

Enhancing Highway Safety Through Engineering Management

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The United States has one of the finest highway systems in the world, a system that is necessary to our economy, our life style, and our very existence as a nation. In recent years, much time and effort have been spent to improve the safety of the highway system, and a dramatic decrease in the highway fatality rate has resulted from more than 10 per 100 million vehicle miles of travel prior to World War II to less than one-third that rate now. While this improvement is attributed to many factors, a large measure of the success can be attributed to the evolution of the Interstate system and its high design standards for traffic safety. Although the Interstate system represents only about one percent of the total highway mileage, it carries about 19 percent of all traffic and has the lowest fatal accident rate of all highway classifications.

Of real concern, however, is the fact that the fatality rate is no longer improving but is actually increasing slightly each year. Furthermore, the yearly number of fatalities which had shown a steady decline in recent years on our 3.9 million miles of highways and streets has again begun to exhibit an increase—to a level of an expected 53,000 in 1981, and projections are that this figure will climb to 80,000 or more by 1990.

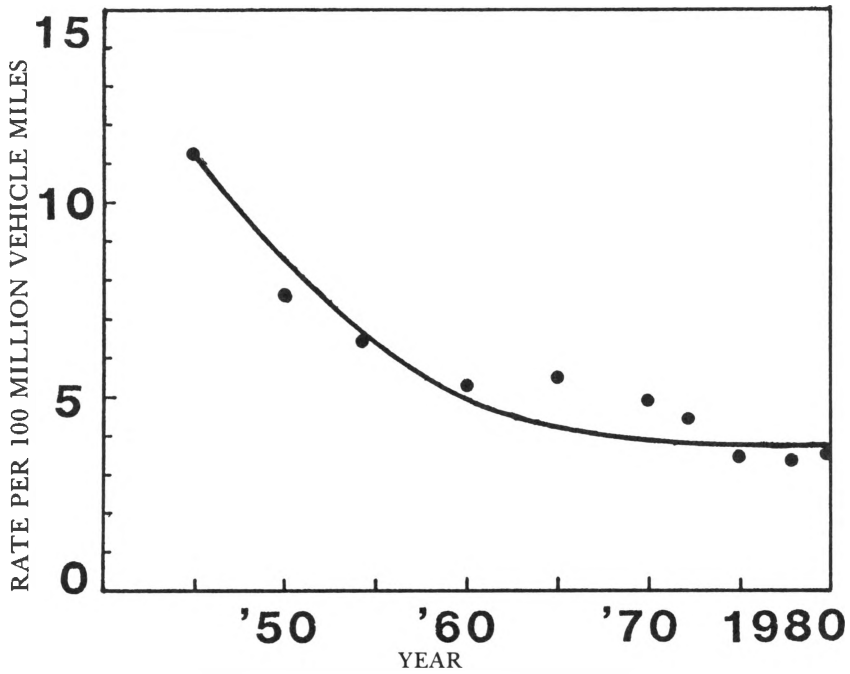


FIG. 1. HIGHWAY FATALITY RATE

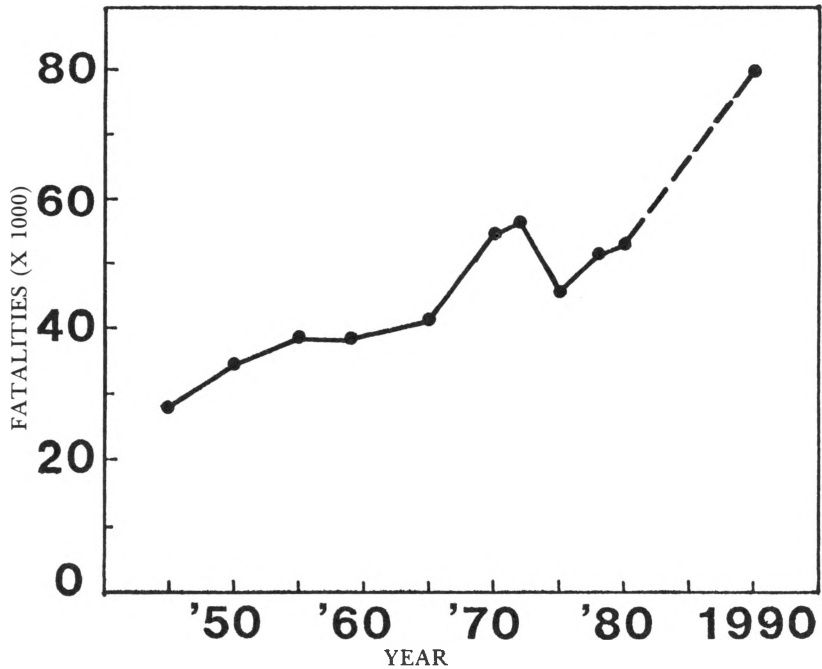


FIG. 2. NUMBER OF FATALITIES

The dollar costs of accidents resulting in injuries, fatalities, and property damage continue to rise, draining valuable economic resources. In 1980, the cost of accidents is estimated to have been about 33 cents per gallon of gasoline used, or 2.6 cents per vehicle mile of travel. These figures exclude non-measurable costs such as pain, suffering, and family disruption.

