REPORT TO CONGRESS

RAILROAD-HIGHWAY SAFETY
PART II: RECOMMENDATIONS FOR RESOLVING THE PROBLEM

U.S. DEPARTMENT OF TRANSPORTATION

PREPARED BY THE STAFF OF

THE FEDERAL RAILROAD ADMINISTRATION
THE FEDERAL HIGHWAY ADMINISTRATION

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EXECUTIVE SUMMARY

Part I of this report described the extent and nature of the safety problem associated with railroad-highway grade crossings nationwide.

Part II contains a further analysis of the matters covered in Part I and makes recommendations for improving safety at both public and private crossings of railroads, together with equitable allocation of costs, and discusses possible funding alternatives for consideration in financing an effective public grade crossing improvement program. It also modifies and refines data contained in Part I, reflecting the latest and best information available.

The primary goal of the entire study was to determine grade crossing improvement needs nationwide and, as appropriate, identify a feasible program level which would lead to a significant reduction in the accidents, fatalities, personal injuries, and property damage, together with reasonable improvement in the mobility of the highway traffic and railroad operations.

THE PROBLEM

Safety at railroad-highway grade crossings has long been a matter of public concern. The high severity of grade crossing accidents makes this a safety issue of major significance. Among all transportation accidents, those at grade crossings rate second in severity only to aviation accidents. The ratio of persons killed and injured to the number of grade crossing accidents is over 40 times that of all motor vehicle accidents.

The 223,000 locations where public roads cross railroads at grade present the most significant and immediate problems of safety and traffic mobility. These crossings consist of some 49,000 on the Federal-aid highway systems and 174,000 off the systems. Approximately 79,000 public crossings are located in urban areas and 144,000 in rural areas. Some 22 percent, or 48,500, have train-activated protective devices.

There are over 12,000 vehicle-train collisions at public grade crossings annually, resulting in about 1,500 deaths and 7,000 injuries. Over 40 percent of these accidents occur at crossings which have some form of active protection.

PUBLIC GRADE CROSSING IMPROVEMENT NEEDS

An economic analysis was used in this study to identify various levels of improvement and to evaluate the reduction in nationwide losses at public grade crossings that would result from each. For purposes of the economic analysis, the types of improvement considered were limited to flashing lights, automatic gates, and grade separation structures.

The cost-benefit analysis indicates that grade crossing protection will return both greater overall benefits and much greater safety benefits for a given level of investment than will grade separation. Accordingly, any new Federal initiative should concentrate on grade crossing protection, while grade separations and similar elimination-type projects should continue to be included in other highway programs.

The total number of grade crossings warranting improvement indicates that at least 3,000 protection installations should be made annually for the next 10 years at an expenditure of about $75 million per year. This would be a rate of installation nearly three times the current rate.

It is anticipated that completion of these improvement would eliminate nearly 4,000 motor vehicle-train collisions annually and save some 500 lives per year.

To effectively treat the large number of lower volume crossings which do not warrant active protection and to provide effective advance warning at all crossings, each railroad and each public agency which does not now have a program for passive device improvements should undertake one immediately.

FUNDING

There are several possible methods for financing the cost of railroad-highway intersection improvements. These range from continuing under existing programs to requiring the expenditure of a fixed amount of funds for grade crossing protection on and off the Federal-aid highway systems. Other alternatives include permissive funding on and off the systems and the inclusion of grade crossing protection as part of a larger safety program.

Any funding method should, as a minimum, reflect the results of the economic analysis in Chapter X, and encourage the undertaking of those improvements which will provide the greatest safety return for a given level of investment. It should also provide a sound basis for dealing equally with all grade crossings, regardless of whether they are located on or off the Federal-aid highway systems.

Those crossings on the Federal-aid highway systems quite consistently have a greater extent of active protection than comparable crossings off the systems. Nearly 60 percent of vehicle-train accidents occur at crossings located off the Federal-aid systems. Some 45 percent of the crossings warranting improvement under this study are located off the systems. Thus, it is apparent that a significant reduction in grade crossing accidents cannot be achieved by giving attention to only those crossings on the Federal-aid systems, and Federal funding should be extended to crossings not on the Federal-aid systems.

ALLOCATION OF COSTS

Currently, on Federal-aid projects the railroad share of the cost is dependent on the type of project but cannot exceed 10 percent on any project. Where Federal-aid funds are not involved, the railroad share is often 50 percent or more. In addition, the maintenance and operation of protective devices are currently almost totally a railroad responsibility although there is some trend to public agencies providing some financial aid to the railroads for the costs so incurred.

For federally assisted projects, no railroad contribution should be required for protection-type projects. For elimination-type projects where benefits accrue to the railroad, the railroad contribution should be administratively reduced from the current 10 percent to 5 percent and for those projects where no benefits accrue to the railroad, there should continue to be no railroad contribution to the project costs.

JURISDICTIONAL CONSIDERATIONS

As set forth in Part I of this report, jurisdiction over railroad-highway intersections resides exclusively in the States. Responsibility is frequently divided among several public agencies and the railroad. The net effect results in a fragmented approach to grade crossing safety. The need for national coordination of an issue that affects the Nation's railroad and highway systems is apparent.

Determinations for selecting individual crossings should be made at the State level consistent with the current decision-making process. However, it is necessary that there be a logical and orderly system for administering funds from a single source to a minimum number of State agencies, using uniform criteria or guidelines. It follows that any Federal assistance for grade crossing protection should be administered through the established administrative mechanism of the Federal Highway Administration and at the State level by the State highway departments or

other appropriate transportation agency, in cooperation with regulatory agencies, political subdivisions, or other decisionmaking bodies. Each State should be strongly encouraged to develop procedures to assure that every crossing in the State will be given equal consideration for improveme under any grade crossing improvement program.

SUPPORTING ACTIVITIES

In addition to making physical improvements at grade crossings, there are other associated activities which are also most important in providing increased grade crossing safety. Among these are the development of an adequate information system, further research and development activities, and driver education activities dealing with grade crossing safety.

Information Systems

The extent, reliability, and accessibility of current information on railroad-highway grade crossings varies widely among jurisdictions. Some modification is needed to produce an effective and efficient information system to assist in a systematic approach to the planning and evaluation of programs for the improvement of grade crossings.

The most effective and efficient method of obtaining this information appears to be for the Department of Transportation, in conjunction and cooperation with the railroad industry and appropriate State agencies to: (1) undertake to develop a national inventory of grade crossings, (2) undertake to develop and implement a uniform national numbering system, and (3) both expand railroad company accident reporting and also work toward the eventual reporting of all police officer railroad-highway accident reports through one State agency for correlation and analysis with inventory data.

Research

In order to achieve the greatest payoff in grade crossing safety, there should be strong emphasis placed on a continuing grade crossing research program conducted by the involved Department of Transportation agencies with advisory and other assistance from the States and railroads. In the interest of developing warning devices or systems which are fully responsive to the drivers' needs, such a program should place importance on human factors involvement and accident data analysis.

Education

A major problem in driver education is how to identify and communicate information which is most effective. The Department of Transportation should: (1) continue and expand its present efforts to gain greater understanding of driver behavior at grade crossings, (2) encourage inclusion of grade crossing related materials in driver education programs and in State driver manuals, and (3) work closely with the National Safety Council and the railroad industry to develop the most effective educational materials.

SPECIAL PROBLEM AREAS

Special problem areas indicated in the legislation or identified by the study staff include the problems created by railroads in urban areas - both those related to grade crossings and those of pedestrian safety along railroad rights-of-way; the grade crossing problems involved with high-speed rail operations; and the private crossing problem.

Railroads in Urban Areas

The most sweeping course of action to resolve urban railroad problems is the relocation or consolidation of railroad lines. This has generally been given only fleeting attention in land use and local transportation planning. However, many urban communities have recently indicated a strong interest in initiating studies of railroad relocation, and other communities want to pursue further planning. Although Federal assistance is often requested, planning funds are not now available at the Federal level for this specific purpose.

The Federal Highway Administration and Federal Railroad Administration have retained a consultant to undertake a study of the nationwide magnitude of the need for railroad relocation and methodology for relocation studies.

Pedestrian Protection

A safety problem of railroads in urban areas involves pedestrians along railroad rights-of-way. Pedestrian accidents on railroad rights-of-way in densely populated areas result in some 350 fatalities annually along the 30,000 miles of railroad lines in such areas.

The pedestrian problem is essentially a localized problem with unique features associated with each location. The local community and the individual railroad company are the parties most aware of the particular

I

INTRODUCTION

LEGISLATIVE REQUIREMENTS

Part II of the report on Railroad-Highway Safety: Recommendations for Resolving the Problem, which follows, is submitted to the Congress in response to Section 205(a) of the Highway Safety Act of 1970. Part I: A Comprehensive Statement of the Problem, was submitted to Congress in November 1971 in response to Section 204 of the Railroad Safety Act of 1970. Pertinent provisions of both legislative acts are set forth in the Introduction of Part I. Both parts are products of a combined study made by the Federal Highway Administration and Federal Railroad Administration.

TERMINOLOGY

Restatement of some terminology clarification contained in Part I of this report may be helpful.

Railroad-highway intersections encompass all bimodal points of crossing of highway traffic and railroad operations.

Grade crossing, sometimes preceded by railroad-highway, denotes a railroad-highway intersection where the intersecting traffic movements of the two modes are at the same level.

Grade separation is employed to distinguish an intersection where the channels of traffic flow of the modes are at different levels. Overpass signifies a grade separation where highway traffic uses the upper level. Underpass signifies a grade separation where highway traffic uses the lower level.

A grade crossing elimination may result from the construction of a grade separation, from the closing or abandonment of the highway, from the abandonment and removal of the railroad or from the relocation of a railroad or highway. Construction of a grade separation at a newly established railroad-highway intersection does not constitute a grade crossing elimination unless an existing grade crossing is actually closed. Nevertheless, construction of a grade separation at a new location is sometimes classed as an elimination on the basis that it avoids establishing a new crossing at grade.

Grade crossing protection is provided at grade crossings to assist the highway traveler - a driver of a vehicle or a pedestrian - in making a safe crossing of the railroad. Active protection, such as flashing light signals or automatic gates, provides a warning indication to the traveler when a train or other railroad movement approaches or

occupies the crossing. Passive protection, such as crossbuck signs or similar fixed signs without flashing light signals or gates, merely designates the location of the crossing, sometimes with appropriate supplemental information on the number of tracks or other significant facts.

The term casualties is employed to include collectively persons killed outright, persons fatally injured, and persons who sustain injuries and are recorded as a personal injury in an accident report.

Each of the following additional terms used in this report has been assigned a specific meaning.

A public grade crossing signifies a crossing at the same level of a public highway, road, street, alley, or other publicly used vehicular traveled way with any railroad track regardless of the ownership or use of the track.

A private crossing signifies a crossing of a railroad track by any vehicular traveled way not open to public use. The distinction between a private crossing and a public crossing is set forth at some length under Chapter VII, Private Grade Crossings.

A pedestrian crossing signifies a crossing of a railroad track by a traveled way restricted to use by pedestrians.

II

STUDY GOALS

REPORT

Part I of this report described the extent and nature of the safety problem associated with railroad-highway intersections nationwide and to pedestrians along railroad rights-of-way, particularly within and near urban locations.

Part II contains a somewhat greater in-depth analysis of the matters covered in Part I and makes recommendations for improving safety at both public and private crossings of railroads, together with equitable allocation of costs, and discusses possible funding alternatives for consideration in financing an effective public grade crossing improvement program. It also modifies and refines the inventory, accident, and other data contained in Part I, reflecting the latest and best information available on the numbers of crossings, accidents, costs, and expenditures.

PRIMARY GOAL

Determine grade crossing improvement needs nationwide and, as appropriate, identify a feasible program level which would lead to a significant reduction in the accidents, fatalities, personal injuries, and property damage occurring at and in the vicinity of railroad-highway grade crossings, together with reasonable improvement in the mobility of the highway traffic and railroad operations which are affected by the conflicts arising from their cross movements.

SPECIFIC OBJECTIVES

1. Identify railroad-highway intersection improvement needs, both on and off the Federal-aid highway systems, including level of economically warranted improvements at public grade crossings.

2. Identify ways to protect pedestrians along railroad rights-of-way, particularly within and near urban locations, and recommend measures for increasing pedestrian safety.

3. Develop and recommend measures for improving safety at private grade crossings.

4. Identify potential high-speed rail corridors and present alternative courses of action for improving grade crossing safety along these corridors.

5. Identify the problems associated with railroads in urban areas and recommend measures for improvement.

6. Develop and present other cogent recommendations regarding the grade crossing environment and its users.

III

THE PROBLEM

THE BASIC NETWORK

There are approximately 220,000 miles of railroad line with nearly 500 million train miles of travel annually on those lines. There are also 3.7 million miles of roads and streets carrying over 1 trillion vehicle-miles of travel annually.

Although estimated motor vehicle miles of travel in the United States increased by a factor of 25, i.e., by 2400 percent, in the 50-year period from 1920 to 1970, the total mileage of roads and streets increased by only 20 percent. Vast improvements to existing highway routes have accompanied the great expansion of vehicular traffic, but even during the most recent 20-year period, during which the greatest highway improvements have been carried out, the total highway and street mileage has grown at a rate of only 0.5 percent per year.

During the 50-year period since 1920, miles of railroad line in the United States have declined by almost 20 percent, at a reasonably uniform rate of 0.4 percent per year. Figure 1 shows the trend in highway and railroad mileage.

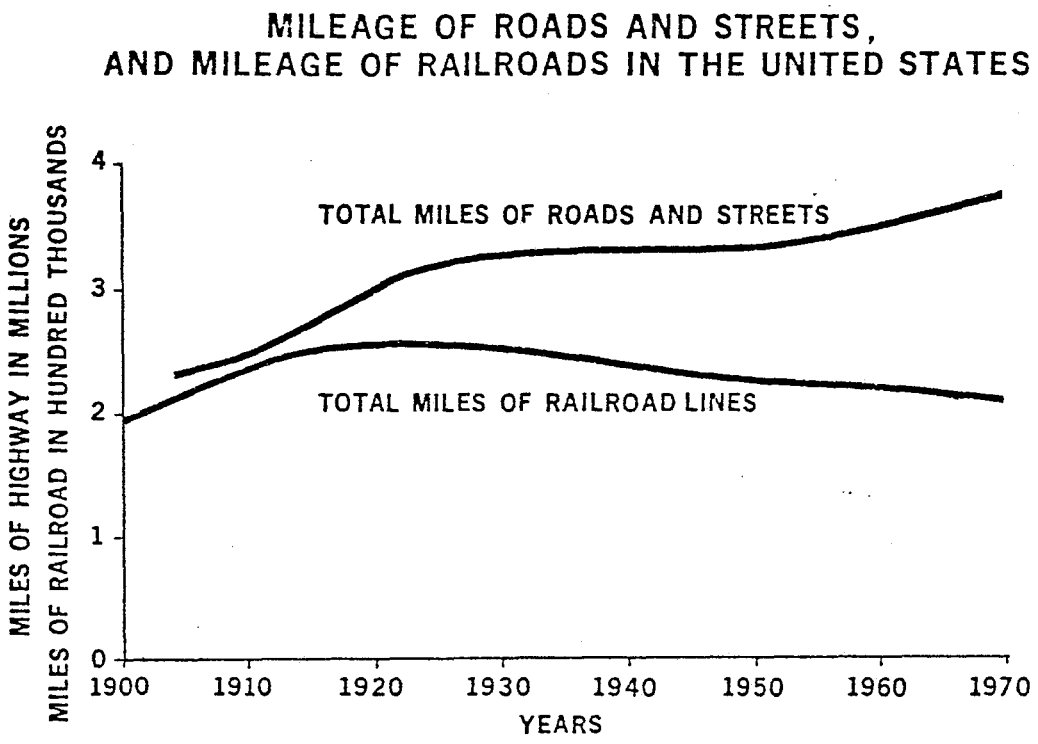
RAILROAD-HIGHWAY INTERSECTIONS

Number and Type

Currently there are approximately 258,000 public railroad-highway intersections composed of 223,000 public railroad-highway crossings at grade and some 35,000 grade-separated intersections where the highway is carried either over or under the railroad at a separate level. In addition, there are approximately 140,000 private crossings which accommodate vehicular travel across railroad tracks on private roads and driveways. The exact number of public and private crossings is not easily determined because of the difficulty which arises in selecting the proper classification of some crossings, i.e., public or private status is not clearly established. However, those in this doubtful category are only a small percentage of the total number of crossings. This problem is discussed further in the report under Chapter VII, Private Grade Crossings, and Chapter IX, Off-Site Programs, Information Systems.

Available statistics indicate that since 1954 there has been a net decrease of some 15,000 grade crossings. This has been primarily due to the abandonment of railroad lines which have more tnan offset the several hundred crossings being added each year.

Figure 1



Public Grade Crossings

Among all of the categories of railroad-highway intersections, the 223,000 public grade crossings present the major problems of safety and traffic mobility. Therefore, this report deals largely with these public grade crossings, although it is recognized that some improvements may be justified at private grade crossings and also at existing grade separations.

In analyzing crossing improvement needs, public grade crossings have been assigned to two administrative groupings: Federal-aid and non-Federal-aid; have been classified by location: urban and rural; and have been distributed among the six major types of crossing protection currently in use; three forms of passive protection: crossbucks, stop signs, and none; and three forms of active protection: flashing lights, automatic gates, and other types (wigwags, automatic bells, watchmen, manual gates). Only the active forms provide a positive warning of the approach or presence of a train on the crossing. Table 1 shows the distribution of public grade crossings by administrative system, rural and urban area, and protection type. There are some 144,000 crossings in rural areas, with the remaining 79,000 in urban areas. About 48,900 grade crossings are on the current Federal-aid

TABLE 1

Number of Public Railroad-Highway Grade Crossings - by Administrative System and Protection Type

Type of Protection	Federal-aid System			Non-Federal-aid			Federal-aid and Non-Federal-aid		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
Passive									
Crossbucks	5,796	19,162	24,958	36,155	93,922	130,077	41,951	113,084	155,035
Stop signs	389	775	1,164	1,837	5,314	7,151	2,226	6,089	8,315
None	768	209	977	5,918	4,470	10,388	6,686	4,679	11,365
Subtotal	6,953	20,146	27,099	43,910	103,706	147,616	50,863	123,852	174,715
Active									
Flashing lights	6,721	8,885	15,606	11,332	5,728	17,060	18,053	14,613	32,666
Automatic gates	2,364	1,716	4,080	3,610	1,254	4,864	5,974	2,970	8,944
Other types 1/	1,037	1,050	2,087	3,198	1,633	4,831	4,235	2,683	6,918
Subtotal	10,122	11,651	21,773	18,140	8,615	26,755	28,262	20,266	48,528
Total	17,075	31,797	48,872	62,050	112,321	174,371	79,125	144,118	223,243

1/ Wigwags, bells, watchmen, manual gates.

systems. Of these, 21,773 or approximately 45 percent have some form of active protection. Of the estimated 174,400 grade crossings located off the systems, only 26,755 or approximately 15.3 percent, have active protection. Table 1 also indicates that 11,365 crossings, most of which are located off the Federal-aid systems, have no form of protection device whatsoever.

Highway and Railroad Traffic at Grade Crossings

In order to permit appropriate analysis of hazards and traffic flow interference, crossings were grouped by the volumes of highway and railroad traffic using them. Table 2 shows the number of public grade crossings, distributed by six highway traffic volume classes and six railroad traffic volume classes.

Figure 2, by the height of the vertical columns and by percentage figures, illustrates the relative proportion of the total number of grade crossings falling into each of the 36 cells formed by the six highway volume classes and six railroad volume classes.

From Table 2 and Figure 2 it is apparent that the greatest numbers of grade crossings lie among the lowest volume classifications. About 70,600 crossings, or almost one-third of the nationwide total, have two or less train movements per day and vehicular traffic of 500 or less per day. By contrast, the smallest number, 43 (0.02 percent) falls within the highest volume class on both the highway and the railroad. It is also significant that more than 63 percent (141,353) of the crossings lie in the minimum highway volume class and that about 47 percent (104,389) lie in the minimum railroad volume class.

It is estimated that most of the public crossings with both low railroad traffic and low highway traffic fall into two groups: (1) crossings located on branch line railroads through rural areas where the primary function of many of the local highways is to provide land service to abutting owners and residents and (2) crossings of industrial spur tracks by service roadways in urban industrial areas. There are individual hazardous crossings in this low-volume category, and some of these crossings have been provided with active forms of grade crossing protection; however, the hazard is generally low at these crossings where both volume and speed of highway traffic and railroad traffic are low. The vast majority of crossings with these characteristics are protected with passive protection only, leaving to the highway traveler the responsibility of determining when a train is approaching.

TABLE 2

Number of Grade Crossings
by Railroad Volume Class and Highway Volume Class

Railroad Volume Class	Number of Grade Crossings						Line Totals
	1	2	3	4	5	6	
6	1,195	559	950	475	206	43	3,428
5	5,867	1,504	2,420	818	387	73	11,069
4	13,248	3,329	4,793	1,410	636	177	23,593
3	25,398	5,760	7,114	1,930	696	252	41,423
2	25,026	5,038	6,379	1,779	935	184	39,341
1	70,619	12,014	14,580	4,498	2,226	452	104,389
Column Totals	141,353	28,204	36,236	10,910	5,359	1,181	223,243

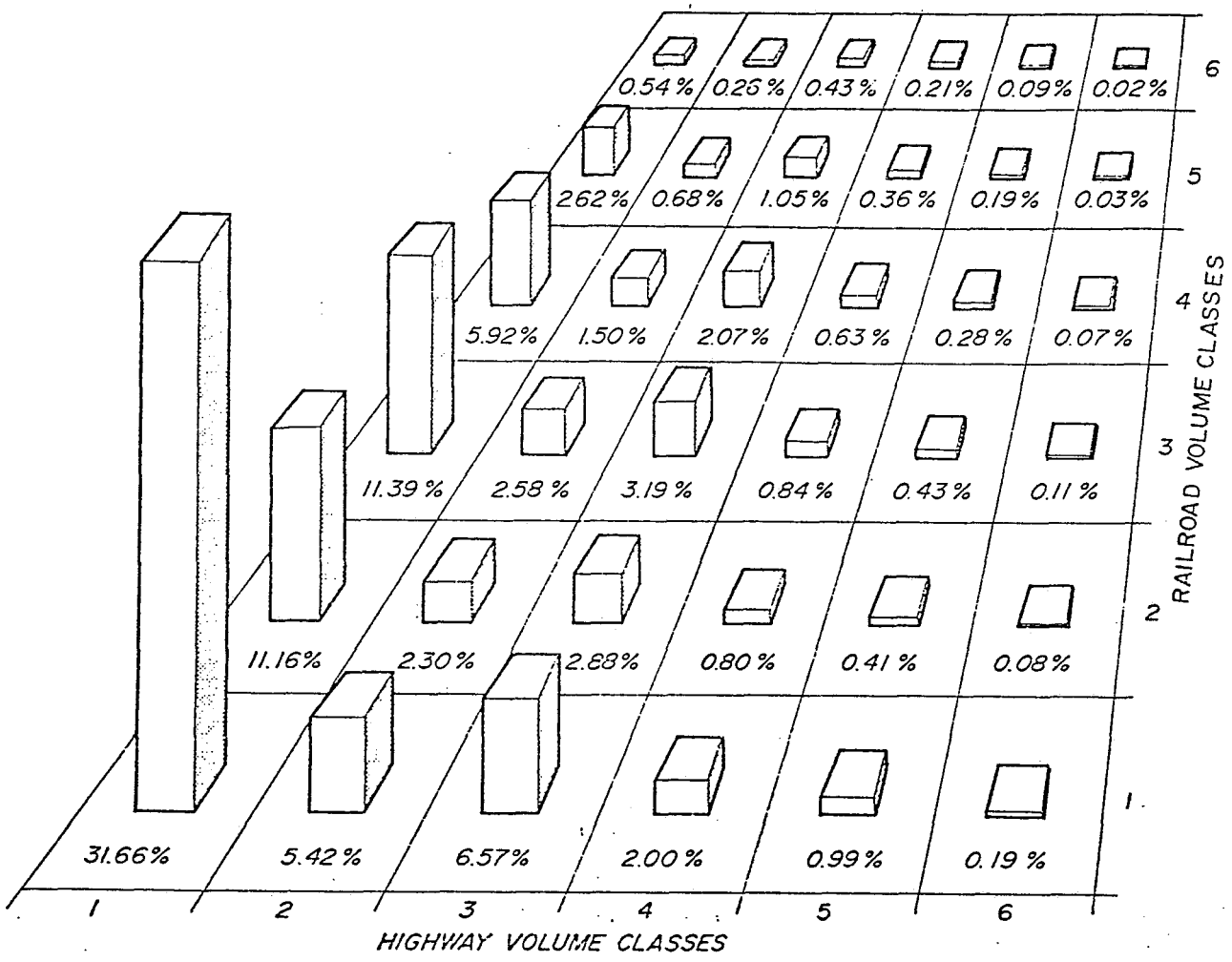
Highway Volume Class

Range of daily volume in each class:

Class	Trains	Highway Vehicles
1	0 to 2	0 to 500
2	3 to 5	501 to 1,000
3	6 to 10	1,001 to 5,000
4	11 to 20	5,001 to 10,000
5	21 to 40	10,001 to 20,000
6	Over 40	Over 20,000

FIGURE 2

Distribution of Public Railroad-Highway Grade Crossings
by Railroad Volume Class and Highway Volume Class



Range of daily volume in each class:

Class	Trains	Highway Vehicles
1	0 to 2	0 to 500
2	3 to 5	501 to 1,000
3	6 to 10	1,001 to 5,000
4	11 to 20	5,001 to 10,000
5	21 to 40	10,001 to 20,000
6	Over 40	Over 20,000

Current Level of Crossing Protection

Table 3 shows, for each traffic volume class, the percentage of actively-protected crossings on and off the Federal-aid systems in urban areas. Table 4 provides the same information for crossings in rural areas.

