Robert C. Hunter

PROCEEDINGS 1974 NATIONAL CONFERENCE ON RAILROAD-HIGHWAY CROSSING SAFETY

AUGUST 19-22, 1974

SPONSORED BY
U. S. DEPT. OF TRANSPORTATION
HELD AT
U. S. AIR FORCE ACADEMY
INTERIM EDUCATION CENTER

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CONFERENCE OBJECTIVE

"To demonstrate how each of the partners in grade crossing improvement programs is using or can best use new techniques and new funding in a cooperative effort to implement an effective grade crossing improvement program."

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The Conference was developed in cooperation with the Transportation Research Board, the National Safety Council, the National Association of Regulatory Utilities Commissioners, the Association of American Railroads, American Association of State Highway and Transportation Officials and the Brotherhood of Railway Signalmen.

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WELCOME TO THE UNITED STATES AIR FORCE ACADEMY

Dr. John C. Reinbold
Director
Interim Education Center

Ladies and gentlemen, I am pleased to welcome you to the United States Air Force Academy. The Academy location is an impressive one, set against the backdrop of the Rampart Range of the Rockies. This inspiring setting is well suited to the training of the future leaders of tomorrow's Air Force.

Your conference is being held here at the Academy under the auspices of the Interim Education Center. The Center is presently using the facilities and support of the Air Force Academy pending the construction of permanent facilities on the Academy grounds. We work closely with the Faculty and Staff of the Academy as well as other governmental and civilian organizations to provide services for conferences, seminars, workshops and other meetings of an educational, problem-solving or communicative nature. Our basic objectives include:

1. Bringing together people of diverse views to encourage cooperative efforts for solutions to national problems.
2. Providing decision-makers with program information and recommendations for better informed decisions and more meaningful choices.
3. Enriching and broadening the educational experience of Air Force Academy cadets and faculty for more productive service to the nation.
4. Providing greater opportunity for the military to demonstrate interest, concern and desire for effective contributions to some of the nation's pressing problems.

I note in reviewing your agenda that it is a busy one, and I must applaud the thoroughness and concern which you bring to this important issue. The subject of safety in general has long been a primary concern to the United States Air Force. Certainly flying safety has received a great deal of emphasis, but you may be interested to learn that the Air Force also has an extensive ground safety program which has been maintained since our creation as a separate service.

I mention this to let you know that the work which you are engaged in this week is of vital interest to the Air Force, and we are honored that the Academy was selected for this important conference. I hope you will find it a fitting compliment to your meetings this week. My staff and I stand ready to assist you in any way possible during your stay, and I hope you will not hesitate to call on us.

Opening Remarks

Honorable John W. Ingram
Administrator
Federal Railroad Administration

I'm delighted, on behalf of the Federal Railroad Administration and the Department of Transportation, to welcome all of you to this conference. We are delighted at the interest that is being displayed; I join each of you in looking toward a day when grade crossing accidents are part of history.

I want to take just a moment, at the outset, to express sincere thanks to both the State of Colorado and the United States Air Force Academy for their help, cooperation, and hospitality. I am especially delighted to note that when they built the academy they had the foresight to build an overpass rather than a grade crossing.

Frankly, I can't say as much for the Federal Railroad Administration's Ground Transportation Development Center down in Pueblo. In order to get there – by either access road – it is necessary to cross a mainline railroad track.

There is no humor intended in that remark, because we have had one grade crossing accident there last year (non-fatal, thank goodness) and we know as well as anyone the danger of a highway crossing a railroad track – even out in the open plains where the view is relatively unobstructed.

But we *know* more about these accidents *at the FRA* than the experience gained in *one* real-life accident on the *access* road. We have also done some *first-of-its-kind* testing at Pueblo, and I think our purposes would be best served if I started this conference with a five-minute film clip. Could we have the lights off and film on, please?

"Five-Minute Film Clip of Locomotive-Automobile Crash Tests Performed at FRA's Pueblo, Colorado High Speed Ground Test Center."

1. Slow motion shot – high speed cameras – for the first time, we now have data on exactly what happens when locomotive hits automobile.
2. These shots are pretty self-explanatory; I won't give a running commentary – just some data. The locomotive is operated by remote control. We had four impact tests – using 1973 automobiles, fully equipped with all the required safety devices. Two of the tests were with the automobile centered exactly over the tracks. The other two struck the front fender.
3. We had cameras on the ground for overall shots, cameras on the locomotive, and cameras on the automobiles themselves.
4. This film runs a total of eight minutes, with each impact shown several times. . . . We'll cut it short because it gets sort of repetitive. . . .

Grade crossings, of course, mean much more than locomotives hitting automobiles, or automobiles running into the side of moving trains. The safety factor is not to be minimized; indeed, I think the main thrust of our research must continue to focus on the saving of lives and the prevention of accidents.

Yet a major – though somewhat subliminal – factor in grade crossing research and activity involves what might be called the "inconvenience factor." A coupled freight train stalled on the tracks can very effectively form an uncrossable barrier.

We are all acquainted with the cops and robbers movies where the party being chased darts across the tracks just as the long slow freight enters the crossing, and the pursuers have to sit and stew and shake fists at the train crew while their quarry gets away. That makes for good film footage.

But it's not so good – and not so exciting – if the moveable barrier holds up an ambulance, a fire truck or other emergency vehicle.

And it's not so good, however mundane it may be, to simply have the daily commerce of a community disrupted.

In our recent demonstration study in Lafayette, Indiana (and I stress that this was a *demonstration* study – we have neither the budgeted funds nor the philosophical desire to solve local problems for local people on an across-the-board basis) we found that the grade crossing problem in Lafayette, Indiana would result in 53.6 wasted man-hours a day for all parties concerned by the year 1980.

Grade crossings are disruptive things. Railroads don't like them any more than cities or highway departments or motorists do. Railroaders are a breed that like to be left alone to go about their business (which may explain some of the problems that some of our railroads are having right now, but that's a different story). The ideal, to a true railroader, is a tangent track going from point A to point B with no hills, no slow orders, no junctions, and – most of all – no grade crossings.

Railroaders have a valid point – in many instances – when they point out that they were there before the roads were.

At the same time, concerned citizens and responsible public officials have a responsibility to help find a solution to the problem. Obviously, the only broadbrush solution to the problem will come through full and committed cooperation among all parties.

Thus far, I think the cooperation has been good. Joint programs within the government, and joint actions between railroads and local and state government have also moved ahead. An overall responsibility has been recognized.

Most of all, this responsibility has been recognized by the United States Congress.

You will note by your programs that our keynote speaker this evening is the Honorable Robert P. Hanrahan, Congressman from the Third District of Illinois, member of the Public Works Committee.

Those of you who know the congressman by sight will realize that he is not here. I don't need to point out that under these circumstances it is very difficult for him to give a keynote speech! Congressman Hanrahan has an exceptionally good reason for staying in Washington today.

This afternoon the house was scheduled for final debate on the Mass Transit Bill – a bill in which the Department of Transportation has a key interest. The bill came from the Public Works Committee, and the Congressman felt a definite responsibility to be there.

He did, however, supply us with a copy of his prepared remarks, and asked that his message be delivered in his absence.

I've had a chance to scan over what he would have said, and if I may presume to pass judgment on what a Congressman says, I think it's about the best summary on the Federal Aid Highway Act of 1973 I've seen.

Because his words deserve repeating, I have used my own "executive authority" – such as it is – to pass the assignment on to a man who can do justice to a congressman's speech.

Since it wouldn't be entirely cricket to give this responsibility to one of my own people, we sought out an impartial party. Since the congressman is from Chicago, we felt we'd be in the clear if the man who delivered the speech came from a different part of the country.

And since the congressman's pre-political background was in the field of education, we thought it appropriate to have his remarks delivered by a professor.

Then we realized we had such a person on the conference staff.

I am delighted now to introduce the first speech by an Illinois congressman ever delivered with a Texas accent.

Standing in for Congressman Bob Hanrahan, with our keynote address, is Professor Hoy Richards of Texas A&M University – Director of the Rail Systems Program at that school and a man who has helped the FRA on a number of occasions in the past.

So, as they say on the P.A. system at Wrigley Field – "Now batting for Bob Hanrahan, Hoy Richards."

Keynote Address

Honorable Robert P. Hanrahan
United States Congressman
3rd District Illinois

Good evening, I am delighted to have this opportunity to participate in the 1974 National Conference on Railroad-Highway Crossing Safety. As some of you may know, I have a long-standing interest in this topic. I hope to be able to shed some light here tonight on the problems encountered in the pursuit of safer railroad crossings, from my particular point of view. That is, what can be seen when you look past all the red tape and roadblocks that we constantly run into at the legislative end of the spectrum.

As a rookie congressman, I received what could be called a baptism of fire when I became involved with the Federal Highway Act of 1973. Trying to make sense out of that piece of legislation was almost as frustrating as waiting for a freight train to pass during rush hour on Chicago's South Side. It was without a doubt one of the most complicated pieces of legislation ever enacted by Congress.

You know, anyone who has a liking for sausage or respect for the law should never watch either one being made. A short history of the 1973 Highway Act should demonstrate my point – and make us all wonder at the fact that some very vital railroad highway safety provisions were not lost in the shuffle.

The seed for this bill was sown in March of 1972 when the then-Secretary of Transportation, John Volpe, presented the country with the Administration's recommendations for the 1972 Federal-Aid Highway Act.

It took 18 months, two transportation secretaries, 2,002 pages of congressional hearings, and over

300 days of hard compromise to arrive at an acceptable bill.

Finally, on August 13, 1973 we saw the legislation become law.

And what was the final outcome?

Well, as the saying goes, "The mark of a good piece of legislation is that it doesn't completely satisfy anyone!"

If we use that gauge to measure the value of the 1973 Highway Act, I think you will find we have a great law on the books.

Let's see what came out of the sausage grinder:

Probably the one word that would best describe the act is FLEXIBILITY. The time has long past when we could legislate from Washington to meet the varied transportation needs of every county and state. No longer do we – nor can we afford to – consider highways, railroads, and airways as separate and distinct forms of transportation. Each of these travel modes must be an integral part of the total transportation system.

The Federal-Aid Highway Act is aimed at providing flexibility to states and local governments in assessing their total transportation needs.

Let's take a look at some of the provisions of the bill before we go on to discuss the section dealing with railroad and highway safety.

Any Federal Highway Act must deal with the INTERSTATE SYSTEM, which is now about 82 percent complete. Under the 1973 Act, states were required to notify the Secretary of Transportation by July 1st of this year – a one-year extension of the previous law – of their intent to build any remaining interstate segments. If the states don't want to go ahead with certain routes, the segments can be moved from the designated system. Substitute interstate segments can be considered until July 1 of 1975. By that date, all states must have submitted a schedule for the completion of the system.

A major new provision of the Act allows states to trade funds from unwanted, large urban area interstate segments for an equal amount of federal mass transit aid from general funds.

Specifically, the legislation allows the Secretary of Transportation to withdraw approval of an interstate route, if the governor and local officials jointly request it, as long as the route isn't an essential connecting segment.

Then, local officials can propose construction of a rail transit project if they find it better serves their needs. With the necessary federal approval, the local officials could obtain federal funding from the treasury equal to the federal share of the route that was withdrawn.

Here, FLEXIBILITY is the key. We are emphasizing the total transportation needs of our counties and states. Local officials are taking an active role in determining their transportation goals.

State highway and transportation departments can now use interstate funds for the construction of exclusive or preferential bus and emergency routes or lanes, in support of transit development.

There have also been changes in the policies applied to primary and secondary highways. The 1973 Highway Act increases funding for the major federal-aid highway systems, other than interstate, by over $5 billion over a three year period.

This increase is due to a new policy to accelerate modernization of non-interstate roads. Part of the increase reflects the change from 50/50 matching for primary and secondary roads to 70/30 matching which started with fiscal 1974.

The act now allows highway departments to transfer up to 40 percent – instead of the previous 20 percent – of the state's apportionment between rural primary and secondary systems.

The same switchability can also apply to urban primary and secondary extensions and the urban sytem. There always seems to be a catch to every good program – but this one isn't bad. Urban systems' money cannot be transferred by a state from the allocated amounts for areas of 200,000 population without the approval of local officials.

The reason for the catch is that the urban systems apportionment is based on population in urban areas.

So we see another example of the increased flexibility that is built into the Highway Act.

I think the increased role local officials will have is important. The federal government has played big brother long enough. The time has come for each level of government to actively participate in assessing the needs of its citizens.

Probably the most-publicized aspect of the federal aid highway act has been the question of financing public mass transit programs from the highway trust fund for rail and bus transit capital improvements.

In fiscal 1974 and 1975 urbanized areas can decide, under certain conditions, not to use urban system funds for roads and receive a like amount in general funds for transit.

The bill provides up to $200 million from the trust fund which can be used – at local discretion – for the purchase of buses in the second year.

In fiscal 1976, $800 million will be available to cities for the construction and improvement of rail transit facilities and purchase of buses.

However, this diversion will not take place in fiscal 1975 or 1976. If an urban transportation fund or some other method of assured financing for highways and mass transit has been established before the effective date.

The question of diversion was probably *the most controversial* issue in the entire bill.

Then-Congressman Jerry Ford, whose name has been in the news for other reasons lately, referred to the amendment as "the camel's nose under the tent."

I believe that allowing diversion simply supports the aim of the entire piece of legislation to create greater flexibility in developing a total transportation system.

We certainly would not try to fit the entire country with the same shoe. Neither should we assume the same type of transportation will meet the needs of the entire country.

Now that we have had a glimpse of some of the major provisions of the 1973 Highway Act, let's take a look at the separately titled section called the Highway Safety Act of 1973. This legislation authorized over $2 billion to various safety programs in the next three years.

Permit me to digress for a moment. As a member of the House Public Works Committee, I sit not only on the transportation subcommittee, but also the subcommittee on investigation and review. We recently completed a report entitled "Highway Safety, Design and Operations."

We found that roadside hazards have proliferated and confusing signs have been installed largely because of an inadequate effort to understand human needs.

The result has been unnecessary death and injury. Total US traffic fatalities in this century are approaching the two million mark.

The 1973 legislation establishes new categories of earmarked funds for three road-related safety programs on federal-aid highways:

1. Protection of railroad-highway grade crossings.
2. Improvements at high hazard accident locations.
3. Elimination of roadside obstacles.

The area of railroad-highway grade crossings is of particular concern to me, and the district I represent, the southwest Chicago metropolitan area.

There are over 232,000 public rail-grade crossings in the US today. That's where some 12,000 motor vehicle-train collisions occur each year. These collisions, averaging about 32 a day, result in some 1,500 deaths and 7,000 injuries a year.

Illinois accounts for 7.5 percent of the total rail-grade crossings in the US, one-fourth more than any other state in the union.

As you can see, the problem is critical in Illinois, especially when you consider that 80 percent of all crossings in the country are not properly protected.

Part of the problem can be remedied by installing protective devices. But the severity of the situation in Illinois prompted me to work for construction of overpasses at certain hazardous crossings. Because many people apparently are not aware of the tremendous hazard presented by rail-grade crossings, the job of getting the legislation included in the Highway Act was immense.

We had our local mayors come to Washington to testify before the Public Works Committee – I testified. Citizen letter writing campaigns were supplemented by editorials in local newspapers.

Members of the Conference Committee received letters from the entireThird Congressional District of Illinois.

And we were successful. Or so we thought. The bill included two demonstration overpass projects for the district, but as we soon found out, the fight had just begun.

Initially, the legislation was included in the 1973 Federal Aid to Highways Act. Even though it was approved by Congress and signed into law, the Office of Management and Budget diverted the funds for the Third District of Illinois in the late stages.

Oddly enough, OMB decided to divert the funds earmarked for my district to senate sponsored projects in Nevada, Nebraska and West Virginia. Knowing the high volume of railroad traffic in the Chicago metropolitan area, I was naturally shocked and angered at what was an obvious example of political clout, and disregard for the need of the people of Illinois.

But the story has a happy ending. Local newspapers and citizens groups rallied support for the projects which was tremendously gratifying to see.

The newspapers provided editorial support, published a pre-printed letter for readers to clip and send to me, and carried up to the minute news stories on the progress of the overpasses.

In all, we received more than 500 letters of protest. That's more letters than I had received on any other issue, until then including Vietnam, Cambodia, and impeachment.

Well it worked. Allow me to read you a quote from one of our local papers in the south suburban Chicago area:

"The groundswell of public protest which forced the Office of Management and Budget to release federal funds for railroad overpasses in Dolton and Blue Island can be considered a great victory for the people of these communities. It proves to us that the voice of the people can be heard in the land, and that that voice can change the tide of events in Washington."

So let's go on with that thought in mind.

People can make a difference.

Congress is listening, and I think we can be assured that the new administration will exhibit all the openness and accessibility we will need to work rapidly toward solutions to our transportation and safety problems.

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Moderator's Opening Remarks

Otto F. Sonefeld
Staff Assistant to
Vice President of Operations
Atchison, Topeka and
Santa Fe Railway Company

Ladies and gentlemen, welcome to the 1974 National Conference on Railroad-Highway Grade Crossing Safety. As I look out over this large audience, I am compelled to applaud the marvelous turnout of wives and other female participants. Colorado Springs is obviously an ideal spot for a short vacation. I want you ladies to know, however, that you are more than welcome to attend the technical sessions. Perhaps then you can understand a bit more fully some of the reasons your spouse often seems to forsake family and all other logical endeavors just to go wandering around the countryside looking at railroad-highway intersections.

Some ten months ago, a group representing various national grade crossing committees met to discuss the need for, and the ways and means of, a fifth National Grade Crossing Conference. I had the dubious distinction of being chosen to the Planning Committee for the Conference and subsequently was chosen by my peers to be moderator. This turns out to be a pretty good deal, however, since it merely involves filling in the blank spots between speakers and, more importantly, saves me from possibly preparing a technical paper. Seriously, I consider it a distinct privilege to be this closely associated with a subject that I have always believed to be of utmost importance. And I am particularly pleased to be associated with this conference, since in a way, it closes the loop on something that began back in the middle '60s.

Many of you have been involved with grade crossing safety efforts for a number of years and I think it is fair to say that for many years grade crossing efforts were conducted on a more or less adversary basis. This was certainly true at the time the US Department of Transportation came into being in mid-1967. One of the early objectives of DOT was to attack the grade crossing problem, and one of its first efforts was to sponsor a national conference with the sole purpose of bringing together the many involved parties "to develop mutual respect and understanding among all interested groups of all problems relating to the rail-highway grade crossing safety".

In attendance at that conference, for the first time, were the same partners we find here tonight – railroads, truckers, labor organizations, federal government agencies, state highway and regulatory agencies, local officials, suppliers, academics and researchers, police officials, the legal profession, and others I may have overlooked. Make no mistake, this was a historic event.

Because of the commendable results of that 1967 conference at Texas A&M University, a second conference was conducted at the University of Illinois in February, 1969. Its purpose was to continue the technical and nontechnical dialogue towards the resolution of grade crossing problems.

In August of 1970 a third conference was held at Georgia Tech. By that time the presentations and program were becoming more technical and broad based, with agencies and companies from across the nation discussing and sharing their techniques, their findings, and their experiences with others.

This same general theme continued at the August, 1972 conference at Ohio State University. One of the rallying points at that conference was the then newly released DOT report to Congress on railroad-highway crossing safety. Subsequent to that conference the Congress, through the Highway Safety Act of 1973, gave dramatic new life to grade crossing programs by the designation of extensive new funding for such work. The time for action was at hand. The seeds of much labor by many dedicated people were finally bearing fruit. It was up to the workers to reap the harvest. Some were prepared, some were not.

It was with this background that many people strongly believed another national conference was desirable as one of the means "to demonstrate how each of the partners in grade crossing improvement programs is using or can best use techniques and new funding in a cooperative effort to implement an effective grade crossing improvement program." That, ladies and gentlemen, is why we are here and why our work over the next few days is so important. All our questions won't be answered, not all our problems resolved, but I do think that we have some very good speakers and that their advice plus the workshop give-and-take should be of great value to our implementation programs.

Getting back to my point, little did many of us think as we entered that conference in 1967 that some seven years later we would be discussing wide scale grade crossing programs. Let us use this opportunity well.

Session I

Partners In Railroad-Highway Grade Crossing Improvement Programs

Max R. Sproles
Vice President and Associate Partner
Harland Bartholomew and Associates
International, Inc Washington, DC

Good morning ladies and gentlemen. It is a pleasure to be on the program with this distinguished group.

The stated objective of this conference is to demonstrate how each of the partners in grade crossing improvement programs is using or can best use new techniques and new funding in a cooperative effort to implement an effective grade crossing improvement program.

