A3BO5: Committee on Safety Data, Analysis, and Evaluation
Co-chairs: Jeffrey F. Paniati,
Warren Hughes, Bellomo-McGee, Inc.

Making Safety Management Knowledge Based

Julie Anna Cirillo, *Federal Highway Administration*
Forrest M. Council, *UNC Highway Safety Research Center*
Michael S. Griffith, *Federal Highway Administration*
Ezra Hauer, *University of Toronto*
Jeffrey F. Paniati, *U.S. Department of Transportation*

The frequency and severity of accidents depends on the amount of travel by mode, how cars and roads are built, and how people behave. The amount of travel, what mode of travel is used, on what roads travel takes place, what vehicles are in use, and—to some extent—how people behave, is determined by our own political, planning, and design decisions. For such decisions to be rational, we need to be able to foresee the safety consequences of contemplated actions. The ability to anticipate the safety consequences of an action constitutes *safety knowledge*. The richer the body of safety knowledge, the larger the scope of rational road safety management. The central role of TRB's Committee on Safety Data, Analysis, and Evaluation is to promote the growth of safety knowledge. This paper examines how safety knowledge and its application in road safety management can be improved in the new millennium.

It would be difficult to make the case against knowledge-based safety management. Yet much of current transportation planning, regulation, design, and decision making does not entail explicit (quantitative) consideration of safety consequences—it cannot (yet) be called knowledge based. There are two types of impediments.

The first type has to do with inadequacies of knowledge. To serve day-to-day decision making

1. Knowledge must exist,
2. Knowledge must be practically available, and
3. Professionals must be trained to be safety knowledgeable and able to apply that knowledge to decision making.

The second type involves the reluctance to use explicit safety knowledge even when available. Organizational self-interest and the inertia of habit or ingrained professional practice are sometimes barriers.

These two types of impediments are interrelated. It is difficult to ask an organization or profession to use explicit safety knowledge if the knowledge does not exist or is not easily available, or if trained people can not be hired. Conversely, safety knowledge will not come into being, nor will professionals be trained in safety, if organizations make no use of safety knowledge and if professions do not insist on it.

The remaining sections of this paper explore the following themes—the institutional barriers to knowledge-based safety management, the need to make already existing knowledge available, the questions related to creating new knowledge, and the creation of resources of knowledge-based road safety.

INSTITUTIONAL BARRIERS TO KNOWLEDGE-BASED SAFETY MANAGEMENT

At the state level, information systems and knowledge-based decision making have traditionally suffered from fragmentation and overlap. Many groups with different objectives have been collecting safety-related information for decades. Unfortunately this information is owned by groups who a) are part of a variety of state or local bureaucracies; b) are often unwilling or unable to coordinate and share information for the purpose of making better transportation decisions in general and specifically better safety decisions, or c) have been rewarded for individual accomplishments rather than for statewide programs.

Since the mid-1960s, technology has provided the means to share information by establishing common reference points and system platforms. However, the owners of data systems have been reluctant to share their information because of a perceived loss of control as well as the inability to see the benefits of knowledge-based decisions. The costs associated with bringing divergent systems together always provided the necessary rationale for business as usual and the many database owners did not present a united front when approaching top management for the funds to achieve the desired goals. This situation was compounded by the perception that sharing information represented loss of control and, therefore, a diminishing ability to reach the goals for which the data were originally established. The concept of knowledge-based decisions was either ignored or not comprehended.

As technology has expanded and resources have diminished, there has been some movement toward sharing data systems and establishing knowledge-based information systems. However, significant institutional barriers to the full use of information decisions still exist. Highway and transportation departments have made the most progress in using infrastructure, traffic, and accident information. However, departments of motor vehicles, enforcement agencies, and most importantly the courts have not made significant progress in sharing that information.

The breakdown of institutional barriers must come from the top. Heads of state governments must insist that the department heads share information for the purpose of making effective transportation safety decisions. The development of a “heads of agency” safety management committee would be the first step in accomplishing this. The second step would be for the committee to develop performance objectives for each agency head in overseeing the appropriate actions to ensure that good information is available to make knowledge-based decisions.

In today’s information environment, the need for better information for decision making continues to increase. Pressures for less government provide an additional incentive for using the information available, and technology makes the job of gathering information somewhat easier, but the focus for information sharing must come from the heads of government.

USING THE KNOWLEDGE WE HAVE

It is often said that safety would be managed better if we had more and better research. While the following section will articulate the need to continue to increase our knowledge base, we must not make the assumption that relevant knowledge does not exist. In fact, a lot of knowledge has been accumulated during many decades of study and research worldwide. Yet, while decisions with road safety consequences are made daily, the store of existing knowledge lies unused.

Why does the big store of existing knowledge lie fallow? One reason is that relevant findings are not easily accessible at the time decisions need to be made. The existing knowledge is difficult to tap into. It is dispersed in inaccessible reports, obscure journal papers, remote libraries, and in unknown people's heads. The existing knowledge, therefore, is of limited practical use to people who need to make safety-related decisions here and now. The question is how do we put safety knowledge into the hands of the decision makers so that safety is explicitly and quantitatively considered?

