Data is Key to Understanding and Improving Safety

by Michael S. Griffith, Carl Hayden, and Hari Kalla - January/February 2003

Road safety audits, more efficient data collection, and a new software tool promise to make our highways safer.

Before the dawn of the *Information Age* and the invention of the computer, safety leaders recognized the need for data on highway traffic crashes as early as the 1920s. A national conference on street and highway safety, held in 1924 in Washington, DC, reported, "Statistics regarding street and highway accidents are so vital to any comprehensive understanding and treatment of the safety problem that their collection and analysis in every State and community are essential." This statement still rings true; it might be even more important considering the interconnected local, State, and Federal transportation and other systems.

A road saftey audit team reviews road plans.

By the end of the 20th century, every State and local government had the mechanisms to collect highway crash data. What safety professionals know today is that a number of ever-changing variables factor into the frequency and severity of crashes: travel mode, the road and roadway conditions, type of vehicle, weather, amount of travel, terrain, and most uncontrollable of all, peoples' behavior. Now, the safety community is looking for the links and correlations among all these factors as it builds better and more accurate safety prediction models. These models will be used by decisionmakers, designers, and planners, to make choices about and implement a safer transportation and highway system.

The amount and quality of available data are key components for improving highway safety performance. The continuing challenge at this junction is gathering complete and accurate data, and making it more accessible and easier-to-use for transportation leaders and decisionmakers. The good news is that data collection tools are improving; road safety audits are now available for tapping into safety knowledge; and a new software resource—*SafetyAnalyst*—is under development.

Filling in the Data Gaps

Although data collection is improving, there are still processing inefficiencies that can impact overall decisions about safety. Not all regional areas have access to the same levels of the latest technology. For example, many law enforcement personnel complete and file paper copies of crash reports and investigations, which are forwarded through an organizational chain for processing. Multiple agencies then manually key in selected data fields at multiple levels of government (local, State, and Federal). Not only does this create duplicative efforts, but it also opens the door for potential data entry errors and missing data at one or more organizations. Incomplete data with crucial elements missing, unavailable, or not capable of being combined for analysis could make the difference in designing and building a safer road or bridge.

Today, the maturity of computer technology makes it practical to collect, edit, distribute, and store data in electronic format with little or no additional manual processing necessary. New technologies make it possible to collect agency-specific data more efficiently and to share it across multiple programs. Further, integrating data from various agencies is now possible, including police crash reports, truck inspections, traffic citations, motor vehicle records, emergency medical services (EMS) run reports, emergency and long-term health care records, highway inventories, and traffic volume records.

A police officer uses an onboard computer to access driver information.

The transportation safety community and other organizations could benefit by stepping back and viewing how data is or might be used, how it is gathered, and the components that are necessary for making life-saving safety models. Finding mechanisms for sharing information vertically and horizontally within an organization, and finding ways to share accurate and complete data among local, State, and Federal agencies could have a profound effect on decisionmaking and safety across the Nation.

National Model

This integration is being done under the National Model for the Statewide Application of Data Collection and Management Technology in Highway Safety project. The National Model is a Federal-State partnership to demonstrate the successful integration of technology for the improvement of public safety. The partnership, which originated in 1997, includes the Iowa Department of Transportation, Federal Highway Administration (FHWA), National Highway Traffic Safety Administration (NHTSA), Federal Motor Carrier Safety Administration (FMCSA), and Bureau of Transportation Statistics.

The National Model is designed to be adaptable for use by a wide range of government agencies, such as law enforcement, EMS teams, motor carrier inspectors, and others collecting incident-based safety data. By enabling an in-vehicle hardware unit to function as both a mobile data terminal to communicate with the computer-aided dispatching (CAD) system and as the unit for field-based reporting, the system provides a more efficient means of collecting accurate and timely crash data.