As a first step toward this conference objective, in my presentation I intend to cover the following:

First, I am going to identify the many agencies, individuals and organizations that are involved in grade crossing improvement programs – the partners. I would like to then define (1) the role of each of the partners, particularly as the role has changed with the changes in legislation and (2) the responsibility of each partner and how each partner works or should work toward the common objective of making substantial improvements in railroad-highway crossing safety. I also will be identifying some of the serious problems that we face in developing an expanded implementation program. These are the issues that later speakers will be discussing in greater detail and which we should be seeking to resolve through the conference sessions today and tomorrow.

First – Who are the partners?

The partners may be divided into 3 groups:

1) legislative and judicial
2) administrative
3) implementation

While I continue to concentrate on groups, all of you know that they are made up of individuals, many of whom are here in this room.

The legislative and judicial group includes the United States Congress and state legislatures who have enacted the basic legislation under which grade crossing programs are established. This group also includes the courts which by their decisions have assigned responsibility for grade crossing safety among the various partners. Judges and juries who render decisions on individual grade crossing accidents are also partners. They may influence the progress of grade crossing safety programs both positively and negatively.

The administrative group of partners involved in grade crossing improvement programs are the railroad companies, the state and local agencies including the state highway departments, the state departments of transportation, and the public utility commissions and the federal government. All of these agencies and companies have been very deeply involved in developing the partnership that exists today, and establishing procedures for carrying out grade crossing improvement programs.

The administrative organizations, as well as the suppliers, the contractors, and the labor unions are very deeply involved in implementation of the programs developed and funded through the legislative process and carried out under administrative procedures.

Each partner in the improvement program has a very definite role. The legislative group at the federal and state level must produce laws which will set up a framework that will allow the grade crossing improvement programs to move forward. At the federal level with the development of the first federal-aid highway program in 1912 federal funds started to be involved in grade crossing improvements. The passage of the National Industrial Recovery Act of 1933 made funds available specifically for grade crossing improvement programs by the federal government. The Hayden Cartwright Act of 1934 provided additional funds for grade crossing improvements. This was the beginning of the programs that we work with today.

The Highway Safety Act of 1973 provided legislation that is bringing about a much larger railroad-highway crossing improvement program than ever before in history. Section 203 of the 1973 Highway Act authorized the expenditure of $175 million from the highway trust fund specifically for railroad-highway crossing projects on the federal-aid system over a three year period. The authorization for fiscal year 1974 is $25 million with $75 million authorized for each of the following two years.

Section 230 of the Highway Act of 1973 authorized $250 million funds for improvements to correct designated safety hazards on public streets and roads not included on any federal-aid highway system. The authorization was $50 million for fiscal year 1974 and $100 million for each of the next two fiscal years. Funds under this program have been made available for three types of safety projects: to eliminate hazards at railroad-highway grade crossings, to improve highway marking and signing, and to eliminate roadside obstacles.

These two programs are in addition to the funds provided for programs under Section 130 of Title 23 of the United States Code which allows up to 10 percent of all funds allocated to a state to be used for grade crossing improvement programs.

The railroads financial responsibility for grade crossing improvements had declined over the years, due to court decision and resultant legislative and administration action at the Federal level by the Congress and by the Federal Highway Administration.

On federally-aided projects the railroad share is now designated as zero for warning device projects, and is limited to five percent on separation projects where there is a railroad benefit.

The legislation regarding grade crossings enacted at the state level varies widely with regard to funding, cost sharing and jurisdictional agencies and their authority. Special state funding for grade crossing improvements has been authorized in about 20 States. Railroad participation under state law varies and is generally not consistent with participation on federal-aid projects. Some participation in maintenance has been legislated in some states. In most states this is still entirely a railroad responsibility. In some states the public utility commission has broad powers over grade crossing matters; in a few states the state highway or transportation department has some authority over all crossings; very often there is divided authority between the PUC, the state highway department and counties and cities. In at least one state (NY) the former PUC and highway department have been consolidated under a Department of Transportation.

So due to the legislative process the partners and their responsibilities at the state and local level vary from state to state.

Apart from influencing the railroad financial responsibility in grade crossing improvement projects, the judicial group probably influences the type and extent of grade crossing improvements by the decisions they render on individual grade crossing accident cases. ~~Because of the liability issue, railroad companies have been conservative in developing and using new equipment — the fail-safe aspect is a major consideration.~~ Also, because of the liability issue railroads and states may be reluctant to formalize long-range improvement programs which imply that a crossing may be hazardous some time before it is actually improved. On the other hand large jury awards in accident cases may be motivation for greater emphasis on grade crossing improvements.

The legislative process and the judicial process have been very, very important in all aspects of grade crossing programs. The important question at this point, is: How the other involved parties can best work with this group of partners so that their influence on grade crossing improvement programs is more positive?

The role and responsibility of the administrative group — the railroad companies, and federal, state and local agencies — includes the development of guidelines to implement the governing legislation, the establishment of grade crossing safety programs and the integration of these programs into their overall safety programs, the development of project priorities, the paperwork procedures to process these projects.

The role of federal, state and local agencies in carrying out the legislative mandate have been very complex and in many cases very non-uniform from state to state and from locality to locality. The overriding federal involvement in the grade crossing program has been very helpful in bringing uniformity and standardization both in implementation methods and administrative practices. However, the vast differences in the state laws relating to railroads and to grade crossing improvement programs has in the past and is still causing difficulty in developing a true partnership approach and a comprehensive solution of the grade crossing problem. Railroads operating across many state lines must be familiar with the individual state laws and the authority and regulations developed and implemented by not only the state highway agencies but the public utility commissions and the administrators of local jurisdictions. Depending on the state law the responsibility for establishing grade crossing programs and selecting specific crossings to be improved can rest with or be divided among the public utility commission, the state highway department, the city and the county.

One of the major changes coming about through funding from the Highway Safety Act of 1973 is the opportunity for crossing improvements on roads and streets that are not part of the federal-aid highway system. This may bring into play another organization at the state level.

In the Highway Safety Act of 1966 each governor was required to appoint someone who would be his representative for all matters relating to highway safety. This was necessary since many of the programs in the highway safety legislation related to other agencies besides the road building agency. In some states the governor's highway safety representative was outside the highway or transportation department and in many cases worked directly out of the governor's office. The funding programs set up in the Highway Safety Act of 1973 will depend a great deal on the organization being utilized at the state level for highway safety programs. Developing the mechanisms for getting projects included in a funding program at the state level will require substantial effort to inform local officials. I would like to call your attention to the brochures issued by AAR, Southern Pacific, and Ohio DOT as good examples of attempts to spread the word. In most cases projects funded through Section 230 of the Highway Safety Act of 1973 will be constructed in the manner that a state highway department uses for federal-aid secondary road projects, that is through agreement with the local agency who has the responsibility for road construction such as the city or county engineering department. This organizational framework is a key element in the success of the grade crossing programs.

As I have been talking about the partners in the most important aspect of the improvement of highway and rail transportation I have alluded to the inner relationships that must be developed by the partners. The development of the administrative processes by the federal government that can be carried out by the state highway agencies cooperatively with the local agencies and the railroads involved and at the same time carry forward any programs that are strictly state sponsored in a most complex inner governmental, private industry undertaking. This becomes acutely complex when you add this program to all the other responsibilities that each of these agencies have, including the development of other highway programs and particularly highway safety programs. Adding grade crossings to the problem a railroad chief engineer has in trying to maintain and upgrade his rail system is equally as difficult as it is to the federal and state agencies.

Developing a statewide program considering all roads and streets will be a much easier effort when the National Grade Crossing Inventory and Numbering Project, a major cooperative effort between the FRA, FHWA, states and railroads, is complete and that data system is made available to the states, counties, cities and railroads. A nationwide accident data file will be implemented during 1975, railroad companies will make a report on all accidents involving trains and highway vehicles directly to the United States Department of Transportation – FRA – in Washington, and another major element of information will be available to assist in developing rational grade crossing improvement programs.

The implementation of specific grade crossing improvements in the past and to the present time has been predominately a railroad's responsibility. The regulation of grade crossing signing was the responsibility of the state and local agencies until the passage of the 1966 Highway Safety Act which called for the development of nationwide standards and adoption of the Manual on Uniform Traffic Control Devices (MUTCD) and its adoption by the state governments. The minimum requirements of the MUTCD are reflectorized crossbucks on each highway approach to a grade crossing. The installation and maintenance of these signs in most states has been the responsibility of the railroads. This procedure is undergoing change with funds made available in the 1973 Highway Safety Act for the improvement of signs and markings at grade crossings. The state in some cases has assumed the responsibility of paying for the installation and in some cases is actually installing the crossbuck with state forces. The installation of active warning systems at crossings has historically been the responsibility of the railroad. This is generally still the case primarily due to the fact that these warning systems have been interconnected with existing railroad signal systems or intergrated with track circuits. This type of improvement brings in two other major elements in the implementation role and that is the role of railroad labor and the role of signal suppliers.

Railroad labor through their agreements with the railroads have divided labor jurisdictions that vary to some degree in each contract between the local labor organization and the railroad company. This relationship is of interest when discussing this program because it is something that most state, federal and local agencies are not familiar with and have a difficult time understanding. It is essential to the success of an expanded grade crossing program that there be a full and complete understanding of railroad labor matters and that the involved partners pursue courses of action which will be mutually beneficial.

The fact that most grade crossing improvement systems or devices are developed by a relatively few suppliers is also of interest in the implementation role. Many of the warning systems have evolved from a very early application of a man with a lantern waving his arm to signal highway users that a train was approaching a crossing. These warning devices were naturally developed by suppliers that made other signaling systems for the railroad companies. These systems are quite different from the systems used by traffic engineers and are quite different from the systems that highway travelers see most often at other intersections. The fact that almost all of the implementation programs are carried out by the railroad with railroad employees also tends to make the grade crossing program unique when compared with other highway improvement programs. Most traffic engineering intersection signaling projects are handled by a state highway, city or county traffic engineering department directly with their own forces or by contract. This is not the case with grade crossing improvement programs. An agreement with the road or highway agency and the railroad operating company to improve a grade crossing becomes a matter for the railroad company to deal directly with suppliers, labor and in some cases contractors. Only with the recent greatly increased program, have companies been developed to contract for the installation of grade crossing improvements. The state or local agency involved in the implementation is generally the one developing the project, signing an agreement with the railroad company and inspecting the work to see that it is being done in accordance with the agreed upon procedures, except in the case of grade separation projects where in many cases the entire project is designed and contracted for by the highway agency with the railroad having the responsibility for reviewing the plans and inspecting the work to make sure that it is in accordance with their previous agreements.

I would like to summarize some of the problems that have caused concern in developing a grade crossing improvement program. One of the most acute problems has been the lack of an adequate data base for decision making in establishing and moving forward with a state by state program of grade crossing improvement strategies. This data base is now well on its way to becoming a reality through the National Grade Crossing Inventory and Numbering Project and I am sure that most of you at this meeting have been involved in this program already.

Another problem has been the lack of a nationwide program with a funding level high enough to allow a systematic improvement program so that every crossing in the United States has an equal opportunity of being improved. A major problem has been the lack of funds for roads that were not on the federal-aid highway system and in this same regard the lack of coordinating agencies to see that all crossings were included in the study to develop the improvement program. This problem is also well on its way to being solved with funds made available in the 1973 Highway Act.

With funding made available we are now running into some other very severe problems in the implementation of projects. One of these problems is the availability of equipment to improve the crossing warning systems. Not having a program developed far enough in advance so that a railroad can put in orders with enough lead time to have the materials available when the project can be constructed is a problem that we all must work on. We also must consider the problem of design capability. With the program leaping ahead from a very low level in an almost quantium jump, the railroads and the suppliers face an almost impossible task of training and hiring employees to do this work. Developing procedures where certain projects can be contracted out, materials stockpiled and training maintenance personnel will be a continuing problem.

Another serious problem that must be faced by top management in railroad companies is to commit themselves to the need to hire and train enough employees to handle this ongoing improvement program. Suppliers must also face this problem so that orders can be shipped in a timely manner.

Grade crossing warning systems must have credibility. A major effort must be directed toward upgrading existing active warning systems so that the traveler is not kept waiting when trains are not approaching a crossing.

In many rural and urban areas there are opportunities for relocation of rail facilities that would make greater improvements to the highway system and to the rail system. It is now time for the railroad industry and highway agencies to look over their entire systems to locate places where these projects are feasible. I think it is the responsibility of all the partners to work together to find and implement these relocation projects. The nation's railroads have reached a point in their history where they cannot afford to operate lines just for the prestige of being at that location. A much larger view must be taken and the individual companies must work together to create joint facilities in order to reduce the miles of railroad lines and therefore reduce the number of grade crossings and also make it feasible to improve and relocate the jointly operated facilities. The rail relocation approach to grade crossing improvements is not just a safety program it also is a means to assist in improving transportation efficiency. We now have 12 urban rail relocation projects underway funded by the 1973 Highway Act. There is a possibility that a program will be forthcoming that will provide enough capital to make many other rail relocation projects possible.

I hope all of you will consider this idea in your overall program to improve railroad-highway safety and transportation efficiency. When opportunities for rail relocation occur, many times they can be developed in concert with transportation and future land use plans. Rail service can then be provided to areas that are appropriate for industrial development, trucking terminals and transportation facilitation centers can be developed.

My main purpose in this presentation has been to encourage you to start thinking of better ways in which you can work together in developing railroad-highway crossing improvement programs. We should not dwell to much on the historical ways in which this program has been handled. We are really on the verge of an entirely new atmosphere related to transportation safety with the increasing emphasis being placed on these programs by the federal government. With the increased emphasis being oriented toward developing departments of transportation at the state level, the highway-railroad crossing program should be an example for continued cooperative programs.

We have arranged at this conference the best possible series of presentations by individuals who are actually working on the program. I know that you will be looking forward instead of backward as you participate in this conference.

I look forward to discussing these issues further with you in the panel sessions this afternoon.

Establishing A Grade Crossing Safety Program

Archie C. Burnham Jr.
State Highway Traffic
and Safety Engineer
Georgia Department of Transportation

The goal of previous conferences on railroad-highway grade crossing safety has been to identify problems and design necessary programs for adequate relief. History reveals that Congress has responded with some provision of funds and various new programs are now beginning to appear. The task we face today is how to address each of the major disciplines involved in the problem with actual details in getting a program set up. This morning I would like to tackle that subject with the thought in mind that in this brief period, we will only touch on subject areas as they affect the major disciplines. Undoubtedly, this will raise many questions requiring more specifics in detail. Thus, the objective of our afternoon panel session will be to address questions or details which are uncovered or alluded to here.

To achieve the best end results in establishing a program to address total improvement to railroad-highway grade crossings, we should learn to better utilize five specific tools. These include appropriate legislation, organization, funding, accident data, and inventory data. I am going to look at these subject areas individually as they relate to our program in Georgia.

Legislation

The foundation upon which to build a successful grade crossing improvement program is a state law which addresses adequate authority in a public body. Such legislation must clearly establish authority for all the elements involved in administering the program. Its importance is so vital that a program can stand or fall on the effectiveness with which it is written.

As in so many efforts, proper timing is essential in obtaining good legislation. Sometimes good legislation will be defeated because other matters are pending on entirely different subjects that get priority handling, or administration endorsement. Georgia was fortunate to satisfy its needs in appropriate railroad-highway legislation by the inclusion of these authorities with the recodification of its entire highway code. Title 95A was introduced and passed with only minimum revision in the 1973 Session of the Georgia Legislature after several years of ground work in developing the necessary tools to be used. Investigating the palatability with the affected partners didn't hurt either. The key elements of Article 2, Chapter 10, as passed, can be summarized under seven headings as outlined below. It is essential that each of these subject areas be addressed in any adequate legislation.

1. *Maintenance of Crossing* – Assigns duties to the railroad. Stipulates they shall assist governmental agency and vice versa in regulating traffic.

2. *Constructing New Crossings* – Assigns duties to the railroad under terms and conditions stipulated by governmental agency with jurisdiction. Includes installation of protective or warning devices. Assigns the Department of Transportation responsibility to resolve disputes.

3. *Elimination of Crossings* – Authorizes the Department of Transportation to direct the elimination of crossings by use of overpasses or underpasses. Describes notices, requires meetings between affected parties, and provides authority if agreement is not reached.

4. *Overpass and Underpass* – Designates maintenance responsibilities to governmental agency and railroads, and authorizes grade crossing elimination by relocation. Improvements are initiated by governmental agency with jurisdiction.

5. *Protective Devices* – Provides for the beginning of work, notice to parties involved, maximum times for review and agreement, and divides the cost of design and installation, as well as designates maintenance responsibility, and provides for obedience to signals, stipulates stop requirements, and provides exceptions. Includes movement of heavy equipment.

6. *Authority for Railroad and Governmental Agency* – Requirements based on the necessity for safety and convenience of the traveling public. Establishes notice to be given and provides of emergency overrides.

7. *Review of Order* – Establishes rights of appeal for any judgments, decisions, or order by the Department of Transportation involving advisability or necessity for:

a. Eliminating grade crossing.

b. Installing warning devices.

c. Improving grade crossing structures.

d. Questions concerning the highway system arising under the provisions of this act.

Organization

In setting up a program, each agency should designate a manager of operations that links into other affected partners. The railroad, highway agency, PSC, local state and federal government, unions, suppliers, and contractors all have complicated functions, any one of which when out of kilter, will affect the overall program and the other partners. But subject to the managers designated responsibility should be other internal efforts with agreements between affected parties; the ranking of established needs, the diagnostic evaluation of prospective improvements; and funding of significant programs. In the Georgia Department of Transportation, our staffing to address this subject is in three parts. Our Planning Office is charged with the responsibility to collect pertinent data. Our Utilities Office will liaison with the railroad in other matters and thus is properly charged with the responsibility to prepare agreements for the official execution of action for protective devices. Our Traffic and Safety Office has been designated the manager to direct an ongoing program for railroad-highway grade crossing safety. This management includes the establishing of priority for a particular crossing, the conduct of diagnostic studies as required, the scheduling of projects, the designating of design and specifications for a particular crossing, and the coordination of various information sources. These sources include information from inventories, accidents, studies, local government, railroads, suppliers, funding officials, or other pertinent sources. In Georgia, a resolving of this type staffing occurred approximately two years ago, when a meeting was held with the policy personnel and the affected partners within the Department. As a result of this meeting, it was realized that some offices of the Department were actually conducting functions which were not basically charged to their responsibility. In an effort to rectify this situation, a flow chart was developed which outlined all of the functions that were required in the highway-railroad grade crossing process and each function was designated the responsiblity of a particular office. The final breakdown was as elaborated above which closely coincides with overall responsibilities which are conducted routinely by these offices.

It should be noted that as a result of this reorganized staffing in the Department, several objectives which are of benefit to anyone involved in this type work, have been realized. For example, administrative overhead and cost can be cut with the elimination of needless red tape, duplication of effort, the consolidation of materials, the streamlining of maintenance and reducing engineering rigidity for design, specifications, and plans are all worthwhile goals which should be set within an organization. I am happy to report to you that as a result of the staffing changes which were made two years ago in Georgia, for the first time, we now realize the fruits of a program which are planned and developed in accordance with a preset policy. There has been a marked change for the better as a result of this process, and I would suggest to you that it would be most appropriate for your agency to reevaluate its position in staffing and organizing to address this subject area.

Well, it is obvious to us that these things should be done, but the problem is that too often they are not done. I submit to you today that unless we soon make changes to comply with this criteria of simple, short, and timely organization, we will have very serious problems in carrying out expanded grade crossing improvement programs. And speaking of timely, there is no time like the present time. If nothing else is taken from this conference, please go back to your respective shop to reappraise the situation. If you know improvements are necessary, then don't keep them a secret. Tell your boss and have him tell his boss. Georgia's approach in organization has been to collect, evaluate, and process the necessary data available to carry out an ongoing program. This data involves three areas of such significant importance that I have devoted the remainder of this paper to them respectively. They are funding, accident data, and inventory data.

Funding

In our state, at best, we will be able to fund 50 railroad-highway grade crossing improvements per year. With over 6,500 crossings existing in the state of Georgia, this on the surface gives us a very bleak outlook for achieving a total solution. In the process of developing overall priorities for improvement, our Department looks at the big picture. Our first concern is the immediate hazard and the amount of relief that can be obtained through an action for improvement. Our second concern is how the cost for the improvement will stack up toward total state needs eligible for the same funding. Our third consideration is how other needs can be discharged in substitution for work accomplished by this program. We consider, for example, the Highway Safety Act of 1973 a tremendous boon to aid in this program. Not only was one section (203) dedicated to railroad-highway grade crossing on-system, but another section (230) was earmarked specifically for improvements off-system, many of which will encompass the railroad-highway grade crossing. Due to homework that had been done in preparation for meeting goals in the railroad-highway grade crossing area, the Department was ready to move when funding for off-system crossings under Section 230 was made available. This, as you know, is 90 percent federal funding. In Georgia, the state contributes the other 10 percent; so in effect, this program does not cost the railroad or local government one thin dime. Unfortunately, there is not sufficient funds in this program to cover all of the needs anticipated in Georgia. Thus, other state programs must be generated to meet the goal of 50 crossings per year. These other programs will have a varying ratio of participation by the railroads and/or local government.

