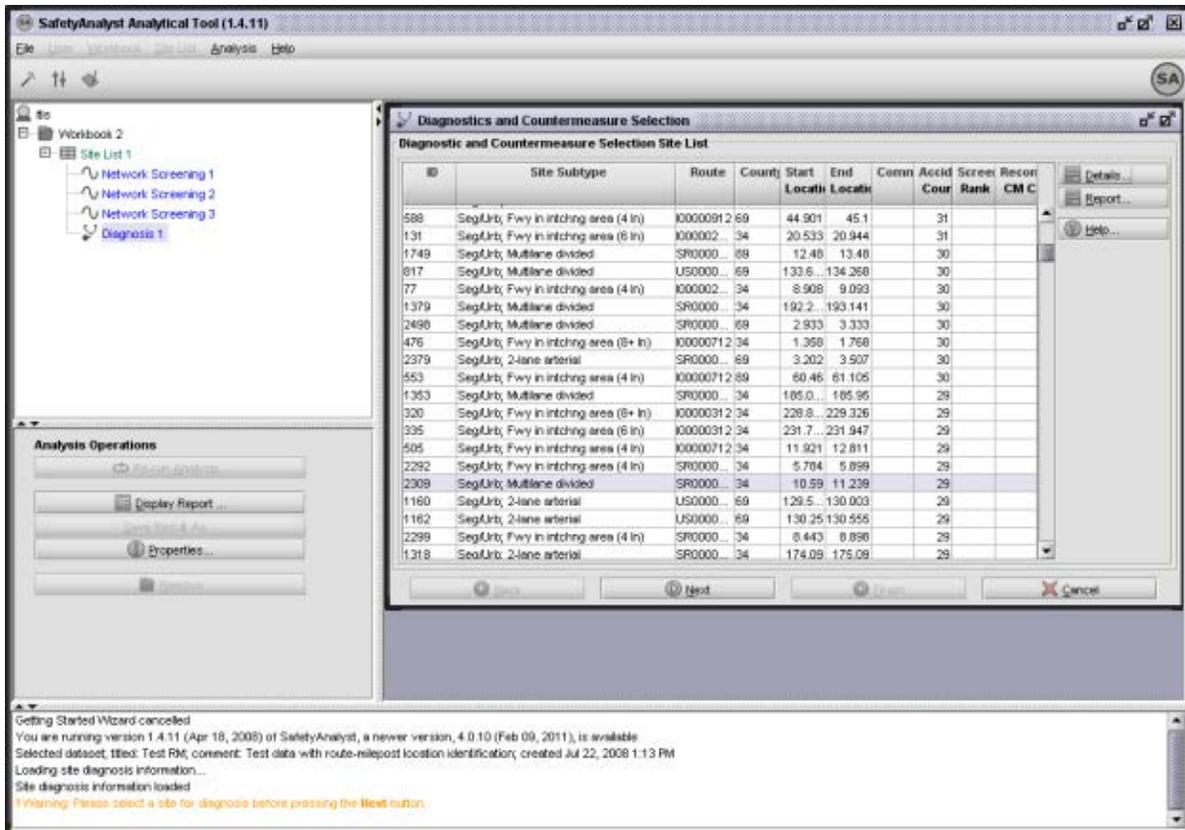


Figure 1: Diagnosis Site Selection

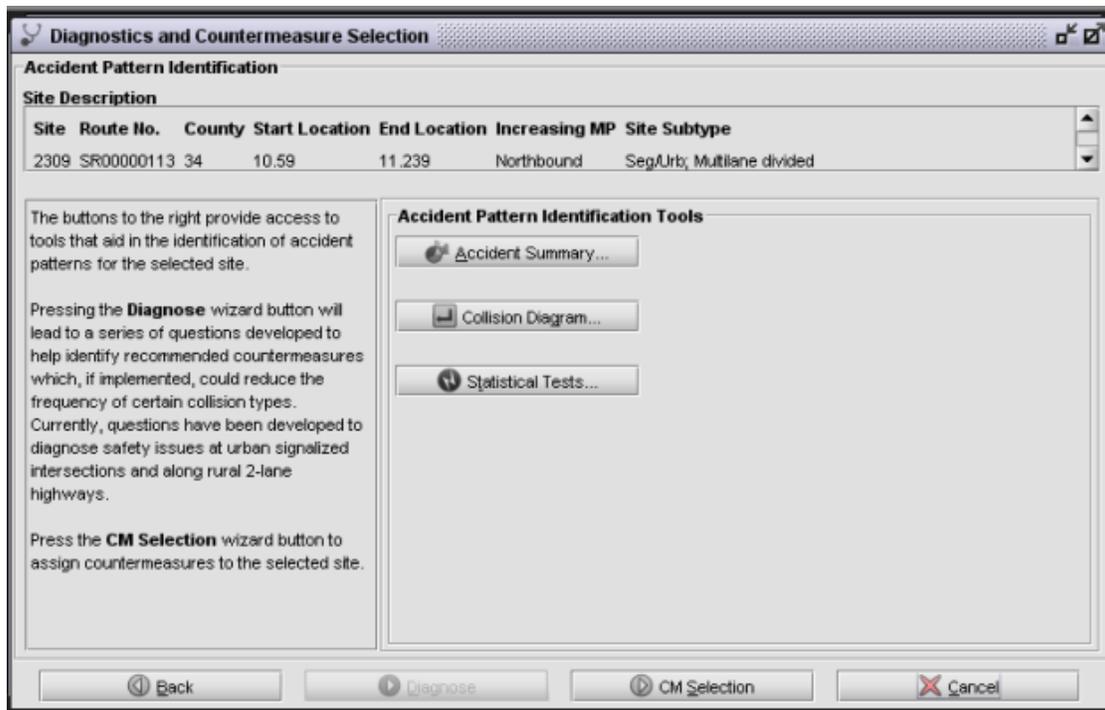


Figure 2: Accident Pattern Identification Tools

i. Accident Summary Statistics

Accident summary statistics are available in the database and are based upon the original importing and setup of the data. The user is guided through a form-driven interface to ultimately output a report about site statistics. The user may vary the output by selecting from a number of options, including the following:

- Analysis Direction
- Accident Severity
- Analysis Limits
- Analysis Period
- Accident Data Attributes

The following form is the input screen for generating the Accident Summary Report:

Create Accident Summary Report

Report Attributes

Report Title : Accident Summary for Segment 2309, Route SR00000113

Report Notes/Comments : Generated by Diagnosis and Countermeasure Selection Module

Analysis Direction

Northbound
 Southbound
 Eastbound
 Westbound
 Not On Roadway
 Unknown

Analysis Limits

Start Location : 10.59

End Location : 11.239

Analysis Period

From : 1995

To : 2002

Exclude Years prior to Major Reconstruction

Accident Data Attributes

Accident Severity Level 1
 Accident Month
 Accident Time of Day
 Accident Type and Manner of Collision
 Alcohol/Drug Involvement
 Bicycle Indicator
 Contributing Circumstances, Environment
 Contributing Circumstances, Road
 Day of Week
 Driver Age (all vehicles involved)
 Driveway Indicator
 First Harmful Event (all vehicles involved)
 Initial Direction of Travel (all vehicles involved)
 Light Condition
 Number of Vehicles Involved
 Pedestrian Indicator
 Relationship to Junction
 Roadway Surface Condition
 Run-Off Road Indicator
 School Bus Related
 Tow-Away Indicator
 Vehicle Configuration (all vehicles involved)
 Vehicle Maneuver/Action (all vehicles involved)
 Vehicle Turning Movement
 Weather Condition
 Work Zone Related

Clear All Select All

Tables

Display Tables
 Display Empty Rows

Bar Charts

Display Bar Charts
 Categories at left
 Categories at bottom

Pie Charts

Display Pie Charts
 Values in chart labels
 Values in legend labels

The following are sample screenshots from the output reports:

