REPORT NO. FRA-ORD&D-75-8

PB244-175

STATE GRADE CROSSING PROGRAMS: A CASE STUDY

Ralph G. Kennedy III

SEPTEMBER 1974

FINAL REPORT

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Prepared for

U.S. DEPARTMENT OF TRANSPORTATION

FEDERAL RAILROAD ADMINISTRATION

Office of Research, Development and Demonstrations

Washington DC 20590

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FRA-ORD&D-75-8		

4. Title and Subtitle	5. Report Date
STATE GRADE CROSSING PROGRAMS: A CASE STUDY	September 1974
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Ralph G. Kennedy III	DOT-TSC-FRA-74-5

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
CONSAD Research Corporation *	RR402/R5328
121 North Highland Avenue	11. Contract or Grant No.
Pittsburgh PA 15206	DOT-TSC-34
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address	Final Report
U.S. Department of Transportation	January 1974-April 1974
Federal Railroad Administration	14. Sponsoring Agency Code
Office of Research, Development and Demonstrations	
Washington DC 20590	

15. Supplementary Notes

*Under contract to: U.S. Department of Transportation
Transportation Systems Center
Kendall Square
Cambridge MA 02142

16. Abstract

This report reviews the California Railroad-Highway Grade Crossing Program, analyzing the factors influencing the reduction in grade crossing accidents. The report concludes that the greater than average success in grade crossing safety in California has resulted from the long standing financial support of the installation and maintenance of grade crossing warning devices, a strong, well managed Public Utilities Commission providing the analytical support for crossing improvement decisions, unusually strong safety efforts by the financially healthy railroads operating within the state, and an effective framework for city-county-state cooperative determination of grade crossing priorities. California ranks eighth overall in terms of active protection installed and first in the percentages of total crossings equipped with automatic gate installations.

Areas for potential improvement and refinement of the California program are likewise discussed.

17. Key Words	18. Distribution Statement
Grade Crossings, California, Railroad-highway Crossing Safety	DOCUMENT IS AVAILABLE TO THE PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22151. **PRICES SUBJECT TO CHANGE**

19. Security Classif. (of this report)	20. Security Classif. (of this page)
Unclassified	Unclassified

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

PREFACE

This work was commissioned by the Transportation Systems Center (TSC), as part of an ongoing program in railroad-highway grade crossing safety research, to ascertain the causes for the continuing improvement in California grade crossing safety. The information developed herein should be valuable to a wide variety of state and federal level personnel concerned with the administration of grade crossing safety at the state level. We wish to recognize in particular the assistance and cooperation provided by Mr. James Gibson and Mr. William Oliver of the California Public Utilities Commission, Mr. Phillip Harris of the California Department of Transportation, and the numerous railroad, city and county personnel who provided information and gave graciously of their time in the course of this work. We sincerely hope this initial analysis will contribute meaningfully to the body of knowledge on ways and means of improving grade crossing magagement efforts.

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1.0 INTRODUCTION

As part of its comprehensive program of research into the ways and means of improving railroad-highway grade crossing safety, the Transportation Systems Center has commissioned this review of the California grade crossing program, to determine which elements have contributed most towards the improvement of grade crossing safety. It is hoped that other states and federal agencies may benefit through the understanding and application of those features of the California program that have proven to be most successful in reducing grade crossing fatalities and injuries.

By all yardsticks, California is a prodigious state, unique in its size, location and the magnitude of its safety problems. It has an area of 158,700 square miles (third largest in the United States), a population of 21,000,000, 12,852,228 registered vehicles, 7500 miles of railroad, and 10,054 public railroad grade crossings. In annual vehicle miles travelled, a common measure of highway traffic, California with its 118,023,000,000* vehicle miles is twice as large as all of New England states combined (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont = 64,426,000,000) and exceeds practically all other individual states by a similar factor.

In traffic density (annual vehicle miles per mile of highway), California ranks far higher than any other state in the union and yet its grade crossing accident record is one of the very best. Even though a total of 154 grade crossing accidents were reported in 1972,** California's accident rate per exposure was found to be lower than 38 other states -- See Table 1 on the following page. Only the New England states, and Middle Atlantic states achieved better safety records based

*Source: 1971 Highway Statistics, Table VM-2, September 1972.
**Total accidents as reported by FRA Office of Safety.

TABLE 1. ESTIMATED RAIL-HIGHWAY GRADE CROSSING ACCIDENT RATE PER VEHICULAR EXPOSURE

State	Total Highway Mileage*	Annual vehicle miles traveled (000,000 omitted)**	Est. avg. traffic density = Annual vehicle miles per mile of highway = Col 3÷Col 2	No. of public railroad highway grade crossings***	Estimated total vehicular exposure at all crossings in state = Col 4 x Col 5	Rail-highway grade crossings accidents 1972****	Accident rate per estimated vehicle exposure Col 7÷Col 6
1 Alaska	79,036	1,469	187,923	176	33,074		
2 Hawaii	3,591	3,656	1,018,100	8	8,144		
3 Rhode Island	5,461	5,038	922,541	186	171,592		
4 New Hampshire	14,926	4,835	323,931	719	232,906	1	.00000429
5 Massachusetts	29,355	28,030	954,862	1,326	1,266,147	8	.00000632
6 Maine	21,424	6,435	300,364	1,012	303,968	2	.00000658
7 New Jersey	32,237	43,289	1,342,835	2,587	3,473,914	26	.00000748
8 New York	106,490	72,217	678,157	4,732	3,209,038	49	.00001527
9 Connecticut	18,531	17,120	923,857	491	453,613	8	.00001764
10 Pennsylvania	115,658	60,892	526,483	7,809	4,111,305	88	.00002140
11 Maryland	26,522	22,215	837,606	1,059	887,024	19	.00002142
12 California	165,990	118,023	711,024	10,103	7,183,475	154	.00002186
13 Delaware	5,104	3,202	627,351	345	216,436	5	.00002310
14 Virginia	61,508	30,504	495,935	2,701	1,339,520	39	.00002911
15 West Virginia	35,941	8,735	243,037	2,414	586,691	18	.00003068
16 Michigan	115,064	55,557	482,835	8,865	4,280,332	132	.00003084
17 Illinois	130,187	57,390	440,827	16,210	7,145,805	232	.00003247
18 Vermont	14,512	2,968	204,520	584	119,439	4	.00003349
19 Kentucky	69,123	21,500	311,039	3,356	1,043,846	37	.00003545
20 Ohio	109,240	61,051	558,870	10,417	5,821,748	215	.00003693
21 Washington	80,219	21,860	272,504	3,957	1,078,298	43	.00003988
22 Wisconsin	103,352	25,856	250,174	7,476	1,870,300	81	.00004331
23 North Carolina	86,478	31,378	362,843	5,686	2,063,125	92	.00004459
24 Florida	93,310	47,493	508,980	6,482	3,299,208	151	.00004577
25 Indiana	90,908	34,292	377,216	10,865	4,098,451	188	.00004587
26 Iowa	112,831	18,881	167,338	9,914	1,658,988	84	.00005063
27 Utah	40,981	6,544	159,683	1,419	226,590	12	.00005296
28 Louisiana	53,340	17,615	330,239	4,468	1,475,507	80	.00005422
29 Arizona	47,085	13,235	281,087	843	236,956	13	.00005486
30 Missouri	115,544	27,077	234,343	7,048	1,651,649	100	.00006055
31 Montana	77,920	5,079	65,182	2,013	131,211	8	.00006097
32 Tennessee	80,290	24,847	309,465	4,009	1,240,645	76	.00006126
33 South Carolina	59,629	17,764	297,908	3,941	1,174,055	73	.00006218
34 Georgia	100,214	31,656	315,884	6,558	2,071,567	134	.00006460
35 Minnesota	127,744	23,404	183,210	8,699	1,593,743	106	.00006651
36 South Dakota	84,078	4,818	57,303	3,368	192,996	14	.00007254
37 Colorado	81,870	13,658	166,825	2,106	351,333	26	.00007400
38 Texas	248,340	70,709	284,726	14,308	4,073,859	302	.00007413
39 Kansas	134,182	13,800	102,845	9,688	996,362	76	.00007628
40 Oklahoma	107,872	18,627	172,676	6,533	1,128,092	89	.00007889
41 New Mexico	68,371	8,015	117,228	786	92,141	9	.00009768
42 Wyoming	40,540	3,198	78,885	606	47,804	6	.00010459
43 Alabama	79,036	18,315	231,729	4,191	971,176	104	.00010709
44 Nebraska	98,765	9,903	100,268	5,422	543,653	63	.00011588
45 Mississippi	66,766	12,255	183,551	3,075	564,419	68	.00012048
46 North Dakota	106,530	3,955	37,125	5,402	200,542	25	.00012466
47 Arkansas	78,680	12,109	153,901	4,043	622,221	81	.00013018
48 Oregon	97,453	14,381	147,568	2,670	394,006	52	.00013198
49 Idaho	57,144	4,930	86,273	2,117	182,639	26	.00014236
50 Nevada	49,702	3,623	72,894	333	24,273	4	.00016479
Averages	76,581	23,668	364,039	4,462	1,522,876	64	.00005596

*Source: 1971 Highway Statistics
**Source: 1971 Highway Statistics
***Source: 1972 Report to Congress on Rail Highway Grade Crossings
****Source: FRA, Office of Safety

on estimated vehicular exposure.* Unlike the rather stable New England and Middle Atlantic states, California's growth in population, home construction, highway miles and highway grade crossings, over the last 20 years has been explosive, and thus the challenge of providing continuing protection at grade crossings has been substantially greater in California than most other states.

California has established a well deserved reputation for progressiveness in the field of railroad highway grade crossing safety, being the first state to establish state funding of crossing protection and one of 12 states that now provide some form of public support of maintenance expense. In 1972 California grade crossing accidents involving motor vehicles declined by 25 percent (see Table 2), making this perhaps the most significant improvement in safety achievement by any state in recent years.

Recognizing the magnitude of California's problems and the results being achieved, the mechanics of the program became of vital interest, for if all states were to achieve similar improvements in safety, there would be approximately 844 fewer grade crossing accidents, 415 fewer fatalities and 821 fewer injuries. This is approximately the same goal that John A. Volpe suggested was possible when he called for a 10 year program of grade crossing protection, involving 30,000 grade crossings and an expenditure of $750 million. This is not to say that the California program, as it is now constructed, provides a perfect example for all other states to emulate in their grade crossing

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*A better exposure index can be calculated as the sum of the product of vehicular crossings times the number of trains for each individual crossing, weighted so as to reflect the type of trains involved. Actually a large percentage of the train miles in Middle Atlantic and New England states would include passenger and commuter trains. These short-fast trains can generally brake very rapidly and thus present far less risk than does a heavy freight train that might require 2 miles or more of track in which to stop. Taking such factors into consideration the relative exposure factor in California would be far greater still than in states like New York, New Jersey, Pennsylvania, Connecticut and Massachusetts which have a large number of commuter trains. It should be possible, with the completion of the National Grade Crossing Inventory, to adequately determine exposure factors for each and every state and thus verify these estimates. We presently believe that these calculations will show that California ranks close to the best, if not the best, of all states in grade crossing safety.