While Table 1 provides an overview of the level of active protection at crossings located both in urban and rural areas and on and off the Federal-aid systems, Tables 3 and 4 provide a more meaningful comparison of these levels of protection by separating the crossings into the various volume classifications. For example, in Table 3, for the cell with railroad volume class 3 and highway volume class 3, 65.3 percent of the crossings on Federal-aid systems in urban areas have active protection in contrast with 47.9 percent of those crossings off the Federal-aid systems. Tables 3 and 4 also show that the percentage of crossings which have been provided with active protection generally increases as railroad and highway traffic volumes increase.

GRADE CROSSING ACCIDENTS

Train-Involved Accidents

Accident Distribution - There were an estimated 12,412 vehicle-train collisions at public grade crossings in 1970. This total was estimated from summaries of accidents reported to the Federal Railroad Administration by the railroad companies and from State summaries of police officer accident reports and selected statewide accident tapes. Assignment of these accidents to urban and to rural areas and to those crossings with active and passive protection was also made on the basis of these statistics. Utilizing accident prediction equations derived from crossing accident data, train-involved accidents were assigned to the highway and railroad volume classes conforming to those established for the inventory of public grade crossings.

Estimated train-involved accidents at public grade crossings in 1970 are broadly distributed as set forth in Table 5.

TABLE 3

Percentage of Urban Railroad-Highway Grade Crossings with Active Protection by Volume Class Cells

Sequence of figures in each volume class cell:
Federal-aid urban
Non-Federal-aid urban

Railroad Volume Class	1	2	3	4	5	6
6	53.7 45.9	56.1 51.4	74.2 57.3	82.5 80.8	82.7 93.5	88.6 100.0
5	40.7 38.9	61.1 58.1	80.2 77.0	82.5 79.8	92.7 81.0	80.7 100.0
4	51.6 24.6	60.6 47.9	74.7 68.6	86.9 74.2	87.8 85.9	92.8 97.9
3	40.6 24.3	47.1 38.9	65.3 47.9	76.9 59.5	76.3 72.4	75.0 68.6
2	21.0 11.0	40.1 18.5	50.9 29.4	65.5 49.5	73.3 52.3	81.1 75.9
1	20.2 6.0	25.6 13.5	39.7 22.0	46.6 35.1	57.4 38.1	56.6 53.4

Highway Volume Class

Range of daily volume in each class:

Class	Trains	Highway Vehicles
1	0 to 2	0 to 500
2	3 to 5	501 to 1,000
3	6 to 10	1,001 to 5,000
4	11 to 20	5,001 to 10,000
5	21 to 40	10,001 to 20,000
6	Over 40	Over 20,000

TABLE 4

Percentage of Rural Railroad-Highway Grade Crossings with Active Protection by Volume Class Cells

Sequence of figures in each volume class cell:
Federal-aid rural
Non-Federal-aid rural

Railroad Volume Class	Highway Volume Class 1	2	3	4	5	6
6	63.6 28.7	89.4 55.3	89.6 70.6	81.0 57.1	100.0 *	100.0 *
5	49.0 15.6	78.3 55.9	89.0 74.4	97.4 80.0	100.0 100.0	100.0 *
4	38.6 10.5	67.3 38.9	82.9 55.0	88.6 87.0	72.7 60.0	66.7 100.0
3	29.0 7.7	58.2 31.4	75.3 39.1	83.3 75.4	75.0 46.7	100.0 *
2	17.1 5.1	49.2 16.3	63.9 37.3	76.3 59.0	80.9 40.0	83.3 94.1
1	7.2 2.2	23.4 12.5	46.0 21.4	54.0 42.9	61.8 16.5	40.0 *

Range of daily volume in each class:

Class	Trains	Highway Vehicles
1	0 to 2	0 to 500
2	3 to 5	501 to 1,000
3	6 to 10	1,001 to 5,000
4	11 to 20	5,001 to 10,000
5	21 to 40	10,001 to 20,000
6	Over 40	Over 20,000

*No crossings in these cells.

TABLE 5

Estimated Number of Train-Involved Accidents
at Railroad-Highway Grade Crossings in 1970

	Federal-aid Systems			Non-Federal-aid			Total Federal-aid and Non-Federal-aid
	Urban	Rural	Total	Urban	Rural	Total	
With passive protection	1,065	1,104	2,169	2,762	2,324	5,086	7,255
With active protection	1,751	1,124	2,875	1,873	409	2,282	5,157
Total, active and passive	2,816	2,228	5,044	4,635	2,733	7,368	12,412

Approximately 60 percent (7,368) of the train-involved accidents were estimated to have occurred at crossings off the Federal-aid highway systems. Distribution of accidents by protection type indicates that over 40 percent occurred at crossings which have some form of active protection. Generally, these are the crossings with higher volumes of vehicle and train traffic and attendant higher accident potential.

In order to establish a more meaningful relationship between the accident records at crossings with passive types of protection and the accident records at crossings with active forms of protection, these train-involved accidents were assigned to the appropriate crossing groups in each protection category. This distribution by volumes of highway and railroad traffic for crossings with passive types of protection is set forth in Table 6 and for crossings with active forms of protection is shown in Table 7.

The figures in these tables showing the annual number of accidents per crossing indicate quite clearly that, particularly in the higher traffic volume ranges, the crossings with active protection can be expected to experience a lower average number of accidents per crossing than those with passive protection. Furthermore, only 8,944 or 18 percent of the 48,528 actively protected crossings are now equipped with automatic gates (Table 1), which is the most effective type of protection. The installation of automatic gates can be expected to further reduce the rate of accidents per crossing to about one-half of that indicated for actively protected crossings without gates.

TABLE 6

Estimated Annual Train-Involved Accidents by
Railroad Volume Class and Highway Volume Class

All Crossings with Passive Protection

Sequence of numbers in each volume class cell:
Number of grade crossings
Average number of accidents per crossing
Number of accidents

Railroad Volume Class	1	2	3	4	5	6
6	735 0.159 117	246 0.435 107	335 0.910 305	90 1.777 160	27 2.593 70	4 3.750 15
5	4,483 0.056 248	589 0.170 100	490 0.353 173	142 0.655 93	37 1.233 46	11 1.455 16
4	11,039 0.035 381	1,696 0.103 175	1,404 0.209 293	266 0.380 101	87 0.586 51	11 0.818 9
3	21,957 0.021 457	3,410 0.062 212	3,111 0.124 387	562 0.224 126	244 0.328 80	64 0.469 30
2	23,111 0.016 363	3,764 0.046 172	3,686 0.092 340	715 0.164 117	307 0.241 74	34 0.353 12
1	68,161 0.012 796	10,099 0.035 352	9,916 0.071 703	2,571 0.126 323	1,102 0.180 198	203 0.261 53

Highway Volume Class

Note: The range of highway traffic and railroad traffic in each volume class is the same as used in previous tables.

TABLE 7

Estimated Annual Train-Involved Accidents by
Railroad Volume Class and Highway Volume Class

All Crossings with Active Protection

Sequence of numbers in each volume class cell:
Number of grade crossings
Average number of accidents per crossing
Number of accidents

Railroad Volume Class	1	2	3	4	5	6
6	460 0.067 31	313 0.150 47	744 0.281 209	405 0.598 242	183 0.940 172	39 1.538 60
5	1,384 0.030 42	915 0.083 76	1,930 0.164 317	676 0.311 210	350 0.414 145	62 0.629 39
4	2,209 0.023 51	1,633 0.059 96	3,383 0.119 402	1,144 0.220 252	549 0.304 167	166 0.470 78
3	3,441 0.018 61	2,350 0.045 106	4,001 0.096 383	1,368 0.167 229	725 0.232 168	188 0.340 64
2	1,915 0.015 28	1,274 0.039 50	2,693 0.085 230	1,064 0.142 151	628 0.189 119	150 0.267 40
1	2,458 0.012 30	1,915 0.033 63	4,664 0.072 337	1,927 0.120 231	1,118 0.159 178	249 0.213 53

Highway Volume Class

Note: The range of highway traffic and railroad traffic in each volume class is the same as used in previous tables.

Accident Severity - High severity is a characteristic of railroad-highway grade crossing accidents. Among all transportation accidents, those at grade crossings rate second in severity only to aviation accidents. The ratio of persons killed in grade crossing accidents to total grade crossing accidents is over 40 times the similar ratio for all motor vehicle accidents.

Statistics maintained by the Federal Railroad Administration show that 1,372 fatalities resulted from vehicle-train collisions at public grade crossings in 1970. These statistics include only those cases where death occurred within 24 hours of the accident. When fatalities occurring after 24 hours are included, the total number of fatalities for 1970, as reported by the National Safety Council, was increased to 1,438. In order to account for the year-to-year variation in this total, the annual average for the years 1967-70 was used to estimate the expected total annual fatalities. On this basis, the expected annual fatality level for motor vehicle-train related accidents at public grade crossings under current conditions can be expected to be slightly in excess of 1,500. It should be noted that this does not include expected annual pedestrian fatalities and non-train-involved fatalities at grade crossings, nor does it include motor vehicle related fatalities that occur at private grade crossings.

Data on the level of severity of the 12,412 train-involved accidents in urban and rural areas were obtained from the State summaries of accident reports and selected State accident tapes. These data indicated one fatality in every five rural accidents (0.21 fatalities per accident) contrasted with one fatality for every fifteen urban accidents (0.065 fatalities per accident).

Statistics for 1970 show that as a result of motor vehicle involved accidents at public grade crossings, 3,259 persons suffered injuries disabling beyond the day of the accident. In addition, analysis of police officer reports of such accidents indicates that additional less severe injuries resulting from train-involved accidents brought the total injuries in 1970 from motor vehicle-train collisions to nearly 7,100. The available data indicated an injury rate of 0.63 injuries per rural accident versus 0.53 injuries per urban accident.

The urban-rural distribution of train-involved accidents, injuries and fatalities is shown in Table 8.

Analysis of Table 8 indicates that while some 60 percent (7,451) of train-involved accidents occurred in urban areas, such accidents only produced slightly over 30 percent (484) of the fatalities.

TABLE 8

Estimated Annual Number of Train Involved Accidents and Casualties - by Urban and Rural Areas

	Accidents	Injuries	Fatalities
Urban	7,451	3,949	484
Rural	4,961	3,125	1,042
Total	12,412	7,074	1,526

The Continuing Trend - In Part I of this report, in the section entitled History and Trends, it was shown that there has been a very significant improvement in railroad-highway grade crossing safety over the past 50 years, but the rate of improvement since 1958 has been slight.

While the number of motor vehicle miles of travel has steadily increased, the number of train miles operated on the Nation's railroads has decreased. The decrease was abnormally large during 1971 (8 percent) as a result of the very significant change in passenger train service. Passenger train miles operated now are only 15 percent of the amount operated just 10 years ago.

However, the view ahead for railroad traffic appears to be different. During the most recent 10-year period, freight train miles have increased about 10 percent, and prospects for continuing increases are indicated. The decline in passenger train miles appears to be stabilized for the next few years, so that total train miles operated may even begin to increase moderately. (The analysis of future needs in this report, however, conservatively assumes no increase in train traffic.)

Concurrently, continuing increases are anticipated in motor vehicle miles of travel. Thus, all indications point toward a greater upward trend in the potential for conflicts of the two modes of travel at railroad-highway grade crossings in the near future. Continuing at the current rate of crossing improvement can then be expected to result in an upturn in the number of accidents and casualties at grade crossings.

Non-Train-Involved Accidents

Those accidents which are related to the crossing but do not involve a train are rather difficult to identify. They may be rear-end collisions triggered by a vehicle stopping at the crossing, vehicles

hitting a fixed object such as a protective device or vehicles losing control in traversing the crossing surface and consequently running off the road. Accident reports often cannot be correlated with the crossing and sometimes are not sufficiently descriptive to identify the grade crossing roadway element as leading to the accident.

There are no national statistics compiled for these types of accidents. The number of non-train-involved accidents has been estimated using accident prediction equations developed from available data on such accidents. Casualties resulting from non-train-involved accidents have been used in the economic analysis of crossing improvement needs, but they are relatively minor in comparison with the losses from train-involved accidents.

VEHICLE AND TRAIN OPERATING AND DELAY COSTS

In addition to the safety problem created by railroad-highway grade crossings, significant operating and delay costs are incurred by motor vehicles in traversing grade crossings. Operating costs are also incurred by railroads because of speed restrictions and other operational restrictions related to the presence of grade crossings, particularly in urban areas.

Vehicle Operating and Delay Costs

The presence of grade crossings has a detrimental effect on smooth and efficient traffic flow. Motor vehicles must slow down and stop in advance of the arrival of the train at the crossing and must await the passage of the train before proceeding. In addition, empirical studies indicate that even in the absence of a train, motor vehicles substantially reduce speed as they approach a crossing. The average speed reduction was found to be as much as 25 percent at passively-protected crossings, while it was less than 10 percent at crossings with active protection. It is significant that the aggregate motor vehicle delay caused by slowing down at crossings in the absence of a train far exceeds the delay caused by the approach and passage of the train.

A less critical yet important characteristic of grade crossings is the delay-producing restriction on passing in the vicinity of the crossing even when no train is present.

Aggregate motor vehicle delay at grade crossings is greatly influenced by the volume of highway traffic which passes the crossing, whereas it is far less sensitive to the number of train movements. At crossings carrying 1,000 vehicles per day, delay attributable to the

passage of trains constitutes from 8 to 38 percent of the total delay, depending on the number of trains, with the remaining delay due to motor vehicles slowing down or being unable to pass in the absence of a train. With higher highway traffic volumes, delay attributable to trains is 4 percent or less.

Train Operating and Delay Costs

In the interest of motor vehicle and pedestrian safety, many communities impose speed limitations on railroad operations within their area of jurisdiction. The operating costs of decelerating trains to conform to these speed restrictions and then accelerating to maintain the desired operating speed outside of these areas imposes a very significant cost upon railroads. This cost appears to be in the order of $75 to $100 million annually, as is explained in greater detail in Chapter V, Railroads in Urban Areas.

STATE-BY-STATE COMPARISON

Jurisdiction over grade crossing improvements is basically at the State and local level. Thus, solutions to the grade crossing problem must be approached on a State-by-State basis. This makes understanding of the distribution of the problem by States a necessary element of a description of the problem.

One measure of the magnitude of a State's grade crossing problem is its total number of public grade crossings. Table 9 indicates the total number of public crossings in each State, varying from a high of over 16,000 in Illinois to a low of 8 in Hawaii. The degree to which a State has dealt with the problem may be reflected by the percentage of crossings with active protection. While six States (excluding Puerto Rico) have active protection at over 40 percent of their crossings, 18 (excluding Hawaii and the District of Columbia) have active protection at less than 15 percent of their crossings. The degree to which crossings are now on the Federal-aid systems is also indicated by Table 9. This is indicative of the potential for Federal assistance in funding crossing improvements under existing law.

A more comprehensive comparison is presented in Table 10 which does not include any actual numbers, but rather simply ranks the various States (excluding Hawaii, District of Columbia and Puerto Rico) in terms of the number of public railroad-highway grade crossings and the percent of crossings with active protection. On the accident side of the problem, the rankings include the total annual number of fatalities, the annual number of fatalities per crossing, the average exposure factor (highway traffic and train traffic), and the fatalities per crossing in proportion to the exposure factor.

TABLE 9

State by State Summary of Public Grade Crossings

State	Total Number of Crossings	Number with Passive Protection	Number with Active Protection	Percent with Active Protection	Number of Crossings on Federal-Aid System	Percent on Federal-Aid System
Alabama	4,191	3,570	621	14.8	724	17.3
Alaska	176	140	36	20.5	74	42.0
Arizona	843	643	200	23.7	182	21.6
Arkansas	4,043	3,613	430	10.6	809	20.0
California	10,103	6,194	3,909	38.7	2,854	28.2
Colorado	2,106	1,581	525	24.9	401	19.0
Connecticut	491	241	250	50.9	37	07.5
Delaware	345	221	124	35.9	188	54.5
Florida	6,482	4,666	1,816	28.0	1,086	16.8
Georgia	6,558	5,793	765	11.7	1,210	18.5
Hawaii	8	7	1	12.5	4	50.0
Idaho	2,117	1,882	235	11.1	391	18.5
Illinois	16,210	10,898	5,312	32.8	2,867	17.7
Indiana	10,863	7,859	3,004	27.7	2,492	22.9
Iowa	9,914	8,580	1,334	13.5	2,715	27.4
Kansas	9,688	8,691	997	10.3	1,958	20.2
Kentucky	3,356	2,416	940	28.0	932	27.8
Louisiana	4,468	3,815	653	14.6	751	16.8
Maine	1,012	454	558	55.1	224	22.1
Maryland	1,059	755	304	28.7	444	41.9
Massachusetts	1,326	718	608	45.9	292	22.0
Michigan	8,865	6,565	2,300	25.9	2,339	26.4
Minnesota	8,699	7,821	878	10.1	2,091	24.0
Mississippi	3,075	2,752	323	10.5	761	24.7
Missouri	7,048	5,760	1,288	18.3	1,020	14.5
Montana	2,013	1,773	240	11.9	339	16.8
Nebraska	5,422	4,691	731	13.5	1,256	23.2
Nevada	333	243	90	27.0	66	19.8
New Hampshire	719	525	194	27.0	163	22.7
New Jersey	2,587	1,489	1,098	42.4	487	18.8
New Mexico	786	637	149	19.0	145	18.4
New York	4,732	2,449	2,283	48.2	1,190	25.1
North Carolina	5,686	4,756	930	16.4	1,588	27.9
North Dakota	5,402	5,207	195	03.6	907	16.8
Ohio	10,417	7,537	2,880	27.6	2,577	24.7
Oklahoma	6,533	6,110	423	06.5	876	13.4
Oregon	2,670	2,251	419	15.7	846	31.7
Pennsylvania	7,809	4,369	3,440	44.1	1,480	19.0
Rhode Island	186	151	35	18.8	57	30.6
South Carolina	3,941	3,657	284	07.2	1,245	31.6
South Dakota	3,368	3,216	152	04.5	719	21.3
Tennessee	4,009	3,426	583	14.5	958	23.9
Texas	14,308	11,332	2,976	20.8	2,194	15.3
Utah	1,419	1,137	282	19.9	264	18.6
Vermont	584	383	201	34.4	155	26.5
Virginia	2,701	1,790	911	33.7	1,066	39.5
Washington	3,957	3,522	435	11.0	1,034	26.1
West Virginia	2,414	2,129	285	11.8	696	28.8
Wisconsin	7,476	5,720	1,756	23.5	1,559	20.9
Wyoming	606	493	113	18.6	124	20.5
Dist. of Col.	53	50	3	05.7	14	26.4
Puerto Rico	66	37	29	43.9	21	31.8
Total	223,243	174,715	48,528	21.8	48,872	21.8

TABLE 10

Consecutive Numerical Ranking* of States in Relation to Railroad-Highway Crossings

State***	Number* of Railroad-Highway Grade Crossings	Percent* of Grade Crossings With Active Protection	Number of Annual** Grade Crossing Fatalities	Annual** Grade Crossing Fatalities* Per Crossing	Exposure Factor* = Average Daily Vehicle Traffic x Average Daily Train Movements	Fatalities* Per Crossing in Proportion to Exposure
Alabama	21	32	16	9	24	17
Alaska	49	24	48	48	16	48
Arizona	40	21	31	1	13	18
Arkansas	22	42	20	14	42	5
California	5	7	3	2	5	38
Colorado	34	20	34	34	33	22
Connecticut	45	2	49	40	7	46
Delaware	46	8	42	15	10	36
Florida	15	14	7	5	15	29
Georgia	13	39	8	7	22	20
Idaho	33	40	30	20	46	2
Illinois	1	11	1	24	17	33
Indiana	3	15	5	8	14	32
Iowa	6	35	12	38	30	28
Kansas	7	44	10	35	43	10
Kentucky	27	13	26	19	18	30
Louisiana	20	33	15	11	23	19
Maine	39	1	44	46	31	40
Maryland	38	12	38	32	9	42
Massachusetts	37	4	40	41	4	47
Michigan	8	19	6	12	11	35
Minnesota	9	45	9	29	39	13
Mississippi	28	43	22	4	35	8
Missouri	12	29	11	22	28	21
Montana	35	37	32	26	47	3
Nebraska	17	36	17	28	44	7
Nevada	47	17	43	13	38	9
New Hampshire	42	18	45	44	36	34
New Jersey	31	6	29	30	1	44
New Mexico	41	26	39	23	37	11
New York	19	3	25	31	6	43
North Carolina	16	30	13	18	19	27
North Dakota	18	49	35	47	48	6
Ohio	4	16	2	3	3	41
Oklahoma	14	47	19	36	40	15
Oregon	30	31	27	17	32	14
Pennsylvania	10	5	23	39	2	45
Rhode Island	48	27	49	49	8	49
South Carolina	25	46	21	16	29	16
South Dakota	26	48	36	45	49	1
Tennessee	23	34	24	21	21	25
Texas	2	23	4	25	26	23
Utah	36	25	33	6	34	12
Vermont	44	9	47	43	41	31
Virginia	29	10	28	27	12	37
Washington	24	41	18	10	20	24
West Virginia	32	38	37	42	27	39
Wisconsin	11	22	14	33	25	26
Wyoming	43	28	41	37	45	4

*Data in this table show comparative ranking only, with the numeral 1 denoting the State having the highest number or highest percentage and 49 denoting the lowest.
**Based upon average for 4 years, 1967-1970.
***Hawaii, District of Columbia and Puerto Rico not included.