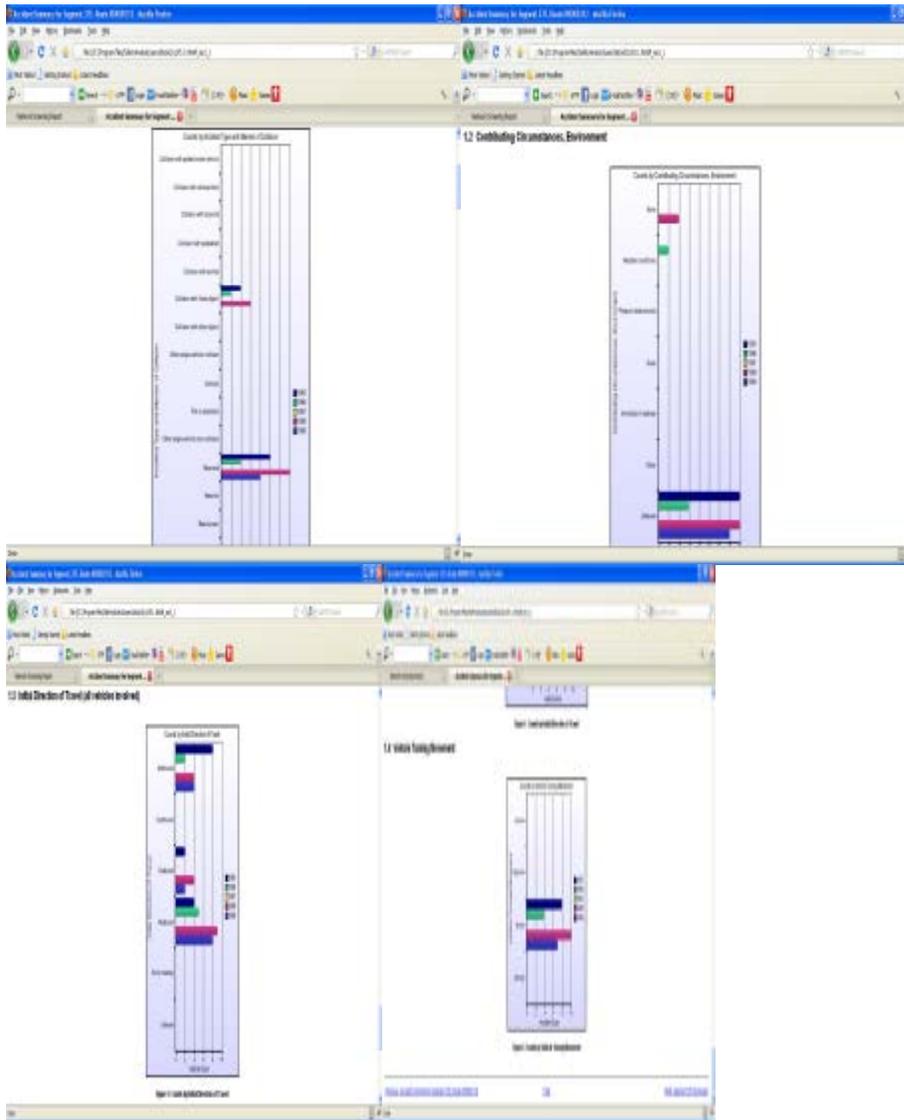


Figure 3: Accident Pattern Summary Statistics

The accident statistics tool provided a good tool for generating reports, but was not useful as an interactive tool. Diagnosing any accident patterns would require rerunning the reporting tool a number of times to deduce a useful result. There did not appear to be any helpful tools to determine which statistics stood out until after running the process multiple times. The output report is of good quality and would be useful once the pattern has been identified.

ii. Collision Diagrams

The software also includes a rudimentary collision diagram tool. The following is a screenshot of an output from this tool:



Figure 4: Collision Diagram Screenshot

The collision diagram tool is simple to use and provides a display for either segment or intersection crashes. The tool provides a different symbol for each accident type, and provides summary information at the bottom of the display. The symbols are not intelligent and no drill-down capability exists on the individual crashes. In testing, the collision diagram ran off the edge of the window and could not be maneuvered into the viewing area without cutting off some of the bottom of the summary info. The display did not include the street names. The display did include information about the median and shoulders of the route.

iii. Statistical Tests

The SA software provides a statistical analysis tool for determining accident frequencies and accident proportions. The software did not seem to produce any results in the versions tested. The image below is of the input form for generating the statistics:

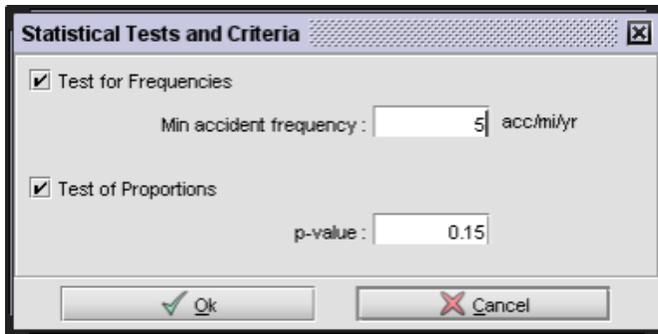


Figure 5: Diagnostics Statistics

b) Safety Diagnostics

The SA software appears to provide what is a strong framework for performing diagnostics.

i. Diagnosis

The user must select a pattern of interest and a single vehicle maneuver which is most prominent (for intersections), and the software will provide a listing of possible diagnoses.

The user may look at single or a set of diagnoses. When a user selects an individual diagnosis, a cause and an expanded rationale for the diagnosis is provided, along with its related countermeasures.

Following this, the user is presented with a series of detailed questions about the diagnosis to identify countermeasures which would reduce the pattern of crashes at this location.

Identified countermeasures are then utilized in further economic analysis by the software. The user can modify the list of countermeasures without going through further detailed question & answers.

ii. Accident Pattern Selection

After selecting a site, the user is provided with a set of Accident Types (AT) and Manner of Collision (MC) attributes, and corresponding counts for that specific site. The Accident Pattern is created by selecting and deselecting the ATs & MCs for that site.

iii. Pattern Selection

Following the creation of accident patterns for a given site, the user is presented with the set of patterns, along with a set of possible vehicle maneuvers (intersections only) for the site. The user then must select an accident pattern and maneuver, and the software will present a set of possible diagnoses for the pattern.