TABLE 2. RAIL-HIGHWAY ACCIDENTS INVOLVING MOTOR VEHICLES, BY STATES, 1971-1972

	State	Total number of accidents		Total persons				Struck by train 1972						Ran into side of train 1972					
								Daylight			Dark			Daylight			Dark		
				Killed		Injured		Number of accidents	Persons		Number of accidents	Persons		Number of accidents	Persons		Number of accidents	Persons	
		1972	1971	1972	1971	1972	1971		Killed	Injured		Killed	Injured		Killed	Injured		Killed	Injured
1	Alabama	104	84	33	22	99	104	58	21	54	19	6	17	13	4	8	15	2	20
2	Alaska	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	Arizona	13	14	3	1	11	14	3	2	1	8	-	8	-	-	-	2	1	2
4	Arkansas	81	68	39	29	78	65	46	25	39	16	4	16	12	4	16	7	6	7
5	California	154	204	58	87	126	190	63	29	38	36	19	25	26	4	27	29	6	36
6	Colorado	26	29	15	7	22	25	16	12	8	3	1	3	3	-	4	4	2	7
7	Connecticut	8	5	5	1	8	3	6	3	7	2	2	1	-	-	-	-	-	-
8	Delaware	5	2	1	-	5	2	1	-	1	-	-	-	3	1	3	1	-	1
9	Florida	131	138	65	69	136	118	76	29	69	26	19	22	27	9	27	22	8	18
10	Georgia	134	121	45	50	143	133	68	21	76	35	18	34	17	2	21	14	4	12
11	Hawaii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	Idaho	26	22	18	18	30	19	13	10	15	8	6	8	2	-	2	3	2	5
13	Illinois	232	242	85	89	231	275	110	46	106	47	9	52	40	18	35	35	14	40
14	Indiana	188	211	72	96	179	207	101	42	105	50	19	41	18	5	17	19	6	16
15	Iowa	84	73	48	26	77	74	41	27	35	9	3	7	11	3	10	23	15	25
16	Kansas	76	87	36	40	67	93	38	20	23	18	12	22	9	2	12	11	2	10
17	Kentucky	37	50	12	22	31	48	25	7	22	7	2	6	2	2	1	3	1	2
18	Louisiana	80	75	30	32	73	78	40	14	39	21	11	16	7	2	8	12	3	10
19	Maine	2	11	-	4	6	7	2	-	6	-	-	-	-	-	-	-	-	-
20	Maryland	19	20	6	6	15	15	5	1	2	5	2	5	3	2	2	6	2	6
21	Massachusetts	8	13	5	5	12	11	5	2	9	2	-	2	-	-	-	1	3	1
22	Michigan	132	152	38	41	160	169	47	19	56	29	6	38	23	6	10	11	7	36
23	Minnesota	106	76	34	35	104	74	50	23	42	17	5	18	23	3	23	16	3	19
24	Mississippi	68	76	19	26	69	97	32	10	31	17	7	14	9	2	9	10	-	15
25	Missouri	100	100	41	44	92	112	61	26	35	21	8	23	12	5	10	6	2	4
26	Montana	8	20	2	11	9	18	3	1	3	1	-	1	1	-	1	3	1	4
27	Nebraska	63	60	34	33	44	57	25	20	15	15	6	10	14	6	12	9	2	7
28	Nevada	4	4	1	-	4	5	2	1	-	-	-	-	1	-	1	1	-	3
29	New Hampshire	1	2	-	-	2	2	-	-	-	1	-	2	-	-	-	-	-	-
30	New Jersey	26	31	7	14	21	27	10	5	8	3	-	3	8	-	7	5	2	5
31	New Mexico	9	8	9	8	3	7	6	6	2	2	2	1	1	1	-	-	-	-
32	New York	49	62	14	21	93	62	20	7	63	14	4	15	6	1	3	9	2	12
33	North Carolina	92	83	36	37	104	84	51	17	54	16	10	11	17	7	26	8	2	13
34	North Dakota	25	26	15	11	19	22	14	9	10	3	3	1	3	-	2	5	3	6
35	Ohio	215	197	71	80	228	192	108	42	85	57	23	73	12	1	16	38	5	54
36	Oklahoma	89	79	34	29	82	82	41	21	31	18	6	17	16	3	20	14	4	14
37	Oregon	52	52	7	17	53	51	23	3	23	14	1	14	8	1	9	7	2	7
38	Pennsylvania	88	67	17	14	78	68	50	11	38	15	2	15	9	2	8	14	2	17
39	Rhode Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40	South Carolina	73	73	30	31	75	81	32	16	37	14	7	8	14	2	13	13	5	17
41	South Dakota	14	12	6	7	17	10	7	4	7	4	2	6	-	-	-	3	-	4
42	Tennessee	76	81	27	40	83	74	44	19	43	22	6	31	6	1	5	4	1	4
43	Texas	302	273	101	90	311	266	133	51	126	65	29	71	45	11	44	59	10	70
44	Utah	12	17	6	7	11	14	5	2	5	3	4	1	1	-	2	3	-	3
45	Vermont	4	3	2	1	4	2	3	2	3	-	-	-	1	-	1	-	-	-
46	Virginia	39	37	15	9	40	45	21	8	20	8	5	9	5	-	5	5	2	6
47	Washington	43	65	12	28	47	56	19	5	22	10	5	9	6	1	8	8	1	10
48	West Virginia	18	21	3	6	19	24	10	3	10	3	-	4	1	-	1	4	-	4
49	Wisconsin	81	74	31	25	75	65	35	17	31	7	2	5	14	8	16	20	4	21
50	Wyoming	5	4	2	-	3	6	4	2	2	-	-	-	-	-	-	1	-	1
51	District of Columbia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
52	State Unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
53	Total	3,222	3,244	1,190	1,267	3,201	3,253	1,573	661	1,475	690	276	685	454	119	465	505	134	570

Source: FRA Office of Safety "Rail-Highway Grade Crossing Accidents", 1972.

efforts, for in fact there are several aspects of the California program that could be improved. However, this review of the program's major components should enable administrations in other states to pick and choose those features which, if incorporated in their own state program, would be most beneficial. The differences in state organizational structures, financial resources, and railroad financial conditions are important factors affecting the extent and potential transferability of practical program features.

2.0 OVERVIEW OF THE CALIFORNIA PROGRAM

Before progressing further, it is important that the word "program" be defined, for in the context of this review, it refers to the sum total of all activities being undertaken by the railroad, or state and local agencies in the field of railroad-highway grade crossing safety. As in most states, the responsibilities for implementing grade crossing safety programs are divided among a number of agencies and thus, when we speak of the California program we are referring to the aggregate result of their joint efforts. The principal participants in the California Grade Crossing Program are the California Public Utilities Commission, the California Department of Transportation-State Highway Division, the 4 Class I Railroads, Southern Pacific, Union Pacific, Western Pacific and Santa Fe, and the many county and city engineers and administrators actively engaged in railroad-highway grade crossing safety activities.

In order to better understand California's current program, a brief review of the major historical developments leading to its establishment, are in order.

2.1 CALIFORNIA PUBLIC UTILITY COMMISSION HISTORICAL ROLE*

The present California Public Utilities Commission (PUC) which has the responsibility and authority for grade crossing safety, started out in 1911 as the Railroad Commission. This Commission, by the Constitution of California and the Public Utilities Code, has exclusive power to determine and prescribe the manner, point of crossing, terms of installation, operation, maintenance and protection of crossings between the railroad and the public agency. The Commission has the authority to require a crossing to be constructed at a separated grade and to dictate how crossings may be altered, relocated, or abolished.

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*Much of the data and input in this section was abstracted from a speech given by Mr. William L. Oliver, Supervising Transportation Engineer, California Public Utilities on "Railroad Highway Crossing Developments in the 50's, 60's and 70's," before the Western District Conference of the Institute of Traffic Engineers, July 18, 1972.

In addition, the PUC performs the following functions in its administration of its grade crossing activities:

- It reviews and approves all applications for installation or changes of grade crossing protection,

- It institutes investigations prompted by requests from cities, individual citizens (often in response to "near misses"), or on its own initiative,

- It conducts county, city, and state surveys of crossing hazards and assists local communities in developing local priority lists of crossings requiring improvements,

- It investigates accidents, particularly at gated crossings and high accident-prone areas; reports on each accident are filed by crossing,

- It publishes an annual report summarizing the accident experiences of the previous year and the progress made in grade crossing protection, and

- It establishes a prioritized list of state highway crossings for upgrading.* The state protection program is actually administered by the state highway department using the prioritized list developed by the PUC. In establishing the priorities for state grade crossings, the PUC utilizes a simple exposure index (number of cars x number of trains), supplementing this with crossing-by-crossing reviews of accident experience and pertinent physical factors. Virtually all of the railroad main line crossings on state highways are protected with gates or separation, or are

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*The PUC does not have a prioritized list for all grade crossings in the state which would include city and county crossings; only the state crossings have been prioritized. However, they are in the process of developing a master list for all crossings pursuant to Section 203 requirements.

scheduled for improvements in the near future. Because of the small number of state crossings (494) a manual analysis and prioritization of crossings was performed. The priority list is open and flexible, permitting an annual readjustment of priorities.

In 1929, the PUC initiated the first statewide crossing inventory which has been updated and maintained ever since. Early in its history, the California PUC established diagnostic team-on-the-site reviews to analyze crossings in terms of their hazardness and made recommendations for subsequent improvements. This activity, which will be subsequently discussed, is one of the central and most successful features of the California program.

A program to gate all crossings on the Southern Pacific Company's commuter line between San Francisco and San Jose was commenced in the late 1940's.

In 1950 when few people in the country were worrying about safety at railroad grade crossings, the California Commission, as a result of a three-year statewide crossing survey, made recommendations that resulted in the paving of 4,055 crossings, installation of 2,791 crossing signs and 272 signals, closing of 83 crossings and installation of 8,509 advance warning signs. This may not seem like much today in times when practically all crossings are at least 24 feet wide, have advance warning signs and have some type of signs or signals, but 23 years ago this was a real step in the advancement of railroad grade crossing safety.

In 1951 the Commission initiated a statewide program for installation of automatic gates at crossings, particularly at double-track crossings where there was a possibility of two trains arriving at the crossing at the same time.

In 1953 California became the first state to establish a state grade crossing protection fund. Under the new legislative provisions, the California PUC was authorized to assist cities and counties in paying their allocated portions of the installation costs of automatic protection (flashing lights, gates, etc.) on non-Federal aid highways and streets. Funds would be expended from the state Highway User Fund and other funds to pay for one half of the local public authority's share of the costs of grade crossing projects. Since the public

authority's share of the costs for such projects was normally 50 percent of the project, with the new funding the state would pay 25 percent of the project, the local authority for 25 percent and the railroad the remaining 50 percent. Five hundred thousand dollars was initially authorized for reimbursement of local communities' crossing expenses.

In 1954 the Commission instituted several small cases (one to six crossings) investigating the necessity for improving protection or closing crossings.

The grade crossing protection fund was increased to $700,000 in 1956 and during this same year many grade separation projects were being initiated and the Commission was assessing the costs between the public agencies and the railroads involved.

An exempt crossing program was initiated in 1957 which allowed certain vehicles required to stop at grade crossings to be exempt if it was felt that public safety could be furthered by their not stopping at particular industrial spur track crossings. This program has been adopted by a number of other states as well. Also in this year, a $5 million grade separation fund was established. Projects were allotted funds on a priority basis and the costs were apportioned 10 percent to the railroad, 45 percent to the public agency and 45 percent to the grade separation fund.

In 1959 the Transportation Division of the PUC made a study into the effectiveness of 227 automatic gate installations on a three-year before-and-after analysis, which revealed that accidents were reduced by 58 percent and injuries and fatalities by 72 percent. Also, in 1959 city and county informal surveys were undertaken with representatives of the public agencies and railroads looking into the solutions of railroad grade crossing problems in designated cities, counties and areas.

In 1961, the Commission instituted its first railroad grade crossing case of any magnitude, which looked into the safety of 51 crossings in the San Fernando Valley, which is just north of the City of Los Angeles. In this same year the Interstate Commerce Commission made a formal investigation of grade crossing accidents and concluded that the basic responsibility for funding grade crossing protection should be borne by the public. This investigation was requested by a group of union leaders reacting to the rather horrible accident in Bakersfield, California, in which the San Francisco Chief struck a gasoline truck, injuring 105 people and fatally burning 13 others.

In 1962 a school bus safety program at railroad grade crossings was inaugurated in conjunction with all of the school districts in the State of California and the California Highway Patrol. Also in 1962, the Commission instituted an investigation of the safety of 250 crossings between Los Angeles and Ontario, which was one of the largest cases ever to be undertaken in California and perhaps elsewhere. This case involved three major railroads and a large number of cities in the area. As a result of the investigation, the Commission ordered the installation of a large number of automatic gates, which had the effect of triggering the recognition by many public agencies and railroads of the necessity for grade crossing improvements in general, and particularly the need for automatic gates on main and major branch line crossings.

In order to cope with the problem of traffic delays at crossings protected with automatic gates, the Southern Pacific Company developed the "predictor", a control device that reduces the down time for automatic gates. In 1964, Southern Pacific Company established a policy on their lines that if automatic protection was to be improved on existing crossings or installed on new crossings, on main or branch main lines, that the protection should be automatic gates. In this same period, the Commission staff made a study of the effectiveness of automatic gates which showed an average decrease of 60 percent in accidents, a 90 percent reduction in fatalities and an 85 percent reduction in injuries.

In 1965 the state legislature established a grade crossing maintenance fund which reimbursed the railroad for the cost of maintenance in proportion to the public agency's cost of installation of the automatic protection. During this period, the Commission instituted a case into the safety of private railroad grade crossings and as a result established a unique sign which distinguishes them from public crossings.

During 1965 the Southern Pacific Company was authorized by the Interstate Commerce Commission to construct a new 78 mile main line track between Palmdale and Colton, which did, in effect, bypass the Los Angeles basin with their main line trains. As a consequence of the Commission's investigation of the safety of the proposed crossings and grade separations, automatic gates were ordered to be installed.

In 1966 the name "BART" appeared and a 75-mile rapid transit system was conceived which partially paralleled the Western Pacific Railroad and the Atchison, Topeka & Santa Fe Railway tracks in the San Francisco Bay Area. The PUC examined the

safety of the adjacent railroad crossings and as a result many crossings were separated or improved.

In 1967 a program was established for the improvement of all state highway crossings in coordination with the state Department of Public Works and as a result, practically all state highway main and branch line crossings are, or will soon be, protected either with gates or with a minimum of flashing light signals.

Finally, in 1973 the California Legislature changed the state's funding provisions on grade separation projects so that the state and local governments are now responsible for 90 percent of the total costs while the railroads must pay the remaining 10 percent. Alternate funding provisions will be discussed in the next section of the analysis.

Over the years the California Public Utilities Commission has provided much of the leadership and management that is so necessary in establishing an effective grade crossing program. They have been strongly assisted by the railroads in California, some of which have been exemplary in their support of grade crossing safety efforts, by the state highway department, by a sympathetic and responsible legislature, and by numerous organizations concerned with improving railroad highway grade crossing safety within the state, not the least of which are: The Brotherhood of Locomotive Engineers, the League of California Cities, the AAA, the County Board of Supervisors Association, and the many cities, counties and individuals who have cooperated with them in the overall execution of the program.