No single ranking in Table 10 provides a realistic total comparison of the problem by States; however, analysis of all of the rankings and their interrelationships does assist greatly in this endeavor. The number of crossings (column 1) is one measure of the magnitude of the grade crossing problem. The percent of crossings with active protection (column 2) indicates the degree to which a State has already undertaken grade crossing improvements. The average annual number of fatalities (column 3) is one of the most significant factors in determining the magnitude of a State's grade crossing safety problem. After considering the number of crossings in each State and amount of traffic using a State's average crossing, the final column reflects the annual fatalities in each State in relation to the individual potential for collision.

As an example, Table 10 indicates that California ranks fifth highest in the number of public railroad-highway grade crossings and ranks a high seventh in the percentage of grade crossings with active protection, with only six States having done better.

On the accident side, California has more annual fatalities at public grade crossings than all but two States and has more fatalities per crossing than all but one State. However, this is somewhat explained by the ranking of exposure factor which shows that only four States have more railroad and highway traffic at their crossings. When traffic volumes are considered, California ranks among the better States in fatalities per crossing in proportion to exposure.

IV

CLASSIFICATION OF AND JURISDICTION OVER INTERSECTION IMPROVEMENTS

In considering a national program for railroad-highway intersection improvements, there are certain basic concepts which are fundamental.

Railroad-highway intersection improvements currently consist of:

1. two administrative groupings: Federal-aid and non-Federal-aid projects,

2. two general types of improvements: Elimination and protection, with subdivisions of each type, and

3. four broad categories of improvements: (1) those generated by and undertaken as part of an overriding highway improvement, (2) those involved in a railroad improvement project, (3) those undertaken as part of an urban area or community improvement, and (4) individual intersection improvements.

ADMINISTRATIVE GROUPINGS

As noted above, railroad-highway intersection improvements are currently divided into two administrative groupings:

A. Federal-aid, limited to intersections on the Federal-aid highway systems, and

B. Non-Federal-aid, which may involve any intersection on any public street or road under the jurisdiction of a State or one of its political subdivisions, such as a county, township, or municipality.

The designation of individual intersection improvement projects as either Federal-aid or non-Federal-aid is based solely on the method of financing. If Federal-aid highway funds are used to pay any part of its cost, it is a Federal-aid project and vice versa. Under existing law, Federal funds may not be used for any project located off the Federal-aid highway systems. However, an improvement project located on a Federal-aid highway system may be financed without the use of Federal funds and thus would be classified as a non-Federal-aid project. The State has the option of using or not using Federal funds on an eligible project. The authority to initiate improvements at railroad-highway intersections, either as Federal-aid or non-Federal-aid projects, lies at the State and local level.

Federal-Aid

The Federal-aid highway systems, as they exist today, comprise about one-fourth of the Nation's roads and carry two-thirds of the highway travel.

Currently, Federal aid is provided for Interstate highway construction on a 90 percent Federal - 10 percent State basis. For all other Federal-aid highway projects, the normal funding ratio is 50 percent Federal - 50 percent State. The Federal-Aid Highway Act of 1970 provides that, beginning with fiscal year 1974, the funding ratio for non-Interstate Federal-aid projects will be 70 percent Federal - 30 percent State.

As set forth in Part I of this report under Improvement Programs - Past and Present, from the onset of the Federal-aid highway program in 1916, some of the Federal funds have been used for projects to eliminate hazards at railroad-highway intersections. Throughout the years, under the Federal-aid programs, many grade separation and grade crossing protection projects have been accomplished under the then current funding ratios. Also, during the depression period of the 1930's many railroad-highway intersection improvement projects were funded from special appropriations under which Federal funds were used to pay 100 percent of the cost, with no contributions from either the States or the railroads.

Beginning with the Federal-Aid Highway Act of 1944, the States have had the option of using up to 10 percent of their total annual apportionment of Federal-aid highway funds for projects to eliminate hazards at railroad-highway intersections - designated as "G" projects -- for which Federal funds could be used to pay up to 100 percent of the construction cost and 50 percent of the right-of-way and property damage cost. On "G" projects, the 100 percent Federal contribution is limited only by the extent of the railroad contribution required, the railroad contribution being determined by railroad benefits accruing from the project, but limited to a maximum of 10 percent of the total project cost.

Non-Federal-Aid

Cost Allocation - At present those railroad-highway intersection improvement projects for which Federal-aid highway funds are not used, either because the intersection is not located on a Federal-aid system and does not qualify for Federal fund assistance, or because the State or political subdivision elects to undertake the work without Federal assistance, the cost of the improvements are usually borne jointly by the railroad and the State and/or political subdivision. Where this occurs, the proportions of cost borne by the railroad and by the

responsible State and local public agencies varies quite widely from State to State, as indicated in Table 11. The range of the railroad's share is from 10 to 100 percent for grade separation construction and from 5 to 100 percent for grade crossing protection installations. In some States these railroad shares are determined by statute and in others they are determined by a regulatory agency. The percentages set forth in Table 11 are the usual allocations; in some States, these figures vary from project to project.

Maintenance and Operation Responsibility - Under existing laws, Federal-aid highway funds are not available to pay any part of the cost of maintenance and operation of facilities. In most States there are no public funds available to pay any part of the cost of maintenance and operation of facilities. However, in recent years a few States have enacted legislation under which they are now providing some financial assistance to the railroads for a part of the cost of maintenance of automatic protection installations, but with the railroads retaining the responsibility for actual conduct of maintenance and operation. Tables 11 and 12 show that the extent of public reimbursement for these costs varies considerably.

Special State Funds - Table 12 shows that 16 States have established special funds for use in railroad-highway intersection improvement projects aggregating somewhat more than $18 million per year. California has the largest, an annual amount of $11,100,000. It was the first such State fund, started in 1953 with an initial fund of $500,000. Currently $10,000,000 of the fund is available annually for grade separations at new locations where no grade crossing is eliminated. The remainder is available to pay the cities and counties share of the cost of grade crossing protection projects.

There is considerable variation in the methods provided for use of the special intersection improvement funds appropriated in the other States. Several are available for use only on grade crossing protection installations and not for grade separation construction.

In addition to these special improvement funds provided by specific legislation, several other States regularly allocate amounts from State motor vehicle fuel tax revenue, and designate them for use on intersection improvement projects.

TYPES OF IMPROVEMENTS

Railroad-highway intersection improvement projects consist of two general types, elimination and protection, of which there are seven specific types:

A. Elimination

(1) New grade separations

TABLE 11

Usual Allocation of Cost to Railroad on
Non-Federal-Aid Railroad-Highway Projects

State	On Improvement Projects: Grade Separation Construction	On Improvement Projects: Grade Crossing Protection Installation	On Improvement Projects: Method of Determination	For Maintenance and Operation of Protection
Alabama	100%	100%	Law	100%
Alaska				
Arizona	10%	50%	Corp.C	100%
Arkansas	100%	100%	Law	100%
California	13%	50%	PUC	100% and 50%[1]
Colorado	10%	10%	PUC	100%
Connecticut	10% and 50%	50%	Law	100%
Delaware	25-50%	50%	Law and PSC	100% and 50%[2]
Florida	0-100%	0-100%	Negotiation	100% and 50%
Georgia	50%	50%	Law	100%
Hawaii				
Idaho		20%	PUC	100%
Illinois		10%	Com.C	100%
Indiana	20%	50%	Law	100%
Iowa		10%[3]	Com.C	100%
Kansas	50%+	25-50%	Law	100%
Kentucky	10%	10%	Law	100% and 0%[4]
Louisiana	50%	50%	Policy	100%
Maine		50-100%	PUC	100%
Maryland	25%	50-100%		100%
Massachusetts				100%
Michigan	15%	50%[5]	Law	100% - $120/yr.
Minnesota	10-15%	10%	PSC	100%
Mississippi	10-100%	10-100%	PSC	100%
Missouri	50%	50%	PSC	100%
Montana		100%	RRC	100%
Nebraska		25%	Law	100%
Nevada	13%	13%	Law	50%[6]
New Hampshire	100%	100%	PUC	100%
New Jersey	15%	5%	PUC	100%
New Mexico		50%	Corp.C	100%
New York	15%-	50%	Law	100%
North Carolina	10%	10%	Law	50%[7]
North Dakota	10%	10%	PSC	100%
Ohio	15%	10%	Law	100%
Oklahoma	50%	10-25%	Corp.C	100%
Oregon	Varies	50%	PUC	100%
Pennsylvania	0-5%	0-20%	PUC	100%
Rhode Island		100%	PUC	100%
South Carolina	100%	100%		100%
South Dakota	10%	10%	PUC	100%
Tennessee	0-100%	0-100%	Negotiation	100%
Texas	10%	10%	Hwy.C	100%[8]
Utah	10%	10%	PSC	100%
Vermont	10%	10%	PSC	100%
Virginia	Varies	25%	Corp.C	50%
Washington	10%	10%	U&TC	100% and 75%[9]
West Virginia	10%	10%	PSC	100%
Wisconsin		30-32%	Law	100%
Wyoming	10%	10%	PSC	100%
Dist. of Col.	10%	100%	Law	100%
Puerto Rico				

[1]On installations made after 10-1-65.
[2]On installations made after 2-3-71.
[3]On State highways only.
[4]On installations made after June 1958
[5]Flashing light signals only, 100% on gates.
[6]On installations made after 4-16-71.
[7]On State highways, also in cities on installations made after 1-1-72, otherwise 100%.
[8]Except on State-maintained highways, where State pays $100 per year for single track crossings and $150 per year for multiple track crossings.
[9]On new installations only.

TABLE 12

Tabulation of Special State Funds Used for Railroad-Highway Crossing Improvements and State Participation in Cost of Maintenance of Grade Crossing Protection

State	Special Funds for Crossing Improvements			Public Participation in Cost of Maintenance of Crossing Protection	
		Jurisdictional Agency			
	Annual Amount	Allocation of Funds	Administration	Extent of Participation (%)	State Highway Crossings Only
Alabama					
Alaska					
Arizona					
Arkansas					
California	$11,100,000[1]	PUC	Hwy.C	50%[2]	No
Colorado	120,000	PUC	PUC		
Connecticut	500,000[3]	DOT	DOT		
Delaware				50%	Yes
Florida				50%[4]	Yes
Georgia					
Hawaii					
Idaho					
Illinois	2,400,000	Com.C	Com.C		
Indiana					
Iowa	120,000	Com.C			
Kansas	300,000[11]	Corp.C			
Kentucky				100%[5]	Yes
Louisiana	100,000	Hwy.C	Hwy.C	50%[6]	Yes
Maine	10,000[7]	PUC			
Maryland					
Massachusetts					
Michigan				$120/yr.	No
Minnesota	360,000	PSC	PSC		
Mississippi					
Missouri					
Montana					
Nebraska	180,000	Hwy.C	Hwy.C		
Nevada				50%[8]	No
New Hampshire					
New Jersey	2,000,000	PUC	PUC		
New Mexico					
New York					
North Carolina				50%	No[9]
North Dakota	25,000	PSC	Hwy.C		
Ohio					
Oklahoma	Indefinite	Hwy.C	Hwy.C		
Oregon					
Pennsylvania					
Rhode Island					
South Carolina					
South Dakota					
Tennessee					
Texas	1,750,000	Hwy.C	Hwy.C	$100-$150/yr.	Yes
Utah					
Vermont					
Virginia				50%	No
Washington	250,000	U&TC	U&TC	25%[10]	No
West Virginia					
Wisconsin	400,000	PSC			
Wyoming	90,000	PSC	PSC		
Dist. of Col.					
Puerto Rico					

[1]Includes $10,000,000 annually for grade separations at new locations where no grade crossing is eliminated.
[2]On installations made after 10-1-65.
[3]For grade crossing elimination.
[4]On installations made after 2-3-71.
[5]On installations made after June 1958.
[6]If funds are available
[7]For grade crossing protection on State and State Aid Roads for 1970-71.
[8]On installations made after 4-16-71.
[9]In cities, only on installations made after 1-1-72.
[10]On new installations only.
[11]Maximum - for protection only.

(2) Reconstruction of existing grade separations

(3) Relocation of highways to eliminate existing grade crossings

(4) Relocation of railroads to eliminate existing grade crossings (Crossings can also be eliminated by simply closing the crossing without any highway or railroad construction. Crossing closure should be fully considered as part of any railroad-highway intersection improvement program.)

B. Protection

(1) Installation of automatic protective devices at new or existing grade crossings

(2) Improvement of existing automatic protective devices at grade crossings

(3) Improvement of static signs and, in some instances, the installation of illumination of crossings

Under past and current programs for railroad-highway intersection improvements, elimination is most frequently accomplished by grade separation (type A-1 above) and protection by installing new or upgrading existing automatic protective devices (types B-1 & 2 above). In most situations, the ratio of costs between providing a grade separation and the best available protection devices ranges from 20-to-1 to 50-to-1.

Protection projects are primarily safety projects usually resulting in a significant reduction in the hazard at grade crossings. On the other hand, elimination projects completely remove the potential for vehicle-train accidents but are much more costly than protection projects. As such, they cannot be expected to compete with protection, solely on the basis of safety improvement. The major benefits stemming from elimination projects are improved highway operations, with reduced motor vehicle delay and operating costs, and, in many instances, improved railroad operation.

CATEGORIES OF IMPROVEMENTS

Railroad-highway intersection improvements fall into four broad categories, depending upon whether the improvements are generated by and undertaken as (1) part of an overriding highway improvement, (2) part of a railroad improvement project, (3) part of an urban area or community improvement, or (4) as an individual intersection improvement.

Highway Improvements

Many railroad-highway intersection improvement projects are initiated and carried out concurrently with general highway improvement projects which encompass an intersection area. This is usually the case at intersections on highway improvement projects. Although highways are grouped administratively for purposes of financing actual improvements, they are also classified by the function they serve. Functional classes of highways range from high volume arterial routes serving through traffic to low volume local roads and streets which have the primary function of providing access to adjacent land. Estimates of highway needs are developed and highways are generally improved on the basis of those classes, using appropriate criteria developed for each class. Outstanding examples occur in the Interstate highway program and in similar programs for other freeway improvements, where the high standards of design require the elimination of all crossings at grade. On other highway improvement projects, including conventional two-lane free access facilities, conformance with certain minimum standards of safety based on the class of highway involved is required; hence, intersection improvements, either elimination type or protection type improvements, are frequently carried out along with and as part of the overriding highway improvement. Under this concept, the level of safety at a railroad-highway intersection encompassed by any highway improvement project, regardless of highway jurisdiction, is elevated to the corresponding level of safety being provided for the associated highway project.

Railroad Improvements

Although the construction of new railroad lines are currently rather infrequent occurrences, they are undertaken from time to time to serve new industrial facilities and to serve new mines and other installations requiring railroad service. Relocations of existing lines to improve railroad grade and alignment and to clear reservoir sites are other typical examples of current railroad construction. It seems appropriate that such projects should be so designed and constructed that crossings of major highways are eliminated and crossings of other highways equipped with appropriate grade crossing protection, all as a part of the overriding railroad project. In all such projects it seems appropriate that adequate railroad-highway intersection improvements be incorporated initially in the design and planning of the overriding railroad improvement project. The choice of the appropriate treatment to be provided at each railroad-highway intersection should take into account both the type of railroad improvement being provided and the functional classification of the highway being crossed.

In selecting the treatment to be provided at a railroad-highway grade crossing, it would be appropriate to consider the functional classification of the railroad as well as the highway involved. Unfortunately, functional classifications of railroads have not been developed. The development of such a system for railroads would permit the improvement of grade crossings using varying design criteria for each functional

system of railroads so developed, thus enabling grade crossing improvement programs to be approached on the same basis as highway improvement programs.

Urban Area Improvements

As set forth in more detail in Chapter V, Railroads in Urban Areas, many urban areas have a multiplicity of railroad-highway grade crossing problems. In many locations, the railroad line itself is a problem because the community has developed around it and the railroad is no longer needed to serve the area immediately adjacent to it. Where these conditions exist, attention should be directed to a possible systems approach to the solution of crossing problems. Frequently, the indicated solution would involve consolidation of two or more lines of railroad or the relocation of one or more lines.

In addition to the elimination or the amelioration of the conflicts between railroad traffic and vehicular traffic, a proposed plan of improvement could involve other benefits for the community, such as urban renewal, flood control, public parks, and other similar public works improvements under a general program of community development. If, in a given situation, no other community benefit is accomplished, nevertheless it would be appropriate to seek a solution to the crossing problem on an urban area basis, giving suitable treatment to all crossings, and wherever possible, eliminating all railroad-highway grade crossings in the area and thereby maximizing safety benefits and providing greater freedom of movement for both vehicular traffic and railroad traffic.

Individual Intersections

Over the years, most of the railroad-highway improvement projects have been planned and accomplished on an individual intersection basis. This method will continue to be used to a considerable extent in any program in order to satisfy the greatest safety needs through a priority approach.

JURISDICTION

As set forth in Part I of this report, jurisdiction over railroad-highway intersections resides exclusively in the States. Within the States, responsibility is frequently divided among several public agencies and the railroad. Table 13 sets forth in brief tabular form, State by State, the agency or agencies with jurisdiction and the extent of their responsibility and control.

Table 13 discloses that, in somewhat more than one-half of the States, jurisdiction is assigned to a regulatory agency designated as a Public Service Commission, Public Utilities Commission or similar denomination, to determine what improvements should be made at public

TABLE 13

Tabulation of State and Local Government Jurisdictional Authorities Concerned with Railroad-Highway Intersections

State	Agency		Has Authority Relating To				
			Public Crossings			Private Crossings	
	Regulatory	Administrative	Improvement	Cost Allocation	Closing	Improvement	Closing
Alabama		S-C-C			No		No
Alaska		Hwy.C	Yes	Yes	Yes	No	No
Arizona	Corp.C		Yes	Yes	Yes	No	No
Arkansas		S-C-C	Yes	No	Yes	No	No
California	PUC		Yes	Yes	Yes	Yes	Yes
Colorado	PUC		Yes	Yes	Yes	No	No
Connecticut	DOT		Yes	Yes	Yes	Yes	No
Delaware	PSC		Yes	Yes	Yes	No	No
Florida	DOT	DOT	Yes	Yes	Yes	-	-
Georgia		S-C-C	Yes	Yes	Yes	No	No
Hawaii							
Idaho	PUC	S-C-C	Yes	Yes	Yes	No	No
Illinois	Com.C		Yes	Yes	Yes	No	No
Indiana		S-C-C	Yes	Yes	Yes	No	No
Iowa	Com.C		Yes	Yes	Yes	No	No
Kansas	Corp.C		Yes	Yes	No	No	No
Kentucky		S-C-C	Yes	Yes	Yes		No
Louisiana		S-C-C		No	Yes		Yes
Maine	PUC		Yes	Yes	Yes	No	No
Maryland		S-C-C	Yes	No	Yes		No
Massachusetts	PUC		Yes	Yes	Yes	No	No
Michigan	PSC		Yes	Yes	Yes		No
Minnesota	PSC		Yes	Yes	Yes	No	No
Mississippi	PSC	S-C-C	Yes	Yes	Yes	No	No
Missouri	PSC		Yes	Yes	Yes	No	No
Montana	RRC		Yes	Yes	Yes	No	No
Nebraska		S-C-C	Yes	Yes	Yes	No	No
Nevada	PSC		No	Yes	No	Yes	Yes
New Hampshire	PUC		Yes	Yes	Yes	Yes	Yes
New Jersey	PUC		Yes	Yes	Yes	Yes	Yes
New Mexico	Corp.C		Yes	Yes	Yes	No	No
New York		DOT	Yes	Yes	Yes	No	No
North Carolina		Hwy-Cty	Yes	No	Yes	No	No
North Dakota	PSC		Yes	Yes	Yes	Yes	Yes
Ohio	PUC	S-C-C	Yes	Yes	Yes		No
Oklahoma	Corp.C		Yes	Yes	Yes	No	No
Oregon	PUC		Yes	Yes	Yes	No	No
Pennsylvania	PUC		Yes	Yes	Yes	No	No
Rhode Island	PUC		Yes	Yes	Yes	Yes	Yes
South Carolina		S-C-C	Yes	Yes	Yes	No	No
South Dakota	PUC		Yes	Yes	Yes	Yes	Yes
Tennessee	PSC	S-C-C	Yes	Yes	Yes	No	No
Texas		S-C-C			Yes		No
Utah	PSC		Yes	Yes	Yes	No	No
Vermont	PSC		Yes	Yes	Yes	No	No
Virginia	Corp.C	Hwy.C	Yes	Yes	Yes	No	No
Washington	U&TC		Yes	Yes	Yes	No	No
West Virginia	PSC	Hwy-Cty	Yes	Yes	Yes	No	No
Wisconsin	PSC		Yes	Yes	Yes	No	No
Wyoming	PSC		Yes	Yes	Yes	No	No
Dist. of Col.		DCC					
Puerto Rico							

LEGEND

Com.C	Commerce Commission
Corp.C	Corporation Commission
DCC	District of Columbia Council
DOT	Department of Transportation
Hwy.C	Highway Commission, Department of Highways, Department of Roads
Hwy-Cty	Highway Commission and City, divided authority
PSC	Public Service Commission, Public Service Board
PUC	Public Utilities Commission, Division of Public Utilities
RRC	Board of Railroad Commissioners
S-C-C	State, County, City divided authority
U&TC	Utilities and Transportation Commission

railroad-highway intersections and what proportions of the cost should be borne by the agencies, public and private. In most of the other States the authority over public intersection improvements is divided among the public administrative agencies of the State, county and city having jurisdiction and responsibility for their respective highway systems. In less than one-fourth of the States do these regulatory and administrative agencies have any jurisdiction over private crossings of railroad lines. Rights and obligations with respect to private crossings are generally established by State statute. In all jurisdictions the railroads are assigned some responsibility, although their current obligations with respect to crossing improvements are generally less than they have been over the years past.

The concept of dual responsibility for grade crossing protective devices, with financing being shared by both modes but with the actual installation, operation and maintenance by the railroad, is unique. It is the only location along the highway where the highway authorities do not have total responsibility for and control over the installation, operation and maintenance of traffic control devices.

Highway authorities have the responsibility to provide a reasonably uniform and suitable highway environment in conformity with design, speed, and other characteristics of each functional classification of highway. When a highway is crossed by a railroad at grade, the type of crossing protection installed should, to the greatest extent possible, conform to the safety needs of the highway traveler whose operating speed and other driving actions are influenced by the quality and environmental aspects of the highway he is traveling.

This, in turn, raises an issue of the merit and desirability for public authorities with jurisdiction over roads and streets assuming additional responsibility with regard to grade crossing protective devices.

It appears to be clearly impractical for highway authorities to assume total responsibility for the installation, operation and maintenance of railroad-highway grade crossing protective devices at this time. In those cases where track circuits are used to detect the approach or presence of a train at a crossing, it would be essential that railroad forces install and maintain the track circuits, inasmuch as such circuits are an integral part of the track structure.

