THE HIGHWAY SPOT IMPROVEMENT PROGRAM
A CRITICAL REVIEW

Daniel J. Minahan

Acknowledgments

Much of the information for this report was gathered in personal interviews with authorities in the highway field. All those contacted gave generously of their time and professional knowledge. Those whose assistance is gratefully acknowledged include:

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Especially appreciated are the contributions of Donald N. Cortright, Associate Professor of Civil Engineering, The University of Michigan, who prepared the Appendix on Federal Aid Highway Legislation and rendered valuable professional criticisms and comments during completion of this report.

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FOREWORD

The Federal Spot Improvement Program was implemented at the same time that some major changes were legislated and ordered implemented in the organization and operations of the federal government. These changes established a new Department of Transportation, brought new people with new ideas into highway matters, and affected considerably the role and policy-making authority of the Bureau of Public Roads. Trying to understand and adjust to them, particularly at a time of rising highway costs and uncertainties regarding the availability of federal-aid funds, has aroused differing opinions as to the role and objectives of the federal government in all phases of the highway program. It is the author's hope that he has impartially and fairly presented all controversial views, particularly those directly related to the Spot Improvement Program. No criticism is intended of any official or private individual, either directly or by implication. In the author's opinion, every member of the highway profession is personally and wholeheartedly dedicated to improving and maintaining for the American people the greatest highway system in the world.

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INTRODUCTION

A spot improvement program by definition is one to eliminate or correct hazards at certain highway locations by geometric changes or by installing appurtenances, for example, by widening, regrading, relocating, and realigning the roadway, or by installing signing, signal control, and marking devices. Other names given to such a program include "elimination of hazardous locations,""highway safety improvements," "correction of design deficiencies," "minor improvements," "highway betterments." The innocuous term "highway safety improvements" is generally preferred to those which imply professional criticism or which may be construed as acknowledging a situation which could lead to a damage suit against a state or local government.

In order to attain a broad, in-depth understanding of the national Highway Spot Improvement Program conducted in recent years, a study designed as a critical review was conducted during the period June-December 1967. The first objective was to determine (1) what federal and state legislative and executive actions had authorized or directed the spot improvement program, (2) what engineering design criteria or what research had been employed to guide the program, (3) how the program was being conducted by various states, (4) what administrative, economic, engineering, and political problems were involved, (5) what progress was being made in improving highway safety through this program, and finally (6) what contributions, if any, the program had made toward reducing highway automobile accidents. The ultimate objective was to identify program changes and research activities desirable to improve or support this program.

Following a review of the literature, visits were made to the Bureau of Public Roads, selected states, and the American Association of State Highway Officials (AASHO) for discussions with knowledgeable individuals to determine how the program was being implemented by the Bureau of Public Roads and its field offices, State Highway Departments, and County Road Commissions. All persons contacted at the federal, state, and county levels were most cooperative in supplying circulars, instruction memoranda, and statistical data, and willingly expressed opinions or answered questions of fact.

SUMMARY

This study undertakes a critical review of the Highway Spot Improvement Program and examines technical, administrative, operational, and economic factors affecting the program with the goal of determining modifications or research activities to improve or support the program.

The study commences with a review of the development of the national highway system and the state highway organization and administration, as well as the basic law governing the Federal-Aid Highway System (Title 23, U. S. Code) which has authorized, since 1916, federal regulation of highway safety design and construction. The study outlines the federal-state partnership that grew out of congressional legislation and the role of the Bureau of Public Roads, the executive agency created to administer the Federal-Aid Highway Program. The influence of legislation on the organization and administration of state highway departments is reviewed, as well as the legal basis for directing highway safety improvements, which until recently were subordinate to the goal of constructing maximum mileage. The review continues with an examination of (1) the Spot Improvement Program, (2) related highway safety programs, and (3) program administration as conducted by the Bureau of Public Roads.

The study reveals that spot improvement programs in different states vary considerably in scope, standards, and progress attained, and that highway safety design criteria have generally evolved from hindsight. Although a methodology for implementing spot improvements is evolving, more effective ways are needed to identify hazardous locations, to establish correction priorities, and to select the most suitable corrective procedure.

The methodologies of implementing and justifying a spot improvement program are then discussed, including the special aspects of urban spot improvements and the need for adequate accident data. Areas for research and development are identified.

The vast economic implications of spot improvements are indicated. Much time and money would be required to correct every driving hazard on the hundreds of thousands of miles of the nation's highways. It is concluded that the large number of conflicting programs and interests competing for federal funds makes it highly unlikely that all roads on the Federal-Aid System will ever be modernized and made hazard-free. Therefore, spot improvement programmers must have realistic objectives, and highway safety planners must recognize that on a national basis the present state of accident reporting is not adequate for reliable identification of existing hazards or measurement of the effectiveness of given improvement projects. Nevertheless, safety improvements must continue to be made in both new and old highways.

The study also reveals that, in addition to inadequate accident-reporting systems, the dearth of knowledge regarding appropriate benefit-cost analyses and desired ultimate goals in highway design standards, both for safety and capacity, hampers progress in the spot improvement program. Progress is further obstructed by governmental sensitivity to political and economic pressure from special interest groups, as well as by the attitudes of the individual citizen, himself the intended major and direct beneficiary of a safer highway system.

THE DEVELOPMENT OF THE NATIONAL HIGHWAY SYSTEM

FEDERAL AND STATE RESPONSIBILITIES

It should first be understood that the vast highway systems of the United States, for the most part, are constructed, maintained, administered and owned by the separate states [1]. Only the small portion of mileage through national parks and forests, Indian reservations, reclamation areas, or military reservations is a direct responsibility of the federal government, and is administered by the Department of Interior through the National Park Service, the Department of Agriculture through the Forestry Service, or the Department of Defense through the Corps of Engineers [2]. Often the actual construction and maintenance of these roads on federal property is contracted to state highway departments.

ORIGIN OF THE FEDERAL-AID HIGHWAY SYSTEM

Prior to 1916, federal aid for developing highways was spasmodic, limited in funds, and directed toward conquering and settling western frontiers and delivering the mail [see Appendix I]. State and local governments independently built most of the nation's highways.

The basic law governing federal aid to the national highway system is the Federal Aid Road Act of 1916, also known as "Title 23, U. S. Code" [3]. All subsequent laws governing federal aid to highways are modifications of or supplements to Title 23 [see Appendix I]. Through Title 23 has been created the so-called Federal-Aid ABC System, consisting of (A) the Federal-Aid Primary System, (B) the Federal-Aid Secondary System, (C) Urban Extensions of the Federal-Aid Primary and Secondary Systems.

The Federal-Aid Primary and Secondary Systems were first created in 1921, when the states were directed to select up to 7 percent of their total rural mileage to become part of the Federal-Aid System of Highways. Three-sevenths of this portion would be Primary or Interstate, the remainder Secondary or Intercounty. The system conceived was a primary-road net connecting the major population centers of the nation, with a secondary-road net connecting state population centers. The Secondary System is also known as "farm-to-market," or "getting the farmer out of the mud roads." Urban Extensions of the Primary and Secondary Systems were later authorized, and in 1944 the mileage limitation of the Secondary System was removed. The mileage selected for any system must be approved by the Bureau of Public Roads.

In general, construction of the Federal-Aid ABC System is financed 50 percent by federal funds and 50 percent by state matching funds. For some western states which contain large areas of public lands the federal-aid percentage is higher. A major change occurred within the Primary System when Congress authorized a "National System of Interstate and Defense Highways" in 1944, providing necessary funds in the Federal Highway Act of 1956. Construction of the Interstate System, which will total 41,000 miles when completed, is financed 90 percent with federal funds and 10 percent with state matching funds.

Programming and construction of any part of the Federal-Aid System depend upon separate appropriations acts, usually voted every two years. Under Title 23, federal-aid funds are apportioned by formula to each state according to its share of the nation's total rural mileage, geographic area, and population [3].

When using federal-aid funds, the states select the system to be improved, the projects to be built, and the design and construction standards to be used. They make the surveys and plans, let contracts, and supervise construction. At each of these steps, the states consult with and obtain the approval of the Bureau of Public Roads. Federal-aid money can be used for purchasing rights-of-way, actual construction costs, and certain later improvements. After construction has been completed, inspected, and accepted by the Bureau, the states are responsible for all maintenance and operations. Failure to provide required maintenance results in loss of future apportionment funds.

Under Title 23, to be eligible for federal aid a state must have a state highway department, which is designated the sole agency responsible to the federal government for the administration of federal-aid funds.

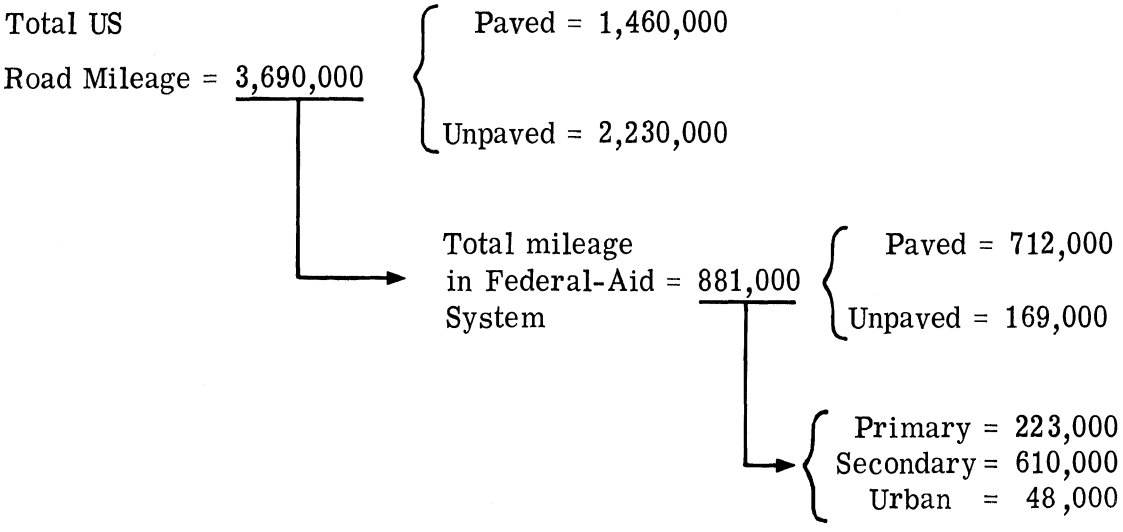
Chart I provides a capsule summary of the nation's highways.

STATE HIGHWAY ORGANIZATION AND ADMINISTRATION

State highway systems vary considerably in organization and administration [1].

Michigan, for example, has (1) a system of state primary roads and urban extensions which are the direct responsibility of the State Highway Department, (2) a system of county primary and secondary roads and urban extensions which are the responsibility of the County Road Commissions, and (3) urban street and road systems under the control of the city or township [1]. County Road Commissions manage their highway systems autonomously except for those portions that are part of the Federal-Aid Secondary System. Some Road Commissions even get involved far afield, e.g., Wayne County Road Commission, which built and operates Detroit Metropolitan Airport. Michigan, like most states, has a Highway User Fund, into which taxes on motor-vehicle fuels and registrations are deposited.

Chart I. SUMMARY OF NATION'S HIGHWAY MILEAGE



Under Michigan law, this fund cannot be used for any purpose other than highway construction and operation; an apportionment formula determines the percentage of funds allocated to state highways, county roads, and urban streets and roads [4]. Therefore, planners generally know from year to year what money will be available from this fund, supplemented by federal-aid apportionments.

New Hampshire, like all New England states, has a state primary and secondary system with urban extensions, directly under the State Highway Department [1]. There are no county roads, but systems of town and city streets and roads under local control. The state highway system and its urban extensions are financed by a Highway User Fund as well as federal aid. Towns and cities finance their own street and road systems. Occasionally, small supplemental appropriations for state and local systems are voted by the New Hampshire Legislature, which meets only every other year.

Colorado has a blend of the above systems, a state primary system and urban extensions under the state highway department, an independent county road system, and systems of urban streets and roads under local control [1]. A Highway User Fund is apportioned by formula to the state, county, and local systems. The Federal-Aid Primary and Secondary Systems are contained in the state primary system. The county road system forms no part of the Federal-Aid System.

California has a system similar to Colorado's except for a part of the county road system that is also Federal-Aid Secondary. California also has over 2,000 miles of roads in state parks and has within its borders 32,000 miles of roads (the most in any state) under federal control in national parks and forests [1].

It is important to note that, historically, highway design criteria and construction standards have been left largely to the states; hence, these vary from state to state. Over the years, practically all design criteria, material standards, and construction standards have grown out of the experiences or research efforts of the various state highway departments [5]. On a regional basis, highway departments have pooled their findings, which eventually became the accepted criteria and standards of the American Association of State Highway Officials. As a matter of fact, instruction material in engineering textbooks stems from AASHO standards [6]. The American Roadbuilders Association, which represents the highway-construction industry, and several other organizations have also contributed to and influenced AASHO standards [4]. AASHO criteria and standards are periodically submitted to the Bureau of Public Roads for review. If approved, they become the Bureau design and construction standards for the Federal-Aid System [5, 7]. (For examples of AASHO standards which have become approved Bureau standards, see references [8-11].) This cooperative effort has produced a professional fraternity of career highway engineers with strong personal ties. The resulting relationships stem from the historical fact that the states were doing road construction long before the federal government became seriously involved.

Regional variations in geography and climate have prevented the establishment of fixed national criteria and standards. Local conditions must often determine what is best [5]. For example, New Hampshire's winding and narrow highways reflect that state's mountainous terrain, cut up by river valleys and lakes. Michigan's terrain, relatively flat and rolling with sandy soil, has permitted the laying out of a state highway system almost in checkerboard fashion. Colorado's flat eastern prairies, which in times of national drought become dust bowls, contrast with the rugged Rocky Mountains in the western part of the state. California's

northern Sierra Mountains are often snow-laden or rain-soaked while the southern desert areas are arid. All these areas present varying problems in engineering, construction, and costs.

Design criteria and standards and the development of a state highway system are also influenced by the economic and cultural development of the state. If the state is populous and rich in industry and has a suitable tax base, this will be reflected in a more advanced highway system. In this respect, Michigan and California rank considerably higher than New Hampshire and Colorado.

LEGAL BASIS FOR FEDERAL HIGHWAY SAFETY IMPROVEMENTS

Although it does not appear to have been a major objective, safety always was a consideration in constructing the federal-aid system [12]. The 1921 Federal-Aid Highway Act not only required that surfaces have a minimum width of 18 feet and be durable and adequate (gravel then being acceptable), but authorized the Secretary of Agriculture (then responsible for highway administration) to prescribe and recommend measures for ensuring safety of traffic.

The Federal-Aid Highway Act of 1933 authorized $400 million in emergency construction of the Federal-Aid System, but also authorized use of these funds to eliminate highway traffic hazards by constructing grade separations, reconstructing railroad crossing, widening narrow bridges and roadways, building footpaths, replacing unsafe bridges, and constructing alternate routes, and for any other construction that would provide safer traffic facilities or eliminate existing hazards to pedestrians or vehicular traffic.

Federal-Aid Appropriations Acts of 1936 and 1937 authorized funds for study and research on traffic conditions and ways to improve them, as well as funds for the Secretary of Commerce to sponsor an accident-prevention conference designed to promote enactment of uniform vehicle regulations in the United States.

Additional money was appropriated in 1938 for the elimination of rail-highway and highway-highway grade crossings.

The 1944 Act directed that traffic-control devices be used only to promote safety and efficient utilization of the highways.

The 1950 Act, which transferred the Bureau of Public Roads and responsibility for highway administration to the Secretary of Commerce, authorized $75,000 for the Commissioner of Public Roads to carry out the highway and street safety action program of the President's Highway Safety Conference. In 1952 an additional $153,000 was authorized to be spent annually on the work of the President's Highway Safety Conference, and the 1954 Act specifically authorized the Secretary of Commerce to engage in research on all phases of highway construction, including safety, either independently or in cooperation with other agencies or organizations.

The 1956 Act directed that a highway safety study be carried out by the Secretary of Commerce to determine what action could be taken by the federal government to increase highway safety. Among the factors to be considered in the study were: (1) need for federal assistance in enforcing highway safety and speed requirements, (2) uniform state and local speed and safety laws, (3) design and physical characteristics of highways. (This comprehensive study was presented to the House Committee on Public Works in 1959 [13].)

The 1963 Federal-Aid Highway Act allowed the use of highway planning and research funds (1.5 percent of the federal-aid appropriations for the state) for, among other purposes, research and studies on highway safety.

The Federal-Aid Highway Act of 1965, better known as the Highway Beautification Act, included an amendment (the Baldwin Amendment) to Title 23, entitled "Highway Safety Programs," requiring that after 31 December 1967 each state must have a highway safety program approved by the Secretary of Commerce, designed to reduce traffic accidents and hazardous accident conditions on the Federal-Aid System, and that such programs must include provisions for surveillance of traffic for detection and correction of high and potentially high accident-rate locations.

Federal highway safety legislation culminated in the Highway Safety Act of 1966, which adds a whole new Chapter 4, "Highway Safety," to Title 23 [3]. Chapter 4 includes all the provisions of the Baldwin Amendment. However, the wording has been changed from "should" to "shall." Chapter 4 specifically provides for uniform standards on the Federal-Aid Highway System by requiring each state to have an approved highway safety program (expressed in performance criteria). Of the many uniform safety standards required, those relating specifically to highways are the accident-records systems, investigations into accident causes, highway design, maintenance, and traffic-control devices, and studies to correct high accident-rate locations. The Secretary is directed to give priority to federal-aid highway construction projects which incorporate improved safety features. States which do not have an approved safety program by 31 December 1968 will have their federal-aid highway apportionments cut by 10 percent until they develop such a program. Additionally, the Secretary is authorized to conduct highway safety research.

In summary, it should be noted that authority always existed (or was implied in the law) for national highway agencies to develop and impose safety standards for new highways, and to make corrections at hazardous locations on existing highways. However, the original emphasis in the federal-aid highway program (as illustrated by actual appropriations for safety versus construction) was on building maximum mileage as rapidly as possible for defense, economic, sociological, and, probably, political objectives, in congressional response to public demand at the time the laws were passed [14]. Over the years, as the national highway system nears completion, the public and Congress have reversed their position on the relative importance of highway safety versus construction [15, 16]. Now all new highways must be designed and constructed to meet the highest possible safety standards for the class of highway under consideration, even though the added costs may reduce the mileage constructed [17].

ADMINISTERING THE SPOT IMPROVEMENT PROGRAM

FEDERAL INITIATING ACTION AND IMPLEMENTATION

It has long been recognized that highway accidents have been significantly increased by the inadequate design of highways and intersections, resulting in short-radius curves, inadequate sight distance, roadways too narrow for traffic conditions, blind intersections, inadequate warning and signal devices, and the locating of utility poles, posts, railing, retaining walls, and abutments where motorists can easily strike them.

Although Title 23 authorized the federal government to establish safety criteria for the design, construction, and operation of the Federal-Aid System, development of safety criteria, as of all other criteria relating to highway design and construction, had apparently been left to the states. These criteria gradually evolved into AASHO standards, which eventually were reviewed and approved by the Bureau of Public Roads for general application on federal-aid projects.

The first positive federal action to institute a national safety-improvement program occurred in March 1964 when President Johnson directed the Secretary of Commerce to use the Bureau of Public Roads in encouraging state and local governments to launch a program for removal of highway hazards [see Appendix II]. Shortly thereafter, the Secretary urged all state governors to reorient state highway programs through special attention to the elimination of highway hazards and to submit their highway safety improvement plans. He advised that the Bureau of Public Roads was prepared to assist them in the programs.

It is important to note that no additional funds were provided for this program, but that the states were expected to implement it by using a portion of their annual federal-aid money, matched as usual on a 50-50 basis with state funds.

About mid-April 1964, the Federal Highway Administration, while acknowledging that some states already had spot improvement programs, began urging each state highway department to commence work on this high-priority program and to shift money from other programs. The Administration pointed out that the first requirement was for each state to conduct a survey to identify and to locate highway hazards.

Shortly thereafter, the Bureau of Public Roads issued a series of instruction memoranda to the Bureau's nine Regional Engineers and their subordinate Division Engineers who maintain offices in each state close to the state highway department [18]. These memoranda, urging Bureau personnel to give impetus to the program, gave detailed instructions on making inventories of hazardous locations and submitting projects for approval for federal aid. Locations selected must have an above-average frequency of accidents, and pure maintenance projects were not eligible. The proposed improvements must conform to Bureau standards for federal-aid projects in that state. The usual contractual procedures must be followed: the state must conduct preliminary surveys, prepare drawings, and obtain cost estimates by competitive bidding, all at its own expense, before submitting projects for Bureau approval.

It appears that in launching the spot improvement program the Bureau of Public Roads initially adopted an advisory role and a cooperative rather than

authoritative attitude, characteristic of its past relations with state highway officials and departments.

However, it appears that the response from the states was less than enthusiastic, as evidenced by the fact that Policy and Procedure Memorandum 21-15 of 15 April 1964, "Improvement of Highway Accident Locations on the Federal-Aid Primary and Secondary Systems, Rural and Urban," made a rather belated point of citing Section 109, Title 23 as Bureau authority for establishing basic safety criteria [see Appendix II].

In November 1964 the Federal Highway Administrator, in a memorandum to Bureau Regional and District Engineers, complained that only 100 safety projects had so far been submitted for approval [see Appendix II]. Regional and District Engineers were urged to prod the states into using substantial proportions of federal-aid funds on safety projects. Apparently in the hope of increasing the projects submitted, the same memorandum created a new category of safety projects for locations for which there were few or no accident records but which had clear accident potential. At the same time, the memorandum pointed out that projects for such locations did not truly fall within the intent of the program because they did not offer prospects of a reduction in accidents.

Again, in December 1964, obviously in the hope of getting the states to submit more projects, Regional Engineers requested District Engineers to have the states review all conventional construction projects to determine whether parts of them might be classified as safety projects [see Appendix II].

On 30 August 1965, in response to the President's directive of 23 March 1964, the Bureau of Public Roads issued Policy and Procedure Memorandum 21-16, "Highway Safety Improvement Projects," to establish what it called the Bureau's program for improving those locations on the Federal-Aid System identified as hazardous because of high accident rates or potentially hazardous by virtue of engineering judgment [see Appendix II]. There was a notable time lapse between the President's directive to the Secretary of Commerce to act through the Bureau of Public Roads and the issuance of this memorandum citing presidential instigation.

The memorandum combined and reiterated all of the previously announced procedures for programming and administering safety-designated projects. While recognizing that the states might prefer to use state funds on small projects, the memorandum requested them to report all safety projects, whether done with or without federal aid. A safety project could be selected as a result of (1) a concentration of accidents at a location, (2) a record of accidents at similar locations, (3) research findings, (4) engineering judgment. However, it must be determined that the proposed project could reasonably be expected to reduce the hazard. The memorandum also contained examples of improvements that might be made, as well as instructions to inventory hazardous locations and to start programming projects to insure completion of most of them by 1 September 1969. The desirability of keeping before-and-after records was repeated.