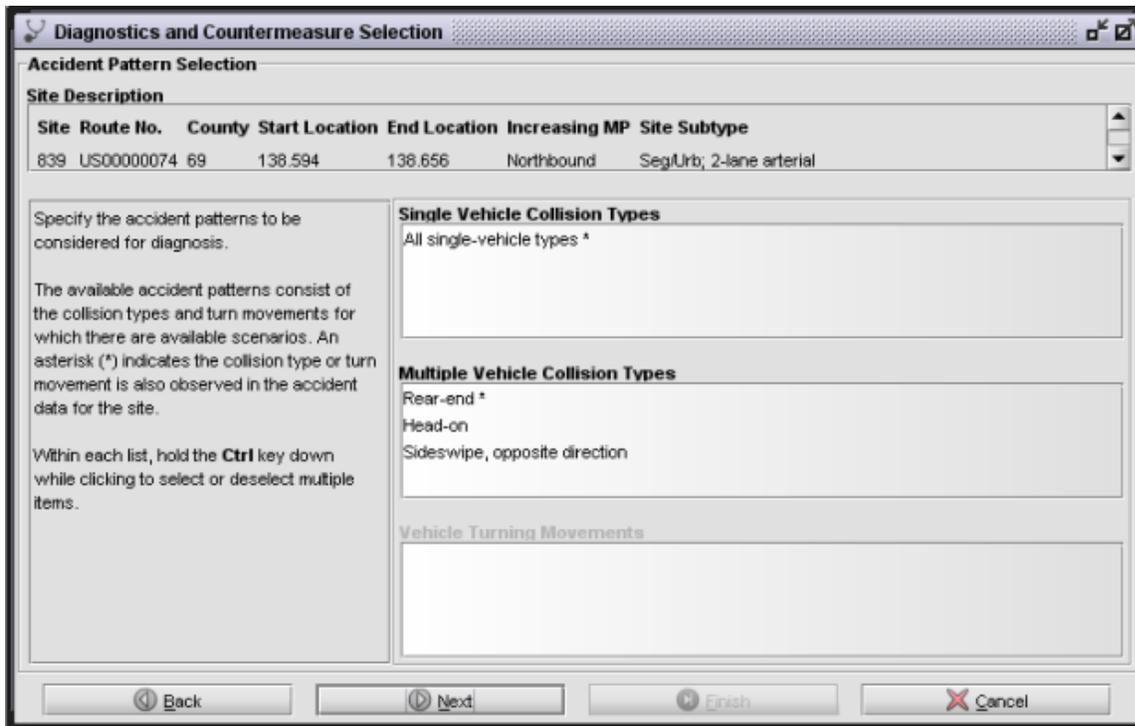


Figure 6: Accident Pattern Selection

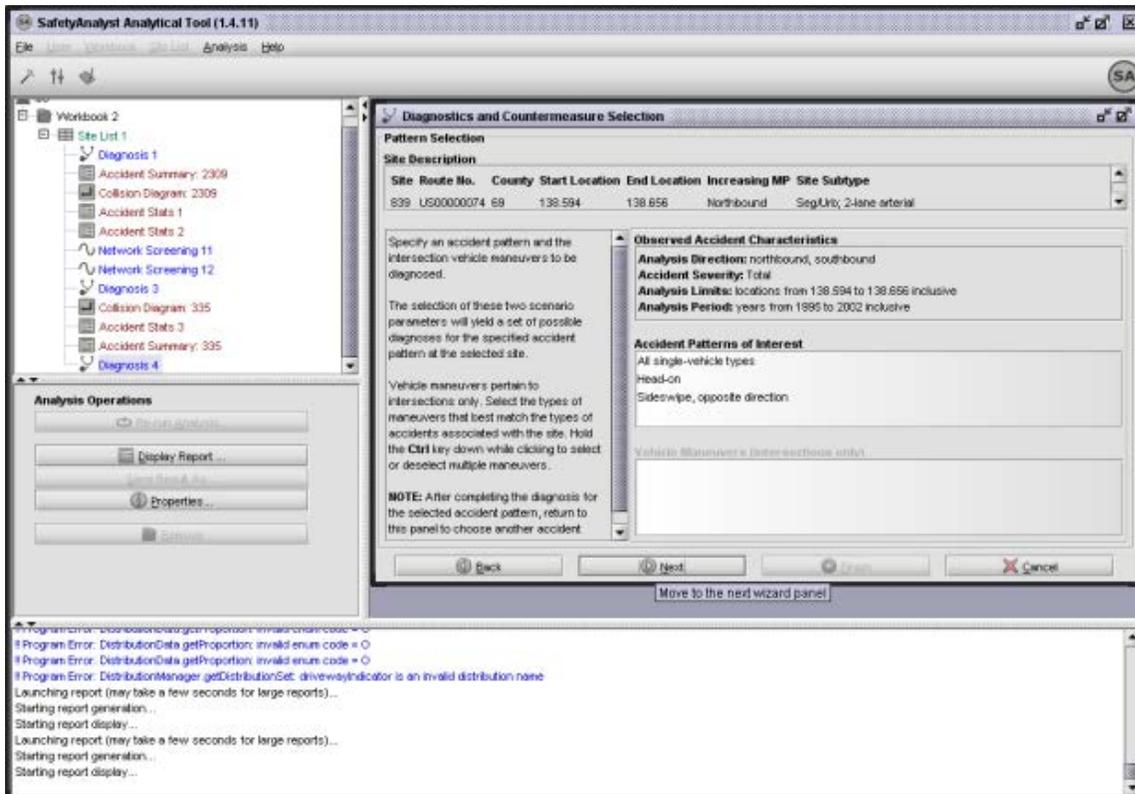


Figure 7: Pattern Selection

iv. Diagnostic Scenarios

This portion of the software guides the user through the selection of countermeasures based upon user selection after diagnosis. The software displays the possible set of diagnoses for a site. The user selects a diagnosis and the software prompts for answers to more detailed questions about the site. Depending upon the answers, the software will then display a set of possible countermeasures. The user can then choose to add the countermeasures to the list of countermeasures for the site. This process is completed for each pattern.

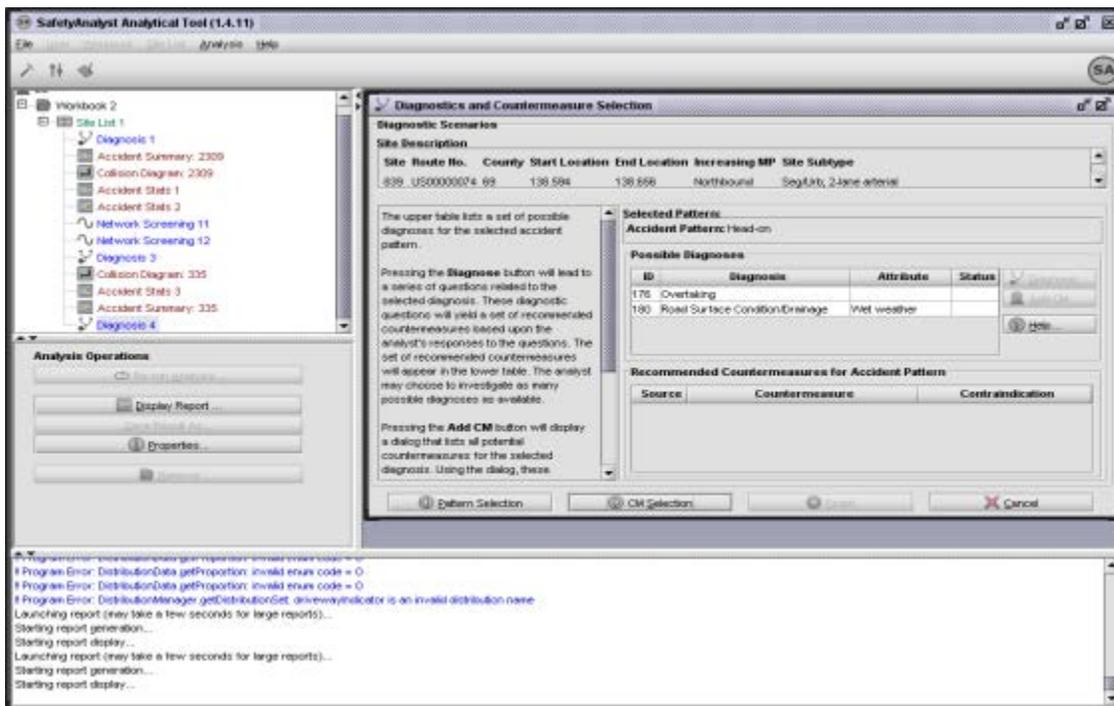


Figure 8: Diagnostic Scenarios – Overtaking and Road Surface Condition Drainage

In the case of the "Head-on" accident pattern, the user is presented with two possible diagnosis for this pattern; either "Overtaking" or "Road Surface Condition Drainage". If the user desires, he can select one of the diagnosis and be led through a series of questions which lead to a possible set of countermeasures (the user could also just select the countermeasures based upon engineering judgment without any aide from the computer).

Diagnostic Analysis

Diagnostic Question

Site Description

Site	Route No.	County	Start Location	End Location	Increasing MP	Site Subtype
839	US00000074	69	138.594	138.656	Northbound	Seq/ Urb; 2-lane arterial

Selected Pattern:
Accident Pattern: Head-on

Possible Diagnosis: Overtaking

Diagnosis Summary:

Statement:
 Head-on crashes can occur when drivers intentionally enter the opposing travel lane to overtake or maneuver around a slowing, stopping, or turning vehicle.

Rationale:
 At locations on the roadway where drivers frequently stop to drop-off or pick-up passengers, other drivers may maneuver around into the opposing lane, and head-on crashes may occur. Drivers may also move into the opposing lane to avoid other drivers leaving or entering parking spaces. Drivers may attempt riskier avoidance maneuvers when congestion is present. In rare cases, drivers may swerve to avoid a pedestrian or cyclist, resulting in an overtaking / evasive maneuver head-on crash.

Question:
 Are crashes occurring at frequent passenger drop-off or pick-up locations?

Answer :

Yes
 No
 Unknown

Recommended Countermeasures:

Back Next Done Cancel

Figure 9: Overtaking Diagnostic Question 1

In the case of the "Overtaking" scenario the first diagnostic question deals with possible passenger drop-off or pick up locations. The user has the option of always providing either a "YES", "NO", or "Unknown" answer.