The Transportation Division of the California Public Utilities Commission is one of the strongest agencies in the United States today in the field of railroad highway grade crossing safety by virtue of their legislative authority, their large staff of experts, and the state funding programs which have given them the financial strength necessary for effecting grade crossing improvements. The depth of the PUC's involvement and commitment to grade crossing safety can be seen in the following table (Table 3) of survey results which was recently prepared by the Grade Crossing Committee of the National Conference of State Transportation Specialists.

As this brief overview of the PUC historical role has evidenced, a continuing program of improvements in the financing, management and installation of grade crossing protection over the last 50 years has been effected. As with any state, it is the cumulative impacts of past

TABLE 3. STATE CROSSING INFORMATION SURVEY SUMMARY OF QUESTIONNAIRE RESPONSES

State	Organization	JURISDICTION-INVOLVEMENT* Crossing Const	Crossing Alt	Crossing Sig	Crossing Separtn	Train Speed	Crossing Blockage	Xing Fund (3)	Priority System	5-yr Accid. Trend
Alabama	PSC	No	No	No	No	No[a]	No	No	No	Down
Arizona	Corp Comm	Yes	Yes	Yes	Yes	[a]	Yes	No	Yes[a]	Up
Arkansas	Trans Comm	Yes	Yes	Yes	No	No	Stat	[a]	No	N/A
California	PUC	Yes	Yes	Yes	Yes	Yes	Yes	Yes[a]	Yes	Down
Colorado	PUC	Yes	Yes	Yes	Yes	No	No	Yes[a]	Yes[a]	
Connecticut	PUC	Yes	Yes	Yes	Yes	Yes[a]	Yes[a]	No	No	Up
Delaware	PSC	No	No	Yes	No	No	Yes	No	Yes	aUp
Florida	DOT	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Up
Georgia	PSC	No	No	No	No	No	No	No	No	Up
Idaho	PUC	Yes	Yes	Yes	No	Yes[a]	No	No	[a]	Up
Illinois	CC[a]	Yes	Yes	Yes	Yes	Yes[a]	Stat[a]	Yes[a]	Yes[a]	Down
Indiana	PSC	Yes	Yes	Yes	Yes	No	No	No	No	No Trend
Iowa	SCC*	Ltd[a]	Ltd	Ltd	Yes	Yes[a]	No	Yes[a]	[a]	No Trend
Kansas	Corp Comm	Yes	Yes	Yes	No	Yes[a]	Stat[a]	Yes[a]	No	aDown
Kentucky	DOT	No	Yes	Yes	[a]	No	No	No[a]	Yes[a]	Level
Louisiana	PSC[a]	Ltd	Ltd			No	Ltd	No		
	Hwy Dept[a]	Ltd	Ltd	Ltd	Ltd	No		No	Yes[a]	N/A
Maine	PUC	No[a]	No	No	No	Yes	Yes[a]	Yes[a]	No	Down
Maryland	Hwy Admin[a]	No	No	Yes	Ltd	No	Yes[a]	No	No	Up
Massachusetts										
Michigan	PSC	Yes	Yes	Yes	Yes	Yes	No	No	No	Down
Minnesota	PSC[a]	Yes	Yes	Yes	Ltd[a]	Yes	Stat[a]	Yes[a]	Yes[a]	Down
Mississipp	PSC[a]	No	No	Yes[a]	No	Yes	Ltd[a]	No	No	Up
Missouri	PSC	Yes	Yes	Yes	Yes	No	No	Yes[a]	No	Down
Montana										
Nebraska	PSC	Yes	Yes	Ltd[a]	No	Yes[a]	No[a]	Yes[a]	No	Up
Nevada	PSC	Yes	Yes	Yes	Ltd[a]	No	No	No[a]	No	Down
New Hampshire	PUC	Yes	Yes	Yes	Ltd[a]	Yes[a]	Yes[a]	No	Yes[a]	Down
New Jersey	DOT	Yes	Yes	Yes	Yes	Yes	Yes	Yes[a]	Yes[a]	aDown
New Mexico	Corp Comm	Yes[a]	No[a]	No	No	No				
	Hwy Dept.	Ltd[a]	Ltd[a]	Yes	[a]	No	Yes	Yes[a]	Yes[a]	No Trend
New York	DOT	Yes	Yes	Yes[a]	Yes	No	No[a]	Yes	Yes	Level
North Carolina	UC	No	No	No	Ltd[a]	Yes[a]				
North Dakota	PSC	Yes	Yes	Yes	Yes	No	Stat[a]	Yes[a]	No	No Trend
Ohio	PUC	Yes	Yes	Yes	No	No	Ltd	[a]	Yes[a]	Level
Oklahoma	Corp Comm	No	Yes	Yes	Yes	No	Yes[a]	No[a]	Yes[a]	Down
Oregon	PUC	Yes	Yes	Yes	Yes	Yes[a]	[a]	[a]	[a]	aDown
Pennsylvania	PUC	Yes	Yes	Yes	Yes	Yes	Stat	No	[a]	Down
Rhode Island	PUC	Yes	Yes	Yes	Ltd	Ltd[a]	Stat[a]	No[a]	Yes	Down
South Carolina	PSC	Ltd[a]	Ltd	Ltd	No	No	Ltd[a]			
South Dakota	PUC	Yes	Yes	Yes	No	No	No	No	No	Up
Tennessee	PSC	Ltd[a]	Ltd	No	No	No	No	No	No	Down
Texas	RRC	No	No	No[a]	No	No	No			
Utah	PSC	Yes	Yes	Yes	Yes	Ltd[a]	Yes[a]	[a]	No	Level
Vermont	PSB	Yes	Yes	Yes	Yes	No	Stat[a]	Yes[a]	No	No Trend
Virginia	Corp Comm		Ltd	Ltd	Ltd	No	Stat			N/A
Washington	U&T Comm	Ltd[a]	Ltd	Ltd	Ltd[a]	Ltd[a]	No	Yes[a]	No[a]	Level
West Virginia	PSC[a]	No[a]	No	No	No	No	No	No	No	Level
Wisconsin	PSC	Yes	Yes	Yes	Yes	Yes	No	Yes[a]	Yes[a]	Down
Wyoming	PSC	Yes	Yes	Yes	Yes	Yes[a]	Yes[a]	Yes[a]	Yes	No Trend

Footnotes

*Abbreviations

(1) Column Headings:
Const = Crossing construction jurisdiction
Alt = Crossing alteration jurisdiction
Sig = Crossing signalization jurisdiction

(2) Others:
CC = Commerce Commission
SCC = State Commerce Commission
Ltd = Limited jurisdiction and/or involvement
Stat = Controlled by statute
N/A = Not available

(3) No distinction is made in the table between crossing maintenance funds and funds established for the construction of new crossings.

[a] = See explanatory information under individual state headings on the supplementary sheets.

A = Slight change.

Source: National Conference of State Transportation Specialists 1973 Report of the Railroad Grade Crossing Committee

activities which establishes present safety results. California's historical efforts to improve grade crossing safety have thus been one of the prime determinants of the state's progress in reducing grade crossing fatalities and injuries.

On the following tables (Tables 4 and 5) and graph, the progress of the California program is charted from 1950 through 1972. As can be seen, while highway accidents have increased, grade crossing accidents have declined. The figures of Table 4 also reflect the start up of the state highway departments grade separation program in 1952 and a similar program established in 1957 by the PUC for all county and city crossings. An analysis of the signal improvements shows the switch from flashing light signals to gates in 1964. The rate of installation of active protection throughout the period has been primarily controlled by the availability of funds.

TABLE 4. CASUALTIES AT CROSSINGS IN CALIFORNIA FROM 1950 TO 1972

Year	Killed	Injured	Total	Total Fee Paid Vehicle Reg.	Casualties Per 10,000 Vehicles
1950	126	772	898	4,976,296	1.8
1951	162	874	1,036	5,303,524	2.0
1952	150	793	943	5,548,642	1.7
1953	171	686	857	5,922,726	1.4
1954	125	712	837	6,119,264	1.4
1955	178	789	967	6,649,765	1.5
1956	137	663	800	7,065,699	1.1
1957	178	833	1,011	7,402,504	1.4
1958	139	586	725	7,963,590	0.9
1959	108	546	654	8,086,571	0.8
1960	133	631	764	8,569,295	0.9
1961	126	567	693	8,889,860	0.8
1962	133	548	681	9,647,505	0.7
1963	131	556	687	9,869,009	0.7
1964	169	620	789	10,575,237	0.7
1965	128	604	732	11,191,199	0.7
1966	144	628	772	11,518,765	0.7
1967	135	601	736	11,748,758	0.6
1968	105	467	572	11,266,778	0.5
1969	87	493	580	13,674,636	0.4
1970	91	454	545	13,934,945	0.4
1971	95	388	483	14,495,889	0.3
1972	70	368	438	15,232,810	0.3

Source: 1972 Annual Report of Railroad Accidents, California Public Utilities Commission

TABLE 5. CROSSING IMPROVEMENTS IN CALIFORNIA FROM 1950 TO 1972

Year	No. Gates Installed	No. Flashing Light Signals and Other Imprv.	No. Crossings Closed	No. Crossings Opened	Separations Constructed
1950					
1951					
1952	16	59			7
1953	18	106			14
1954	21	95	170	40	9
1955	16	103	179	49	16
1956	27	143	106	54	21
1957	23	162	138	58	36
1958	17	119	222	47	35
1959	14	97	275	77	31
1960	25	135	231	59	30
1961	28	128	171	72	31
1962	33	127	108	77	51
1963	44	126	206	71	28
1964	62	154	158	67	45
1965	103	111	177	75	29
1966	168	84	175	50	42
1967	240	85	167	94	58
1968	264	67	95	83	34
1969	212	32	171	44	28
1970	234	51	113	67	31
1971	237	42	123	67	33
1972	219	34	172	53	32

Source: Railroad Highway Crossing Developments in California in the 50's, 60's and 70's, William L. Oliver, Supervising Transportation Engineer, California PUC.

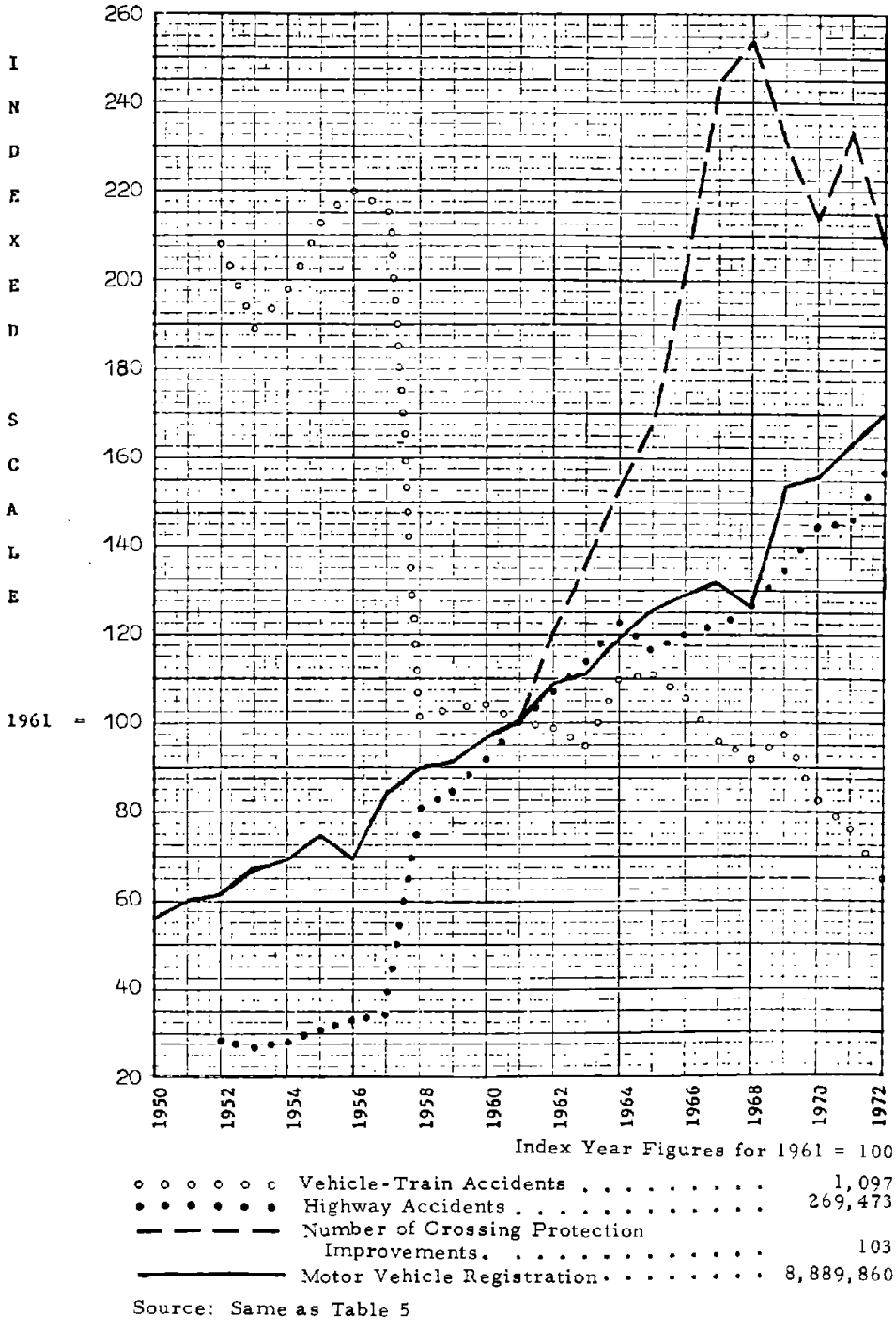

Figure 1. Crossing Protection Improvements and Motor Vehicle Registration, California: 1950-1972

3.0 DESCRIPTION AND ANALYSIS OF CALIFORNIA PROGRAM

As previously mentioned, the California grade crossing program is a composite of activities and programs being administered by the PUC, the state Highway Department, local city and county governments and the railroads. Understanding the responsibilities of each group from the standpoint of program administration will help to clarify the basic mechanics of the California program.