COST OF ACCIDENTS

33¢/GALLON FUEL

FIG. 3

It is clear that the highway accident problem must continue to be of primary concern to each and every citizen of the U.S. and especially to those with responsibilities for the highway transportation system. A total of over 50,000 deaths each year is truly of a disaster nature. We deplore every infrequent major air crash in this country, such as the recent Air Florida crash near National Airport in Washington, and expend huge amounts of dollars and effort to minimize future air crashes. Each average week, however, the fatalities on our highway system are more than 10 times the number that occurred in that disaster—and we expend relatively little effort or money to enhance highway safety.

One might ask why the same safety techniques and experience gained with the Interstate system aren't applied to the remaining 99 percent of the highway system to reap the benefits of even fewer fatalities. There are several reasons. First, the country cannot afford to allocate 99 times the amount of funds spent on the Interstate system. Second, even if the funds were available, such an expenditure would be wasteful, since less expensive alternatives can accomplish a reasonable goal at lower costs. Lastly, freeways are inherently safer because of access control, lack of conflicting movements, etc.—features impossible to apply to land service roads and streets.

What can we do? Let's first consider several factors currently impacting safety in the system. One major current concern is that there is a radically different mix of vehicles on the road today as compared with 10 years ago, and that mix will change even more in the years ahead. The era of the small car is with us, mixing on highways in growing numbers with large cars and increasingly bigger trucks and buses. Data from the National Highway Traffic Safety Administration for

1980 indicate that small cars do not afford the same occupant protection as do standard size cars.

Fuel-efficient small cars have an adverse effect on highway safety in several significant ways. First, in collisions between a light weight vehicle and a heavier vehicle, the passengers in the smaller car are at a greater risk of injury. Second, in collisions with fixed objects, even fixed objects which are designed to yield under impact, passengers are likely to sustain more serious injuries than they would in a heavier vehicle.

The roadsides of even the most advanced highways were not designed for this new traffic mix. Recognizing that it requires 5 to 10 years to develop and begin installing new hardware on the roadside, it should not be surprising that much of the existing appurtenances were not designed to perform with the small car, a vehicle size that was relatively limited until recently. Many recent roadside hardware developments have become obsolete long before their 20-year life expectancy. Accordingly, we can anticipate increasing problems in roadside safety.

There is further concern over the increasing number of teenage driving accidents. The automobile insurance industry has reflected this in the extremely high rates charged on vehicles driven by young people.

In addition, the overall drunk driving problem is receiving significantly greater attention. While these problems are the concerns of other safety professionals as well as the highway engineer, they must be considered and actions must be taken that protect the public to the extent feasible.

The highway safety situation is exacerbated by the increasing number of tort liability cases in which highway agencies are directly involved. They frequently must defend their actions in various aspects of highway management, especially in the areas of operations and maintenance.

Faced with various challenges, the highway administrator must operate in a complex decision-making environment. There results a tendency to emphasize pavement repair to save the investment in the existing highway system. While safety has always been a major consideration in the decision system, it is probable that unless management now specifically includes safety in the decision process, safety may be sacrificed for more roadway maintenance and repair, given limited financial resources.

Certainly we are very aware that this nation faces a large and growing problem of road finance. It is evident that revenues adequate to improve highways in accordance with the best techniques will not always be available in the years immediately ahead. At a time when the 825 thousand mile federal-aid highway system is in need of significantly

increased support, spending reductions are being made because of the condition of the national economy. State and local governments are struggling for more money simply to hold their own, and the prospect for additional dollars to meet the new safety challenges is poor. While the nation's energy problem has been alleviated somewhat by the decrease in motor vehicle fuel consumption, that same action has adversely affected highway revenues, much of which are based on fuel taxes.

But success in highway safety is being achieved in some countries today and in some areas of this country. Three major areas are proving to be fruitful ones to enhance highway safety.

First, safety awareness of everyone about highway related factors is very helpful. This is especially true for the very young person as he approaches and becomes a driver. But it is also important that everyone emphasize continually the importance of safety as an objective in whatever they do relative to the highway. Second, reduction of driving by persons who have been drinking through effective procedures is very important in reducing accidents. Finally, highway improvements which minimize roadside hazards and improve the driver environment materially reduce accidents.