On the other hand, public authorities might appropriately give consideration to assuming responsibility for the installation and maintenance of other types of grade crossing signal protection not requiring the use of track circuits, as well as grade crossing signs, signal units, and other devices not located on or within operating clearance limits of the railroad track. Such signs and signals are located within the limits of highway rights-of-way.

The net effect of the current division of responsibility and authority among the private and public interests involved at the State and local level results in a fragmented approach to grade crossing safety. Where there is divided public responsibility, frequently none of the involved public agencies have either legal authority or sufficient resources to make more than token progress in dealing effectively with the problem. The need for national coordination of an issue that affects the Nation's railroad and highway systems is apparent.

V

RAILROADS IN URBAN AREAS

THE URBAN GRADE CROSSING PROBLEM

Urban areas (over 5,000 population) generally contain a number of rather closely spaced railroad-highway grade crossings. This is a result of the network of streets and highways, which provide access and highway transportation service to the urban land, intersecting with the various railroad lines which render rail service to the community.

Approximately one-third of the Nation's public grade crossings are found on the 15 percent of the highway mileage located in urban areas. About 50 percent of the Nation's traffic moves on this 15 percent of the road mileage. There are also a generally greater number of railroad movements over urban area crossings because, in addition to through-train movements, many urban area railroad tracks accommodate railroad service to industries, switching operations at yards and terminals, and interchange movements between railroad lines.

The potential for conflicts between vehicular traffic and railroad movements at grade crossings is increased in urban areas by this generally higher density of both traffic streams and by the proximity of these crossings. This alone has a very significant effect on intensifying the grade crossing problem in urban areas.

The distribution of urban grade crossings by highway and railroad volume classes is shown in Table 14 which indicates the number of urban crossings in each volume class and the percentage that this number is of the total number of grade crossings nationwide in that volume class. Overall some 35 percent of the Nation's crossings are in urban areas. More than 95 percent of the grade crossings with the highest volumes of both highway traffic and railroad traffic are in urban areas. By contrast, urban areas contain less than 16 percent of the crossings having the lowest volumes of both modes of traffic. Some 85 to 90 percent of all of the crossings in highway volume classes 4, 5, and 6--carrying more than 5,000 vehicles per day--are in urban areas, and more than 63 percent of the crossings with daily highway volumes of 1,000 to 5,000 are urban crossings. Approximately 70 percent of those crossings with more than 40 trains per day are in urban areas.

EFFECT OF URBAN LAND USE

In many urban communities today, there are quite significant incongruities in land use which have been created by incompatible developments adjacent to railroad lines.

TABLE 14

Distribution of Urban Crossings by Railroad Volume Class and Highway Volume Class

Sequence of numbers in each volume class cell:
Number of urban crossings
Urban crossings as a percentage of total crossings within that volume class

Railroad Volume Class	1	2	3	4	5	6	Line Totals
6	551 46.1	380 68.0	786 82.7	447 94.1	204 99.0	41 95.3	2,409 70.3
5	1,250 21.3	838 55.7	1,692 69.9	710 86.8	372 96.2	72 98.6	4,934 44.6
4	2,889 21.8	1,968 59.1	3,557 74.2	1,250 88.7	604 95.0	172 97.2	10,440 44.3
3	5,308 20.9	3,115 54.1	4,624 65.0	1,652 85.6	926 95.6	247 98.0	15,872 38.3
2	4,690 18.7	2,720 54.0	3,949 61.9	1,508 84.8	873 93.4	161 87.5	13,901 35.3
1	11,157 15.8	5,901 49.1	8,456 58.0	3,619 80.5	2,005 90.1	431 95.4	31,569 30.2
Column Totals	25,845 18.3	14,922 52.9	23,064 63.6	9,186 84.2	4,984 93.0	1,124 95.2	79,125 35.5
	1	2	3	4	5	6	Total

Highway Volume Class

Range of daily volume in each class:

Class	Trains	Highway Vehicles
1	0 to 2	0 to 500
2	3 to 5	501 to 1,000
3	6 to 10	1,001 to 5,000
4	11 to 20	5,001 to 10,000
5	21 to 40	10,001 to 20,000
6	Over 40	Over 20,000

During the period of rapid railroad expansion in the 19th century, most communities and cities welcomed and actively encouraged the construction of railroad lines to and within the community. As the benefits of this transportation service were realized, the communities grew. In most cases, the railroad system within the communities also expanded. Today, with vastly changed transportation technology, highway-oriented transportation provides much of the service needed for commercial and other land uses in and near the central city. Newer industrial developments which still need rail transportation are frequently located in outlying areas of the urban complex.

In many instances railroads are no longer needed in the central city and their locations constitute an incompatible and blighting activity. They are frequently an obstacle to orderly expansion of commercial areas; they are often unwanted neighbors in residential areas that have grown up around them.

In the past, land use planning and local transportation planning have generally given only fleeting attention to the possibilities of railroad relocation and consolidation. However, about 30 urban areas have special planning studies on this matter either underway or completed. Some cities have developed preliminary plans for such improvements and a few have carried out improvements to solve some of their community development needs.

MAGNITUDE OF THE URBAN RAILROAD PROBLEM

Special Study

The Federal Railroad Administration and the Federal Highway Administration jointly have retained a consultant to undertake a study entitled "Urban Railroad Relocation: Estimation of Nationwide Needs and Methodology for Future Relocation Studies." This study is scheduled for completion in 1973. The results of the study should provide a more complete analysis of the need for urban railroad relocation in terms of numbers of cities and the costs and benefits to be obtained from such relocations. The study should also provide a methodology which will permit rational distribution of costs between the parties involved in any relocation project.

As information from the study becomes available, it should be of great benefit to State and local government agencies and to the railroads in reaching a decision on the methodology to be employed in a railroad-highway grade crossing improvement program, i.e., whether to use an urban area systems approach concentrating available funds in urban areas, moving consecutively from one area to another, or to use funds concurrently in several areas concentrating on the most important immediate problem in each one.

Current Data

Presently available information emphasizes the importance of the urban area railroad-highway crossing safety problem. About one-third of the urban crossings have some form of active protection, which gives an indication of the approach of a train, whereas only about 10 to 15 percent of the crossings in rural areas have such protection. Despite this higher level of protection, accident statistics indicate that about 60 percent of train-involved collisions and one-third of the fatalities resulting from such collisions occur at the 35 percent of the crossings located in urban areas. The high accident record in urban areas (over 5,000 population) stems largely from the greater concentration of vehicular and train traffic.

In addition to being the location of accidents, grade crossings impede the flow of traffic on both the highways and the railroads. The flow of automobile traffic is interrupted by train movements and impeded at other times by the necessity for caution in crossing the tracks and the abnormal roadway surface characteristics created by the tracks. Railroad operations on the other hand are hampered by lower speed limits and other operating restrictions often imposed on trains by local government regulations because of the existence of grade crossings.

Railroad Operating Costs - The Association of American Railroads provided data from one major railroad company showing the cost and time involved in decelerating and accelerating trains. The costs include additional fuel consumed and repair costs allocated to fuel costs, as well as brake and wheel wear costs. The Association also provided information from three other major railroad companies regarding both the number and magnitude of speed changes required because of speed restrictions imposed on railroad operations by municipal ordinances or other governmental regulation for tracks crossing streets and highways at grade. It is assumed that these restrictions would be removed in each area where all grade crossings along a given rail line were eliminated. Expanding these limited data by using a gross ton-mile factor, indicates an estimated operating and delay cost to railroad companies of as much as $75 to $100 million per year for decelerating and accelerating trains through urban areas where speeds are restricted by local ordinance or other regulation.

Variation in the Problem

The nature of the problem varies among urban areas, depending upon the relative emphasis on safety, motor vehicle delay and operating cost, railroad delay and operating cost, incompatibility of railroad facilities with existing or proposed land use, and other considerations. The problem in small urban areas (5,000 to 50,000 population) may also differ somewhat from that in larger urbanized areas (50,000 population or greater).

With the continuing trend to greater urbanization, urban area problems including those involving railroads, can be expected to increase.

ALTERNATIVE SOLUTIONS

Any major effort to resolve an urban area's railroad problem should be preceded by a comprehensive study. This study must well define the specifics of the problem and consider alternative ways of treatment. The type of solution should generally be guided by the nature of the problem and may involve one, or more likely a combination, of the following approaches:

Alternative 1 - Consider the railroad facilities as fixed and adapt community development and land use planning and transportation planning to the presence of the railroad in its existing location. This philosophy has been followed in many urban area transportation studies.

Alternative 2 - Consider modifications in railroad operations by negotiated agreements or by enactment of laws and ordinances to restrict speed, switching operations, time that crossings can be blocked, and scheduling of trains, where such restrictions are feasible. This has been done in many situations, but may aggravate certain problems for both the community and railroad while relieving others. Speed restrictions, for example, are imposed in the interest of safety but have a negative effect of increasing both motor vehicle delay and train delay and operating costs.

Alternative 3 - Improve grade crossings along the existing railroad alignment(s) in the form of grade separations at principal arterials, closing crossings of minor streets, and improving protection at other crossings. Variations of this solution could consist of a general track elevation or track depression project along existing or immediately adjacent horizontal alignment. Proposals to close the crossings of minor local streets frequently meet with objections from property owners and nearby residents who would suffer some inconvenience in travel or some loss of business because of lack of accessibility to customers. In some cases it may be necessary to provide for connecting streets to reduce inconvenience to a minimum. An incentive to the community to cooperate in such closures might well be to reduce the local government share of the cost of the improvement project in return for grade crossing closures.

Alternative 4 - The most sweeping course of action is railroad relocation, which may involve one or more railroad lines. The relocation of rail lines, including consolidation and joint operation of two or more railroads on a single line, is being increasingly recognized as the solution to the urban area railroad problem as evidenced by the number of cities which have recently undertaken relocation studies and are currently attempting to implement the results of those studies.

Railroad relocation often may prove to be more economical and feasible than the other fragmented methods of treating the grade crossing problem in an urban area. Relocation also permits the rail lines to achieve greater compatibility with the community's proposed land use as it continues to grow.

A proposed relocation plan may be in several forms for a single urban area, with different benefits involved with each plan. Relocation either removes the barrier created by the tracks or mitigates its adverse influence, thus increasing community cohesiveness and appearance as well as providing greater mobility to the citizens than would be afforded by grade separations at principal highway arterials. Where consolidation of railroad lines is involved, railroad right-of-way becomes available for other uses. Consolidation of rail lines also provides increased justification for improving all of the grade crossings along the relocated line, thus permitting increased railroad operating speed, reduced delay to both railroad and highway traffic, and increased safety to both modes.

PLANNING ASSISTANCE

Many urban communities have indicated a strong interest in initiating in-depth planning studies of their railroad relocation possibilities and other communities want to proceed with further planning for potential projects already identified in previous studies. Although Federal assistance in these planning activities is often requested, planning funds are not now available at the Federal level for this specific purpose under on-going Federal programs.

As stated previously, about 30 cities have special planning studies on this problem either underway or completed, and in most instances, under the restraint of limited and hard-pressed budgets. Meanwhile, there is a critical need for similar studies in many other communities and, most important, a corresponding need for assistance in financing such studies.

VI

HIGH-SPEED RAIL CORRIDORS

The Highway Safety Act of 1970 includes a requirement for a ". . . full and complete investigation of the problem of providing increased highway safety at public and private ground-level, rail-highway crossings . . . including specifically high-speed rail operations in all parts of the country, ..."

Assessment of the magnitude of the problem requires development of a basis for estimating the cost of eliminating or substantially reducing the hazards of grade crossings along the route of potential high-speed rail corridors. In turn, the estimated costs so developed may be applied to several potential corridor candidates located in representative parts of the Nation. In this context it is important to keep in mind that the following discussion offers no recommendations on the merit and need for initiating high-speed railroad service along the corridors included in this study.

BACKGROUND

The rapid growth of population in and around such areas as the Eastern Seaboard megalopolis has put new demands on the high-speed movement of large numbers of people, along with increasing volumes of freight. Transportation through these densely populated areas is rapidly taxing the present highway and air modes. While many advanced systems have been proposed, high-speed rail transportation has proved to be a viable and practical alternative. The Northeast Corridor high-speed rail demonstration has proved that rail travel can be an important part of the mix of intercity passenger travel.

There are other corridors that have either current or future potential for high-speed rail service. While an optimum physical solution would consist of the construction of entirely new facilities similar to Japan's Tokaido Line, the "real world" approach taken in this country is to mount demonstration projects, utilizing existing rail facilities, to measure the public demand and acceptability of high-speed rail service. These demonstrations present various operating and safety problems, particularly with regard to grade crossings.

THE PROBLEM

An important safety problem along a high-speed railroad line arises from the existence of grade crossings of both public highways and private roadways.

On the average existing line with potential for high-speed operation, these crossings are estimated to occur at the rate of one crossing per mile of line. About 60 percent are estimated to be public and the remaining 40 percent private.

The probability of vehicle-train collisions at grade crossings of a high-speed rail corridor, like other grade crossings, is influenced significantly by the volume of highway and rail traffic using the crossing and the type of protection at the crossing. Furthermore, the inherent hazards at "normal" crossings are compounded with the presence of high-speed trains, particularly when there is a mix of high-speed and low-speed movements.

The types of problems created by introducing high-speed rail service on an existing railroad line vary with the type of crossing and type of protection at the crossing.

At grade crossings that have active protection such as flashing light signals or automatic gates, their actuation is usually determined by the length of the approach circuit in the track. These circuits are arranged to give at least a 20-second warning before the train enters the crossing. If the approach circuits are arranged to give such advance warning at train speeds of 50 mph, it is obvious that a train traveling at twice that speed would provide only half the warning time, and modification of the signal circuits becomes a necessity.

At public crossings protected by static warning signs only, the driver's task of determining whether a train is approaching and whether it is safe to proceed is difficult. Even with good visibility up and down the track, it is difficult to judge the time and distance from the crossing of a train approaching at moderate speed. At high train speeds the problem is critically compounded because of the great distance along the track that must be visible to the driver approaching the crossing.

A third, and perhaps the most potentially dangerous type of crossing is the private crossing. These crossings, providing access to industrial facilities, private residences and farm land, often are on narrow, unimproved or gravel-surfaced roads with narrow crossings of the track, limited visibility along the road to the tracks, and limited visibility of approaching trains.

The introduction of high-speed passenger trains, using existing facilities, is clearly a complex problem that can have severe impact on safety at railroad-highway grade crossings. It should be apparent that introduction of high-speed rail service, regardless of its anticipated duration, should be undertaken only after anticipated grade crossing problems have been fully analyzed and corrective action taken.

PROPOSED SOLUTIONS

A significant factor in developing practical solutions to the grade crossing problem in a specific corridor is the anticipated duration of the high-speed demonstration in that corridor.

Short-Term Projects

Prior to initiating even short-term rail passenger service at moderately high speeds, certain actions should be taken as a minimum, including:

1. A comprehensive field review should be conducted to determine the adequacy of existing signing at and approaching each passively protected crossing. New signs should be installed to replace missing standard signs. Existing signs or pavement markings which are less than fully effective should be replaced or refurbished. Special signing should be installed to alert drivers to the need for special attention to the possible approach of a train.

2. Publicity campaigns should be undertaken to advise the populace in the area of the rail corridor of the inauguration of the high-speed train service.

3. Instructions should be issued that trains approaching actively protected crossings operate at required slower speeds in order to provide the minimum 20 seconds of signal activation prior to arrival of the train. Adoption of this practice, however, will compromise the primary goal of high speed.

4. In lieu of (3) at actively protected crossings, the timing circuits should be extended to provide the minimum 20 seconds activation prior to arrival of high-speed trains, with appropriate speed-detection equipment to prevent excessively long periods of activation for slow-speed trains. Without speed prediction equipment, the credibility of the crossing device will be suspect and there may well be an overall negative effect on crossing safety.

5. At all crossings, but particularly at passively protected crossings, an effort should be made to improve sight visibility along the tracks. This action is desirable with or without high-speed service and, if properly maintained, should be of continuing benefit. It is recognized, however, that in many cases private property is involved.

Projects for Extended Periods

For a corridor with higher rail operating speeds or where the duration of the demonstration is to be for extended periods, automatic gate protection should be provided at crossings and activated advance warning signals on the approaches, together with the necessary additional track circuitry, including speed prediction equipment for all crossings, public and private, which are to remain at grade.

While this action is relatively expensive, it provides the highest level of grade crossing protection available with existing technology short of total elimination of crossings at grade, and will be of continuing benefit.

Permanent High-Speed Corridors

In evaluating the feasibility of permanent high-speed rail service along a given corridor it is most important that the grade crossing problems be fully considered as an integral part of the analysis and included as a part of the total cost of the high-speed rail service.

Complete elimination of grade crossings is the desirable solution for high-speed rail corridors which are being established on a permanent basis. Only crossing elimination will afford complete protection to the vehicle driver and occupants and to the train and its passengers. Elimination of grade crossings is the only means to achieve the full potential of high-speed rail service.

As an example of the integral nature of the high-speed rail service and the grade crossing problem, any program to implement permanent high-speed service over a given corridor should include, in conjunction with treatment of the grade crossings, consideration of relocating the rail line to improve the track alignment and/or eliminate grade crossings. On many existing rail lines curvature is severe enough to limit train speed and/or severely restrict visibility along the track for drivers at crossings. Construction of grade separations either over or under the track tends to fix the track alignment permanently. Thus, this coordination is essential in order to achieve the maximum potential for the high-speed service. In some instances, relocation of fairly long sections of rail lines may prove less expensive than construction of several grade separations.

Because of the high cost of grade separations, the elimination of grade crossings along a high-speed rail line must include a mix of grade separations and crossing closures with or without improvement to the existing road network. For example, several closely spaced crossings could be treated as a unit with all but one of them barricaded and improved access roads built to carry the traffic to the remaining crossing provided with a grade separation. This procedure would eliminate the hazard of vehicle-train collisions, while at the same time retaining reasonable continuity of local highway travel. When a configuration of access roads is developed that allows for free movement of vehicular traffic, then the location, type, and number of grade separations can be determined.

Estimated Costs

Table 15 lists representative potential high-speed rail corridors with miles of rail line and estimated total number of public and private grade crossings in each corridor. These corridors represent varying geographic terrain and a wide divergence in crossings per mile.

The method of estimating the costs associated with crossing elimination in the high-speed corridors is based on costs incurred in constructing the Interstate Highway System, along with analysis of approximately 1,000 miles of potential high-speed rail corridor in a typical urban-rural environment. From this it is estimated that complete crossing elimination in such corridors would consist of 35 percent of the crossings being closed and 65 percent being grade separated.

For purposes of this analysis, and based on data described in previous chapters of this report, it is assumed that the 35 percent of crossing closings would occur in the low highway volume categories. Inventory data on all crossings having the rail traffic characteristics of the remaining 65 percent, provided a reasonable estimate of the location and type of crossings to be grade separated, with percentage distribution as follows:

	Rural	Urban
Two lane	50 percent	35 percent
Four lane	2 percent	13 percent
Total percent	52 percent	48 percent

Preliminary cost estimates for grade crossing elimination were determined using four prototype designs for grade separation and estimated unit construction costs. While these figures can vary widely in any particular instance, they represent typical, average costs and are applicable to representative corridors. The estimated costs are:

	Rural	Urban
Two lane	$380,000	$ 825,000
Four lane	$715,000	$1,350,000

The estimated costs associated with closing a grade crossing are:

1-1/2 miles of connector road per crossing	$165,000
Barricades	5,000
Total cost per crossing	$170,000

TABLE 15

Estimated Cost of Complete Elimination of Railroad-Highway Grade Crossings on Potential High-Speed Railroad Corridors

Corridor	Miles	Total Crossings 1/	Elimination Cost 2/ $ Millions
Chicago - St. Louis	284	441	220
Chicago - Milwaukee	85	118	59
Los Angeles - San Diego	126	125	63
Chicago-Toledo-Cleveland	341	350	175
Cleveland - Pittsburgh	131	120	60
New York - Buffalo	439	90	45
Pittsburgh - Philadelphia	349	69	40
Miami - Orlando	370	391	195
Orlando - Tampa	92	200	100
Detroit - Chicago	283	284	142
Chicago - Carbondale	307	410	205
Seattle - Portland	186	157	79
Washington - Richmond	114	114 3/	57

1/ Railroad industry sources.

2/ Based on average cost of $500,000 per crossing.

3/ Estimated from national average.

An analysis based upon these estimated requirements yields an average cost amounting to about $500,000 per crossing for a complete elimination program. This average cost has validity only when applied to a substantial length of track. This figure was used to produce the crossing elimination costs indicated in Table 15.

RECOMMENDATION

Planning and funding of future high-speed railroad corridors give full consideration to the appropriate treatment of railroad-highway grade crossings in accordance with the proposed solutions set forth above.

VII

PRIVATE GRADE CROSSINGS

The Highway Safety Act of 1970 includes a requirement for "...a full and complete investigation and study of the problem of providing increased highway safety at public and private ground-level rail-highway crossings..." (Underscoring supplied).

It is appropriate to consider the problem of railroads crossing private roads separately from the problem of railroads crossing public streets and highways, inasmuch as private crossings raise significantly different questions regarding the magnitude of the problem, the jurisdiction of public agencies and responsibilities of all parties involved.

PRIVATE VS. PUBLIC CROSSINGS

For the purpose of this study, a publicly traveled way which crosses a railroad line may be distinquished from a privately used way by utilizing the following principles:

1. A traveled way located on a right-of-way dedicated to public use is a public route;

2. A roadway on which public funds have been expended for improvement or maintenance is a public way regardless of its right-of-way status, unless the public agency denies its public status;

3. A traveled way which has been found by action of a court of law or by a State regulatory agency to be a public way across a railroad track constitutes a public crossing. Conversely, such determination of a private way across a railroad track constitutes a private crossing;

4. A railroad-highway crossing on which the railroad or property owner has a legal right to restrict use by the public under the terms of an agreement with the adjoining land owner is a private crossing;

5. A traveled way over which access to the crossing is controlled by movable gates or similar barriers at or near the railroad right-of-way is a private crossing;

6. A crossing which is inaccessible except by ingress and egress over private property on both sides of the railroad right-of-way is a private crossing.

TYPES OF PRIVATE CROSSINGS

Most private grade crossings of railroad tracks are of one of the following types:

1. Farm crossings which provide access between tracts of land lying on both sides of the railroad track;

2. Industrial plant crossings which provide access between plant facilities on both sides of the railroad track. Some industrial plant crossings involve main line railroad routes, but most of them cross tracks restricted to switching movements or other low-speed operations. Most of the private crossings having active grade crossing protection are industrial plant crossings;

3. Residential access crossings over which the occupants and their invitees, typically their visitors and people rendering service functions, reach private residences from another road, frequently a public road paralleling and adjacent to the railroad right-of-way;

4. Temporary crossings established for the duration of a private construction project or other time activity, such as logging.

Although a great majority of the grade crossings established as private crossings remain in the private category, in some instances changes in land use have resulted in an expansion of crossing use so that it has become a "public" use which justifies a reclassification from "private" to "public." When such a change in use occurs, reclassification should be made.

PRIVATE CROSSING SAFETY PROBLEMS

The safety problem at private crossings is of a lower order of magnitude, but in several respects is much more difficult to resolve, than at public crossings. Part I of this report indicates that private crossings, 140,000 in number, were the site of 425-450 accidents in the year 1969 and that they resulted in 49 fatalities. At this rate, less than 1 in 300 private crossings can be expected to be the site of an accident in a year, and less than 1 in 2,800 can be expected to be the site of a fatality. This contrasts with public crossings, where one crossing in every 20 can be expected to be the site of an accident in a year and 1 in 150 can be expected to be the site of a fatality. Thus, the number of accidents per crossing is 15 to 20 times greater at public crossings than at private crossings.