3.1 GRADE CROSSING PROTECTION INSTALLATION PROGRAM FOR NON-STATE, NON-FEDERAL CROSSINGS (NOT APPLICABLE TO GRADE SEPARATION)

Requests for installation of railroad-highway grade crossing protection can be initiated by local cities, county governments, by railroads, or in those cases where the local agency appears unwilling or incapable of making such a request, by the Public Utilities Commission, on its own initiative. In actual practice, the vast majority of crossing installations in California are initiated by the PUC and local governmental agencies and the PUC has only stepped in and exercised its authority to direct that a crossing installation be made in instances where the public safety appears jeopardized by the lack of protection, and in instances where the local community has failed to establish a proper program of improvement and corrective action. Thus, the 424 cities and 58 counties in California* with participation by the PUC, are primarily responsible for originating the requests for installation of crossing protection. The methods and procedures used by these communities and cities in evaluating and ranking the hazardness of each crossing within their jurisdictions are of prime importance to us in evaluating the overall effectiveness of the California program.

Most of the communities have taken advantage of the joint field surveys conducted by the PUC engineers and have used the results of such surveys to establish a prioritized list of crossings requiring protection.** Other communities, particularly the smaller municipalities, have relied upon consulting firms or better staffed public

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*Note: In California, the cities and counties do not overlap, geographically speaking, and thus there are no jurisdictional duplications.

**About 75 cities and counties have programs underway with PUC.

agencies to perform this work. From the information available from a recent PUC questionnaire on grade crossing improvement criteria and procedures, used by counties and cities in California, there is little uniformity in the evaluation of railroad highway grades for the purposes of protection improvement by local communities. The warrants or criteria used ranged from informal, somewhat subjective and sporadic ones to sophisticated and regularly recurrent procedures. The less formal criteria are often based on only one or two factors such as accident history, "local need" and complaints -- with catastrophic accidents many times being the motivating force. The results obtained by weighting and ranking alternate physical and environmental factors were similar to those obtained in other studies and showed that the five most important physical factors considered by local California communities in making a grade crossing improvement decision are:

- Annual Average Daily Traffic
- Number of Daily Trains
- Obstruction to Vision (corner visibility)
- Speed of Trains

The normal steps followed by most communities in making an improvement decision are:

- Evaluate the crossing including a traffic study and review of accident history.
- Complete an engineering study and design the project.
- Negotiate agreement with the railroad and seek the California PUC approval for financing.
- Request budgeting of funds from local public agency governing board.
- Install crossing protection once funding is approved.

The time span for the above procedures normally ranges from one to five years, depending upon the public agency involved and the scope and complexity of the project. An average crossing takes two years from original application to first installation, which can create problems for the local communities, from a budgetary standpoint.

Even though the railroad will provide 50 percent of the cost of installation and the state 25 percent, the local community must provide the remaining 25 percent, and thus there is undoubtedly a direct correlation between local community finances and the degrees of safety and protection provided through new crossing installations. Those communities which generally have poorer financial postures by virtue of their economic resources or lack of suitable tax basis would find it far more difficult to finance new crossing installations than would their wealthier counterparts. In this sense the financing provisions of the California railroad-highway grade crossing program are somewhat regressive with the burden of funding falling equally on communities without regard to their financial abilities* (see footnote on the following page).

In addition the procedures by which the funding is accomplished have provided some additional impediments to local communities. Under the California program, the local community first notifies the railroad of the installation costs. The railroad assigns a signal engineer to each request to determine the necessary design and costs of installing the equipment. These estimates are then returned to the local community which then either agrees to the charge or else abandons the project. If the projected charges are acceptable to the local community, it then negotiates an agreement with the railroads establishing the specific charges and conditions negotiated and submits a copy of this agreement with its application to the PUC for an allocation of funds from the Crossing Protection Fund. Since the state is reimbursing the local community, it is necessary for the local community to first receive authority to provide financing for 50 percent of the total cost of the installation, even though it will ultimately only have to pay for 25 percent of the total. This requirement has created problems for a number of local communities that can provide the 25 percent financing but for various reasons cannot handle the 50 percent requirement. According to one PUC official, the California program would be greatly improved by having the PUC reimburse the railroads directly for 25 percent of the initial installation costs instead of placing the burden on the local community to first secure the PUC funds and then reimburse the railroads.**

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*Footnote on the following page.

**States that are considering establishing similar grade crossing protection funds should structure their reimbursement provisions accordingly.

*On the other hand, it can be argued that the requirement for local community financing participation acts to insure that prudence and reasonableness are exercised in the request and applications for installation of crossing protection.

When the grade crossing protection fund was first established, the California Public Utilities Commission in Decision No. 49565, Case No. 5495, examined the question of allocating funds to local agencies on the basis of their financial needs.

Representatives of local agencies were apprehensive of a suggestion that requests for allocation contain a statement showing the local agency's need for financial assistance. It was urged that allocation not be based upon financial need, nor upon the basis of a "pauper clause". So to do, as expressed by one city official, would be unsound and unfair because, although every local agency has legal authority to raise money, financial need exists in each agency. Moreover, it was suggested that allocation on the basis of financial need could give special assistance to those agencies which have refused to face the problem of crossing protection, and penalize communities which are making serious effort to solve the problem. The local agencies contend that the appropriation statute is based upon an equitable principle of mutual interest by the State, the railroads, and the local governmental agencies, and was intended to assist in solving a problem of statewide concern without consideration of possible financial distress on the part of local agencies.

If a showing of financial need is required, it would be necessary for the Commission to make a detailed examination of the financial affairs of each applicant agency, including the agency's financial structure, assessed valuation of tax purposes, tax rates, availability of other sources of revenue, charter limitations, and like matters. The California PUC did not believe that the Legislature, by adoption of the appropriation statute, intended to confer upon the Commission the additional power and duty of passing upon the financial needs of local agencies. Nor did they feel that it was the legislative intent to require a showing of financial need or pauperism by a local agency in order to qualify for an allocation from the fund. Consequently any change in the California funding program towards greater progressiveness would require legislative action.

It normally takes about six months from the time a community first notifies the railroad of its intent to request the funding of a crossing improvement until the time the railroad returns the engineering cost estimates. In general, there have been no unnecessary delays on the part of the railroads in providing these estimates for it normally takes a full six months to design and price out the complete installation.

However, once the installation has been approved and funded by the PUC and the go ahead given to the railroad for installation and construction of the crossing protection, the time required for completion of this work can range from three to twelve months. Construction delays sometimes force local communities to make a second budget application when the first fiscal year authorization has elapsed. Ordinarily this is not a big problem, but in some communities the local governing board has seen fit to allow the funding of the originally budgeted crossings only and will not authorize protection of additional crossings. In those cases the delays in construction have reduced the effective rate of new installations in the community. The problem in California is principally confined to the smaller railroads. *

So far we have been discussing the procedures followed by local communities in requesting a grade crossing improvement involving active protection, not grade separations. The procedures establishing the prioritization and funding of grade separation are separate and distinct from those involving signalization and will be subsequently discussed.

The California Public Utilities Commission receives approximately 250 requests a year for funding the installation of grade crossing protection by all the counties and cities in California. Since they have had adequate funds to provide the necessary 25 percent state support, they have not had to prioritize local community requests, consequently if a local community can afford the installation, the PUC has always been able to fund the requests. As indicated previously, local financing thus dictates the rate of new installation. Between

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*Perhaps the problem can be avoided in other states and in California by establishing an incentive payment plan that would provide railroads with a premium for completion of the project within the budget year or by penalty clauses for delays. An alternative suggestion might provide advance partial payments to the railroads from the grade crossing fund on a mutually agreeable time schedule for completion of work.

1953 and December 31, 1972, a total of 2,403 requests for funding have been processed by the PUC of which only 28 were denied.

Within a local community's jurisdiction, the priorities for crossing protection are often established by agreement between parties after reviews by representatives of the railroad, the PUC, and the local agency. These reviews or on-site inspections are quite thorough and generally result in agreement by all parties as to the ranking and priority of crossings for treatment. If there is any disagreement between the parties, the PUC may set the matter for public hearing after which the PUC will issue an order based on the evidence submitted.

Over the past 10 years, as of January 1974, the PUC has completed surveys with public agencies, with the assistance of the railroads involved, in approximately half of the counties in California. Over the years, all of the crossings in California have been individually surveyed on different occasions.

For most cities and counties in California, the PUC maintains a list of crossings that should be protected. Thus, a crossing in say, Fresno, which might be No. 1 on the Fresno list, is not compared with some crossing in Los Angeles or San Diego for priority standing, for reasons which will be subsequently explained.

In one sense, the California legislature avoided the problem of choosing among crossings and communities by providing sufficient funds in the grade crossing fund to more than match the funding that local communities could afford. However, in the case of state crossings of which there are only 494, and which are financed 50 percent by the state and 50 percent by the railroads, where federal funds are not utilized, a priority list is developed. In the past the establishment of a prioritized list of crossings requiring protection for all non-state crossings has been strongly resisted on political and technical grounds. There was considerable doubt that a satisfactory statewide priority formula could be developed that would give reasonable results when applied to a large number of crossings within the state. The opinion of the engineer on the Los Angeles County Grade Crossing Committee, for example, was that a definite statewide priority list based on a formula would be inappropriate because of the need for the exercise of judgment in regard to many changing factors. It was also argued that attempts to develop such a list would tend to produce unreasonable delay in the construction of needed safety improvements. What was feared most was the potential unresponsiveness of the PUC to local needs that

the application of such a formula portended. Local representatives could readily envision situations where accidents had occurred at a local crossing and their being required to tell their angered constituents that the crossing was only ranked 892 on the state list and would perhaps be protected in five years. Such situations, though perhaps far-fetched, can theoretically occur and have the potential for agitating not only the local populace but their beleagured legislative representatives as well.

The California system of separate priority lists for each community has actually avoided these problems. On the other hand, the question can and should be raised as to the efficiency of such a system. Undoubtedly there are some crossings that are being protected because a local community desires to have them protected and can afford the financing, at the expense of other crossings that may offer greater potential savings in accident reductions but which cannot be financed due to a lack of local funds or local unwillingness to do so. This discussion raises many questions concerning what is the "best" and "right" approach to state management of grade crossing installation programs which we shall not attempt to answer here, for in one sense the question is moot, as Sections 203 and 230 of the 1973 highway safety act has required that every state establish a priority list of crossings requiring protection as a precondition of their receiving federal funding.

The California PUC is currently attempting to assemble such a list by consolidating their local lists and reviewing the physical data and other factors provided on each crossing submitted for improvement. It is their intent to also use the National Grade Crossing Inventory Data as soon as it is completed in their state to further assist them in establishing a prioritized list of crossings.

California's procedures for establishing crossing protection priorities within a local community are politically sensitive and generally effective in that the list represents a consensus of opinions as to the most serious problems in any given area; nevertheless, on a statewide basis this procedure -- however workable -- may not ultimately be the most effective.

It will therefore be interesting to see whether the new list of priorities being established pursuant to federal requirements becomes anything more than just a list.

3.2 GRADE CROSSING PROTECTION UPGRADING ON STATE HIGHWAYS

By a cooperative and voluntary agreement between the Public Utilities Commission and the Highway Commission, a program was established several years ago for the systematic upgrading of protection at grade crossings on state highways throughout the state. To implement this program, the PUC staff each year compiles a priority list of grade crossings on state highways which they deem to be most in need of upgrading. The Highway Commission reviews the list to ascertain if any of the proposed crossings will be affected by proposed highway projects, relinquishments to other agencies, abandonments, etc., and then initiates negotiations with the railroads involved for the recommended improvement. The Highway Commission allocates approximately $400,000 annually for the state's share of the program. During the four years ending June 30, 1971, this program has provided for the upgrading of protection at 95 grade crossings on state highways at a total estimated cost of $2,200,000, which cost was divided equally between the state and the railroads involved.

3.3 GRADE CROSSING MAINTENANCE PROGRAM

In 1965 the legislature enacted statutes which require that the cost of maintaining grade crossing protection installed after October 1, 1965, be apportioned between the railroad and the governmental agency in the same ratio as the cost of construction of the protection is apportioned. The new statutes also required the Highway Commission to provide $1,000,000 from the state Highway Fund each year to pay the cities' and counties' shares of the cost of maintenance. Since most of the installations of automatic grade crossing protection are paid for on a 50-50 basis between the railroad and the public agency, this means that approximately one-half of the cost of maintaining these devices is paid on behalf of the cities and counties from State highway funds. On new crossings, the PUC can pay as much as 100 percent of the cost of maintenance. The Public Utilities Commission administers this program insofar as city and county streets and roads are concerned. For grade crossings on the state highway system, the Division of Highways administers the program and the funds come from regular state highway maintenance funds and/or federal funds. The cost of maintenance is based on a system quite similar to the AAR unit system which assigns a certain number of units to each component of an automatic grade crossing protection installation. The Public Utilities Commission has

established $30 as the annual cost of maintenance for one unit. * The amount of money required to support this program increases each year as new crossings are added. Consequently, the maintenance fund has been augmented by annual budget appropriations since its inception, the most recent being $1,000,000 for the 1972-73 fiscal year. A total of $2,226,314.38 has been authorized for payment as of June 30, 1973.