In a covering letter to this memorandum, the Bureau's Regional and District Engineers were reminded that the program did not apply to the Interstate System. They were also urged to prod states not already in the program and to encourage diversion of sufficient federal-aid funds to insure completion of the program in four years, even if it meant deferring other needed construction. Although first priority was given to completing the inventories of hazardous locations, the states

should be encouraged to concurrently start programming projects. Again, it was directed that the states be urged to report those projects done with state funds, including number, type, and total cost.

In mid-November 1965, in IM 21-13-65 [see Appendix II], the Bureau of Public Roads, citing the spotty progress made in programming safety projects, advised that if those states using their own funds for improvement projects were not spending sufficient funds each year to correct one-fourth of the hazardous locations existing as of 1 September 1965, approval of regular federal-aid programs would be deferred until funding was considered adequate. In some cases, the memorandum advised, this would require using 25 percent or more of annual federal-aid apportionments on highway safety projects.

This threat to cut funds apparently produced considerable reaction, because on 30 November 1965 the Bureau issued another memorandum [see Appendix II] to Regional Engineers saying that the previous 25-percent figure was intended as a guideline in determining whether a state would reach the goal of 100-percent completion of safety projects by 1 September 1969, regardless of whether the state used its own funds or federal-aid funds. It explained that each state should reserve 25 percent of federal-aid funds for this purpose, unless the state had definitely committed other funds for this goal. (This meant a state was expected to spend twice as much, because the federal-aid portion would have to be matched 50-50.)

Once again, in February 1966 [see Appendix II], the Bureau urged the states to begin or complete their inventories of hazardous locations, provided instructions and guidelines for inventories, and urged them to start programming before inventories were completed.*

In February 1967, the Bureau issued Instruction Memorandum 21-3-67, "Selection of Highway Safety Improvement Projects," which stated that selection of safety projects would henceforth be based on actual accident experience and that priorities would be set according to potential for accident reduction in relation to the cost of improvement [see Appendix III]. This memorandum, which is based on a study made for the Bureau by Roy Jorgensen & Associates [19], outlined a benefit-cost analysis for selecting spot improvement projects which the states should use, unless they could justify an alternative method offering equal or better results in terms of sound identification and appropriate priority scheduling. The memorandum eliminated selection of locations on the basis of similarity to high accident-rate locations, or engineering judgment. It therefore required a review of all previous inventories of hazardous locations, confronted those states and counties which lacked experienced personnel or had inadequate accident records with a difficult if not impossible problem, and introduced a delay in the spot improvement program.

Recent informal discussions with Bureau personnel disclosed that they now are less concerned with the deadline for completion of the program (1 September 1969) than with the proper method of identifying hazardous locations.

The criteria for selecting and establishing priorities outlined in IM 21-3-67 assume a good accident-reporting and data-analysis system. Even so, the Bureau

*According to Bureau personnel, the threat to defer regular highway construction funds did cause those states which had not done so to complete their inventories and start programming projects.

realizes that few states have such a system. Although the new criteria may delay the program, the Bureau's main objective now is to emphasize the need for each state to initiate better accident-reporting and data-collection procedures.

In summary, it seems that established policies governing relations between the Bureau of Public Roads and the states and the prevailing lack of a spot improvement philosophy caused the Bureau to be slow in implementing the presidential directive. At first the Bureau prodded the states into inventory of their hazardous locations, using broad guidelines. Then, by threatening to withhold federal-aid highway funds from other programs, the Bureau induced the states to program corrections. Later, the Bureau initiated and completed its own studies of spot improvement practices; it then endeavored to redirect the states toward adopting a benefit-cost approach after the states were already committed to less sophisticated programs.

RELATED FEDERAL HIGHWAY SAFETY ACTIVITIES

TRAFFIC CONTROL DEVICES. To take one example of the several highway safety programs or activities collateral to or duplicating elements of the Spot Improvement Program, the Bureau of Public Roads, through Policy and Procedure Memorandum 21-15, 16 June 1964 [see Appendix II], began urging all states to inventory and update traffic control devices on the entire Federal-Aid System in conformity with the Manual on Uniform Traffic Control Devices [8] and the Manual for Signing and Pavement Marking on the National System of Interstate and Defense Highways [9]. The execution of this program presumably should result in spot improvements being made in many locations. This program, as enunciated in 1964, is a continuing one, and is said by the Bureau to be about 60 percent complete [20].

TOPICS. The Traffic Operations Program for Increasing Capacity and Safety, or TOPICS, was initiated by the Bureau of Public Roads through Instruction Memorandum 21-7-67, 13 February 1967 [18]. The stated purpose of the program is to raise the efficiency and safety of existing street and highway systems in urban areas [21]. Under this program the states may (1) add to the Federal-Aid Primary System, without charge against their mileage limitation, selected arterial routes and local streets in urban areas of 5,000 or more population, and (2) apply federal-aid highway funds for traffic operation improvements [22]. A new Type 2 Primary System of streets and highways is created. Criteria for selection include heavy concentrations of traffic on those arterial highways, major streets, or downtown street grids which connect with or lead directly to the already-established Federal-Aid Highway System. Selection of Type 2 highways is made by the State Highway Department, in cooperation with appropriate local officials, with the approval of the Bureau of Public Roads Division Engineer. The selection must be preceded, however, by an urban transportation planning study in the community concerned. The necessary street and traffic inventories and development of plans may be financed either with HPR (1.5%) or PR (0.5%) funds on the usual 50-50 matching ratio. TOPICS does not represent new or additional funding. The federal-aid share comes out of regular state apportionments. Approval of a project for financing does not constitute authorization for new construction, but only for such items as signal-control devices, turning lanes, lane markings, and signing. Although the program is designed to increase traffic flow and vehicular capacity, it should indirectly constitute spot improvements at street and highway intersections where there have been vehicle collisions or pedestrian injuries.

Progress to date in the TOPICS program has been disappointing, according to the Secretary of Transportation [23]. As of February 1968, according to the Chief of the Traffic Operations Division, Bureau of Public Roads, only 19 cities, ranging in size from Searcy, Alabama (8,000), to Indianapolis (984,000), were involved in the program. Of these cities, only Canton, Ohio; Stamford, Connecticut; Woonsocket, Rhode Island; and Lincoln, Nebraska, seem to have made significant inventories and preliminary studies. No city yet has a project under contract. The TOPICS program appears to be held up by the required urban transportation planning studies, which in turn are bogged down in conflicts over urban renewal, mass transportation, parking, and commercial (or industrial) objectives.

GRADE CROSSING PROGRAM. A special safety program to reduce rail-highway grade crossing accidents was initiated early in August 1967, by the Department of Transportation, through the Federal Highway Administration and the Federal Railroad Administration [24]. Particular emphasis is given to crossings in the heavily traveled Northeast Corridor, where high-speed train operation is envisioned. Each state highway department has been asked to select one grade crossing for each 4,000 miles of Federal-Aid Highway System to test the "most suitable known or proposed system of protection [25]." Such a program will subject about 200 rail crossings to closer examination and will involve research seeking to develop better methods of accident data gathering and optimal means of controlling the problem. The railroads are asked to rehabilitate existing protective devices and grade crossing sites under their jurisdiction.

About 14,000 rail-highway grade crossing accidents occur each year, resulting in 1,800 fatalities, 15,000 injuries and over 100 million dollars in property damage [25, 26]. Rail-highway grade crossing corrections are also considered part of the Spot Improvement Program and reportedly represent about 17 percent of programmed spot improvements. In many states, complicated laws affecting railroad right-of-way and apportionment of maintenance costs among state or local governments and the railroads have delayed programming.

HIGHWAY SAFETY STANDARDS. Three of the National Highway Safety Bureau's Highway Safety Standards promulgated on 27 June 1967 [27] bear on the spot improvement program. The "Traffic Control Devices" standard calls for uniform and general upgrading of signal-control devices. The "Highway Design, Construction, and Maintenance" standard sets minimum goals for safe geometric design, lighting, skid prevention, construction site safety, maintenance, and crash protection. The "Identification and Surveillance of Accident Locations" standard refers to the current Bureau of Public Roads spot improvement program and calls for systematic identification and correction of accident locations on all roads and streets.

All three standards are part of the overall program which the states are expected to have implemented by 31 December 1968. The Bureau of Public Roads anticipated these standards with (1) PPM 21-15, 16 June 1965 "Traffic Control Devices on Federal-Aid Highways," (2) IM 21-3-67, 1 Feb. 1967 "Selection of Highway Safety Improvement Projects," and (3) IM 21-15-67, 19 May 1967, "Safety Provisions for Roadside Features and Appurtenances [see Appendix II]."

PUBLIC WORKS COMMITTEE: SUBCOMMITTEE HEARINGS ON ROADS. The 1967 hearings of the House Public Works Committee's Subcommittee on Roads,

chaired by Representative John A. Blatnik, were concerned in part with the spot improvement program [28]. Initially, the subcommittee expressed concern regarding: (1) alleged reluctance of the National Highway Safety Bureau to set priorities to guide the states in programming, (2) evidence of poor communication between the Department of Transportation, the National Highway Safety Bureau, and the states, and (3) the expressed intention of some states to sacrifice 10 percent of their highway construction money rather than comply with recently announced Highway Safety Program Standards.

As the hearings developed, interest centered on design of roadside appurtenances such as guardrails, abutments, and signposts that constitute hazards to a vehicle which leaves the road. Photographs gathered by the Committee were used to illustrate examples of improper or hazardous design features, particularly on the Interstate System [29]. While claiming no punitive or headline-seeking intent [15], Committee members did charge that the Bureau of Public Roads, state highway departments, and other responsible officials had remained "oblivious" to hazards being incorporated into new highway construction, ignored the accident rate, and failed to apply the information and findings published by AASHO, the Highway Research Board, researchers in highway safety, and other sources [30].

The Committee claims to have influenced the following developments, although they were implemented before the hearings started:

(1) Bureau of Public Roads Safety Criteria, IM 21-11-67 of 19 May 1967.

(2) National Highway Safety Bureau, Highway Safety Standards, 27 June 1967.

(3) Bureau of Public Roads provision of 90-10 federal funds for correction of design errors on the Interstate System.

THE ROLE OF AASHO IN HIGHWAY SAFETY IMPROVEMENTS

In 1964, in recognition of the increasing problem of highway safety and emphasis being placed on it, the American Association of State Highway Officials created a special safety committee to study and coordinate the Association's many functions related to traffic safety [31]. The committee, chaired by the President of AASHO and composed of the chairmen of the Committees on Planning and Design Policies, Design, Traffic, and Maintenance and Equipment, officially represented AASHO within the Bureau of Public Roads Advisory Committee which was responsible for drafts of safety standards for consideration by the Secretary of Commerce.

In October 1965, the Special AASHO Committee on Traffic Safety submitted a report to the Bureau of Public Roads containing a series of recommendations for consideration in drafting national traffic safety standards [31]. This report suggested a cooperative effort in the development of national traffic safety regulations and recommended adoption of current AASHO design policies and standards, with provision for continuing review and updating. Other recommendations included the use of official sign manuals to ensure uniform signing and marking, better accident reporting and analysis by state traffic-operations surveillance teams, studies on the effects of alcohol on traffic, compulsory driver training, improved driver licensing examinations, mandatory motor-vehicle inspections, uniform and vigorous law enforcement, and improved emergency services. In essence, all these recommendations appeared in the 1966 Federal Highway Safety Act.

Early in 1966 when Congress was considering national traffic safety legislation, the Federal Highway Administrator proposed that AASHO conduct a special study of the traffic and safety characteristics of the Interstate System and other highways, concentrating on signing and marking practices and traffic safety conditions where accidents indicated traffic operational problems. The same Special AASHO Traffic Safety Committee undertook the project, spent several months observing conditions throughout the states, and reviewed the practices then in effect [32]. In 1966, in addition to the members enumerated above, the Committee included as Secretary the Director of the Office of Highway Safety, Bureau of Public Roads, as well as four other key Bureau personnel, among them the Bureau Chief Engineer, serving on the Committee as special representatives [31].

The final report of the Committee, Highway Design and Operational Practices Related to Highway Safety, commonly referred to as the "Yellow Book," was approved by AASHO in November 1966 and published in February 1967 [31]. This report summarizes the composite findings of the committee and includes discussions, comments, and recommendations concerning highway design and practices as they relate to safety on roads and streets under the control of state and local highway departments. It also includes a compilation of the work and findings of many other agencies, including university-oriented highway safety research projects. The booklet is well illustrated and succinctly points out what should and should not be done in highway design and construction to remove existing hazards, and to prevent similar hazards from being incorporated into future highways. The Committee urged that all highway and traffic departments apply the recommendations wherever appropriate.

A review of the booklet indicates that the Committee recommendations were intended for the Interstate Highways and the Federal-Aid Primary System, both rural and urban. Nevertheless, on 19 May 1967, through Instruction Memorandum 21-11-67, entitled "Safety Provisions for Roadside Features and Appurtenances [see Appendix II]," the Bureau of Public Roads announced approval of the recommendations of the AASHO Special Safety Committee as contained in the Special Report and declared them to be the acceptable standards for safety design and construction on the entire Federal-Aid System—Interstate, Primary, and Secondary, Rural and Urban. The memorandum further said that all Federal-Aid System construction, in progress or planned, where the design speed was 50 mph or greater, must be reviewed for compliance with those standards. As far as feasible, the standards should be applied to all primary and secondary roads with lesser design speeds.

A supplementary clarifying addendum to IM 21-11-67, issued 29 June 1967 [see Appendix II], stated that the Yellow Book standards applied to all Interstate projects, to all Federal-Aid Primary and Secondary projects initiated after 31 July 1967, and, as far as practical, wherever design speed was 50 mph or greater and average daily traffic was 750 vehicles or more.

FOUR STATE SPOT IMPROVEMENT PROGRAMS

State highway departments in Michigan, New Hampshire, Colorado, and California were visited for the purpose of discussing the status of their highway spot improvement programs. All have programs which antedate by several years the federally sponsored program:

The Michigan Operation Betterment program (MOB) is twelve years old. The initial fund allotment of one million dollars annually was increased to two million in 1965. In 1966, Michigan began a spot improvement program expenditure of 5 million dollars per year for four years to end in June 1970.

New Hampshire's Betterment Program, started about eight years ago, is currently funded at one million dollars annually.

Colorado's program is about ten years old and applies to all roads in the state. Colorado has programmed 25 million dollars in spot improvements for the Federal-Aid System, to be completed by September 1969, at an expenditure rate of approximately 6 million dollars a year.

California's Minor Improvements Program, started about ten years ago, has been upgraded constantly through extensive research and generous funding to its current level of about 14 million dollars annually.

Typical projects in all four states include delineation, edge line marking, barrier and guardrail installation [33], intersection channelization, new or modified traffic control and warning signals, elimination of short and sharp vertical and horizontal curves, widening of narrow bridges, and improved highway lighting [34, 35].

DIVERSITY AMONG STATES. Each state undertakes or experiments with special projects. For example, Michigan has repaved many miles with skid-resistant asphalt aggregate mixture and, like New Hampshire, has removed thousands of trees from the right-of-way. New Hampshire and Colorado have done considerable work cutting back rock ledges and removing roadside boulders. California has installed considerable lengths of guardrail of its own design [36], experimented with double solid yellow lines for median and barrier delineation, and very successfully tried pavement serrating to reduce skidding [37]. California experiments with raised retroreflective lane markers have resulted in an observed 40 percent reduction in lane switching [38].

In each state, geographic and climatic problems obscure distinctions between spot improvements, normal maintenance, and major construction. For example, flattening slopes to one on six in New Hampshire and western Colorado represents a costly removal of rock ledge. In Michigan and eastern Colorado, one-on-six slopes create drainage problems. Tree removal is usually a simple spot improvement, but in the forest areas of northern Michigan and New Hampshire, it may cost as much as miles of maintenance. In Colorado, constructing snow sheds in the mountains to protect against avalanches or rock fall may cost as much as tunneling. Maintaining or repairing guardrails damaged or broken by ice and snow is expensive in California's mountains.

Each of the four states has a surveillance team for evaluating hazardous locations. Team members include the Traffic, Maintenance, Design, and Construction Engineers of the Highway Department, the District Engineer, and a State Highway Patrol representative. In New Hampshire the team is headed by the Planning and Economics Engineer of the State Highway Department and includes a representative from the Division Office of the Bureau of Public Roads. In the other states the Traffic or Safety Engineer is team chief. Each team makes periodic safety surveys of highway conditions, inspects an accident site upon receipt of the engineer's

copy of an accident report from the State Highway Patrol, determines what geometric or other feature may have caused the accident, recommends corrective action, and maintains post-correction surveillance. The team also attempts to identify sites of similar geometric configuration but with a history of fewer or no accidents, and to make an engineering judgment regarding corrective action.

In each state accident reports are made by the State Highway Patrol. Members of the California Highway Patrol spend six weeks with the Division of Highways learning what highway features to consider and include in their accident reports. New Hampshire reports accident locations with reference to highway bridges, all of which are accurately located and numbered. Michigan has a computerized system within the Highway Department for recording accident data in relation to the state trunkline milepost system within an accuracy of 0.2 miles. California exceeds that by feeding detailed accident reports into a computer system with a location accuracy of 0.01 miles.

ADMINISTRATIVE OBSTACLES TO USE OF FEDERAL AID. Despite pressure from the Bureau of Public Roads to use federal aid money for spot improvements, all four states complain about the problems of obtaining federal aid. In their experience, getting federal approval is as involved for a small safety project as for a construction project costing several million dollars. The state must spend its own money making preliminary surveys and obtaining competitive bids without knowing whether the project will qualify as a safety project or be rejected as maintenance or major construction. Therefore, the states prefer to use their own funds for spot improvements and to reserve federal-aid funds for major new construction and reconstruction.

Since the ordeal of obtaining approval for two spot improvement projects for intersections in the city of Lansing in 1965, the Michigan Department of Highways has requested federal aid only for major spot improvements on the Primary System and uses state funds for other spot improvements in sufficient amounts to satisfy federal requirements.

The New Hampshire Highway Department found the Bureau of Public Roads definition of a spot improvement too vague and unpredictable. One example cited was a proposed improvement of a multitrack railroad grade crossing frequently traversed by school buses. The track area was too wide for buses to cross without stopping en route on an island which was too narrow to accommodate them. Therefore an overhead bridge costing $150,000 was proposed. The Bureau disapproved, saying it was a major construction project; New Hampshire then decided to build the bridge with state funds and was surprised when the Bureau reconsidered and approved it for federal aid. Another New Hampshire example was a project to remove a roller-coaster dip which had no passing-sight distance. To eliminate the vertical curve required two cuts and one fill. However, a town road which intersected the primary road at the bottom of the dip did not qualify for federal aid, so the state paid for reconstructing the intersection, the most costly part of the project.

Colorado asks for federal aid only when a safety project costs over $1,500. Seeking federal-aid money for lesser projects is considered too expensive in time and effort.

Discussions with the California Division of Highways revealed that California usually does not apply for federal aid for spot improvements because of administrative delays and costs. Ninety percent of projects to date have cost less than $50,000 and have been completed entirely with state funds.

In states where county roads form a large part of the Federal-Aid System, completion of county inventories of hazardous locations has constituted a difficult problem. E.g., of the four states dealt with in this study, only in Michigan were large portions (26,800 miles) of the Federal-Aid Secondary System on county roads [39]. Considerable prodding was required before all counties completed the requested inventories by the end of 1966. Aware of their limited staffs and insufficient accident records, the Michigan Highway Department advised all counties to use engineering judgment in preparing their lists and to use their own funds on small projects [40].

The highway departments on the four states resent what they considered to be the "pressure techniques" used in launching the federal spot improvement program. The highway departments also feel they are unjustly bearing the onus for local economic and political conditions which affect the defining and correcting of highway hazards, but which are beyond their control. I.e., in Michigan, according to Highway Department personnel, public and private interests, especially in rural areas, call for more surfacing and more roads, rather than elimination of hazards. In New Hampshire, essentially a vacationland of private summer and winter resorts backed up by state-owned and -operated attractions such as racetracks, liquor stores, and recreation areas, Department personnel said there is constant pressure to keep highways open for traffic, especially in summer, the logical time for highway construction. Often what the Highway Department would like to do in acquiring more right-of-way, reconstructing, or installing guardrails and medians is blocked by high costs or the conservative State Legislature, which convenes only every other year. The Colorado Highway Department attributes many errors to pressure to get mileage completed and to save money by such techniques as eliminating a planned grade separation and substituting a curvature which later proved to be dangerous. The California Division of Highways points out that many of the roads being improved were built 50 years ago, with features not safe for today's traffic. With the funds available, even if the growth of California's auto population had been accurately predicted, the highways would still have been saturated faster than they could be rebuilt or corrected.

All four departments indicate that the highway safety criteria contained in the AASHO-prepared Yellow Book [31], although fine in theory, cannot be implemented overnight, and that spot improvement criteria must fit local geographic, economic, and social conditions. New Hampshire highway engineers ask whether the standards now considered desirable might not be rejected as out of date in another decade, after considerable expenditure to implement them, because of changes in automobiles or traffic patterns.

According to highway engineers of the four states, the errors decried in medians, guardrails, slopes, bridge abutments, and sign posts on the Interstate were made under pressure to get the system completed in the face of rising costs [41]. In Colorado the urban elements of the Interstate System were completed first, after acquiring only 200 feet of right-of-way instead of the now-standard 300, resulting in bridges that are too narrow and abutments that are too close to the

roadway. In Michigan, median design and width of slopes were modified to fit drainage problems and still stay within budgets. The New Hampshire budget limited the breadth of slopes through mountainous areas, and hazardous features of guardrail and signpost design were not really noticed until the accident pattern growing out of higher speeds began to develop.

Most significant of all, maintenance costs on the Interstate System, originally predicted as low, began rising alarmingly [7, 41, 42]. Because the states are responsible for all Interstate maintenance, the Bureau of Public Roads' contention that correction of Interstate hazards fell into the category of maintenance led to delays and squabbles. In Michigan, for example, inability to decide the state and county shares of costs for median guardrails along high accident-rate sections of I-94 between Ann Arbor and Detroit held up installation. The Bureau's recent policy change, making available 90-10 money for "correction of design errors" on the Interstate System [18] and crediting portions of these projects to the states as safety improvements, provided the safety element is so identified when the project is submitted for approval, has benefited all four states in making such major Interstate improvements.