However, this does not indicate the relative potential hazard to an individual driver using a private crossing. The average highway traffic volume at public crossings averages about 700 vehicles per day. For accidents at private crossings to occur at the same rate as at public crossings, the volume of traffic at private crossings would have to average at least 35-40 vehicles per day. This is quite unlikely. On many days, numerous private crossings have no vehicular traffic; at some private crossings, primarily farm crossings, movements over the tracks may amount to only a few each year. Thus, it is reasonable to expect that the potential for an accident per movement across a private crossing would be greater than at a public crossing.

assume complete responsibility for the crossing including the cost of signing as well as active protection if and when the latter is adjudged to be necessary.

Alternative 4 - In high-speed railroad corridor improvement projects, include the complete elimination of private grade crossings, as well as public grade crossings, as part of the total cost of the corridor improvement project.

Alternative 5 - Where and to the extent that it has not already been done, modify State statutes to establish regulatory agency jurisdiction over opening and closing of private crossings of railroad tracks with authority to establish and to close crossings, taking into consideration legal right of access.

Alternative 6 - As a supplement to and expansion of Alternative 5 above, and within existing allocations of funds, the Federal Railroad Administration establish an inventory and data collection system: (a) to identify and record by unique number, each private grade crossing of railroad tracks, (b) to assemble a complete inventory of private grade crossings with information on vehicle and railroad traffic volumes, types of protection (if any) and pertinent physical conditions, and (c) to obtain accident records for each crossing and to review accident statistics. This would be undertaken in conjunction with the establishment of such a system for public grade crossings as set forth in greater detail under Chapter IX, Off-Site Programs, Information Systems.

RECOMMENDATIONS

1. State legislatures, State regulatory agencies, and railroad organizations take appropriate steps to implement concurrently, the courses of action set forth in the preceding Alternatives 2, 3, 4, and 5.

2. FRA proceed as indicated in Alternative 2 and give further consideration to the establishment of an inventory and data collection system for private crossings of railroad tracks as outlined in Alternative 6.

VIII

PEDESTRIAN PROTECTION ALONG RAILROAD RIGHTS-OF-WAY

The Railroad Safety Act of 1970 includes a requirement for ". . . a study of measures to protect pedestrians in densely populated areas along railroad rights-of-way. . . ."

STATEMENT OF THE PROBLEM

As indicated in Part I of this report, there are about 1,350 pedestrian casualties annually along railroad rights-of-way, about 840 of which occur in densely populated areas. The latter figure comprises about 355 fatalities and 485 injuries distributed over approximately 30,000 route miles. Railroad employee casualties are excluded from these figures.

The major incidences of pedestrian accidents involving trains are:

1. Persons being struck by trains while crossing, standing on, sitting on, or lying on tracks and persons hurt by jumping out of the way of trains, primarily from bridges or trestles.

2. Persons falling off freight cars, being run over or caught between freight cars while riding freight trains or attempting to cross under or through trains.

Of the total number of pedestrian accidents, category number one accounts for 66 percent, while the second class comprises 22 percent. The remaining 12 percent do not involve trains and consist primarily of persons slipping or falling on railroad property. An average of 126 train-involved pedestrian casualties--87 fatalities and 39 injuries--occur at grade crossings each year. These are divided between 31 casualties classified as trespassers and 95 classified as non-trespassers. These accidents are not automobile related.

About 35 percent of the pedestrian casualties on railroad rights-of-way, including grade crossing sites, are persons 20 years old and under, and over half of this group are children under 14 years of age. A large percentage (30 percent) of those less than 14 years old are killed or injured while occupying bridges or trestles. In urbanized areas, another significant proportion results from contact with overhead electrical wires (catenary) when the railroad line is electrified for train power.

Most of the older-than-twenty group appear to be hoboes and drifters who are illegally on railroad property. This older-than-twenty group also includes an undetermined number of suicides.

It appears that the general public, especially the young, do not have a full appreciation of the dangers present upon railroad rights-of-way. Trains cannot be stopped in a relatively short distance if a dangerous situation presents itself. Education can help, but the only really effective answer is prohibition of access to railroad rights-of-way.

ALTERNATIVE SOLUTIONS

Alternative 1 - Fence enclosing the rights-of-way, usually on both sides of the tracks and with a height ranging between 6 feet and 8 feet, can be an effective barrier if properly constructed and maintained. Its drawbacks are the high cost of installation and maintenance and its susceptibility to vandalism.

Fencing cannot be completely effective in an area where there are streets or highways crossing the railroad tracks at grade, inasmuch as such crossings afford points of access to the rights-of-way. Nevertheless, suitable fencing along right-of-way lines at strategic locations, particularly where it would serve to divert trespassers to available underpasses or overpasses, can be an effective safety measure. Although other, more expensive types of fencing might be more difficult to climb or breach, an 8-foot high chain link fence serves as a reasonable obstacle to most potential trespassers.

Alternative 2 - At some locations the planting of high hedges of dense shrubbery along the edge of the railroad rights-of-way could, to some degree, be an effective deterrent to trespassers. Experimental work along highways has shown a fair degree of effectiveness of hedges against the trespasser. This method is limited by initial cost as well as continuing maintenance attention. Two advantages are that shrubs improve the environmental layout as well as deter some trespassers.

Alternative 3 - Inter-track fencing, approximately waist high, between parallel tracks has been effective in preventing pedestrians crossing tracks at grade in passenger station areas and other locations where alternative means of crossing is available. Inter-track fencing needs to be installed for only a limited distance on either side of an otherwise attractive point of crossing.

Alternative 4 - Erection and adequate maintenance of strategically placed "NO TRESPASSING" and "DANGER" warning signs, coupled with reasonable enforcement of laws prohibiting trespassing on railroad rights-of-way, can bring about a reduction in pedestrian casualties.

Alternative 5 - In the design and construction of property improvements on land adjacent to railroad rights-of-way, attention can be given to the pedestrian trespasser problem. Doorways and gates should not open directly on the rights-of-way. Parking lots should not be established "across the tracks" from an industrial or commercial installation without appropriate pedestrian access.

Alternative 6 - The design and installation of protective devices for railroad-highway grade crossings should continue to give emphasis to pedestrian use of streets and roadways in urban areas. Although it is impractical to provide a complete physical barrier at a crossing to prevent pedestrian access as a train approaches, the protective devices should direct the pedestrian's attention to the danger. Bells or other audible warning devices, signs or pedestrian gates, serve this purpose. At multiple-track crossings, an effort should be made, through signing, to warn pedestrians to keep clear of all tracks while a train is passing on one track since another train may be approaching the crossing from the opposing direction on another track.

Alternative 7 - Safety education in schools and other community programs can help in bringing attention to the hazards facing pedestrians on railroad rights-of-way as well as at grade crossings. Visual aids are sometimes helpful in illustrating the hazards along the tracks and at railroad bridges and trestles.

Alternative 8 - Surveillance and enforcement of laws prohibiting trespassing on railroad rights-of-way is another important direct way to improve safety. Surveillance and enforcement duties rest with railroad police and public law enforcement agencies, who may be assisted by other railroad employees.

AREAS OF RESPONSIBILITY

There are a large number of different physical characteristics which come into play along each railroad line, particularly in urban areas. The manner in which a community has grown around the railroad rights-of-way dictates the procedure to be used in developing pedestrian protection improvement programs. The local community and the individual railroad company are the parties most directly involved in discovering that a problem exists. Because of their understanding of all the issues, the community and the railroad are the most qualified to recommend proper corrective measures. Overall guidance and assistance is needed from other public agencies, particularly in education and enforcement efforts.

Much can be done by the owners of adjacent land to reduce the temptations to use railroad rights-of-way as a means of access to their property. Although they may have only a moral obligation to do so, the developers of property adjacent to a railroad would serve well the

users of the property if they eliminated the temptation to utilize the rights-of-way as a means of access or other adjunctive use. In some situations, zoning and building codes could provide useful controls.

The design and construction of public work projects should include appropriate fencing and other measures to discourage use of railroad rights-of-way by pedestrians.

In areas where pedestrian casualties on railroad rights-of-way are a significant problem, a solution should be sought through joint consultation and agreement by railroad officials and public authorities.

ECONOMICS OF FENCING

Some analysis of the economics of fencing, based upon currently available statistics and reasonable assumptions, is appropriate.

Construction of 8-foot high chain link fences on the presently unfenced right-of-way lines on both sides of the tracks on the 30,000 miles of railroad line located in congested urban areas would cost an estimated $2.3 billion. This estimate assumes that 20 percent of the rights-of-way is already adequately fenced and that the fence would cost $9.00 per lineal foot in place, along each right-of-way line or a total of $18.00 per foot to fence both sides.

While there is no available means to predict the safety impact of fencing, assuming that such fencing would reduce pedestrian fatalities on railroad rights-of-way in urban areas by 50 percent, 3,500 lives could be saved over the period of the 20-year life of the fence. This would result in an estimated cost of $1.5 million per life saved, based on 10 percent per annum cost of money. A 50 percent reduction in fatalities is an optimistic estimate in view of the fact that about 25 percent of pedestrian fatalities now occur at grade crossings, and that even with right-of-way fencing, unimpeded pedestrian access to the railroad rights-of-way will remain wherever there are highway and street crossings at grade across the railroad tracks.

If a right-of-way fencing program was confined to the 22 percent of railroad lines in urban areas which carry an average of more than 10 trains per day, the cost would be approximately $500 million. Inasmuch as these railroad lines carry approximately 65 percent of the train movements in urban areas, it is estimated that a fencing program of this magnitude could reduce pedestrian fatalities by 65 percent of the 3,500 contemplated in the larger program. Hence, this smaller program might save as many as 2,300 lives over the period of the 20-year life of the fence at an estimated cost per life saved in the amount of approximately $500,000 based upon a 10 percent discount rate.

As indicated by the two examples, more effective results could be obtained by utilizing a selective process to determine appropriate locations for constructing fences on railroad rights-of-way, rather than constructing them everywhere. A selective process could determine the railroad right-of-way locations where the greatest pedestrian accident reduction potential exists. It seems probable that right-of-way fencing on a carefully selected 10 percent of the total 30,000 miles of railroad lines in densely populated areas could bring about at least a 25 percent reduction in the annual total of 355 pedestrian fatalities on railroad rights-of-way in those areas. Such a program would cost an estimated $230 million for initial construction and the estimated reduction in fatalities would amount to 1,775 over the 20-year life of the fence. Using the same 10 percent discount rate, this selected program would cost about $300,000 per life saved.

In addition to a reduction in pedestrian fatalities, a railroad right-of-way fencing program would result in a reduction in personal injuries to pedestrians on railroad property as well as a reduction in vandalism.

RECOMMENDATIONS

1. Safety education in schools and community programs be expanded to give special attention to the hazards to pedestrians on railroad rights-of-way.

2. Surveillance and enforcement of laws prohibiting trespassing on railroad rights-of-way be implemented to the greatest extent practicable.

3. Attention be given to the pedestrian problem as well as the vehicle problem in the design and construction of railroad-highway grade crossing protection.

4. Land developers be advised to avoid practices which will encourage pedestrian movements along or across railroad rights-of-way and to adopt policies of fencing and appropriate location of improvements to this end.

5. Railroads and local government agencies jointly review the physical conditions and citizen conduct in the use of railroad rights-of-way for pedestrian travel and juvenile play areas to determine hazardous locations and take practical steps to reduce such trespassing on railroad property, including cost sharing of the construction of fences or planting of hedges at strategic locations to reduce the proclivity to such use.

6. A study be initiated by FRA to better define those characteristics which make certain sections of railroad rights-of-way in urbanized areas particularly susceptible to incidence of pedestrian casualties. Such study should establish criteria which will permit the selection of those sections of rights-of-way which require the construction of fences or other economically feasible access-prevention measures.

IX

OFF-SITE PROGRAMS

In addition to making physical improvements at grade crossings, there are other associated activities which are also most important in providing increased grade crossing safety. Among these are:

1. The development of an adequate information system (inventories, accident reporting, and crossing identification);

2. Further research and development activities; and

3. Driver education activities dealing with grade crossing safety.

All of the foregoing are considered as off-site programs.

A. INFORMATION SYSTEMS

BACKGROUND

To assist in a systematic approach to the planning and evaluation of programs for the improvement of railroad-highway crossings, certain information is essential, both for individual crossings and for groups of crossings. This essential information fits into two categories, (1) inventory data and (2) accident statistics, with a third factor, crossing identification, equally essential for correlation of the first two. Both the inventory data and the accident statistics information must be obtained on a crossing-by-crossing basis, and be of sufficient detail for planning and program purposes.

Currently, information regarding railroad-highway grade crossings is collected or maintained by various local, State, and Federal agencies and by the individual railroad companies. Existing crossing information systems are fragmented and incomplete. The extent, reliability and accessibility of this information varies widely among jurisdictions. Some modification is needed to produce an effective and efficient information system.

Federal Agency Involvement

At the Federal level, the creation of the U.S. Department of Transportation brought about the consolidation of all Federal Government railroad-highway grade crossing safety responsibilities within a single agency. Presently, however, Federal requirements for railroad company reporting of grade crossing information is divided. Inventory information is currently reported to the Interstate Commerce Commission (ICC) while railroad accident reporting is to the Federal Railroad Administration (FRA).

Class I railroads are required to report annually, to the Interstate Commerce Commission, the number of public railroad-highway intersections by State and by type of protection or separation. These reports contain no information regarding railroad and highway traffic volumes and nothing about physical characteristics of the crossing.

Under the Accident Reports Act of 1910, some, but not all, railroad-highway grade crossing accidents were reported monthly to ICC. With the creation of the Department of Transportation and the Federal Railroad Administration, railroad accident reporting was transferred from ICC to FRA.

Except for periodic special studies, the information received from these railroad reports generally comprises the total nationwide information effort regarding railroad-highway grade crossings.

State and Local Agency Involvement

Inventory - Over the years inventory information of various types has been compiled and maintained at the State and local level by highway departments, regulatory agencies, counties, and cities.

Most State highway departments have periodically compiled information for each public railroad-highway grade crossing included in that State's Federal-aid highway systems. A few States have continuously maintained an inventory, some even including crossings not on the Federal-aid systems.

In some States the regulatory agency maintains inventory information. This is generally not complete, sometimes including only data for crossings which have experienced an accident and usually not including certain significant data such as highway traffic volume. As a minimum, the number of public crossings and type of protection are generally provided to the regulatory agency from the railroads annual report to the Interstate Commerce Commission.

Some counties and cities have attempted to maintain an information system regarding those crossings over which they have jurisdiction. On the whole, however, reasonably complete and accessible inventory data is available for only a small percentage of the crossings.

As a special effort, a limited data inventory of all public railroad-highway grade crossings was undertaken by the State highway departments during the summer of 1971 in order to provide information for this report. Due to the time and budget restraints, sampling techniques were permitted. Furthermore, the inventory format required reporting of the number of crossings only within very broad classes. Concurrently, the Federal Railroad Administration in cooperation with the American Short Line Railroad Association conducted a special survey of public and private grade crossings on Class II railroads in order to provide information for this report.

Accident Statistics - Individual States usually maintain some grade crossing accident reports within regulatory agencies and in Departments of Public Safety or related State agency. Accident information by the State regulatory agencies (Public Utility Commission) is generally obtained from the railroad companies while the Department of Public Safety records usually are based on police officer and driver reports of accidents.

Many State public utility commissions require railroads to file with them, duplicates of railroad-highway grade crossing accident reports submitted to the Federal Railroad Administration. A recent study of State public utility commission reporting requirements indicates that in only a few States does the commission's accident reporting differ significantly from current Federal Railroad Administration reporting requirements, which leaves many motor vehicle-train collisions unreported.

Police officer reports are generally made for all accidents involving a fatality or personal injury and for those non-casualty accidents involving more than an established level of property damage. They may be made by State, county or city police, depending upon the agency having jurisdiction at the crossing. While police officer reports usually specifically locate the accident on the roadway, such site-specific information is generally not included in the railroad report. Therefore it is difficult if not impossible to relate the two reports and the information contained in them.

Some States have attempted to relate accidents to specific grade crossings. These generally have been fixed time period studies and have not been maintained on a continuing basis. Such information is available in only a few States.

As mentioned in Part I of this study, the National Highway Traffic Safety Administration receives information for all traffic accidents reported to State agencies, including railroad-highway grade crossing accident data. Currently, State summaries of police officer accident reports are prepared monthly. In practice, however, some States do not include all accidents - omitting those occurring in certain cities. Efforts are underway by NHTSA to improve this deficiency.

Highway Safety Standards

A significant development in highway safety, including that at railroad-highway grade crossings, occurred with the enactment of the Highway Safety Act of 1966. Two of the National Uniform Standards for State Highway Safety Programs issued pursuant to that legislation relate specifically to information systems for railroad-highway grade crossings.

Standard 12, section G, provides that in each State, "The program shall provide as a minimum: ...G. There is a systematic identification and tabulation of all rail-highway grade crossings and a program for the elimination of hazards and dangerous crossings." Implementation of this

standard would provide an inventory of the highway-railroad data at all public grade crossings. While a few individual States and cities have undertaken inventories under this standard, to date there has been little accomplishment.

Standard 9 entitled "Identification and Surveillance of Accident Locations" includes a requirement that each State have a program for identifying accident locations. Specifically, each State is required to have a procedure for accurate identification of accident locations on all roads and streets.

When fully implemented, this requirement should permit correlation of all police officer reported train-involved accidents and other highway accidents which occur within an established distance from a railroad-highway grade crossing. Implementation of this requirement is in varying degrees of advancement by the States.

Implementation of the National Uniform Standards is the responsibility of the individual States. At the Federal level, responsibility for insuring their implementation rests with the Federal Highway Administration.

INFORMATION SYSTEM NEEDS

Inventory

Site specific information in great detail is not necessary to determine broad programs of railroad-highway grade crossing improvements by means of aggregated data analysis. However, some such information is important to the task of accurately defining appropriate classes of crossings. Average daily vehicle traffic, train volume per day, and type of protection are most important. Sight distances, maximum train speed, and speed of vehicles are also of importance in an analysis of the relative hazard of individual crossings.

Crossing Identification Needs

Unique identification of each crossing is essential to the correlation of inventory data and accident data originating from different sources. Although some interest has been shown in the development of a uniform identification system, to date it has been advanced in only one State. A means of providing positive identification for all crossings seems basic to the development of an adequate information system.

Accident Data

Although the railroad reports to the Federal Railroad Administration under the provisions of the Accident Reports Act of 1910 cover the more serious accidents, including all accidents resulting in fatalities or serious injuries, addition of the accidents involving minor

injury and property damage only to the accident data file increases the number of train-involved accidents to about three times the number included in the railroad reports. Utilizing this larger number permits the railroad-highway accident problem to be better defined and better understood. It is significant also that the present railroad accident reports do not include some of the important information contained in police officer and driver reports, which may be essential to an understanding of the cause of the accident. As an investigative report, the police officer report is superior to the railroad report. However, information included on both reports is required for identification of the factors that contribute to the cause of the accident. It is highly desirable that a system be developed to correlate accident reports from these two sources.

ALTERNATIVE SOLUTIONS

Site-Specific Inventory Alternatives

Alternative 1 - Through the ongoing highway planning and research activities of the Federal-aid highway program, (23,U.S.C.,307), the Federal Highway Administration would continue to encourage each State highway department to conduct and maintain on a continuing basis a site-specific inventory of all public railroad-highway grade crossings.

This is basically the approach which is being followed currently with very limited success. To date it has resulted in such an inventory in only a small number of States. Most State highway departments have jurisdiction over only a small percentage of the crossings within the State. Thus, a complete inventory would likely require further assistance. In any event the railroads would be required to furnish certain railroad-related inventory data to State authorities.

Alternative 2 - In conjunction with the implementation of Highway Safety Standard 12, Section G, the Federal Highway Administration would require a complete site-specific inventory of all public railroad-highway grade crossings in each State. The inventory would be conducted by, or under the auspicies of, the appropriate State agency with primary jurisdiction and would be financed with Highway Safety funds, (23,U.S.C.,402).

If a non-highway State agency were given the responsibility for this effort, it would require the highway departments, counties, and cities, to furnish to that agency, highway-related data and the railroads to furnish railroad-related data.

Under the provisions of the Highway Safety Act each State establishes the level of priority for its safety problem elements and allocates funds for their accomplishment. Characteristically, the kind of action proposed in this alternative would be given varying priorities among States, precluding the timely development of a reasonably complete and uniform inventory nationwide.

Alternative 3 - Require, and within existing allocations, provide Federal funds for each railroad to make a site-specific inventory of each crossing on its lines and provide the information to the Federal Railroad Administration. Also require each railroad to annually update these inventories and report appropriate changes to the Federal Railroad Administration.

The railroad companies, with direction and guidance from the Association of American Railroads and the American Short Line Railroad Association, would initially locate and provide unique identification for each crossing, and provide continuing railroad-related inventory information. The Federal Railroad Administraiton in turn, would make such data available for use by appropriate Federal, State and local agencies.

The Federal Railroad Administration, having principal responsibility at the Federal level for administering this activity, would provide financial support to the railroad companies for the initial inventory.

Railroad company employees have the experience and access to company records necessary to provide this information. Either by review of company records, by on-site observations or by a combination of these two methods, the inventories could be accomplished in a systematic pattern by proceeding from one point on the railroad line to another. Information on private crossings could be obtained along with the inventory of public crossings.

The railroads would produce the basic inventory and all of the railroad-related data which would then be supplemented by State and local governmental agencies to provide complete inventory information to meet the needs of all agencies.

Under this alternative the annual Class I railroad reports to ICC on railroad-highway intersections could be eliminated.

Alternatives for Crossing Identification Systems

Alternative I - Through cooperative agreement between FHWA and individual States, the highway departments would be encouraged to assign and display an identification number at each public railroad-highway grade crossing within the State.

However, inasmuch as in most States, the highway department has jurisdiction over only a relatively small percentage of the highways, the accomplishment of this task would involve also, the cities, counties, and other political subdivisions having jurisdiction over roads and streets. Universal participation and uniformity of method would be difficult to achieve.

Alternative 2 - Under Highway Safety Standard 12, Section G, the Federal Highway Administration would require each State to identify each public grade crossing within that State by assigning and displaying identification numbers. The State agency responsible for implementation would probably be that with jurisdiction over the greatest number of crossings. Again, this would not result in a standardized national system.

Alternative 3 - The Federal Railroad Administration would provide some financial support from existing program allocations and request railroads to assign and display a unique identification number at all railroad-highway grade crossings, using a prescribed national system. The Federal Railroad Administration would have the principal responsibility for administering this activity.

This alternative could provide a national system of identification of all public and private grade crossings.

Accident Statistics Alternatives

Alternative 1 - Continue the current railroad-highway grade crossing accident reporting by the railroads to the Federal Railroad Administration but expand the requirements to include all train-involved public and private grade crossing accidents.

This would provide a continuing record of all train-involved grade crossing accidents. If in each State a regulatory agency or other statewide agency received a copy of each accident report submitted to FRA, as is now done in some States, a complete record of train-involved accidents would be available at one location in the State.

The Federal Railroad Administration is currently completing a study of the requirements for reporting railroad accidents including railroad-highway grade crossing accidents.

