Making Better Use of Existing Facilities Through Highway Safety Improvements

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This paper describes work done on NCHRP Project 17-2A. Part of the project goal was to develop a users manual giving a step by step approach to establishing safety improvement programs. This paper summarizes some of the findings and management issues and outlines the system incorporated in the users manual.

Making improvements that reduce safety hazards is obviously one of the ways in which we can make better use of existing highway facilities. But what, specifically, do we mean by highway safety improvements?

First, we mean identifying hazardous locations, places where the relationship between physical conditions and operating characteristics of traffic creates a special hazard. It may be an intersection with a variety of or no traffic control devices. It may be a stretch of highway with soft shoulders or a narrow bridge or a blind sight distance or a slippery pavement, i.e., places on the highway that may lead drivers to wrong decisions, or compound the mistakes of drivers.

Second, we mean determining what can be done by the highway agency to reduce the hazard at specific locations. What alternatives should be considered? Should we consider signs, signals, or channelization at problem intersections or problem areas? Widening the bridge, flashing lights, and reflectorization may be alternatives at a narrow bridge.

Third, we mean evaluating alternative safety improvements as the basis for establishing a specific project improvement and the development of short-term and long-term highway safety improvements. How much of an improvement can be expected, and what will it cost? How in the short term can we get the maximum payoff in safety? How can we obtain adequate long-run financing of safety improvements? And how do we merge the desire of early payoff with the maximizing of safety in the long term?

For many years highway agencies have been making improvements specifically designated and programmed for safety. Many agencies have earmarked funds for so-called spot improvements for safety. The federal government has promoted spot improvements for 10 years. The 1973 Highway Safety Act establishes programs oriented toward specific types of improvements such as striping and railroad grade crossing protection.

Many agencies have reported striking accomplishments through their safety improvement programs.

In spite of all the attention that has been given to safety improvements, there are no well-defined scope and objective and planning and evaluating process to ensure attainment of the objective. To meet the need for a coordinated system and to give

guidance and impetus to the highway safety improvement programs, the National Cooperative Highway Research Program established a project on methods for evaluating highway safety improvements. The project included development of a users manual that provides a step by step approach to establishment of safety improvement programs and evaluating accomplishments.

Carrying out the project included

1. Examination of the state of the art,
2. Development of a coordinated system for evaluation of needs and programming and control of improvements,
3. Examination of management issues related to the system, and
4. Development of a users manual.

In this brief presentation, we are summarizing some of the findings and management issues and briefly outlining the system incorporated in the users manual.

FINDINGS

In conducting the project, we determined that most agencies use accident data to identify hazardous locations, but there is need for more accurate data and better use of data. The users manual presents several basic procedures for identifying hazardous locations.

Only one agency has an operational system that evaluates needs, considers alternative improvements, programs improvements, and evaluates postimprovement accomplishments. The users manual outlines a management system that can serve as a guide to all highway agencies.

Agencies with low-volume road systems have difficulty using statistical techniques for establishing hazards. The users manual provides alternatives.

Most agencies now have inadequate record data on which to evaluate the potential for accident reduction. Before and after evaluations need to be systematized, and the results of these evaluations should be used to continually improve the data base on which forecasts may be made. The users manual establishes these evaluations as a basic part of the coordinated system.

Most agencies have safety improvement programs based on a more or less arbitrary level of financing. Existing funding levels are not necessarily based on knowledge of the problem size. How much of the safety problem is soluble by highway safety improvements at different levels of funding needs to be determined. Most agencies have not taken the time to determine how much funding is needed to solve the problem. They have tended to make the most of relatively small but protected earmarked funds instead of preparing the facts needed to sell legislators on longer solution-oriented programs.

No agency has put the safety improvement program into open competition with regular construction programs for construction dollars. The users manual can help in several ways to increase the justification for highway safety improvement funding. First, the program evaluation method provides the facts needed to justify highway safety improvements as a program. Second, the evaluation of alternative improvements can be applied to comparisons of safety improvements and regular improvements.

Existing systems are almost totally based on analyses of accident data, and so is the users manual. However, many new approaches are being developed, including the following.

1. Conflicts analysis and other similar field observations may soon provide much quicker ways of identifying hazards and evaluating results shortly after improvements have been installed. In a period of hours, two men can collect conflicts data, which may tell the same story that we now hear after waiting 1 year for accident statistics.
2. Operations research techniques such as economic models can be used to select better programs. Alabama recently developed a dynamic programming model to

maximize benefits from its annual highway improvement program budget.

Many innovative people are developing these new methods. It is very encouraging from the methods side. Establishment of the system outlined in the users manual will ensure that the new methods are directed toward achieving the highway safety goals.

THE SYSTEM

The system outlined in the users manual consists of six major steps:

1. Identifying hazardous locations,
2. Identifying problem causes and selecting possible alternative improvements,
3. Evaluating the alternative improvements,
4. Programming and implementing the improvements,
5. Evaluating implemented improvements, and
6. Evaluating the highway safety improvement program.