Obviously, the federally sponsored Spot Improvement Program made all four states more conscious of highway hazards and caused them to expand their own programs, however large they had been, under threat of loss of federal-aid apportionments. However, all four states have found it more feasible to use state funds on small spot improvements and to reserve federal aid for large projects or new construction.

COUNTY SPOT IMPROVEMENT PROGRAMS

The highway system as established within each state determines the existence of county spot improvement programs. New Hampshire, as has been noted, has no county roads, and Colorado's county roads are outside the Federal-Aid Highway System. The counties make spot improvements on their own roads as they see fit, out of the total funds apportioned them from the state's Highway User Fund. The Colorado State Highway Department is available to advise them on whatever spot improvement programs exist at the county level.

The road nets of the 83 counties of Michigan, in contrast, all include portions of the Federal-Aid Secondary System [4]. Just as for normal Federal-Aid Secondary construction and maintenance, counties make spot improvements under the supervision of the State Department of Highway.

As with other federal-aid secondary projects, and as authorized by the 1954 Federal-Aid Highway Act [43], the Bureau of Public Roads, because of its limited field staff, has delegated to the Michigan State Highway Department responsibility for reviewing and supervising secondary spot improvements and ensuring that the required administrative procedures, preliminary engineering, and competitive bidding are performed [44]. When a job is completed, the Bureau of Public Roads conducts an "inspection in depth," a detailed, sheet-by-sheet analysis of all the paperwork, followed by a site inspection [45].

Two Michigan counties, Washtenaw and Jackson, were selected for examination of their spot improvement programs. Each county has had such a program for several years and has an annual total highway budget of approximately two million dollars. Washtenaw County receives about $73,000 and Jackson County

about $84,000 in annual federal-aid money. Each county spends about $45,000 annually on spot improvements—over 50 percent of the federal aid received. However, both follow state highway department advice and use only their own funds on spot improvements [40]. Each county spends about one-third of its annual budget on new construction and about two-thirds on maintenance, the latter including the amounts spent on traffic-control devices and spot improvements. Both counties have small staffs which are overworked or unqualified for extensive administration, so they find it best to do small projects with county money and to create a bank of federal-aid money for major projects. For example, Jackson County recently completed a $405,000 project with a three-year accumulation of federal-aid and county money set aside specifically for this project.

Officials of both counties said they prefer to do most of their own maintenance, including spot improvement work, to avoid the high cost of letting contracts for small projects. The counties could obtain federal aid without letting competitive bids, but detailed records and data would be required to show that the county cost of doing the project was in line with competitive bidding [44]. The detailed procedures required if a county uses federal aid can be expensive. For example, Jackson County officials described a $300,000 construction project which required $1,000 worth of asphalt paving. The material was hauled in three truckloads from an electronically operated plant which loaded fixed batches with a maximum variation of ±100 lb/truckload. Because no weighmen certified the loads before the trucks moved off, months of justifying explanations and valuable staff time were required to obtain Bureau approval. Paying an additional $400 in salaries to have a weighman certify that the loader poured $1,000 worth of asphalt would have cost less than the paperwork.

Both counties have submitted to the State Highway Department their inventories of hazardous locations on the Federal-Aid Secondary System. Jackson County's inventory includes projects varying in cost from $75 to $90,000, totalling about $175,000.

In each county, hazardous locations are identified by accident frequency. Each County Engineer receives a copy of every accident report from the County Sheriff's Office. The accidents are then pin-plotted on a map to determine high accident-rate locations. Correction priority is determined by informal analysis, tempered by public reaction. Each county is trying to maintain before-and-after accident records for a minimum of one year. Jackson County's accident records are well detailed, even including collision diagrams. However, many counties in Michigan do not have the staff to maintain such records. Washtenaw and Jackson County engineers believe it will require two or three years of study to understand fully the effect, if any, of engineering improvements on the accident rate.

Washtenaw and Jackson Counties have completed the previously discussed inventory of signs and signal devices required of each state by Bureau Instruction Memorandum 21-15 [see Appendix II]. However, the updating of signs and signal devices to conform with the Manual on Uniform Traffic Control Devices will take time and money. Signs on county roads are numerous and expensive, therefore are replaced only as they deteriorate. In Jackson County, the cost of upgrading stop signs alone is estimated at $50,000. Repainting every center line in Jackson County once a year would cost $90,000; this is one reason why some blacktop roads are not centerlined. At present, when signs, signal devices, or markings are replaced, each county applies the latest standards of the Department of State Highways.

Both the Washtenaw and Jackson County engineers said the criteria and standards in the AASHO Yellow Book [31] are not attainable in their counties in the foreseeable future. Most of the county road system, whether Federal-Aid or not, is limited to a 66-foot right-of-way, typical of roads in states which were settled by the division of public lands. There is little or no public or private interest in extending the right-of-way just to remove trees or to level slopes to one on six. Even if there were, funds are not available under the present user-tax structure.

Legal and other social conditions are also unfavorable for application of Yellow Book standards, e.g., growing crops right up to the intersection boundary is not illegal. In Washtenaw County, standing corn which blocked visibility at intersections was cut back through the personal cooperation of crop owners with the County Engineer. However, attempts to remove sight-blocking roadside brush with defoliating chemicals aroused the opposition of nature lovers. Moreover, county residents appear to be more interested in obtaining maximum miles of blacktop per tax dollar than in safety. Residents claim that they know their road system and that visitors and through traffic should slow down and watch out for roadside hazards.

THE DISPUTE OVER SAFETY STANDARDS FOR SECONDARY ROADS

The most controversial part of the spot improvement program has been its application to the Federal-Aid Secondary System. At both state and county levels, it has been attacked as impractical [46, 47]. The Special AASHO Traffic Safety Committee intended their Yellow Book to provide guidelines for the states to use, where practical, to improve highway design standards and safety. It appears, however, that the Department of Transportation felt that these guidelines, as approved by the Bureau of Public Roads, offered a means to deflate increasing criticism of highway hazards issuing from the Blatnik Committee [29, 48]. However, when the Bureau of Public Roads issued Instruction Memorandum 21-11-67 of 19 May 1967 [see Appendix II], declaring that the Yellow Book guidelines were in fact required standards for all future construction on the Interstate, Primary, and Secondary Systems, the reaction among the states, particularly at the county level, was consternation and confusion [47]. During the summer of 1967, construction and repairs on the Federal-Aid Secondary System almost came to a halt in many states [46, 49].

A study of the Yellow Book indicates that its recommendations apply mainly to the Interstate and Primary Systems. Very little, if anything, is said about county or secondary roads, though it is known that many highway accidents (probably an undue portion) occur on secondary roads. Failure of the Bureau of Public Roads to coordinate the Yellow Book with the Board of County Consultants and the National Association of County Engineers, the people who are largely involved in the Federal-Aid Secondary System, also appeared to cause resentment [47]. The 29 June Addenda [see Appendix II] to Instruction Memorandum 21-11-67, in which the Bureau of Public Roads advised that Yellow Book standards applied, where practical and feasible, to those Secondary roads with an average daily traffic of 750 and a design speed of 50 mph or greater, did not lessen the furor.

During the annual AASHO meeting at Salt Lake City, 16-20 October 1967, no subject was more hotly discussed than the Yellow Book standards and their application to secondary roads. While the fifty state highway departments seemed unanimously to accept the Yellow Book criteria as urgently needed for the Federal-

Aid Interstate and Primary Systems, they just as unanimously agreed that applying them to the Secondary System was unrealistic and economically impossible.

A typical reaction was that of E. P. Gilgen, Secondary Roads Engineer, Utah Department of Highways:

> Utah, which receives a little over $3 million annually for 3,906 miles of Federal-Aid Secondary, by spending the required minimum equivalent 50 percent, or $1.5 million, on spot improvements, could not possibly raise the Secondary System to "Yellow Book" standards, especially in view of the rising costs of highway construction. Therefore, Utah believes more practical and reasonable standards must be applied to the Secondary System.

Frank Virr, speaking for Kansas, said:

> Kansas has 21,580 miles of Secondary roads, of which only 2.7 percent carry traffic volumes in excess of 750 vehicles per day. If the original criteria of the Yellow Book standards applied, it would be economically impossible to improve the whole system. Instead, Kansas has design standards for Secondary highways of low volume which it is felt are perfectly adequate for the time being [51].

B. C. Goode, Chief, Bureau of County Aid, Alabama Highway Department, summed up majority attitudes:

> Alabama is just as anxious as any state to improve its roads and reduce highway accidents, but everyone seems to forget the original purpose of these roads—farm-to-market. As far back as 1954, the Alabama Highway Department, along with other State Highway Departments, adopted what were called minimum design standards for county roads, based on their current and anticipated traffic figures. Admittedly, the forecasting was inaccurate, particularly in Alabama, where some of these roads are now used by people who work in industrial plants located in rural areas. Limited as these standards are, the Bureau of County Aid has had to push constantly to get county governing bodies interested in making county roads safer for the motoring public. Making it mandatory that a certain percentage of Federal funds be spent on the Federal-Aid System for safety projects has helped us overcome much of this resistance. However, even though all the Yellow Book design criteria are excellent and should be adhered to closely where they can be economically justified, where is Alabama going to get the funds to manicure the entire roadway from right-of-way line to right-of-way line? Is Alabama, primarily a rural state, expected to spend all of its gasoline and excise tax revenue on "x" miles of roads to take care of drunken drivers, drivers who are fatigued, drivers who do not care about checking their cars against mechanical failure and tire failure, and drivers who do not use common sense on the highways? With reasonably good design the state could build "x" plus "y" number of miles of needed highways for the same cost, and probably eliminate more fatalities. To obtain one-on-six slopes in Alabama takes an average minimum right-of-way of 80 feet, but this requires getting considerably more costly right-of-way, more expensive clearing and grubbing, more costly erosion control, more costly drainage structures. Although we regret to see a single life lost

needlessly, we cannot finance the extremes in design standards of the AASHO Yellow Book on our Secondary System [52].

S. E. Farin, Seventh Regional Federal Highway Administrator, in discussing the federal interest in rural roads, pointed out that County Engineers attending the July National Association of County Engineers meeting in Detroit discussed the application of the Yellow Book to the county Secondary Systems [43]. Also, the Bureau of Public Roads Board of County Engineer Advisors attending this meeting were asked to give their impressions as to where the standards would be "feasible" and "practicable" on the Secondary System, and each state was requested to amend its secondary road plans to include the features of the Yellow Book "to the maximum extent practicable and feasible" in the design of federal-aid secondary projects "whereon the average daily traffic is at least 750 vehicles at time of submission of program request and the design speed for the project is 50 mph or greater."

He also pointed out that, by law, the Bureau's dealings are with the state highway departments and, by law in most cases, the highway departments must certify that secondary projects were selected in cooperation with appropriate local officials and the public.

It appears that part of the argument over improving secondary roads has its roots in United States history. A century ago, less than 25 percent of the population lived in urban areas, and 75 percent on farms. Today, on the contrary, the urban population is better than 75 percent of the total, and still rising. While in the past there was strong emphasis on the rural road program to get the farmer out of the mud, there is now increasing emphasis on expanding the urban road and street programs.

Shifts in population and program emphasis are accompanied by a shift in the tax base, which in turn is eventually reflected in the apportionment procedures used by all states in allocating highway funds. These shifts are bound to have considerable effect on the amount of funds available for the secondary road system [39]. Meanwhile, rural residents want to get all the hard-surface mileage possible while funds are available [53].

URBAN SPOT IMPROVEMENT PROGRAMS

Federal implementation of the Spot Improvement Program in urban areas is limited to the Urban Extensions of the Federal-Aid Primary and Secondary Systems, which in most towns and cities comprise only a small part of the overall system of streets and roads [1]. Because the principal function of the Federal-Aid Urban Extension is to expedite the flow of through traffic in urban areas, spot improvements on Federal-Aid Urban Extensions are more likely to occur at intersections with high accident rates [54]. Usually these intersections also have high traffic volumes and additional traffic complications due to adjacent commercial enterprises. Typical spot improvements include directional channelization, lane and edge-line marking, signalization, additional traffic lanes, left-turn lanes, lighting and signing modification, and construction of medians, grade separations, and turning loops. The state highway department or the county road commission normally programs spot improvements on the Federal-Aid Urban Extensions, on which they also maintain surveillance and keep accident records [54]. However, the type of spot improvement to be made is usually coordinated with the urban jurisdiction concerned, particularly if it is a large city.

When approved by the Bureau of Public Roads, an urban spot improvement project, like any other federal-aid project, is the responsibility of the state highway department, although a county road commission or the urban government concerned may do the construction. The community involved pays part of the state or county matching funds as determined by local laws, policies, or agreements.

The highway departments of Michigan, New Hampshire, Colorado, and California have undertaken numerous spot improvement projects on their Federal-Aid Urban Extensions, particularly on U. S. 24 through Detroit, U. S. 3 through Manchester, U. S. 36 through Denver, and U. S. 50 through Sacramento. Such projects or programs should not be confused with the previously discussed TOPICS program, under which federal aid is authorized for selected city streets or roads not on the Federal-Aid Primary or Secondary Urban Extensions but feeding directly into them. TOPICS projects include route marking, lane and edge marking signalization, and channelization. While contributing to safety, their main purpose is to expedite traffic flow into the Primary and Secondary Systems [21]. To be eligible for aid under the TOPICS program, a community must have completed an urban transportation study and have a fully integrated urban transportation program, which includes the proposed TOPICS projects. As was previously pointed out, no city as yet has contracted for any TOPICS projects.

SPOT IMPROVEMENT PROGRAMS ON FEDERAL ROADS

When the Federal-Aid Spot Improvement Program was launched, the Bureau of Public Roads initiated a program for highway safety improvements on those federal roads under the National Park Service, the Forestry Service, the Corps of Engineers, the Bureau of Reclamation, TVA, etc., by requesting that they initiate projects for roads under their jurisdiction. These agencies get copies of all Bureau memoranda. Coordination is accomplished through a Federal Projects Division in the Bureau's Office of Engineering and Operations.

Although these other federal agencies have been urged to program safety projects, the status of these projects is not known, according to Bureau personnel, because no reporting is required. Usually, however, federal agencies responsible for highway construction coordinate design standards with the Bureau's Regional or District Engineer. Generally, the Bureau Division Engineer will arrange for the work to be done. For example, in Michigan the Bureau Division Engineer, when requested by the Forestry Service, engages private contractors to do construction on forest roads, and also pays the Michigan Department of State Highways to do the engineering and job inspections.

Because of the small amount of funds available ($400,000 annually for forest roads in Michigan), it is assumed that spot improvements on these roads are a part of normal maintenance.

FIELD ACTIVITIES OF THE BUREAU OF PUBLIC ROADS

The Office of the Bureau of Public Roads Division Engineer in Lansing, Michigan, was contacted to learn the procedures and administrative actions required for approval of a state spot improvement program. The Bureau Division Engineer deals directly with the state highway department in all matters relating to the Federal-Aid Highway System and supporting programs.

For spot improvement projects on the Federal-Aid Primary System and its Urban Extension, the state highway department must submit detailed plans and engineer cost estimates, just as for normal construction projects. The highway department must detail the entire project, showing the location of the hazard, the correction to be made, the cost, and, on a major construction project, what part is specifically related to safety. Urban spot improvement projects must be on an Urban Extension of the Federal-Aid System within communities of 5,000 or more. It is up to the state to work out with the community its share of state matching funds. All of this admittedly consumes the state highway department's time and money. Federal funds are obligated only after final approval of the plans. The Bureau Division Engineer makes a preliminary inspection of the site, inspections during construction, and a final inspection upon completion of the project.

Once a project is approved, Title 23 authorizes the state to let contracts as provided for in state laws. According to Bureau personnel, this is a routine matter in Michigan, but it can be complicated in some states. Illinois law, for example, permits a city, a county, or the state to prepare plans and let federal-aid contracts. Yet, the Bureau must deal exclusively with the highway department.

As was previously mentioned, the Michigan Department of Highways has the responsibility for reviewing a secondary project in detail to ensure that it is a safety project, that it is so noted on the required forms, and that the project meets justification requirements. These tasks are particularly difficult for Secondary projects in those counties which have not kept adequate accident records for the many locations where accidents occur. Accordingly, the Bureau Division Engineer Office tends to be lenient regarding justification for a county Secondary project. Bureau approval of the project means automatic obligation of funds. After approval, the Highway Department supervises contract performance and makes site and construction inspections; the Bureau Division Engineer makes only a final inspection when the project is completed.

According to the Bureau Division Engineer, most projects submitted by Michigan are legitimate and worthwhile. A few fall into a gray area of maintenance. The Yellow Book standards have required considerable revision of safety-design criteria, raised cost estimates, and introduced delays. While the Bureau Division Engineer urges that the standards aimed for be met, he has to use judgment in determining their attainability locally.

Division personnel doubt that Michigan can at this time implement Instruction Memorandum 21-3-67, 1 February 1967, "Selection of Highway Safety Improvement Projects," which calls for identifying hazardous locations and establishing improvement priorities by a benefit-cost analysis. This is complicated and requires a much better history of accidents than now exists. A re-examination of the Michigan spot improvement inventories already submitted will delay completion of the program. In their opinion, the Department of State Highways now has neither the personnel nor the accident-report data to make the review required. Certainly none of the 83 counties, except possibly Wayne, could undertake such a task.

Regarding the complaints of delays, expense, and paperwork required to get safety projects approved, Division Office personnel cited the need to be ready for detailed justification of expenditure of federal funds as required by federal law because the General Accounting Office, if it investigates, is prone to make political capital of any errors or poor judgment exercised in authorizing federal funds.

Members of Division Office realize that a shortage of trained administrative personnel at both state and county levels also complicates matters. Therefore, they understand that the time and money required to get projects approved often determine whether the state and the counties decide to do the job with their own funds.

THE PROGRAM AS CURRENTLY VIEWED BY THE BUREAU OF PUBLIC ROADS

As of 30 September 1967, the states had reported a total of 9,353 highway safety improvement projects which totalled $758,206,000 in costs, according to a Bureau of Public Roads internally distributed Quarterly Status Report [55], 6,176 projects were entirely state-funded at a cost of $195,655,000. 3,177 were federal-aid projects, costing $562,551,000, of which $275,327,000 was federal-aid money and $287,224,000 came from state funds. A breakdown of the federal-aid projects by state is given in Chart II.

The 6,176 state-funded projects average $30,000 per project, and the 3,177 federal-aid projects average $177,000 each [55]. This difference reflects the fact that state-funded projects are small and major projects are reserved for federal-aid financing.

The participation rate for federal-aid spot improvement projects is now at a level of 8.7 percent. The Bureau defines participation rate as the percentage of all federal ABC apportionments spent for spot improvement plus an equal amount of state matching funds. If all state-funded and federal aid projects are combined, the participation rate is 11.7 percent. The Bureau's goal is 25 percent for all states.

This status report was the first to include a total for entirely state-funded projects [55]. However, the Bureau did not break it down state by state because not all states have reported, and a comparison of states was therefore considered unfair. It is expected that more information will be available in future reports.

As the above figures indicate, the program has reached a level of over three-quarters of a billion dollars. The average cost per project has dropped from $188,000 in fiscal 1966 to $177,000 in fiscal 1968 [55]. The Bureau attributes this to increased awareness of the need for cost-benefit analysis.

Which states are leading and which are lagging in the program is not yet known by the Bureau. To determine this would require evaluation by Regional and District Engineers. Examination of Bureau figures indicates the states vary in the number of federal-aid projects they have completed or have programmed, but the Bureau does not know the quality of these projects.

For example, as of 30 September 1967 [see Chart II], Kansas had programmed the largest number of projects (233) at a total funding of $23,527,000, whereas Ohio had programmed 71 at almost the same funding, $23,637,000, and Illinois had programmed the most money, $69,825,000—about three times as much as Kansas, for 204 projects. Bureau personnel said that this lack of spot improvement criteria was one factor that led to approving the Yellow Book recommendations.

The Bureau, it was said, recognizes that geography and lack of funds limit the correcting of all highway hazards; hence the need for establishing priorities. In the opinion of the Bureau, not all hazards require a geometric change in the highway. Speed reductions, restrictions on type vehicles allowed, or proper marking and signal devices will often suffice. But first the states must find out just what is happening and where.

CHART II. HIGHWAY SAFETY IMPROVEMENT PROGRAM: FIRST QUARTER, FISCAL YEAR 1968. From Highway Safety Improvement Projects for First Quarter FY 68, Bureau of Public Roads, Washington, D. C., November 7, 1967.

REGION	STATE	No. of Projects			Total Costs (Thousands)	Federal Funds (Thousands)	Cost/Project (Thousands)	Part. Rate
		Total	Current	Closed				
1	CONNECTICUT	38	38	--	5,948	3,683	157	9.5
	MAINE	40	39	1	5,223	2,656	131	11.1
	MASSACHUSETTS	55	55	--	6,772	3,414	123	5.9
	NEW HAMPSHIRE	33	33	--	13,109	4,476	397	43.0
	NEW JERSEY	11	11	--	859	430	78	0.7
	NEW YORK	50	47	3	15,904	7,443	318	4.1
	RHODE ISLAND	14	14	--	1,418	967	101	3.9
	VERMONT	8	7	1	1,621	802	203	5.8
	PUERTO RICO	3	3	--	1,356	648	452	2.9
	Region 1	252	247	5	52,210	24,519	207	5.9
2	DELAWARE	37	37	--	2,465	1,312	67	8.3
	MARYLAND	5	5	--	2,504	1,302	501	3.1
	OHIO	71	71	--	23,637	7,773	333	8.8
	PENNSYLVANIA	1	1	--	581	523	581	0.2
	VIRGINIA	12	12	--	2,498	1,381	208	1.8
	WEST VIRGINIA	31	31	--	8,259	4,845	266	12.0
	DIST. OF COL.	27	27	--	2,027	1,200	75	5.5
	Region 2	184	184	--	41,971	18,336	228	4.6
3	ALABAMA	91	89	2	11,770	5,567	129	8.9
	FLORIDA	31	27	4	5,546	3,286	179	3.7
	GEORGIA	66	66	--	4,417	2,748	67	2.8
	MISSISSIPPI	144	143	1	16,939	8,564	118	16.2
	NORTH CAROLINA	30	30	--	4,393	2,306	146	2.7
	SOUTH CAROLINA	60	57	3	8,071	4,201	134	9.2
	TENNESSEE	104	100	4	35,718	18,036	343	25.6
	Region 3	526	512	14	86,854	44,708	165	9.3
4	ILLINOIS	204	202	2	69,825	30,147	342	23.9
	INDIANA	107	107	--	21,248	10,330	198	13.5
	KENTUCKY	28	28	--	4,133	570	148	3.6
	MICHIGAN	69	65	4	11,092	4,761	161	4.7
	WISCONSIN	99	99	--	13,879	6,521	140	8.9
	Region 4	507	501	6	120,177	52,329	237	12.6
5	IOWA	102	98	4	11,191	5,724	110	7.7
	KANSAS	233	206	27	23,527	11,400	101	17.1
	MINNESOTA	198	166	32	27,463	12,146	139	16.5
	MISSOURI	75	72	3	21,307	10,768	284	11.6
	NEBRASKA	104	82	22	4,577	2,741	44	4.5
	NORTH DAKOTA	82	79	3	8,465	3,425	103	11.3
	SOUTH DAKOTA	69	61	8	10,711	5,302	155	14.9
	Region 5	863	764	99	107,241	51,506	124	12.2
6	ARKANSAS	20	20	--	6,682	3,007	334	7.2
	LOUISIANA	34	34	--	19,366	10,369	570	17.5
	OKLAHOMA	176	173	3	41,828	16,939	238	32.8
	TEXAS	109	79	30	33,844	19,641	310	8.2
	Region 6	339	306	33	101,720	49,956	300	13.7
7	ARIZONA	18	16	2	7,592	4,940	422	13.5
	CALIFORNIA	28	28	--	2,202	1,894	78	0.6
	NEVADA	26	19	7	5,682	4,850	219	16.8
	HAWAII	14	14	--	2,461	961	176	7.6
	Region 7	86	77	9	17,937	12,645	209	3.8
8	IDAHO	16	16	--	456	315	29	0.9
	MONTANA	139	137	2	5,643	3,382	41	6.4
	OREGON	26	21	5	1,719	1,194	66	2.3
	WASHINGTON	55	41	14	7,647	3,851	139	7.6
	Region 8	236	215	21	15,465	8,742	66	4.9
9	COLORADO	75	58	17	11,818	6,829	158	12.6
	NEW MEXICO	28	23	5	1,132	862	40	1.7
	UTAH	29	29	--	1,868	1,532	64	6.0
	WYOMING	30	29	1	1,609	1,072	53	3.5
	Region 9	162	139	23	16,427	10,295	101	6.9
10	ALASKA	22	22	--	2,549	2,291	116	1.7
	TOTAL	3177	2967	210	562,551	275,327	177	8.7

Bureau personnel stated that, until recently, accident reporting at the national level was very inaccurate. Accordingly, they did not know where most accidents were occurring. For example, some states reported as Interstate or four-lane Primary System accidents only those which occurred on the roadway. Others reported as Interstate System accidents those that occurred on frontage roads paralleling the system or on access roads leading to it. Many states do not yet have a milepost system for pinpointing accident locations, but all are at least programming or planning for one as soon as funds are available.