The National Model also is capable of incorporating multiple field-based reporting areas, such as motor carrier safety inspections, citations, Implied Consent (DUI) forms, and incident/crash reports. Data and images are transmitted from both local and State law enforcement agencies to administrative offices in order to eliminate redundant data entry and expedite data processing. Finally, the National Model increases the efficiency of distributing and analyzing safety data by providing accurate data to the user community in hours instead of days and weeks.

An officer scans a driver's license electronically.

The use of wireless data communications, mobile video, global positioning system/geographic information system (GPS/GIS), and bar codes enable field staff to collect timely and error-free data. The flexibility of the system to support a variety of reports can support officers and other field personnel in their other activities.

The Web site for the National Model is located at www.dot.state.ia.us/natmodel/index.htm.

TraCS Software

It is often said that police officers are too busy at a crash scene to spend much time collecting data. Yet, this data is vital for planning safer roads that help decrease the number of crashes. The National Model project developed Traffic and Criminal Software (TraCS), currently used by many agencies in Iowa and by other agencies. Police officers report that they prefer using TraCS to prepare the required crash reports, especially in multi-vehicle crashes, because of the increased speed and efficiency in completing multiple forms with repetitive data fields.

Three factors are key to TraCS's success. First, it was developed with total user (police) involvement. Each function or new technology incorporated into TraCS must support day-to-day activities that officers and other field personnel actually perform. Secondly, TraCS is modular and customizable so it can be used by law enforcement and motor vehicle agencies nationwide. And finally, the TraCS architecture and the Software Development Kit enable agencies outside Iowa to design their own forms to have the "look and feel" of their existing forms and choose their own process flow.

The TraCS Software is available for license to State and other government agencies. As of August 2002, 17 States had signed license agreements. At least two States, notably Georgia and New York, have successfully pilot-tested TraCS and begun installing computers with the software in their patrol cars.

A collaborative effort of the International Association of Chiefs of Police, National Sheriffs' Association, FHWA's Office of Safety, FMCSA, and NHTSA produced a new video for law enforcement officers, "Safety Starts With Crash Data." The video was sent to law enforcement agencies to be incorporated into training for officers who perform crash investigations. For a copy of the video, contact David Smith at david.smith@fhwa.dot.gov.

MMUCC

A fundamental component in data collection is the necessity for consistent data elements with clear definitions of terms. Voluntary consensus standards for data elements in crash reports are available in the American National Standards Institute (ANSI) *Manual on Classification of Motor Vehicle Traffic Accidents* (ANSI D16.1), and in ANSI's *Data Element Dictionary for Traffic Records Systems* (ANSI D20). Even now, the data collected locally and among States lacks uniformity.

The *Model Minimum Uniform Crash Criteria* (MMUCC), published in 1998 by NHTSA, FHWA, and the National Association of Governors' Highway Safety Representatives, includes 75 minimum data elements that need to be collected by police at a crash site and an additional 38 data elements that can be derived from those collected at the scene or by linking to other data files, such as road inventories or EMS run reports.

A safety audit team conducts a field review.

The MMUCC has come at an opportune time. Many States are updating their safety data systems, including crash reports, or are considering doing so in the near future. An important consideration for revision of State forms to match the MMUCC is the need for constancy. The MMUCC was offered with the promise that no changes would be made for 5 years. In August 2002, an MMUCC expert panel presented its recommendations at the National Safety Council's Traffic Records Forum. A Revised MMUCC will be published in 2003.

Road Safety Audits

Road safety audits are formal safety reviews of existing (in-service) roads or proposed highway projects by an independent multidisciplinary team of experts. The team assesses crash potential and safety performance of a roadway and prepares a report that identifies potential problems. The report provides the project manager with information and tools to evaluate, select, and justify design changes. The road safety audit process is a proactive, cost-effective, preventive approach to enhance safety of roadways.

The cost of the audit depends on the size and complexity of projects. Pennsylvania has reported costs of audits ranging from $2,000 to $5,000. The costs will be absorbed in the overall project cost if the audits are done early in development phases. The benefits come in terms of reduced crashes and fatalities.