For example, it should be recognized that the first year's appropriations under Section 203 for Georgia, provided $600,000. At the current cost of protective devices, this will be sufficient to enable the signalization of approximately 20 crossings. With a goal of 50 crossings set out, obviously the funds for the other 30 must come from other source. That source will continue to be made up from other federal-aid funds and/or state funds as has been used in the past.

The Highway Safety Act also provided funds for off-system crossings but this standard area, Section 230, must also be used for other type improvements off-system. Thus, exclusive use of this money cannot be channeled directly into railroad-highway grade crossings. However, due to the overwhelming need for crossing improvement in Georgia, we had determined that a majority of the Section 230 money shall be dedicated to the off-system railroad crossing program, a least for the first two fiscal years of the funding. This amounted to 1.2 million dollars in fiscal year 1974 funds and has doubled for fiscal years 1975 and 1976. The monies made available by the Highway Safety Act will then enable Georgia to make deep thrust into the crossing problems in accordance with goals which have been preset. As can be plainly seen, however, additional funds for other state programs must be generated. With a commitment of a goal of crossing improvement, as stated, it will be possible to continue the efforts of the Department in such a way to continue utilization of other funds to enable this development. As a matter of fact, we are seriously considering the possibility of expansion of this policy to include in the future 50 on-system and 50 off-system railroad-highway grade crossings. This particular policy has not been set at this time, and we continue to operate as has been explained.

These actions do not come about by the efforts of any one person or organization. They come about through a solid partnership between all affected members. We have been fortunate in Georgia that we have had an open, aggressive, competent leadership in areas of our operating railroads, our affected municipalities and countries, and our own policy setters within the Department of Transportation. But let's look now at other data needs.

Accident Data

It is essential that we evaluate railroad-highway accident experience. Tragic as it is when events allow the elimination of an entire family or a significant personality through a railroad-highway fatal accident crash, even more tragic it becomes if we fail to analyze these accidents. Only an understanding of the causes of these catastrophic accidents can assist us in avoiding further such accidents in the future. It is imperative that we remove or minimize the same error producing environment. There are several areas that we need to pay particular attention.

First, let us be sure that we properly evaluate the total accident history at a specific location. Because so many individuals are involved in a reporting process, it is easy to overlook major fractions of data. For example in Georgia, we have as thorough a correlation on fatal accidents as we do on any other sector of our traffic accident experience. Yet, so many times due to error editing, lack of reporting, miscoding and location problems, data reaching the Department may be off as much as 5 percent in fatality records. And if we can't get within 5 percent on fatal accident experiences, imagine the inaccuracy on injuries and property damage only. But complete accident files are essential and each program which entails the use of accident data must make special effort to assure that the data furnished is in fact complete. In Georgia, this completeness is verified through a close coordination between the Department of Transportation and the Department of Public Safety.

Suggested helpful aids to assure a cross reference between various reporting agencies includes knowledge of the fact that reporting is accomplished by other agencies as well. The railroads report accidents through their own communication sytem and report certain accidents to the federal and state agencies. The law enforcement personnel report accidents through their own organization. Likewise, data may be available through a cross-check of death certificates, hospital records, autopsy reports, coroner's inquest, and work logs from wrecker services and maintenance crews restoring the areas.

In addition to completeness, one should strive to obtain accuracy or thoroughness in the reporting of data to accident files. This is an effort largely dependent on our partners in the enforcement area or in specialized diagnostic teams which represent our own specific interest. For example, in the highway field, every fatal accident that involves the State Highway System of Georgia is investigated by an engineer within 24 hours after the time of occurrence. This report is cross-filed with reports from police officers and others in order that more thoroughness in detail can be obtained. When conflicts arise in the reports, they are resolved through a discussion with the parties involved.

Once you have adequate accident records, the next step is to analyze them in the proper manner. This analysis includes evaluation of accident experience not only at the crossing itself but within a reasonable distance of the tracks. Such evaluation will point out to both the railroad and the highway agencies any significant trends which may be developed due to the specific geometrics of the crossing, as well as to the presence of traffic on either the track or the highway. As in so many other things, the best solutions to these problems are always the simplest. Do not automatically conclude that bells, lights, and gates are the only solutions. Other improvements should be considered, and they are many and varied. Although they will be mentioned in future papers at this conference, let me suggest to you that an investigation of the possibility of grade separation, provision of escape areas beside the tracks, use of attenuation devices for fixed objects, improvements of surface textures, the use of street illumination, the use of improved passive devices such as raised pavement markers, the use of words and symbols on pavement, or double indication signing and reflectorized crossbucks, all are pertinent devices that should be investigated. And don't overlook closing the crossing. Alternate routes, relocated crossings, and customized control (special flagmen, speed zones, blocking ordinances, etc.) are all vital considerations beyond the sole solution bells, lights, and gates. There are many ways to improve a crossing and they are not all price tagged at $30,000 each.

But accident records will not be of true value until they are properly used. Let me suggest a twofold use. First, the records should be classified for history by making available all facts regarding the occurrences in a format with easy identification and location. Second, the data file should be relied upon as input into a workable system of comparisons with accidents and other data for ranking purposes. This should be done for each of the improvement projects to be funded within a program. Note that I have indicated that accident data should be included only as one element in a ranking comparison.

Inventory

An inventory file is vital because no one can solve any problem until they first understand what the problem is. In Georgia until recent years, we have had no idea of the number of railroad-highway grade crossings in our state. Subsequently, we learned in 1971 we had 650 crossings on our state highway system. These crossings along with 450 others on federally funded highways were the only crossings formerly eligible for federal aid participation. To our surprise, our initial inventory efforts unveiled over 6500 total crossings in the state, meaning that only 17 percent were eligible for federal aid participation. Naturally, we were thankful and appreciative for the 1973 Highway Safety Act providing for improvement on off-system crossings with federal aid. The nationwide inventory of railroad-highway crossings now underway will go a long way in assisting us in understanding the depth and scope of the problem including the need for funding, supplies, stockpiling, organization, maintenance, and other vital areas involved in administering a crossing improvement program. In order for needs to keep abreast of demands, an understanding of the scope of the problem is mandatory.

First we need closer togetherness regarding partnership in the problem. In our state, the inventory has been a catalyst which required meetings between railroad and highway officials where both could sit and air their differences regarding the approach to the problem and in closer communication develop a unique harmony for addressing problems of this magnitude. Additionally, the inventory has required a reevaluation of internal organization in order to insure that feedback and proper handling of the data goes without duplication or loss of effort. Important also has been the opportunity to evaluate the processes available as end products from the inventory and to incorporate these findings into an expected data flow through our organization. Of major importance in this inventory effort is an opportunity to project needs against realistic time tables, where scheduling, programming, and funding can find compatible habitat. Of particular importance is the unique identification number for each crossing, which is being assigned as part of the national inventory. This provides the link between all inventory and accident data for that crossing and thus permits the consideration of all relevant data in the process of selecting crossings for improvement. This numbering process is mandatory if we are to have a successful link between various modes of data. As mentioned previously, in Georgia another office is charged with the responsibility of collecting data, then is charged with the responsibility to use the data. Thus, it is important that various types of data can be assembled under a common denominator. The identification and numbering process which is a byproduct of the national inventory will be a valuable aid in accomplishing this coordination.

Summary

An improvement program at railroad-highway grade crossings can come about. But it will come about only when as partners in improvement, we each elect to do things differently in the areas of preparation and performance of our assigned duties. We have called these different actions five specific foundation stones in setting up a program. We have listed them as improved legistation, organization, funding, accident data, and inventory data. The proper development of each of these areas is mandatory if we are to establish an improved program. We alluded that no one partner or program would solve the problem, but that all are important and all affect the other partner in some particular way.

I trust that in these few minutes, we have been able to touch on some areas of interest to your organization and that we might from this brief introduction, carry forth into our afternoon session where a detailed discussion of any of these activities would be most appropriate. Hopefully, we will be able to address questions of specific nature dealing with the reasons for success or failure in developing a program along these specific foundation points. I will look forward to discussing these with you further.

Panel I

A panel discussion and open forum on issues related to "Partners in Improvement" and "Establishing a Crossing Safety Program"

Moderator: Hoy A. Richards, Texas A&M University

Panel Members

Max R. Sproles
Archie Burnham
C. J. Chamberlain, President
Brotherhood of Railway Signalmen
Charles Fain, Commissioner
Missouri Public Service Commission
Frank Kaylor, Assistant Vice President
Southern Railway Company
Richard Thomas, Director, Transportation Division
City-County, Denver, Colorado
Cliff Shoemaker, Crossing Engineer
Union Pacific Railroad

Prepared Remarks

Charles J. Fain, Commissioner

Missouri Public Service Commission

Part I

Mr. Sproles refers to partnerships and their roles in implementing programs for crossing improvements. These programs exist in Missouri and are functioning under a high degree of partnership between three state agencies and the railroads.

I would briefly like to explain our Missouri system.

The involvement with railroad grade crossings and the Missouri Public Service Commission dates back to the original 1913 law creating the Commission in Missouri. These laws have been ever amended and improved over the past 50-odd years to provide safer grade crossings.

The Public Service Commission has the jurisdiction over all aspects of every public grade crossing in the state, allowing for uniform control and protection. This uniformity is essential to both the state's railroads and the motoring public. Neither are confounded with several sets of standards occurring under separate controls.

The Commission is directly responsible for the protection of each crossing on individual cases. This also allows a uniformity to exist throughout the state.

Public funding for crossing protection is threefold in Missouri.

1. The Missouri Highway Department administers funds for federal aid system highways.
2. The Missouri Public Service Commission administers funds established under the Missouri grade crossing fund laws of 1971.
3. The Missouri Highway Safety Commission administers funds under Section 230 of the 1973 Highway Safety Act.

The Missouri Highway Department established a program in 1970 whereby a fund of $800,000 per year was set aside to pay for crossing protection.

Under this program, approximately 50 crossings were protected during the period of 1970-73. This program was discontinued upon implementation of the 1973 Safety Act.

The Highway Safety Act of 1973, Section 203, allocated $1,500,00 to be used on federal aid highways.

The Grade Crossing Fund was established by the Missouri legislature in 1971. During 1973, the first year funds were available for the improvement of crossings, 17 crossings were ordered protected under the Grade Crossing Fund, with a total expenditure of approximately $286,000. Thus far in 1974, applications have been received for five crossings with estimated expenditures of $120,000.

Now with the implementation of 1973 safer roads demonstration program and specifically Section 230, Missouri has an additional $1.2 million made available for improvements on highways off of federal aid systems.

The key to any program with three separate sets of pocketbook strings must be cooperation.

And cooperation is the spirit in which our grave tasks are approached.

However, no amount of funding is worthwhile unless applied properly. It is necessary to have available complete data files involving train-car accidents. Our staff maintains open files on grade crossing accidents back to 1951, which are implemented in any study of a crossing.

Equally important to accident history is current information on accident patterns. In March 1973, this Commission implemented a new reporting requirement that would make telegraphic notice of all serious accidents mandatory. In addition, a system exists whereby all highway patrol reports on grade crossing accidents are automatically routed to our office so that information may be obtained as to conditions at the time of the accident.

Upon receipt of either the highway patrol report or the railroad telegram, a member of the railroad safety staff makes the proper inspection. Attention is paid to what improvements can be made to prevent any future accidents.

If the crossing is found to warrant automatic protection, then our three funding programs are called upon to find the most suitable method to protect the crossing.

Part II

Mr. Burnham makes reference to the selection of five specific tools to be used in the selection of ammunition. I would like to expand his very apt observations a little, if I may.

1 & 2. *Legislation and Funding*. Legislation and funding go hand in hand. Without proper legislation funding cannot be provided.

The federal government has accelerated this program with the enactment of the Highway Safety Act of 1973 by providing monies explicitly for the improvement of grade crossing safety. Now state governments must enact or enforce their own regulations in regard to improving or eliminating hazards at crossings.

3. *Organization*. It is important to leave the responsibilities centralized under one state agency so that uniformity may exist on the state level. This state agency, though responsible on the state level, must be readily accessible to local problems. It must remain accessible to local governments (cities and counties), railroads, federal agencies, and even to other similar state agencies to work with combined-cooperative effort toward solving the problems within the state.

4. *Accidents*. Good reporting procedures are necessary in order to establish accurate data files. In Missouri, the State Highway Patrol is the designated agency in regard to traffic control and accident investigations. A trooper is dispatched to the scene of any grade crossing accident and his report gives full details as to conditions at the time of the accident. Mr. Burnham states that cross reference between agencies is an important tool and should be utilized to the fullest extent.

5. *Inventory*. The federal government has again set the pace on an inventory project. Upon completion of inventories within each state, they will have an accurate accounting of the crossings, and I am sure that as Mr. Burnham said, each state will discover crossings which were not known to exist. It is an undisputed fact that an accurate accounting will be an immense aid to identifying problem areas. However, particular care must be exerted by railroads that once in place, these inventory tags are not forgotten and must be maintained.

In Missouri, in the spring of 1975, the Missouri Public Service Commission hopes to host a state grade crossing conference. County and city officials, along with railroad representatives, will meet and familiarize themselves with certain local and county conditions and problems. We hope to gain greater cooperation between county and city groups, railroads, and state agencies by such an experimental venture.

Cliff Shoemaker
Crossing Engineer
Union Pacific Railroad

The scene has been set – the participants at previous conferences have discussed the grade crossing problem and some possible solutions in depth, and the theme at this conference is that of partnership and coordination of efforts. Max Sproles has today identified the necessary partners and their roles and responsibilities. Archie Burnham has outlined how the State of Georgia is utilizing the tools available in the development of their improvement program. I would like to discuss the railroads role in the development of a successful grade crossing program.

As indicated in Messrs, Ingram and Hanrahan's presentations last night, there has recently been an intensified interest on the federal level in the highway-railroad grade crossing situation. This interest is exemplified by the 1973 Federal Highway Act, the National Grade Crossing Inventory and Numbering Project now in progress, and the new FRA requirements for the reporting of grade crossing incidents. This federal interest and in particular the financial involvement has in turn generated much new activity on the state and local level, as there is finally some federal financial assistance available for almost every circumstance, irregardless of what highway system is involved or what types of crossing improvements are being considered. The suppliers are stepping up production because of the increased demands for signal equipment, crossing surfaces, signs and other related materials. The Brotherhood of Railway Signalmen is involved because of the increasing work load, both from the initial installation and the future perpetual maintenance.

So how does the railroad industry as a whole fit into this picture? And what can we do to effectively contribute to the work being done by the other partners in improvement?

In answer to the first question, almost all phases of railroading are involved, not just the engineering departments which seem to be the center of attention when discussing grade crossings. The operating departments are concerned with the welfare of train and engine crews as well as potential train delays. The claims and legal departments are involved for obvious reasons. The security departments spend considerable time and effort investigating incidents, and in working with public agencies on educational programs, as do the safety and public relations departments. This list could go on and on, but the point is *every* department in *every* railroad is and must be vitally interested in this problem, from the top executive officers down.

This then brings up the second question – what can we do about it? We can sit back and wait for a series of accidents to occur, or we can wait for a public agency to order improvements. Or, we as railroads can initiate our own comprehensive improvement program, utilizing the tools available to us and work together with the other partners in improvement in an effort to get on the preventive side of the situation.

The often referred to "three Es" outline for a grade crossing improvement program, that being engineering, education and enforcement still applies, and I would like to briefly discuss how this plan can be applied from a railroad standpoint.

We can utilize and supplement the national inventory files and incident histories to develop a long range improvement and elimination plan. This will not necessarily agree with the public agencies priorities but should be used as a tool to present the railroads views and to jointly develop a realistic program. As Mr. Shumate indicated last night, a coöperative effort between the state of Colorado and the railroads has solved a major problem here in the Colorado Springs area. The state of Utah and the Union Pacific are anticipating similar success in the Salt Lake City to Ogden area, where we are in the final stages of negotiations to install new or upgraded signal devices at 14 locations which have had a high history of incidents. Almost every type of funding available is being utilized on this project, including federal aid system funds, off-federal system federal funds, as well as state and railroad participation. Without a cooperative effort, however, programs such as these could never materialize.

Another area that needs a good hard look is that of the materials we are now using for grade crossing installations and of their related costs. We can work with manufacturers in the research and development of new and improved products with the goal of providing the optimum warning device and crossing surface for each of the various conditions. For example, the Union Pacific has installed several strobe-type flashing light systems under test conditions for evaluation purposes. Different types of crossing surface materials are being used side by side to compare the relative economics and rideabilities. Other roads are doing similar testing, but we are several years behind. The attitude that "if it was good enough then, its good enough now" just doesn't apply today, and it's time for us to initiate some changes.

The educational and enforcement aspects of a grade crossing program are too often left entirely up to the public agencies, when we as railroaders have the best possible data available to be used in educational programs. The local officials are generally quite receptive to any assistance the railroads can give in this area, and we should be intensifying our efforts to develop films, slide presentations and make personal contacts in cooperation with the other partners in improvement to get our message across.

We have in the past identified many contributing factors to the problem, and determined methods by which we can reduce the problem. And now I feel that we have identified the "missing link" heretofore not discussed in depth. Coordination of efforts is the key to a successful program, as not one of us can do it alone.

If each of us pledges ourselves to become a true partner in developing an improvement program, the task will not be insurmountable. We have to stop going off on separate tangents, worrying only about our own problems and get our heads together for the purpose of solving the problem at hand – that of saving lives.

Prepared Remarks

C. J. Chamberlain

President

Brotherhood of Railroad Signalmen

Members of the Brotherhood of Railroad Signalmen can play a key role as partners in improvement and in implementing a grade crossing safety program. Our members can actually participate in three ways. First – they are the men who install automatic warning devices at railroad-highway grade crossings. Second – Signalmen maintain these automatic warning devices; and third – BofRS has established a special committee made up of competent, skilled technicians that are developing standards for the installation and maintenance of automatic warning devices for these railroad-highway grade crossings. Standards, that we hope would be approved by the Federal Railroad Administration, would be the work of the three most interested and competent parties – BofRS, Association of American Railroads and FRA. Also, I would imagine that the Federal Highway Administration would be an interested party to such standards.

Our members can also become involved because of their knowledge of railroad operations in general; their skills and knowledge as motorists; and their abilities of being good citizens. For example, signalmen, being familiar with various lines of railroads, can help in identifying grade crossings that should be equipped with automatic warning devices. As motorists, they will know which crossings are heavily traveled, which ones require warning devices. And, of course, as citizens they can appreciate the need for improving safety at rail-highway grade crossings.

As citizens, they can also play a role in supporting local governments and state agencies in their efforts to reduce accidents at rail-highway grade crossings. In small communities, the signal maintainer often is the railroad's only trained signal expert available to explain the need for and operation of automatic warning devices. He is usually the man called – often by the local police – to repair damaged warning devices or to correct failures in equipment. Naturally, it is his job to do so, but the point is that the signal maintainer is the railroad company's contact with the motoring public in these instances, and a most important contact.

Mr. Burnham mentioned the inventory of grade crossings – now well underway – and accident reporting. Signalmen can often supply valuable information as regards crossings in their territories. Also, they are usually called to an accident scène, especially if automatic warning devices were involved, so that their knowledge of the operation of such devices and the condition of the equipment before and after the accident are most helpful to local authorities.

Mr. Sproles spoke of the partnership of the various governmental agencies, the railroads, the equipment suppliers and the labor organizations. We in the BofRS accept the invitation – or challenge, if you wish – to actively participate in this partnership for greater safety at rail-highway grade crossings.

We have worked with some railroads and welcome the opportunity to work with all of them in the hiring and training of new signal employees. More men will be needed for the installation of these devices, but the manpower requirements will also be greater for men to maintain automatic warning devices.

We certainly are willing to work with the various parties to implement the grade crossing program, but I would be remiss in my duty and responsibility as President of the Brotherhood of Railroad Signalmen if I did not mention our position with respect to jurisdiction of signal and communication work occurring to our organization under the scope rules of our agreements on most all carriers in the U.S. We are a highly skilled craft railroad labor union whose membership, jurisdiction and interests are confined to work in the railroad industry. ~~We insist in retaining that jurisdiction and will retain it.~~

We insist on maintaining the integrity of our agreements and as long as that is understood by all concerned, they can look forward to an atmosphere of cooperation and assistance from the Brotherhood of Railroad Signalmen.

We will sit down and endeavor to satisfactorily work out problems with extenuating circumstances that confront the carriers, and we have done this with some railroads and contractors regarding installation of automatic warning devices. In these instances, honest efforts were made by the carriers to hire more signal employees to handle the increased work loads but circumstances became so acute that we did work out agreements between the carrier and our general committee on the affected property whereby contractors having representation agreements with our organization now permitted to install automatic grade crossing devices. The Railroads' Signal Employees in all cases, however, maintain these devices in accordance with existing agreements. In all cases the contractors' forces must belong to the BofRS.