According to the Bureau, state economic conditions do not always indicate progress in highway safety. West Virginia, for example, was said to have a very fine central records system and was the first state to send in its inventory. Some states which have had spot improvement programs for years, e.g., California, submitted unusually good inventory lists. Now all state highway departments have at least a planning organization, and the spot improvement program has caused them all to realize the need for accident-data research and analysis.

Originally the Bureau held that the spot improvement program did not apply to the Interstate System, and that safety work on the Interstate was "correction of hazards due to failure to meet design criteria." It was assumed that the basic design concepts for the Interstate System were safe. The considerable variation among the states in building medians, guardrails, barricades, and slopes, as well as in locating signposts, light posts, and bridge abutments on the Interstate, was viewed as a failure of the states to require contractors to meet specifications and therefore something which the states themselves had to correct. In a recent policy change [18], the Bureau approved the use of 90-10 money for projects to "correct design errors" on the Interstate System.

Some states, say Bureau personnel, originally expected that highway hazards could be eliminated by one concerted drive. Now all states recognize that safety improvement results only from constant surveillance of highway and traffic conditions, reviewing of accident reports to see where hazards exist, and then determining, by a benefit-cost analysis, what corrections to make in what order with the money available. The Bureau is trying to tell the states that an effective highway safety improvement program requires a sophisticated surveillance system and adequate accident data. The Bureau is also hoping that the states will apply the safety improvement program to their entire road net, not just the Federal-Aid System.

TECHNICAL ASPECTS OF THE SPOT IMPROVEMENT PROGRAM

METHODOLOGIES USED

The determination of hazardous locations and ways to improve road conditions in order to reduce accidents is far from an exact science. Nevertheless, an evolving methodology is being practiced to a varying degree among the states.

Highway locations are normally categorized as a specific point on the highway, the intersection of two or more highways, or a length or section of highway. Highway and traffic engineers define a point as one-tenth of a mile or less, and a section as over one-tenth of a mile of highway, wherein highway geometrics and cultural and economic features remain constant.

Hazardous locations have often been identified simply by public or private reaction to a spectacular accident or one involving prominent or influential citizens. This unscientific method of identification can be decisive, particularly when news media or political leaders take an interest. In several states, including Michigan and New Hampshire, highway department officials admitted that public opinion does influence the programming of some spot improvements.

Of the recognized rational identification methods, the simplest is to tally the total number of accidents at a specific location to date or during a given period of time [56]. If this number is larger than the number of accidents which occurred at similar locations, or if it exceeds a defined minimum, the location is classified as hazardous and singled out for correction.

A more significant method of identifying hazardous locations is the accident rate expressed in terms of total vehicles passing versus total accidents occurring at a spot, or in terms of vehicle miles versus accidents for a section. Accident rates in excess of a selected cutoff rate identify the location as hazardous.

Another method is the number-rate, a procedure in which the sum of the total accident count and the accident rate is compared with an established criterion to identify the location as hazardous.

The rate quality control method is similar to the accident rate method, except that the location is considered hazardous only if the accident rate is significantly greater than the mean accident rate for similar sections or locations within the entire state or jurisdiction.

A theoretically more advanced method is a mathematical formula which includes such factors as traffic volume, number of lanes, and type of accidents.

The most sophisticated method is correlation of circumstances. This is a computerized approach involving continuous analysis, taking into account past experience with similar accident locations and changes in environment or driver habits.

As was pointed out earlier, the federal spot improvement program initially proposed very broad criteria for identifying hazardous locations, namely, a concentration of accidents at a location, a record of accident concentrations at similar locations, research findings, or engineering judgment. In 1966, however, after the program had become established and all states had substantially listed their hazardous locations, the Bureau of Public Roads contracted with Roy Jorgensen and

Associates to study the spot improvement program and to develop better criteria for identifying and priority-rating hazardous locations, forecasting results that might be obtained, and determining the costs of improvements which could reduce accidents [56].

The recommendations of the Jorgensen study were incorporated into Instruction Memorandum 21-3-67, 1 February 1967, "Selection of Highway Safety Improvement Projects." [See Appendix III.] This memorandum outlines two methods for identifying hazardous locations, number rate and rate quality control, the latter preferred. In either method, hazardous locations must be pinpointed by a milepost ing system and must be identified by the incidence of accidents during a minimum period of one year.

After hazardous locations are identified, priorities for correction are determined by a benefit-cost analysis. The memorandum provides the formulas for this analysis which includes such project costs as right-of-way, construction, drainage, appurtenances, annual maintenance, and capital recovery based on expected project life, all totaled and compared to the benefit or saving in the cost of accidents prevented. In computing costs of accidents, the memorandum uses National Safety Council estimates of average costs as follows:

Fatality	$34,400
Injury	1,800
Property damage	310

The Bureau of Public Roads expects all states to use this benefit-cost method of analysis in selecting and programming spot improvements unless they have a system that is equivalent or better. So far, it appears that only a few states are able to or are trying to implement the Bureau's methodology. Reportedly Ohio, Illinois, and Idaho imploy the number-rate or quality control method [19]. However, in discussions, Jorgensen has said that, in his opinion, only California, Pennsylvania, and Connecticut have the necessary accident statistics to implement either method. Because many states are financing their spot improvement programs without federal aid, they apparently have considerable freedom regarding the methodology used.

California (whose research efforts and data on spot improvements were extensively incorporated into the Jorgensen Study) currently employs an interesting alternative method described as the "number of accidents versus the cost of the safety project" method. California highway personnel believe that they have a simple system based on cost per accident reduced. Specifically, detailed accident reports are fed continuously into a computer system. A monthly printout listing accidents and accident concentrations by Engineer District, route number, and milepost location provides: (1) "a summary of all accidents during the calendar year," (2) "a summary of all accidents for each 0.01 miles," (3) an "indication of accident concentrations for each 0.1 miles," and (4) the ADT at each location. Three accidents or more per 0.1 mile/year is the signal for a detailed investigation of the location by the District Engineer concerned to determine whether highway conditions are a factor [57]. The location also appears on a quarterly printout of locations with high accident concentration, identified by route number, function (ramp, intersection, etc.), and accident type and rate, in decreasing order of frequency, in order to facilitate further observation and study. Depending on the findings of the District Engineer, the location is entered on a Division of Highways

Status Report, together with recommended improvements. This Status Report is continually reviewed; after the last entry has been made, signifying completion of improvements, post-correction surveillance is maintained for a year.

In order to determine the type of improvement to be made, the Division of Highways performs a benefit-cost analysis. However, California uses cost-of-accident values different from those contained in the Bureau of Public Roads Instruction Memorandum. Beginning with figures that Illinois derived in 1958 on the direct costs of accidents, California developed its own techniques for determining accident costs and for deciding whether to program spot improvement projects [61]. (Direct costs are the money value of damages and losses to persons and property, that is, a reasonable estimate of the cost of traffic accidents to society. The considerably larger National Safety Council cost estimates include such indirect costs as the estimated loss of future earnings of persons killed or permanently disabled.)

The Illinois figures are the average direct costs for vehicles involved in various categories of accidents. California went further and estimated costs of accidents on the basis of the number of vehicles involved per accident in California's rural and urban areas, then updated cost values to 1964 prices. In the process, California found that more vehicles were involved but fewer persons were killed and injured per accident in urban than in rural accidents, and that, numerically, more people were killed and injured per accident in freeway accidents than in accidents in urban areas [58]. As a result, California now uses for benefit calculations the average costs of accidents shown in Chart III [58].

Chart III. COMPUTED AVERAGE COSTS OF ACCIDENTS: CALIFORNIA

Area	Cost per Reported Accident			
	Fatal	Injury	Property Damage Only	All
Rural	$9,700	$2,600	$800	$1,800
Urban	7,700	2,100	600	1,200
Total	$9,000	$2,300	$700	$1,400

These include the cost of both reported and unreported accidents and are the unit costs per reported accident. Cost values for reported accidents only and for reported single and multi-vehicle accidents have also been derived [58].

In computing benefits, an estimate is required of the accident reduction expected to result from a proposed project. This estimate can be made by examining past accident reports to determine the percentage of accidents susceptible to correction, or by using the average percentage accident reduction yielded by similar types of improvement projects. Accordingly, California has analyzed and evaluated many types of spot improvements to determine what effect they have on accident reduction [59]. For example, in a before-and-after study of 45 flashing beacon projects, it was found that 75 percent of these installations were followed by reduced accident rates (although not all reductions were statistically significant) and 25 percent by an increase in accidents. However, the flashing beacons studied effectively reduced accidents by 80 percent at railroad crossings, 40 percent at intersections, and 20 percent of advance-warning beacon installations, for a combined average of 30 percent reduction. Assuming a 20-year life for a flashing

beacon, the cost reduction per accident averages about $38.00 [59]. In other before-and-after studies [59] [see Appendix IV],California has analyzed the cost of and the results obtained from safety lighting, left-turn channelization, delineation, guardrails [36], and pavement grooving or serrating [37].

As a brief example of the California method, assume that a signalized intersection with a high accident rate is being considered for left-turn channelization at an estimated total construction cost of $19,000. The accident record from 1 January 1964 to 30 June 1966 shows a total of 11 accidents, none fatal, of which four involved injury and 7 property damage only, with a yearly average of 4.4 accidents. The accident reports indicate that many of these 11 accidents involved vehicles turning left. As shown in Appendix IV, the average accident reduction for left-turn channelization at signalized intersections is 15 percent. Assuming a maximum service life of 20 years for the modification, the expected accidents saved = (Accidents/Year) × (% Reduction) × (Service Life) = 4.4 × 0.15 × 20 = 13 accidents. The cost per accident saved is $19,000/13 = $1,460.

To determine whether this project is justified by accident reduction alone, the average cost of accidents in the past can be calculated using the cost data shown in Chart III, which reflect both reported and unreported accidents. For example,

$$\text{Average Cost per Accident} = \frac{4(\$2,100) + 7(\$600)}{11} = \$1,140;$$

therefore, the project would appear to be unjustified.

However, if the accident records showed one fatal and three injury accidents, resulting as follows:

$$\text{Average Cost per Accident} = \frac{\$7,400 + 3(\$2,100) + 7(\$600)}{11} = \$1,650,$$

the project would appear to be justified, since the construction cost per accident saved is $1,460.

Using a cutoff criterion of $1,500, California would list this as a Priority #1 Safety Project. This example illustrates the difference that one fatal accident can make in the conclusions drawn where few accidents are involved. The line between fatality and injury can be obscure, and not necessarily related to inherent danger in the location. The difference may depend on whether or not the vehicle occupant is wearing a seatbelt.

California studies take cognizance of the fact that not all accidents susceptible to correction are indeed eliminated, and some types of project will even increase one type of accident while eliminating or reducing another. For example, installing traffic signals usually reduces right-angle and approach-turn accidents but increases rear-end collisions.

California studies also point out that knowledge is still lacking on what constitutes a good accident record in a specific location [58], or an acceptable one in relation to the least number of accidents to be expected considering such relevant factors as traffic volume, general ability and sobriety of drivers, mechanical safety of vehicles, weather conditions, and traffic conditions at the site. Until such data are available, "average" reduction factors must be used with the understanding that they are just educated guesses.

Finally, California researchers state that since a small number of accidents at a given location can be charged to chance, the question still remains how much the accident rate should be allowed to increase before the figure is considered significant statistically and the hazard corrected. Quite often engineers will be required by social pressures to make changes before a significant figure is reached.

The Michigan Department of Highways has a simpler technique for identifying and assigning priority to spot improvements. Accident records are fed into electronic data processing equipment, and the number method is used to identify accident concentrations within each 0.2 of a mile. Accident-concentration criteria are three per 0.2 of a mile in the Upper Peninsula and northern regions of the Lower Peninsula, and four per 0.2 of a mile in the remainder of the Lower Peninsula, beyond which point the surveillance team investigates, determines causes, and recommends corrections. Then a severity point system is applied to each identified location to determine priority for correction. In the Michigan system one point is assigned for each property-damage accident, three more (for a total of four) for each accident resulting in injury, and nine additional points (for a total of ten) for each fatal accident. A year of observation is required for selection of each location.

Until recently, Michigan highway personnel considered this system to be satisfactory, simple to apply, and more realistic than a formula based on accident-cost estimates. However, they now find their point system does not reflect the difference between some areas where accidents are frequently fatal, and the Detroit metropolitan area, where accidents are numerous but less often fatal. Neither does it respond to the public clamor aroused by fatal accidents, a reaction to which the Department of Highways is sensitive, and which is a serious impediment to the prolonged gathering of accident data required for Bureau of Public Roads methods.

The Michigan Department of Highways, when analyzing the costs versus benefits derived from various types of spot improvements, discovered that sanded asphalt, a skid-resistant surfacing, had lowered accident rates at intersections considerably. The cost of such surfacing is minimal and can be partially charged to maintenance when intersections due for repairs are resurfaced. Michigan is now making many such improvements. The accident reductions obtained by skid-resistance of road sections in both California and Michigan tend to support the theory that many drivers become involved in accidents through inattention or failure to see a looming crisis until it is too late to stop under normal tire-road-friction circumstances. Further research in this area is indicated.

That a supposedly well-thought-out spot improvement can be disappointing as well as costly is illustrated by a New Hampshire Highway Department experience. A work crew, having completed signalization and island channelization at a rural intersection with a high accident rate, stepped aside to observe the timing of the signals. Just then a truck rolled down the highway, jumped the island, and wiped out the entire installation. Later investigation revealed that the driver was excessively fatigued after taking pep pills. Results of this kind are discouraging to highway safety engineers and taxpayers.

All four states reviewed could cite spot improvements with which the accident rate did not change, or even increased—indicating either that the role of the highway as a causative factor was not fully understood, or that the selected "corrections" were wrong or inadequate.

In summary, it appears that only a few states are capable of applying the benefit-cost methodology urged by the Bureau of Public Roads. Methods currently employed by some states are still in a developmental stage and vary greatly in sophistication and successful application. To apply any benefit-cost system successfully to spot improvement requires both understanding of the basic causes of past accidents and knowledge of the results to be expected from various types of improvements.

TECHNIQUES OF URBAN SPOT IMPROVEMENTS

With the possible exception of those urban areas which contain portions of a state or county primary or secondary urban extension which is not part of the Federal-Aid System, the overwhelming majority of urban streets and roads are under the complete control of local governments. Urban street and road systems and traffic patterns vary in response to geographic, industrial, or sociological influences and rate of expansion. However, in all urban areas, the exploding automobile population has compounded the conflicts between divergent demands such as parking convenience, pedestrian freedom of movement, fast public transportation and emergency service, rapid delivery of services and supplies, and avoidance of noisy through traffic, especially truck and bus movement on residential streets.

Amid these turbulent environmental conflicts, urban traffic and civil engineers are expected to keep traffic moving at a moderate rate and provide parking space. Their task is further complicated by urban problems and conflicting economic interests produced by the very presence of automobiles [60], such as distracting and sight-blocking advertising; obstacles in the form of buildings or utility poles; drive-in shops, car washes, restaurants, and theaters on already overcrowded thoroughfares; exorbitant prices for necessary rights-of-way; and insistence on retention of traffic patterns that benefit a few individuals or businesses to the detriment of the rest of the community [60]. Hence, the approach used in spot improvements for urban areas generally differs from that for rural highways. Urban traffic engineers concentrate on traffic operations, i.e., traffic-control devices or methods of assigning right-of-way, rather than on change of road and street geometrics [61].

In large cities generally, traffic engineers have found that sometimes simply painting traffic striping or pedestrial cross-walks helps identify an intersection and reduces accidents. "Stop" and "yield" signs help on occasion; sometimes they do not. According to San Francisco traffic engineers designating one-way streets, eliminating left-hand turns, and rigid control of parking, particularly elimination of angle parking, prove to be more effective [61]. However, these latter procedures often arouse the opposition of local commercial interests [60], and some researchers have noted that one-way streets are in themselves a cause of accidents due to increased speeding [61].

The removal of trees, light poles, curbs, walls, or barriers usually is not considered in making urban spot improvements unless it can be shown that these objects affect the flow of traffic. It is often easier to let drivers pay for collision damage than to fight the interests which control utility poles, signs, or property. For example, it is reported that the city of Columbus, Ohio, charges motorists for knocking down light poles, even though the replacement poles are set further back from the roadway.

Even in the case of new construction, urban traffic engineers will, on occasion, compromise traffic safety (against their better judgment) in order to meet the demands of vested interests. For example, Ann Arbor is constructing a new city parkway which will contain a built-in hazard in the form of a left-turn intersection just beyond the abutment of a major bridge and immediately adjacent to a merging entrance ramp. This arrangement results from pressure not to disrupt the operations of a nearby golf course and racket club. Ann Arbor is not unique in such policies or practices.

Spot improvements by means of changes in traffic operations generally require rigid enforcement of traffic laws to be effective. In contrast to rural traffic operations, failure to conform with local laws controlling vehicle operation is quickly detected in an urban setting. In addition, many cities, e.g., Detroit and Los Angeles, now impose stiff fines on pedestrians for jaywalking or ignoring traffic signals. Such measures can be viewed as extensions of or part of a spot improvement program.

The methodology of programming urban spot improvement projects also differs from that employed on rural roads and highway in the relative significance attached to the accident rate when determining priorities for correction [19]. Detroit, for example, annually identifies the 25 locations with the most accidents. Analysis and investigation then follow to determine traffic volumes and decide what signalization to use. The list is also publicized in the hope that drivers will be more cautious at these 25 locations and thereby help reduce the accident rate. Some of these locations may be on the Federal-Aid Urban Extensions, in which case they may eventually be programmed for correction by the State Highway Department, provided city accident figures coincide with or support the Highway Department findings.

Portland, Oregon, uses electronic data processing [62] to identify annually the ten intersections with the highest number of accidents [19]. However, being in the top ten doesn't guarantee priority for improvement. A signalization priority rating which considers accident experience as only one factor is used to determine where improvements are to be made. Accident reductions are considered a by-product of the regular signalization program.

Phoenix, Arizona, also maintains an annual signalization priority listing which compares intersections by a point system based on the number of reducible accidents, traffic volume, and the split between the major and the minor street traffic volumes [19]. Analysis is then made to determine how many conflict-type accidents, e.g., left-turn, head-on, vehicle/pedestrian, or speeding, can be eliminated by signalization, assuming reasonable obedience to traffic signals by drivers and pedestrians. Only those locations with a high potential for accident reduction by signalization are improved.

Los Angeles, as might be expected, has a very sophisticated computer system for identifying accident concentrations at intersections and in midblock. A detailed list of criteria is used to identify accident concentrations by type and rate (e.g., five or more right-angle accidents during the last twelve months, six or more right-angle/pedestrian accidents during the past three or four years; five accidents involving stop-sign violations during a three- to four-year period; five or more driveway, parking, sideswipe accidents in one location in 12 months). Periodic printouts are made. Priorities for signal installation are then determined.

Ann Arbor, Michigan, like most small cities or towns, monitors accident locations by means of a pin-plot map from which an annual list of the ten highest accident locations is prepared. Observation of local practices showed that this list does not match correction priorities. Instead, the limited funds available for traffic safety improvements have been devoted mainly to signalization and to redirecting traffic through bottlenecks created by two bridges which connect the north and south sides of the city, even though, in so doing, traffic hazards such as limited sight distance, inadequate warning of side traffic, and confusing head-on situations for nonresident drivers have been created, possibly contributing to the overall accident rate.

In approaching urban spot improvements through traffic operations, traffic engineers have made significant progress in getting their cities and towns to adopt voluntarily the criteria and standards contained in the Manual on Uniform Traffic Control Devices. While the results of such standardization are not measurable, it can be assumed that it has had a beneficial influence on the national accident rate, as compared to the situation prevailing twenty to thirty years ago when every urban area had its own system to trip the unwary out-of-town driver.

In summary, it appears that current practice in urban areas is to rely mainly on the side benefits of improved traffic operations (i.e., traffic control and warning devices) to reduce urban accident rates, because of the prohibitive cost and practical difficulty of making geometric modifications.

ACCIDENT DATA AND SPOT IMPROVEMENTS

Execution of all of the aforementioned spot improvement methodologies, whether rule-of-thumb or sophisticated, intuitive or theoretically justifiable, requires a matching system of accident reports and data analysis. Spot improvements can be considered to have four phases, (1) identifying the hazardous location, (2) establishing correction priority, (3) determining what engineering correction to make, (4) following up to see what resulted. Even the simplest systems depend on adequate accident reports, properly interpreted.