For the six month period ended June 30, 1973, a total of 1,049 payments amounting to $429,253.54 have been made.

On the following page is a Summary of Claims paid from the Automatic Grade Crossing Protection Maintenance Fund for the calendar years of 1968 through December 31, 1972. Under the Crossing Protection Maintenance Fund, assistance has been given to 184 cities and 42 counties in the amount of $2,226,314.

3.4 GRADE SEPARATION PROGRAM

In 1957 the California legislature established the Grade Separation Program to assist cities and counties in the construction of grade separations to eliminate grade crossings and the reconstruction of existing separation structures to increase capacities. Each year, after holding public hearings, the Public Utilities Commission establishes a priority list of projects most in need of construction. This list is valid for one calendar year and is released just prior to the beginning of each calendar year. The Highway Commission is required to set aside $10,000,000 each year to pay the state's share of these projects. ** The state's share is one half the cost of the project after deducting the railroad's contribution. The railroad's contribution normally is 10% of the cost of the project plus the capitalized savings in maintenance cost of the crossing and the automatic protection;*** therefore, the apportionment of cost is approximately 44% each to the state and the local agency and 12% to the railroad. Allocations are made by the Highway Commission from the $10,000,000 in accordance with the

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*Railroads within California are currently attempting to have this increased to $50 which includes the cost of commercial power.

**An additional $5,000,000 has been authorized by the legislature for 1973 and 1974.

***A revision in the law to become effective July 1, 1974, eliminates the requirement for the railroad paying its capitalized savings and changes the shares to 80% state, 10% railroad, and 10% local agency. See Section 3.7 for discussion.

Year Paid	Resolution Nos. From	To	Maint. Year	No. of Crossings	Amount Paid	Average Per Crossing
1972	53	66	1965	4	$ 57.95	$ 12
			1966	12	3,801.13	317
			1967	39	11,953.27	306
			1968	76	22,706.27	299
			1969	114	37,996.98	333
			1970	248	89,693.86	362
			1971	1,063	473,076.66	445
			Total	1,556	$ 639,286.12	$411
1973	67	69	1965	1	$ 25.63	$ 26
			1966	2	400.77	200
			1967	8	1,415.74	177
			1968	9	2,772.59	308
			1969	13	3,009.90	232
			1970	40	6,214.30	155
			1971	220	54,011.76	246
			1972	756	361,402.85	478
			Total	1,049	$ 429,253.54	$409
1968 to 6-30-73	1	69	1965	42	$ 1,379.22	$ 33
			1966	269	58,160.69	216
			1967	496	147,846.12	298
			1968	782	270,306.08	346
			1969	1,016	381,705.05	376
			1970	1,218	478,425.95	393
			1971	1,283	527,088.42	411
			1972	756	361,402.85	478
			Total	5,862	$2,226,314.38	$380

II - SUMMARY OF AMOUNT PAID IN CALENDAR YEAR

1965	$
1966	
1967	
1968	68,749.16
1969	53,042.43
1970	320,503.10
1971	715,480.03
1972	639,286.12
1-1 - 6-30-1973	429,253.54
Total	**$2,226,314.38**

Figure 2. Automatic Grade Crossing Protection Maintenance Fund, Average Cost Per Crossing Years, 1965-1972

priority list established by the Public Utilities Commission after applications are received from local agencies. During the 16 years the program has been in effect, 145 projects have been completed or have received allocations of a total of $67,153,575.* For a number of years any money not allocated within each year reverted to the State Highway Fund; however, several years ago the statute was changed to provide that unallocated money would be held over and would be available for allocations from the next year's list. The total of $67,153,575 in allocations represents a total cost to the railroads, the local agencies and the state of approximately $149,000,000 over the period of 16 years.

3.4.1 Grade Separations in Regular State Highway Projects

All railroad crossings by freeways are at separated grades. Railroad crossings by state highways other than freeways may or may not be at separated grades, depending upon circumstances at the individual crossing. On projects financed with state funds, the railroad's share according to statute is 10 percent of the cost attributable to the presence of the railroad plus the "amount computed by capitalizing at 5 percent per annum the direct and computable savings to the railroad resulting from the elimination or reduction of the cost of physical maintenance of such crossing or crossings, and from the elimination or reduction of the cost of maintaining crossing protection at the existing grade crossing or crossings", when one or more grade crossings are eliminated by the project. When the project consists of an alteration or reconstruction of an existing grade separation to increase the capacity for highway purposes, the railroad's share is 10 percent of the cost of the project. When Federal funds are used on a project the railroad's share is 5 percent of the cost of the project when a principal grade crossing is eliminated and zero under other conditions. For internal accounting reasons none of the federally financed grade separation projects are scheduled specifically as railway/highway hazard elimination projects; therefore, none would appear in Federal Highway Administration records of such projects. In connection with regular state highway projects an average of 50 grade separation structures are constructed, reconstructed or widened annually and approximately six grade crossings are eliminated at an estimated cost of approximately $30,000,000 annually.

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*Approximately eight to ten grade separations are completed a year.

3.5 GRADE CROSSINGS IN REGULAR STATE HIGHWAY PROJECTS

Each year a number of projects in the regular ce highway construction program require widening, alteration or relocation of one or more grade crossings. Concurrently with the design of the project the grade crossing protection is reviewed and, if warranted, a service contract is negotiated with the railroad to upgrade the protection at the time of construction of the highway project. For state financed projects, the usual apportionment of cost is 50 percent each to the state and the railroad; if federal funds are used, the apportionment is 10 percent or zero, depending upon circumstances, to the railroad. Occasionally a project will require the construction of a new grade crossing where none existed before. Automatic protection of the type and class to fit the circumstances is installed at the time of construction. The cost of installations at new crossings is borne 100 percent by the state. An average of about 12 crossings per year receive new automatic protection in connection with regular state initiated highway projects.

3.6 RECENT CHANGES IN CALIFORNIA GRADE CROSSING FUNDING PROGRAMS

Effective July 1, 1974, a number of changes in the California grade crossing protection programs will be effected pursuant to the legislation passed in Senate Bill 456 entitled "An Act to Amend Section 1202.5 of the Public Utilities Code."

These changes have eliminated the requirement that railroads must pay maintenance savings realized from any grade separation project financed with state funds capitalized at 5 percent, and have retained the provision that railroads pay nothing more than 10 percent of the total project cost.

In addition, the state will provide 80 percent of the total construction costs. The local communities' contribution in this case is reduced to 10 percent and the railroads to 10 percent.

3.7 SYNOPSIS OF CALIFORNIA GRADE CROSSING PROGRAM

The previous review has summarized the alternative programs and financial underpinnings of California's grade crossing program.

As can be seen, the specific funding alternatives available to local communities are rather extensive and while some problems have arisen in administering this rather complex assortment of financial grab bags, their very existence insures that the burden of financing is well distributed. The contributions made by railroads, local communities, the state and the FHWA are determined in each individual case by the nature of the project (installation of crossing protection, grade separation, crossing maintenance, crossing eliminations) the originating party (local communities, state, PUC, railroad) and the funding selected (federal, state, local).

In the past, California DOT has decided to use most of its discretionary funds, established for the elimination of highway hazards (G type projects), on projects other than grade crossing projects, utilizing state funds for grade crossing protection. This strategem enables the state to secure the maximum funds available from all sources for safety projects, since in state funded projects railroads were required to pay 50 percent of the total cost. Use of federal funds for G type projects would have reduced the overall contributions from the railroads had the state chosen this option. Since California has had an effective grade crossing funding program, this action has not seriously reduced the installation of new crossing protection, whereas in those states lacking such programs, this form of federal aid has the potential for producing limited progress in their installation of new grade crossing protection.*

*This problem has been reviewed in the report to Congress on grade crossing safety.

4.0 1973 HIGHWAY AND SAFETY ACT (PUBLIC LAW NO. 93-87) IMPACT ON CALIFORNIA

The new highway safety act has provided substantial additional funding for California's already strong program under Sec. 203 and Sec. 230:

Sect. 203 provides for railway-highway safety projects on federal aid systems (50% to rural areas, 50% to urban areas). At least 50% of the funds authorized and expended under this section must be spent on the installation of grade crossing protection devices at railroad highway grade crossings. This requirement is significant for if California were in fact to fail to spend this money, amounting to $938,337 in fiscal 74 or roughly enough to protect 31 crossings with flashing lights and automatic gates, they would lose it, since it is not available for other types of projects. For this reason and others which shall be subsequently discussed, the state highway department and PUC have tentatively agreed to utilize most of the money for the installation of protective devices. In addition, Sec. 203 provides $938,337 for fiscal 74 for the elimination of hazards and these funds can also be used to finance the installation of additional crossing protection devices, as well as other types of railway-highway safety projects.

All funds authorized by the federal government under IM-30-4-73 are subject to OMB obligational control procedures. A state cannot obligate federal funds beyond OMB's prescribed limits which have been established as follows for the state of California:

California Total Obligated Authority for FY 1974

Non-Interstate in Urbanized Areas	All Others	Total
$94,565,000	$198,798,000	$293,363,000

In addition, they have a $99,000,000 ACI conversion carryover from 1973 which gives them a current obligational authority of $393,024,895. At this time the obligational authority is not preventing California's use and application of IM 30's funds for grade crossing projects.

From a state management standpoint, there are two basic options for financing grade crossing signalization improvements.

1. Using State Funds

State	25%
Local Community	25%
Railroad	50%

2. Using Sec. 203 Funds

State or Local Agencies	10%
Federal	90%

Use of state funds is limited by the financial capacity of local governments in programs financed with state funds. Under Sec. 203, however, the federal funds may be used to cover the local governments contributions and thus a greater number of installations can be financed under the federal government program. The final decision of the state with regard to the type of financing selected and the percentage contribution of each funding source is determined by the overall California posture vis-a-vis OMB obligational limitations and the strategy being followed with regard to fund sourcing in grade separation projects.

Sec. 230 of the 1973 Highway Safety Act establishes for the first time in recent history federal funding of grade crossing projects not on federal aid highways. A total of $4,041,778 or 8 percent of the total $50,000,000 authorized for this "Federal-Aid Safer Roads Demonstration Program" for FY 1974 has been made available to California under the provisions of this section. FHWA will fund 90 percent of any project designed to eliminate or correct highway safety hazards. Railroad highway grade crossings would thus be eligible for funding under this section

Both Sec. 203 and Sec. 230 require that the State of California establish a prioritized list of crossings requiring upgrading; however, the manner by which this list is developed is left to the discretion of the state.* FHWA has indicated that the Railroad Grade Crossing Inventory being undertaken jointly by DOT and AAR will provide adequate information for rail highway grade crossing improvements under Sec. 203

*By California law, the state cannot spend Sec. 230 money on non-state highways without enabling legislation; however, this legislation should be forthcoming in the near future.

and Sec. 230, however, the California authorities in the interest of expediting federal funding support may resort to other information sources rather than wait for the completion of the inventory.

The new federal support has made it highly attractive for railroads and local communities in California to seek federal funding of crossing improvements under Sec. 203 and 230. For railroads, the least-cost position is naturally favored, which is for 95/5 grade separation, for 100/0 Federally funded signals, for 50/50 state signals, and 25/25/50 for county and city signals. As long as Federal aid highway funds are not grade crossing specific then states like California may prefer to finance crossing projects with state funds, requiring the railroads to pay 50 percent of the costs, using their Federal funds for other purposes which they feel are more important. California DOT is currently meeting with the PUC to resolve and balance this funding program with those local communities and thus establish their priorities for grade crossing safety and other safety areas. Federal support of crossing protection removes the burden of initiating and funding a crossing from local communities and places the responsibility on the PUC and California DOT for program implementation. This action thus makes it possible for state officials to protect non-Federal aid highways where local communities have been financially unable or unwilling to finance crossing improvement. The combination of the new Federal financing plus California's own internal program will produce a strong and well-balanced program for financial support of grade crossing safety.

5.0 PRESENT OPERATIONS
CALIFORNIA PUC

Having discussed the major programs and funding mechanisms, it would be wise to review the manner in which these programs are being administered by the Public Utility Commission. As has been indicated, the PUC keeps a complete inventory (Grade Crossing Report) of all crossings in its files and updates this information as changes or improvements are made. *

A copy of a typical Grade Crossing Report illustrating the type of physical data maintained and nature of protection devices is provided on the following page. All updating is completed on a monthly basis.

An initial effort has been made to mechanize the storage and retrieval of this data and as of this writing, a tape containing each crossing and basic information on its location and type of protection has been prepared. This data does not include applicable accident data and thus computer analysis of the effectiveness of grade crossing protective devices is not possible at this time.