Alternative 2 - Place added emphasis on obtaining accident data from police officers and driver reports. Under this alternative NHTSA would take the following steps: (a) Encourage the States to complete early implementation of a requirement for police officer and driver reports of highway accidents, including those at grade crossings, to be reported to some central point at the State level; and (b) Require reporting of the crossing identification number on all grade crossing accident reports in order to permit the correlation of data received from police officer reports with other inventory and accident data.

RECOMMENDATIONS

It is recommended that inventory Alternative 3, crossing identification system Alternative 3, and accident statistics Alternatives 1 and 2 be adopted.

Under these alternatives the Department of Transportation, in conjunction and cooperation with the railroad industry and appropriate State agencies would: (1) undertake to develop a national inventory of specific grade crossing locations; (2) undertake to develop and implement a uniform national numbering system; and (3) both expand railroad company accident reporting and also work toward the eventual reporting of all police officer railroad-highway accident reports through one State agency for correlation and analysis with inventory data.

To implement the inventory, numbering and accident reporting systems in an effective and timely manner, it is specifically recommended that:

1. the Federal Railroad Administration issue requirements for the railroads to assign and display identification numbers at all railroad-highway grade crossings based upon a uniform national standard to be prescribed by the Department of Transportation. Further, contract with all railroads to provide site-specific inventory data for all crossings on their respective lines, and to annually provide information updating this inventory, following inventory standards established jointly by the Federal Highway Administration and the Federal Railroad Administration, working with appropriate railroad and State representatives.

2. the Federal Railroad Administration expand the current railroad-highway grade crossing accident reporting by the railroads to include all train-involved public and private grade crossing accidents.

3. the National Highway Traffic Safety Administration, give early attention and emphasis to implementation of a plan to have all grade crossing accidents reported through some central State agency. Also, NHTSA require the inclusion of the crossing identification number in the accident report form used by police officers in reporting grade crossing accidents to permit correlation of railroad and police reports and correlation with the crossing inventory data.

B. RESEARCH AND DEVELOPMENT

A systematic program of research and development which addresses critical elements of the grade crossing problem could culminate in:

1. increased effectiveness of advance warning devices and active crossing protection systems considering the inherent capabilities and limitations of the driver in the grade crossing environment;

2. improved methods of determining warrants for crossing improvements, taking into consideration all relevant benefits and costs; and

3. improved methods for reducing the severity of grade crossing collisions.

BACKGROUND

Included in the Immediate Action Program for the Improvement of Safety at Railroad-Highway Grade Crossings, announced in August of 1967 by the Secretary of the newly organized Department of Transportation, was the need for "a research and development program designed to bring forth more effective measures and devices to reduce accidents at grade crossings." In the five years following the announcement of this program, the Department has sponsored several railroad-highway safety oriented research projects and several major research studies and projects are currently underway. These studies have addressed the delineation of the elements of the grade crossing problem, the establishment of warrants for crossing improvements and the feasibility of adapting recently developed technology to improvements in the form of crossing protection and the reduction of improvement costs.

Although a few States, cities and counties have also sponsored railroad-highway safety research projects, most of these studies have had limited budgets and were directed primarily toward the development of a "hazard index" for use in determining protective device improvement priorities. Suppliers of railroad equipment have sponsored or performed research in the area of light intensity and reflectorization. The railroad industry has performed some testing and experimental work with various components of protective devices.

RECENT GRADE CROSSING RESEARCH PROJECTS

In addition to the completed projects described briefly in Part I of this report, specific research projects in the railroad-highway grade crossing area that have been completed recently are:

1. Accident Potential at Rail-Highway Grade Crossings - This project, funded by FHWA, studied techniques for assessing accident potential and severity at railroad-highway grade crossings.

2. Speed Profile and Time Delay at Rail-Highway Grade Crossings - This project, jointly funded by FHWA and FRA, obtained and analyzed data regarding driver behavior in the vicinity of railroad-highway grade crossings as measured by changes in motor vehicle speed in the vicinity of crossings. This data was used to develop improved estimates of motor vehicle delay and operating costs attributable to the presence of grade crossings.

3. The Visibility and Audibility of Trains Approaching Rail-Highway Grade Crossings - This project, funded by FRA, evaluated various marking schemes to increase train visibility, the use of various types of lights on locomotives, and various locomotive horns. It concluded that a locomotive horn with enough output to be totally effective would be an unacceptable nuisance. It recommended some marking and lighting schemes but also recommended further research which is now underway in this area.

The results of the first two of these studies were used in the benefit-cost analysis to estimate the number of crossings which warrant improvement, as reported in Chapter X.

CURRENT RESEARCH

Specific projects currently underway are:

1. A Study of Human Factors Countermeasures to Improve Railroad-Highway Grade Crossing Safety - This study, jointly funded by FRA and NHTSA, will analyze the human factors associated with motor vehicle drivers in their perception of the grade crossing environment and develop appropriate countermeasures. The analysis will include an intensive review of accidents to determine causitive factors, covert observation of driver behavior and the elucidation of driver knowledge and attitudes by interviews. As a result, this study will identify what drivers in different parts of the country actually do at different grade crossings and why, which will, in turn, permit development of appropriate countermeasures.

2. An Urban Railroad Relocation Analysis - This study, jointly funded by FRA and FHWA, will identify the nationwide magnitude and nature of the urban railroad problem. The study will include the development of a methodology for determining the economic, environmental and social consequences of urban railroad relocation for use in future relocation studies. This project is being coordinated closely with ongoing railroad relocation demonstration projects which include the relocation work under construction in Greenwood, South Carolina, and the feasibility analysis in East St. Louis.

3. A Railroad-Highway Grade Crossing Multi-State Project - This two-year project is to evaluate the costs and the effectiveness of new advance warning signs and marking systems in advising drivers of the possible hazards at crossings. This project involves approximately 20 State highway departments and will be conducted under FHWA leadership in cooperation with FRA and the Association of American Railroads.

4. New Active Protection Systems - Research on various types of train detection and signal activation, including the use of microwave telemetry, is currently underway for FRA at the Department of Transportation's Transportation Systems Center (TSC) at Cambridge, Massachusetts. The goal of this research is to develop an effective warning system which will be less costly to manufacture, install and maintain than existing active protection systems.

5. A Study of the Visibility and Audibility of Trains - FRA is sponsoring further study on methods for increasing train visibility which is being conducted by the National Bureau of Standards. This study will include: the development of on-train visual aids, such as attention-arresting lighting and reflective devices; review of day/night and dawn/dusk railroad operations; special visual warning devices for locomotives;

evaluation of the effectiveness of various paints and retro-reflective materials applied to the sides of rolling stock. It will include the construction of prototypes of selected laboratory-candidate devices and field evaluation of selected prototypes.

6. Uniform Accident Reporting Methods - An FRA study designed to improve all railroad accident reporting will specifically consider the reporting of railroad-highway grade crossing accidents. This process entails a complete evaluation of the present reporting and analysis process, the identification of data requirements for an improved system, and the design and implementation of an accident information system.

7. A Signing Demonstration Project - This project, being conducted in the States of West Virginia and Maryland, is a cooperative effort between the two States, FRA and the Baltimore and Ohio Railroad to determine the effectiveness of new passive warning devices in alerting motorists to the possible dangers of high-speed trains at railroad-highway grade crossings.

RESEARCH NEEDS

In order to achieve the greatest payoff in grade crossing safety there needs to be a continuing research program. Some areas which should receive early attention are:

1. Active Protection Devices - In addition to the research currently underway, other specific areas to which research efforts should be directed are:

(a) Continue the development, now underway, of devices for general application which are as effective as current devices but are less expensive to install and maintain.

(b) Improving the credibility of active devices by providing a uniform warning time prior to arrival of a train. This requires the development of less expensive methods of train speed detection so that a more universal application of these devices can be made.

(c) The development of more effective devices for application at high-hazard locations.

(d) The development and evaluation of devices to indicate both the presence and absence of trains in the crossing.

There should be close coordination between human factors studies and device-oriented research efforts in the interest of developing devices which are fully responsive to the driver's needs.

2. Evaluation of Devices - As a part of a systematic analysis of improved warning systems, both passive and active, there is a need to

develop and validate quantitative measures of safety effectiveness. That is, there is need to isolate those motor vehicle and train characteristics which are most indicative of hazard and which can be used with confidence in evaluating, within a short time, the safety benefits of alternative forms of protection.

3. Crossing Illumination - Additional work is needed in analyzing the cost and effectiveness of increased crossing illumination as contrasted with improved train illumination and visibility.

4. Crossing Surface - Attention should be given to the effect of upgrading the highway alignment in the vicinity of crossings and providing smoother crossing surfaces to determine whether reducing the crossing roughness would result in a decrease in loss of vehicle control at crossings and a decline in rear-end collisions due to sudden stops or abrupt speed changes.

5. Driver Education - Another area for potentially improving the safety performance of drivers at grade crossings is driver education, as discussed in greater detail later in this chapter. Currently, there is not sufficient knowledge available regarding driver limitations and his attitude and behavior at grade crossings. Such information is needed in order to upgrade driver education efforts.

6. Functional Classification of Railroads - Highways currently are divided into several functional classes and improvement needs are estimated on the basis of those classes using varying criteria. Railroads are not so classified, at least not on a national basis.

Development of a similar functional classification system for railroads, in addition to having other benefits, would permit the improvement of grade crossings using varying criteria for each classification. There is definite need to develop a functional classification of railroads so that future programs of grade crossing improvement can be fully responsive to the need for better protection at grade crossings along the more functionally important railroad lines.

DEMONSTRATIONS

As research efforts in specific areas of hardware development advance, there is need to demonstrate the laboratory development prototypes by field installations and evaluation. Some areas in which demonstrations should be undertaken in the near future are:

1. New Protection Systems Under Study at TSC - There will be a need to install a system at one or more actual crossings, utilizing the new technology developed at TSC.

2. On-Train Devices - Prototypes of new on-train devices, including both new color and lighting schemes being developed under current

research efforts, need to be tested by installation on railroad rolling stock in order to evaluate their effectiveness under actual railroad operating conditions.

3. New Passive Systems - It can be expected that any new passive systems developed under the multi-State contract will need extensive field evaluation before they can be adopted as standard devices.

RECOMMENDATION

A continuing research program including a schedule of priorities be established by FRA and FHWA with advisory assistance from the States and railroads.

C. EDUCATION

BACKGROUND

Drivers are human and therefore subject to error of judgments. Nearly all grade crossing accidents can be said to be attributable to some degree of driver error.

On-site programs must be directed to providing the driver with a message commensurate with his ability to understand it. Off-site, driver-related activities must be directed toward maintaining the proper driver attitude with respect to the potential hazard at the grade crossing and toward assisting the driver in recognizing and understanding highway warning systems.

One off-site activity is in the area of education. A major problem facing educators, safety officials, railroad officials, and others involved in educational activities, is methodology which will provide information in the most effective way.

The general area of education can be divided into three realms of emphasis: General Public Education, Driver Education, and Elementary School Education.

GENERAL PUBLIC EDUCATION

Part I of this report discussed programs inaugurated and pursued by the railroad industry and the National Safety Council to educate the public to the inherent hazards at railroad-highway grade crossings.

Many such campaigns have been carried out over the years. A variety of media have been employed to transmit messages to the public.

To be successful, a public education effort directed toward the general driving public must be carefully planned and executed and aimed

at the driving public via the most attractive media possible. All messages should be presented in prime time, if television and radio are used, and in the most popular periodicals, books and newspapers.

Messages should be positive and informative. Railroad crossings should be depicted as dangerous but necessary. The public information campaign should be endorsed and supported by the highest public officials. The campaign should be coordinated with other traffic safety messages and activities planned by States and local communities.

Due to the limited amount of media time that may be effectively directed to transportation safety, the Department of Transportation might appropriately become more involved in the public education effort on railroad-highway grade crossing safety by providing technical assistance in the preparation of public educational materials by the railroad industry or others and in promoting selected materials which are considered to be outstanding presentations.

It should be noted that one of the deterrents to special emphasis campaigns in traffic safety is lack of funds. To offset this shortcoming, the States and their political subdivisions should be encouraged to use highway safety funds, administered by NHTSA under 23,U.S.C.,402.

DRIVER EDUCATION

Background

Driver education is an area for potentially improving safety. However, current efforts in this area are considerably constrained by: (1) the scarcity of applicable knowledge regarding the driver's limitations, his attitudes toward, and behavior approaching and at grade crossings; (2) the limited attention currently devoted to railroad grade crossing safety in driver education textbooks, high school courses, or commercial driving courses; and (3) the inadequacy of the attention given to grade crossing safety in license examinations.

A significant step toward correcting this situation was the enactment of the Highway Safety Act of 1966, which provided in Section 402(d)(1): "The Secretary shall not approve any State highway safety program under this section which does not...(E) provide for comprehensive training programs for driver education in the school systems or for a significant expansion and improvement of such a program already in existence...." To implement this section of the Act, the NHTSA (formerly NHSB) issued standards to assist States in developing driver education training programs and has since sponsored various studies to evaluate the effectiveness of such programs.

Current Efforts

In an attempt to learn more about driver attitudes toward grade crossings and driver behavior approaching and at grade crossings, a joint

FRA-NHTSA study was recently initiated for the purpose of identifying and codifying driver behavior and attitudes at grade crossings. It will also delineate human factor countermeasures for improving grade crossing safety. These countermeasures will include recommendations related to driver education, licensing and enforcement programs.

Future Activities

NHTSA plans to closely coordinate the grade crossing countermeasure study with other ongoing studies aimed at the development and evaluation of secondary school driver education curricula. Aspects of driver education related specifically to railroad-highway grade crossings will thereby be included in defining driver education curricula requirements and programs.

In the area of adult driver education, a NHTSA study to improve the driving of young Coast Guard recruits will also use the countermeasures study findings to develop training materials. The study attempts to identify the driving weaknesses of each recruit and to provide the most appropriate remedial action. This program is a model for a series of adult driver training programs to be developed and tested by NHTSA.

A national data bank for driver knowledge tests is being developed by NHTSA to be used in driver licensing. Based upon a grade crossing driver task analysis study, conducted in 1970 and in conjunction with the countermeasures study, tests are to be developed for drivers of passenger cars, motorcycles, trucks and buses. There are also plans to develop audio-visual knowledge tests for use in driver licensing and public education.

State Laws

As noted in Part I of this report, there is considerable variation between States in the laws and ordinances governing motor vehicle operations at grade crossings. This acts as a major deterrent to both effective education and enforcement.

ELEMENTARY SCHOOL EDUCATION

Although not directly related to driver education, elementary traffic safety educational programs can help develop good pedestrian habits among young students. As indicated in Chapter VIII, juveniles constitute a significant part of the pedestrian safety problem. Providing elementary schools with materials on railroad-highway crossing safety should be most helpful to establish a base for future traffic safety activities.

RECOMMENDATIONS

1. Treat driver education as a supplement to, and not a replacement for, physical improvement of grade crossing warning systems.

2. The Department of Transportation:

(a) continue and expand its present efforts to gain greater understanding of driver behavior at grade crossings.

(b) encourage inclusion of grade crossing selected materials in driver education programs and in State driver manuals.

(c) work closely with the National Safety Council and the railroad industry to develop the most effective educational training and public information materials.

3. Special attention be directed to obtaining nationwide uniformity in the laws and ordinances governing motor-vehicle operations at grade crossings.

X

PUBLIC GRADE CROSSING IMPROVEMENT NEEDS

AN OVERVIEW

The existing public railroad-highway intersection problem, including numbers and characteristics of intersections, extent and distribution of grade crossing accidents and resulting casualties, as well as other costs to the public and to the railroad industry, was presented in Chapter III. The formulation of definitive solutions to the problem requires a systematic evaluation of alternative courses of action.

Utilizing an economic analysis, this chapter presents alternative levels of improvements to reduce the nationwide losses at public grade crossings and quantifies the benefits that would accrue from them. Included is a brief description of the methodology employed in formulating these alternatives.

The costs associated with crossing improvements are reasonably straight-forward and include initial and recurring costs. For purposes of this analysis the types of improvement have been limited to flashing lights, automatic gates, and grade separation structures.

The benefits from crossing improvements may be categorized into safety and non-safety elements. Safety benefits include the prevention of both train-involved and non-train-involved motor vehicle collisions and the resultant decrease in fatalities, personal injuries and property damage. Non-safety benefits are restricted to the reduction in highway traffic interference as measured by the decrease in motor vehicle delay and lower operating costs.

A monetary value was placed on the estimated benefits (safety and non-safety) and an incremental economic comparison with improvement costs was used to isolate the "warranted" courses of action and the associated expenditure of funds. An improvement was considered warranted when the return on investment (benefit) exceeded the investment (cost). This procedure required assigning a dollar value to the cost to society from loss of life and personal injury. However, supplementing the benefits expressed in monetary terms, the estimated number of accidents which would be eliminated and number of lives which would be saved are presented in relation to the several types of improvements and initial costs of making these improvements.

ECONOMIC ANALYSIS

The Benefit-Cost Approach

The use of benefit-cost analysis as a tool in the decision making process is well established. It was used in this study to evaluate flashing lights, automatic gates and grade separations as alternative types of improvement since the costs and benefits of these types of improvements can be substantiated.

It was not possible to include in the economic analysis, other possible types of improvements such as passive device improvements, crossing illumination, or improvement of the general crossing environment since the benefits from these types of improvements have not been quantified.

Procedure

Inventory data and accident histories for several thousand grade crossings were obtained and equations were developed from these data to predict the expected number of accidents at crossings grouped by administrative category (on and off the current Federal-aid highway system), by location (urban and rural), by type of crossing protection and by volume of railroad traffic and volume of highway traffic which use the crossings.

These equations formed the basis for predicting the expected number of accidents per crossing in each of the several groupings. Variations in the expected number of accidents resulting from variations in the type of crossing protection permitted an estimate of the expected accident reduction which would result from each particular type of crossing improvement. The severity of accidents both in urban areas and in rural areas was determined from available accident data and appropriate costs were assigned.

At railroad-highway crossings with various levels of protection, delay and operating costs incurred by motor vehicles were estimated, using available analytic and simulation models supplemented with data from empirical studies. Primary variables entering into models were level of protection, vehicle and train volumes, urban/rural designation, and number of highway lanes. Particular effort was devoted to isolation of the influences of the varying levels of crossing protection, railroad volume, and highway volume.

Total accident costs and total delay and operating costs were computed for all crossings grouped according to train and vehicle volume, type of protection device, urban vs. rural location, and

Federal-aid vs. non-Federal-aid highway system. Thus, it was possible to estimate the savings in accident costs, plus delay and operating costs, which would be achieved in the several crossing groupings by the various types of improvement.

There were originally six existing protection types - three passive and three active. However, there was not sufficient data to consider distinction between the effectiveness of the three types of passive protection - crossbucks, stop signs, and none. Thus, four types of existing protection - passive, flashing lights, automatic gates, and other active were used in the economic analysis. The initial and recurring costs of each improvement decision were computed and compared with the predicted benefits for each of the 576 groups[1/] of crossings. For some groups of crossings, the incremental benefits resulting from one or more of the alternative improvements exceeded the incremental cost of the improvement. Where this was true for more than one alternative, the improvement selected as being warranted was that which provided the maximum net benefit. For example, at a crossing now protected by a passive device, the net benefit (gross benefit less total improvement cost) of improving that crossing with flashing lights was first determined. Second, the net benefit was determined for improving the crossing from passive protection to automatic gates, and third, the net benefit of improving the crossing from passive protection to a grade separation was examined. The improvement which resulted in the largest net benefit was selected as the warranted improvement for that group of crossings.

Under the analysis procedure used in this study, all crossings in a single group were considered to be identical. If the mean values for that group of crossings resulted in a justified improvement, all crossings in that group were considered to warrant improvement. Conversely, if the mean values did not substantiate improvement, no crossings in that group were considered as warranting improvement.

Such assignment of identical status to all crossings in a group is not appropriate for selecting individual crossings for improvement. However, it does afford a reasonable basis for determining levels of need. Because of varying physical characteristics and other factors, some individual crossings in any such group will have greater need for improvement than the average and some will have less need than the average. The actual selection of individual crossings for improvement would take all of these factors into consideration.

1/ The 576 groups of crossings are composed of the two location designations (urban, rural), the two highway system categories (on and off the Federal-aid system), the four types of existing protection and the six levels each of highway traffic volume and railroad traffic volume.

The Economic Data Base

Accident Costs - Most of the accident costs are attributable to train-involved collisions although they do also include those costs due to non-train-involved collisions. These costs include the estimated loss to society from fatalities, personal injuries and property damage. In order to place highway safety programs on a common base, the costs used in this analysis were derived from data reported by the National Highway Traffic Safety Administration.[2/] The loss to society from a fatality was estimated at $200,000 which includes $132,000 for loss of future earnings. The loss to society from personal injuries was estimated for each of three categories of injury: (1) permanent and total disability ($260,000), (2) partial disability ($65,000) and (3) no permanent disability ($1,900). The severity of injuries resulting from motor vehicle-train collisions was estimated using Federal Railroad Administration statistics and individual State statistics. The resulting loss to society for an injury incurred in an urban grade crossing accident was estimated at $22,000 and for an injury incurred in a rural grade crossing accident was estimated at $29,000. Motor vehicle property damage costs were estimated from the selected State data tapes at $900 for an urban accident and $1,500 for a rural accident.

The resulting composite total cost of train-involved accidents used in this analysis is a little over $60,000 per accident in rural areas and about $25,000 per accident in urban areas.

Delay and Operating Costs - Motor vehicle operating costs were derived by applying unit cost data reported by Winfrey[3/] to information on speed profiles of vehicles traversing grade crossings. The speed profiles were developed through an analysis of motor vehicle responses to the presence of a crossing under various forms of protection and at different volume levels of highway traffic and railroad traffic. The motor vehicle delay assignable to grade crossings was also derived directly from the speed profile data. Delay costs were based on time value of $3.00 per passenger-car hour and $6.00 per hour for commercial vehicles. Based on a mix of 85 percent passenger cars and 15 percent commercial vehicles, the composite cost per vehicle-hour of delay was estimated to be $3.45.

Improvement Costs - Improvement costs of the several forms of protective devices include both initial investment and recurring costs. Typical initial installation costs of protective devices range approximately from $17,000 for flashing lights at a rural crossing to somewhat more than $30,000 for automatic gates at an urban crossing. The annual maintenance cost of the new devices varies from approximately $800 to more than $1,400 per year per crossing.

2/ Societal Costs of Motor Vehicle Accidents, National Highway Traffic Safety Administration, April 1972.

3/ Economic Analysis for Highways, Robley Winfrey, International Textbook Company, Scranton, Pennsylvania, 1971.

Typical costs of grade separations range from $380,000 for two-lane highways in rural areas to $1,350,000 for four-lane highways in urban areas.

Discount Rate - The discounting technique was used for converting all values to present worth equivalents. At the direction of the Office of Management and Budget, the Department of Transportation has been using a 10 percent discount rate and that rate was used in this analysis.

Analysis Period - An estimate of current needs was based upon current traffic volumes using a 20-year analysis period. Additional needs due to growth in highway traffic volumes are expected to develop during the time that the current needs are being met. In order to take into account these developing needs, 1992 traffic volumes were estimated and the resulting needs established.

It is anticipated that train traffic will remain essentially constant during the analysis period. For freight traffic, the trend in increased gross ton-miles of freight is expected to be offset by the trend in increased load per freight car. Passenger traffic is a minor element and is expected to remain constant.