Diagnostic Analysis

Diagnostic Question

Site Description

Site	Route No.	County	Start Location	End Location	Increasing MP	Site Subtype
839	US00000074	69	138.594	138.656	Northbound	Seq/ Urb; 2-lane arterial

Selected Pattern:
Accident Pattern: Head-on

Possible Diagnosis: Overtaking

Diagnosis Summary:
 In rare cases, drivers may swerve to avoid a pedestrian or cyclist, resulting in an overtaking / evasive maneuver head-on crash.

Question:
 Are crashes occurring at frequent passenger drop-off or pick-up locations?

Answer:
 No

Recommended CMT:
 None

Question:
 Are crashes occurring due to drivers attempting to avoid other vehicles parking?

Answer :

Yes
 No
 Unknown

Recommended Countermeasures:

Back Next Done Cancel

Figure 10: Overtaking Diagnostic Question 2

Diagnostic Analysis [X]

Diagnostic Question

Site Description

Site	Route No.	County	Start Location	End Location	Increasing MP	Site Subtype
839	US0000074	69	138.594	138.656	Northbound	Seq/Urban; 2-lane arterial

Selected Pattern:
Accident Pattern: Head-on

Possible Diagnosis: Overtaking

Diagnosis Summary:

Question:
 Are crashes occurring due to drivers attempting to avoid other vehicles parking?
 Answer: Yes
 Recommended CM: Provide a wider lane near parking area

Question:
 Is visibility of the access to entering, exiting or approaching vehicles a contributing factor?
 Answer :
 Yes
 No
 Unknown

Recommended Countermeasures:
 Provide a wider lane near parking area

[Back] [Next] [Finish] [Cancel]

Figure 11: Overtaking Diagnostic Question 3

Diagnostic Analysis [X]

Diagnostic Question

Site Description

Site	Route No.	County	Start Location	End Location	Increasing MP	Site Subtype
839	US0000074	69	138.594	138.656	Northbound	Seq/Urban; 2-lane arterial

Selected Pattern:
Accident Pattern: Head-on

Possible Diagnosis: Overtaking

Diagnosis Summary:

Question:
 Is visibility of the access to entering, exiting or approaching vehicles a contributing factor?
 Answer: Yes
 Recommended CM: Improve sight distance to access

Question:
 Can the access name signs be read at a distance from the access, equivalent to at least 7 seconds at the 85th percentile operating speed?
 Answer :
 Yes
 No
 Unknown

Recommended Countermeasures:
 Provide a wider lane near parking area
 Improve sight distance to access

[Back] [Next] [Finish] [Cancel]

Figure 12: Overtaking Diagnostic Question 4

Question 4 deals with sight distance issues.

The screenshot displays the 'Diagnostic Analysis' window. At the top, it shows the 'Diagnostic Question' and 'Site Description' table. The table has columns for Site, Route No., County, Start Location, End Location, Increasing MP, and Site Subtype. The data row shows: 839, US0000074, 69, 138.594, 138.656, Northbound, and Seq(Urb), 2-lane arterial. Below this, the 'Selected Pattern' is 'Accident Pattern: Head-on'. The 'Possible Diagnosis' is 'Overtaking'. The 'Diagnosis Summary' section contains a 'Question' about reading access name signs at a distance, an 'Answer' of 'Unknown', and a 'Procedure(s)' of 'Visit site.'. The 'Recommended Countermeasures' section lists: 'Provide a wider lane near parking area' and 'Improve sight distance to access'. The bottom of the window features 'Back', 'Next', 'Finish', and 'Cancel' buttons.

Site	Route No.	County	Start Location	End Location	Increasing MP	Site Subtype
839	US0000074	69	138.594	138.656	Northbound	Seq(Urb), 2-lane arterial

Figure 13: Diagnosis Complete

After answering all the questions, the software provides a couple of recommendations for countermeasures. In this case "Provide a wider lane near parking area", and "Improve sight distance to access". In this example, an experienced safety engineer would have immediately come to similar decisions (if appropriate) in almost instantaneous fashion. The detailed diagnosis is only really helpful, if the number of countermeasure options and diagnosis situations begins to exceed the ability for an experienced engineer to make similar decisions. This situation is not likely, but this could be a helpful tool in certain odd or uncommon situations.

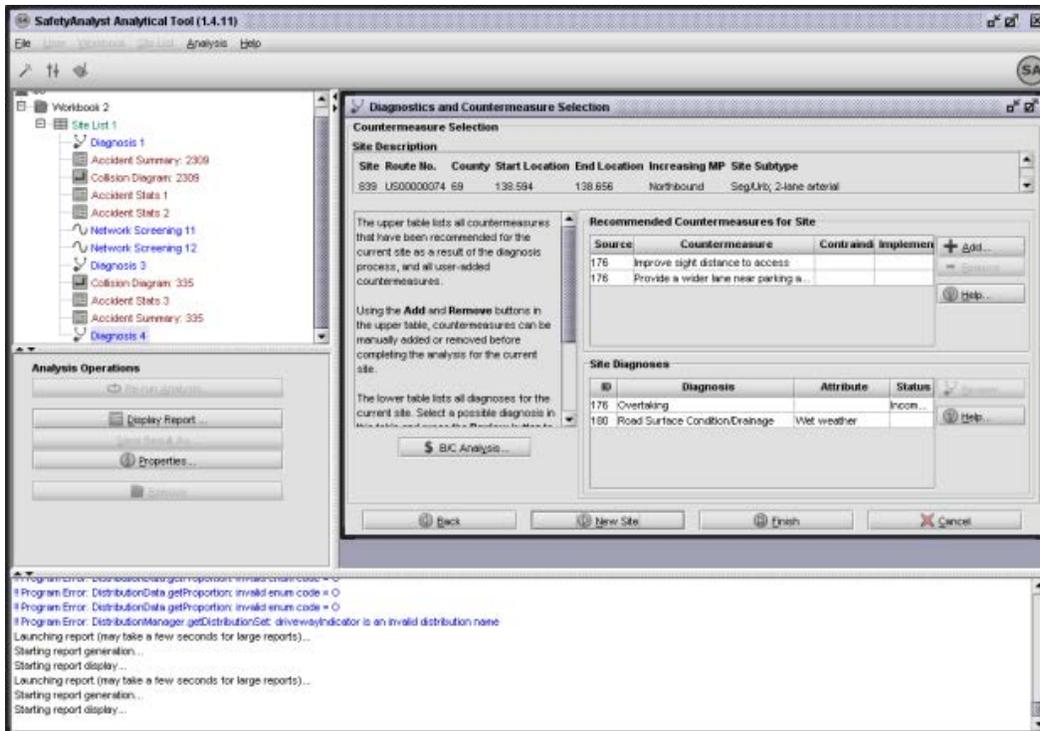


Figure 14: Resulting Countermeasure

c) CounterMeasure Selection

The software provides a single location for accumulating countermeasures from all patterns at a single site. The user has the ability to add, remove, or review all countermeasures for the given site.

Once the countermeasures have been added to a site, they are also included in the overall database.

Cost/Benefits Analysis

This software function provides a basic economic analysis of implementing a particular countermeasure. The software returns the maximum cost for a countermeasure which can be justified economically at this site's location. This portion of the software does not perform economic appraisal for a given site. That functionality is provided separately in Module 3 of SafetyAnalyst.

2. Economic Appraisal and Ranking Analysis

The stated purpose of this module is to provide an "economic analysis of a countermeasure, combination of countermeasures, at a site and to program countermeasures across a network".

a) Countermeasures

This module has the ability to add or eliminate countermeasures from inclusion in the analysis. No countermeasures from previous sections are automatically included, but are all available to include in the analysis.

3. Economic Analysis

This module provides economic analysis using four different methods as follows:

- Cost Effectiveness
- EPDO-based cost-effectiveness
- Benefits-Cost ratio
- Net Benefits

Cost Effectiveness

Cost Effectiveness is the ratio of total costs and expected number of accidents reduced.

EPDO-based cost-effectiveness

EPDO or Equivalent Property Damage Only based cost effectiveness method works similarly to the cost effectiveness method, but assigns a weight to each crash based upon the severity of the crash.