Audits provide a valuable learning experience for new and seasoned transportation professionals. An audit is an excellent tool for building on lessons learned on previously audited projects. Working with a multidisciplinary team during audits helps build partnerships among various stakeholders and sensitizes team members to each other's needs and constraints.

The Audit Process

To minimize the cost, it is desirable to perform audits during preliminary design stages. But road safety audits also can be conducted during detailed design stages and construction.

The audit process starts with selecting projects and teams for audits. The team's independence, diverse backgrounds, and expertise are keys to successful audits. Once the team is selected, the members meet with the project team to discuss all relevant background information, such as record plans, proposed plans and drawings, pertinent traffic and crash information, and statement of the expected outcomes.

The audit team then performs site and plan investigations to identify safety concerns and deficiencies. The next step is to hold an audit completion meeting to present its findings to the project team. The audit team's final step is to write an audit report that contains all identified safety concerns and recommendations for corrective actions.

What Resources Are Available?

FHWA provides technical expertise and facilitation in conducting safety audits and setting up agency-wide audit programs. The National Highway Institute offers a 2-day course on road safety audits. This training provides practical information on how to conduct an audit, and participants receive a copy of the *Road Safety Audits and Road Safety Audit Reviews Reference Manual*. For more information, contact hari.kalla@fhwa.dot.gov.

The Institute of Transportation Engineers maintains an FHWA-supported Web site on road safety audits at www.roadwaysafetyaudits.org. This site contains an array of reference material, a list of technical experts and consultants, and a discussion board.

SafetyAnalyst

SafetyAnalyst, currently under development and formerly known as the Comprehensive Highway Safety Improvement Model (CHSIM), will be a set of software tools for use by State and local highway agencies in the management of site-specific programs to improve highway safety. The project is a partnership between FHWA and nine States: Colorado, Georgia, Indiana, Maryland, Minnesota, New York, North Carolina, Washington, and Wisconsin. Additional States are expected to join the consortium in the future.

Pedestrian safety is one of the issues that will be addressed by *SafetyAnalyst*.

SafetyAnalyst will identify sites with promise, diagnose safety problems at specific sites, select appropriate countermeasures to reduce crash frequency and severity, perform an economic appraisal of candidate countermeasures, prioritize them based on benefit and cost estimates, and use statistical techniques to conduct before-after evaluations of safety improvement projects.

Diagnosis of safety problems at specific sites and selection of appropriate countermeasures are closely related, as are the economic appraisal of candidate improvements and priority rankings for candidate improvements. Rather than developing software to perform each function independently, it is anticipated that the tools most closely related will be combined into a single software module incorporating both tools. Thus, *SafetyAnalyst* will be comprised of four modules: network screening, diagnosis and countermeasure selection, economic appraisal and priority ranking, and evaluation of implemented improvements. The software will be designed so that each module can be operated by itself or in an integrated sequential fashion with the other modules.

SafetyAnalyst will require an extensive data set describing the highway system and its safety performance history. Specific data types will include, as a minimum, traffic crash data, roadway segment inventory data, intersection inventory data, interchange ramp inventory data, and traffic volume data.

SafetyAnalyst will have the capability to import data from existing files or databases maintained by highway agencies. Interim software modules will be available in 2004, and final software modules will be available in 2006.

Network Screening

State transportation agencies generally have automated procedures for network screening to identify potential improvement sites, often known as high-crash locations. Typically, these procedures use threshold values of observed crash frequencies or crash rates, combined at times with a crash severity index.

The traditional procedures have several potential drawbacks. Observed crash data are subject to regression to the mean, because high short-term crash frequencies are likely to decrease and low short-term crash frequencies are likely to increase as a matter of course, even if no improvements are made. Further, the relationship between crash frequency and traffic volume is known to be nonlinear, but procedures based on crash rates treat that relationship as if it were linear. In addition, most existing procedures focus on those sites that have experienced the most crashes, not those that could benefit most from a safety improvement. Another drawback is that some existing procedures do not distinguish explicitly between intersection and non-intersection crashes.