All needs derived from the economic analysis are for crossings already in existence. Needs at crossings expected to be created in the forthcoming years are not reflected.

WARRANTED IMPROVEMENTS

The three specific types of improvements - flashing lights, automatic gates, and grade separations - divide into two general categories, grade crossing protection and grade crossing elimination. Crossing protection may constitute either the installation of new active protection at crossings now equipped with passive protection or the upgrading of existing active protection. Grade crossing elimination contemplates grade separation.

Alternative Levels of Improvements

As a result of the economic analysis, three alternatives surfaced as being the most viable.

1. Improvements warranted by considering safety and non-safety benefits equally.

2. Improvements warranted by considering safety and non-safety benefits equally with restraints on grade separations.

3. Improvements warranted by emphasis on safety.

Improvements Warranted by Considering Safety and Non-Safety Benefits Equally (Alternative 1) - The first alternative considered safety benefits of accident reduction and non-safety benefits of reduced motor vehicle delay and operating costs equally.

In this analysis, grade separations were not accepted as a potential improvement at those locations with two or less trains per day because of the potential for abandonment of those railroad lines. While some additional grade separations would be warranted if this constraint were relaxed, the benefits which would accrue from the construction of grade separations at these low train-volume crossings were not considered commensurate with the risks of abandonment. There is no intention to imply that grade separations should not be constructed at such locations as part of an important highway system improvement, or that they should not be constructed at other locations if a careful analysis of all influencing factors should so dictate. Also, restrictions have not been imposed on warranted improvements in the form of active protection at these crossings. This solution would secure almost the same safety benefits and would be much less expensive and have a shorter economic life. Therefore, such installations were considered to be appropriate pending resolution of the future of some of these railroad lines.

The results of this analysis, by type of improvement, are summarized in Table 16. Some 32,143 railroad-highway grade crossings warrant immediate improvement, including 3,265 which warrant grade separations. The initial cost of making these improvements is estimated at about $5 billion with $702 million for protection and $4.3 billion for grade separations. It is anticipated that completion of these improvements would eliminate 4,367 train-involved accidents and 507 fatalities per year at current traffic levels. Some 3,021 of these accidents would be eliminated by the protection improvements.

Table 16 also indicates that a cumulative total of some 35,464 crossings would warrant improvement by 1992, including 4,705 grade separations. The initial cost of these improvements based on current costs is estimated at $6.4 billion. The anticipated safety benefits resulting would include the elimination of 5,190 accidents annually and a saving of 632 lives per year based on 1992 traffic volumes.

The present worth of the gross benefits from completing the immediately warranted improvements is estimated at $6.5 billion contrasted with the present worth of the total improvement costs of $3.8 billion. The overall rate of return on investment for this alternative would be about $1.70 for each dollar invested.

The present worth of the gross benefits from only the protection improvements is estimated at $2.6 billion, contrasted with the present worth of total improvement costs of $753 million. The overall rate of return on investment for the protection improvements under this alternative would be about $3.45 for each dollar invested.

TABLE 16

Alternative 1

Summary of Costs and Benefits of Current and Total (to 1992) Warranted Improvements

(Dollar Amounts in Thousands of Dollars)

	Number of Improvements	Initial Cost	Reduction in Annual Accidents	Annual Lives Saved	Gross Benefits 2/	Total Improvement Costs 1/2/	Net Benefits 2/
Current Needs (1972)							
Protection	28,878	$702,093	3,021	403	$2,624,018	$752,655	$1,871,363
Separation	3,265	4,271,860	1,346	104	3,895,367	3,038,592	856,775
Total	32,143	$4,973,953	4,367	507	$6,519,385	$3,791,297	$2,728,138
Total Needs (to 1992)							
Protection	30,757	$744,500	3,235	440	$3,317,599	$800,547	$2,517,052
Separation	4,705	5,697,225	1,955	192	6,997,009	4,047,768	2,949,241
Total	35,464	$6,441,725	5,190	632	$10,314,608	$4,848,315	$5,466,293

1/ Total Improvement Costs include both initial and recurring costs.
2/ Gross Benefits, Total Improvement Costs, and Net Benefits are expressed in terms of present worth at the time the improvement is made.

Improvements Warranted by Considering Safety and Non-Safety Benefits Equally with Restraints on Grade Separations (Alternative 2) - This second alternative also considered safety benefits and non-safety benefits equally. However, under this alternative, grade separations were not accepted as an improvement at locations in urban areas with ten or less trains per day. In consonance with the desirability of pursuing urban railroad relocation, particularly the consolidation of railroad lines, in urban areas, it is expected that some lower-volume railroad lines in urban areas may well be moved or eliminated. Hence, any proposed construction of grade separations at these lower-volume railroad lines should be preceded by thorough consideration of the potential for eliminating the crossings by relocating or abandoning the railroad line(s) involved.

In the absence of such study, these lines may well be in the same risk-of-abandonment category as those in rural areas with two or less trains per day. Also, as in Alternative 1, grade separations were not accepted as an improvement at locations with two or less trains per day in rural areas.

As in Alternative 1, although the construction of an expensive grade separation, with its long life and the attendant disruption to the area involved, at railroad lines with abandonment potential, has not been included in assessing the level of need, restrictions have not been imposed on warranted improvements in the form of active protection at these crossings.

The exclusion of grade separations as potential improvements for crossings on urban railroad lines with train volumes of 10 or less per day is not intended to imply that all such lines will be moved or eliminated. It is an effort to reflect the general decrease in programmed grade separations which would result from careful analysis of the future prospects of these urban railroad lines with only moderate traffic.

Table 17 summarizes the results of this analysis by type of improvement, including both those improvements warranted immediately and the total improvements warranted by 1992. This table shows that for Alternative 2 some 31,970 crossings warrant immediate improvement, including 1,500 grade separations. The initial cost of completing all of the immediately warranted improvements is estimated at about $2.6 billion with some $1.9 billion for grade separations. It is anticipated that completion of these immediately warranted improvements would eliminate 4,147 accidents and save 493 lives annually with 3,274 of these accidents eliminated by protection improvements.

It may be noted from Table 17 that by 1992, an estimated cumulative total of 35,139 crossings would warrant improvement, of which 2,500 would be grade separations. The estimated initial cost of these

TABLE 17

Alternative 2

Summary of Costs and Benefits of Current and Total (to 1992) Warranted Improvements

(Dollar Amounts in Thousands of Dollars)

	Number of Improvements	Initial Cost	Reduction in Annual Accidents	Annual Lives Saved	Gross Benefits 2/	Total Improvement Costs 1/2/	Net Benefits 2/
Current Needs (1972)							
Protection	30,470	$746,377	3,274	420	$2,874,312	$809,879	$2,064,433
Separation	1,500	1,889,110	873	73	1,688,617	1,329,021	359,596
Total	31,970	$2,635,487	4,147	493	$4,562,929	$2,138,900	$2,424,029
Total Needs (to 1992)							
Protection	32,639	$796,418	3,512	441	$3,768,411	$852,265	$2,916,146
Separation	2,500	2,717,775	1,363	144	3,407,812	1,927,125	1,480,687
Total	35,139	$3,514,198	4,875	585	$7,176,223	$2,779,390	$4,396,833

1/ Total Improvement Costs include both initial and recurring costs.
2/ Gross Benefits, Total Improvement Costs, and Net Benefits are expressed in terms of present worth at the time the improvement is made.

improvements, in current dollars, is $3.5 billion including $800 million for protection. Completion of the improvements warranted by 1992 would eliminate an anticipated 4,875 accidents annually at that time and would result in saving some 585 lives per year.

Table 17 also indicates that the present worth of the gross benefits ($4.6 billion) from completion of the immediately warranted improvements is more than double the present worth of the total improvement costs ($2.1 billion). The overall rate of return on investment under this alternative would thus be more than $2.00 for each dollar invested.

For protection improvements alone, the comparable figures are gross benefits of $2.9 billion and total improvement costs of $810 million. The rate of return for protection would be about $3.55 for each dollar invested.

Improvements Warranted by Safety Emphasis (Alternative 3) - The third alternative gives greater emphasis to safety benefits by reducing the full impact of operating and delay costs. Both Alternative 1 and Alternative 2 consider safety benefits and non-safety benefits equally. In addition to those restraints against grade separations included under Alternative 2, a further restraint was imposed in Alternative 3 that any economically justified improvement must also return at least one-half of the improvement cost in safety benefits in order to be warranted. This additional restraint was imposed to give safety benefits greater emphasis than non-safety benefits.

Non-safety benefits consist of reduced motor-vehicle delay and operating costs which are composed mostly of a relatively small individual cost incurred by each motor vehicle using a crossing. As such, these are undoubtedly more palatable costs to the public than is a casualty incurred in a motor vehicle-train collision.

The results of this analysis, summarized in Table 18 by type of improvement, indicate that an estimated 26,121 existing crossings warrant immediate improvement including only five grade separations. The initial cost of completing these improvements is estimated at about $665 million. Completion of the immediately warranted improvements would eliminate an anticipated 3,595 accidents annually and save 450 lives per year based on current traffic.

Anticipated growth in highway traffic volumes and the resulting increased accident potential would result in an estimated 30,033 crossings now existing which would warrant improvement by 1992, including seven which warrant grade separations. The initial cost of improving these 30,033 crossings is estimated at $764 million in current dollars. Their completion would eliminate an anticipated 4,224 motor vehicle-train collisions with a resulting saving of 541 lives in 1992.

TABLE 18

Alternative 3

Summary of Costs and Benefits of Current and Total (to 1992) Warranted Improvements

(Dollar Amounts in Thousands of Dollars)

	Number of Improvements	Initial Cost	Reduction in Annual Accidents	Annual Lives Saved	Gross Benefits 2/	Total Improvement Costs 1/2/	Net Benefits 2/
Current Needs (1972)							
Protection	26,116	$661,691	3,588	449	$2,426,070	$691,050	$1,735,020
Separation	5	3,575	7	1	6,226	2,512	3,714
Total	26,121	$665,266	3,595	450	$2,432,296	$693,562	$1,738,734
Total Needs (to 1992)							
Protection	30,026	$759,146	4,213	539	$3,798,590	$797,728	$3,000,862
Separation	7	5,005	11	2	15,776	4,524	11,252
Total	30,033	$764,151	4,224	541	$3,814,366	$802,252	$3,012,114

1/ Total Improvement Costs include both initial and recurring costs.
2/ Gross Benefits, Total Improvement Costs, and Net Benefits are expressed in terms of present worth at the time the improvement is made.

Table 18 also indicates that completion of the immediately warranted improvements would provide gross benefits whose present worth of $2.4 billion is more than three times the present worth of the $694 million total improvement costs.

Excluding the five grade separations reduces the total improvement costs of the protection to $691 million while holding $2.4 billion gross benefits. The rate of return for protection alone would thus be about $3.50 for each dollar invested.

Discussion of Alternatives

Table 19 summarizes the costs and benefits of each of the three alternative levels of needed improvements, including both current needs and total needs to 1992.

From a benefit-cost standpoint, the magnitude of the improvements under Alternative 1 are justified. However, selection of a program at the level of need under Alternative 1 presumes that other remedial activities will not proceed concurrently in addition to the installation of new or upgraded active protection and the construction of grade separations. If, in fact, the impact of potential related activities such as urban railroad relocations are considered, Alternative 2 surfaces as being a more prudent choice than Alternative 1. Of course, the overriding assumption in considering either Alternative 1 or 2 is that safety and non-safety benefits can and should be equated on a monetary basis.

The reasonableness of that assumption is open to question insofar as grade crossings are concerned, since non-safety benefits at grade crossings are in the form of reduced motor vehicle delay and operating costs generally composed of a relatively small individual cost incurred by a large number of motor vehicles. Thus, these delay and operating costs should be a more acceptable burden to the public and to program administrators than the losses associated with the occurrence of a death or a personal injury in a vehicle-train collision.

Alternative 3, in addition to providing the greatest overall rate of return on investment, would result in by far the greatest safety benefit for a given level of investment. It would save over 80 percent of the accidents and 85 percent of the lives which would be saved by Alternative 2 at some 20 to 25 percent of the initial cost of Alternative 2.

Alternative 3 obviously becomes the best investment of the three alternatives from both the standpoint of safety benefits and the standpoint of overall benefit per investment.

TABLE 19

Summary of Estimated Costs and Anticipated Benefits for Three Alternative Levels of Needed Improvements (Dollar Amounts in Thousands of Dollars)

Program	Number of Improvements	Initial Cost	Reduction In Annual Accidents	Annual Lives Saved	Gross Benefits	Total Improvement Cost 1/ 2/	Net Benefits 2/
Alternative 1							
Current	32,143	$4,973,953	4,367	507	6,519,385	$3,791,247	$2,728,138
Total (to 1992)	35,464	6,441,725	5,190	632	10,314,608	4,949,315	5,466,203
Alternative 2							
Current	31,970	2,635,487	4,147	493	4,562,929	2,138,900	2,424,029
Total (to 1992)	35,139	3,514,198	4,875	585	7,176,223	2,779,390	4,307,833
Alternative 3							
Current	26,121	665,266	3,595	450	2,432,296	693,562	1,738,734
Total (to 1992)	30,033	764,151	4,224	541	3,814,366	802,252	3,012,114

1/ Total Improvement Costs include both initial and recurring costs.

2/ Gross Benefits, Total Improvement Costs, and Net Benefits are expressed in terms of present worth at the time the improvement is made.

Grade Separation vs. Protection

From examination of the results of the three analyses, another comparison becomes apparent, even when safety and non-safety benefits are considered equally. There is a significant variation between the ratio of benefits to costs for protection and for grade separation. While protection improvements have a benefit-cost ratio of around 3.5, grade separations warranted under Alternatives 1 and 2 have a benefit-cost ratio of only 1.3 and the five grade separations warranted under Alternative 3 have a benefit-cost ratio of about 2.5

It is also apparent from examination of Tables 16, 17, and 18 that for a given investment, much greater safety benefits would be obtained for a given level of investment from grade crossing protection, than from grade separation.

In recognition of these facts and since grade separations are constructed primarily to provide for the smooth and efficient flow of traffic, in contrast with the safety-oriented benefits from protection, it becomes reasonable to consider these two types of improvements separately.

It is also reasonable to assume that current funding, particularly Federal-aid highway funding, will continue to be available for the construction of grade separations at existing grade crossings since they are constructed primarily to accommodate the movement of traffic as a phase of highway improvement.

Accordingly, it becomes appropriate to consider what would happen if no grade separations were included under any of the three alternatives. This tends to put the alternative levels of grade crossing protection on a common base.

If only protection is considered, the three alternatives reduce to two with Alternatives 1 and 2 becoming the same. Table 20 indicates that if only protection were accepted, there would be 31,419 crossings which would warrant immediate protection by considering both safety and non-safety benefits equally at an initial cost of $772 million. Completion of these improvements would eliminate 3,719 accidents annually and save 458 lives per year at current traffic levels.

The additional cost of $110 million of Alternatives 1 and 2 over Alternative 3, when considering protection only, would result in a reduction of 128 more accidents annually and would save nine more lives annually. The incremental cost per accident saved over the 30-year life of the device becomes $28,200, and the same cost per life saved becomes about $400,000. These values may be contrasted with the similar values of $6,150 and $49,000, respectively, for protection only improvements under Alternative 3.

TABLE 20

Comparison of Costs and Safety Benefits of Alternatives with only Protection as an Improvement

Program	Number of Improve-ments	Initial Cost ($1,000)	Reduction in Annual Accidents	Annual Lives Saved
Alternatives 1 & 2	31,419	$771,669	3,719	458
Alternative 3	26,120	$661,783	3,591	449

Thus, while the overall costs and benefits of protection under the three alternatives are similar, Alternative 3 provides a far greater safety return per investment.

Distribution of Costs and Benefits

The costs and benefits associated with the program of protection only under Alternative 3 would be distributed as set forth in Table 21.

Some $295 million would be required to complete the immediately warranted improvements off the current Federal-aid systems. The total $662 million initial cost would be distributed between urban and rural areas in the amount of $265 million urban, and $397 million rural.

The anticipated reduction of 3,591 in annual accidents would include 1,857 on the Federal-aid systems and 1,734 off the systems. The urban-rural distribution of accident reduction would be 2,100 urban and 1,491 rural.

New Crossings

While the existing crossings are being improved, new road and street construction, particularly in connection with urban development, can be expected to create additional new crossings.

Many of these crossings will warrant the installation of active protection. Statistics of the Interstate Commerce Commission for a recent year, and shown in Part I of this report, indicate that over 600 grade crossings were created in that year by a new or relocated road or street. It is reasonable to assume that several hundred of these new crossings would warrant the installation of active protection.

TABLE 21

Distribution of Costs and Safety Benefits of Recommended Program
by Location and Administrative Highway System

(Dollar Amounts in Thousands of Dollars)

Costs and Benefits	Federal-aid			Non-Federal-aid			Total
	Urban	Rural	Total	Urban	Rural	Total	
Initial cost of improvements	$113,635	$253,477	$367,112	$151,135	$143,536	$294,671	$661,783
Reduction in annual accidents	928	929	1,857	1,172	562	1,734	3,591
Annual lives saved	60	195	255	76	118	194	449

Program Time Requirements

The total number of grade crossing protection installations (30,033) which would be warranted by 1992 because of the increased traffic volumes on existing crossings indicates that such traffic increases will add about 200 existing crossings annually to the number now warranting improvement. In addition, the provision of appropriate protection at new crossings being created in the meantime can be expected to add several hundred more crossings annually.

Therefore, to erase the backlog at the end of 10 years, at least 3,000 protection installations would need to be made annually at an expenditure of about $75 million on the basis of current costs. This would be a rate of installation of nearly three times the current rate.

OTHER IMPROVEMENTS

In addition to the specific improvement needs of various groups of grade crossings previously identified, there are other forms of improvement activities for which benefits cannot be quantified at this time.

Passive Device Improvement

It is not possible at this time to make a benefit-cost analysis of improved passive devices, such as pavement markings and signing at and in advance of the crossing. The inventory conducted for this study indicated that there are 11,365 crossings at which there are no signs. In addition, it is known that there are many crossings that have a crossbuck sign on only one highway approach. The inventory did not record those crossings with missing or otherwise deficient advance warning signs. As a first step in improving grade crossing safety, each railroad and each responsible public agency which does not already have one should undertake a program of passive device improvement. Such programs should also include the removal of obstacles from the crossing quadrants, i.e., those which impair visibility, to improve safety. The estimated cost to correct these deficiencies in passive signing and markings alone may be on the order of $10 million.

Multiple Crossing Improvements

In urban areas there is high payoff potential for programs whereby a crossing is improved and one or more nearby crossings concurrently closed. Under such a program, an indefinite additional number of crossings would warrant improvement, inasmuch as the cost of the improvement at a single crossing would be offset by benefits accruing from the total number of crossings involved.

One type of multiple crossing improvement is the improvement of all crossings along a given railroad line through an urban area to the extent that every grade crossing left open is provided with active protection. The inventory indicates nearly 80,000 crossings in urban areas divided by highway volume classes as follows:

Average Daily Traffic (ADT)	Number of Crossings	Percentage
0 - 500	25,845	32.5
500 - 1,000	14,922	18.9
1,000 - 5,000	23,064	29.2
5,000 - 10,000	9,186	11.7
10,000 - 20,000	4,984	6.3
Over 20,000	1,124	1.4
Total	79,125	100.0

On this basis, an urban railroad line with 10 crossings could expect, on the average, to have five with less than 1,000 vehicles per day (ADT) and three with less than 500 ADT. The expected two crossings with over 5,000 ADT might warrant improvement. When considered collectively, some of the remaining eight would warrant improvement if others were closed and their traffic diverted to the improved crossing. This might result in additional motor vehicle delay in return for greater safety. However, the improvement or closure of all crossings along a railroad line may be followed by permitting higher railroad operating speeds. This has the positive benefit of reducing train delay and reducing delay to vehicles waiting for a long train to clear the crossing.

CONCLUSIONS

Any new initiative should concentrate on grade crossing protection while grade separations and similar elimination-type projects should continue to be included in other highway programs. For a given level of investment much greater safety benefit can be obtained from a program of grade crossing protection than from a program including both protection and elimination of crossings by grade separations and the like. The ratio of benefits to costs for a given level of investment is much greater for protection than for grade separations and the initial cost of protection is much less than the initial cost of grade separations.

To be fully effective, any Federal funding made available for grade crossing protection should be extended to crossings located off the Federal-aid systems. The initial cost of the warranted improvements located off the systems is some $295 million or 45 percent of the $662 million initial cost of all warranted improvements. The estimated 3,591 accidents which would be avoided annually by the completion of these improvements would include some 1,734 or 48 percent at crossings not on the system. Under existing legislation, highway trust funds are not available for use in financing off-system improvements.

Further, the warranted improvements identified under Alternative 3 should be considered the proper level of expenditure for the protection of existing grade crossings since it concentrates on safety by avoiding the inclusion of those protection improvements which are justified largely on the basis of non-safety benefits. It will provide a level of safety nearly as great as any other alternative, but at significantly less cost, and accordingly will result in the greatest safety benefit for a given level of investment and it will provide a ratio of overall benefits to costs of about 3.5 which is equivalent to other alternatives. An estimated total of $75 million annually for a period of 10 years would adequately fund both those protection devices now warranted and those which will be added by increased traffic at existing crossings as well as those protective devices which will be warranted at new crossings, as indicated in the economic analysis.

Finally, any Federal assistance for grade crossing protection should be administered at the Federal level by the Federal Highway Administration and at the State level by the State highway departments, in cooperation with political subdivisions since there is already Federal assistance for grade crossing improvement through these agencies. Each State should be strongly encouraged to develop procedures to assure that every crossing in the State will be given equal consideration for improvement under any program for grade crossing protection.

In administering a program of grade crossing improvements, emphasis should be placed on multiple crossing improvements involving closure of some crossings, particularly in urban areas.

Also, to effectively treat the large number of lower volume crossings which do not warrant active protection and to provide effective advance warning at all crossings, each railroad and each public agency which does not now have a program for passive device improvement should undertake one immediately.

XI

FINANCING

This chapter discusses five possible funding alternatives for consideration in financing the cost of railroad-highway intersection improvements located on and off the Federal-aid highway systems which are warranted by the results of the economic analysis under Chapter X of this report. In pursuing this task, current sources of funds for financing these improvements are set forth and compared with the corresponding average level of expenditures being made for crossing improvements nationwide.

CURRENT SOURCES OF FUNDS

Highway Funds

Under current programs for grade crossing safety improvements, approximately 80 percent of the highway agency funds are received from highway user taxes, with most of the remainder coming from State and local government property taxes and general fund appropriations. All of the Federal Highway Trust Fund receipts are from highway user taxes.

As shown in Chapter IV, (Tables 11, 12, and 13) some 16 States have established special categories of funds to be used specifically to share in the cost of railroad-highway crossing improvement projects. Generally, these projects are located off the Federal-aid highway systems. In most of those States, the special funds are allocated from their available general highway funds. The special funds aggregate somewhat more than $18 million per year, a portion of which is used to provide some financial assistance to railroads toward the cost of maintenance and operation of protection devices.

Railroad Funds

On the railroad side, the funds for capital expenditures and maintenance of way and structures are provided basically from operating revenues, of which about 95 percent is from freight service.

CURRENT ANNUAL EXPENDITURES - RAILROADS AND HIGHWAYS

Capital Improvements

As set forth in Part I of this report, current annual expenditures for railroad-highway intersection improvements during the four calendar years 1967-1970 averaged about $239.4 million per year. The sources and amounts of funds used for this purpose were distributed approximately as shown in Table 22.