All accidents occurring at grade crossings are reported to the PUC by the railroads and the dates, numbers of fatalities (K) and injuries (I) are posted on the rear of the form. Normally, the PUC, in its monitoring of the grade crossing program and review of accident statistics, learns of a problem area and contacts the appropriate local parties suggesting that they meet to review the crossing program. On other occasions a local community may informally notify the PUC that they are having difficulties and would like PUC assistance and recommendations as to the best corrective actions to take. The PUC may set up a field inspection survey or may take other appropriate actions necessary to help the local community. The PUC has assigned each of their 12 traffic engineers responsibility for a group of crossings and over a period of years many of these men have become familiar with the characteristics of the crossings for which they are

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*The assigned crossing identification number in California consists of a numeral indicating the railroad, a letter indicating the branch, and numerals indicating the mileage to the nearest tenth; for example, 2H-5.1, or 31ASC - 206.7. A letter suffix is added on for other than main or branch line crossings, and a different suffix letter for grade separations. Pedestrian and alley crossings are included in the inventory, but not private crossings. Up to 12 digits may be required at a given crossing.

Form 1

GRADE CROSSING REPORT

County Los Angeles Railroad S.P. Co. Line or Branch El Paso Line Crossing No. E-499.3

City or Town San Gabriel Local Names of Road Mission Drive Jurisdiction City (State, County, City)

Between ..... and ..... See also Crossing No. ..... Crossing Rating .....

PUBLIC UTILITIES COMMISSION STATE OF CALIFORNIA

PHYSICAL DATA

TRACKS: Main 1 Ltr. ... Pass. ... Side ... Spur ... Y ...
On P.R./W or Highway ... Steam or Electric? ...
Cur. at Xing ... 2 ... ft.; Grade ... % ... % ...
... ft. (*adj) (cur. ...°); ... ft. (adj) (cur. ...°)

Crossing—Width 60 ft. Type 3B AC Condition Fair
Approach—Width 45 ft. Type AC Condition Good
Angle of Crossing 30°; Approach Grades 1%; 1%
Turn in Highway ... ft.; ... ft.
Intersecting Highway ... N. 40 ft.; ... ft.
Width factors

CORNER VIEWS

N.W.	Good	N.E.	Good
S.W.	Bad	S.E.	Bad

Remarks:

*Proposed
(Note: "+" indicates "ascending toward crossing")
Rating .....

PROTECTION DATA

Std. No. 1 signs—How many? ... Properly located? ...
Std. No. 1A signs " " ... " "
Advance signs " " 1 " " Yes
Std. No. 2 signs " " ... " "
Boulevard Stops " 4" on Intersection North
Ped's'n "X" Signs " " ... " "
Automatic Signals " " (2) 66051/4 Yes
Type 7 ... With bell Yes Bell only ... Light only ...
Ringing circuits— W. of Xing 880 ft.; E. of Xing 2960 ft.
Manually controlled ... M. to ... M. ...
Human flagman ... Hours ...
Police officer ... Hours ...
Traffic signals Yes Hours ...
Crossing gates manual ... Hours ...
Crossing gates automatic ...
Ringing circuits— ... of Xing ... ft.; ... of Xing ... ft.
Night illumination 1 large
Remarks: Double white stripes curbs painted 100' on R/R 300' south
*Proposed
Rating .....

SKETCH

HIGHWAY TRAFFIC

Vehicles per day 6000 - 1250
Pedestrians per day ...
Data from LA Co. Date 2-1-48
Principal traffic ... (Local, through, rural, industrial)
Speed restrictions ...
Remarks: 12 noon - 1PM 328

9/63

Rating .....

RAILROAD TRAFFIC

Trains:	No.	Speed
Passenger	13	30
Freight	18 28	30
Switch		

Speed restrictions ...
Switching restrictions ...
Remarks:

Rating .....

*TRANSPORTATION DEPARTMENT ENGINEERING SECTION

Date 4-13 19 48 Inspector A.F.W. Revised .....

(OVER)

Figure 3. Sample California Grade Crossing Report

Remarks: S.P. desires to be relieved of maintenance of human flagman.

1966 3
1967 1
1968 2
1969 2
1972 2

Recommendations: Grant authority if additional wigwag installed at N.E. corner.

DATE OF ACCIDENTS SINCE 1-1-26			FILE REFERENCES IN CONNECTION WITH THIS CROSSING		
DATE	K	I	FILE NO.	DATE	SUBJECT
8-13-36	1	-	183-19	2-1-29	Authorized to remove human flagman & install addl. wigwag.
11-26-36	-	1			
6-26-38	-	-	Form G	Jul.'29	Human flagman removed & addl. wigwag installed, 7-31-29.
1-25-41	-	1			
2-28-44	-	-	Form J	1-1-31	Shows 1 Standard No. 1 Xing sign only.
12-7-51	-	-	L.A.		4 SETS of Traffic Signals installed & coordinated.
4-27-54	-	1	Form G	10/23/52	1 RAW Sign installed S.
4-27-57	-	-		9-48	1 RAW Sign Installed S
1-24-58	-	1		10-10-48	4 Sets traffic signals installed and coordinated.
2-13-67	-	-			2 FL installed - effective 9-8-55
			Form G	Oct '55	
			C.5495	2-6-56	Allocation Req. #186 for funds to install 2 #8 FL signals.
			CP-196	2-28-56	Allocation Req. granted.
			S.7521	12-28-63	Commission Investigation
			D.67887	9-22-64	Ordering protection by 2 #8 fl w/auto.gates
			Form G	6-66	Installed 2 #8 fl w/auto.gates- eff. 5-11-66
			C.5495	9/13/66	Allocation request #1069-A Granted CP-1362 2#9
			D.72226	3-28-67	Maint. cost apport. 50% to rr, 50% to public agcy

Year	Misc. No.	K.	I.	Ped. No.	K.	I.
1932	1	-	-			
1940				1	1	-
1947				1	1	-
1957	1	-	-			

Figure 3. Sample California Grade Crossing Report (Continued)

responsible. As a consequence, their evaluations of crossing hazards encompass a wide range of factors and on-site observations. The California PUC has a total of approximately 20 people including engineers, typists, analysts, and supervisors administering their grade crossing program.

5.1 PRESENT OPERATIONS: STATE HIGHWAY DEPARTMENT

The state highway department has responsibility for the administration of federal funds, the funding of crossing improvements on state highways, and the administration of the grade crossing separation fund. They have a 10 man staff which spends perhaps 40 percent of their time on grade crossing matters. In cooperation with the PUC, the state is now planning a major program for protecting some 1200 additional crossings using federal funds available from the 1973 Highway Safety Act.

The program will emphasize completing and upgrading protection on all state highways and will structure the installations so that all crossings on main lines are provided with automatic protection. This will allow for the potential upgrading of railroad operating speeds on these lines and will provide additional insurance against accidents involving passenger (AMTRAK) or commuter trains.

The state highway people have the burden of clarifying and interpreting the provisions of the new highway safety act for local communities and a good percentage of their time will be involved in seeing that pertinent instructions and explanatory memorandums are forwarded to all local communities so that they can take advantage of the new federal funding.

The state maintains a prioritized list of 454 crossings requiring improvements. Each year the list is updated and revised based on work completed, changes in exposure, or other new developments.

5.2 CURRENT OPERATION: RAILROADS

California is fortunate in having for the most part strong solvent railroads* to work with in effecting grade crossing improvements. In

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*The Western Pacific is slowly improving its financial position.

recent years there have been very few instances where new installations were requested by local communities or by the state that have been refused by the railroads. Two Class I carriers, the Southern Pacific and the Santa Fe (ATSF) account for 75 percent of all grade crossings in California, as shown on the table on the following page (Table 6) and accompanying chart.

It is fairly well documented* that there are no ascertainable net benefits to the railroad from the installation or improvement of grade crossing protective devices and as the Part II report to Congress on railroad highway safety indicates, the total costs railroads must bear in maintaining existing grade crossing protection already exceeds the total benefits that they would receive through the elimination of accident expenses and local speed restrictions.** This being the case, it is easy to understand why most railroad managers are sympathetic with grade crossing programs which will ultimately increase their maintenance costs proportionally more than they reduce their operation and accident expenses.

With this framework in mind, the activities and philosophies of the Southern Pacific Transportation Company as regards grade crossing safety and the California program in particular are unusual. The Southern Pacific conducted a "Study of the Protection and Accident Records of 77 Main Track Railroad-Highway Grade Crossing on the San Francisco Peninsula" in 1962 and on the basis of their analysis concluded that the installation of automatic gates at all double tracked grade crossings on main lines was warranted. In addition they made a basic decision about 1963 to actively support grade crossing protection programs, and since that time they have established a record of support for grade crossing protection that is noteworthy and commendable. On the basis of their evaluation of the effectiveness of gates, Southern Pacific believed that they would not only reduce accidents but enhance its defensive position in litigation.

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*FHWA Instructional Memorandum 21-5-72 issued October 27, 1972.

**Grade crossing accident settlements have been climbing, especially in California in recent years, thus providing somewhat greater incentive for improvement of crossing protection.

TABLE 6. VEHICLE-TRAIN ACCIDENTS AT PUBLIC CROSSINGS BY RAILROAD*

	----CROSSINGS---- TOTAL	% TOTAL	---ACCIDENTS--- TOTAL	% TOTAL	/100 XNGS	--CASUALTIES-- TOTAL	% TOTAL	/100 XNGS
Southern Pacific	5345	53.16	436	60.47	8.16	208	56.22	3.89
Atchison, Topeka and Santa Fe	2157	21.45	144	19.97	6.68	91	24.59	4.22
Union Pacific	369	3.67	26	3.61	7.05	12	3.24	3.25
Western Pacific	572	5.69	45	6.24	7.87	25	6.76	4.37
All Others	1611	16.02	70	9.71	4.35	34	9.19	2.11
Total	10054	100.00	721	100.00	7.17	370	100.00	3.68

* Source: California PUC Annual Report of Railroad Accidents for 1972.

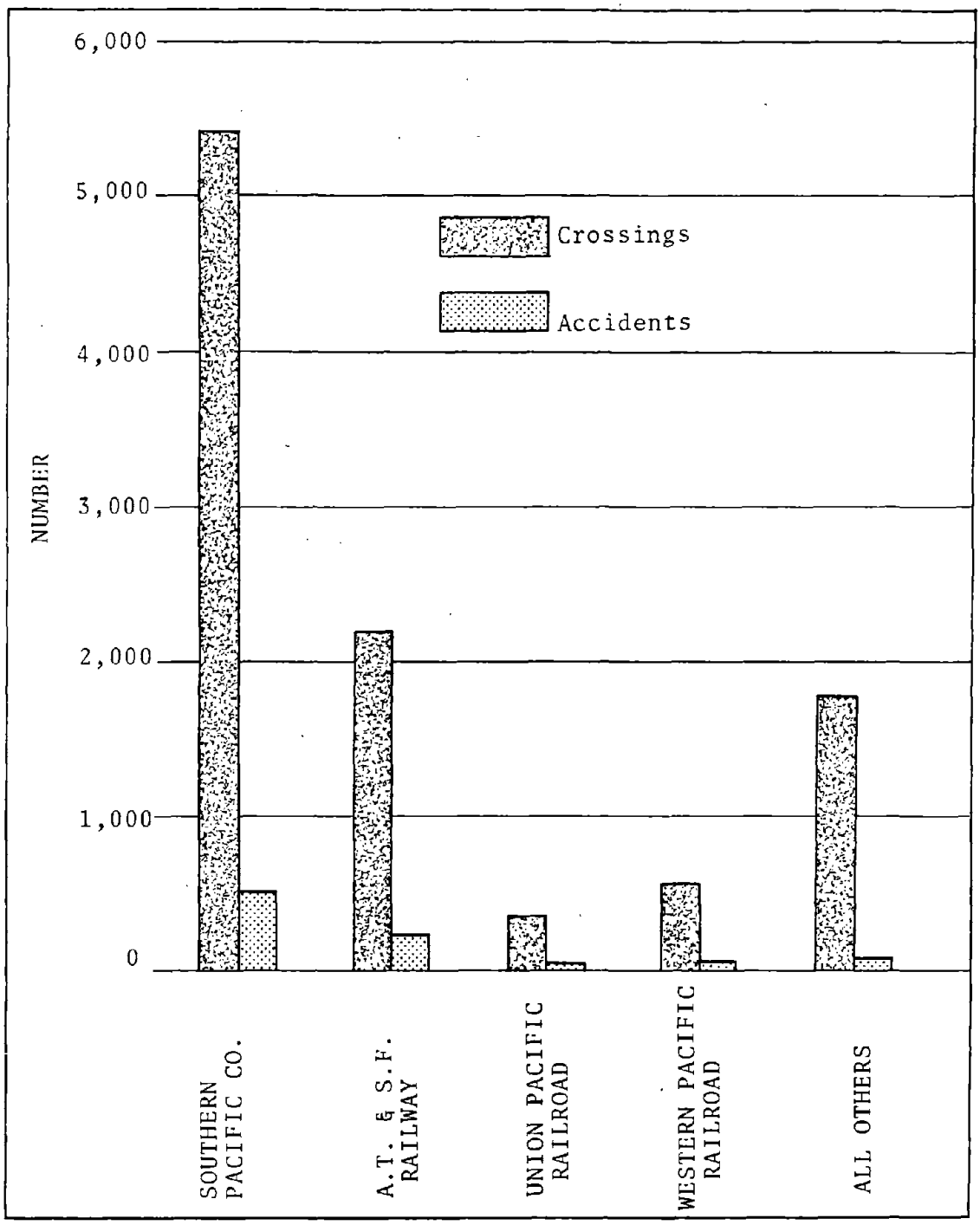

Figure 4. Crossings-Accidents By Railroads

Being the largest carrier in California and having the greatest responsibility for crossing protection, the Southern Pacific's support of grade crossing safety programs as manifested by its willingness to pay for its share of crossing installations and improvements has been one of the more important factors in the California grade crossing program.