Another reason why we insist on jurisdiction over the installation forces is that the controls for these automatic warning devices are interconnected with the basic element of the railroad's signal system — namely, the track circuit. It is essential for safety that such warning devices be installed correctly and by skilled men who are knowledgeable about signaling. It is not enough to be an electrician, one must have specific and particular skills in signal work to properly install these automatic warning devices. That is why, we in the BofRS insist that the men installing such equipment be skilled BofRS members.

We stand ready, willing and able to work with all parties concerned to provide the necessary skilled signalmen to install and maintain grade crossing warning systems.

Prepared Remarks

J. W. Walsh, Jr.

Vice President

Brotherhood of Railroad Signalmen

As regards program management, we in the BofRS, are desirous of becoming active partners, and I will make my remarks concerning the installation and maintenance of grade crossing warning systems. President Chamberlain briefly touched on the policy of the Brotherhood of Railroad Signalmen in this regards, but "to keep the record straight," as they say, we do insist that the men who install and maintain these grade crossing warning systems — that is, automatic flashing-light signals and automatic half-gates — are members of the Brotherhood of Railroad Signalmen.

Of course, we have signed agreements with railroads for BofRS men to do this work, but it is also logical that our members who are skilled technicians in signal work perform the installation and maintenance function.

We have worked with several railroads and with manufacturers of automatic warning devices to obtain and train men to become skilled signalmen, whom we represent.

We have worked closely with the Federal Railroad Administration on signal matters, and I am sure we can work as closely with state and local governmental agencies in this matter of grade crossing safety. Several of our members have become signal and train control inspectors with FRA. Our cooperation with FRA in this matter could also be carried out with state agencies as well.

Because our men are skilled in signal work, and because we have members working in every state in the continental U.S., BofRS can provide an advisory member to every state transportation department or state highway agency that is concerned with grade crossing safety. Our signal expert, if you wish, could provide valuable experience, knowledge and help in planning the implementation of grade crossing safety programs. He could be the expert as regards installation of automatic warning devices — not only the how but the where so that effective use of such devices would be obtained.

The key to implementation of the Florida program has been the continuing cooperation of the railroads, signalmen, manufacturers and the state department of transportation. Meetings are held every three months by the state DOT secretary in which all concerned parties participate. BofRS has been very active in this activity, and will continue to do so. We have an obligation to the public to implement these grade crossing safety programs. Also, we have an open door policy of discussing the situation with all parties concerned. These state DOT meetings are most important.

BofRS stands ready to offer its services to federal, state and local governmental agencies in this program to improve safety at rail-highway grade crossings. Let us help you, I'm sure we can.

Session II

New Approaches To Program Management

Lamar H. Hargrove
State Railroad Coordinator
Florida Department of Transportation

First, let me give you some background of the Florida Department of Transportation and how it relates to railroads. Then I will deal more specifically with the subjects of new approaches to accelerate projects, priority systems, master agreements, contracting design and installation of warning devices, equipment standardization, material stockpiling and shared maintenance.

In 1967, the Florida Legislature created a new agency, the Department of Transportation. Its primary functions were to plan, develop and provide the state of Florida the most efficient, balanced and safest transportation system in the USA and to develop the most efficient and effectively managed Department of Transportation organization in the USA. Also created was a Transportation Commission to "approve all rules and regulations adopted by the Transportation Department" and a Transportation authority to "coordinate the functions of the Public Service Commission, the State Road Department and the Department of Transportation." However, the Department of Transportation primarily was concerned with transportation policy and planning and exercised no control over state highway functions still under the State Road Department except through the "advisory coordination" of the Transportation Authority.

Under the Governmental Reorganization Act of 1969 the Department of Transportation was reconstituted to include the following agencies: The State Road Board, the State Road Department, the State Turnpike Authority, the Board of Highway Secondary Trustees and the Aviation Section of the Board of Commissioners and State Institutions, the Transportation Commission, and the Transportation Authority. The Department of Transportation in the state of Florida is headed by a Secretary of Transportation appointed by the Governor and subject to Senate confirmation, there are four divisions: Division of Administration, Division of Road Operation, Division of Transportation Planning and Programming and the Division of Mass Transit Operations.

In 1970, legislation was passed to allow gasoline tax revenue funds to be used for all transportation purposes, rather than strictly highway purposes.

Florida has 11,107 miles of primary roads and 3,331 miles of secondary roads on the state maintained system. This does not include 963 miles of interstate highway constructed so far and 30,516 miles of city and county paved roads.

Since the concept of the Department of Transportation, it has been the purpose of the state government to develop a compatible transportation network consisting not only of state highways, but including all other streets and roads and all other modes of transportation, such as railroads. It has been necessary to establish additional at-grade rail/highway crossing. It has also been necessary in this development of a compatible transportation network, to close some at-grade rail/highway crossings. It also has been necessary to deny the establishment of additional railroad spurs or tracks over certain highways in the state.

Railroads operate 4,215 miles of mainline in Florida. In this network of railroads there are 8,784 crossings; 283 of these are grade separations which leaves a total of 8,511 at-grade rail/highway crossings. Of this total, 1,857 crossings have no signalization, at all. This information we determined from the data at the completion of Florida's grade crossing inventory.

The extensive highway construction within the boundaries of the state of Florida cannot be accomplished fully without the cooperation of those who own and operate the most attractive traffic corridors in the state, the railroads. Unlike the State Road Department which existed prior to 1969, the Department of Transportation includes the railroads in all plans of future project for development within the state. The goal is to keep the railroads informed and the end result is the project concept can be accelerated to complete plans development and contract letting.

At the 1972 National Conference on Railroad-Highway Grade Crossing Safety, Mr. Ed Mueller, then Senior Engineering Advisor to the Secretary of the Florida Department of Transporation, reported 67 persons died in Florida in 1971 in rail/highway crossing accidents, and 300 persons suffered serious or permanent injuries in this type of tragedy. Recent reports from our Department's safety section indicate 78 persons were killed and 266 suffered serious injuries in 1973. The economic loss in 1971 was calculated at 5 million dollars, and in 1973, the economic loss was calculated to 7.3 million dollars.

At the 1972 Conference, Mr. Mueller made a presentation regarding implementation problems related to the rail/highway grade crossing safety program. The problems have been reduced, but not eliminated.

New Approaches To Streamline the Implementation Process and Accelerate Projects

In 1966, the State Road Department of Florida, had, as many Highway Departments did, a hazard index formula. This was applied to an inventory conducted in 1971 rail crossings on all state roads. A new hazard index was computed based on the inventory data accumulated and a list of priorities was generated according to relative hazards of each crossing involved.

The system did not fulfill the overall need. One main reason was that no funds were set aside specifically for installation of recommended warning devices at the selected crossings. To improve the situation, the Florida Department of Transportation set aside $1,000,000 in state funds in its 1971 construction budget to fund improvements at crossings identified as most dangerous. The inventory information available at that time was not complete and was limited to information on state roads, some 1,189 crossings or less than 20 percent of the crossings in Florida.

Immediately evident factors which had to be considered in accelerating the grade-crossing safety program were proper planning and budgeting for the expenditure of money. To plan and budget for these activities, it was similarly evident we had to know the *entire* highway rail intersection situation. This is the beginning of grade crossing inventory thoughts in Florida.

In May 1972, the Department announced to the railroads the need for the railroads to supply certain information on crossings on their system. The requested information was, in fact, needed, but the requirement placed an undue burden on the railroads. From May until November 1972 the process for acquiring this information was discussed with the railroads. In November 1972, the two railroads in Florida with the largest number of crossings were asked to conduct the inventory jointly with the Department on their lines. They were asked to supply a high/rail car and personnel to operate the equipment while Department personnel would accompany them to collect the data required to plan improvements. The plan was to collect the information from the rail frame to ensure the inventory of all existing crossings.

To establish the data base for the development of the Safety Index, the inventory data collected in the 1971 inventory was used although certain protection type information, such as the presence of a flagman or the presence of automatic signals, was not collected in this inventory.

Each accident report was reviewed manually to ascertain the correct location, ensure that a train was involved and note the type of protection at the grade crossing. Railroad Company installation notices were reviewed to determine which year the signals were installed. Also, accident records from two railroad companies were reviewed. Various edit programs were run on the existing data and errors corrected where possible. Of the original 1189 crossings inventoried in 1971, 1144 valid records were utilized.

Since the object is to relate the variations in accidents to physical characteristics and since the accident distribution did have considerable variations, the theory of linear statistical models has been applied.

Each grade crossing has a particular environment. Factors comprising the environment either increase or decrease the potential for an accident. The most significant quantifiable factors are used in calculating the accident potential. The relative influence of additional factors such as parallel roads, are being researched. The factors selected as those most influencing the probable number of train vehicle collisions per year are: average daily traffic, number of trains per day, maximum train speed, type of crossing warning devices, highway speed limit, number of lanes, ability of driver to see approaching train and vehicle stopping sight distance.

The model for predicting the number of accidents is based upon a study, using regression analysis techniques, "Influencing Factors for Rail/Highway Grade Crossing Accidents in Florida" by Dr. Gerald Van Belle, Professor at Florida State University. The approach utilized was influenced by research conducted by Allan M. Voorhees and Associates, published in the National Cooperative Highway Research Program Report Number 50, "Factors Influencing Safety at Highway Rail Grade Crossings" and "Study for Rail Highway Grade Crossing."

The FSU study states: "The precision of this accident prediction is limited by three (3) components of an inherent variation:

1. Inherent variations at a particular crossing which would exist even if all available influencing variables were held a constant.

2. Grouping of casual variables such as, characterizing average daily traffic by an estimate from the middle of the 5 year period (assuming the

variable of interest is number of accidents per year), or, predicting annual rates from 5 year or 6 year totals.

3. Failure to include all independent variables."

The Safety Index was designed as a guide for determining construction priority. The Safety Index used the premise that as the probability of accidents increases, the opportunity for accident prevention also increases. The grade crossing with the greatest accident probability will receive the lowest safety index. It has been determined that the maximum risk index value attainable for any grade crossing is 90.

The details of the formula are too voluminous to discuss at this time. The point is, the formula was applied to all crossings inventoried in 1973 to determine the safety indices for all grade crossings.

The guidelines, established by the Department for grade crossing warning device improvement or initial installations, use the safety index as the major factor in establishing priorities, except in mandatory schedules due to highway construction. All grade crossings with a safety index below 60 shall be considered for improvement. Grade crossings with hazards reflected by the safety index and those grade crossings with only passive warning and a safety index above 60 also may be considered for improvement. The safety index is listed on the computer printout selected in the 1973 inventory.

Now, with this information available and the calculated safety index indicating the need for improvement at each crossing on each system of highway, the selection apparently must be made from each of the highway or street systems.

Systems Approach

As of April 30, 1974, the Department had 226 currently proposed projects involving installation or modification of existing crossing warning devices. The annual construction capability of the railroads in Florida has been determined to be 200 projects. This determination was made by consulting with the railroads and receiving their commitment of their ability.

By using the railroads' figure the Department then proposed a 5 year funding program, beginning with the 1974-75 fiscal year, annually to fund 200 warning devices, divided between the various highway and street systems and applying the money available under the 1973 Highway Act to the various systems.

The first year of the system funding includes 50 projects for which funds were obligated from the emergency highway funds released in 1971, and referred to as EHS projects. The 5 year program by highway system and section of the 1973 Highway Act is as follows:

Existing safety projects (50) costing $1,245.000; state primary system on federal aid system under Section 203, 92 crossing costing $4,048,000; Department of Transportation maintained secondary system on federal aid system under Section 203, 57 crossings costing $2,177,000; city or county maintained roads on federal aid system under 203, 189 crossings costing $7,243,000; Department of Transportation maintained highways not on the federal aid system under Section 230, 46 crossings costing $1,794,000; city or county maintained roads not on federal aid system under Section 230, 566 crossings costing $18,654,000. The total 5 year program of 1,000 crossing signalizations amounts to $35,152,000. The only signilization needed at the expiration of the program will be on the city or county maintained roads not on the federal aid system.

These figures are further distributed by year to each railroad operating in the state of Florida and dependent upon each lines capabilities along with the highway system involved.

On April 25, 1974, the Florida Department of Transportation forwarded to the Federal Highway Administration the Department's Grade Crossing Improvement Program, as required by Section 203, and Section 230 of the 1973 Highway Act. The program was approved May 15, 1974.

The inventory, the administrators' and coordinators of it, the computer program, the 1973 Highway Act, the cooperation of various railroads operating in Florida, the assistance, advice and cooperation of the division office of the Federal Highway Administration and surely not least, the interest and cooperation of the equipment manufacturers, all have contributed to produce a 5 year program we think is a good program and one we can all live with. I mean literally *LIVE* with.

This idea of system programing and funding is not limited or restricted to a highway systems. Our Division of Mass Transit Operations is reviewing and planning with the railroad companies high speed ground transportation corridors. These corridors, when studies are completed, will require safety improvement and will be added to the above program.

Some other types of system approaches were funded under the TOPICS Program before the inventory, or the 1973 Highway Act. In one instance, 28 warning devices were installed in the city of Orlando under the TOPICS Program and five warning devices in a city just south of Orlando named Kissimmee, located on the same rail line as that passing through Orlando.

The funding of the grade crossing program from the state and federal level is not complex, except, that it requires two submissions to the Federal Highway Administration, one to obtain approval and one to obtain authority to proceed on each project location. The funding really becomes a burden of the railroad companies first to finance and then submit bills for reimbursement. This procedure has an inherent built-in delay of one type or another. In an effort to overcome delay of any kind in the warning devices installation program, the Department reviewed several avenues. The ideas of master agreements, contracting designs and installations, standardization of equipment components, stock piling materials and the state sharing in the maintenance cost were explored.

Master Agreements

The idea of master agreements covering a number of specific locations is not new to the Department. The idea has been employed since 1934. This type of "master agreement" whereby the locations are identified with estimates of cost was employed to obligate 3.5 million dollars of the emergency highway release funds.

We realized a true "master agreement" would save valuable time in the negotiation stages involving grade crossings and warning devices. With a master agreement, change orders to these agreements could be used and would be utilized when no agreement or record existed for a particular location. The terms and conditions were previously negotiated on an individual basis with an individual agreement.

On January 28, 1972, we sent each of the railroads operating in the state of Florida a draft master agreement covering grade crossings and grade crossing warning devices. We advised each railroad that the intent of the documents was to circumvent the necessity of processing for legal execution a separate agreement for each individual state highway project involving grade crossings and/or signals controlled or operated by their companies. We advised them no provision in the agreement had been changed from those previously executed by them. The agreement proposal was not retroactive and would apply only on those future highway projects wherein they receive an individual project notice according to the terms of the document on, or after the date of the execution of the agreements. We further advised this procedure did not involve any change in current liaison procedures and predesign conferences or normal development of railway crossing and signal plans or scheduling.

Now, the first two clauses of the Warning Device Master Agreement read as follows:

"Whereas, the Department proposes to engage in certain projects for the construction, reconstruction or other change of portions of the State Highway System which will call for the installation and adjustment of automatic grade crossing signals and other protective devices;

And WHEREAS, the plans for said construction, reconstruction or other change are to be reviewed by the DEPARTMENT and the COMPANY;"

Paragraph 1 of this agreement reads: "When the DEPARTMENT has served an order on the COMPANY regarding the installation of automatic grade crossing signals and other protective devices on said highway projects, the company will prepare detailed plans and specifications of the work to be performed, which plans and specifications will be in accordance with DEPARTMENT'S Plans and Standard Index Number 1467, and supplements thereto, or revisions thereof as of the date of this agreement, attached herto and by this reference made a part hereof. The COMPANY hereby agrees that it will clearly state the applicable sheet number of the DEPARTMENT'S Standard Index number 1467 in its plans and specifications."

Paragraph 2 of the agreement states: "The COMPANY shall furnish the necessary materials and install automatic grade crossing signals and other protective devices on an actual cost basis and in accordance with DEPARTMENT'S Plan and Standard Index Number 1467."

The objections to the (WHEREAS) clauses raised by one company were that these clauses provide for review of plans for the installation of the railroad grade crossing warning devices by both parties, but, Paragraph 1 and 2 permit the Department to order the company to install devices without requirement for hearing or determination of public need.

Paragraph 3 of the agreement provided that the department or the Department's contractor shall give the company's division engineer or superintendent at least 48 hours notice prior to the performance of any work within the limits of the company's right of way. The provision was objected to by one railroad which wanted this notice extended to 72 hours.

The one company having the most objections to the master agreements concluded by saying the company did not approve of a blanket agreement for installations. It had been their experience that nearly every situation was different and they felt each crossing should be handled on its individual merits.

We are pleased, however, with the response of the railroads signing master agreements. All except one of the railroads operating in Florida have signed agreements. The result is less time involved in negotiations for crossing and/or crossing warning devices. The one railroad which did not sign the agreement simply did not like blanket agreements.

Contracting Design and Installation

The secretary of the Florida Department of Transportation conducts, usually quarterly, the Secretary's Railroad Conference. Since establishment of these conferences, railroad management can, and often does receive quick, efficient and binding administrative decisions from the executive level of the Department of Transportation. This eliminates costly time-consuming negotiations for Department and/or railroad projects.

At the September 29, 1971, Secretary's Railroad Conference, the subject of railroad signal contracts was discussed in connection with the backlog of signal projects. A method was sought for greatly increasing the rate of installations in Florida.

Subsequent to that discussion, we developed a proposal for each company's consideration. It was a contract arrangement wherein the Department would be responsible for signal placement including foundations, cables, masts (complete), cantilevers, gates, control boxes, conduit, etc. The company would be responsible for all track circuit work, interconnection hook-ups, testing and other necessary work to place the device in service.

After forwarding the sample proposal to each railroad operating in the state, a personal visit took place with each officer of the company involved.

These personal visits and conferences revealed the proposal as originally submitted was impractical because of existing working agreements between the companies and the Brotherhood or Railway Signalmen. However, the Brotherhood recognized the significant values to be enjoyed if the signalization program could be accelerated.

With this attitude existing, two railroads in Florida negotiated new agreements with the Brotherhood to allow the companies to contract signal installation projects at specified locations not in railroad-signalized territory. There were restrictions in the newly-negotiated Brotherhood of Railway Signalmen agreements, but this step has been instrumental in completion of 43 installations we feel would have been delayed for an extreme period of time, or not installed to date. The first project to be installed by contract awarded by a railroad under this agreement was in May 1973.

The procedure followed in contracting by a railroad company is explained briefly as follows:

1. The Department assembles recommendations to be sumbitted to the railroad company consisting of site plans and work description of what is proposed.
2. The railroad company then prepares their own site plans and estimates and returns them to the Department indicating whether or not the project is to be contracted.
3. The necessary document is prepared, either a change order to the master agreement, a change order to an existing agreement or an individual agreement if the project is off the state maintained system.
4. This document then is funded and executed on behalf of the Department. If federal aid is involved, approval is obtained from the Federal Highway Administration.
5. The authorization to proceed with the installations by contract in compliance with PPM 30-11 is furnished the railroad.
6. The railroad then solicits bids from bidders qualified with their company.
7. A tabulation of bids received by the railroad is then furnished to the Department for concurrence in the award.
8. If federal aid is involved, the Department obtains concurrence from the Federal Highway Administration relative to the concurrence.
9. The lowest bid is concurred with a railroad is so advised.

We have found that design of these projects by outside parties on a contract basis would assist in speeding up the rate of installation. The railroad with the largest backlog is continuing to perform final engineering with their own forces, but are arranging for some engineering to be done by contract.

We have suggested that this final engineering and design be contracted when the forces of the railroad are not sufficient to keep up with the projects pending.

Standardization Of Equipment Components

Standardization of equipment is related closely to stockpiling materials in the Florida program to accelerate installation of projects. We do not intend that standardization of equipment components will decrease innovative design, reduce quality of warning, or adjust quality of products already in use. It is a recommendation that like components be purchased in quantities, rather than individual orders or requisitions from the company stores or stocks. It must be emphasized we recognize each project has unique characteristics requiring individual engineering and design to meet criteria for maximum warning.

However, stockpiling of material can relieve the railroads of financial burden and give direction to the manufacturers for their production schedules.

Stockpiling Materials

The idea of stockpiling materials has been generated through the course of pinpointing delays in the installation of warning devices.

On December 13, 1973, we wrote to all railroads in Florida appealing to them to review the situation in order to meet the commitment made to the Florida Senate Transportation Committee in February of 1973. That commitment was:

> 200 completed warning device projects annually. Each company was shown its production as reflected by the Department's records and list of needs. One railroad responded in detail regarding progress and problems. This particular railroad is assigned 160 installations annually in Florida.