Benefits-Cost ratio

Benefits – Cost ratio is the ratio of safety improvement benefits compared to construction costs.

Net Benefits

Net Benefits effectiveness is the difference between the safety improvement benefit and the construction costs.

Ranking Criteria

The SA ranking criteria is based upon the economic appraisal methods plus some additional choices. The list of criteria includes the following:

- Cost effectiveness
- EPDO based cost effectiveness
- Benefits-cost ratio
- Net benefits
- Construction costs
- Safety benefits

- Total accidents reduced
- Fatal and severe injury accidents reduced
- Fatal and injury accidents reduced

Optimization

The optimization routine provides an analysis of maximizing the benefit of implementing countermeasures within a fixed budget. The summary table from the output provides the following cost and benefit for the selected countermeasures:

- Safety benefits
- Construction costs
- Net benefits
- Total accidents reduced.

Report Samples

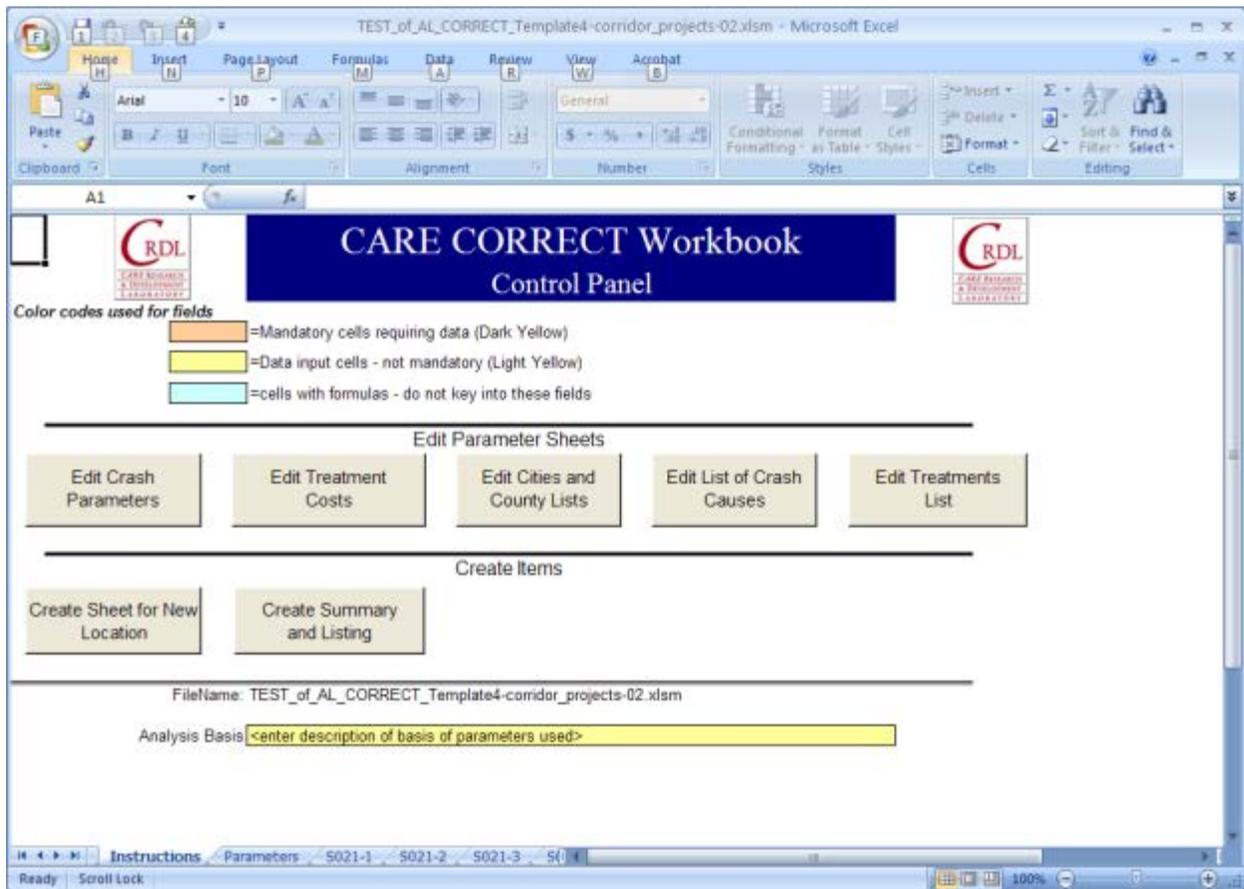
The following are links portions of Sample Reports from SafetyAnalyst:

- [Diagnosis and Countermeasure Selection Report](#)
- [Accident Summary for Segment Report](#)

CARE Correct

The CORRECT application is designed to calculate the cost and benefits safety countermeasures to be applied to roadways and/or intersections. The application has been built as an Excel Workbook. The application is primarily organized by distinct sites in which cause, treatment, and economic analysis for that specific site are performed. The application has an instruction page which acts as the controlling page for the program/workbook. The application includes benefit – costs analysis for each site, along with summary listing, and optimization analysis of all countermeasures.

The following is an image of the primary worksheet:



Input Parameters

Crash Parameters

The crash parameters sheet is for entry of summary level crash information for analysis of federal, state, county, and city crash ratios and costs in urban and rural areas.

Treatments Costs

Treatment costs currently contain no information.

Cities and Counties

The Cities and Counties listing provide raw information pull-downs on the site specific screens.

Crash Causes

This page provides input of crash cause groups and specific crash causes. This information is used by pull-downs on the site specific screens.

Safety Treatments

This page provides input of safety countermeasure categories and countermeasures or treatments for crash causes for use on site specific screens. No economic information is provided.

Sites (Candidate Analysis Site Evaluation Form)

These forms perform the site-specific crash cause, treatment, and economic evaluation. The user provides basic information about the site, and enters the location, crash data, crash cause, treatment, and treatment cost information. The form then calculates the benefits and benefits to costs ratios. An image of the CASE form is below.

Candidate Analysis Site Evaluation Form (CASE Form)

Reference Number: **S021-1** Create New Location Sheet Copy This Sheet Clear This Sheet

(1) Funding: DN-System: **Sec 102** OFF-System:

Time Period of: **3** (3) Date: **2007-2009**

(2) Accident History: **3** (3) Date: **2007-2009**

(4) System - Urban: **Federal** **State** **County** **Municipal**

System - Rural: **Federal** **State** **X** **County**

(5) Location: **Test Location 1220** Description: County: City:

(6) Segment ID: **S021** From: **20** to **00** System: **RURAL STATE**

(7) Investigators: **Test**

(8) Roadway Environment Causes of Accidents	(9) Total Number of Accidents	(10) Number of Fatal Accidents	(11) Number of Injury Accidents	(12) Number of P.D.O. Accidents
Major cause (PDOs marked on, before, after)	267	1	54	232
Reduced Road Width	196	5	23	168
Conflicts at Intersections	155	2	31	122
Other	0	0	0	0
Total Number of Roadway Environment Causes	3			

(13) Description of Alternative Safety Treatments	(14) Initial Cost	(15) Life in Years	(16) Maint. Cost Per Year	(17) % Accident Rate Reduction For Roadway Environment Causes			
				Aa	Bb	Cc	Dd
13a) Convert two-lane road to multi-lane road	\$ 13,350,000	20	\$ -	20.00%	10.00%	0.00%	
13b) Modify Curvature - Moderate	\$ 20,000,000	20	\$ -	30.00%	15.00%	0.00%	
13c) Modify Curvature - Moderate	\$ 30,000,000	20	\$ -	40.00%	20.00%	0.00%	
Total Number of Safety Treatments	3						

Figure 15: Correct CASE Form

Summary

The Correct Instructions form contains a command for creating the Summary worksheet. This worksheet contains listing summary of all sites, and their respective alternative treatments, constructions costs, maintenance costs, benefits, and benefits to costs ratios.