Research over the last 20 years has developed new measures of effectiveness and new statistical methodologies for network screening to overcome the drawbacks of existing procedures, and the *SafetyAnalyst* software will implement these new approaches.

SafetyAnalyst will use an Empirical Bayes (EB) approach that combines observed and expected crash frequencies to provide estimates of the safety performance of specific sites that are not biased by regression to the mean. The sites identified by the network screening methodology are referred to as "sites with promise" because they will be sites that have promise as locations where improvements can result in substantial crash reduction.

One new measure proposed for network screening is the potential for safety improvement (PSI) index. PSI is a measure of the excess crash frequency, above the expected value, that might be reduced if a safety improvement were implemented. PSI provides site rankings that differ from those based on crash frequency and crash rate. Based on the crash frequency rankings in Table 1, a city might improve the location with the highest volume first. With PSI, a lower volume intersection might show a greater potential for crash reduction. If a city improved the highest-ranking intersections based on crash rate (see the rankings in Table 2), it might not improve any of the highest-ranking intersections based on the potential improvement benefits. Scarce financial resources would be allocated to sites ranked low in PSI, while many more intersections with greater potential for safety improvements might go untreated. State-of-the-art technology can help highway agencies make better decisions about where to invest the funds.

Table 1
Comparison of Rankings by Crash Frequency And PSI for Signalized Intersections in a Particular City

Signalized Intersection	Total Crash Frequency (1995-99)	Average Annual Daily Traffic (veh/day)	Crash Frequency Ranking	Potential for Safety Improvement (PSI) Ranking
A	131	63,502	1	2
B	104	35,284	2	3
C	77	57,988	3	11
D	75	46,979	4	6
E	66	51,933	5	10
F	51	48,427	6	1
G	51	20,423	7	15
H	46	34,759	8	5
I	42	53,396	9	61
J	38	25,223	10	17

Table 2 Comparison of Rankings by Crash Rate And PSI for Signalized Intersections In a Particular City

Signalized Intersection	Total Crash Frequency (1995-99)	Average Annual Daily Traffic (veh/day)	Crash Rate Ranking	Potential for Safety Improvement (PSI) Ranking
N	18	5,063	1	33
M	22	7,009	2	9
L	27	8,152	3	8
R	14	4,402	4	35
K	33	10,458	5	4
B	104	35,284	6	3
O	18	4,242	7	14
A	131	63,502	8	2
P	16	7,815	9	19
J	38	25,223	10	17

Diagnosis and Countermeasure Selection

Diagnosis of safety concerns at specific sites, whether those sites were identified by network screening or by other methods, is conducted manually by most highway agencies at present. An important step in diagnosis is the preparation of collision diagrams. Some agencies have automated this process, but in many agencies the preparation of collision diagrams, as well as the rest of the diagnostic process, is conducted manually.

The *SafetyAnalyst* software will automate the preparation of collision diagrams, the identification of collision types that are overrepresented at specific locations, and the investigation of the specific crash patterns that are present. The software will serve as an expert system to guide the user through office and field investigations of particular sites. For example, *SafetyAnalyst* will generate a site-specific list of questions to be answered during a field visit. The questions will be based on the available data about the crash experience, geometric design, and traffic control at the site; the answers will provide more detailed information on site conditions and field assessments of whether particular conditions are present. The answers are entered into the software and will be used in identifying appropriate countermeasures.

Red-light running cameras like this one provide data for analysis. *SafetyAnalyst* will contain safety effectiveness measure for red-light running cameras.