This is an age of limited resources for meeting highway needs, but it is also an age when there is a need to further enhance highway safety. The only short-term solution is to improve efficiency and productivity and to use available resources very wisely. The most effective tool to use to accomplish this is engineering management, which can be applied in every highway agency across the United States.

Recognizing the situation which I have just described, a number of highway-oriented organizations—the American Association of State Highway and Transportation Officials (AASHTO), the American Automobile Association (AAA), the American Trucking Associations (ATA), the Federal Highway Administration (FHWA), the Highway Users Federation for Safety and Mobility/Automotive Safety Foundation (HUF), the Institute of Transportation Engineers (ITE), the Motor Vehicle Manufacturers Association (MVMA), and the National Association of Governors Highway Safety Representatives—contracted with the Transportation Research Board to sponsor a “Conference on Enhancing Safety Through Engineering Management in an Age of Limited Resources.” The conference was held under the direction of a 16-member steering committee with attendance of almost 100 invited officials.

The objective of this project was to develop guidance for highway administrators and others on elements to consider and on management techniques to use to assure that safety objectives are properly weighed in the allocation of available resources among the engineering aspects of highway improvements.

Today I want to briefly outline the principal findings and recommendations of that conference in its five major topical areas: Program Administration; Highway Traffic Operations; Maintenance; Upgrading and Rehabilitation; and Construction and Reconstruction.

Program Administration

Highway Traffic Operations, Maintenance, Upgrading and Rehabilitation, and Construction and Reconstruction were readily agreed as the four major activities of a highway agency. Any good highway program must have an optimal mix of these activities.

In developing such a program, highway administrators must meet three equally important objectives:

- Preserve the physical structure
- Preserve and improve the capacity and service level
- Preserve and enhance safety

Clearly, priority should go to those projects that will contribute to all three objectives.

Although safety has always been a major consideration of highway management in planning, designing, and constructing highway facilities, as well as in developing programs for highway maintenance and operations, limited available funds will simply not permit management to accomplish all it desires. Some projects will have to be sacrificed; only the most important activities can be implemented. While every major activity of a highway agency affects highway safety to some extent, safety is not automatically optimized by programs designed to achieve other objectives. The overriding issue is how to decide which activities are the most cost effective—that is, which strategies will give the best overall results in achieving all objectives for the least cost. The most important step administrators can take is to establish the legitimacy of safety as an organizational goal. Many agencies assume safety to be a criterion in all actions. However, it is important that safety be clearly enunciated and accepted as a legitimate objective of the organization. It is also appropriate that this objective be extended to the legislative and political levels as well. As technical managers, highway administrators have the responsibility to communicate to policy-makers the importance of safety issues in highway management. In order to make reasonable decisions, it is vital to set logical objective measures. Basic to this is the requirement for good data derived from a data collection program that will enable the manager to understand the overall system, its condition, volumes of traffic by location, measures of service, and relative measure of safety.

Another area of strategic responsibility is the analysis and definition of all objectives of the organization, recognizing the legitimacy of

all service areas in addition to safety—system accessibility, capacity, and reliability; energy; the environment; and, of major importance, preservation of the investment in the system.

Having identified the objectives, the administrator needs to estimate the consequences of the program, projects, and actions. Each of them requires resources and therefore incurs costs to some degree. Costs include direct costs (capital or current operating costs or maintenance funds), indirect costs and life-cycle costs (costs over the life of the project). Accompanying the costs, of course, are benefits, which must be estimated in the total scheme.

This procedure goes beyond making mere budget estimates and includes evaluation of societal costs and benefits, some of which may be negative. Costs and benefits must be measured as accurately as possible, using objective standards to the extent they are available; of course, many of these measures can only be assessed subjectively.

Nevertheless, it is crucial that analysis be applied to the greatest degree possible, using available methodologies and within the financial capability of the agency. Cost/benefit or cost-effectiveness must be measured as accurately as possible, using objective standards to the extent they are available. Engineering judgment should then be applied to ensure that decisions are made on a rational, defensible basis.

Highway Traffic Operations

The most cost-effective traffic operations projects from a safety standpoint should be given priority in developing the highway operations annual program. Such projects typically were agreed to be delineation, signs and markings, intersection improvements, parking regulation, passing lanes, left turn lanes, and improved skid resistance.

A rational prioritization scheme is necessary to select and implement projects effectively. Good traffic records including accident data are essential in identifying problem areas, both on a systemwide basis and at localized sites. In general, a safety improvement program should be directed toward those highway systems having the higher accident experience. The program should involve projects designed to respond to recognized high-accident locations, as well as projects for which safety considerations may be only part of the overall project need.

Other findings noted that:

1. Adherence to policies and rational decision processes which give proper consideration to safety is essential with respect to liability cases. Highway agencies are increasingly being held accountable for actions or omissions that may have adversely affected the safety of highway users.