Reference Number	S355-3	System	RURAL STATE	Based on	3	years of accident history
Location	TEST LOCATION 1220		County	City		
	Cost	Benefit	Maintenance Cost	B/C Ratio1	Total Cost	B/C Ratio2
Alt 1 Extend SB off-ramp	\$ 250,000	\$ 1,354,000	\$ 20,000	5.4160	\$ 270,000	5.0148
Alt 2 Widen ramp	\$ 200,000	\$ 930,000	\$ 20,000	4.6500	\$ 220,000	4.2273
Alt 3 Both a and b	\$ 400,000	\$ 1,833,000	\$ 40,000	4.5825	\$ 440,000	4.1659

Figure 16: Site Benefits

The Correct Summary also contains summary level analysis comparing overall costs to benefits. An example chart image is provided below.

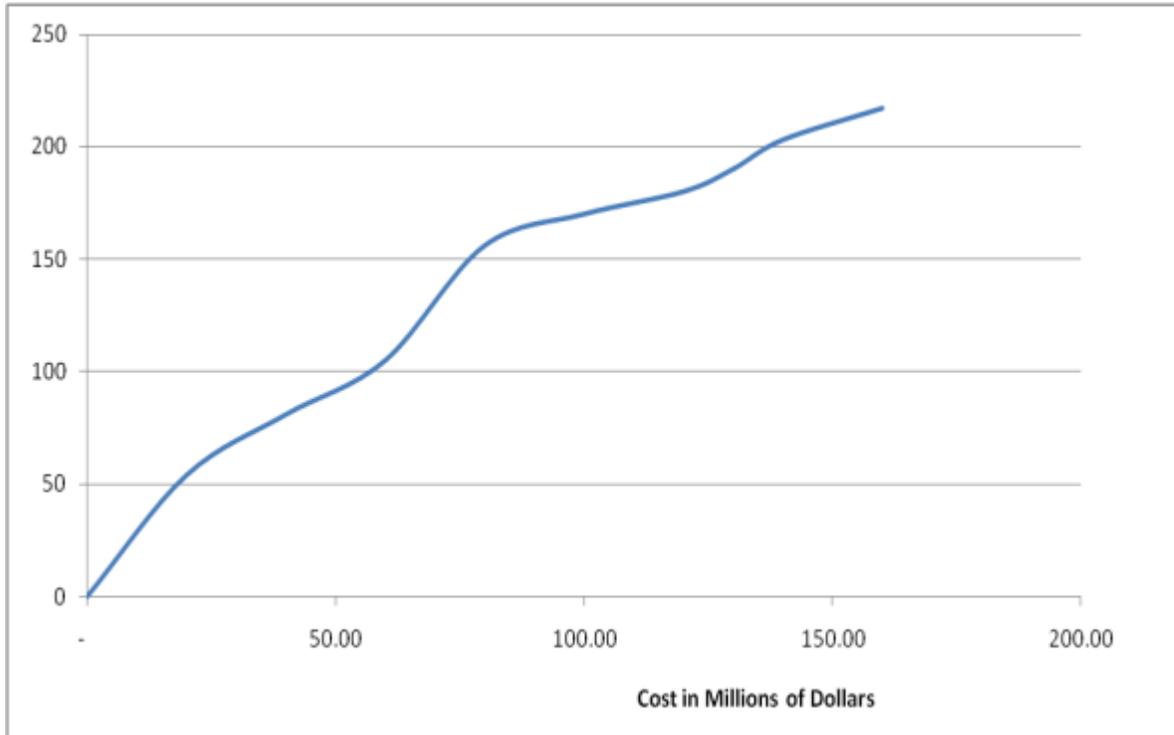


Figure 17: Cost-Benefits Chart

Optimization

The CARE Correct software also provides an optimization worksheet. The program allows the user to collect the input data from the CASE forms and assemble into a summary listing. An image of the listing is found on the following page.

Sheet	Alternative	Benefit	Cost	C/B Ratio
S021-1	Modify Curvature -- Minimal	\$23,133,000.00	\$10,350,000.00	0.447412787
S021-1	Modify Curvature -- Moderate	\$34,699,000.00	\$20,000,000.00	0.576385487
S021-1	Modify Curvature -- Maximum	\$46,265,000.00	\$30,000,000.00	0.648438344
S021-2	Roadside clearance 20 feet	\$8,423,000.00	\$3,000,000.00	0.356167636
S021-2	Roadside clearance 40 feet	\$21,057,000.00	\$6,000,000.00	0.284940875
S021-2	Roadside clearance 60 feet	\$33,692,000.00	\$9,000,000.00	0.267125727
S021-3	Corridor consistent channelization	\$9,623,000.00	\$12,860,000.00	1.336381586
S021-3	Corridor signalization upgrade	\$24,057,000.00	\$38,462,000.00	1.598786216
S021-3	Both channelization and signalization upg	\$38,492,000.00	\$48,754,000.00	1.266600852
S015-1	Modify Curvature -- Minimal	\$12,517,000.00	\$5,350,000.00	0.427418711
S015-1	Modify Curvature -- Moderate	\$18,776,000.00	\$10,000,000.00	0.532594802
S015-1	Modify Curvature -- Maximum	\$25,034,000.00	\$18,000,000.00	0.71902213
S015-2	Roadside clearance 20 feet	\$4,215,000.00	\$1,500,000.00	0.355871886
S015-2	Roadside clearance 40 feet	\$10,539,000.00	\$3,500,000.00	0.33209982
S015-2	Roadside clearance 60 feet	\$16,862,000.00	\$5,000,000.00	0.29652473
S015-3	Corridor consistent channelization	\$3,871,000.00	\$6,860,000.00	1.772151899
S015-3	Corridor signalization upgrade	\$9,677,000.00	\$20,462,000.00	2.114498295
S015-3	Both channelization and signalization upg	\$15,482,000.00	\$22,754,000.00	1.469706756
S138-1	Modify Curvature -- Minimal	\$4,908,000.00	\$2,135,000.00	0.435004075
S138-1	Modify Curvature -- Moderate	\$7,362,000.00	\$3,500,000.00	0.47541429
S138-1	Modify Curvature -- Maximum	\$9,816,000.00	\$7,200,000.00	0.733496333
S138-2	Roadside clearance 20 feet	\$2,339,000.00	\$500,000.00	0.213766567
S138-2	Roadside clearance 40 feet	\$5,846,000.00	\$1,200,000.00	0.20526856
S138-2	Roadside clearance 60 feet	\$9,354,000.00	\$1,800,000.00	0.192431046
S138-3	Corridor consistent channelization	\$1,203,000.00	\$2,860,000.00	2.377389859
S138-3	Corridor signalization upgrade	\$3,008,000.00	\$6,462,000.00	2.148271277
S138-3	Both channelization and signalization upg	\$4,813,000.00	\$8,754,000.00	1.818824018
S210	Roadside clearance 20 feet	\$2,275,000.00	\$150,000.00	0.065934066
S210	Roadside clearance 40 feet	\$5,686,000.00	\$600,000.00	0.105522336

Figure 18: Summary Listing in Optimization

The user can then perform an optimization of the all of the countermeasure alternatives by entering a target budget and selecting "Run Optimizer". The results of the optimization provide a listing of funded and unfunded projects. The funded projects list is a selection of the highest ranked projects fitting within the target budget. An image of the resulting listing is provided below.

Results - Funded Projects				
Sheet	Alternative	Benefit	Cost	C/B Ratio
S021-1	Modify Curvature -- Maximum	\$46,265,000.00	\$30,000,000.00	0.648438344
S021-2	Roadside clearance 60 feet	\$33,692,000.00	\$9,000,000.00	0.267125727
S021-3	Corridor consistent channelization	\$9,623,000.00	\$12,860,000.00	1.336381586
S015-1	Modify Curvature -- Moderate	\$18,776,000.00	\$10,000,000.00	0.532594802
S015-2	Roadside clearance 60 feet	\$16,862,000.00	\$5,000,000.00	0.29652473
S015-3	Both channelization and signalization upgrades	\$15,482,000.00	\$22,754,000.00	1.469706756
S138-1	Modify Curvature -- Maximum	\$9,816,000.00	\$7,200,000.00	0.733496333
S138-2	Roadside clearance 20 feet	\$2,339,000.00	\$500,000.00	0.213766567
S210	Roadside clearance 60 feet	\$9,098,000.00	\$750,000.00	0.0824357
S315	Add two-way left-turn lane (TWLTL)	\$1,270,000.00	\$350,000.00	0.275590551
S355-1	Add NB & SB Left T Lanes at first median openi	\$2,549,000.00	\$85,000.00	0.03334641
S355-2	Resurfacing, widening, gaurd rail	\$2,462,000.00	\$235,000.00	0.095450853
S355-3	Both a and b	\$1,833,000.00	\$400,000.00	0.218221495
		\$170,067,000.00	\$99,134,000.00	0.582911441

Figure 19: Correct Funded Project Listing

III. System Analysis

This section contains the analysis of the findings from the system review. The section includes three parts: general findings, comparison matrix, and alternative analysis. The general findings provide a bulleted listing of comparative strengths and weaknesses of the two software packages. The Comparison Matrix section provides a specific comparison of common features between each software package. The Alternative Analysis section provides a trade-off of possible approaches of moving forward with either of the two software packages.