Part of their response to our appeal was as follows:

"On the basis of 160 installations annually, we must install them at an average rate of thirteen (13) per month. Based on cost of thirteen (13) installations for which bills were prepared in December, 1973, we funded material procured on a four (4) to six (6) months' lead time valued at approximately $200,000. To assure that this specialized material is available when needed, it must be ordered months in advance to afford an adquate stockpile from which to work. We need relief from the requirement of advancing $2,400,000 annually for this purpose. We believe that a satisfactory arrangement can be worked out whereby we order the materials for your account, consigned to you at your warehouse in Florida. As projects require, your personnel would load material in a boxcar at the warehouse, and we would accept delivery there and arrange transportation to the worksite. We will furnish personnel familiar with the equipment to assist your personnel, if you wish. We request that you give this matter favorable consideration. The non-availability of material has made it necessary to divert forces from crossing signal projects to other work in Florida on several occasions in 1973. We anticipate that lead time on signal material will increase substantially in 1974 and 1975."

The ideal of Florida warehousing the components of specialized material for these projects was discussed with Department personnel and Federal Highway Administration on February 26, 1974. While this idea was found to be unworkable in view of state laws regarding bidding practices and already burdened warehouse availability, reimbursement procedures were progressed to the extent a firm commitment was obtained from Department management and the Federal Highway Administration that major materials could be ordered by the company and be reimbursed by the Department when the material payment becomes an obligation of the company. This obligation has been construed to be a "cost incurred."

The refinement of this approach has not been developed fully at this time, but it is Florida's intention to pursue the matter starting first with 21 projects of the Emergency Highway Safety program.

This idea is further supported in the new draft of PPM-3, Paragraph 12A, which reads as follows:

BILLINGS

A. "After the executed State-Railroad agreement has been approved by the Division Engineer, the Company may begin to submit monthly progress billings of incurred costs. Materials stockpiled at the project site or materials specifically purchased and delivered to the Company for use on the project may be reimbursed on monthly progress billings. One final and complete billing of all incurred cost shall be made at the earliest practicable date."

With this idea expressed concisely in the new draft of the PPM 30-3, the railroad companies should have little doubt that capital outlay burden can be passed on to the state agency immediately.

In the area of financial burden relief, such as stockpiling materials or materials procurement processes, Florida has adopted a shared maintenance responsibility.

Shared Maintenance Responsibilities

With the warning device installation program anticipated to increase, the railroads were concerned, as was the Department, regarding proper maintenance of the devices. The Department felt, too, an incentive program to increase the number of installations was in order. Several meetings were held regarding this subject. Finally, on January 15, 1971, at a Secretary's Railroad Conference, the decision was made for Florida to participate in the maintenance cost of warning devices.

To arrive at Florida's amount of participation, a review was made of the October 1963 report of the Communications and Signal Section, Highway Grade Crossing Protective Committee of the Association of the American Railroads. The report showed the results of a study on 73 installations of warning devices on 41 railroads. Annual costs were developed for both flashing light signals and flashing light signals with gates. Virginia and North Carolina had classified warning devices as follows:

Class	Description
I	Flashing signals – one track
II	Flashing signals – multiple tracks
III	Flashing signals and gates – multiple tracks
IV	Flashing signals and gates – multiple tracks

The costs, as given in the Association of American Railroads report, involved Classes I and IV. Interpolation was used to develop costs for Classes II and III. By comparing the costs reflected in the Association of American Railroads' study and the costs used in the states of Virginia and North Carolina, the Department adopted as cost the lowest figures for each class as was determined from available figures. The Department adopted an Administrative Rule to permit annual payment of 50 percent of the costs reflected on any installation after February 3, 1971. This amounts to $325 to $615 annually on any installation installed after that date.

Success To Date

Now, let us review for a few moments what Florida has done in the past few years to accelerate the grade crossing safety program. We have:

1. Completed the grade crossing inventory and numbering program;
2. Developed a formula through a study with Florida State University to determine a safety index rating of each crossing inventoried to enable a priority rating of all crossing in Florida;
3. Developed a computer program to enable setting of train speeds and highway speeds in certain areas;
4. Acquired approval from the Federal Highway Administration of a five year program for grade crossing safety improvements;
5. Developed the master agreement concept to save time in negotiations;
6. Increased the ability of Florida to meet its goal of 200 installations per year through installations by railroad qualified contractors.
7. Encouraged railroad purchase of multiple project standard components in large quantities with assurance of prompt reimbursement; and
8. Developed a fair and equitable maintenance sharing policy.

Other means of accelerating Florida's Program have contributed greatly to accomplishing results. This includes:

The Secretary's Railroad Conference

At this conference, the Secretary and those attending speak freely of the problems and the recommendations to solve the problems before us. The conferences are attended by representatives of the railroads, the Brotherhood of Railway Signalmen, Association of American Railroads, Federal Highway Administration, State Senate and House Representative Transportation Committee staff directors and equipment manufacturers along with selected staff and division directors of the Department of Transportation.

The overall Rail/Highway Program has gained considerable attention and direction from these conferences.

Special Legislation has been of great assistance to the Department and the railroads in establishing a more uniform program, that is, a transportation network not fragmented by jurisdiction, by act of the 1972 Legislature, Section 338.21 Florida Statutes was amended to become effective July 1, 1972. It authorized the Department to:

1. Eliminate all highway crossing hazards;
2. Have regulatory authority over all public railroad crossings;
3. Issue permits to open or close such crossings;
4. Regulate speed limits of railroad traffic; and
5. Give notice and conduct public hearings on this subject.
6. Enforcement of this act is provided in Section 316.016 Florida Statutes and all statutes in conflict were repealed.

Future Potential

Needless to say, we feel our future potential is great. We have the program. We have the legislation. We have the cooperation of the railroads in trying to adjust the work forces. We have the cooperation of Brotherhoods to allow contracting when railroads forces are exhausted. The Federal Highway Administration is leading assistance and advice. Department management has authorized the establishment of district railroad coordinators in each of our five district to coordinate field review from concept to completion of installations. With all of this, our future is great.

Thank you for the opportunity to share with you Florida's activity and Florida's concern in this very important field of grade crossing safety.

Panel II

"A panel discussion and open forum on issues related to "New Approaches to Program Management."

Moderator: James E. Kirk, Chief, Railroads and Utilities Branch, Federal Highway Administration

Panel Members

Lamar Hargrove

Thomas B. Hutcheson, Assistant Vice President Engineering, Seaboard Coastline Railroad Company

Joseph Walsh, Vice President Brotherhood of Railway Signalmen

Gene Harmon, President Harmon Industries

William L. Oliver, Principal Transportation Division California Public Utilities Commission

Prepared Remarks

James E. Kirk

Chief, Railroads and Utilities Branch

Federal Highway Administration

Introduction

The purpose of this session is to afford an opportunity to all in attendance to participate in an open forum discussion of those issues related to "New Approaches to Program Management." This includes the issues identified in the paper presented this morning by Mr. Hargrove (Florida), as well as any other ones which warrant discussion at this time – ones which must be dealt with effectively to successfully advance an accelerated program.

Funds are now available at the federal and state level for a strong program of grade crossing safety. Are all the "partners in improvement" ready to advance this program in a timely and efficient manner? Or are we going to continue to add to the present backlog of grade crossing safety improvements which, under the federal-aid highway program, has reached the staggering total of more than 700 crossing improvement projects. These are projects for which funds have been obligated over the past several years but for which installation work is not yet complete. The total estimated cost of these projects is in the order of $22 million, involving about $21 million of federal funds.

The answer is fairly obvious. We not only have to find ways to promptly reduce this backlog but we must begin to utilize on a broader basis some of the "New Approaches to Program Management"; those which are now being employed by only a few states and railroads. We must also be alert for other techniques; ones that will meet the challenge and promise offered by the new legislation; and ones that will advance an accelerated program in a timely and efficient manner. To do otherwise could convince the Congress that we neither have the skill nor the will to cope with the challenge or meet the promise.

While the answer may be obvious, the solution is not. In seeking a solution, I am first going to ask each of our distinguished panelists to respond briefly from the view of the organization or industry he represents. I will then briefly discuss what the Federal Highway Administration is doing to meet this challenge. Following these presentations, the session will then proceed as an open forum with questions and discussions from the floor. All of you are encouraged to participate. Feel free to direct questions or remarks to members of the panel or others in attendance.

FHWA's Position on New Approaches to Program Management

The Federal Highway Administration is taking steps, as Mr. Hargrove mentioned this morning to simplify our procedures and to encourage accelerated safety programs. New instructions for implementing highway safety programs under the Highway Safety Act of 1973, were issued on July 3, 1974. (They are contained in Volume 6, Chapter 8, Section 2, Subsection 1 of the Federal-Aid Highway Program Manual.) This directive has been made available to the states and to the railroad industry through AAR.

The directive advocates the use of certain timesaving procedures for specific projects on various types of safety improvement projects. These include the grouping of several improvements under a single project. Improvements may be grouped by federal-aid system, geographic area, improvement type, railroad company, or other similar methods. In taking advantage of this provision a number of states have included several sites for installing train-activated warning devices under a single project. Others have advanced signing and marking projects on an areawide basis by railroads.

Revised directives to replace Policy and Procedure Memorandums 21-10 and 30-3 have recently been drafted and circulated for comment by FHWA field offices, the states and railroads. A primary objective is to facilitate and encourage accelerated grade crossing safety improvement programs. The proposed engineering directive includes and encourages the use of a simplified procedure for accelerating grade crossing improvements. This procedure provides for the use of a simplified written agreement covering single or multiple improvements at an early stage in the program planning. The final complete agreement would not be required until physical construction is ready to begin. Under this proposed procedure, individual railroad companies and states are encouraged to get together and develop a list of grade crossing improvement projects which can reasonably be expected to reach the construction stage within 1 year and be completed within 2 years after the initial authorization date.

A provision is being added which would permit reimbursement on monthly progress billings for materials stockpiled at a project site or materials specifically purchased and delivered to a railroad company for use on the project. This will permit better planning and scheduling for the design, procurement of materials, and installation work. The resulting increased lead time should help to accelerate the design and installation process.

An option is being added which would permit a state and railroad to reach agreement for final payment on the basis of a predetermined lump-sum amount in lieu of actual costs incurred for the installation or improvement of grade crossing warning devices and certain other work.

A proposed management by selection process (as opposed to a case by case review) has been added. Its use is to be at the election of the state. Under this alternate procedure, following the programming of projects, the state will act in the relative position of FHWA's division engineer on all actions for advancing and completing grade crossing safety improvements and minor adjustments to railroad facilities. Savings in review time and the processing of paper work will be significant.

Other proposed time saving features of the new directives include examples of model cost estimates to support authorizations to proceed, provision for the use of master agreements, and a simplified system for classifying projects. All of the foregoing steps, and others not mentioned at this time, combine to represent a monumental effort to cut red-tape and modernize procedures leading to a favorable environment for advancing an accelerated program of grade crossing safety. Are our "partners in improvement" ready and willing to match this effort?

Thomas B. Hutcheson
Assistant Vice President - Engineering
Seaboard Coastline Railroad Company

In the four years which have passed since the Georgia Tech conference held in August, 1970, when I last had the privilege of appearing on the program of these conferences, there has been a considerable increase in the level of activity in installing grade crossing warning devices.

Much of this increased activity dates from the Highway and Rail Safety Acts of 1970 and publication of the REPORT TO CONGRESS ON RAILROAD-HIGHWAY SAFETY, prepared by the Federal Department of Transportation and published in two parts.

These reports set the basis for enactment of the Federal Highway Act of 1973, which instituted a much expanded federal role in funding of grade crossing protection. This increased level of federal participation, including a provision for participation of the federal system, together with the TOPICS program, the release of emergency highway safety funds, increased activity at the state and local level, and federal urban demonstration projects have resulted in a substantial increase in the number of crossing warning devices installed.

On the Seaboard Coast Line, installations for the system have increased from a level of 70 per year for the years 1970-72 to 111 in 1973, and in 1974 are expected to reach an annual rate of 200 installations.

The state of Florida has been in the forefront in development of a program for installation of grade crossing warning devices. As you have heard from Mr. Hargrove earlier, Florida was in position, through prior preparation, to move quickly into the expanded federal program and, at the same time, to substantially step up its own highway-railway crossing program. SCL installations in Florida have increased from a level of about 37 crossings in 1970-72 to 63 in 1973, and expected to reach an annual rate of 160 in 1974.

Since SCL has a major involvement in Florida with 2,896 miles of track, or 32 percent of its line mileage, and 70 percent of the state's rail mileage, it is deeply involved with the Florida Department of Transportation's expanded program. This has required the closest liaison with the Florida DOT while, at the same time, maintaining a proper stance with other states through which we operate, whose programs are also on the increase.

The accelerated program of installing crossing warning devices came at a time when the Railroad's signal forces are also engaged in a major program to expand and improve its rail traffic control signal system.

The execution of this major expansion in signal construction requirement has indeed required that we look to new approaches to program management. What has been accomplished could only have been done with the closest cooperation of each organization involved.

A major step forward has been the successful use of a type of open end master agreement in the grade crossing situation. The use of the master agreement simplifies the negotiation process and saves a tremendous amount of paper and time. It defines provisions applicable to all situations and contains a provision to add individual projects by appropriate change orders issued to bring additional crossings under the master agreement. The change order defines the added project by DOT number, name or number of road, type of crossing or extent of warning devices, gives Railroad's mile post tie in, inventory number and estimated cost. Our experience with this type of agreement has been most satisfactory, and its use has substantially reduced administrative time.

The inventory of highway-railway crossings taken jointly by the Railroad and Florida DOT as a pilot project under FRA grade crossing inventory has been used in establishing priorities based on a risk index used by DOT to develop its program. Adherence to this priority program by DOT and the Railroad enables both to establish workable administrative, design, material acquisition and construction programs, which allow for an orderly progression of work and expedites project completion.

The greatly increased program in Florida and other states through which we operate has overtaxed our construction forces. With the cooperation of the Brotherhood of Railroad Signalmen, the Federal DOT, the Association of American Railroads and others interested, agreement has been reached for the contracting of some of the work for the initial installation of warning devices. This step has been an important factor in increasing the installation rate. This support of the program by the Signalmen's organization represents an important contribution to crossing safety.

In order to meet design schedules imposed by the greatly increased activity, we have supplemented the Railroad's design staff by the use of consultants. This has been accomplished using the process contained in procedures manual.

A major concern on the part of the Railroad has been the high level at which its funds are involved in the program. This problem has been attacked at two levels. First, arrangements were established with the various Departments to render billing on 90 percent of the estimated cost at the time of physical completion, with final billing after accounting is complete. This program is working satisfactorily.

A second proposal is now under active study by the Florida DOT and the railroad to forecast and order major items of materials and equipment for those projects confirmed to the railroad from the priority list. Under this proposal, materials would be ordered by the railroad and shipped to a special warehouse where they are to be checked and assigned by project. The railroad would then approve and pay invoices for materials and bill DOT for cost of materials received. When forces move in for construction, materials would be sent to the site. After installation, the railroad would prepare a partial bill for 90 percent of the estimated cost, less materials previously paid for by the Department, with final billing to be rendered after accounting in the usual manner. This procedure, or a similar one, would reduce the railroad's carrying cost for projects and speed up delivery of commonly used components in an ongoing program.

With the expanded federal emphasis on grade crossing safety and increasing demands at the state legislative level for grade crossing safety and increasing demands at the state legislative level for grade crossing protection, the most essential ingredient in the successful management of a crossing warning device installation program is close liaison between the individual railroads and the Departments. When this is established and working, a program of agreement document simplification, a site specific program based on a risk or hazard index, and an acceptable plan for reducing the carrying cost of the program to the railroad by using appropriated funds at the earliest time consistent with adequate controls will greatly assist program management from the railroad viewpoint.

William L. Oliver
Principal, Transportation Division
California Public Utilities Commission

First, I would like to say that it is a pleasure to be in this beautiful state and also that any opinions I may express are strictly my own and not those of the California Public Utilities Commission. One disadvantage of being last on such a distinguished panel is that by the time it is your turn to make some comments they have already been made. However, I would like to start and make some comments on Mr. Hargrove's presentation and later make some general comments as to the subject of program management. From an analysis on this paper it is fairly clear that Florida has established an excellent program in a very short period of time. I was wondering how, with approximately 9,000 crossings in Florida and with 2,000 without even signs, how they came up with the figure of about 4,000 crossings or 45 percent of the total needing signalization. With all of the inquiries we get in California as to criteria, formulas, etc., I was curious as to how these numbers were developed. The quarterly meetings mentioned with the railroads appear to be an excellent management approach and good means of communication. Being from a public utility commission, I was curious as to how the July 1972 legislation that put the Florida DOT in charge of crossings, affected the Florida Public Service Commission and what it was doing, if anything, regarding railroads or grade crossing safety. Also, I wondered with DOT having the authority over crossing safety, how differences between the railroads and DOT were being resolved. In California, DOT and the railroads are the parties that most often appear before our Commission to resolve their differences. Also, I was wondering what the positions of the city and county governments were to this program since it appears that state highway crossings are being taken care of at the expense of county roads and city streets. From an analysis of some of the improvements, the average cost of installation of signals appears to be about $35,000. This seems high compared to our experiences in California. Also, I noticed there was very little mention of grade separation programs of planning or grade crossing elimination through separation. Florida's goal to signalize all grade crossings may be a little ambitious and it may be that funds should be spent on other projects such as grade separations, relocations and so forth, rather than signalizing crossings with little rail or vehicular usage. There was some mention as to the Florida Legislature hindering DOT's objectives and I was wondering what segment of the legislature was behind this and what the hinderance was. All in all, it appears that Florida has done a commendable job in getting grade crossing improvements under way.

I now would like to make some general comments or observations as to the subject of new approaches to program management. I am not sure all of these approaches are new but they may be new to some of us. It is my opinion that nobody from Florida, the railroads, the brotherhoods, Washington, DC or California can or should be telling you how to approach your own program management. Neither should you be patterning your program after others, even though they may appear to be highly successful. I would be wary of the claims of the results of some of these programs. I happen to believe, even though those in Washington, DC may not believe it, that most states have their own individual problems.

At this point I am presuming that every state has an adequate crossing inventory to use as a basis for crossing improvement and analysis. With this, my suggestion is that if you have not already done it, establish an accurate and complete accident reporting system for all of the railroad accidents, including crossings. Again, don't just accept others' forms. Find out what individual states, cities and countries require; then with great suspicion, analyze these accidents to see where your efforts should be concentrated to eliminate the largest number of accidents, fatalities and injuries and reduce property damage. If you don't have a problem in one area, don't fall into the trap of establishing a problem in one area, don't fall into the trap of establishing a program just to say you have one. Your problem may be closures, or signing or signalling or grade separation or track relocation or street relocation or a combination of all of these. It may be much better to signalize 50 crossings rather than construct one expensive grade separation or it may be better to construct one expensive grade separation and close 50 unnecessary crossings. You should make an analysis at least annually and that doesn't mean just produce an annual accident report. You should review the results and compare them against other years, other states, etc. You should analyze improvements you made to see what they produced and their effectiveness. And, most importantly, you should analyze your program to see if you are spending your time and money where it is doing the most good in improving grade crossing safety. In order to do this, you must have the authority to do several things. You must have control over the establishment of new crossings so that your problems are not growing faster than your solutions. You must have the ability to close unnecessary crossings. You must have the authority to order existing crossings improved up to ordering a grade separation's construction.

From here I would like to paint, with a broad brush, as to program management. I hear a lot about safe highway systems, safe county road systems, safe city streets and this has been the approach that city and county and state DOT people have been using. I would like to get away from index hazards, priority lists, criteria and etc. I think the approach to grade crossing safety should be to develop and establish a safe system of railroads, not only in cities, counties and states or certain areas, but throughout the nation. To steal someone else's language, an interstate railroad system should be developed. We should be analyzing total lines and systems of railroads, not individual crossings, accidents, etc. We should now be in a position to reach out and take great strides in grade crossing safety. It is my opinion that if the federal government will implement their program and require state DOT's to carry out these programs, and make the money they have been promising available, then this type of a program can be carried out.

Session III Establishing The Program Mix

Harry M. Williamson
Chief Engineer-System
Southern Pacific Transportation Company

In order to present to you my ideas on how to establish a total program on railroad grade crossing safety and how the various elements may be properly mixed, I would first like to discuss the several activities which can contribute to such safety and then examine the available methods of financing.

First, let me emphasize that no single agency can establish or implement a crossing safety program. At the minimum, it requires a cooperative partnership of the state, county or city having jurisdiction over the road, the state-wide regulatory body such as the public utilities commission, and the railroad. Many disciplines should be involved, such as civil, traffic and signal engineers; representatives of the managerial staff of the public agency; right of way experts; legal counsel; and last, but by no means least, law enforcement officials. Lay groups such as neighborhood improvement clubs and parent-teacher associations and the like can often add desirable input and assistance.

On a broad basis, a total program must consider many alternatives, and I am not going to discuss them in any special order of priority.