There is a sizable literature on accident reporting and its relationship to highway safety in general [63]. For spot improvements, just as for other purposes, the accident reporting system must be a functional one based on geographic location [64]. It must pinpoint the exact location of an accident and accurately describe the conditions under which it occurred, the underlying and the obvious causes, in order that it can be understood in terms of traffic volumes, circulation patterns, and general environmental factors. With this information, the location can be properly evaluated as a comparative hazard [65, 66].

Spot improvement programming also requires a detailed, critical, and continuing survey and inspection of existing urban and rural streets and roads, with special attention to skidmarks, pavement gouges, vehicle debris, damage to roadside facilities, and other evidence of unreported collisions. The survey must include appraisal of existing traffic-control devices for placement, effectiveness, uniformity, legibility by day and night, and maintenance. The survey must particularly include hazards which would trap the inattentive or reckless driver [66].

Researchers point out that the results of such an accident reporting and surveillance system should (1) feed into an automated centralized data source, providing ready access to data required for all purposes, including enforcement,

education, licensing, judicial, engineering, inspection, and research needs, (2) be augmented by supplemental data sources, providing for one of the specific purposes noted, and (3) be available for analysis by those utilizing the data bank of accident records [59, 67]. It appears that only with such a system can highway and traffic engineers effectively review all proposed improvements, new designs, and new traffic conditions for built-in traffic hazards, or evaluate the public's comments and suggestions regarding objectionable design features [66].

All proponents point out that a benefit-cost analysis requires continual post-accident surveillance and followup, generally for a minimum of one year. This followup, if it is to discern the effects of engineering improvements on accident rates, should be accomplished by automatic data analysis which also considers the effects of other factors such as changes in driving habits, automobile safety improvements, or new approaches to law enforcement [59].

Conversations with New Hampshire, Michigan, and Colorado State Highway officials indicated that these states lack the data to implement a sophisticated benefit-cost analysis system at this time. At the county level, it appears the system will continue to consist for some time of pin-plotting accident locations on the county map and noting where large clusters of pins occur. Indeed, inaccuracies and incomplete data in accident reporting prevent application of a benefit-cost analysis by most states. Some researchers estimate that over two-thirds of the states don't have the means to report accurately the two most vital factors in accidents—where and why [68]? Jorgensen, in conversation, expressed the belief that only California, Pennsylvania, and Connecticut have the accident data to implement the methodology he outlined for the Bureau of Public Roads. However, studies indicate that even in California less than 50 percent of all accidents are even reported [69].

In discussing the hoped-for results from the memorandum on methodology, Bureau of Public Roads staff members admitted few states can implement such a procedure now, but they said that the main purpose of the memorandum is to highlight the need for a modern system of automobile accident reporting. The Bureau believes many states now at least recognize this need.

In summary, it appears that researchers, administrators, and practitioners of spot improvement programs all recognize that better systems of accident reporting and data analysis must be developed if spot improvement programs are to attain optimum results in accident reduction.

AREAS FOR RESEARCH AND DEVELOPMENT

The experiences and the progress attained among the four states reviewed in this study indicate that more research is needed in several areas before the program can attain its intended goal of significantly reducing traffic accidents on the nation's highways. The research areas listed are not new, and in fact have been under investigation for some time. However, some of the research has been criticized as unproductive and lacking in new approaches and new ideas [70].

The inadequacy of accident reports as they currently exist has already been pointed out. It is urgent that better ways be found to determine what happened in accidents. Of the driver it must be known not just whether legally he was at fault or failed to yield, but what were his mental and physical state, his driving abilities, his observations, impulses, reactions, decisions, and successes or failures in maneuvering the vehicle. Regarding the vehicle, more information is needed on

design characteristics, makes, models, age, mechanical condition, limitations, and function failures and successes. More detailed information about the highway is needed, such as the type, quality, and characteristics of pavement, condition of maintenance, design characteristics which would limit maneuvers for either vehicle or driver, the presence of obstacles or debris, skid-marks, etc. The environment needs to be described more precisely to include weather conditions, especially gusty winds, visibility, illumination, precipitation, ice, and wetness.

A corollary to the need for research on accident-reporting methods is the need for research on the problem of selecting and training accident investigators. What, for example, should be the basic qualifications of an accident investigator? How can investigator training be standardized? How can the researcher, when determining accident causes from reports, assess individual investigators for objectivity, knowledge, skill, available technical aids, or time of arrival at the accident scene?

It appears that the problem of data analysis would be greatly simplified if the problems of accident investigation and reporting were adequately resolved. Finally, although it is recognized that accident reports can be computerized and subjected to data analysis, ways must be found to perform this function on a regional, cooperative, and sharing basis, especially if states and subordinate governmental echelons now without the financial resources are to be included in the overall program of accident research and reduction.

The benefit-cost approach to programming spot improvements, as outlined by the Bureau of Public Roads, the Jorgensen study, and others, does not seem to fit the requirements of the real world. Programming dollar savings in accident reductions over a ten- or twenty-year period seems elusive and unrealistic, especially since highway construction costs are rising rapidly each year, medical and insurance costs are rising, and it really cannot be determined what an individual's future earnings will be. The analysis is even more complicated by the growing tendency of individuals to sue for damages as a result of alleged unsafe or hazardous highway conditions. The method sanctioned by the Bureau of Public Roads means little or nothing to the public, which is prone to make emotional demands for immediate corrective action. Therefore, study is needed to find a way to relate benefit-cost analysis to public understanding and acceptance. It must be borne in mind that the target still is a significant reduction in actual deaths and injuries in trade for dollars, rather than dollars for dollars, and within an observable time limit, as far as the public is concerned [70]. California experiences and philosophy suggest an approach. They say, "We install expensive guardrails and median barriers on the basis that we are trading a 25 percent increase in total property damage and injuries for a 15 percent reduction in fatalities, and a 16 percent reduction in multivehicle accidents. We spend $2.5 million to save 60 lives a year by installing guardrails at all freeway bridges." This is the kind of benefit-cost analysis that the public and legislators comprehend.

The success of California and Michigan in certain types of spot improvement such as skid-resistant pavement, pavement serrating, edge lining, and lane delineation indicate that a potential research field exists in the development of new ideas and approaches for overcoming the driver's inattention, alerting him either consciously or subconsciously, or giving him more opportunity to stop in a given time and distance [71-72]. Much more could be done, for example, to corrugate or corduroy shoulders, ramps, median strips, or lane dividers to alert or slow down the wandering, drifting, or even skidding driver, and bring him back on course.

Highway design criteria and standards vary even within states. Research is needed to determine what highway design characteristics seem to be most prevalent in highway accidents. For example, what is the effect of the different design standards used in the transition from tangents to curves, both horizontal and vertical, on accident rates [70]? Some studies, such as one recently conducted by the Michigan Highway Department, indicate that wrong-way drivers on four-lane divided highways most frequently enter the wrong-way ramps at diamond intersections. Sections or lengths of highways need more study to determine what characteristics have a significant influence on accidents. California, for example, has found that a minimum of 1,000 feet of sight distance is needed to spot and evade a wrong-way driver on an expressway. Does the very costly 30-foot recovery area with one-on-six slope eliminate the accidents claimed [12], or does it, as Michigan findings suggest, induce drivers to exceed the speed limits?

Research in signing and signal control is badly needed as evidenced by the huge number of intersection accidents, particularly those involving rear-end collisions. One fruitful area would appear to be an in-depth comparison of the European international system of signs, signals, and symbols in color codes with that of the Manual on Uniform Traffic Control Devices [8] and their relative effects on accident rates. Is the United States system better, or is it merely assumed to be better? Only the city of Washington, D. C., has started a small program under Bureau of Public Roads encouragement to study this area.

CONCLUSIONS AND RECOMMENDATIONS

In general, it is concluded that the federally sponsored Spot Improvement Program begun in 1964 caused all the states to start programs for eliminating highway hazards or to accelerate existing state programs. While the program's full effects on the national highway-accident rate are presently not measurable, it can be assumed that, like other nonmeasurable programs such as driver training, it has been beneficial. It is also concluded that implementation has been hindered by difficulties or shortcomings in administration, funding, and methodology. Specific conclusions and recommendations regarding these areas follow.

ADMINISTRATION

State spot improvement programs vary considerably in scope, standards, and progress attained, but, carefully researched and implemented, have been effective in reducing accidents. Highway safety design criteria have generally evolved from hindsight. Built-in hazards on newly constructed roads and highways must be eliminated by better preliminary planning and analysis and adherence to approved criteria during construction.

FUNDING

Geography, climate, and economic conditions affect state programs for highway funding and construction.

The federally sponsored Spot Improvement Program was adversely affected by unexpected withholding of federal-aid apportionments for highway construction.

Much time and money would be required to remove or correct every driving hazard on the hundreds of thousands of miles of the nation's highways, especially on the antiquated secondary roads. Removal or correction of most of the highway hazards on large portions of the Secondary System would probably require 100 percent federal funds. However, the number and diversity of programs and interests competing for available federal funds make it highly unlikely that all roads on the Federal-Aid System will ever be modernized and made hazard-free.

Because of limited funds and rising highway costs, it is essential that a spot improvement program have a realistic objective of removing the primary hazards as evolving traffic patterns continue to develop new hazards.

METHODOLOGY

A methodology for implementing the Spot Improvement Program is evolving, but many inadequacies in techniques must be overcome:

Urgently needed are more effective ways to identify hazardous locations, establish correction priorities, and select the most effective, yet feasible, correction.

Incomplete and inaccurate accident data hamper the program at federal, state, and local levels.

Because of inadequate accident reporting, it is not yet known what the federally sponsored Spot Improvement Program has done to reduce the national highway accident record.

The results to be expected from an individual spot improvement program are unpredictable, so that progress in the program can be measured only in terms of the results obtained from a great number of projects.

Fluctuations in such variables as medical, insurance, and highway construction costs, property values, obsolescence, and living patterns have invalidated current methods of measuring program success by predicted dollar savings in accidents avoided.

RECOMMENDATIONS

In order to attain more substantial and measurable progress in accident reduction, a continued research and development program is recommended in the areas of accident reporting, benefit-cost analysis, highway design, and signs and signals, in order to attain the following objectives:

(1) An accident reporting system that is uniform, accurate, complete and applicable in all jurisdictions, whose output is available to all legitimate users.

(2) A benefit-cost analysis technique that uses realistic values, is understandable to legislators and the public, and ensures the selection of the most effective spot improvements.

(3) Design and construction of devices for effectively alerting inattentive drivers about to leave the roadway.

(4) Elimination of highway design standards and construction practices which may contribute to accidents.

(5) Improved traffic signs and signals for optimal communication with drivers.

(6) A compilation and synthesis of nationwide "before-and-after" experiences with various spot improvements as an aid to the highway and traffic engineering profession.

REFERENCES

1. U. S. Bureau of Public Roads, Highway Statistics—1965, Washington, D. C., 1967.

2. U. S. Chamber of Commerce, Nation's Highway Program, Washington, D. C., 1960.

3. United States Congress, Public Law No. 156 (Federal Aid Road Act of 1916), Title 23, U. S. Code, July 11, 1916 and all amendments thereto, to include Public Law 89-574 (Federal-Aid Highway Act of 1966), September 13, 1966.

4. R. F. Durfee, "Country Road Responsibilities Under Act 51," Michigan Contractor & Builder, July 15, 1967, pp. 19, 94, 96.

5. Eugene M. Johnson, "President's Address," Annual Meeting, Association of State Highway Officials, Salt Lake City, October 16, 1967.

6. Highway Research Board, Highway Capacity Manual, Washington, D. C., 1965.

7. Eugene M. Johnson, "Industry Government Partnership," American Road Builder, April 1967, pp. 12-14.

8. U. S. Bureau of Public Roads, Manual on Uniform Traffic Control Devices for Streets and Highways, Washington, D. C., 1961.

9. American Association of State Highway Officials, as approved by U. S. Bureau of Public Roads, Manual for Signing and Pavement Marking of the National System of Interstate and Defense Highways, Washington, D. C., 1961; revised edition, 1962.

10. American Association of State Highway Officials, A Policy on Geometric Design of Rural Highways, Washington, D. C., 1965.

11. American Association of State Highway Officials, A Policy on Design Standards—Interstate System, Washington, D. C., 1956.

12. D. W. Loutzenheiser, "Highway Safety," Presentation to AASHO Committee on Design, Salt Lake City, October 18, 1967.

13. U. S. Secretary of Commerce, Federal Role in Highway Safety, Report to the House Committee on Public Works, House Document No. 93, 86th Congress, First Session, Washington, D. C., 1959.

14. Alfred E. Johnson, "The Traffic Safety Program in the United States," World Highways, Washington, D. C., June 1967, pp. 47-50.

15. E. E. Halmos, "Highways Designed for Safety," Civil Engineering, September 1967, pp. 50-53.

16. W. G. Johnson and G. Miller, "Traffic Accidents and Preventive Measures" (Draft Two), National Safety Council, Chicago, December 15, 1965.

17. Sherwood K. Booth, "Federal Law and Highway Safety," American Road Builder, February 1967, pp. 5-7.

18. U. S. Bureau of Public Roads, Policy and Procedure Memoranda—Instruction Memoranda, Washington, D. C., 1064-1967.

19. Roy Jorgensen and Associates, Evaluation of Criteria for Safety Improvements on the Highways, Gaithersburg, Maryland, October 1966.

20. J. A. Rummel, "'TOPICS' to Authorize Highway Funds," American Road Builder, July-August 1967, p. 23.

21. C. W. Prisk, "Future Requirements for Traffic Control," Presentation, American Road Builders Association Convention, Detroit, September 18, 1967.

22. Gerald D. Love, "TOPICS—A Positive Approach to Urban Congestion," Presentation to AASHO Committee on Design, Salt Lake City, October 17, 1967.

23. "Transportation Secretary, Allen S. Boyd, Disappointed with Progress of TOPICS," Newsletter, American Road Builders Association, Washington, D. C., August 29, 1967.

24. "Program to Reduce Rail-Highway Grade Crossing Accidents," Newsletter, American Road Builders, Washington, D. C., August 15, 1967.

25. "At the Crossroads," Transport Topics, August 14, 1967, p. 6.

26. "Grade Crossing Projects," Traffic Safety, February 1968, p. 7.

27. National Highway Safety Bureau, Highway Safety Program Standards, Washington, D. C., June 27, 1967.

28. John A. Blatnik, "Closing Statement of Chairman," Hearings of the House Subcommittee on Public Roads, Washington, D. C., July 20, 1967.

29. "House Subcommittee Criticizes Highway Design," Highway Division Newsletter, American Society of Civil Engineers, August 1967, pp. 3, 4.

30. Cullison Cady, "Highway Hazards," Highway User, August 1967, pp. 16-19.

31. American Association of State Highway Officials, Highway Design and Operational Practices Related to Highway Safety, Washington, D. C., February 1967.

32. U. S. Bureau of Public Roads, Highways and Human Values, Washington, D. C., 1966.

33. G. J. McCarthy, Median Width Analysis in the State of Michigan, Presentation, American Association of State Highway Officials, Salt Lake City, October 21, 1967.

34. "States Attack Highway Accidents," Engineering News Record, July 28, 1966, pp. 9-11.

35. "Roadside Hazards—Target of State Highway Commission Safety Program," Michigan Contractor and Builder, July 15, 1967, p. 44.

36. California Department of Public Works, Division of Highways, Objective Criteria for Guard Rail and Installation, Sacramento, July 1966.

37. G. L. Russell, "Evaluation of Minor Improvements—Pavement Serration" (Interim Report), California Department of Public Works, Division of Highways, Sacramento, November 1967.

38. R. J. Isreal, "Pavement Parkings for Traffic," Proceedings, 18th California Street and Highway Conference, Institute of Transportation and Traffic Engineers, University of California, Berkeley, January 27, 1966.

39. P. Van Roekel, "What Happens After 1972—Federal Aid for Interstate Feeder Roads?" Michigan Contractor and Builder, October 21, 1966, p. 80.

40. Michigan Department of State Highways, Bulletins and Letters of Instruction, Lansing, 1966-1967.

41. "Highway Prices on the Rise," Engineering News Record, November 16, 1967, p. 22.

42. D. W. Moulton, "Maintenance of the Interstate System of Defense Highways," Proceedings, 45th Annual Tennessee Highway Conference, Knoxville, March 11, 1964, pp. 52-56.

43. S. E. Farin, "Federal Interest in Rural Roads," Address, AASHO Secondary Roads Committee, Salt Lake City, October 17, 1967.

44. John R. Sargent, "How Cities and Counties Qualify for Federal Aid," address, date and location unknown.

45. C. B. Laird, "Federal Aid System Program: Administration of a Construction Project," Michigan Contractor and Builder, July 15, 1967, p. 46.

46. Melvin B. Larsen, "Effect of Design and Operational Practices Related to Highway Safety on Secondary Roads," Address, AASHO Secondary Roads Committee, Salt Lake City, October 20, 1967.

47. "Trouble on the Safety Front," Better Roads, August 1967, pp. 6-8.

48. "Congress Prods Road Agencies on Safety," Engineering News Record, July 27, 1967, p. 18.

49. Joseph A. Sturrett, "Highway Safety on Secondary Roads Versus Political Policy," Address, American Road Builders Convention, Detroit, September 18, 1967.

50. Paul E. Gilgen, "Effect of Highway Design and Operational Practices Related to Highway Safety on Secondary Roads," Address, AASHO Secondary Roads Committee, Salt Lake City, October 20, 1967.

51. Frank Virr, "Effect of Highway Design and Operational Practices Related to Highway Safety on Secondary Roads," Address, AASHO Secondary Roads Committee, Salt Lake City, October 20, 1967.

52. B. C. Goode, "Effect of Highway Design and Operational Practices Related to Highway Safety on Secondary Roads," Address, AASHO Secondary Roads Committee, Salt Lake City, October 20, 1967.

53. R. J. Franklin, "County Highway Construction," Proceedings, 45th Annual Tennessee Highway Conference, Knoxville, March 1, 1964, pp. 9-11.

54. Harold H. Cooper, "Implementing a Spot Highway Safety Program," 51st Annual Michigan Highway Conference, University of Michigan College of Engineering, March 8-10, 1966, pp. 52-55.

55. Bureau of Public Roads, Highway Safety Improvement Projects for First Quarter FY 68, Washington, D. C., November 7, 1967.

56. Roy E. Jorgensen, "Standards for Highway Safety Improvements," American Road Builder, June 1967, pp. 11-13.

57. James E. Wilson, "Minor Improvements Program," Traffic Digest and Review, Northwestern University Traffic Institute, June 1965, pp. 9-14.

58. California Department of Public Works, Division of Highways, Direct Costs of California State Highway Accidents, Sacramento, July 1, 1967.

60. Allen T. Hayes, "City Problems," Proceedings, 51st Annual Michigan Highway Conference, University of Michigan College of Engineering, March 8-10, 1966, pp. 52-55.

61. William Marconi, "Accident Reduction Through Operational Measures," Proceedings, 18th California Street and Highway Conference, Institute of Transportation and Traffic Engineering, University of California, January 27, 1966.

62. T. Edwards, "Program for Determination of High Accident Locations," Highway Research Board, Record 79, Washington, D. C., 1965, pp. 45-50.

63. J. T. Baerwald, "Traffic Accident Reporting Criteria of Principal Users in Illinois," Traffic Engineering, June 1966, pp. 28-34.

64. John W. Garrett, "Development of Improved Methods for Reduction of Traffic Accidents," Presentation to AASHO Committee on Traffic, Salt Lake City, October 17, 1967.

65. J. A. Head, "Highway Safety Elements in Aesthetic Designs," Journal of the Highway Division, American Society of Civil Engineers, October 1966, pp. 15-19.

66. Paul H. Fowler, "Designing for Traffic Accident Reduction," Proceedings, 18th California Street and Highway Conference, Institute of Transportation and Traffic Engineering, University of California, Berkeley, January 27, 1966.

67. R. A. Jorgensen, "Programming Hazard Reducing Improvements," Highway Research Board, Record 79, Washington, D. C., 1965, pp. 51-52.

68. W. E. Corgill, "A System for Accurate Location of Accidents," Traffic Engineering, June 1966, pp. 17-19.

69. R. N. Smith, "The Reporting Level of California State Highway Accidents," Traffic Engineering, June 1966, pp. 20-25.

70. Automotive Safety Foundation in Cooperation with U. S. Bureau of Public Roads, Traffic Control on Roadway Elements—Their Relationship to Highway Safety, Washington, D. C., 1963.

71. Highway Research Board, Traffic Behavior as Related to Several Highway Design Features, Bulletin 170, Washington, D. C., 1958.

72. Grant D. Mickel, "Accidents and Expressway Driving," American Road Builder, June 1967, pp. 8-10.

73. Highway Research Board, Geometric Highway Design, Highway Research Record 172, Washington, D. C., 1967.

74. Institute of Traffic Engineers, Traffic Engineering Handbook, Washington, D. C., 1965.

75. W. J. Burmeister, "The Changing Image of the Highway Official," American Road Builder, February 1967, pp. 12, 13, and 20.

76. E. A. Lewis, "Laws Relating to Federal Aid in Construction of Roads," Government Printing Office, Washington, D. C., 1954.

77. American Highways (Quarterly of the American Association of State Highway Officials, Washington, D. C.), years 1956-1967, incl.

APPENDIX I
DIGEST OF FEDERAL AID FOR HIGHWAYS

This chronological outline of the growth of federal participation in the development of the national highway system is based on a review and consolidation of information from published sources [see references 3, 76, 77] and personal notes taken from various highway history sources. Selected digests of Public Laws indicate the gradual federal concern for the development of adequate and safe highway systems. To keep congressional action in proper perspective, one must bear in mind the national economic and social conditions which prevailed when each law was enacted.

Excerpts marked with an asterisk (*) are especially significant to highway safety.

1700's

The central government financed military roads for use against the Indians.

1806

The National (Cumberland) Road connecting the Ohio Valley with the Atlantic Seaboard, was financed mainly by the federal government. This road was built as (1) a mail route, (2) a passage for emigrants to the frontier, (3) a means to cement the two sections politically, (4) an invaluable aid for movement of troops and supplies. A total of $7,000,000 was appropriated by Congress from 1806 through 1838. The road was toll-free up to 1838, when the road was given to the states through which it passed. Rock surfacing was completed to Columbus, Ohio, and grading to Vandalia, Illinois, by 1838. The National Road is the predecessor of the present route U. S. 40 between Wheeling, West Virginia and St. Louis, Missouri. Federal support for this road was withdrawn due to the rapid growth of the railroads after the Charter for the B & O (Baltimore & Ohio) Railroad was issued in 1830.

1838-1891

No active federal aid participation in roads.