A. General Findings

The following represents general overarching statements regarding the two software packages:

- SafetyAnalyst represents a complete turnkey software solution for most of the entire lifecycle of safety engineering data (assess, diagnose, treatment alternatives, program, evaluations). A key strength of this approach was a common overall database for the entire lifecycle.
- SA is more oriented towards sequential processing of safety data through the overall safety engineering process. It is less flexible than CARE and less interactive.
- SA is restrictive in nature and has heavy specific data input requirements. It provides extensibility in adding data, but only within predefined elements.
- SA is more advanced in its use of network screening techniques which eliminate problems resulting from the "regression to the mean" effect.
- SA's Network screening is complicated to use and not intuitive to obtain valid results.
- SA has strong tools for diagnosing accident patterns and assisting in selecting countermeasures.
- SA integrates the various steps of diagnosing patterns, selecting countermeasures, and performing economic analysis.
- SA's approach to identifying accident patterns is limited, and tools supporting this process are limited.
- SA's approach to diagnosing countermeasures is good, but needs to be greatly expanded.
- SA's approach to selecting and de-selecting countermeasures is very good and allows the user to either use engineering judgment or get assistance through diagnosis.
- SA's reporting capabilities are very good.
- SA's approach to identifying accident patterns can be time consuming and somewhat ineffective.
- SA provides only very simple filtering capability.
- It is difficult within SA to interrogate detailed crash information.
- SA does not intuitively provide access to site data.
- SA is not open and not easy to interface with.
- SA appeared to have a number of bugs while operating. None fatal, but a large number were displayed in the message area during operation.

- Data management (setup and importing) with SA is difficult and not very intuitive.
- Data management within a project in SA is very good.
- SA provides a good ability to add data to the database once it has been set up.
- SA provides multiple approaches to economic analysis.
- CARE software represented a highly interactive, rapid response, and easy-to-use approach to the entire lifecycle of safety engineering data. A key strength of this software was its extremely powerful filtering and data interrogation techniques.
- CARE's ability to filter and interrogate data to obtain significant data is extremely effective.
- CARE's ability to integrate with GIS provides a powerful data visualization tool.
- CARE's integration with Intersection Magic provides a powerful collision diagram tool.
- CARE's operation appears to be much smoother overall as compared to SA.
- CARE Correct is easy-to-use and provides much of the same information as SA.
- CARE Correct does not appear to maintain the economic information on safety countermeasures.
- CARE Correct does not appear to have an integrated database with CARE desktop.

B. Feature Comparison Matrix

The following table provides a summary feature comparison between CARE/Correct and SafetyAnalyst

Feature Name	CARE/Correct	SafetyAnalyst
Accident Pattern Identification	Very Good	Weak
Accident Pattern Diagnosis	None	Very Good
Site Database	None	Very Good
Counter Measure Recommendation	None	Good
Countermeasure Select / De-select	Good	Very Good
Site Benefit Costs	Good	Good
Countermeasure economics	Weak	Good
Economic Appraisal Methods	Good	Very Good
Countermeasure Ranking	Good	Good
Economic Optimization	Good	Very Good
Overall Reporting	Good	Very Good
Collision Diagram	Very Good	Good
Site Creation and Management	Very Good	Good
Site Review and Access	Very Good	Good
GIS Integration	Very Good	None
Site Statistics	Very Good	Good

The comparison table was created to demonstrate the gaps in the various features between the two software packages.

At the top level, SA is very good at network screening, integrated database, countermeasure diagnosis, and economic appraisal. CARE is very good at accident pattern identification, overall accident interrogation, and visualization. Each has strengths and both are useful.

In an ideal world, a tool built with CARE's flexibility, ease-of-use, data visualization, GIS capability, filtering and rapid analysis techniques, and combined with SA's integrated database network screening algorithms, accident pattern diagnosis, countermeasure selection, and economic analysis would be a perfect tool for overall safety engineering analysis.

It is probably not realistic to believe that either tool will be able to add all of the other's key features. I believe that the capabilities in both tools are too important to just ignore. The question becomes which set of features are most important to replace in the other's toolset? This question can best be answered by determining which feature most greatly effects the ability to improve safety.

Aside from the technical comparison, we should also consider the results of the recent SafetyAnalyst survey. Of all the survey responders, only one was heavily using Module 2 within SafetyAnalyst. This leads me to believe that there is some flaw in either the software or the software's response to the workflow. In general, I believe that there are two major problems with SafetyAnalyst software at this phase of the lifecycle:

- The normal practice by safety engineers is to visit sites once they have been identified by a network screening operation. During or in preparation for this visit, safety engineers identify accident patterns and causes and prospective treatments. Currently a great reliance on engineering judgment is used to determine cause, treatment, and treatment cost.
- The study showed that SA was weak in the area of accident pattern identification, and did not provide very powerful tools for filtering and rapidly analyzing crashes. The study shows that CARE accomplishes this much more effectively.

Also worth noting from the survey was the strong inclination to want to use a more sophisticated approach to network screening. It was clear that the concern over "regression to the mean" affect, has caused many to change from previous network screening techniques to use SA. This was perhaps the single most important justification for moving to SA from previously utilized techniques.

After re-considering the actual usage of SafetyAnalyst in the field; netting out the differences between the two economic approaches, there are actually only very small differences. The major and significant difference in the software is primarily in the network screening approach.

C. Alternative Analysis

In determining how to proceed, ALDOT must consider several possibilities:

- Replace CARE with SafetyAnalyst
- Utilize a hybrid approach between CARE and SA
- Make improvements in CARE to provide with the features which are contained in SA
- Acquire SA and make changes in it to match up with the capabilities in CARE.
- Keep on the current path the CARE and make no changes

Option 1: Replace CARE with SA

If ALDOT were to replace CARE with SA, they would be moving to a software package that many in the US have decided to make their primary Safety Analysis tool. SA would provide a very strong tool for network screening. The study shows it would also be very useful for accident pattern diagnosis, countermeasure selection, and economic appraisal. A key consideration from ALDOT would have to be whether the cost of maintaining the data required by SA would justify the move from CARE.

If ALDOT moved from CARE to SA, ALDOT would lose a: Flexible data model

- Strong filtering capabilities
- Strong accident pattern diagnostics
- Strong accident interrogation techniques
- Visualization
- GIS integration
- Intersection Magic integration
- Behavioral analysis capabilities

Option 2: Hybrid SA/CARE

If ALDOT were to decide to have both CARE and SA, ALDOT could obtain the best of both worlds.

In order to maximize the benefits of each, it might be necessary to be able to pass data back and forth between the two systems. If so, CARE could best be used for performing statewide and behavioral analysis and answering "what if" type questions. SA would be used in a programmatic manner to systematically develop a safety program each year. CARE datasets could potentially be created from the SA database, and CARE could be used in parallel to SA. Ideally, the datasets could be created in CARE in order that SA homogeneous sections and analysis sites (hot spots) could be placed into CARE (obviously a pre-processing routine would need to be done, but this is easily accomplished). Once in CARE, the sites could be spatially located and compared against other sites (using Impact and Profile), etc.

CARE could significantly add value to the SA offering. Moreover, the structure of the attribute data in SA would be very useful in a CARE environment. In particular, the filter by homogeneous section subtypes in impact or profile analysis would make it very easy to visualize overrepresentations within these subtypes, in turn making it easy to find accident patterns.