Southern Pacific has taken the leadership in installing automatic gates after having studied their effectiveness, which was later confirmed by the PUC over a slightly different time interval. Both found them to be far more effective in reducing accidents than flashing lights. Southern Pacific engineers conceptualized the grade crossing predictor*, authorized its development by Stanford Research Institute, and has installed these devices at more than 850 grade crossings in California protected by automatic gates, where variable train speeds and operating conditions dictate. Southern Pacific has taken a national leadership role in the installation of all grade crossing devices as evidenced by the following statistics:

Crossing Protection Installations-United States
Class I Railroads-1972

	U.S. Total	SPT Co. & SLSW (Cotton Belt)
All types	1288	278 - 22%
Automatic gates	566	219 - 39%

Southern Pacific and their subsidiary, the St. Louis Southwestern Railway (Cotton Belt), have 7% of all Class I mileage, but install 22% of all automatic protection and 39% of all automatic gates.

Closest "competitor" to SP:

All types - Penn Central with 88, or 7%
Automatic gates - Penn Central with 34, or 6%.

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*A device that provides a constant warning time at crossings regardless of the speed of the approaching train.

SPT's California installations account for more than half of the installations in the state, as shown in the following summary:

New Protection Installed at Crossings in California-1972

By Railroad By Railroad	Column I New Crossings Opened w/ Automatic Protection	Column II Crossings Provided w/ or Initial Improved Automatic Protection	Column III Crossings Provided w/ Automatic Gates**
Southern Pacific Transportation Co.	25	128	136
The A. T. & S. F. Ry. Co.	3	52	50 50
Union Pacific Railroad Co.	3	11	12
The Western Pacific RR. Co.	1	9	7
Other Railroads	7	14	14
Total	39	214	219***

**Included in Columns 1 and 3.

The very fact that the SP is continuing their current installation program for installation of automatic gates ensures that California's safety record will steadily improve.

The Southern Pacific is a "believer" in the efficiency of automatic gates and grade crossing protection programs. However, their altruistic approach is strongly supported by a pragmatic desire to minimize skyrocketing accident claims. The California courts in

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*California Public Utilities Commission Annual Report of Railroad Accidents, 1972.

***Note: The 219 total crossings provided with automatic gates in California in 1972 by all railroads is not to be confused with the 219 shown on the previous page as the total number of crossings SP and SLSW have installed nationwide in 1972. This is simply a numerical coincidence.

particular have often been sympathetic to claimants even in cases where negligence on the part of the motorist was established.

Other railroads in California have cooperated well with state, local, and PUC officials in implementing grade crossing protection programs and have also strengthened the California program by virtue of their support.

In summary, the support and cooperation of railroads has been a major factor in the California program and undoubtedly reflects the fact that crossing maintenance and installation costs are underwritten with state and local financial support. As is shown in the table on the following page (Table 7), it generally costs the railroads less to install and maintain grade crossing improvements in California than in most other states.

5.3 RAILROAD-INTERAGENCY COOPERATION

One of the more important ingredients in the California program has been the degree to which each of the participant agencies have worked together with the railroads to coordinate and jointly plan their overall program. Running through all of our interviews with various agency officials and railroad representatives was not only a common interest in improving grade crossing safety in California but an unspoken pride in the progress being made and a feeling of mutual cooperation. Mr. William R. Johnson, Secretary of the California PUC, reviewing his program, made this comment:

> "The most important factor in any success we have had is the willing cooperation received from all parties involved, i.e., the members of our commission, both individually and collectively, members of the state legislature, the officials of the railroads, and the officials of the cities, counties, and state division of highways.
>
> The California Public Utilities Commission members have given the program full support by making the requisite staff time available and making requests for additional staff when needed. The California legislature has approved the expenditure of state funds for our staff time and also has established programs for state assistance to cities and counties in paying their share of the construction and maintenance costs of the crossings. The railroads have

TABLE 7. USUAL ALLOCATION OF COST TO RAILROAD ON NON-FEDERAL AID RAILROAD-HIGHWAY PROJECTS

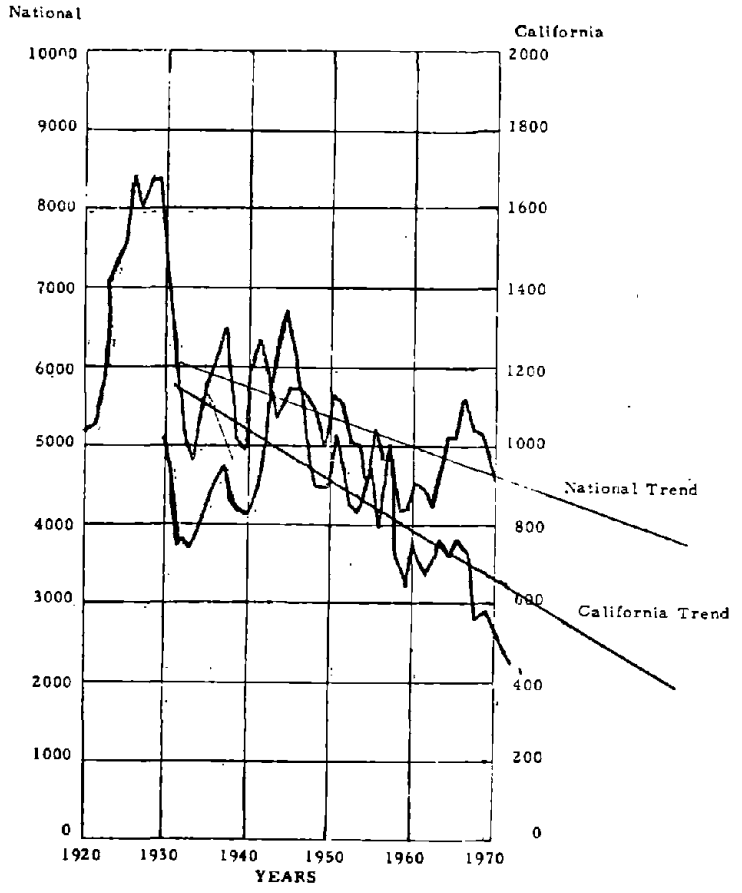
State	On Improvement Projects			For Maintenance and Operation of Protection
	Grade Separation Construction	Grade Crossing Protection Installation	Method of Determination	
Alabama	100%	100%	Law	100%
Alaska				
Arizona	10%	50%	Corp.C	100%
Arkansas	100%	100%	Law	100%
California	13%	50%	PUC	100% and 50%[1]
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%[3]	Law	100%
Iowa		10%[3]	Com.C	100%
Kansas	50%+	25-50%	Law	100%
Kentucky	10%	10%	Law	100% and 0%
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%[6]
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%[8]
Texas	10%	10%	Hwy.C	100%
Utah	10%	10%	PSC	100%
Vermont	10%	10%	PSC	100%
Virginia	Varies	25%	Corp.C	50%
Washington	10%	10%	UTC	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.

cooperated willingly in the program and have not hesitated to spend their money for the necessary improvements. Here we have been fortunate that we have not been dealing with the bankrupt or nearly bankrupt railroads such as no doubt many of the eastern states have seen. The cities, counties and State Division of Highways have also contributed financially to the program on those crossings within their jurisdiction."

6.0 CALIFORNIA GRADE CROSSING PROGRAM PERFORMANCE - COMPARATIVE ANALYSIS

By examining the overall effectiveness of the California grade crossing program in reducing accidents and fatalities, and by comparing its performance with national averages and that of other states, we can gain some measure of the relative efficiency of the program. As can be seen in the following graph, the total casualties for the nation and for



Source: CONSAD projection using national data provided in the report to Congress coupled with California data provided in the California PUC 1972 annual report. Note that the scales are different and were selected to illustrate the relatively greater improvement in safety achieved in California versus national trends.

Figure 5. Number of Casualties in Grade Crossing Accidents Involving Motor Vehicles

California paralleled one another until the early 60's when the California results began to show marked declines due primarily to the stepped up rate of installations of active protection and the cumulative effectiveness of the automatic gate installation policy instituted by the Southern Pacific.

There is a direct correlation between the percentage of crossings equipped with active protection devices and a state's overall safety record (as measured by the number of casualties per exposure factor), consequently we would expect those states with the greatest percentage of active protection to have better safety records than those states having less active protection.

In the table on the following page, the relative ranks for each state in terms of their safety rates per estimated vehicle exposure and their percentage of active protection are established. California, which has the 12th best accident rate* shows up 8th in terms of its active protection. The relative position and closeness of rankings are evident throughout this table illustrating the well known fact that the greater the numbers of crossings equipped with active protection within a state, the better its overall safety record is likely to be.

California's safety record, like any other state's, is also influenced by the nature of its active grade crossing protection. The data on the following table (Table 9), which is the latest available from the ICC, illustrates the high proportion of automatic gate installations in California as a percent of the total active protection. By weighting this type of active protection installed (i.e., gates 4, flashing lights 1, etc.) it could be shown that California provides more effective protection at its grade crossings than any other state.

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*Notwithstanding our earlier remarks about exposure factors.

TABLE 8. RATES PER ESTIMATED VEHICLE EXPOSURE AND PERCENTAGE OF ACTIVE PROTECTION

State Rank by Accident Per Vehicle Exposure	Accident Rate per estimated Vehicle Exposure Col 7 Col 6	State Rank By Percentage of Active Protection	Percent Active Protection*
Alaska		Maine	55.1
Hawaii		Connecticut	50.9
Rhode Island		New York	48.2
New Hampshire	.00000429	Massachusetts	45.9
Massachusetts	.00000632	Pennsylvania	44.1
Maine	.00000658	Puerto Rico	43.9
New Jersey	.00000748	New Jersey	42.4
New York	.00001527	California	38.7
Connecticut	.00001764	Delaware	35.4
Pennsylvania	.00002149	Vermont	34.4
Maryland	.00002142	Virginia	33.7
California	.00002186	Illinois	32.8
Delaware	.00002310	Maryland	28.7
Virginia	.00002911	Florida	28.0
West Virginia	.00003061	Kentucky	28.0
Michigan	.00003084	Indiana	27.7
Illinois	.00003247	Ohio	27.6
Vermont	.00003349	Nevada	27.0
Kentucky	.00003545	New Hampshire	27.0
Ohio	.00003693	Michigan	25.9
Washington	.00003988	Colorado	24.9
Wisconsin	.00004331	Arizona	23.7
North Carolina	.00004459	Wisconsin	23.5
Florida	.00004577	Texas	20.8
Indiana	.00004587	Alaska	20.5
Iowa	.00005063	Utah	19.9
Utah	.00005296	New Mexico	19.0
Louisiana	.00005422	Rhode Island	18.8
Arizona	.00005486	Wyoming	18.6
Missouri	.00006055	Missouri	18.3
Montana	.00006097	North Carolina	16.4
Tennessee	.00006126	Oregon	15.7
South Carolina	.00006218	Alabama	14.8
Georgia	.0006460	Louisiana	14.6
Minnesota	.00006651	Iowa	13.5
South Dakota	.00007254	Nebraska	13.5
Colorado	.00007400	Hawaii	12.5
Texas	.00007413	Montana	11.9
Kansas	.00007628	West Virginia	11.8
Oklahoma	.00007889	Georgia	11.7
New Mexico	.00009768	Idaho	11.1
Wyoming	.00010459	Washington	11.0
Alabama	.00010709	Arkansas	10.6
Nebraska	.00011588	Mississippi	10.5
Mississippi	.00012048	Kansas	10.3
North Dakota	.00012466	Minesota	10.1
Arkansas	.00013018	South Carolina	07.2
Oregon	.00013198	Oklahoma	06.5
Idaho	.00014236	D. of Columbia	05.7
Nevada	.00016479	South Dakota	04.5
		North Dakota	03.6

TABLE 9. TRANSPORT STATISTICS IN THE UNITED STATES, 1971 (LATEST AVAILABLE) GRADE CROSSING: RAILROAD WITH HIGHWAY--BY KIND OF PROTECTION AND STATE (CLASS I LINE-HAUL RAILROADS AND SWITCHING AND TERMINAL COMPANIES), DECEMBER 31, 1971

State	Automatic Gates with Flashing Lights	Total Crossing at Grade	% of Total Crossing at Grade Equipped With Automatic Gates and Flashing Lights
Alabama	57	3,984	1.43
Alaska	--	--	--
Arizona	91	906	10.04
Arkansas	85	3,318	2.56
California	1,786	8,997	19.85
Colorado	67	2,506	2.67
Connecticut	44	391	11.25
Delaware	33	383	8.62
Florida	597	5,354	11.15
Georgia	131	4,591	2.85
Hawaii	--	--	--
Idaho	8	1,775	0.45
Illinois	1,442	14,402	9.87
Indiana	593	10,045	5.90
Iowa	318	9,640	3.30
Kansas	185	10,237	1.81
Kentucky	132	3,267	4.04
Louisiana	76	4,204	1.81
Maine	58	949	6.11
Maryland	73	1,048	6.96
Massachusetts	146	1,110	13.15
Michigan	514	9,078	5.66
Minnesota	100	8,461	1.18
Mississippi	16	2,777	0.58
Missouri	182	6,975	2.61
Montana	51	2,228	2.29
Nebraska	151	6,036	2.50
Nevada	19	307	6.19
New Hampshire	24	526	4.56
New Jersey	226	1,936	11.67
New Mexico	44	683	6.44
New York	618	4,316	14.32
North Carolina	157	3,501	4.48
North Dakota	36	6,114	0.59
Ohio	631	10,454	6.04
Oklahoma	65	6,272	1.04
Oregon	147	2,574	5.71
Pennsylvania	549	7,487	7.33
Rhode Island	7	102	6.86
South Carolina	81	2,957	2.74
South Dakota	3	3,772	0.08
Tennessee	71	3,286	2.16
Texas	369	14,131	2.61
Utah	25	1,399	1.79
Vermont	12	239	5.02
Virginia	210	2,362	8.89
Washington	55	4,101	1.34
West Virginia	57	2,597	2.19
Wisconsin	193	7,491	2.58
Wyoming	14	632	2.22

Note: These figures do not agree with those published by California PUC in their annual reports due to reporting differences.