One of the first things to be considered is whether the particular crossing under investigation can be closed and traffic diverted to other nearby crossings with adequate warning devices or to nearby separated crossings. Such a suggestion is frequently met with vociferous objection from public officials, due to the circuitry of travel which may be presumed to be involved, but is not necessarily the fact. In this connection, consider, if you will, the analogy of freeway design standards. We are familiar with the situation where a freeway is constructed through an urbanized area and all intersecting streets are closed except where grade separation or interchanges are provided at about one-half to one mile intervals. Generally, the public accepts such minor inconveniences in favor of the great increase in safety by the elimination of intersections at grade. The situation involving the intersection at grade of streets and railroads is really not very different and the public should be willing to accept minor inconveniences and additional travel in order to cross railroads, where proper safety measures have been, or can be, provided. No one can argue with the fact that the safest of all intersections are those which "don't exist" – whether they be railroad-highway or highway-highway grade crossings.

Again, using the freeway analogy, a frequent tool of highway designers is to provide a frontage road parallel to the main traffic artery to collect vehicles and move them to points where the freeway may be crossed without intersection traffic. The same tool is available and should be used to enhance railroad grade crossing safety. Frequently, one encounters situations where the construction of a road parallel to the railroad, or the building of relatively simple and inexpensive connections between existing streets, will collect traffic and move it to locations where measures can be taken to eliminate, or greatly minimize, vehicle-train conflicts.

Having determined that a particular railroad-highway grade crossing cannot feasibly be closed, one must then determine the best method of increasing the safety of those vehicles using it–both automotive and train–consistent with the availability of public and private funds.

Only rarely will safety conditions alone warrant the construction of an overpass or underpass replacing a grade crossing. We therefore must then examine all of the relevant circumstances and decide how best to enhace safety at the crossing.

Among the first things which should be examined are the physical and geometric characteristics. Visibility of the train from the vehicle contributes to safety and often great improvement can be made by simple elimination of natural growth both on and off the railroad right of way. Railroads must guard against activities by themselves and by their tennants in spotting freight cars on side tracks too close to crossings and in permitting the construction of buildings and sign boards in locations which will impair visibility. Sometimes this results in friction between the engineer interested in grade crossing safety and the man in the real estate department interested in rental income. It is foolish economy to realize a few dollars from a lease if it may directly contribute to a crossing accident which could cost the owner of the right of way many times the rental income.

Of great importance are the angle of intersection between the road and the railroad, and the gradients on the road approaching the track. The optimum angle of intersection is 90 degrees and any substantial deviation from this increases the potential for accident. You are familiar with situations where a road runs nearly parallel with a railroad and then crosses it at a very flat angle. This is particularly objectionable in the case of high vehicle speeds because some drivers fail to turn their heads as sharply as necessary to observe the track in the quadrant with the acute angle. Another troublesome situation is the road parallel to the track which makes a sharp bend and then quickly intersects the track.

Some roads, especially in rural areas, are "humped" over the railroad with excessive gradients, preventing a full view of the railroad until the vehicle is too close to the track to take evasive action.

The correction of existing problems of alignment and grade is usually difficult and expensive, but any good safety program must consider them and attempt to find an economical solution.

Having concluded that a particular crossing cannot be closed and that the physical situation is, or will be, as good as can reasonably be achieved, we must then determine the kind of hardware justified to minimize the potential of train-vehicle accidents. Starting with what some might term the "lowest" form of protective devices and progressing to what is probably the "highest" and most efficient device, the more commonly used types of hardware are:

1. Passive devices such as crossbucks, and standard "stop" signs at the crossing and advance warning signs along the highway some distance from the crossing
2. Flashing light signals without gate arms
3. Cantilevered flashing light signals for multi-lane highways, and
4. Automatic gates.

You may have noticed my intentional omission of the wig-wag signal. This is an obsolete device and should not be considered for modern installations.

Another type of hardware which can and should be used to protect grade crossings in certain special circumstances is the conventional traffic signal, controlled or pre-empted by train movements. I am not recommending this for crossings in general, but it has value where a track runs along and within a street and is intersected by cross streets. In this situation, the railroad-highway crossing is really within the highway-highway crossing and a pre-empted traffic signal can readily furnish indications for all vehicles and train movements through the common grade crossing. Where such hardward is employed, a fail-safe method of operation during commercial power outages can be obtained without providing stand-by batteries. To do this, the signal heads governing the vehicular movements can be augmented with two special heads displaying either a red or green "X". When the red "X" is displayed, the train has to wait for it to change to green at which time the cross street traffic has been stopped. If, because of a power outage, no signal is displayed to the trains, basic railroad operating rules provide that the absence of a signal where one is usually shown is to be regarded as the most restrictive indication that can be given by that signal. In such a case, the train would have to stop and proceed through the intersection only under manual flagging protection.

I know of no way to determine in advance of a study the proper type of protective devices to be used at a given crossing. The selection can only be made after a careful review of all relevant factors. Neither do I believe in mathematical formulas which attempt to predict expected accident rates and costs, and which attempt to dictate the types of hardware to be used in given situations. There are simply too many variables subject to personal interpretation and evaluation to make the routine application of such formulas appropriate. I do know that the automatic gates generally provide greater safety, and my company has a policy to install them on any primary or branch main track where automatic devices are determined necessary. As an illustration, in a very recent year Southern Pacific installed 219 sets of gates and 59 of flashing lights—a ration of almost 4 to 1.

In considering any type of automatic device, one of the most important design criteria is the selection of proper control circuitry. One of the reasons the public does not always respect railroad warning signals is what I call the "credibility factor." When motorists become aware that railroad crossing signals operate for unnecessarily long periods of time in advance of the arrival of a train, or perhaps without a train arriving at all, they tend to ignore them with increasingly regularity. We must, therefore, make further use of sophisticated control devices like the grade crossing predictor, motion sensor, and others, which cause the crossing signals to operate for a pre-determined time in advance of the arrival of any train—and for no longer.

Another important aspect of grade crossing safety which must receive constant attention is the surface of the area common to the track and the highway. In passing over a grade crossing, the driver's principal attention should be directed to the avoidance of a collision with a train. If the crossing surface is uneven, the driver will be inclined to choose the smoothest path and the attention devoted to the observance of signals or an approaching train. To the extent possible, a grade crossing surface should be smooth and should lie in one plane without change in grade. There should be a smooth transition between the plane of the crossing and the gradient of the approaching highway. It is extremely important that the width of the crossing be at least equal to the width of the adjacent highway to prevent a vehicle's being caught between rails.

So far, I have talked about the measures which should be considered in those cases where one must accept the presence of a grade crossing and then attempt to make it as safe as possible under all of the circumstances. There are other, more exotic, methods which must be considered in special situations.

The separation of the grades of the railroad and the highway is the safest method short of outright elimination of the crossing. Earlier, I said that only rarely will safety conditions alone warrant the construction of an overpass or underpass, because a high degree of safety can be achieved by installing properly controlled automatic gates, and about 70 crossings can be equipped with such devices for the same expenditure as a grade separation priced at the relatively commonplace cost of two million dollars.

There will be occasions when the desire to eliminate vehicular delays and increase public convenience dictate the desirability of grade separations. Such projects can take the form of a simple structure carrying a road over or under a railroad, or they may involve a much more ambitious plan to relevate or depress a section of railroad so that all cross streets may pass beneath or above it. A case which comes to mind is in the city of Alhambra, California, where a plan is being developed to depress 2.8 miles of Southern Pacific main track and eliminate all 9 existing crossings in the city. Seven of the cross streets will be carried over the depressed railroad on simple bridges. The estimated cost is $11.5 million, which compares to an estimate of $10.5 million to construct conventional overpasses for only the three most important streets and $22.5 million for all seven streets.

Another type of project which is being considered by several municipalities on our lines is the relocation of railroads from the downtown core areas, or the combining of two or more railroads into a common corridor, for the purpose of minimizing grade crossings. Frequently, such horizontal relocations of railroads also require the construction of a limited number of relatively simple grade separations to carry the more important streets across the relocated, or combined, railroads.

Considering the fact that there are some 223,000 public grade crossings in the country, plus a possible equal number of private crossings, it is obvious that a program for total railway-highway crossing safety represents a staggering sum of money. The railroads cannot be expected to assume any substantial part of such a cost and the Federal Highway Administration has determined that the installation of protective devices is of no ascertainable net benefit to the railroads and that the elimination of grade crossings by the construction of separations is of only minor benefit, measured by a maximum railroad contribution of 5 percent.

Experience has also shown that local levels of government cannot finance the tremendous sums involved in total grade crossing safety, even though a few of the states have established very sizeable funds to assist cities and counties in defraying at least part of their shares of these costs.

The Federal Highway Act of 1973 is really the first significant break-through in the financing of crossing improvements and eliminations. It is true that, for many years, it has been possible to finance such projects under various federal highway assistance funds as "G" projects for the elimination of hazards at railway-highway crossings. Prior to the passage of the 1973 Act, the deficiency was that federal funds could be spent only on one of the federal aid routes.

This act, which is now Public Law No. 93-87, makes it possible to finance all of the many types of safety improvements which I have discussed with substantial federal fund participation, whether they be on one of the federal highway systems or on purely local roads or streets. Although this new legislation is directed primarily at the installation of protective devices, while leaving grade separation and similar elimination-type projects in other highway programs, it still provides funding for these kinds of projects on local roads. For example, Section 163, entitled "Demonstration Project – Railroad-Highway Crossings," authorizes funds for projects in 12 designated cities throughout the country. These are primarily the "exotic" types involving the relocation and combination of existing railroads.

Section 203 is for the improvement of crossings on the federal systems, but it is unique in requiring that at least half of the funds authorized shall be spent on protective devices, leaving the other half available for separations or other types of safety improvements. It is important to note that the $175 million authorized by this section is in addition to funds which may otherwise be available for the same purposes.

Section 230, called the "Federal-Aid Safer Roads Demonstration Program," authorized $250 million for three fiscal years for projects *not* on one of the federal systems and needing improvements to correct safety hazards. While the elimination of hazards at grade crossings is only one of the four types of projects for which Section 230 funds are available, it is my opinion that few other types will provide greater safety benefits for a given level of investment than will grade crossing protection.

Establishing a proper program mix for a systematic approach to total grade crossing safety is therefore a complex and multifaceted problem when one properly considers the many approaches and treatments available. Fortunately, we now have a new tool in the 1973 Highway Act and the federal government has clearly recognized that the solution to the problem is a public responsibility. If we dedicate ourselves to an energetic pursuit of the ultimate solution, I am convinced that Congress and FHWA will provide even greater financial assistance in subsequent legislation.

Thank you.

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Panel III

A panel discussion and open forum on issues related to "Establishing the Program Mix"

Moderator: James E. Kirk, Chief, Railroads and Utilities Branch, Federal Highway Administration

Panel Members

Harry M. Williamson

L. V. Topaz, Assistant Commissioner for Rail, Air and Marine, Oregon Public Utilities Commission

Byrd Finley, Jr, Engineer of Project Planning, Ohio Department of Transportation

R. M. Karow, Marketing Manager, Railroads WABCO–Union Switch & Signal Division

Prepared Remarks

James E. Kirk

Chief, Railroads and Utilities Branch Federal Highway Administration

The Highway Safety Act of 1973 requires each state to:

1. Conduct and maintain a survey (inventory) of *all* crossings.

2. Identify crossings requiring improvement.

3. Implement a schedule of projects for these improvements.

It also emphasizes the need for adequate signs at all crossings.

As mentioned yesterday, the Federal Highway Administration's instructions for implementing the highway safety program, under the Highway Safety Act of 1973 were issued July 3, 1974. These instructions, among other things, announce that:

1. The DOT–AAR inventory will satisfy the legislative survey requirement; further that an existing state inventory which includes all crossings and contains sufficient data to develop a priority ranking will suffice.
2. A first priority for grade crossing improvements shall be a program to provide signing and pavement marking in compliance with the Manual on Uniform Traffic Control Devices at all grade crossings.
3. Next, the states' selection of grade crossings for improvement should be based on (1) ranking of crossings, using each state's current priority index, (2) an on site inspection, and (3) accident history.

The use of a priority index is a necessary first step in the process of identifying those crossings which are candidates for improvement. The ranking developed using this index may be adjusted, based on accident experience and other special considerations. The priority given to those crossings may be modified, based on on-site inspection by a diagnostic team at the crossings which have been identified as candidates for improvement. (The diagnostic team may also recommend a change in the contemplated type of improvement.)

FHWA has not endorsed any particular priority index but we stand ready to discuss the merits of the various one available.

A discussion now follows on the various kinds of grade crossing improvements (in addition to signs and markings) which are appropriate as a safety project.

First, another legislative mandate, and a good one we believe, is the requirement mentioned by previous speakers that one-half of the funds authorized under Section 203 of the 1973 Act must be used for crossing warning devices.

In view of the numerous grade crossings needing safety improvements we expect that the construction of railroad-highway grade separations will receive a low priority for the use of Section 203 and 230 funds.

In considering the type of improvement to be made we encourage very strongly that the use of automatic gates be given every consideration and that adequate circuitry be provided at every crossing with train-activated devices.

Roughly 40 percent of all vehicle-train accidents now occur at the 20 percent of the crossings with train-activated warning devices, most often flashing light signals. This high accident occurrence is, of course, due in part to the fact that these crossings carry the higher volumes of both rail and highway traffic. However, there is obviously an opportunity to significantly reduce the total number of grade crossing accidents by reducing the large number occurring at the relatively few crossings with train-activated warning devices.

One most effective way of reducing these accidents is by greater use of automatic gates. Automatic gates have consistently been shown to provide more effective protection than flashing lights alone. The addition of gates to flashing light signals can be expected to reduce the probability of an accident by two-thirds or more.

A year ago, the Federal Highway Administration issued a directive encouraging increased use of automatic gates. This is our policy and we hope it will be your policy.

Circuitry should be included which will assure reasonable uniformity in the amount of warning time provided in advance of the amount of any train over the crossing, regardless of variations in train speed, and also to avoid operation of the warning devices when no train movement is to be made over the crossing. Otherwise the motor vehicle driver loses trust in the warning devices. When this happens, he resorts to his own judgment to determine whether a train is coming and the value of the positive warning of the train-activated device is lost.

In many situations the upgrading of existing train-activated warning devices by the addition of automatic gates to existing flashing lights or the improvement of the circuitry of existing train-activated warning devices can be expected to result in a greater improvement in safety than the installation of new devices at other locations.

Other types of railroad-highway improvements eligible for funding under Sections 203 and 230 of the 1973 Act include:

1. Installation of flashing light signals without gates.

2. Other upgrading to improve the effectiveness of existing train-activated warning devices, including interconnection with highway traffic signals.

3. Crossing illumination.

4. Crossing surface improvements.
5. Other site improvements.

Crossing surface improvements may be undertaken in conjunction with improvement of the warning devices. Of course, if a crossing surface improvement is undertaken alone, you should first be fully assured that the crossing is equipped with warning devices which provide adequate safety.

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L. V. Topaz
Assistant Commissioner
Rail-Air-Marine
Public Utility Commissioner of Oregon

Mr. Williamson's remarks are cogent and speak clearly to the public involvement. Little is said, however, as it relates to the railroad responsibility.

Crossing safety is indeed a cooperative effort on the part of all parties concerned.

Part of the equation is railroad support of public body decisions. Railroad awareness of vehicular and pedestrian traffic requirements greatly aids in the development of a comprehensive crossing safety plan.

Railroad operations and traffic requirements interface at the crossing. Total planning and over abundant communication between railroad, state and local officials will lend to comprehensive planning which is the only way to provide the ultimate cures to crossing safety problems.

While crossing closure is an enviable goal, particularly to the railroad, it can only be accomplished if safe and adequate passage over the railroad is provided.

In Oregon, we push very strongly for crossing closure and have closed quite a few in the last year. We are most successful when all parties gain from the transaction.

Mr. Williamson's comments on the use of predictive formulas is fairly accurate. It is necessary, unfortunately, for public agencies to establish priorities for fund expenditures. The use of predictive formulas is justified as one of the tools in establishing priorities.

There is no doubt that the final selection has to be made as to which crossings to signalize and the proper level of signalization. In making these decisions, many other factors should be used to modify formula data.

Mr. Williamson's comments on the importance of signal actuation devices has my complete agreement. I do feel that Mr. Williamson should have gone a step further. Crossing safety could be greatly enhanced by improvement of actuation devices at *existing* signalized crossings.

The effectiveness of many signal devices is often discounted because of the type of signal device, when, in fact, the device is satisfactory—the actuation controls are old, outmoded or poorly designed.

It is interesting to me, as a person deeply involved in crossing safety, that Mr. Williamson places strong emphasis on crossing surface condition as a crossing safety element.

I agree wholeheartedly with this comment and hope that the railroad pays heed to this point.

Crossing safety is a cooperative effort that calls for total comprehensive planning and complete communication between all parties.

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Byrd Finley, Jr.
Engineer of Project Planning
Ohio Department of Transportation

A successful railway-highway grade crossing safety program requires the full cooperation of all affected governmental agencies. The general public, the railroad companies, and materials suppliers. However, I firmly believe that one single agency must have the authority and responsibility for establishing and administering a program if any reasonably orderly program is to be attained. The programming of any project must be based on a uniformly administered set of guidelines otherwise local pressures will prevail and the most deserving projects will not always be constructed.

The closing of crossings is the most effective way of eliminating hazards at any particular location; however, care must be taken to assure that the solution does not create other hazardous situations which, while not a spectacular as railroad crossing hazards, could lead to more frequent accidents. We have found that, because of the home rule principal in our state, it is practically impossible to obtain concurrence in closing a crossing even though a much safer crossing is not more than one city block away.

It is only fair to recognize that the additional traffic congestion that is often created by closing one street and routing traffic to another can be less desirable to a community than continuing to use an unsafe railroad grade crossing.

Many of the hazards associated with railroad-highway grade crossings are physical and geometric features of long standing. The degree of hazard at crossings can often be substantially decreased at a very nominal cost by the removal of obstructions such as trees, underbrush and farm crops that effectively reduce sight distances. Additional hazards are created daily by ineffective land use management which permit construction such as industrial facilities, rail sidings and other such facilities to be located in such a way as to further limit sight distances. Governmental agencies issuing building permits as well as railroad companies need to be more aware of hazards that are being created and alter construction to avoid the introduction of additional hazards.

Highway alignment and profile changes can and often should be made to improve sight conditions and reduce the probability of highway-highway accidents as well as railway-highway accidents. However, we have experienced situations where such highway improvements have encouraged higher operating speeds on the highway with the end result being more railway-highway accidents after the improvement then occurred prior to the improvement.

In any railroad-highway grade crossing program, every effort should be made to provide, as a minimum, standard advance warning signs, pavement markings and railroad crossbuck signs at every crossing. The next level of protection to be provided at any crossing is then determined after all relevant factors have been considered. Certain prerequisites can be established such as constant warning time and automatic gates where flashing lights have been or are being installed. The degree of sophistication necessary to accomplish these goals is then determined on an individual project basis.

I would agree that the use of mathematical formulas to attempt to determine the type of hardware to be used in any given situation is inadequate. However, I do believe it is necessary to employ mathematical formulas to establish a hazard rating for each crossing when one has 10,000 crossings to consider and the physical and financial capacity to provide automatic protective devices at only a small percentage of this number. Otherwise an orderly protection program cannot be maintained.

One of the most common causes of accidents at railroad-highway grade crossings is the condition of the crossing. In my state the statutes provide that the railroad companies are responsible for providing good, safe and adequate grade crossings or public highways. This statutory requirement prohibits the use of state highway funds to maintain crossing surfaces unless a highway improvement project requires a major change in the crossing. Consequently, it is an unending task to try to see that railroad companies perform the necessary maintenance to keep their crossings in good condition.

The safety provisions of the 1973Federal-Aid Highway Act attempt to relieve this condition to some degree; however, we have experienced considerable difficulty in selecting those crossings which should be improved with public funds without encouraging further deferred maintenance on the part of railroad companies which would eventually lead to the use of public funds for normal maintenance operations.

In closing I would suggest that a much greater effort needs to be devoted to the development of more modern and less expensive grade crossing protection systems. Particular attention should be given to the development of a system that is not tied to the railroad track or signal system so that it can be mass produced and installed by public authorities. Otherwise there is little hope that we will be able to install automatic protection devices at a sufficient number of grade crossings to provide the traveling public with the level of protection that is desired.

R. M. Karow
Marketing Manager, Railroad
WABCO - Union Swith and Signal Division

Mr. Williamson's opening paragraphs regarding the need for cooperative efforts by several agencies and a number of disciplines is to be noted. Too many times each of us tends to look upon problems from a singular point of view or at most, in the case of highway crossing protection, as a problem involving only a state agency and the railroad's signal department. This, quite well, could be the reason that attention to highway crossing protection on a broad scale has been so long in coming. We certainly should involve more people to add visibility to the problem. The more people who are involved, the more who will become aware of the needs and thus, the more pressure that can be brought to bear on the problem.