1891

Office of Road Inquiry established in Department of Agriculture. Beginning of systematic federal aid for highways.

1893

A strong motive for road improvement came from a demand for rural free delivery of mail. Congress passed, on an experimental basis, the first act authorizing rural mail delivery and appropriated $10,000 for this purpose.

1897

Office of Road Inquiry initiated construction of short sections of object-lesson roads to demonstrate how good roads should be built. It is of interest to note at this point that pressure was directed toward local, state and federal officials for

rural roads by the American Wheelman's Association (a group of bicycle enthusiasts).

1901

Office of Road Inquiry set up the first laboratory for testing road materials.

1904

Office of Road Inquiry published the first road mileage survey ever made.

1905

Office of Road Inquiry cooperated with the State of Tennessee in experiments to determine whether crude oil could be used as a binder for earth and macadam roads.

1912

Public Law No. 336 (Post Office Appropriation Act)—62d Congress (Approved August 1912)

1. A joint committee of Congress was established with five members each from House and Senate, to make inquiry into subject of federal aid for construction of post roads and report to Congress at the earliest practicable date.
2. $500,000 appropriated:
   a. To be expended by the Secretary of Agriculture in cooperation with the Postmaster General in improving the conditions of roads selected by them over which rural mail delivery is or may be established.
   b. Improvements to be for the purpose of ascertaining the increase in territory which could be served by each rural mail carrier as a result of road improvements.
   c. To estimate the possible increase in the number of delivery days in each year.
   d. To estimate the amount required in excess of local expenditure (from property taxes) for the proper maintenance of post roads.
   e. Estimate the relative savings to the government in the operation of the rural mail delivery service, and to local inhabitants in the transportation of their products by reason of the improvements of the post roads.
3. States to furnish two-thirds of the amount spent on the improvement, and federal government one-third.
4. The Secretary of Agriculture and the Postmaster General to report on operations of the Act. The report to cover:
   a. Recommendations relative to a plan for national aid for improvement of postal roads in cooperation with the states and counties.
   b. Efforts to bring about cooperation among states to insure uniform and equitable interstate highway regulations (first reference to interstate highways).
   c. Recommendations on a financing plan other than from the United States Treasury.

5. Under this Act, 425 miles of roads were improved.

6. Office of Road Inquiry renamed Office of Public Roads. This office started tests on experimental roads in Maryland and Virginia.

1916

Public Law No. 156—64th Congress (Approved 11 July 1916)

An Act to provide that the United States shall aid the states in the construction of rural post roads. Other provisions of this Act, which represents the beginning of federal aid to roads on a nationwide basis, included:

1. Each state must establish an agency responsible for the expenditure of the federal funds. (For a few states this was the beginning of their highway departments—for most others, including Michigan, state highway departments were in existence prior to this date.)

2. An appropriation of $75,000,000 for five years ending 30 June 1921.

3. A distribution formula for the appropriation as follows:

   a. One-third of the funds in the ratio which the area of each state bears to the total area of all the states.

   b. One-third of the funds in the ratio which the population of each state bears to the total population of all the states, as shown by the latest available federal census.

   c. One-third of the funds in the ratio which the mileage of rural delivery routes in each state bears to the total of all such routes in all the states at the close of the next preceding fiscal year. (The present formula for distribution of federal-aid funds for the primary and secondary systems is essentially the same.)

4. To receive federal aid funds a state highway department must:

   a. Submit to the Secretary of Agriculture project statements setting forth the proposed construction.

   b. On approval by the Secretary of Agriculture of a project proposal, furnish surveys, plans, specifications and cost estimates of the project.

5. Maximum cost per mile to the Federal government was limited to $10,000 exclusive of bridges of more than twenty feet of clear span.

6. The states must construct and inspect projects, with final inspection by the Secretary of Agriculture. (This of course would be done by the Office of Public Roads as the representative of the Secretary.)

7. The states must maintain the roads after construction is completed.

8. Secretary of Agriculture was authorized to employ persons to administer the appropriations and to construct buildings in the city of Washington and elsewhere. (This is the beginning of the Bureau of Public Roads.)

1919

Public Law No. 299—65th Congress (Approved 28 February 1919)

1. This is an amendment of Public Law No. 156 (1916), as are all of the following Public Laws.
2. Increased federal-government participation, from $10,000 to $20,000 per mile.
3. $200,000,000 additional funds to 30 June 1921.

1921

Public Law No. 87—6th Congress (Approved 9 November 1921)

1. This is the first authorization for Public Law No. 156 (1916) and its Amendments, of which this law is one, to be cited as the Federal Aid Highway Act.
2. Preference is to be given to projects that will expedite the completion of an adequate and connected system of highways of interstate character.
3. States must select or designate a system of highways not to exceed 7 percent of the total highway mileage of the state:
   a. 3/7 of the 7-percent system to be known as the primary or interstate highways.
   b. Remainder of 7-percent system to be known as secondary or intercounty highways.
   c. Not more than 60 percent of federal aid to be spent on primary system.

*4. Highway surfaces of a durable type must be used on the primary and secondary systems capable of meeting existing and probable future traffic needs and conditions. (Rock or gravel surfaces considered durable at this date.)

5. Federal aid highways must be toll-free.

*6. Wearing surfaces must be of adequate width, but not less than 18 feet, unless in the opinion of the Secretary of Agriculture this requirement is impractical.

*7. Ample right-of-way must be provided.

8. $20,000-per-mile limitation is increased in proportion to federal aid.

*9. The Secretary of Agriculture shall prescribe rules and regulations for carrying out this Act, including recommendations to Congress and the state highway departments as he may deem necessary for preserving and protecting the highways and insuring the safety of traffic.

*10. 2.5 percent (maximum) may be spent to administer this Act and to carry on highway research and investigative studies.

1922

Public Law No. 244—67th Congress (Approved 19 June 1922)

*1. Bridges as referred to the Federal Aid Highway Acts include railroad grade separations.

2. Maximum federal participation exclusive of bridges is reduced from $20,000 to $16,250 per mile. After 30 June 1923 this amount is further reduced to $15,000 per mile.

1927

Public Law No. 773—69th Congress (Approved 3 March 1927)

Use of federal aim is allowed in the construction of toll bridges, all tolls to pay the cost of the bridge. After the bridge is paid for, the tolls shall cease.

1928

Public Law No. 458—70th Congress (Approved 21 May 1928)

1. Federal aid may be increased on selected projects to 100 percent in those states with more than 5 percent unappropriated public lands and nontaxable Indian lands. States must spend their federal-aid allotment on other highway projects during the fiscal year.

*2. The planting of shade trees along the highways is authorized.

3. Federal aid may be spent in municipalities of 2500 or more if space between houses averages more than 200 feet.

4. No federal aid is authorized for bridges in municipalities of 30,000 or more.

1928

Public Law No. 493—70th Congress (Approved 23 May 1928)

(This law is not a part of the Federal Aid Highway Acts. However, portions of the law are of interest, for they appear to be the first references to beautification of a federal-aid highway, and to rules and regulations governing the use of a highway.)

1. Location and construction of a highway connecting Mount Vernon and the Arlington Memorial Bridge are authorized. (The highway commemorates the 200th birthday of George Washington.)

*2. The plans and specifications shall include provisions for the planting of shade trees and shrubbery and for such other landscape treatment, parking, and ornamental structures.

3. The plans must be approved by the U. S. Commission for the Celebration of the Two Hundredth Anniversary of the Birth of George Washington.

*4. Secretary of Agriculture shall cause the highway to be properly maintained and shall issue rules and regulations to govern traffic and the uses of the highway, including limitations on size, kind, weight, and speed of vehicles.

1930

Public Law No. 90—71st Congress (Approved 4 April 1930)

Federal aid is increased to $25,000 per mile if the 7-percent system (see 1921) has been surfaced. (Note: Surfacing could be gravel.)

1933

Public Law No. 67—73rd Congress (Approved 14 June 1933)

*1. An expenditure of $400,000,000 is authorized for emergency construction on the federal-aid highway system and extensions to the system into and through municipalities.

a. States may use funds to pay all or any part of the cost of surveys, plans, and highway and bridge construction, including the elimination of hazards to highway traffic, such as the separation of grades at crossings, reconstruction of existing railroad grade crossing structures, relocation of highways to eliminate railroad crossings, widening of narrow bridges and roadways, building of footpaths, replacement of unsafe bridges, construction of routes to avoid congested areas, construction of facilities to improve accessibility and the free flow of traffic, and the cost of any other construction that will provide safer traffic facilities or definitely eliminate existing hazards to pedestrian or vehicular traffic.

b. No funds may be spent to acquire right-of-way or easements for railroad grade elimination.

2. Removed per mile maximum expenditures by the federal government.

1934

Public Law No. 393 (Hayden-Cartwright Act)—73rd Congress (Approved 18 June 1934)

*1. Allowed 1 1/2 percent of the amount apportioned for any year to any state to be used for surveys, plans and engineering investigations of projects for future construction in such state, either on the federal-aid highway system and its extensions or on secondary or feeder roads.

2. Reduced federal aid to those states that allowed user taxes to be diverted to other than highway uses in amounts greater than those in effect at the time this Act was passed.

1936

Public Law No. 768—74th Congress (Approved 23 June 1936)

*1. Provided funds for study and research of traffic conditions and measures for their improvement.

*2. Report results of study and research, and of the status of uniform motor-vehicle traffic laws throughout the country.

1937

*Public Law No. 272—75th Congress (Approved 8 August 1937)

(This Public Law is not a part of Federal Aid Highway System legislation but is of interest for its reference to safety.)

Appropriated funds to be expended by the Secretary of Commerce for the furtherance of the work of the Accident Prevention Conference. The Accident Prevention Conference works in the broad area of safety and accident prevention, including the preparation and attempts to obtain enactment of uniform vehicle regulations in the United States.

1938

Public Law No. 584—75th Congress (Approved 8 June 1938)

*1. Federal funds may be spent on roadside and landscape development, including such sanitary and other facilities as may be deemed reasonably necessary to

provide for the suitable accommodation of the public, all within the right-of-way and adjacent publicly owned or controlled recreational areas of limited size, and with provision for convenient and safe access thereto by pedestrian and vehicular traffic.

*2. Extra funds appropriated for the elimination of both rail-highway and highway-highway grade crossings.

3. Chief of Bureau of Public Roads directed to investigate the feasibility and cost of constructing three east-west and three north-south superhighways, the study to cover the feasibility of toll charges.

1940

Public Law No. 780—76th Congress (Approved 5 September 1940)

Commissioner of Public Roads directed to investigate the service afforded to traffic, population, and lands by all highways of each state, as determined by statewide surveys. An annual report must be made to Congress on progress made in classifying the highways into groups composed of roads of similar service importance.

1941

*Public Law No. 295—77th Congress (Approved 19 November 1941)

Offstreet parking facilities to improve the flow of traffic on the strategic network of highways forming bypasses around and connections into and through cities and metropolitan areas. These facilities are to be considered highway projects. This provision of the law is not to be exercised if widening or relocating the highway will serve the purpose equally well.

1944

Public Law No. 521—78th Congress (Approved 20 December 1944)

1. Establish a federal-aid secondary road system outside of and through municipalities of less than 5,000 population.

2. The selection of the system to be in cooperation with county and local officials.

3. Establish federal-aid highway system in urban areas.

4. This law provides funds for what is now known as the ABC system of highways. The law also states the formula for the distribution of federal funds to the three systems given below:

Federal Aid Primary (A)

Federal Aid Secondary (B)

Federal Aid Urban-Primary (C)

5. Established a National System of Interstate Highways not to exceed 40,000 miles to connect the principal metropolitan areas, cities, and industrial centers, to serve the national defense, and to connect with routes of continental importance in Canada and Mexico. This system is a part of the total Federal Aid Primary System.

6. The 1.5 percent of federal-aid funds authorized by the 1934 Act may be used for surveys, plans, engineering, and economic investigations of projects for future construction without state matching funds.

*7. Traffic control devices only to be used to promote safe and efficient utilization of the highways.

1948

Public Law No. 834—80th Congress (Approved 29 June 1948)

1. Law specifies the distribution of total authorized sum for each fiscal year among the ABC systems.

(A) Primary System	45%
(B) Secondary System	30%
(C) Urban-Primary System	25%

2. Funds to be apportioned as per Federal Aid Highway Act of 1944.

3. Public Roads to study the status of the Interstate System with Secretary of Defense and National Resources Board.

1950

Public Law No. 769—81st Congress (Approved 7 September 1950)

1. Requires the establishment of a secondary road unit in the State Highway Departments.

2. Bureau of Public Roads transferred from the Department of Agriculture to the Department of Commerce.

*3. Commissioner of Public Roads to assist in carrying out the action program of the President's Highway Safety Conference to advance the cause of highway and street safety. $75,000 was authorized for this purpose.

1952

*Public Law No. 413— 82nd Congress (Approved 25 June 1952)

Authorized $150,000 annually to be spent on the work of the President's Highway Safety Conference.

1954

Public Law No. 350—83rd Congress (Approved 6 May 1954)

*1. Secretary of Commerce is authorized to engage in research on all phases of highway construction, reconstruction, modernization, development, design, maintenance, safety, financing, and traffic conditions, including the effect thereon of state laws, and is authorized to test, develop, or assist in the testing and development of any material, invention, patented article, or process. This research may be carried out independently or in cooperation with other agencies or organizations.

2. The Secretary shall include in the highway research program authorized above studies of economic highway geometrics, structures, and desirable weight and size standards for vehicles using the public highways, and of the

feasibility of uniformity in state regulations with respect to such standards. A report is to be made to Congress from time to time. (In the year 1954 President Eisenhower appointed a special committee headed by General L. D. Clay to study the current problems of highway transportation related to the national economy and defense, and to make recommendations. From the Clay report was formulated the Federal Aid Highway Act of 1956.)

1956

Public Law No. 627 (Federal-Aid Highway Act of 1956)**—84th Congress (Approved 29 June 1956)

1. This Act declared that it is essential to the national interest to provide for the early completion of the National System of Interstate Highways as authorized and designated in accordance with Section 7 of the Federal-Aid Highway Act of 1944.
2. It is the intent of the Congress that the Interstate System be completed as nearly as practicable over a thirteen-year period, and that the entire system in all the states be brought to simultaneous completion.
3. Because of its primary importance to the national defense, the name of such a system is changed to the "National System of Interstate and Defense Highways."
4. $24,825,000,000 authorized for the Interstate System over the thirteen-year period in addition to previous authorizations and appropriations for federal-aid highways.
5. The funds for the Interstate to be appropriated among the states as follows:
   a. One-half in the ratio which the population of each state bears to the total population of all the states as per the latest Federal Census, with no state receiving less than 3/4 of 1% of the appropriated money.
   b. One-half in the manner now provided by law for apportionment of funds for the federal-aid primary.
6. The federal share of the Interstate System is 90%, with the state paying 10%, except those states which have federal and Indian lands in excess of 5%. These states may obtain up to 95% federal aid on the Interstate System.
7. Geometric and construction standards to be adopted for the Interstate must be approved by the Secretary of Commerce in cooperation with the State Highway Departments. Standards are to be adequate for the year 1975. The standards are to be applied uniformly throughout all states.
8. Placed maximum weight and width limitations on vehicles operating on the Interstate System as follows:
   a. 18,000 lb per one axle
   b. 32,000 lb per tandem-axle

**All previous and following highway legislation regarding the federal-aid system may be referred to as Federal-Aid Highway Acts.

c. 73,280 lb maximum gross weight

d. 96 inches maximum width

These values not valid if on 1 July 1956 higher values were in effect in a state.

9. Secretary of Commerce directed to determine desirable maximum dimensions and weights of trucks in cooperation with states, Highway Research Board, and others.

10. Interstate System increased from 40,000 to 41,000 miles.

11. Federal Government may acquire right-of-way for Interstate System if requested by state.

12. Right-of-way acquired by the Federal Government is deeded to the state except for the outside five feet in those states which do not provide for control of access.

13. Federal-aid funds available at the request of state highway departments for purchase of right-of-way, provided actual construction starts within five years following the fiscal year in which the request is made.

14. No commercial establishments within the right-of-way of the Interstate System.

15. Airspace and underground space may be used for parking provided it does not interfere with the free flow of traffic.

16. If a toll road, bridge or tunnel, built to Interstate standards, will promote the development of an integrated Interstate System the Secretary of Commerce is authorized to approve the toll facility as part of the Interstate System, provided no federal-aid highway funds are expended except as permitted by existing laws. (See Federal-Aid Highway Act of 1927.)

17. Any state highway department submitting plans for a federal-aid highway project involved by-passing or going through any city, town or village, either incorporated or unincorporated, must certify to the Bureau of Public Roads that it has held public hearings, or has afforded the opportunity for such hearings, and has considered the economic effects of such locations. If hearings are held, a transcript of the hearings must be submitted to BPR together with certification.

*18. Highway Safety Study: The Secretary of Commerce is authorized and directed to make a full and complete investigation and study for the purpose of determining what action can be taken by the federal government to promote the public welfare by increasing highway safety in the United States. In making such an investigation and study the Secretary of Commerce shall give consideration to:

a. The need for federal assistance to state and local governments in the enforcement of necessary highway safety and speed requirements, and the forms such assistance should take.

b. The advisability and practicability of uniform state and local highway safety and speed laws and what steps should be taken by the federal government to promote the adoption of such uniform laws.

c. Possible means of promoting highway safety in the manufacture of the various types of vehicles used on the highways.

d. Educational programs to promote highway safety.

e. The design and physical characteristics of highways.

f. Such other matters as it may deem advisable and appropriate.

The Secretary of Commerce shall report his findings, together with such recommendations as he may deem advisable, to the Congress not later than March 1, 1959. The Secretary of Commerce shall conduct such study and investigation under the general authority contained in Section 10 of the Federal-Aid Highway Act of 1954, except that the amount expended for the purpose of this section shall not exceed $200,000. (The report requested above is in the HSRI Library and is catalogued as HSRI #01685. The official title of the report is "The Federal Role in Highway Safety" (1959). The unofficial title is the "Prisk Report.")

19. Federal-Aid Highway Funds may be used for archeological and paleontological salvage in compliance with the Act entitled "An Act for the Preservation of American Antiquities," approved June 8, 1906.

20. The uses of photogrammetric methods in mapping may be used to carry out the provisions of the Act. Commercial enterprises may be used for such services.

21. To fund the Federal-Aid Highway Systems the Highway Revenue Act of 1956 was passed at the same time as the Federal-Aid Highway Act of 1956. This Act imposed taxes on various highway user products, and required varying percentages of these taxes to be deposited in a newly created Highway Trust Fund from which appropriations for the Federal-Aid Highway Systems are to be paid.

1958

Federal-Aid Highway Act of 1958 (Approved 16 April 1958)

1. Additional appropriations for the fiscal year 1959 to speed the construction of the Federal-Aid Highway Systems.

2. Increased the federal government's share of the additional appropriation, but not to exceed 66 2/3% of the total cost in those states containing unappropriated and unreserved public lands and nontaxable Indian lands exceeding 5 percent of the total area of all lands within the state. The remaining 33 1/3% of cost is apportioned on the basis of the area of the above-named lands to the total of the state. In no case will the federal government pay more than 95% of costs.

3. To promote the safety, convenience, and enjoyment of public travel and the free flow of interstate commerce and to protect the public investment in the National System of Interstate and Defense Highways, it is declared in the public interest to encourage and assist states to control the use of and to improve areas adjacent to the Interstate System by controlling the erection and maintenance of outdoor advertising signs, displays, and devices adjacent to the system.

4. The Act declares it to be a national policy that the erection and maintenance of outdoor advertising signs, displays, or devices within 660 feet of the edge of the right-of-way and visible from the main-traveled way of all portions of the Interstate System constructed upon any part of the right-of-way (the entire width of which is acquired subsequent to 1 July 1956) should be regulated, consistent with national standards to be prepared and promulgated by the Secretary of Commerce. The Act limits the standard to four types of signs.
5. The Secretary of Commerce is authorized to enter into agreements with State Highway Departments to carry out this section of the Act, based on the national standards.
6. If an agreement is entered into, the federal share of all Interstate System projects in the state will be increased by 1/2%.
7. This Act amends the public-hearing provision of the 1956 Act by requiring public hearings to be held in places convenient to those persons concerned.

1959

Federal-Aid Highway Act (Approved 21 September 1959)

Temporary increase in motor fuel taxes between 1 October 1959 and 1 July 1961.

1960

Federal-Aid Highway Act (Approved 14 July 1960)

Requires State Highway Departments to erect informational sign or signs as prescribed by the Secretary of Commerce to identify the federal-aid highway project, giving the respective amounts contributed by the state and federal governments.

1961

Federal-Aid Highway Act (Approved 29 June 1961)

Made an upward adjustment in user taxes paid to the Highway Trust Fund.

1962

Federal-Aid Highway Act (Approved 23 October 1962)

1. Assistance for displaced families and businesses:
   a. Relocation assistance by state highway department for those persons displaced by acquisition or clearance of right-of-way.
   b. Cost of relocation considered a cost of construction.
   c. State not required to pay assistance if not allowed by the laws of the state.
   d. Federal participation limited to $200 per individual or family and $3,000 for a business concern. Transportation costs for a business concern are limited to cost of moving a maximum of 50 miles.

*2. This Act established the requirement that a continuing comprehensive transportation planning process shall be carried on cooperatively by state and local communities of 50,000 population, or more by 1 July 1965, or highway projects requesting federal aid will not be approved.

*3. Required that the Highway Planning and Research Funds (1 1/2% of a state's federal aid) shall be used only for planning, studies, and research. (See

Federal-Aid Highway Act of 1934. Much of this money had been used for construction by many states prior to this Act.)

4. An additional 1/2% of a state apportionment was authorized for the same purpose as Item 3.

5. Funds provided in Items 3 and 4 require state matching funds unless the Secretary of Commerce determines the interests of the federal-aid highway program will be best served without matching funds.

1963

Federal-Aid Highway Act (Approved 24 October 1963)

1. Removed the year 1975 as the design year, as specified in the Federal-Aid Act of 1956, and substituted 20 years from the date of approval of plans, specifications, and cost estimates for a specific project.

*2. Amended the use of highway planning and research funds (1 1/2% of federal-aid appropriation for a state) as follows: the 1 1/2% funds shall be available for expenditure upon request of the state highway department, with the approval of the Secretary, with or without state funds, for engineering and economic surveys and investigations; for the planning of future highway programs and the financing thereof; for studies of the economy, safety, and convenience of highway usage and the desirable regulation and equitable taxation thereof; and for research and development, necessary in connection with the planning, design, construction, and maintenance of highways and highway systems, and the regulation and taxation of their use. (A much more specific statement of the possible use of the 1 1/2% funds than had been given in previous Acts.)