Several efforts are emerging that may provide an answer. First, there are the Federal Highway Administration's efforts to develop the Interactive Highway Safety Design Model (IHSDM). IHSDM will be a set of computer tools that facilitates the evaluation of the safety implications of design alternatives throughout the planning, design, and review phases of highway construction and reconstruction projects.

Second, a successful conference session on highway capacity and safety at the 1999 TRB Annual Meeting is serving as the catalyst for the development of a highway safety manual (HSM). Several safety-related TRB committees are developing a joint initiative to achieve for highway safety assessment what the *Highway Capacity Manual* has accomplished for highway capacity, operations, and mobility analysis. The proposed HSM would assemble the best available knowledge for quantitatively estimating the safety impacts of highway design and operations, and raise the credibility of safety impact analysis through a peer-review and consensus-building process. The aim of this manual is to put safety on the same playing field as delay, air quality, noise, and other factors through the development of quantitative tools for estimating safety.

Third, there is emerging discussion on the need to create a safety-knowledge base. This knowledge base would not just be an assembly of references, abstracts, or papers. It would provide a review of the current state of the art on many subjects of interest; it would lead the user to the references on which the review is based and to persons who have contributed to what is known, or who are currently engaged in related research. Since useful knowledge about road safety is gradually accumulating everywhere, the effort to create a safety knowledge base should be worldwide. Its principal users and beneficiaries should carry the cost of this effort: governments, industry, business, professional and other organizations, and international institutions. The Committee on Safety Data Analysis and Evaluation will attempt to lead the establishment and maintenance of a road-safety knowledge base.

INCREASING THE KNOWLEDGE BASE

While much of what we know about safety lies unused, that must not deter us from continuing to increase our knowledge base. The development of safety knowledge is often a long process filled with imperfect data and analysis tools. It is only through continual reexamination of the existing knowledge base and the conduct of new research that we are able to improve on our knowledge. There are two key components to improving the safety

knowledge base: the development of improved analysis methods and the collection of better data.

Over the past decade, the safety analysis field has seen clear advances in the use of more appropriate methods. Because of both increased interest and funding by the U.S. Department of Transportation (DOT) and the initiative of safety researchers, we have seen advances in methods for modeling and evaluating safety treatments. There is now near-standard use of more appropriate Poisson and negative-binomial models in research studies, the introduction of Bayesian procedures, and innovative use of other statistical methods such as metanalysis. For the first time, there is a complete textbook on the design of before-and-after treatment evaluation (*1*). There continue to be needs for further improvements, primarily the development of a similar reference concerning safety modeling and the development of improved problem identification methodologies.

Unfortunately, it does not appear that the second component of improved safety research—safety data—is enjoying the same pace of advancement. Although there are some advances, there are also considerable threats to the availability of the crash, driver history, and roadway data needed to conduct knowledge-building research.

National Databases

The quality and accessibility of national databases is increasing. While the Fatal Analysis Reporting System (FARS) and the National Automotive Sampling System (NASS) have been in existence for a number of years, data from these two systems is now much more available, with FARS data on the Internet. The U.S. DOT funds both of these systems, and data quality is ensured through sound collection and quality control checks. A third national database—Highway Safety Information System (HSIS)—provides linkable data on crashes, roadway inventory, and exposure information with which the researcher can associate risk of crash with roadway variables. Since the data contained in the HSIS is not federally funded, but state collected, there is not the same level of control on the data that is collected as there is in FARS and NASS. However, the HSIS does include the highest quality state data available and provides a tremendous quantity of data.

Crash Data

State or local police agencies collect the vast majority of crash data. Pressure on these agencies to reduce the costs of data collection continues to increase. Technological and institutional changes, such as those outlined in *Highway Safety Data; Costs, Quality, and Strategies for Improvement* (*2*), will be required to avoid a significant degradation in the quality and quantity of data. Data accuracy can be improved through increased education and use of technologies—such as expert systems—by police officers in the field. Injury information can be enhanced by linkage to medical care databases through efforts like the Crash Outcome Data Evaluation System (CODES) project. Accurate reporting of the crash location, critical to all highway-based analyses, can be improved through the use of the Global Positioning System (GPS). National consistency can be fostered through efforts to define critical data elements and codes (Model Minimum Uniform Crash Criteria) and through the development of standardized software.