2. Training programs should be implemented to raise the consciousness of employees to the safety implications of routine tasks.
3. A strong and continuing accident research program is justified to increase knowledge of cause and effect relationships.
4. Agency policies and surveillance procedures should be fully responsive to the potential of highly cost-effective accident reduction actions on all classes of roads, even though high-volume segments of the system frequently present the greatest opportunity for cost-effective safety improvements.

Maintenance

The maintenance activities with the highest priority for safety are:

1. Traveled way surface maintenance.
2. Snow and ice control, especially on higher order facilities.
3. Shoulder drop-off and high shoulder repair, where critical.
4. Traffic control device maintenance, especially pavement markings.

Improving safety in maintenance work areas is a high priority safety item for all projects, both on the road surface and on the roadside.

A major programming system is also required for maintenance. Problem areas and critical needs can be best identified by evaluating accident data, outputs from maintenance management systems, and objective road rating reports. From these, key program work functions can be targeted, based on a prioritization framework.

All highway personnel should be trained in how to identify and report roadway conditions that warrant improvement from a safety or operational standpoint.

Upgrading and Rehabilitation

Actions in this category range from resurfacing to upgrading a facility. These actions should be viewed as a continuum, and not as a series of discrete choices. Conclusions reached for such activities included:

1. No rehabilitation project should ever degrade safety—safety must be enhanced.
2. Priority should be given to the improvement of high-hazard locations.
3. An overall ranking process should be employed considering highway class, severity of deterioration, alternatives, and available resources. Factors to be considered in setting priorities include accident statistics, determination of roadside elements being damaged, elements affecting traffic flow and capacity, and adjacent road or approach characteristics.

Construction and Reconstruction

For safety enhancement, design standards developed by AASHTO and adopted by FHWA should be applied to all new construction pro-

jects, especially on national systems where uniformity is an overriding issue. To design reconstruction projects to the same criteria as new construction, however, is not always feasible. Some flexibility is necessary for applying the standards within a range of guidelines based on road volumes, location, climatic conditions, etc. A new publication "A Policy on Geometric Design of Highways" currently under preparation by FHWA and AASHTO, will provide this flexibility.

A standard evaluation process is also necessary for assessing both construction and reconstruction actions and the cost effectiveness of such measures. The process should be based on quantitative evaluation criteria supplemented by engineering judgment. For many projects, careful assessment is required in deciding whether a project is reconstruction or rehabilitation. Factors to be considered include:

1. Role of the project within the framework of the entire route.
2. Accident experience.
3. Consistency of existing geometric or other design features.
4. Road function and traffic volumes.
5. Pavement condition.
6. Major purpose of the project.

Other Conclusions

In addition, a number of areas were noted as requiring special attention:

Data Requirements. Good accident information is essential in determining the safety performance of a highway system. However, the quality and quantity of this information are being drastically reduced as law enforcement and other reporting agencies experience reduced levels of funding and place greater demands on personnel. Highway agency administrations should work closely with reporting agencies to develop accident reporting procedures that are not burdensome, but will provide an adequate level of reporting in terms of site location, site characteristics and condition, roadside obstacles, environmental setting, etc. An effective threshold of reporting should be established to include property damage only incidents, as well as those with injuries. Appropriate procedures should be developed to utilize information from all sources, including maintenance field reports and complaints to supplement accident data.

Training. Within the highway agency, declining revenue resources and increasing costs have caused many agencies to reduce staff. Because remaining staff must be assigned essential activities and responsibilities previously carried out by others, it is important that they be qualified to carry out new or additional assignments. The changing technology and processes available for accomplishing programs require that remaining staff broaden its outlook, develop new skills, and maintain or improve existing skills. Investment in training in the short-term

can have long-term payoff for safety enhancement. There is a further need to upgrade state-of-the-art skills, especially in view of the increasing volume of litigation cases.

Litigation. With loss of sovereign immunity in many states, there is a need to improve not only the safety characteristics of the highway system, but also the decision-making process to support actions. Complaints must be analyzed to determine the actions an agency should take to avoid situations that lead to litigation.

Decision Process. Finally, highway improvement decisions must be based on a systematic, logical, well-documented, decision process to support the funding and implementation programs. The evaluation process selected will vary by type of action, e.g., operations or rehabilitation, and by location, but there must be some supportable decision process to justify actions to the administration, the public, and the lawmakers. The process can range from a ranking of alternative actions to a mathematical optimization scheme, but some prioritization methodology is necessary, including a cost-effectiveness or cost/benefit analysis. In most cases, engineering judgment alone will not be sufficient. A documented analysis method which considers all important factors must provide support for the decisions made.

As highway authorities responsible for highways in the state of Indiana, we must recognize that highway safety is our responsibility. We must always be in a position—legally, morally, ethically, and professionally—of enhancing highway safety in all that we do.