TABLE 22

Grade Crossing Improvement Projects
Annual Average Federal, State, Local, and Railroad Expenditures
For Calendar Years 1967-1970, Inclusive

Source	Amount in $ Millions
Federal aid	139.0 1/
State and Local Governments	91.0
Railroads	9.4
Total	239.4

1/ Includes Interstate highway funds

Of this total amount, about $222.4 million was expended for elimination projects and about $17 million for protection projects. These expenditures resulted in an average annual mix of 426 grade crossing eliminations, including new grade separations, reconstructed separations and railroad relocations, combined with 1,136 installations of train-activated protection devices.

The average annual total expenditures for railroad-highway crossing improvements under the Federal-aid program for these four years amounted to $164.3 million or 68.6 percent of the national total, distributed as set forth in Table 23.

The average annual accomplishment under the Federal-aid program was 292 eliminations, 34 grade separation reconstructions, and 249 installations of grade crossing protection.

Operation and Maintenance

In addition to these capital expenditures for railroad-highway improvements, the annual costs of operation and maintenance of grade crossing protection during this period were borne approximately as shown in Table 24.

Total Expenditures

These average railroad-highway intersection expenditures for the last four years may be compared with the corresponding total expenditures during 1970 for all improvements and maintenance of the Nation's highways and railroad lines. While not strictly comparable, these data do provide a reasonable perspective of combined total expenditures as shown in Table 25.

TABLE 23

Average Annual Expenditures on Federal-Aid
Railroad-Highway Crossing Improvement Projects
For Calendar Years 1967-1970, Inclusive

Item	Amounts in $ Millions		
	Total Cost	Federal Funds	State and Railroad Funds
Eliminations [1]	147.0	125.5	21.5
Reconstructions	13.6	10.4	3.2
Total	160.6	135.9	24.7
Grade Crossing Protection	3.7	3.1	0.6
Total Expenditures	164.3	139.0 [2]	25.3

1/ Includes construction of grade separations at new and existing locations and eliminations by railroad relocation.
2/ Nearly 65 percent of these costs were on Interstate freeway projects

TABLE 24

Annual Costs of Operation
and Maintenance of Grade Crossing Protection

Source	Amounts in $ Millions
State and Local Governments	1.1
Railroads	43.6 [1]
Total	44.7

1/ $35 million for maintenance of automatic protection devices and $8.6 million for watchmen at crossings

TABLE 25

Comparative Annual Expenditures on Highway and Railroad Fixed Properties and on Railroad-Highway Intersections

Element	Annual Expenditures in $ Millions: Total Expenditures	Expenditures on R.R.-Hwy. Intersections	R.R.-Hwy. Intersections as percent of total
Capital Expenditures			
Highway			
Federal	5,009[1/]	139.0[1/]	2.77
State and Local	6,547[2/]	91.0	1.39
Total Highway	11,556	230.0	1.99
Railroad - Roadway, Tracks and Structures	357	9.4	2.63
Maintenance and Operation			
Highway	4,797[3/]	1.1	0.02
Railroad	1,665[4/]	43.6	2.62
Totals			
Highway	16,353	231.1	1.41
Railroad	2,022	53.0	2.62

1/ Federal-aid funds allocated to the State and local governments and dispensed by them including Interstate highway funds.

2/ Excluding Federal-aid.

3/ Almost entirely State and local government expenditures. No part of the Federal Highway Trust Fund is used for maintenance.

4/ For maintenance of way and structures. Does not include maintenance of locomotives and cars or any train operating cost.

FUNDING ALTERNATIVES

The Problem

Analysis of the inventory data in Chapter III shows that quite consistently those crossings on the Federal-aid highway systems have a greater extent of active protection than comparable crossings off the systems. Analysis of the distribution of motor vehicle-train grade crossing accidents (Table 5) indicates that an estimated 7,368 accidents, or nearly 60 percent, occur at crossings located off the Federal-aid systems. Thus, it is apparent that a significant reduction in grade crossing accidents cannot be achieved by giving attention to only those crossings on the Federal-aid systems.

The analysis of needed improvements under Alternative 3 of Chapter X indicates that improvements off the system which are warranted immediately would cost over $295 million, or about 45 percent of the total cost of all protection improvements warranted under that alternative.

The problem of funding grade crossing improvements centers around three factors. The first is the present and longstanding legislative requirement that Federal-aid highway funds cannot be used for improving crossings that are not located on designated Federal-aid highway systems. A second arises from the limited amounts and sources of other public funds available for this purpose, particularly at the local government level. A third stems from the rising need and competition for funding safety improvements at all levels of government.

Alternative Courses of Action

In light of the foregoing, five possible funding alternatives for financing the cost of railroad-highway intersection improvements are set forth as follows:

Alternative 1 - Continue under existing Federal programs and encourage all States, in cooperation with local governments, to establish special categories of funds, or to make other public funds available, to be used exclusively to share in the cost of railroad-highway intersection improvements located off the designated Federal-aid highway systems. As noted earlier, 16 States have established similar funds aggregating somewhat more than $18 million per year, generally, but not entirely, limited to use on off-system improvements.

Alternative 2 - For financing projects involving the elimination or protection of railroad-highway crossings located on the Federal-aid highway systems, continue without change under the current Federal-aid highway program.

For financing similar projects located off the Federal-aid highway systems, make appropriate provision in any new legislation which may evolve from the National Highway Needs Report of 1972 for making funds available for financing critical surface transportation needs off the Federal-aid highway systems. In any amount so established, take into account the results of the economic analysis under Chapter X for financing off-system grade crossing improvement projects.

Alternative 3 - Amend the Federal legislation under 23, U.S.C., 120(d) and 130 as necessary to (1) make Federal-aid highway funds available to the States for financing both elimination type and protection type crossing improvements that are located off, as well as on, the Federal-aid highway systems, and (2) for such improvements, require each State to spend a minimum of 5 percent of all sums apportioned to it for A-B-C-D highway system improvements under 23, U.S.C., 104.

Alternative 4 - Amend the Federal legislation so that a fixed amount of Federal-aid highway funds would be used for financing the entire cost of railroad-highway grade crossing protection improvements at locations both on and off the Federal-aid highway systems. The use of such funds would be limited solely to financing those improvements involving the installation or improvement of passive and active grade crossing protection devices, including signs, illumination, signals, gates, and other similar devices. Since there is such a direct relationship to highway transportation involved, these funds would be appropriated from the Highway Trust Fund for the exclusive purpose of meeting the level of need for crossing protection, set forth under Alternative 3 of Chapter X.

Alternative 5 - Consider the railroad grade crossing safety problem as a part of a much larger program of highway safety and address its solution in that context. The scope of a complete highway safety program is not for consideration as a part of this report but it would include such elements as the necessity for achieving clear roadways through removals of roadside obstructions, the correction of skid prone surface conditions, an increased emphasis on proper signing and striping in accordance with the recently issued Manual on Uniform Traffic Control Devices, spot reconstruction projects at high hazard locations as well as the protection of railroad-highway grade crossings. Major construction projects would not generally be included under this program.

Discussion of Alternatives

Alternative 1 - In utilizing this approach, the existing program for grade crossing safety under the Federal-aid highway program would continue, complemented by various corresponding programs that may emerge at the State and local level, as indicated above. However, since the efforts would be extensively fragmented among the Federal, State, and local governments, this approach does not appear to offer any visible ways and means for effectively resolving the grade crossing safety problem nationwide. Instead, the status quo is likely to continue with low priority given to protection projects versus elimination projects.

Of added concern is the problem of financing improvements off the Federal-aid systems in those States not responding favorably to this approach and the necessity to defer critical projects in any State, because of a railroad's inability to assume the proportionate share of costs now required of it, particularly on improvement projects undertaken without Federal assistance.

Alternative 2 - This approach would permit Federal-aid highway funds to be used off the Federal-aid system for a variety of surface transportation needs that cannot now be reached under the existing Federal-aid highway program. It would also afford local officials maximum flexibility for determining priorities and making decisions on the type and location of projects to be undertaken.

In this light, it is important to recognize that program administrators at the local level (city and county) are faced with an abundance of demands for major and costly surface transportation needs and improvements under the restraint of limited and hard pressed budgets. The net effect tends to relegate safety needs, including those at grade crossings, to the lower end of the priority scale.

Alternative 3 - Under this approach, for crossing improvements that are located on and off the Federal-aid systems, each State would be required to spend a minimum of 5 percent of the sums apportioned to it for A-B-C-D highway system improvements. This would assure that each State would fund a minimum number of grade crossing protection or elimination projects. It should also result in an increased level of expenditures for such projects in some States.

The magnitude of grade crossing safety needs in individual States is not directly related to the highway needs in each of those States. Some States have a large number of crossings where rail and highway movements are of sufficient volume to establish these locations as points of significant hazard. In other States, rail service may be greatly diminished, and the grade crossings may not constitute a significant safety problem. Therefore, a mandatory requirement for financing grade crossing improvements using a fixed percentage of 5 percent of the sums apportioned to a State for all A-B-C-D highway system improvements would not provide an efficient solution to the grade crossing safety problem.

Alternative 4 - Under this approach, the existing program for grade crossing safety under the Federal-aid highway program would be expanded to include at-grade protection-type projects located off the Federal-aid highway systems and implemented by the State highway departments, in cooperation with political subdivisions. This would be complemented by various existing programs, and others that may emerge at the State and local level, for elimination-type projects located off the systems. Elimination-type projects located on the Federal-aid highway systems would continue to be financed as they are now under the current Federal-aid highway program.

While funds have been and will continue to be spent for safety needs at the State and local level, understandably these expenditures have been concentrated at locations where accident experience dictates the correction of a critically hazardous and dangerous condition. In turn, only nominal effort can be expected for improving potential accident locations. The severe nature of grade crossing accidents requires that the latter approach be used in grade crossing safety programs. This approach overcomes this problem by focusing attention exclusively on meeting critical grade crossing protection needs by providing passive and active protection devices at hazardous crossings nationwide, both on and off the Federal-aid highway systems. However, with respect to the funds made available under this alternative, local officials are not afforded the flexibility of expending such funds for other than meeting critical grade crossing protection needs.

Alternative 5 - Two variations are possible under this alternative. A specific percentage of the proceeds from existing A-B-C-D authorizations could be determined legislatively or administratively as available only for projects meeting the highway safety program criteria. A second alternative would provide a new authorization specifically for highway safety program purposes. Either of these variations properly should include provision to permit improvements to be made on or off the Federal-aid highway systems. An increased emphasis on railroad-highway grade crossing problems could result if the program concentrated on selecting lower cost projects for upgrading the safety of existing highways, rather than concentrating resources on major and expensive improvements.

CONCLUSIONS

The selection of a method for financing a program on grade crossing protection hinges upon a broader decision of whether the grade crossing safety problem should be treated separately and exclusively or whether it should be considered as part of a much larger and costlier program of highway safety. Since the scope of a complete highway safety program has not been included as part of this study, it is not considered appropriate at this time to make recommendations on which of the funding alternatives discussed in this Chapter offers the most feasible and effective approach for resolving the problem.

However, any funding alternative chosen should as a minimum, reflect the results of the economic analysis in Chapter X, and encourage the undertaking of those improvements which will provide the greatest safety return for a given level of investment. It should also provide a sound basis for dealing equally with all grade crossings, regardless of whether they are located on or off the Federal-aid highway systems.

XII

ALLOCATION OF COSTS

The Railroad Safety Act of 1970 includes a requirement for, "...recommendations for appropriate action including, if relevent, a recommendation for equitable allocation of the economic costs of any program proposed as a result of such study."

This chapter explores three possible methods for allocating the costs of railroad-highway grade crossing improvements between the two modes, railroad and highways, and between Federal, State, and local governments. In pursuing this task, current requirements and practices associated with these matters are evaluated, including the merit of and need for their modernization as necessary to reflect present-day conditions. For the purpose of this report, the term "allocation of costs" means the methods employed, by law or practice at various levels of government, for determining the share of costs to be borne by each transportation mode on crossing improvement projects.

THE PROBLEM

The problem associated with allocating the costs of grade crossing improvements between the two modes is centered around three factors. First, is the wide range and variation in current requirements and practices for allocating costs between the two modes on Federal-aid and non-Federal-aid projects. Second, is the financial position of some railroads which, in turn, diminishes their ability to assume the proportionate share of construction costs now required of them, particularly on projects financed without Federal assistance. Third, is the merit and propriety of requiring a railroad to contribute to the initial cost of improvements for which they assume all or the major portion of the maintenance and operations costs and from which they derive only a minor share of the benefits.

CURRENT REQUIREMENTS AND PRACTICES

Federal-Aid Projects

Under existing Federal law (23, U.S.C., 130) the railroad's share of the costs for eliminating hazards at railroad-highway intersections is based upon the net benefit a railroad receives from the project, if any, not to exceed 10 percent of the project cost.

Operating experience under this legislation has shown that railroad benefits are most difficult to evaluate accurately in order to reach amicable agreement on a case-by-case basis. Consequently,

in implementing these provisions of law, it was found to be desirable from an administrative standpoint to forego an analysis of specific benefits on each individual crossing improvement project and to place crossings in broad classifications with respect to the railroad share of the cost. Under this concept, the railroad is not required to contribute to the cost of a project unless the project is of a nature to provide benefits to the railroad. When the project is classed as providing railroad benefits, the railroad's share is fixed at 10 percent of the railroad benefit related portion of the project cost.

Non-Federal-Aid Projects

On railroad-highway improvements financed without Federal-aid fund participation, the proportions of cost borne by the railroad and by the responsible State and local governments vary quite widely, as set forth in Chapter IV, (Tables 11, 12, and 13).

Railroads are frequently required to pay 50 percent, and in some instances 100 percent, of the cost of the improvement, although in many States the statutes and State regulatory commissions require them to bear a smaller proportion. Railroads usually pay a smaller proportion of the cost on grade separation projects than on grade crossing protection improvements.

BENEFITS ACCRUING TO RAILROADS AND HIGHWAYS

Historical Background

Over somewhat more than a century of railroad history, there have been significant changes in the financial responsibility of the railroad industry for railroad-highway intersections. In the late 19th century, the railroad was the dominant mode of transportation and the entire financial responsibility rested with the railroads, but the advent of the automobile and its thousand fold increase between 1900 and 1920 changed and added to the grade crossing safety problem.

Continuing development of the improved highway transportation system led to the landmark decision of the United States Supreme Court in 1935 in which it was stated that:

> "The railroad has ceased to be the prime instrument of danger and the main cause of accidents. It is the railroad which now requires protection from dangers incident to motor transportation."

At the Federal level, a significant step was taken in the Federal-Aid Highway Act of 1944, in which the financial responsibility of the railroads was limited to a maximum of 10 percent of the cost of Federal-aid projects for the improvement of safety at railroad-highway crossings.

Continuing Railroad Involvement

The railroads have declined financially. Twenty-one of the Nation's largest railroads recorded a deficit in 1970. Five are now operating under bankruptcy laws, including the Nation's biggest-- Penn Central-- and 18 others, mainly in the East and Midwest, have indicated they are in deep financial trouble.

Although railroads have been relieved of some of their original complete financial responsibility for railroad-highway intersections, they are currently spending about $43.6 million per year for maintenance and operation of grade crossing protection and about $21 million per year in grade crossing personal injury and death claims. It is estimated that the cost of processing and defending claims amounts to approximately one-third of the amount of the claim payments.

The sum of $28 million per year for damage claim payment and associated costs is a consequential item of such importance as to justify a continuing interest on the part of the railroads in bringing about a reduction in grade crossing accidents.

Over the useful life of grade crossing protective devices, the cost of maintenance and operation is a substantial part of the total long-range improvement cost.

In broad perspective, the aggregate annual cost to the railroads for maintenance and operation of grade crossing protection and for providing watchmen is already substantially more than the annual cost of death and personal injury claims resulting from grade crossing accidents.

Railroad Benefits

Railroad benefit from the installation of train activated devices can be measured in terms of the anticipated reduction in grade crossing accidents. This in turn brings about some reduction in the cost of claims for personal injuries, fatalities, and vehicle damage resulting from accidents which otherwise may occur at the crossing.

It has been demonstrated that the construction of grade separations will actually eliminate, and the installation of improved crossing protection will substantially reduce, grade crossing accidents. Analysis of data available indicates also that the average claim payment made by the railroads as the result of an accident at a crossing with modern automatic protection is substantially less than the average claim payment resulting from an accident at a crossing with ordinary passive crossbuck protection. An installation of improved automatic protection producing a combination of fewer accidents and a lower cost per accident would be financially beneficial to the railroads. However, in most

instances these benefits would be offset by the railroad's assumption of some or all of the cost of maintenance and operation of the improved protection.

On elimination projects (grade separations and the like) the railroad benefit can be measured in terms of: (1) the anticipated reduction in grade crossing accidents and (2) the savings accruing to the railroad as a result of eliminating the cost of maintaining and operating the crossing protection and of providing watchmen.

Highway Benefits

The ratio of inter-city passenger travel between highway and railroads is about 90 percent highway and less than 1 percent railroad with the remainder using other modes of travel. It is in passenger travel that the greatest safety problems arise.

Benefits to the highway user can be measured in terms of anticipated reduction in grade crossing accidents and reduced motor vehicle delay and operating costs.

It is difficult to assign a monetary amount to such intangible items as reduction in loss of life and personal injury due to accidents when determining benefits to the highway user. However, an effective cost analysis must include values for these intangible items since monetary value is an appropriate common denominator for relating various safety improvements.

COST ALLOCATING ALTERNATIVES

As set forth and defined under Chapter IV, there are four broad categories of railroad-highway crossing improvements: (1) those generated by and undertaken as part of an overriding highway improvement, (2) those involved in a railroad improvement project, (3) those undertaken as part of an urban area or community improvement, and (4) individual crossing improvements.

Taking these into account along with the historical background, the current relative volumes and growth trends of highway transportation and railroad transportation in the United States, the economic viability of the two modes, and the benefits accruing to each mode and its users from railroad-highway crossing improvements, three alternative methods of allocating the initial cost of such improvements are worthy of consideration. These methods are specifically suggested for consideration on crossing improvements financed with Federal assistance, either under current Federal-aid programs or under an expanded Federal program, as follows:

Alternative Courses of Action

Alternative 1 - Continue under existing Federal legislation (23, U.S.C., 120(d) and 130); however, pursuant to the administrative authority under subsection 130(b), reclassify the various types of railroad-highway improvements and reset for each classification a percentage of the costs of construction deemed to represent the net benefit to the railroad, thereby determining the railroad's share of the cost. To this end, it is suggested that:

A. on Highway Improvements and Individual Crossing Improvements, where crossing improvements are undertaken either as part of an overriding highway improvement project or as an individual crossing improvement,

(1) for all protection type projects there would be no railroad contribution to the project costs.

(2) for elimination type projects:

(a) For those projects where benefits accrue to the railroad under current classifications, the railroad contribution would be 5 percent of the railroad benefit related portion of the project cost.

(b) For those projects where no benefits accrue to the railroad under current classifications, there would be no railroad contribution to the project costs.

(c) From the standpoint of public funding, all projects would be financed either as "G" funded projects, with 100 percent Federal funding for protection projects and 95 percent Federal funding on elimination projects, under 23, U.S.C., 120(d) or at the same rate and basis used for financing regular Federal-aid highway improvement projects, as elected by the State.

B. on Rail System Improvements, where railroad-highway intersection improvements are undertaken as part of or generated by an overriding railroad improvement project, the cost of the intersection improvements would be the responsibility of the railroad undertaking the overriding railroad improvement.

C. on Urban Area or Community Improvements, where a group of railroad-highway intersections are to be improved as part of or generated by an overriding urban area or community improvement project and result in special benefits to the parties involved, the cost of the intersection improvements would be distributed among the several parties of interest based upon the amount and type of benefits accruing to each party.

Alternative 2 - Amend the Federal legislation so that:

A. on Highway Improvements and Individual Crossing Improvements, a cost-sharing arrangement between the two modes would be established by incorporating the provisions advocated by administrative action under Alternative 1 in the overriding provision of law, 23, U.S.C., 120(d) and 130.

B. on Rail System Improvements, the cost of railroad-highway intersection improvements would be the responsibility of the railroad, as in Alternative 1.

C. on Urban Area or Community Improvements, the cost of railroad-highway intersection improvements would be distributed among the parties of interest, as in Alternative 1.

Alternative 3 - Amend the Federal legislation (23, U.S.C., 120(d) and 130) so that:

A. on Highway Improvements and Individual Crossing Improvements railroad-highway intersection improvements would be financed entirely with public funds in the same manner as highway-highway grade separation structures and highway traffic signal devices. From the standpoint of public funding and as elected by the State, such projects would continue to be financed either at the rate established pursuant to 23 U.S.C. 120(d) or at the same rate and basis used for regular Federal-aid highway improvement projects.

B. on Rail System Improvements, the cost of railroad-highway intersection improvements would be the responsibility of the railroad, as in Alternatives 1 and 2.

C. on Urban Area or Community Improvements, the cost of railroad-highway intersection improvements would be distributed among the parties of interest, as in Alternatives 1 and 2.

Discussion of Alternatives

Where crossing improvements are undertaken either as part of an overriding highway improvement project or as an individual crossing improvement, Alternatives 1 and 2 are essentially the same, except the first proposes to accomplish the intended result by administrative action under existing legislation, while the second proposes to amend the legislation expressly for this purpose. The end results stemming from either alternative are identical, except the first would permit adjustment of the railroad's share by administrative action as conditions may dictate, while the second would be fully reinforced by the force and effect of law.

Both alternatives reflect the philosophy that the minor share of benefits accruing to a railroad from protection-type improvements is generally offset by the railroad's assumption of some or all of the cost of maintenance and operation of the improved protection. They also take into account that the railroad's share of benefits from elimination-type projects (grade separations and the like) is generally more on the order of 5 percent of the railroad benefit related portion of the project costs, rather than the flat 10 percent rate used under the current Federal-aid highway program.

Alternative 3 proposes to amend the existing legislation as necessary to permit the financing of all railroad-highway intersection improvements entirely with public funds. This is premised on the principle of equity by treating railroad-highway intersection improvements in the same manner and on the same basis as highway-highway grade separation structures and highway traffic signal installations. This also recognizes the declining financial condition of the railroad industry.

All three alternatives treat crossing improvements alike where they are to be undertaken as part of or generated by an overriding rail system improvement or by urban area or community improvements. The proposed position involving rail system improvements follows the "Senior-Junior" principle of responsibility described in Appendix A of Part 1 of this report.

Groups of crossings to be improved as part of urban area or community improvement projects are treated as a special case in each instance, recognizing that the benefits accruing to each party will vary from project to project. However, the principles set forth for individual crossing improvements would be applied to the extent practical in establishing the case-by-case allocation of cost. It is anticipated that the urban railroad study now underway, as discussed in Chapter V, may provide further guidance in this area.

RECOMMENDATION

Adoption of Alternative 1 is recommended. It will provide for the most equitable allocation of costs on a continuing basis by:

A. continuing the existing special Federal financial involvement in grade crossing safety,

B. establishing a railroad share of the improvement cost which reflects the current benefit to the railroad from the type of improvement involved,

C. providing administrative flexibility to adjust the railroad's share of the cost, as may be dictated by changing conditions,

D. providing appropriate relief to the railroad industry in light of their current financial position,

E. requiring the party which creates a new crossing to assume the financial responsibility for appropriate protection (or separation), and,

F. providing for special consideration for allocating costs on complex urban projects which result in special benefits.

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