Mr. Williamson addresses a number of factors, other than train vehicle exposure, that can contribute to accidents at crossing including the angle of the crossing, the relative gradient and obstructions to a clear view of approaching trains. Some of these, if not all, might easily be eliminated or greatly reduced at little or no cost if considered at the time highways are constructed or improved.

I would like to add the conventional flashing light signal along with the wig-wag to the category of obsolete devices as suggested by Mr. Williamson, and substitute automatic gates in their place wherever automatic protection is installed. Statistics from a number of studies, notably those from the state of California, show that automatic gates are some 3 to 4 times as effective in reducing the number of accidents and fatalities as flashers alone; and this, incidentally at an increase in hardware cost of only 25 percent to 40 percent. The effectiveness of gates could very well be related to the fact that they are more absolute in the warning they provide than in a flasher. The ordinary traffic signal also provides a similarly absolute signal. The motorist is inclined to stop until the gate raises or the traffic signal changes to a more permissive indication and not proceed, if stopped at all, after a cursory view of the railroad as happens so often with flashing light signals.

My final comment is that we should consider a mathematical factor for rating the accident potential of crossings. There have been a number of attempts to do so in the past. Apparently such attempts go hung-up on the details rather than the purpose. "Someone once said, it is better to be vaguely right than precisely wrong". The objectives of such a rating factor are at least, twofold. First, to provide a means for setting priorities. It would be unreasonable to expect that we will see the day when all crossings are equipped with some type of automatic warning device. Therefore, any mathematical factor based upon train vehicle exposure times, with other danger criteria thrown in, is better than seat of the pants judgments with political overtones. The second objective and probably the most important, is to provide a rating that can be associated with different types of protection. Such an association of protection to accident rating, if nationally adopted, would remove the burden of proof of adequacy from the railroads. In case after case awards are made to the motorist even though the crossing was protected. In a recent case, it was proven that the flashers were operating, but the type of protection was judged inadequate for the volume of train-vehicle traffic. A standard rating system could provide a legal umbrella from such awards.

Session IV

Urban Railroad Relocation

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Active interest in urban railroad relocation (or what we at FRA consider Urban Railroad Facilities Improvement) at the federal level dates back to the "Highway Safety Act of 1970" which authorized a demonstration project in Greenwood, South Carolina. At the same time many other cities which had special urban railroad relocation planning studies contemplated, underway or completed came forward. Some of these cities were seeking assistance on how to conduct the necessary analyses; others were seeking financial assistance either for planning or construction.

State and local governments have extremely limited resources for planning imporvements in railroad facilities. This is especially critical in urban areas where major railroad facilities create social and environmental problems for barriers despite the fact that the railroad is a critical, economic asset of the community. The immediate involvement of the railroads and their influence on social and environmental goals is clear. The identification of the railroads as a means of providing economic solutions to social and environmental problems has been made by the Federal Railroad Administration, and research programs to provide data and planning procedures aimed at improving the railroad system while enhancing social and environmental conditions have been undertaken. But because the industry is, after all, private enterprise and despite widespread economic regulatory authority, only a very small amount of railroad alternative planning dealing with social and environmental problems has been done. I should point out here that railroad cooperation and assistance has been provided, often substantially, to both the Department and individual communities in the planning or railroad relocation projects.

Urban railroad relocation in most cases must be viewed as only a partial solution to a complex array of urban problems in the community. It does, however, offer the potential for combining several kinds of benefits from one project: improved highway safety and mobility, improved environment, improved land use, and improved railroad efficiency. The tangible and intangible benefits from all of these improvements could justify relocating or consolidating railroad facilities, whereas any one of the benefits would not necessarily, by itself, make the relatively high cost worthwhile.

Let me lay down one area of critieria that we at FRA consider absolutely essential. Regardless of whoever else is interested in community railroad problems, there must be not only some benefit to the railroad company in terms of no additional cost, etc., but overall efficiency of the rail system should be improved as a result of relocation projects.

In order to achieve a better understanding of the total problem of urban railroad relocation, including the magnitude of the problem nationwide, techniques for advancing and evaluating projects and other issues involved, the Federal Railroad Administration and the Federal Highway Administration jointly sponsored a study which began in 1972 and is now essentially complete. The interdisciplinary research team headed by the Stanford Research Institute has been probing into the problems of urban railroad relocation and has visited and interviewed representatives of many cities.

The two-fold objective of the study was to determine the nature and magnitude of the problem nationwide and to develop a methodology for conducting railroad relocation studies. The results of this study are being prepared in a four-volume series:

1. Executive Summary
2. Community Guidebook for Preliminary Planning
3. Guidebook for Planning
4. Nature and Magnitude of the Problem.

The *EXECUTIVE SUMMARY* of course, summarizes the project by synopsizing the key issues and findings.

The *COMMUNITY GUIDEBOOK FOR PRELIMINARY ASSESSMENT* shows community leaders how to get started, includes consideration of costs and benefits in a simplified way, and tells the community what its share of the cost of planning and of construction is likely to be, thus allowing an early appraisal of the financial feasibility of the project.

The *GUIDEBOOK FOR PLANNING* provides guidance to planners for use in analyzing and evaluating alternative proposals.

The *NATURE AND MAGNITUDE* discusses the types of railroad/community conflicts, their magnitude and assesses the nationwide potential for their solution by railroad relocation and consolidation.

Their analyses has found that evidence of conflict between the railroad operations in urban areas and the activities of the community can be found not only in the delays and increased operating costs for highway users at grade crossings, but also in the hazards to the safety of the community, community barriers created by the railroad facilities, environmental degradation from railroad operations, incompatible land use patterns, and reduced railroad efficiency. The relative importance of these elements of conflict varies from community to community because there are many differences in topography, land-use patterns, railroad service and traffic density, local economy, and community attitudes toward their environment and toward the railroads.

The conflicts are widespread. Study findings indicate that of about 4,100 communities in the United States with populations greater than 5,000 in 1970, an estimated 1,650 show evidence of conflict. Since there are no railroads in many communities, there is a conflict in most communities served by a railroad. The conflict is avoided in places where the railroad passes through largely industrial areas; or follows natural barriers such as highways, hills, or rivers; or passes through areas where compatible land uses suffer the effects of the railroad.

The ability to measure the intensity of conflict varies greatly with the effect. Costs to highway users at grade crossings are estimated nationwide at $775 million annually. Community costs from other safety hazards, environmental degradation, barriers, and incompatible land uses are not known because of the difficulty of measuring some of the social costs. Railroad costs due only to slowing and accelerating trains in urban areas are estimated at $75 to $100 million yearly. There are other railroad costs from maintenance of grade crossings, losses due to theft and vandalism, and use of outmoded facilities.

Benefits from railroad relocation involve all aspects of the conflict – elimination of grade crossings speeds both trains and highway traffic, railroad-highway related accidents and hazards are eliminated, barriers are removed, land values and the environment are improved, and railroad companies can realize cost reductions. But railroad relocation projects are expensive. The limited data available from field work and from proposals prepared by communities indicate that average costs for relocation might range from about $5 million in cities of 5,000 to 10,000 population to over $50 million for the largest cities. Moreover, because of local variations in railroad service, topography and land use, cost of an individual project might vary by a factor of 10 from this average.

Using these average costs and uncertainties, it is estimated that remedying the railroad conflict in all of the 1,650 places that were identified with a conflict would cost about $12 – $14 billion. Again you have to remember this blue sky number is only to gain a useful perspective. The uncertainty in the total cost is less than that for individual projects because the variations tend to cancel out when considering a large number of projects.

The completed study will be available from the National Technical Information Service Clearinghouse soon. Railroads and state agencies will receive complimentary copies.

Railroad relocation and/or consolidation are potential remedies for conflict. Railroad relocation generally involves complete rebuilding of railroad facilities in some other location. Local consolidation of railroad lines into common corridors or joint operations over the same line may offer a lower cost solution in achieving the benefits from a project, and may be beneficial both to the community and the railroads.

By now, it must be evident to everyone that the location of railroad facilities and the extent to which they exist in most urban areas are not necessarily required for today's railroad traffic. Railroad system needs today in the era of superhighways and canalized rivers obviously have greatly changed since the mid 1800's. Today railroad facilities may be superflous to the industry and create an impediment to urban progress.

For the railroads, poorly located facilities poses severe problems. It sometimes means needless maintenance costs, low speeds through areas with grade crossings, and other operating restrictions. These result in inefficient railroad service – an important factor in railroad costs.

Urban planning has typically "worked around" railroads or tried to capitalize on their presence (e.g., by developing industrial buffer zones). This approach may lead to a correct solution. However, it is not the proper method since it ignores the potential solution of relocating or consolidating railroad facilities.

On the other hand, plans to deal with the urban railroad problem have been undertaken without adequate coordination with or into the master transportation plan for the community. It is important that consideration of railroad relocation and consolidation be a part of a community's long-range comprehensive planning.

Planning as it may affect railroads is a new process evolving within the Government, and therefore, will move slowly. Where some of the transportation planning processes start with grant legislation as a base, the railroad planning process often begins with the public debate over issues or problems. In the absence of a grant program, the Federal Railroad Administration has assisted in several instances in problem definition and priority determination while participating with various community and railroad company officials in railroad relocation research projects. Grant programs differ in that they delegate a share of the planning process to the states of institutions involved.

In recent years we have seen that there is a real need for planning for the railroads. Planning what will happen to privately owned railroads and financing the needed work is something that is usually left to other than government agencies. And this is as it should be! But, as a result, most of the improvements in transportation have taken place in highways and waterways where government grants support the needed planning and implementation. We would like to work toward including railroads in this planning process. Frequently, public money would be better spent on railroads than on other modes of transportation, but at present this option is usually not even considered.

A foremost factor which undoubtedly will influence the ultimate decision and adoption of a specific plan will be the cost and who will pay for it. It will be important to perform exhaustive, in-depth cost-benefit analyses, so that all of the parties involved in a possible railroad relocation – the community, the railroads, industrial and other interest – will know the economic consequences of the implementation of any specific plan. It would be a serious mistake to develop a major railroad relocation plan and not be concerned with the means to finance its implementation.

We in the Department of Transportation have participated in a number of studies intended to develop the feasibility and cost-effectiveness of railroad relocation projects in the context of transportation improvements. It is our feeling that transportation at the state and metropolitan levels can no longer be planned and developed in modal isolation and without regard to general land-use planning.

In a number of selected cities, the Federal Railroad Administration is participating with the unified planning process in a separate but coordinated effort. This will enable us to gain additional experience concerning railroad transportation planning and funding policies, programs, and procedures, including a common planning frame work and guidelines for institutional arrangements. In each case the result should be an integrated product for combining transportation improvement with associated new transportation improvements. Together, these improvements should serve to economically satisfy travel damand, reduce adverse impacts of transportation, and generally promote the quality of life by helping to solve other urban problems.

In conclusion, we believe that our participation and involvement in urban railroad relocation will ultimately enhance our ability to include railroad transportation programs in the states and metropolitan areas' planning and implementation package. We further believe that our efforts are consistent with a broad spectrum of potential legislative actions and would in fact, facilitate recommendation of new legislation, should it be appropriate.

Thank you!

Robert C. Hunter
Railroads & Utilities Branch
Federal Highway Administration

For some time railroad relocation has been an acceptable method of eliminating hazards of railroad-highway grade crossings under the Federal-aid highway program.

This is spelled out specifically by section 130(a) of Title 23, United States Code-Highways, the legislation which governs the elimination of hazards of railroad-highway crossings under the Federal-aid highway program. Section 130(a) also permits a special higher Federal funding ration than that applicable on highway improvements generally. This special ratio, commonly designated as "G" funding, may be used on railroad relocation projects so long as a crossing or crossings warranting grade separation can be eliminated at less cost by relocating the railroad than by other methods.

However, historically, the option of eliminating a grade crossing under the federal-aid highway program by relocating the railroad has not been used very often. For example, records for calendar years 1963-1967 indicate that, in 5 years, the sum of $8.4 million dollars in federal-aid highway funds was devoted to railroad relocation. This was about 2 percent of the total of $424 million expended for railroad-highway projects during that period. Also, it is likely that a significant part of this work was for track relocation required by highway location but not for the elimination of grade crossings.

A special federal interest and involvement in urban railroad relocation was brought about by the Federal-Aid Highway Act of 1970. That Act authorized as a demonstration project, a railroad relocation and consolidation project in Greenwood, South Carolina.

Greenwood, with a 1970 population of 21,000, grew up around the railroads, like many other cities in the country. It became a rail center, having at one time five railroads operating within its city limits. Mergers had by 1970 reduced this number to two – the Southern Railway System and the Seaboard Coast Line Railroad.

These two systems had eight radial rail lines which bisected Greenwood and carried 28 trains per day, resulting in downtown traffic congestion and loss of mobility of emergency vehicles. The operation of long trains at slow speeds through the center of Greenwood, and the time required for their passage literally divided the central business district and the services essential to the safety of its population.

The now partially completed demonstration project includes the relocation and consolidation of several miles of track. Tracks are being removed from the downtown area with operations being consolidated on other existing tracks nearby, but not actually in, the central business district and routed over new connecting tracks constructed in outlying areas.

The merger of the former Seaboard Air Line and the Atlantic Coast Line to form Seaboard Coast Line greatly simplified the consolidation of their former separate lines through Greenwood.

Completion of this project will eliminate nearly 8 miles of track and some 38 grade crossings from the urban area. The results will be (1) an improvement in the appearance and cohesiveness of the downtown business district (2) increased highway safety and mobility and (3) improved railroad operations.

An analysis of the costs and benefits of this project concluded that it is mutually beneficial to the community and to the involved railroads. The cost of the project will be outweighed by the benefits which are already beginning to be received. The analysis indicates that the Seaboard Coast Line Railroad will benefit significantly by reduced operating costs and will also have reduced maintenance cost under this new consolidated operation. The Southern, while benefiting to a much less degree, nevertheless will gain by reduced maintenance costs.

The Federal-Aid Highway Act of 1973 included two provisions which reflect the significantly increased attention to the issue of urban railroad relocation. First, Section 163 of that Act authorized railroad-highway demonstration projects in 12 specific cities and directed that the Secretary of Transportation report annually to the President and the Congress on the advancement of these 12 projects. Secondly, subsection 163(L) directed that the Secretary of Transportation, in cooperation with state highway departments and local officials, conduct a study of the problem of providing increased highway safety by the relocation of railroad lines from the central area of cities on a nationwide basis, and report to the Congress his recommendations resulting from this study not later than July 1, 1975, including an estimate of the cost of such a program.

Demonstration Projects

With regard to the projects in the 12 cities specified in the 1973 Act, four of the projects will solve acute problems of traffic mobility by the elimination of a single grade crossing in each of the four cited cities: Anoka, Minnesota, Blue Island, and Dolton, Illinois, and Greenville, Texas.

The remaining 8 projects were conceived to alleviate more widespread urban community railroad conflicts by various combinations of track relocation, grade separation and grade crossing warning devices, usually involving many existing grade crossings. These eight projects are located in Lincoln, Nebraska; Wheeling, West Virginia; Elko, Nevada; Carbondale, East St Louis, and Springfield, Illinois; Brownsville, Texas; and New Albany, Indiana.

A total of $90 million was authorized to be appropriated to carry out these projects: not to exceed $15 million for fiscal year 1974, $25 million for fiscal year 1975, and $50 million for fiscal year 1976. The total estimated cost of these projects is $140 million. The federal share of this cost will generally be 95 percent. Obviously, further authorizations and further appropriations will be required to complete these projects.

For fiscal year 1974 a total of $6 million was initially appropriated for these projects including $1,700,000, designated for the project at Elko, Nevada, $700,000 for the project at Lincoln, Nebraska, and $600,000 for the project at Wheeling, West Virginia. The remaining $3 million was made available for advancing preliminary engineering on the other nine demonstration projects.

Procedures to be followed for advancing these projects, along with immediately needed funding, were released in early January. The procedures under which these projects are being advanced are generally those employed on regular federal-aid projects undertaken in cooperation with state highway departments under the federal-aid highway program. Special procedures for those projects involving railroad relocation include the establishment of a steering committee at a very early stage of the project to facilitate understanding and agreement among the various involved parties. This committee generally includes, as a minimum, representatives from each affected railroad, the state and the city. Also, on projects involving railroad relocation there is required a memorandum of understanding covering a general overall plan or independent portion(s) of the plan signed by all involved railroads, the city, and the state and approved by FHWA. This is to ensure that all involved parties are in agreement on the advancement of the project in accordance with the plan, following compliance with normal public hearing and environmental impact statement requirements. The agency responsible for administering these projects is generally the city or some specially designated agency established by state legislation. Such special agencies include the Railroad Transportation Safety District in Lincoln, Nebraska; the Capitol City Railroad Relocation Authority in Springfield, Illinois; and the Brownsville Navigation District in Brownsville, Texas. In each of the projects involving railroad relocation, one or more consultants are being retained to carry out some part of the project planning.

The size of the urban areas involved ranges from the smallest, Elko, Nevada, with a 1970 population of 7,600 to East St. Louis which is of course part of the St. Louis metropolitan area. Several of the cities are in the population range of 50,000 to 150,000.

The number of railroads involved in each relocation project ranges from one in Carbondale and New Albany to five in both East St Louis and Springfield and six in Lincoln.

In several of these cities the need for railroad relocation was recognized sometime ago. For example, in Springfield a report on railroad relocation was prepared in the late 1950's and in Lincoln the first comprehensive plan, done in 1950, recommended relocation of one of the railroad lines. In Carbondale, a consultant study completed in 1968 recommended lowering the railroad through the city along the existing right-of-way. In Springfield and Lincoln the agencies referred to above were subsequently created and further planning done. However, in all cases the high cost of the projects and the lack of sufficient funds has been a major deterrent to orderly progress of these projects into construction.

The present estimated cost of the relocation projects ranges from less than $3 million for the project in New Albany, which is expected to eliminate six grade crossings and significantly improve railroad operations, to $47.5 million for the project in Springfield, which is expected to relocate and consolidate railroad operations on a grade separated railroad corridor around the south and east sides of the city and eliminate some 100 grade crossings.

An annual report to the Congress on these projects is to be submitted by the Department of Transportation by January 1, 1975, and January 1 of each subsequent year. The first annual report will include more detailed information on these projects. For example, it is expected to include a detailed description of the existing situation in each city and any plans for alleviating the situation which have been finalized.

Each of these projects, is expected to provide valuable guidance for those with an interest in resolving city-railroad conflicts elsewhere. These projects will be serving as models for the organization and administration of any future railroad relocation projects, for effective city-railroad interaction and cooperation in order to reach solutions which are mutually acceptable and for development of methodology for dealing with the variety of problems which are sure to arise, particularly in the more complex projects.

Report to Congress

These 12 urban railroad demonstration projects – up from only the one in the Federal-Aid Highway Act of 1970 – and with the knowledge that other projects are waiting in the wings – mandates a thorough examination of the merit and need for urban railroad relocations and consolidations and the manner in which such projects can best be advanced. Obviously, the demonstration projects already authorized can provide guidance for future projects and the designation of additional specific demonstration projects hardly seems to be the best way to go. Thus the Congress, by requiring the nationwide study of urban railroad relocation, is requesting the Department of Transportation's view on further potential for advancement of projects of this type.

Within the Department of Transportation the responsibility for conducting this study has been assigned to the Federal Highway Administration with assistance from the Federal Railroad Administration.

Our previous speaker has reported to you on the current state of our knowledge on the nationwide need for urban railroad relocation and methodology for future studies as developed by Stanford Research Institute (SRI) for the two Administrations – FHWA and FRA.

The SRI findings on the many aspects of urban railroad relocation will be carefully considered in the development of the report to the Congress.

Although the legislation refers specifically to "... providing increased highway safety by the relocation of railroad lines..." through discussions with the congressional staff, general accord has been reached that the scope of the study must be broader than just highway safety. In fact it is expected that other types of benefits from these projects will significantly outweigh the highway safety benefits. It has been found that the most consistently significant benefit is reduced operating and delay costs to highway users. In developing estimates of the number and cost of warranted projects it is expected that emphasis will be placed on a program justified primarily by highway benefits, railroad benefits, and other transportation benefits taking into account also those community benefits of noise abatement, visual enhancement, and incidental property value effects resulting from such projects.

SRI has been retained to further analyze the magnitude of this problem, and to prepare estimates of the number and cost of projects which appear to be warranted nationwide in cities whose population is 5,000 or greater.

It should be emphasized that these projections of the numbers of justified projects and their costs will be estimated on a nationwide basis. It is not considered economically feasible, for the purpose of this study, to develop these estimates on a city-by-city or a state-by-state basis. It is expected that the estimates will be divided into various population classes.

To provide some understanding of the geographical distribution of the urban railroad problem, each state highway department is being requested to furnish a complete listing of urban and urbanized areas in the state, showing the population and the number of railroads providing service to each one, as well as the total number of railroad-highway grade crossing in the state which are located in urban areas.