The "trick" would be where and how to bring the two software packages together. Integration of the CARE and SA software could be considered at a couple levels, as follows:

- Input Database level
- Post Network Screening Database level

If CARE datasets were created once network screening had been completed, this would allow the use of the network screening operation from SA, and allow CARE to be used for accident pattern identification, data visualization, GIS integration, collision diagramming, and general data interrogation.

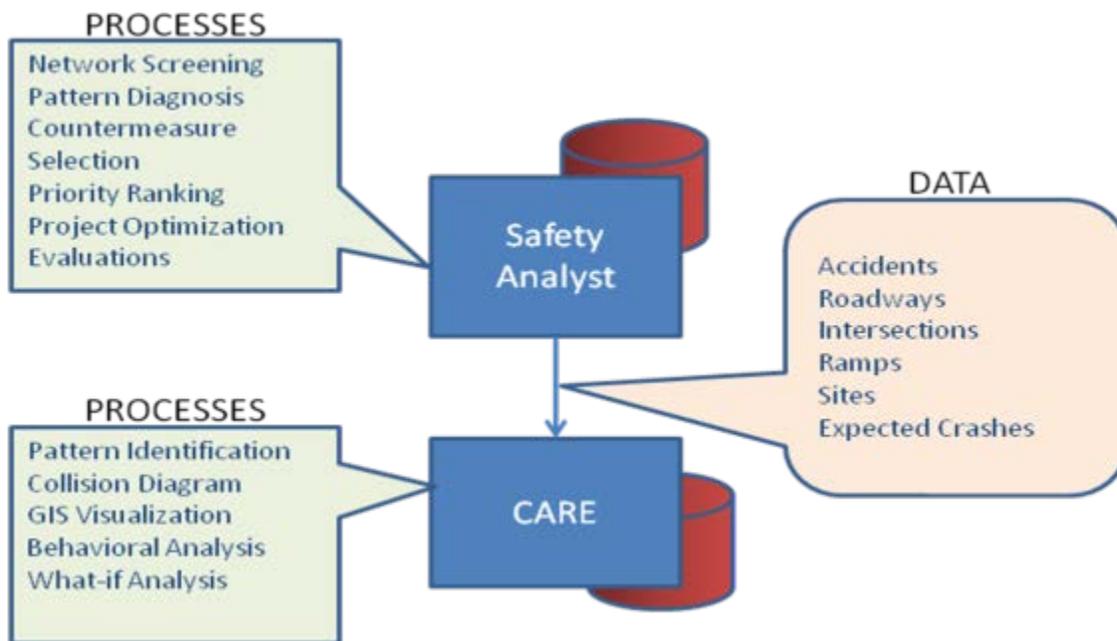


Figure 20: CARE/SA Hybrid

Option 3: Improve CARE

If ALDOT decide to solely improve CARE and not utilize SA, the most important area to improve would be to add an Empirical-Bayes or some other Bayesian approach for network screening. The Bayesian math models are somewhat complex and are not easily programmed, however, several "open source" programs exist which offer these capabilities. This software could either be integrated, or could be source coded to write a Bayesian network screening algorithm.

Secondly, if funding permits, ITIS recommends that CARE Correct be moved from a spreadsheet application to a database application and that a site-oriented data-model is created, somewhat similarly to SA, such that sites and countermeasures could be better managed in diagnosis, treatment, program, and evaluation lifecycles.

In this scenario, ITIS also recommends that CARE Correct be modified to include the countermeasure cost information. In this scenario CARE Correct could be modified to incorporate the countermeasures which are being created and maintained within the Countermeasure Clearinghouse of the FHWA.

Option 4: Improve SA

In this option, ALDOT would pay to have SA improved to incorporate many of the functions available within CARE. These would include:

- Better accident pattern identification techniques
- GIS integration
- Better filtering capabilities
- Improved data model flexibility.

Most of these options would be very costly, and most likely prohibitive in nature. This option is most likely not a valid option worth further consideration.

Option 5: Do Nothing

Currently the ALDOT has a successful program making use of CARE software within its current state, and can implement most all of the characteristics of the Highway Safety Manual without any necessary modifications to its software. Indeed, the differences in the diagnosis, countermeasures selection, and economic analysis are not significant enough between CARE and SA to warrant a major change. The only key difference within the two systems is the network screening approach using Bayesian models.

IV. Recommendations

This section includes the recommendations based upon reviewing the SafetyAnalyst and CARE software, reviewing the respective documentation, testing the software applications, and reviewing the results of the related survey.

The recommendations include suggestions resulting from the alternative analysis in the previous section, and provide suggestions for possible next steps for ALDOT.

It is recommended that ALDOT remain using CARE as its primary safety analysis tool for the short term, but to continue to investigate SafetyAnalyst. The conclusion arising from the alternatives analysis is that we don't currently have enough information to make a long term

decision. Our current recommendation would be to move forward with either Option 2: CARE/SA Hybrid Approach, or Option 3: Improve CARE Approach. We believe that the following questions still need to be resolved prior to making a long term commitment in either direction:

- Can CARE be reasonably modified to include Advanced Network Screening using empirical-Bayes techniques?
- What is the impact of implementing SafetyAnalyst from a data perspective?
- To what degree could CARE be interfaced with SafetyAnalyst and thus possibly obtain the best of both software packages?

It is recommended that a short term plan for ALDOT contain the following elements:

- **CARE/SA Integration:** Investigate the feasibility of interfacing CARE and SA. Determine how and where the integration should take place. Determine if it is reasonable or feasible to have a live interface between the two software packages, or just to just share data. At a minimum level it should be feasible for both packages to have a common ETL approach which provides both packages with basically the same data. A better interface would allow for passing data from SafetyAnalyst to CARE after networking screening has taken place. An even better interface would be for two--way communication between both applications, whereby data, commands, and messages could pass in both directions. This would require investigation and most likely prototyping to be accomplished. The results of this task will help to clearly indicate the degree to which interaction is more feasible for ALDOT.
- **CARE Advanced Network Screening:** Investigate the feasibility of adding an empirical Bayes based network screening method for peak searching and sliding widow analysis. This might best be accomplished by developing a prototype for network screening using an existing open source package, or by obtaining the source code from an early (public domain) version of SafetyAnalyst. Being that the Bayesian network screening approach is the most significant difference between SA and CARE, the results of this effort would greatly assist in determining whether to stick with CARE as the primary safety analysis tool for the long term, or whether to consider phasing it out.
- **CARE/SA Dataset:** Create a joint prototype dataset for use in CARE and SA to determine the impact of developing a statewide implementation of SA, from a data and a data maintenance perspective. The results of this effort would provide the necessary information to determine the cost of maintaining a SafetyAnalyst database and would shed light on whether the cost of maintenance would make it prohibitive. This effort would also provide a datasource for use in testing integration and network screening.
- **Long-Term Plan:** The outcome of the above tasks will provide the needed information to create a longer term plan. For example, if creating the advanced network screening proves to be more challenging than expected, and the CARE/SA interfacing proves easy to accomplish, then a path of using SA for pattern diagnosis, countermeasure selection and economic planning would make a good choice. If however, the converse is proven, and it is feasible to do the advanced network screening in CARE, then CARE would become the obvious platform for most all safety analysis and development; an improved

CARE Correct module would then be recommended. The results of this effort would set the stage for long term support of the HSM computing strategy.

References

- Brown, D.B. 2011. "CARE, *SafetyAnalyst*, and CORRECT Integration." Working Paper 6.1. July 14.
- ITIS Corporation. 2011. "CARE (Correct)/*SafetyAnalyst* Gap Analysis Study." Clovis, California. November.
- ITIS Corporation. 2011. "Gap Analysis of CARE/Correct Software and *SafetyAnalyst* Software." Draft. Clovis, California. June.
- ITIS Corporation. 2011. "*SafetyAnalyst* State of Practice Review." Draft. Clovis, California. June.
- ITIS Corporation. 2011. "*SafetyAnalyst* State of Practice Review." Version 2. Clovis, California. November.
- University of Alabama. 2011. "Identifying Users and User Needs for the HSM." Working Paper 2.1. July 4.
- University of Alabama. 2011. "Project to Develop the Scope for Implementing the HSM." Working Paper 1.1. July 4.
- University of Alabama. 2011. "Site Selection for Preparation of Safety Performance Factors." Working paper 7.1. July 23.