7.0 AUTOMATIC GATES AND PREDICTORS EVALUATION AND EFFECTS ON CALIFORNIA PROGRAM

The California Grade Crossing Program has benefited enormously from the installation of automatic gates, presently the most effective form of crossing protection and as has been previously shown, almost 20 percent of all California crossings are presently equipped with this type of protection. It is therefore relevant to consider what factors occasioned this development and review the data and decisions which led to the establishment of the current California policy.

7.1 AUTOMATIC GATES

Since 1963, the California PUC has recommended the installation of automatic gates with flashing lights at all major crossings. This policy resulted from a study of the effectiveness of automatic gates in reducing grade crossing accidents. This study, completed on April 1, 1963, which examined the accident records of 104 grade crossings in Southern California* from 1951 to 1962, concluded that the installation of automatic gates reduced accidents by 60 percent, deaths by 90 percent and injuries by 84 percent. Subsequent PUC studies produced the following results:

Percentage Decrease Accomplished by Automatic Gate Installation

Study Dates and Period	No. of Crossings Studied	Accidents	Deaths	Injuries
September 1, 1961 Northern California* 1946-1960	61	74%	94%	85%
December 18, 1961 Southern California** 1951-1960	79	62%	85%	83%
April 1, 1963 Southern California 1951-1962	104	60%	90%	84%

*Southern California was defined as all points east or south of Tehachapi and San Luis Obispo.

Study Dates and Period	No. of Crossings Studied	Accidents	Deaths	Injuries
October 1, 1964 Southern California 1954-1963	132	57%	89%	88%
March 1, 1965 Northern California 1954-1964	168	78%	93%	89%
June 1, 1967 Southern California 7/1/61-6/30/66	178	49%	80%	83%
March 1, 1968 Northern California 7/1/61-6/30/67	146	63%	94%	83%

Source: California PUC, "A Study of 1552 Public Grade Crossings in California Where Automatic Protection Was Installed Between January 1, 1960 and December 31, 1970 Inclusive."

* Northern California includes all crossings north or west of Tehachapi and San Luis Obispo.

** Southern California includes all crossings in the balance of the State.

While none of these studies examined more than 178 crossings, the results were significant enough to warrant a major change in policy with regard to crossing protection. Up until 1963, the PUC policy had been to recommend the installation of flashing light signals at the more hazardous grade crossings. These early studies failed to focus on prior protection and consequently interpretation of the results was often misleading. In June, 1973, a major study of all types of automatic protection was undertaken which examined the before and after accident experience at 1552 grade crossings wherein automatic protection was installed, and calculated the effectiveness of each type of protection. This study encompassed the 10 year interval from January 1960 to December 31, 1970. The results, which are presented in terms of the percentage reduction in accidents, deaths, and injuries per crossing year, and in terms of the reduction in accident severity as measured by the percentage reduction in accident deaths and injuries per accident, are as follows:

June 1973 Analysis of the Effectiveness of
Alternate Types of Grade Crossing Upgrading

Prior Protection	Upgraded To	No. of Crossings Studied	Percentage Reduction Per Crossing Year In			Percentage Reduction in Accident Severity	
			Accidents	Deaths	Injuries	Deaths	Injuries
Flashing Lights	Automatic Gates & Flashing Lights	498	65.9	83.3	78.9	57.1	28.9
Wig Wags	Automatic Gates & Flashing Lights	248	66.7	75.0	88.9	54.5	61.7
Crossbucks	Automatic Gates & Flashing Lights	243	87.5	100.0	93.3	76.0	40.0
Wig Wags	Flashing Lights	98	50.0	0	53.3	66.7	9.8
Crossbucks	Flashing Lights	245	64	83.3	84.2	45.5	54.0

About 1964 the Southern Pacific Railroad established the policy that automatic gates with flashing lights would be installed at all crossings, requiring automatic protection, on main lines, branch lines, and spur tracks that were crossed by heavily traveled highways.

The latest PUC study covers 75 percent of the gated crossing installations in California, the remaining 25 percent being those installations completed in the post-1970 period. The 1552 grade crossings studied were all crossings having at least two or more trains a day. Although single train crossings were eliminated from the study due to programming limitations, this does not affect the validity of the results. A number of the crossings included in this study, perhaps as many as 500 or more were equipped with grade crossing predictors however, the exact number is not known. According to the Southern Pacific, the grade crossing predictor primarily benefits the highway user by reducing vehicle delays and doesn't alter the safety or total effectiveness of the installation. It can be argued that predictors, by minimizing vehicle delays, tend to condition drivers to stop and wait until trains have passed. Conversely, at gated installations lacking predictors, drivers can become frustrated by extended delays perhaps to the point of prompting them to drive around the gates. Crossings equipped with an automatic gate and predictor would theoretically be safer and more effective than a similarly equipped crossing lacking the predictor. This would also mean that the PUC study results would likely be biased upwards, that is, they would show that automatic gates are perhaps more effective than they really are since a portion of their sample is benefited by the presence of the predictor. The PUC study did not account for the effects of the predictors in any way and while this may not bias the results significantly, it should be taken into consideration by anyone planning to use these results in developing and administering grade crossing programs.

7.2 PREDICTORS

The grade crossing predictors developed by the Southern Pacific provide a constant warning time at crossings where train speeds may vary enormously, thus improving -- theoretically speaking -- drivers response to crossing activation. The savings in vehicle delays can be calculated and in the opinion of SP management, they more than justify the cost of installation -- $2710 basic materials price with no adjacent crossing, $3645 with adjacent crossings.* With the rectifier and installation labor, an average cost of $4000 per predictor is not unusual.

Predictors are normally installed where yard or switching operations within the proximity of a grade crossing tend to activate the crossing protection unnecessarily, creating extended delays and where the train operating speeds are likely to vary greatly. If switching operations only occur on one track and in one direction then only one predictor is required, however, at some crossings on the SP as many as 4 to 5 predictors are necessary. As mentioned earlier, the SP questions whether the predictor actually provides any measurable degree of improvement as far as accident reduction and prevention is concerned. Similar reservations were held by the California PUC and state DOT.

In order to determine the effectiveness of the predictor per se, it would be necessary to make a before and after evaluation of the accident experience at all crossings equipped with predictors. However, the present California grade crossing reports (inventory records) do not carry this information.

Since 1965, 50 percent or more maintenance costs for crossings is paid for by the state and consequently on the maintenance bills submitted by the railroads to the PUC, major crossing components requiring maintenance are identified.

From these bills the PUC has been identifying each crossing equipped with predictors and has been posting this information to their records;

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*When the first predictors were installed, the SP installed a recording device to calculate how long the crossing would have been activated under normal circumstances and the resultant savings with the predictors.

however, a large percentage of the predictors were installed concurrently with automatic gates and thus the before and after accident experience would fail to discriminate between the effects of the gates and the effects of the predictors.

According to C.P. Darrough, Public Projects Engineer-Signals, Southern Pacific, there are occasionally instances where predictors are installed separately as part of a welded rail program. If these crossings can be identified then the "before-predictor" and "after-predictor" accident experiences could be developed, however, this would take considerable time, since the SP's records are organized in such a way that a manual, crossing-by-crossing inspection of each of the 850 records is necessary.

Assuming this could be accomplished, the question arises as to whether there is enough accident experience to realistically evaluate the predictors effectiveness at this time. Practically all of the predictors are installed for a relatively short period of time (1963-1974), the average predictor installation is only five and a half years old, therefore, the likely results of this analysis of a limited number of crossings for a short period of time would be statistically insignificant.

An alternate approach to measuring the potential effectiveness of the predictor would be to compare the summary accident experiences of crossings having predictors with a like set and number of crossings lacking predictors and weighting each crossing experience in terms of its exposure; however, this approach is statistically unsound and inelegant at best. Since the basic data necessary to effectively evaluate the effectiveness of the predictor is immediately unavailable, it is recommended that the analysis be deferred until the PUC and/or SP can provide a meaningful statistical base which will support such an analysis.

8.0 SUMMARY

8.1 STRENGTHS

California is making greater progress than the rest of the nation, under its grade crossing program, despite the state's continuing rapid growth in total vehicle miles. One explanation offered by the PUC was that there has perhaps been a shift of motor vehicle traffic to limited access interstate highways and freeways coupled with a slight reduction in train miles due to the elimination of passenger trains and consolidation of other rail movements that has helped to hold down the increase in exposure factors (number of vehicles x number of trains) at railroad-highway grade crossings. However, on the basis of this review, the strength of the California program is primarily responsible, in our opinion, for its overall success. Installation of active protection, particularly automatic gates, continues at high levels due to the excellent financial programs and the strong support of the Southern Pacific and other solvent railroads. PUC authority and staffing, adequately supported and funded by the California legislature, provides strong overall direction for a joint cooperative planning and installation program. While authority for establishing priorities ultimately rests with the PUC, a participative approach is followed in developing individual lists with local communities, which generally produces a consensus of local, PUC, and railroad opinions about what should be done. Interagency-railroad communication and cooperation is excellent and provides the human interaction necessary for program implementation. California is basically one of the more progressive states in the union and the grade crossing program reflects this character in many respects. A willingness to try new approaches, with high priorities on the protection of human lives at grade crossings, characterizes much of the evolution and development of the California program.

As a model for other state programs, California has much to offer in its funding program, joint planning reviews, and on site surveys. On the other hand, there are some areas in which other states may have made greater progress.

Somewhat surprising was the manual system of record keeping which works well and yet inhibits a faster and potentially more productive mechanized approach. The work load facing all agencies, with the stepped up funding and increases in installation, may require additional

staffing and greater attention to administrative efficiencies. While most of the big cities and counties have been surveyed, many remain to be completed.

Reimbursing the local community directly rather than the railroad for installation cost has created some problems which could be resolved by a system of direct payments to the railroad.

The quality of the individual engineering analysis of crossing hazardness and periodic analysis of protection effectiveness, and installation costs, are thorough, although seemingly less sophisticated than in other states.

Specific information on the effectiveness of the predictor cannot be developed at this time. However, as an innovation that minimizes driver delays at grade crossings, it has enjoyed considerable success.

Total time for installing protection varies from 18 months to two years to implement, and while most of the time can be readily accounted for by each of the steps in the process, some improvements/reductions in the cycle would obviously benefit everyone. From a safety standpoint alone, a one year total implementation time would be appropriate and should perhaps be considered as a general program goal.

At the present time there has been some definite compromising and negotiating necessary, among participants in California's grade crossing program, to establish the method of funding that will be used, now that Sec. 203 funds are available. At latest report, all parties have come to an agreement on a three year program of crossing improvements utilizing federal funds available in fiscal 74, 75, and 76.

Considerable work must be done in establishing an overall state priority list for crossing protection as recommended by the new Highway Safety Act, and in this respect, California lags behind those states that have already established such lists. In this review, we have raised the question of efficiency as regards establishment of local priority lists versus a master list for the state. There is an obvious trade off to be made here between program sensitivity to local needs and maximum effectiveness in the application of funds vis a vis a master list. The new federal funding will help state officials balance out any inequities which may have resulted from financial constraints limiting local communities.

Traffic volume updates on city and county crossings are probably the weakest data link in the overall planning process. Since program efficiency is ultimately based on an understanding of the exposure factors present at any grade crossing, the California PUC should attempt to find economical means of improving this update.

Finally, this review of the California program has not focused on the cost-effectiveness of the total California program, for in fact, this would require a massive assemblage of information on installation costs, maintenance costs, salary and overhead expenses data, personal assignments and job responsibilities and would require a substantial data input from all agencies involved in the California Grade Crossing Program. However, there is some summary data available which will facilitate a rough approximation of total program costs which can then be related to the total lives saved. In the event additional state program analyses are contemplated, it may be desirable to have a program cost-effectiveness analysis to use as a yardstick in evaluating alternate program efficiencies.

9.0 REPORT OF INVENTIONS

After a diligent review of the work performed and the results obtained under this contract, it has been determined that no inventions, innovations or new products have been developed.