1965

Federal-Aid Highway Act (Approved 22 October 1965)

This Act, better known as the Highway Beautification Act of 1965, is an expansion of the provisions for control of outdoor advertising along the Interstate System as provided in the Federal-Aid Highway Act of 1958. Main features of the Act:

1. Requires the States to provide effective means of control of outdoor advertising on the Interstate and primary systems by 1 January 1968, which would prohibit signs within 660 feet of the right-of-way except for:

   a. Directional and other official information signs.

   b. Signs advertising the sale or lease of property on which they are located or activities conducted on such property.

   c. Signs located in areas zoned industrial or commercial under state law, or areas used for industrial or commercial purposes.

2. Requires that nonconforming signs be removed not later than 1 July 1970, or at the end of the fifth year after they become nonconforming.

3. Requires just compensation to be paid the sign owners and landowners whose property rights would be adversely affected by the program authorized under this section.

4. Continues the one-half of one percent bonus to the states which have signed outdoor advertising control agreements with the Department of Commerce under authority of Public Law 85-767.

5. Requires the states to provide effective means of control of junkyards on the interstate and primary systems by 1 January 1968 which would eliminate junkyards from within 1,000 feet of the edge of the pavement unless they are:

   a. Effectively screened from view of the main traveled way of the system, or

   b. Located in industrial areas.

6. Requires just compensation to be paid junkyard owners whose facilities must be removed or disposed of, and provide a cost-sharing formula for screening facilities which need not be removed.

7. Authorizes the approval of landscaping and roadside developments as part of the costs of highway construction.

8. Provides the equivalent of 3 percent of a state's annual apportionment for this purpose, without state matching funds.

9. Requires the Secretary of Commerce to report to the Congress by 10 January 1967, on the implementation of each of the programs authorized, including a detailed estimate of the costs subsequent to the fiscal year ending 30 June 1967.

10. Authorizes a total expenditure of $230 million for 2 years.

1966

Federal-Aid Highway Act (Approved 13 September 1966)

*1. Requires the Interstate System in all cases to be built with at least four lanes for traffic.

2. Authorizes a study of advance acquisition of right-of-way for the federal-aid highway systems relative to:

   a. Provision of adequate time to remove and dispose of improvements located on the right-of-way.

   b. Provision for removal of persons and business establishments in an equitable manner.

   c. Methods of financing right-of-way purchases from federal funds.

3. Permits state highway departments to engage private engineering firms to assist in carrying out the provisions of the Federal-Aid Highway Acts.

4. Requires a relocation assistance study which will look into the:

   a. Need for additional payments or other financial assistance to displaced persons, business concerns, and others due to the location of a federal-aid highway.

   b. Feasibility of constructing, within the right-of-way or upon real property adjacent to the right-of-way of a federal-aid highway, publicly or privately owned buildings to aid in the relocation of displaced persons, business concerns, etc.

c. Cost of such facilities.

d. Source of funds to pay the portion of the cost of acquiring real property and constructing buildings for displaced persons and business concerns.

5. Directs that guidelines be set to minimize possible soil erosion due to highway construction.

6. Makes it a national policy to preserve wherever possible federal, state, and local government parklands and historic sites.

APPENDIX II
DIGEST OF FEDERAL EXECUTIVE ACTION RELATING TO THE SPOT IMPROVEMENT PROGRAM

23 March 1964

President Johnson, by letter, directed Secretary of Commerce Luther Hodges to launch an accelerated attack on traffic accidents by using the Bureau of Public Roads to encourage and assist state and local governments to develop priority safety programs which would give special attention to hazards on high accident highways. This safety priority program would be undertaken solely within the existing federal-aid program and the resources of the Highway Trust Fund.

7 April 1964

The Secretary of Commerce, in a letter to all 50 state governors, explained his directive from the President and urged the governors, through the federal-aid highway program, to reorient their state programs to provide special attention to the elimination of hazards on highways with high accident experience. He advised that the Bureau of Public Roads had given each highway department a report on research into the use of certain control and roadside design improvements for safety, emphasized the need for speedy action, and asked them to submit their highway safety improvement plans.

10 April 1964

The Federal Highway Administrator, by letter to the head of each state highway department, reiterated the message of the President and the Secretary of Commerce, pointed out that technical knowledge was available for immediately commencing this high-priority program "to reduce extreme accident hazards on the highways," and urged them to shift money from other programs and start work on this program.

He cautioned that there must be a balanced program and acknowledged that some states already have "spot improvement programs" (first use of this expression). He also said that studies may be needed if the highway hazards have not been identified, that money for such studies should come from Highway Planning and Research funds, and that the Bureau's regional and division staffs would keep the state highway department advised of the details of the program.

15 April 1964

In "Improvement of Highway Accident Locations on the Federal Aid Primary and Secondary Systems, Rural and Urban," a memorandum to Bureau Regional and Division Engineers, the Federal Highway Administrator said Section 109, Title 23 USC clearly identified safety as one of the basic criteria for federal approval of highway projects and gave authority for the Bureau of Public Roads to give attention to high accident-rate locations. He urged that they take action to get State Highway Departments to use substantial portions of federal-aid funds for improving conditions at points or sections of greater than normal hazard as identified by an above-average frequency of accidents.

Selected projects should have a potential for accident reduction by appropriate engineer work. Pure maintenance projects are not eligible. Within this limitation, the Bureau would be as liberal as possible in determining eligibility. State highway departments should conduct work in all districts or subdivisions, insofar as the requirement for high accident experience will permit.

Improvements must conform to Bureau of Public Roads standards specified for use on federal-aid projects in that state and must follow the same contractual procedures as other projects. Safety projects must not be combined with or reported as part of another project but must be identified with the symbol "S" on forms, reports, and all documents relating to each specifically approved safety improvement projects.

The memorandum outlines the project, emphasizes that Interstate Highways are ineligible, and gives examples of typical projects. "Before-and-after" documentation of projects, including a description of the physical changes made (preferably supported by photographs) and later accident experiences, are requested. Highway Planning and Survey funds may be used in identifying hazardous locations. In special cases, limited technical assistance is available from Washington.

16 June 1964

Bureau of Public Roads Policy and Procedure Memorandum 21-15, "Traffic Control Devices on Federal-aid Highways" (superseding IM-21-2-62, 12 January 1962), citing Section 109 (d), Title 23 USC as authority, said the Bureau standards for highway signs, markings, signals, and islands are the Manual on Uniform Traffic Control Devices of June 1961 and the Manual for Signing and Pavement Marking of the National Systems of Interstate and Defense Highways, 1961. The objective sought is uniformity in traffic control devices, specifically on the federal-aid system and eventually on all other state and local roads, streets, and highways. The Bureau of Public Roads will cooperate with the states in attaining this objective. As a necessary first step it is desired that each state make a detailed inventory of all traffic control devices in use. Once the inventory is completed, programs can be established for replacing, updating, or expanding traffic control devices.

The memorandum outlines procedures for inventory and for obtaining Bureau approval of state programs. Each state is urged to review and update state manuals to insure conformity with the Manual on Uniform Traffic Control Devices, and to submit them to the Bureau of Public Roads for review and approval.

1 July 1964

The Bureau of Public Roads revised Chapter 5, Traffic Control Devices Inventory, of the Highway Planning Program Manual (the original chapter was dated 15 November 1963). This revision says the states are generally following the 1961 edition of the Manual on Uniform Traffic Control Devices as jointly written by AASHO, ITE, the National Committee on Uniform Traffic Laws and Ordinances, the National Association of County officials, and the American Municipal Association of County officials, and the American Municipal Association. Citing Sections 109 and 131 of Title 23 USC, which prohibit installing on the Interstate System, or any other federal-aid project constructed since 20 December 1944, signs not in conformity with approved standards, the chapter says an inventory of traffic control devices existing on federal-aid systems is an essential first step towards attaining compliance with this legislation. The inventory should be statewide and desirably should include non-federal-aid roads, especially those carrying considerable volumes of traffic. PPM-21-15, 16 June 1964, now part of Volume 20, Appendix 4 of the Highway Planning Program Manual, outlines the scope and procedures for conducting such an inventory. States are asked to report on present conditions based upon the inventory and to report observed deficiencies in such form as to facilitate preparation of a program for adding new devices where needed and replacing nonstandard or defective devices in an orderly and effective manner.

25 November 1964

The Federal Highway Administrator, in a memorandum to Regional and District Engineers, "Improvement of High Accident Locations on the Federal-Aid Primary and Secondary System— Rural and Urban," said that so far only 100 "S" projects had been submitted. He repeated the 15 April criteria for "S" projects: (1) the location or section should have an above-average accident frequency, (2) the proposed physical improvements should markedly reduce the accident-inducing features of the location or section. Designating ordinary federal-aid projects as "S" is not allowed. States were too slow in reprogramming funds for high-priority safety improvements. Regional and district engineers were urged to prod the states into using substantial proportions of federal-aid funds on safety projects. (Apparently some states simply redesignated regular projects as safety projects as an easy way to comply.)

The same memorandum established a new "P" (potential) category of safety project. The letter "P" should precede the word "safety" on specified forms and be used for projects in which accident criteria could not be met due to lack of accident records or insufficient accidents, but where there was a clearly identifiable accident potential. The memorandum said, however, that such projects do not fall within the intent of the "S" program because "S" projects offer prospects of a reduction in accidents.

16 December 1964

The Bureau of Public Roads Region IV Engineer, in a memorandum "Improvement of High Accident Locations on the Federal-Aid Primary and Secondary Systems— Rural and Urban," to District Engineers in Illinois, Indiana and Kentucky, Michigan, and Wisconsin, expanded the Federal Highway Administrator's memoranda of 15 April and 25 November and again explained "P" and "S" projects. The states may not be designating some federal-aid projects "P" or "S" even though they meet the criteria for safety projects, either because of the extra programming effort required or because of lack of knowledge or intent of the safety program. Therefore, each District Engineer should review all programs for cases where a substandard curvature is corrected or a substandard sight distance is extended, largely in the interest of accident prevention and request the State Highway Department to correct the cost breakdown into "P" or "S" projects as applicable, and to indicate the split designation on applicable forms. (It is assumed that other regional engineers issued similar memoranda in order to get more safety projects from the states.)

30 August 1965

Policy and Procedure Memorandum 21-16 ("Highway Safety Improvement Projects"), superseding IM 21-2-65, 24 February 1965 ("Highway Safety Improvement Projects 'S' and 'P' "), was published in response to the President's directive of 23 March 1964, to establish the Bureau of Public Roads program for improving locations on the federal-aid system identified as hazardous because of high accident rates or potentially hazardous by virtue of engineering judgment. The memorandum combined and repeated all previously announced procedures for programming and administering safety designated projects. While states might prefer to use state funds on small projects, reporting of all safety projects—— whether done with or without federal-aid funds— was desired. Criteria for selecting safety projects should be one or more of the following: (1) a concentration of accidents at the location, (2) a record of accidents at similar locations, (3) research findings, (4) engineer judgment. Thereafter, it should be determined that the engineering work would reduce the accident rate. (By omission of any reference to the "P" designation, it was implied that a project location might be designated "S" without an accident history.)

The memorandum gave many examples of types of improvement that might be made. It repeated the required procedures, viz., completing an inventory to identify the hazardous locations, selecting and scheduling projects on a priority basis to ensure completing most if not all by 1 September 1969, programming projects in the same way as regular federal-aid projects, coding systems, and reporting procedures to be used. It also said projects would not be redesignated as safety projects if not so classified when authorized. It repeated the desirability of keeping "before-and-after" records, including photographs.

30 August 1965

In a covering letter for the preceding memorandum, the Federal Highway Administrator reminded Regional and District Engineers that the safety improvement program did not apply to the Interstate System. He urged them to elicit action from those states which had not already started on the program, and to encourage diversion to annual programs of federal-aid funds in amounts substantial enough to ensure completion of the program in four years, at the cost of deferring other needed construction if necessary. Although completion of their inventories should have first priority, the states should start some programming at the same time. Explaining that the elimination of "S" and "P" designations placed all highway safety projects in the same category, the Administrator directed that states using their own funds be urged to report their own projects, including the number, type, and total costs of projects.

25 October 1965

The Federal Highway Administrator, in a memorandum, "Highway Safety Legislation," to Regional and Division Engineers, quoted in full Section 135, Title 23 USC, enacted 28 August 1965 (Baldwin Amendment), requiring each state to have an approved highway safety program by 31 December 1967. He said the Office of Highway Safety of the Bureau of Public Roads would be responsible for administration of the program and was compiling standards from all available federal, state, and local highway associations and professional sources for thorough study and evaluation in order to establish criteria for evaluating state safety programs. He said no precipitous action was planned in administering Section 135.

18 November 1965

Instruction Memorandum 21-13-65 to Regional and Division Engineers cited the spotty progress of the states so far in programming highway safety improvement projects. While it was recognized that some states were using state funds, unless state funds so used were clearly sufficient to correct each year until 1969 one-fourth of the hazardous locations existing as of 1 September 1965, approval of regular federal-aid programs would be deferred until funding for safety improvement projects was adequate. In some cases this would require using 25 percent or more of federal-aid funds on highway safety projects. States must expedite the inventory described in Paragraph 5a, PPM 21-16, so that a measure of the amount of state or federal-aid funds needed for the safety programs was available.

30 November 1965

The Director of Highway Safety, Bureau of Public Roads, in the memorandum "Programming Highway Safety Improvement Projects," referring to IM 21-13-65, 18 November 1965, informed Regional Engineers that questions had arisen regarding the use of 25 percent or more of federal-aid fund apportionment on highway safety projects. This figure was intended to be used as a guideline in determining whether a state was going to reach the goal of 100 percent completion of safety projects by 1 September 1969, regardless of whether the state used its

own funds or federal-aid funds—and that 25 percent of federal-aid funds should be reserved for this purpose unless the state had definitely committed other funds for this goal. The November 18 memorandum was not designed to stop other programming unless there was reason to believe the state was not going to correct one-fourth of the hazardous locations each year.

23 February 1966

The Director of Highway Safety, Bureau of Public Roads, in a memorandum to Regional and Division Engineers, "Guidelines for Inventory as Required in PPM-21-16," provided inventory samples from an imaginary state, but advised the situation was different in each state depending upon the records available. Details on how to inventory, what should be in the inventory, and ways to determine priorities were discussed. Once again the states were urged to get going on the inventories, but to start programming before the inventories were completed. Regional and Division Engineers were directed to accept the inventories as proof of intent by the states but not to approve a project until it had been programmed in the manner prescribed for all federal-aid projects.

1 February 1967

IM 21-3-67, "Selection of Highway Safety Improvement Projects," gave the following procedure for selecting safety projects: (a) identify by the actual accident history, (b) set priorities for potential for accident reduction in relation to the cost of improvement. The memorandum presented recommendations for identifying hazardous locations and benefit-cost methodology for setting priorities, together with the mathematical formulae required.

The states were requested to use the methods described unless they could justify an alternate method of equal or better results in terms of sound identification and appropriate scheduling. (This memorandum, in effect, eliminated selection of a location determined to be hazardous because of similarity with a known high accident location, or because engineer judgment indicated need for improvement. It required a review of all previous inventory lists. For states and counties short on experienced personnel or accident records it created a problem. Also, it would delay the overall program.)

13 February 1967

Instruction Memorandum 21-7-67, "Guidelines for 'TOPICS' Program," was issued in response to the President's direction to the Secretary of Commerce in his 2 March 1966 Transportation Message to increase traffic capacity in urban areas. ("TOPICS" means Traffic Operations Programs for Increasing Capacity and Safety.) The memorandum created a Category 2 Federal-Aid Primary System within urban areas, allowing the use of federal funds for improving the capacity and safety of those urban streets and roads which lead directly to the Federal Interstate and Primary System. The states were urged to initiate pilot projects as test guidelines.

19 May 1967

Instruction Memorandum 21-11-67, "Safety Provisions for Roadside Features and Appurtenances," announced approval of the February 1967 report of the special AASHO Traffic Safety Committee "Highway Design and Operational Practices Related to Highway Safety"—and said it confirmed the provisions of IM 21-6-66. Plans for all projects on high-speed highways yet to be contracted must incorporate the safety features presented in the AASHO report. Construction projects under way must be reviewed and modified by contractual change to incorporate these standards. The standards apply to high-speed highways, all projects on the Interstate System and all Federal-Aid Primary and Secondary Systems where the design speed is 50 mph or more. To the extent practicable and feasible, the safety features should be applied to projects on primary and secondary roads with lesser design speed. On completed Federal-Aid highways, each state highway department should establish an active corrective program per the findings of the AASHO report, especially to correct features affecting the safety of the motorist who strays from the roadway. The most serious existing conditions should be assigned highest priority for correction. Bureau Division Engineers will be liberal regarding improvement programs proposed by state highway departments. The usual project programming procedures will be followed. Finally, the safety provisions for performing construction under traffic conditions must be rigidly observed, lest more hazards be created than eliminated.

19 May 1967

The Federal Highway Administrator wrote to each state highway department head, drawing attention to the AASHO report, particularly its recommendations dealing with roadside hazards, and offered to assist every state highway department in immediate and continuing application of its findings, to provide the highest possible level of roadway safety on the federal-aid highway systems.

29 June 1967

IM 21-11-67 (1), "Safety Provisions for Roadside Features and Appurtenances," supplemented and clarified the interpretation and application of IM 21-11-67, 29 June 1967. In designing all projects, the safety features of the AASHO Special Report, "Yellow Book," should be considered to the extent practicable and feasible, specifically on the Interstate System and all projects of the Federal-Aid Primary and Secondary Systems where the design speed is 50 mph or more and the current ADT is 750 or more. 750 ADT is the AASHO traffic grouping in "Geometric Design Standards for Highways other than Freeways." In states using criteria of higher ADT's at 50 mph the Bureau division engineer may make exceptions. In urban areas and in areas of the Secondary System where existing right-of-way limits the extent to which side slopes can be flattened and roadsides cleared, a smooth and obstacle-free roadside must be obtained to the extent feasible in the space available and properly designed guardrail installed to protect against those roadside features which cannot be corrected or removed. Projects initiated after 31 July 1967 and placed under construction prior to 1 January 1968, in accordance with the present state secondary road plan, will be accepted when satisfactorily completed. States will be asked to submit a supplement to state secondary road plans to incorporate the applicable provisions of the safety program.

The program purpose ((1) to modify designs being prepared, (2) to make changes in going construction contracts, and (3) to modify completed projects so as to remove roadside elements proven hazardous or to place protection between these elements and the travelled way) can be attained through sound engineering, judicious use of public funds, and common sense.

27 June 1967

The Federal Highway Administrator, citing as authority the Highway Safety Act of 1966 and Title 23, Par. 402 (a) USC issued "Highway Safety Program Standards," of which three relate to the Spot Improvement Program:

(a) Identification and Surveillance of Accident Locations

(b) Highway Design, Construction and Maintenance

(c) Traffic Control Devices

Appendix III

SELECTION OF HIGHWAY SAFETY IMPROVEMENT PROJECTS

U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS
WASHINGTON, D.C. 20235

February 1, 1967

INSTRUCTIONAL MEMORANDUM 21-3-67
47-03

SUBJECT: Selection of Highway Safety Improvement Projects

The effectiveness of a program for the improvement of hazardous locations on Federal-aid highway systems, which has been stated as a policy of the Bureau of Public Roads in PPM 21-16, depends on the careful application of two procedures. These are:

(1) The identification of hazardous locations based on actual accident experience and the exposure to accidents; and

(2) The setting of priorities among identified projects based on the potential for accident reduction in relation to cost of the improvement.

The identification procedure requires an adequate records system to provide accurate location information on accidents, which can be correlated in turn with traffic volumes and geometric features of the highway. The points or locations brought to light by this system must contain identifiable hazards which lend themselves to engineering correction, and field inspection is thus a necessary part of this process.

The identified hazardous locations must then be ranked in some order, so that the most vital can be treated first. The most logical answer, in view of the limited funds available, is to give the highest priority to those with the greatest benefit-cost ratio, thus achieving the maximum return per dollar invested. For this purpose, a method must be determined for evaluating the results of the improvement proposed, so the savings in accidents may be related to the cost of the improvement.

This memorandum presents (1) recommendations for identifying hazardous locations, and (2) a benefit-cost methodology for setting priorities.

Each State is requested to initiate in principle these two procedures on at least an annual basis. It is recognized that this may mean in some cases an immediate review and possible revision of previously prepared and submitted inventories of hazardous locations. In all States, it will mean that there will exist a logical, comprehensive, and continuing basis for the selection and programing of safety improvement projects. The specific techniques outlined in this memorandum should be used unless the State can justify another method. Any such alternate method must demonstrate equal or better results in terms of sound identification and appropriate scheduling of high-accident locations.

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CORRECTED PAGE

It is recognized that identification and ranking of hazardous locations are but the first steps of the total safety improvement program, and that it is from this orderly array of locations that a final selection of work must be made, based on financial capabilities, engineering judgment, and many other factors.

IDENTIFYING HAZARDOUS LOCATIONS

Two alternate methods are offered for identifying hazardous locations. The first considers the number of accidents and the accident rate as criteria, and the second uses the accident rate, to which is applied a statistical test to determine whether or not the rate is significantly high.

The first method (referred to hereafter as the number-rate method) may be expected to yield reasonably good results. However, this method is not recommended for use unless rapid field analysis is the main objective and the precision of the results is of secondary importance. The second method (referred to hereafter as the quality control method) is considered better and is statistically sound. Therefore, it is recommended that this method be used wherever possible.

Both methods identify sections and spots separately. A section is defined as a length of roadway over 0.1 mile long possessing homogeneous geometrics, traffic and culture. Sections should be homogeneous as to cross section, surface type, access control, and rural-urban characteristics. Spots are roadway sections of 0.1 mile or less. Intersections are spots, but are identified in a separate schedule. In urban areas, the usual maximum length of a spot should be the distance between intersections but not including either intersection.

The methods outlined here are described in more detail in the report, "Evaluation of Criteria for Safety Improvements on the Highway."

NUMBER-RATE METHOD

In the number-rate method, locations are ranked first in order of the number of accidents. A cut-off point is established (usually related to the Statewide average) and the locations are re-ranked in the order of the accident rate. A second cut-off is established, and the locations above this value are considered to be hazardous.

The selection of the cut-off points becomes the critical decision in this method. It is necessary first to consider separately sections, spots, and intersections. Statewide or average rates are calculated for each of the three, with individual rates calculated for urban and rural, 2 lanes, 4-or more lanes undivided, 4-or more lanes divided, and freeways. With ADT and mileage figures, the following formulas can be used to determine the Statewide averages (all data for one year).