The user, not the software, selects the countermeasures. However, *SafetyAnalyst* will assist by suggesting a list of alternative countermeasures that are appropriate for the site-specific safety concerns. The logic that identifies appropriate countermeasures will consider the crash patterns and related site conditions investigated in the diagnostic process. Users then can select one or more of the suggested countermeasures for further consideration or add other countermeasures that they consider appropriate.

The automation of these traditionally manual procedures will assure that diagnosis and countermeasure selection activities are comprehensive and thorough. Field investigation checklists and lists of candidate countermeasures may help assure that all potentially effective countermeasures are considered. Very experienced engineers have traditionally conducted these activities in highway agencies; however, many of those experienced engineers are retiring, and *SafetyAnalyst* may help their less experienced successors to conduct such studies.

Economic Appraisal and Priority Ranking

SafetyAnalyst also will permit users to conduct economic appraisals of the costs and safety benefits of any countermeasures selected for implementation. The economic appraisal results can be used to compare alternative countermeasures for a particular site and to develop improvement priorities across sites. The software will include an optimization program that is capable of selecting a set of safety improvements that maximizes the system-wide safety benefits of a program of improvements with a specific improvement budget.

The software tool also will provide a consistent approach to economic appraisal that is consistent with the requirements of the FHWA Highway Safety Improvement Program, while still providing flexibility for highway agencies to adapt the process to their own needs and policies. Most highway agencies do not currently use formal optimization tools. The priority-ranking tool will provide agencies with the ability to determine an optimal set of projects to maximize safety.

SafetyAnalyst will incorporate the best accident modification factors (AMFs) available to represent the safety effectiveness of specific countermeasures. Highway agencies across the Nation have used a wide variety of AMFs, many of which are based on older evaluations that were not well designed and executed. The software will incorporate the most reliable estimate of the safety benefits for each improvement type, and these estimates will be updated as new research results become available.

Evaluation of Implemented Improvements

SafetyAnalyst will include the capability to conduct evaluations of improvements after they are implemented. The statistical approach to before-after evaluation will be based on the EB approach and thus will be able to compensate for regression to the mean. Evaluations will use crash and traffic volume data from existing highway agency records, together with the same regression relationships between crash frequency and traffic volume used in the network screening tool.

Most highway agencies do not routinely conduct evaluations of implemented countermeasures, and the few evaluations that are conducted are not well designed. *SafetyAnalyst* will provide a tool to make well-designed before-after evaluations easy to conduct. This feature should help highway agencies document the benefits of their safety improvement program and will provide better estimates of the effectiveness of specific countermeasures to use in programming of future improvements.

Expected Benefits

SafetyAnalyst will provide state-of-the-art tools for safety management that go beyond those currently available to highway agencies. These analytical tools will be used in the decisionmaking process to identify and manage a system-wide program of site-specific improvements to enhance highway safety by cost-effective means. *SafetyAnalyst* will provide improved procedures for some functions that highway agencies already perform in automated fashion. In addition, *SafetyAnalyst* will automate procedures that are now performed manually. Together with more efficient data collection and road safety audits, *SafetyAnalyst* holds the promise of making our highways safer.

Michael S. Griffith is the technical director FHWA's Office of Safety Research and Development. He currently leads FHWA's *SafetyAnalyst* development effort, chairs the committee for a new study evaluating the safety effectiveness of red-light running cameras, and chairs the Transportation Research Board's Statistical Methodology and Statistical Computer Software for Transportation Research Committee.

Carl Hayden is a highway engineer. For 26 years, he served in the Office of Safety Design in positions related to wet weather safety, highway design, safety data analysis, and traffic records. A registered engineer in Washington, DC, he received his B.S. in civil engineering from Virginia Tech and completed FHWA's Highway Engineering Training Program.

Hari Kalla is a transportation specialist for FHWA in Washington, DC. He leads the intersection safety program area in FHWA's Office of Safety. He received a master's degree in civil engineering from State University of New York and is a registered engineer in New York.

For more information, visit www.safetyanalyst.org