Roadway Inventory Information

Inventory information used in individual state and local systems and in HSIS may be facing even more serious problems. Such systems are often based on data extracted in the distant past from paper documents or photo logs rather than actual field surveys. The accuracy of

the data is eroding due to decreases in funding for data maintenance and updating. There are also major gaps in the data elements being collected. A glaring deficiency in most states is the lack of computerized data on curvature, grade, and the roadside—all important predictors of crashes. Technologies, such as instrumented vehicles using digital photography, laser-based measurement, and GPS, offer the promise of collecting such data "on the fly." However, although crash data are the subject of legal pressures for continued collection, there is often no agency or group of agencies that accept ownership of the inventory data and are willing to invest in it. One encouraging sign is the move by Washington State to collect detailed data about the roadside, a contributor in approximately 30 percent of all fatalities. Leadership by states like Washington will be required to harness the promise of technology, to overcome organizational and institutional barriers, and to obtain the data from which new safety knowledge can be created.

Driver History Data

For legal and sanction reasons, each state has a driver history file containing licensing, crash, and violation data on all its drivers. Problems with this data lie less in the number and accuracy of the variables collected than in the size of the files and the technical and privacy barriers to both analysis and linkage with other pertinent files (e.g., crash files). Increasing computer memory size and speed and use of well-structured database management systems could greatly ease the analysis issues. California is currently developing a combined system in which these data will be linkable with all other safety-related data quickly and easily. The privacy barriers appear to be surmountable in a research context with appropriate human subject protection procedures.

Exposure Data

Finally there is a continuing need for better exposure data. Available exposure data usually consist of traffic volume data collected from a large number of locations within each state, and a limited number of vehicle classification counts. There is little or no exposure on individual driver groups or pedestrians. It would appear that future improvements could result from two fronts—the development of innovative methods to collect exposure data, and the development of innovative ways to conduct safety analyses through which exposure can be imputed. Innovative data collection might include collection of vehicle-based mileage through annual vehicle-inspection odometer reports or driver-license odometer reports as well as capturing the vast amount of data being collected as part of the implementation of intelligent transportation systems (ITS). Addition of a new Archive Data User Service to the national ITS architecture is now under way. Methods to impute exposure data when it is not available would include the development of improved methodologies for "induced exposure," development of nonvehicular predictive equations based on land use and other data available in geographic information systems, and the development of analytical methods in which exposure is less critical to the measurement of crash risk.

Data Linkage

Finally, in addition to the availability of linkable or linked data through CODES, HSIS, and other existing systems, there is a promising trend toward "data warehousing." Here, preexisting data files from many different sources, including crash, roadway inventory, traffic, maintenance data, bridge and railroad grade-crossing inventories, and financial data, are being given common identifiers to make them computer linkable. The availability of

these linkable data sources should greatly increase the quality and scope of safety studies without additional field data collection.

RESOURCES OF KNOWLEDGE

The role of bringing extant knowledge to bear on decisions is that of the trained professional. Medical knowledge bases are used by doctors, legal knowledge bases by lawyers, etc. Unfortunately, few transportation and engineering professionals can claim to be trained road safety professionals, and even fewer are employed by organizations that contribute to road safety management.

Consider, for example, how much road-safety training civil engineers in a transportation option receive before graduation. Typically there will be three one-semester courses: traffic engineering, highway design, and transportation planning. In the traffic-engineering course perhaps one hour will be spent on road safety. Nothing will be said about the relationship between safety and design in the highway-engineering course except to instill in the student the erroneous belief that following geometric design standards somehow satisfies the interest of safety. The transportation-planning course has no safety content. It follows that graduating civil engineers have virtually no factual knowledge about road safety. Even in the typical transportation engineering graduate program, there is only limited coverage of highway safety. Few programs have a single course devoted to the study of highway safety and there is little emphasis on the fundamental safety relationships.

Perhaps it is a chicken-and-egg situation. We have little rational safety management because transportation professionals are not trained in road safety, our institutions do not value safety professionals, and the store of safety knowledge is so inaccessible. Conversely, there is no training in road safety, and our institutions do not value safety professionals, because so few are trained in road safety. We are allowed to make decisions that affect the safety of road users without training in road safety and without the requisite knowledge. There are few jobs for road safety experts and no progressive career paths in road safety. Other disciplines that base decisions on knowledge require extensive training and have efficient knowledge bases available to them. The practice of medicine or law without training or access to factual knowledge is hard to imagine. Practitioners in road safety have no such training and resources.

CONCLUSION

If safety is to be improved in the new millennium, we must

- Break down the institutional barriers that prevent us from making knowledge-based safety decisions;
- Develop a knowledge base and tools that allow decision makers to manage safety using the experience that has been accumulated;
- Continue to invest in improving the analysis methods and data that are the foundation of increased safety knowledge.
- Train our transportation professionals in the fundamental safety relationships and encourage them to value this knowledge; and
- Meet these challenges even though doing so will not be quick or easy—our profession must not be deterred from facing them.

REFERENCES

1. Hauer, E. A. *Observational Before-After Studies in Road Safety.* Elsevier Science, Inc., 1997.
2. Pfefer, R. C., R. A. Raub, and R. E. Lucke. *Highway Safety Data; Costs, Quality, and Strategies for Improvement.* U.S. Department of Transportation, Federal Highway Administration, FHWA-RD-96-192, 1996.