Note that there are three distinct evaluations in this system. They relate to the following questions:

1. What is the potential problem-solving value of an alternative improvement, and how much is it likely to cost?
2. What was the value of benefits actually obtained from an improvement?
3. What is the actual value of benefits from the overall program?

The first two steps in the system narrow the field of candidate locations and attempt to determine why each location is hazardous and how the hazard can be eliminated. In addition to the proven tools such as collision diagrams, the users manual presents guidelines for using methods such as multidisciplinary investigation teams and fault tree analysis to get to the cause and effect relationships leading to the identified accident experience.

In developing methods for the third step, we recognized that different economic analyses are used according to the point of view of the agency. For example, budget-oriented engineers generally think in terms of getting the most benefit obtainable from each annual budget. Thus, they use the familiar benefit-cost ratio as a measure of economy. On the other hand, economists are oriented toward solving the entire problem. They look at the big picture and use net benefit as a measure of economy.

These two approaches are in conflict. And the economist is correct in theory. In an environment with an undefined problem scope and apparently inadequate funds, should engineers continue to maximize benefits from the available funds? The response to this question in the users manual is no. The proposed system approach is directed toward a reconciliation of the two viewpoints.

The fourth step is the implementation of the improvements. The users manual provides guidance in (a) setting objectives and policies for the highway safety improvement program, (b) coordinating highway safety improvements with other projects, (c) assigning responsibilities for implementation, (d) formulating the program, (e) budgeting for the program, and (f) scheduling individual projects.

It is difficult to overstate the need to express objectives and agency policy. For this reason, a sample policy statement is presented in the users manual.

The last two steps in the system use conventional statistical analysis to determine the degree of success of individual projects and the program as a whole. The reports from these two steps are a major input to refining the other steps in the system. An example reporting system was designed for the users manual. It consists of

1. Hazardous location identification worksheet,
2. Probable accident cause analysis worksheet,

3. Potential improvement identification worksheet,
4. Improvement analysis worksheet,
5. Improvement evaluation worksheet,
6. Program priority listing worksheet, and
7. Improvement effect worksheet.

These reports contain the basic information needed to begin continuous evaluation and analysis. Suggested forms for these worksheets are shown in Figures 1 to 7. They should be modified as more refined procedures are developed and data requirements change.

CONCLUSIONS

Achieving greater utility from highway safety improvements will depend on more consistently applying the right improvements to the right problems, implementing increased numbers of improvements proven by evaluation to be effective, and altering the highway safety improvement program to meet broader goals and reflect evaluation findings. The highway safety improvement evaluation system is the way to accomplish these things. And it will work if top management takes the following steps:

1. Commit the organization to solve the problem of unsafe conditions on the highway system through systematic evaluation;

Figure 1.

Highway Safety Program
Documentation Record
FORM 101

Location Identification Code_____
Date_____
Prepared by_____

HAZARDOUS LOCATION IDENTIFICATION WORKSHEET
(One for each hazardous location)

LOCATION:_____

Intersection ☐ Spot ☐ Section ☐ Section length_____

CATEGORY: Rural ☐ Urban ☐ 2-lane ☐ 4-lane Undivided ☐ Divided ☐ Freeway ☐

DESCRIPTION: Sketch on back of sheet ☐ See collision diagram ☐
No sketch or collision diagram drawn ☐

ACCIDENT EXPERIENCE:

Year						Total
From (date)						
To (date)						
AADT						Ave=
Exposure						
Total accidents						
Fatal accidents						
No. fatalities						
Injury accidents						
PDO accidents						
Accident rate						

SYSTEMWIDE AVE. RATE FOR CATEGORY:_____ Acc/MV

CRITICAL RATE FOR LOCATION:_____

INDEX OF SEVERITY:_____

COMMENTS:_____

Figure 2.

Highway Safety Program
Documentation Record
FORM 102

Location Identification Code_____
Date_____
Prepared by_____

PROBABLE ACCIDENT CAUSE ANALYSIS WORKSHEET
(One for each hazardous location)

LOCATION:_____

COLLISION DIAGRAM: ☐ Attached ☐ Not drawn

ACCIDENT CHARACTERISTICS:

No. of Accidents

Type of Accident	Fatal	Injury	P.D.O.	Total	Percent
Head on					%
Rear end					%
Right angle					%
Side swipe					%
Fixed object					%
Overturned					%
					%
					%
Total					100%
Percent	%	%	%	100%	

CONDITIONS:

No. of accidents

Time of day - 6:00 am - Noon_____ 6:00 pm - Midnight_____
Noon - 6:00 pm_____ Midnight - 6:00 am_____

Light conditions - Day_____ Night_____

Surface conditions - Dry____ Wet____ Snow or ice____

Weather - Cloudy___ Clear____ Rain____ Snow____ Other_____

Other - _____

PROBABLE CONTRIBUTORY CAUSES:_____

Figure 3.