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(1) $Rm = \frac{A}{\Sigma M}$

where Rm = accidents per mile
A = total number of accidents on a specific category of roadway in the State
M = miles of each location of this category of roadway

(2) $Rmvm = \frac{A\ (1,000,000)}{365\ \Sigma(ADT \cdot M)}$

where Rmvm = accidents per million vehicle-miles
A = total number of accidents on a specific category of roadway in the State
ADT = annual average daily traffic on each location of this category of roadway
M = mileage of each section of roadway of this category

(3) $Rmv = \frac{A\ (1,000,000)}{365\ \Sigma ADT}$

where Rmv = accidents per million vehicles
A = total number of accidents on a specific category of roadway in the State
ADT = annual average daily traffic on each location of this category of roadway

For sections (locations more than 0.1 mile in length), two types of rates are to be calculated: accidents per mile and accidents per million vehicle miles.

For spots (locations 0.1 mile or less in length), accident rates per million vehicles are to be calculated, and absolute numbers of accidents recorded.

For intersections, the same data are developed as for other spot locations. However, both accidents and traffic on the cross-road are to be included in the calculation. The formula becomes:

$$Rmv = \frac{A\ (1,000,000)}{365\ \Sigma(ADT_m + ADT_c)}$$

where ADT_m = ADT on the main road

ADT_c = ADT on the cross road

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The cut-off points are set as follows:

Location Type	Measure Used*	Criteria**
Sections		
First cut-off	Acc/mile	Twice the average
Second cut-off	Acc/million vehicle miles	Average
Spots		
First cut-off	No. of accidents	Twice the average
Second cut-off	Acc/million vehicles	Average
Intersections		
First cut-off	Accidents	Twice the average
Second cut-off	Acc/million vehicles	Average

*All measures are determined separately by roadway category

**The criteria specified here are recommended but may be revised up or down if the State can justify such revisions on the basis of experience

A recommended refinement involves use of a sliding section. Thus, if the criterion (based on twice the average) is 10 accidents per mile, the highway may be examined for clusters of 10 accidents within a length of one mile starting at any point on the road. Such searching for clusters can be done manually on a strip map or by a computer.

In summary, the number-rate method requires the tabulation of locations by appropriate classes and roadway categories, and the array of these data in descending order of number of accidents or accidents per mile. The array is cut off at a point in some relation to an average value, and the locations above the cut-off point are re-arrayed in descending order of accident rate until a second cut-off point is reached. The locations above this second cut-off constitute the list of hazardous locations, which then require field investigation to suggest appropriate improvement.

QUALITY CONTROL METHOD

In the quality control method, locations (sections, spots, or intersections) are identified and accident rates are calculated for each. Average rates are determined (as in the number-rate method, except that only rates per million vehicles and per million vehicle-miles are required). These average rates are then used in conjunction with the exposure at each location (in terms of vehicles or vehicle-miles) to test statistically the reliability of the specific rate for the location. In this process, a "critical" rate is determined for each location, and specific rates higher than the "critical" rates determine hazardous locations.

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The criterion thus becomes the "critical" accident rate. This is determined for each location by the formula:

$$Rc = Ra + k\sqrt{\frac{Ra}{M}} - \frac{1}{2M}$$

where Rc = critical accident rate
Ra = average accident rate on a specific category of highway, (for sections, in accidents per million vehicle miles, and for spots, in accidents per million vehicles)
M = vehicle exposure for the study period at the location, (for sections, in million vehicle miles, and for spots, in million vehicles)
k = a constant, the value of which determines the level of probability. The value of 1.5 is suggested, but a lower value of k will produce a longer list by reducing the difference between the average rate and the critical rate. A value of k below 1.5 will also increase the probability that a rate is high by chance.

As in the number-rate method, uniform sections or spots are first identified. A sliding spot location technique may also be used.

For each section, an accident rate per million vehicle miles is calculated, the critical rate is calculated, and each individual section rate is compared with the critical rate. Rates above the critical rate identify hazardous sections.

For each spot, a similar procedure is followed except that rates are in terms of accidents per million vehicles.

For spot locations along a highway in which ADT values are constant, such as are located by the sliding spot location technique, a simplification of the previous formula may be used.

$$A_c = M\,(R_a) + k\sqrt{M(R_a)} - 1/2$$

where A_c = critical number of accidents in a cluster
M = vehicle exposure for the study period at the location in million vehicles
R_a = average accident rate in million vehicles for the category of roadway
k = a constant, for which a value of 1.5 is recommended

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An increment which straddles two roadway categories will be evaluated by weighting two values of the average rate and the exposure and then calculating a mean value for each.

Intersection calculations should use both main road and cross road accidents and ADT, as in the number-rate method.

Clusters with a number of accidents exceeding the critical number are identified as hazardous spots.

Attention is directed to the Circular Memorandum dated April 1, 1966, from Mr. J. D. Lacy to Regional and Division Engineers entitled "Highway Safety Improvement Projects - Evaluation of Improvements." This document provides a graphical solution to a similar problem.

SPECIAL CONSIDERATIONS FOR LOW VOLUME ROADS

In sparsely populated States as well as in some areas of other States, low traffic volumes are a problem in the identification of hazardous locations. Many sections of road, and many intersections, are very similar in design and operation. The occurrence of accidents is subject to large variability, and the total number of accidents at a single location may be too small for analysis.

It is recommended therefore that similar locations be grouped and evaluated as one location. Improvement projects at such locations are usually easiest to justify when they are low-cost, probably maintenance-type work such as brush or crop clearing, more visible stop or warning signs, etc. Uniformly applied improvements of a major nature must be able to compete on a total benefit-cost basis with other improvements under consideration.

SETTING PRIORITIES

The development of a list of hazardous locations on a highway system must be followed by a decision as to which are to be improved first, because in few if any cases are funds available to do all necessary work at once. The setting of priorities thus becomes the second major step in a safety improvement program.

In the determination of priorities, two aspects of the problem must be considered. First, there may be a choice of improvements possible at a single location, and a selection must be made. Second, a number of locations may have to be ranked to determine which is to be improved first.

In the first case, when more than one improvement is possible at a location, the selection should be made on the basis of total net benefit, i.e., the anticipated savings minus the cost.

Once the improvement for each location has been determined, the individual locations should be ranked in order of benefit/cost ratio, i.e., the ratio of the anticipated savings to the cost.

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ANNUAL COST OF A PROJECT

The annual cost of an improvement project is the sum of the capital costs expressed on an annual basis and the change in the annual cost of maintenance and operations, or as a formula:

$$C = (C_1 \cdot K_1 + C_2 \cdot K_2 + C_3 K_3 + C_4 K_4) + M$$

where C = net average improvement project cost
$C_1, C_2, C_3 + C_4$ = capital costs for right-of-way, grading and drainage, major structures, and pavement and appurtenances
$K_1, K_2, K_3 + K_4$ = capital recovery factors for known interest rate and service life for $K_1, K_2, K_3 + K_4$ respectively (see appendix A)
M = change in annual maintenance and operation costs

The annual cost thus derived is used in calculating the benefit-cost ratio and may also be used in calculating the net benefit of the project.

ANNUAL BENEFITS

Although a safety improvement project may have benefits in the form of reduced operating costs, reduced delays, or increased comfort and convenience, for the purposes at hand, only reductions in accidents will be considered.

Accident reduction benefits are of two types--direct and indirect. The direct benefits are measurable in terms of reductions in wages lost, medical costs, property damage, etc. The indirect benefits are not readily measurable, including reduced loss of production when an employee is injured, lessened disruption of family life, and other intangibles. No attempt is made here to estimate the indirect benefits, although these may equal or exceed the direct benefits.

The direct costs of traffic accidents (and conversely the benefits gained by preventing traffic accidents) are estimated on a national basis by the National Safety Council as follows:

Fatality	- $34,400
Non-fatal injury	- $ 1,800
Property damage accident	- $ 310

If the State has available better data, presumably more significant to the State, such State data should be used rather than the national figures.

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The calculation of benefits derived from accident reduction following a safety improvement is as follows:

$$B = \frac{ADT_A}{ADT_B}\left[34{,}400(A_F)P_F + 1{,}800(A_I)P_I + 310(A_{PD})P_{PD}\right]$$

where B = annual benefit in dollars
ADT_A = average traffic volume after the improvement
ADT_B = average traffic volume before the improvement
A_F = annual number of fatalities at the location
P_F = percentage reduction in fatalities expected
and A_I and A_{PD} are number of injuries and property damage accidents respectively
and P_I and P_{PD} are corresponding percentage reductions expected.

The accident figures to be inserted in the formula may not all be available, particularly the number of property damage accidents. It is not recommended that assumptions be made for unreported accidents, and available data only should be used in calculating benefits.

Because fatality figures are often small and a matter of chance, the State may prefer to combine fatality and injury totals to play down the possibility of selecting an improvement project on the basis of chance. In this case, the previous formula becomes:

$$B = \frac{ADT_A}{ADT_B}\left[Q(A_{FI})P_{FI} + 310(A_{PD})P_{PD}\right]$$

where A_{FI} = annual average number of fatalities and injuries combined at the location
P_{FI} = percentage reduction in fatalities and injuries expected
and $Q = \frac{34{,}400 + (I/F)1{,}800}{1 + I/F}$

where I/F = ratio of injuries to fatalities in the State for the class of highway (rural 2-lane etc.)

MULTIPLE IMPROVEMENTS

If more than one improvement is required at a single location, the calculation of benefits must be adjusted to reflect the fact that the values of P (reduction in accidents) must be applied successively rather than simultaneously. Thus, if the first improvement will produce a reduction of P_1 percent, and the second improvement will produce a reduction of P_2 percent, the second reduction does not apply to the total number of

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accidents but rather to $(1 - P_1)$ times the original accident total. A third improvement, with an expected reduction of P_3 percent, likewise will affect $(1 - P_1)(1 - P_2)$ times the total number of accidents.

It is essential to the success of this benefit-cost concept that there be available a reasonable method to estimate the values of P, or the expected percentage reduction in accidents. If, as the result of previous work, the State has available supporting values for P, these may be used. In the more usual case, however, other published values must be used. These are available in many parts of the literature, including Traffic Control and Roadway Elements and Evaluation of Criteria for Safety Improvements on the Highway.

VALIDATION OF PREDICTED RESULTS

The entire highway safety improvement program is based on the assumption that accidents can and will be reduced by appropriate corrective engineering measures. The methodology proposed herein for establishing priorities is based on the use of estimated reductions in accidents. There are therefore two reasons for measuring the actual results of the improvements made: (1) to confirm the assumed potential of engineering to reduce accidents, and (2) to validate the estimates of accident reduction used in the priority methodology.

It is necessary therefore that States establish a procedure to record accident experience after the improvement has been completed. At least one year's experience should be accumulated before any conclusions are drawn. The after experience should be compared with the predicted experience and used both to measure the effectiveness of the improvement and to evaluate the accuracy of the prediction made before the improvement was undertaken.

As experience is accumulated from a number of similar projects, the results should be analyzed to provide guidance for the future in selecting the type of improvement to be made and in refining the forecasting factors used in predicting results.

Enclosure

F. C. Turner
Acting Federal Highway
Administrator

Enclosure

TABULATED VALUES FOR THE CAPITAL RECOVERY FACTOR

	Rate of Interest, in percent										
Years	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1	1.0100	1.0150	1.0200	1.0250	1.0300	1.0350	1.0400	1.0450	1.0500	1.0550	1.0600
2	0.5075	0.5113	0.5150	0.5188	0.5226	0.5264	0.5302	0.5340	0.5378	0.5416	0.5454
3	0.3400	0.3434	0.3467	0.3501	0.3535	0.3569	0.3603	0.3638	0.3672	0.3707	0.3741
4	0.2563	0.2594	0.2626	0.2658	0.2690	0.2723	0.2755	0.2787	0.2820	0.2853	0.2886
5	0.2060	0.2091	0.2121	0.2152	0.2183	0.2215	0.2246	0.2278	0.2310	0.2342	0.2374
6	0.1725	0.1755	0.1785	0.1815	0.1846	0.1877	0.1908	0.1939	0.1970	0.2002	0.2034
7	0.1486	0.1515	0.1545	0.1575	0.1605	0.1635	0.1666	0.1697	0.1728	0.1760	0.1791
8	0.1307	0.1336	0.1365	0.1395	0.1425	0.1455	0.1485	0.1516	0.1547	0.1579	0.1610
9	0.1167	0.1196	0.1225	0.1255	0.1284	0.1314	0.1345	0.1376	0.1407	0.1438	0.1470
10	0.1056	0.1084	0.1113	0.1143	0.1172	0.1202	0.1233	0.1234	0.1295	0.1327	0.1359
11	0.0965	0.0003	0.1022	0.1051	0.1081	0.1111	0.1141	0.1172	0.1204	0.1236	0.1268
12	0.0888	0.0917	0.0945	0.0775	0.1005	0.1035	0.1065	0.1097	0.1128	0.1160	0.1193
13	0.0824	0.0852	0.0881	0.0910	0.0940	0.0971	0.1001	0.1033	0.1065	0.1097	0.1130
14	0.0769	0.0797	0.0826	0.0855	0.0885	0.0916	0.0947	0.0978	0.1010	0.1043	0.1076
15	0.0721	0.0749	0.0778	0.0808	0.0838	0.0868	0.0899	0.0931	0.0963	0.0996	0.1030
16	0.0679	0.0708	0.0737	0.0766	0.0796	0.0827	0.0858	0.0890	0.0923	0.0956	0.0989
17	0.0643	0.0671	0.0700	0.0729	0.0759	0.0790	0.0820	0.0854	0.0887	0.0920	0.0954
18	0.0610	0.0638	0.0667	0.0697	0.0727	0.0758	0.0790	0.0822	0.0855	0.0889	0.0923
19	0.0581	0.0609	0.0638	0.0668	0.0698	0.0729	0.0761	0.0794	0.0827	0.0861	0.0896
20	0.0554	0.0582	0.0611	0.0641	0.0672	0.0704	0.0736	0.0769	0.0802	0.0837	0.0872
21	0.0530	0.0559	0.0588	0.0618	0.0649	0.0680	0.0713	0.0746	0.0780	0.0815	0.0850
22	0.0509	0.0537	0.0566	0.0596	0.0627	0.0659	0.0692	0.0725	0.0760	0.0795	0.0830
23	0.0489	0.0517	0.0547	0.0577	0.0608	0.0640	0.0673	0.0707	0.0741	0.0777	0.0813
24	0.0471	0.0499	0.0529	0.0559	0.0590	0.0623	0.0666	0.0690	0.0725	0.0760	0.0797
25	0.0454	0.0483	0.0512	0.0543	0.0574	0.0607	0.0640	0.0674	0.0709	0.0745	0.0782
26	0.0439	0.0467	0.0497	0.0528	0.0559	0.0592	0.0626	0.0660	0.0696	0.0732	0.0769
27	0.0424	0.0453	0.0483	0.0514	0.0546	0.0579	0.0612	0.0647	0.0683	0.0719	0.0757
28	0.0411	0.0440	0.0470	0.0501	0.0533	0.0566	0.0600	0.0635	0.0671	0.0708	0.0746
29	0.0399	0.0425	0.0458	0.0489	0.0521	0.0554	0.0589	0.0624	0.0660	0.0698	0.0736
30	0.0387	0.0416	0.0446	0.0478	0.0510	0.0544	0.0578	0.0614	0.0651	0.0688	0.0726
31	0.0377	0.0406	0.0436	0.0467	0.0500	0.0534	0.0569	0.0604	0.0641	0.0679	0.0718
32	0.0367	0.0396	0.0426	0.0458	0.0490	0.0524	0.0559	0.0596	0.0633	0.0671	0.0710
33	0.0357	0.0386	0.0417	0.0449	0.0481	0.0516	0.0551	0.0587	0.0625	0.0663	0.0703
34	0.0348	0.0378	0.0408	0.0440	0.0473	0.0507	0.0543	0.0580	0.0617	0.0656	0.0696
35	0.0340	0.0369	0.0400	0.0432	0.0465	0.0500	0.0536	0.0573	0.0611	0.0650	0.0690
36	0.0332	0.0361	0.0392	0.0425	0.0458	0.0493	0.0529	0.0566	0.0604	0.0644	0.0684
37	0.0325	0.0354	0.0385	0.0417	0.0451	0.0486	0.0522	0.0560	0.0598	0.0638	0.0679
38	0.0318	0.0347	0.0378	0.0411	0.0445	0.0480	0.0516	0.0554	0.0593	0.0633	0.0673
39	0.0311	0.0341	0.0372	0.0404	0.0438	0.0474	0.0511	0.0549	0.0588	0.0628	0.0669
40	0.0305	0.0334	0.0365	0.0398	0.0433	0.0468	0.0505	0.0543	0.0583	0.0623	0.0665
41	0.0229	0.0328	0.0360	0.0393	0.0427	0.0463	0.0500	0.0539	0.0578	0.0619	0.0661
42	0.0293	0.0323	0.0354	0.0387	0.0422	0.0458	0.0495	0.0534	0.0574	0.0615	0.0657
43	0.0287	0.0317	0.0349	0.0382	0.0417	0.0453	0.0491	0.0530	0.0570	0.0611	0.0653
44	0.0282	0.0312	0.0344	0.0377	0.0412	0.0449	0.0487	0.0526	0.0566	0.0608	0.0650
45	0.0277	0.0307	0.0339	0.0373	0.0408	0.0445	0.0483	0.0522	0.0563	0.0604	0.0647
46	0.0272	0.0303	0.0335	0.0368	0.0404	0.0441	0.0479	0.0518	0.0559	0.0601	0.0644
47	0.0268	0.0298	0.0330	0.0364	0.0400	0.0437	0.0475	0.0515	0.0556	0.0598	0.0641
48	0.0263	0.0294	0.0326	0.0360	0.0396	0.0433	0.0472	0.0512	0.0553	0.0595	0.0639
49	0.0259	0.0290	0.0322	0.0356	0.0392	0.0430	0.0469	0.0509	0.0550	0.0593	0.0637
50	0.0255	0.0286	0.0318	0.0353	0.0389	0.0426	0.0456	0.0506	0.0548	0.0591	0.0634
60	0.0222	0.0254	0.0288	0.0324	0.0361	0.0401	0.0442	0.0485	0.0528	0.0573	0.0619
70	0.0199	0.0232	0.0267	0.0304	0.0343	0.0385	0.0427	0.0472	0.0517	0.0563	0.0610
80	0.0182	0.0215	0.0252	0.0291	0.0331	0.0374	0.0418	0.0464	0.0510	0.0558	0.0606
90	0.0169	0.0203	0.0240	0.0280	0.0323	0.0367	0.0412	0.0459	0.0506	0.0554	0.0603
100	0.0159	0.0194	0.0232	0.0273	0.0316	0.0362	0.0408	0.0456	0.0504	0.0553	0.0602

APPENDIX IV
ACCIDENT REDUCTION FACTORS FOR HIGHWAY SAFETY PRODUCTS

(From Evaluation of Minor Improvements, Parts 1-5,
California Dept. of Public Works, Division of Highways, Sacramento, 1967.)

Type of Improvement	Average Accident Reduction[1]	Significance[1]
New Signals	15% of all accidents	S
Modified Signals	10% of all accidents	S
New Signals with Channelization	20% of all accidents	S
Modified Signals with Channelization	35% of all accidents	S
Left-Turn Channelization		
a. At signalized intersections	15% of all accidents	S
b. At non-signalized intersections		
1. With curbs and/or raised bars	65% of all accidents	S
2. Painted channelization	30% of all accidents	S
Flashing Beacons		
a. At intersections	40% of all accidents	S
b. Advance warning flashers	20% of all accidents	S
c. Railroad #8 flashers	80% of all accidents	S
Safety Lighting	60% of night accidents	S
Delineation		
a. Median double yellow stripe	5% of all accidents	S
b. Right edge lines	2% of all accidents	NS
	(Or 25% of ran-off-road accidents)	NS
c. Reflectorized raised pavement markers	5% of all accidents	A
d. No passing stripes	65% of all accidents	S
	(Or 85% of passing accidents)	NS
e. Reflectorized guide markers		
1. At horizontal curves	30% of all accidents	S
2. At bridge approaches	40% of all accidents	NS

Type of Improvement	Average Accident Reduction	Significance[1]
Protective Guardrail		
a. At bridge rail ends	40% of EPDO[2] accidents	S
b. At bridge piers and abutments	50% of EPDO[2] accidents	S
c. At steel sign posts	60% of EPDO[2] accidents	S
d. At embankments	20% of EPDO[2] accidents	
Pavement Grooving	75% of skidding accidents	A
	(Or 25% of wet pavement accidents)	A
Signing		
a. Curve warning arrows	20% of all accidents	NS
b. Advance curve warning	45% of all accidents	S
with advisory speed	45% of all accidents	S
c. 4-way stop	75% of all accidents	S
Median Barriers		
a. All accidents		
1. Cable barrier	30% increase in accidents	S
2. Blocked-out beam barrier	20% increase in accidents	S
b. Fatal accidents		
1. Cable barrier	35% decrease in accidents	NS
2. Blocked-out beam barrier	15% decrease in accidents	NS
c. Injury accidents		
1. Cable barrier	20% increase in accidents	S
2. Blocked-out beam barrier	30% increase in accidents	S
d. PDO accidents		
1. Cable barrier	40% increase in accidents	S
2. Blocked-out beam barrier	10% increase in accidents	S
Reconstruction and Miscellaneous (Widening, superelevation correction, construct shoulders, increase curve radii, increase sight distance, etc.)	20% of all accidents (or reduction based on study of individual accident reports.)	

Notes:

(1) The average accident reduction factors listed above are from the latest analyses of approximately 500 "Before and After" reports of past safety improvement projects. Depending on the number of accidents in each category, the results are significant (using the chi square test at the 10% level) or not significant. "S" indicates reductions that are significant, and "NS" indicates those that are not significant. The two "A" notations indicate approximate or estimated accident reductions. Adequate "Before and After" reports are not now available for these two categories.

(2) EPDO means the equivalent number of PDO* accidents reduced. For example, one fatal accident costing $9,700 is equivalent to 19.4 reported PDO accidents costing $500 each. The cost per accident reduced for projects where equivalent accident factors are used should be equal to or less than $800 in rural areas and $600 in urban areas.

(3) The above average accident reduction factors are not used in all cases. The study of accident histories at individual locations sometimes indicate that higher, or lower, reduction factors are more appropriate.

Assigned Priorities of Safety Projects

Priority #1	Estimated cost per accident reduced equals $0 to $1,500, or the average cost of past accidents exceeds the estimated cost per accident reduced.
Priority #2	Estimated cost per accident reduced equals $1,501 to $5,000.
Priority #3	Used where engineering judgment indicates a potential accident savings, but the accident history does not support a first or second priority. Priority #3 is usually limited to projects costing a total of $15,000 or less.
Priority #4	An operational improvement project to improve traffic flow, reduce congestion, and/or to reduce accidents where the estimated cost per accident reduced exceeds $5,000. This is considered a non-safety project.

*Property damage only.