Highway Safety Program
Documentation Record
FORM 103

Location Identification Code_____
Date_____
Prepared by_____

POTENTIAL IMPROVEMENT IDENTIFICATION WORKSHEET
(One for each hazardous location)

LOCATION:_____

APPLICABLE IMPROVEMENTS:

IMPROVEMENT	EXPECTED RESULTS

SPECIAL COMMENTS:_____

Figure 4.

Highway Safety Program
Documentation Record
FORM 104

Location Identification Code_____
Date_____
Prepared by_____

IMPROVEMENT ANALYSIS WORKSHEET
(One for each potential improvement)

LOCATION:_____

IMPROVEMENT CODE:_____
IMPROVEMENT DESCRIPTION:_____

ESTIMATED SERVICE LIFE_____YRS.
CURRENT 19___ AADT_____ EST. 19___ AADT_____

☐ Constant
☐ Increasing by ____ % annually
☐ Increasing by ____ VPD annually

ESTIMATED ACCIDENT REDUCTION:

By Types:				By Severity:	
Left turn	___%	Skidding	___%	Fatal	___%
Head on	___%	Wet pavement	___%	Injuries	___%
Rear end	___%	Night	___%	PDO	___%
Right angle	___%	RR crossing	___%	Total	___%
Side swipe	___%	_____	___%		
Fixed object	___%	_____	___%	All Accidents	
Lost control	___%	_____	___%	___%	

EQUIVALENT UNIFORM ANNUAL BENEFITS:

From accident reduction	$_____
From secondard benefits	$_____
Total	$_____

ESTIMATED COSTS:

Initial implementation	$_____
Annual operation and maintenance	$_____
Terminal value	$_____
Equivalent uniform annual cost	$_____

NET ANNUAL BENEFIT $_____ BENEFIT/COST RATIO_____

SPECIAL COMMENTS:_____

Figure 5.

Highway Safety Program
Documentation Record
FORM 105

Location Identification Code_____
Date_____
Prepared by_____

IMPROVEMENT EVALUATION WORKSHEET
(One for each hazardous location)

LOCATION:_____

SUMMARY OF EVALUATIONS:

Code					
Description					
Initial cost	$	$	$	$	$
Annual cost	$	$	$	$	$
Salvage value	$	$	$	$	$
Service life	yrs	yrs	yrs	yrs	yrs
Equiv. uniform cost	$	$	$	$	$
Equiv. uniform benefits	$	$	$	$	$
Net annual benefits	$	$	$	$	$
Benefit/cost ratio					

REJECTED IMPROVEMENTS (and explanation):_____

ELIGIBLE IMPROVEMENTS AND RANKING:

Code	Description	B/C Ratio

COMMENTS:_____

Figure 6.

Highway Safety Program
Documentation Record
FORM 107

Location Identification Code _____
Date _____
Prepared by _____

IMPROVEMENT EFFECT WORKSHEET
(One for each hazardous location)

LOCATION: _____

IMPROVEMENT: _____

DATE IMPLEMENTED: _____ SOURCE OF FUNDING: _____

INITIAL COST: $_____ ANNUAL COST: $_____

BEFORE ACCIDENT EXPERIENCE: See Hazardous Location Identification Worksheet (Form 101)

AFTER ACCIDENT EXPERIENCE:

Year						Total
From (date)						
To (date)						
AADT						Ave=
Exposure						
Total accidents						
Fatal accidents						
No. fatalities						
Injury accidents						
PDO accidents						
Accident rate						Acc/MV

BEFORE ACCIDENT RATE: _____ Acc/MV AFTER ACCIDENT RATE: _____ Acc/MV

PERCENT ACCIDENT REDUCTION: $100 \left[\frac{\quad}{\quad}\right] = \_\_\_\_\_ \%$

ADJUSTED NUMBER OF BEFORE ACCIDENTS: _____ $\left[\frac{(\quad)(\quad)}{(\quad)(\quad)}\right] = \_\_\_\_\_$ Acc

SIGNIFICANT ACCIDENT REDUCTION AT _____ % LEVEL OF CONFIDENCE:

☐ POISSON DISTRIBUTION TEST ☐ POISSON COMPARISON OF MEANS TEST

COMMENTS _____

Figure 7.

Highway Safety Program
Documentation Record
FORM 106

Prepared by _____
Date _____

PROGRAM PRIORITY LISTING WORKSHEET
Year _____

Location		Improvement		Estimated Cost	B/C Ratio
Code	Description	Code	Description		

2. Organize personnel, procedures, and organizational units to implement the system;
3. Schedule implementation of the system; and
4. Coordinate development and operation of the system to ensure cooperation from all involved organization units.

The highway system is not likely to fade away soon as a major mode of transportation. Witness to this is the recent panic at the nation's gas stations when motorists found themselves being deprived of power to use their highways. But the recent gasoline shortage and subsequent reactions, such as lower speed limits and reduced traffic volumes, also showed us that the safety picture can change—all the more reason for evaluating and understanding the effects of highway safety improvements and organizing to make better use of existing facilities through such improvements.