Both the state highway departments and the railroad industry, through the Association of American Railroads, are being requested to provide available information on the location of urban railroad relocation projects either completed, underway or proposed, together with the actual or estimated costs and the grade crossing changes involved. This data, by expanding the available sample of information, will enable SRI to develop more accurate and reliable estimates on the number of justified projects and their costs.

Major issues which we expect to address in the report include:

- The Federal role
- Financing
- Cost sharing
- Institutional constraint's, such as ICC abandonment proceeding requirements
- Treatment of industries which require rail service
- Extent of required railroad facilities
- Consolidation of railroad facilities, including joint use of trackage and yards
- The great importance of including consideration of railroad relocation potential in the communities' comprehensive planning process
- Ownership and use of land released by relocation

Positions on these issues have not yet been developed.

Keeping in mind that the report is to be submitted to the Congress by July 1, 1975, FHWA has established target dates to complete our first draft of a text by next March 1 and a final draft by April 1, 1975.

Any comments you may wish to offer on either the demonstration projects or the Report to Congress will be appreciated. Likewise, we will do our best to answer any questions you may have on these matters.

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Panel IV

A panel discussion and open forum on issues related to "Urban Rail Relocation."

Moderator: Hoy A. Richards
Panel Members
Richard J. Crisafulli
Robert C. Hunter
Al Cisneros, General Manager and Port Director Brownsville, Texas
A. C. Parker, Chief Engineer Louisville and Nashville Railroad
Albert E. Moon, Senior Transportation Systems Analyst, Stanford Research Institute

Prepared Remarks

A. C. Parker, Jr.
Chief Engineer
Louisville and Nashville Railroad

It is obvious that railroad operations and rapidly expanding urban areas do not mix. Numerous grade crossings are hazardous from highway and railroad standpoints. There is no question that grade separations, railroad relocations or other means of separation are highly desirable and badly needed. But, the cost of accomplishing these changes is extremely high. Just as a starter, to construct one mile of track with 132 lb. rail costs $180,000, plus the cost of right-of-way, roadbed, drainage structures, signals, communications, grade crossings and separations, station facilities, utilities and relocation of industries. It is expensive to relocate railroads and oftentimes difficult for the railroad to justify expenditures on such projects, even though there are seemingly many advantages.

As in any free enterprise corporation, railroads are limited in funds available for capital expenditures. Several relocation projects could consume the entire allocation of capital funds, therefore, due to the lack of funds by railroads, there must be other means of funding these projects. The Highway Safety Act of 1970 enabled the Greenwood project to get started when otherwise it would have been difficult or impossible to progress.

This project certainly improved railroad operations by eliminating 14 street crossings, one railroad grade crossing, upgrading crossing signals on seven crossings, increasing train speed through the urban areas, all of which made for a more efficient and safer highway and railroad operation and eliminated a barrier that separated the downtown business district. The Seaboard Coast Line Railroad operations through Greenwood before the change in May of 1973, split the downtown business district in half. Many times a 125-car freight train would arrive during the morning rush hour and drag through the city at slow speeds required by city ordinance, blocking crosstown vehicular traffic for several minutes. If for some reason the train experienced difficulty, such as broken train line, drawhead failure, or an accident with a highway vehicle requiring the train to stop, this would tie up traffic for hours. This type situation was unbearable for vehicular traffic as well as the railroad and had to be corrected.

In order to bypass the downtown area of Greenwood, it was necessary to build connections on each side of town – one was only a short crossover, while on the opposite side of town a 4,000 ft. moderate speed connection was built, including a bridge over US Highway 221. This permitted the removal of approximately 6,000 ft of main track through the downtown area. This change now allows the Seaboard Coast Line to bypass the congested business district and operate through town at moderate speeds, minimizing delays to highway and railroad traffic and provide a safer operation for everybody. You can be sure that it was a great day for the community of Greenwood and the railroad when that portion of the project was completed.

The consummation of the Seaboard Coast Line's portion of the Greenwood project from the time the first talks started, took approximately 12 years. After meetings between the city, county, state, citizens groups, Federal Highway Administration, Federal Railroad Administration, Congressional Delegations and the railroad, the project was finalized and progressed to completion in 1973.

Urban congestion complicates railroad service to its customers and delays the handling of rail traffic. In making plans for railroad relocation, there are many factors that must be taken into consideration from the railroader's point of view. These include good alignment and grade to permit moderate operating speeds. Good drainage, wide roadbed, clearances (vertical and horizontal, and elimination to the extent possible of all grade crossings are also desirable. Further, consideration should be given to constructing the railroad on right-of-way of sufficient width to allow for additional rail facilities as the community grows. Wider right-of-ways would also assist in abating the noise and vibration problem. The railroad corridor can be further isolated from residential and commercial activity by zoning the property adjacent to the railroad as light to heavy industrial. This not only provides a buffer zone but allows space for locating displaced industry affected by the relocation. There are situations where one or more railroads can consolidate facilities, streamlining their operations and make the vacated right of way and property available for other uses. Heavy emphasis should be put on each of these items when considering railroad relocation.

Even before the "Highway Safety Act of 1970" railroads were working with communities in an effort to work out a solution to our mutual problem. Relatively few of these projects were completed due to the problem of funding. There have been numerous studies made, many of which were worthy of implementation, however, funds simply were not available to progress the project. Hopefully, with the assistance of the Federal Railroad Administration, the Federal Highway Administration and legislation such as Federal-Aid Highway Act of 1973, the projects that deserve consideration can be progressed to completion. Additionally, the professional know-how of these agencies are welcome in initiating and progressing these studies to completion.

Albert E. Moon

Senior Transportation System Analyst

Stanford Research Institute

For the past 2 years our project team has studied reports and maps and traveled to almost 20

American cities in our efforts to identify the nature and magnitude of the urban railroad relocation problem. You have heard some of the results in the papers that were presented earlier.

This afternoon I would like to share with you my experience and thoughts in one specific aspect of railroad relocation planning – the assessment of community benefits.

It has been pointed out that only a few railroad relocation projects have been implemented although many have been proposed. Many of those that have been implemented have been justified largely by estimating reductions in costs to highway users or to railroad operating companies. It has also been mentioned that the highway user benefits are the largest single benefit item in many of the studies reviewed.

But railroad relocation has benefits for the community as well as for highway users and for railroads. Our preliminary studies show that in only 20 percent of the 1,650 communities with railroad/highway conflicts can highway user benefits alone justify relocation. Clearly, a combination of benefits is required to justify the expense of relocation.

While community benefits are obvious in many cases, the practice of quantifying them is not nearly so well developed as it is for highway user and railroad benefits. We can measure savings in time due to elimination of delays, we can measure the cost of accidents avoided by eliminating crossings, the savings in vehicle operator's cost from eliminating the crossings, and savings to railroads from shorter routes or higher speeds. But community benefits are frequently not quantified.

Claims I have heard about community benefits can be classified into three categories:

- Vague Generalities:
  "Removal of the railroads will allow us to expand our central business district to the area across the existing tracks." (No justification for the need or desirability for this expansion was found, and no graphics had been prepared to illuminate the claim.
- Emotional:
  "The railroads are a Chinese wall that divides our community." "We are bound up in chains forged by rails." (How does one Chinese wall trade off with $100,000 annual savings to highway users?)
- Non-Related Activities:
  "We must move the railroad in order to develop our new industrial park." (The railroad would be a nice service to offer potential tenants.)

What can and should be done? Detailed analyses. Analyses just like those we use to solve other kinds of design problems. The steps are:

1. Identify alternative solutions.
2. Describe the alternatives in detail
3. Analyze the benefits and costs of the alternatives
4. Compare the benefits and the costs of the alternatives.

In this context, the problems of communicating benefits revolve about the incomplete identification of alternatives and the almost total lack of detailed description of the alternatives. As in any other design problem, it is the completeness of the description that governs the thoroughness of the analysis that can be made of the benefits.

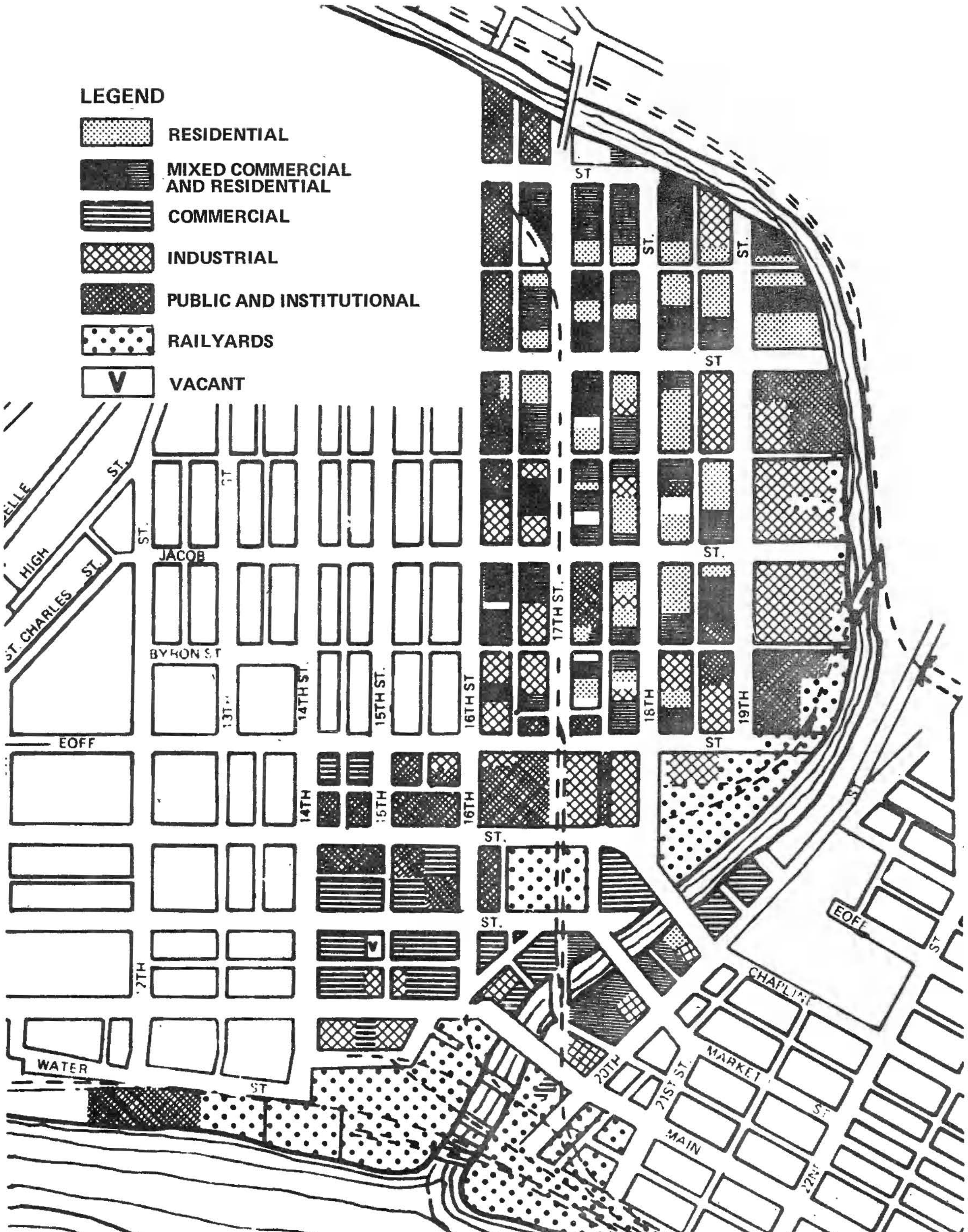
Our project team was fortunate to be able to participate in the planning process of two of the study cities. I would like to illustrate the process of describing the alternatives from our experience in one of these cities. Figure 1 shows the present land uses and railroad siting down 17th Street in Wheeling, West Virginia. There is a bend in Wheeling Creek and mixed area, largely residential and commercial, between the railroad and the creek. The area is old and lighted. Two alternative ways of redeveloping it were considered:

1. Leave the railroad in place and develop an industrial park
2. Move the railroad across Wheeling Creek and develop the area for a regional shopping center.

Figure 2 shows a detailed plan for the industrial park alternative that was developed by our urban design team with the assistance of Wheeling citizens and city staff. The plan specifies precisely the size of plots and the number of acres that are available for development.

Figure 3 shows the alternative shopping center plan. Again, the details developed included the number of square feet that could be accommodated in the parcels considering the location of the freeway, the area needed for parking, and the access from the streets and freeways.

With this kind of detail, our urban economics team was able to estimate property values, employment, payroll, and sales and property tax for the alternatives, comparing this site with alternative sites within the metropolitan area. The conclusion of the analysis was that the shopping center would offer significantly more jobs, payroll, and taxes than would a series of smaller centers which this centrally-located one would supersede.



EXISTING LAND USE

RAILROAD RELOCATION STUDY

Prepared For: Wheeling, West Virginia

0 300 600 900

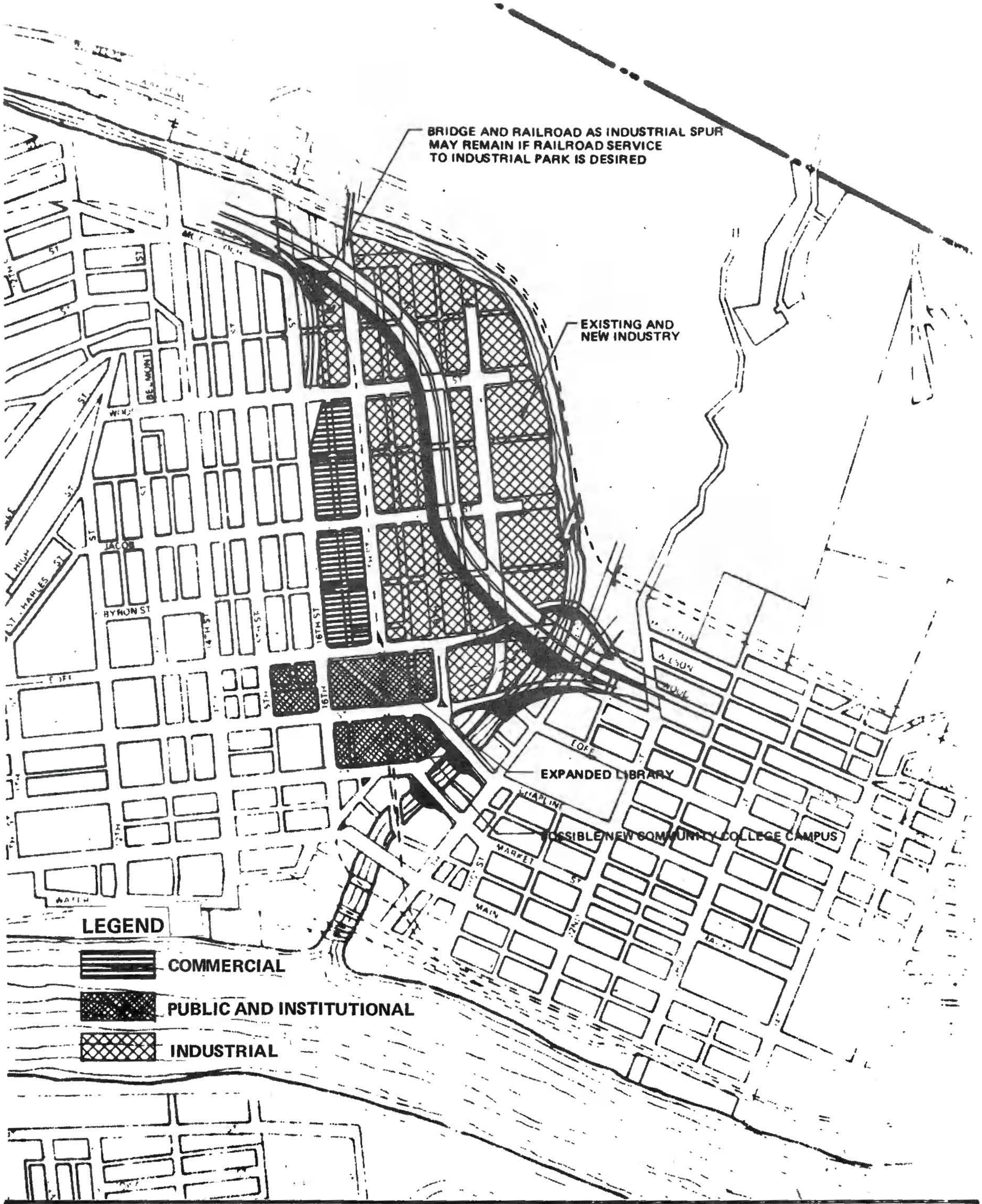
Scale in Feet

North

Figure 1

)RD RESEARCH INSTITUTE

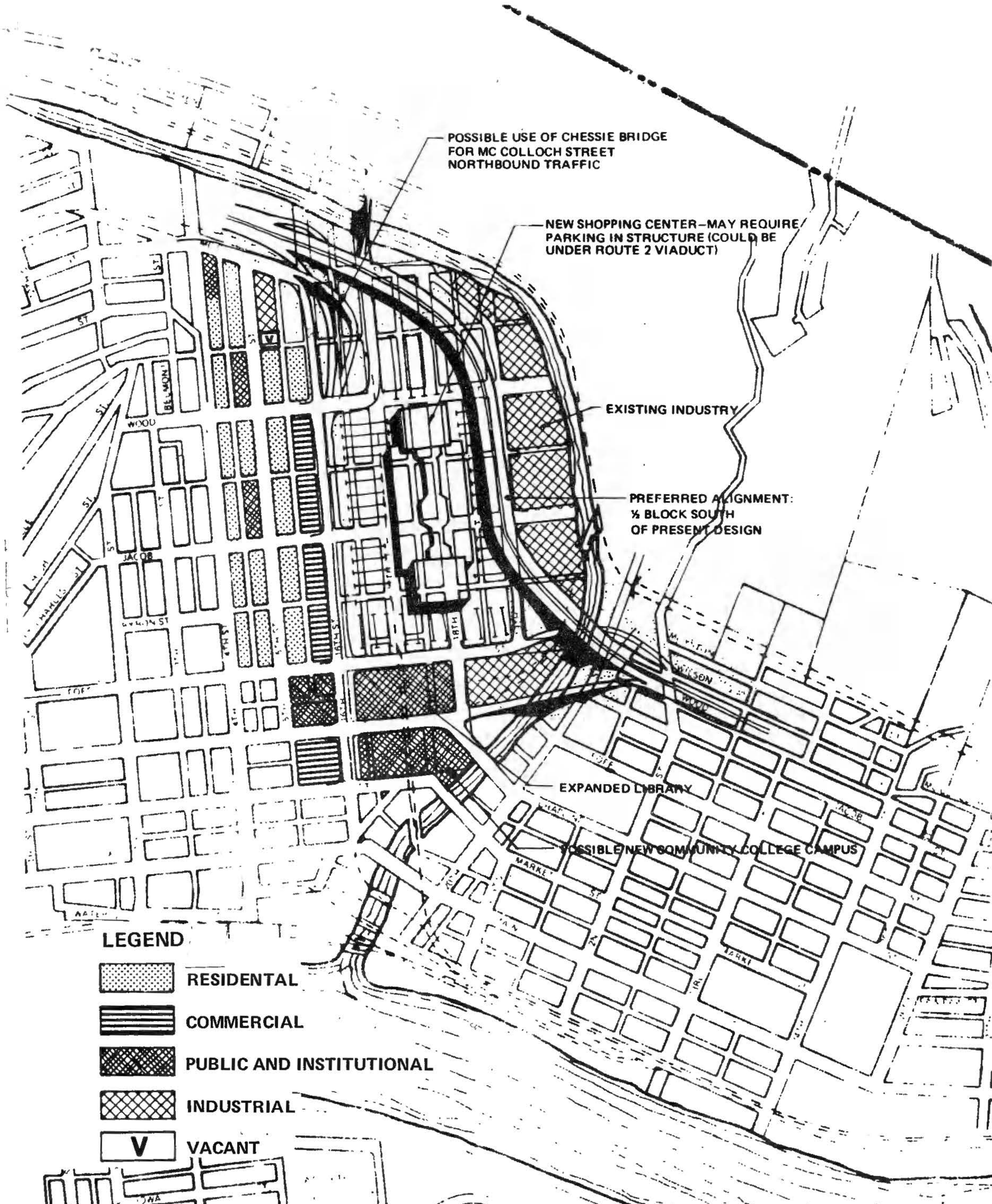
GRUEN ASSOCIATES



EAST WHEELING
PROPOSED INDUSTRIAL PARK RENEWAL
COMPATIBLE WITH ALTERNATES 1, 2 AND 3
RAILROAD RELOCATION STUDY
Prepared For: Wheeling, West Virginia

0 400 800 1200
Scale in Feet
North

Figure 2
STANFORD RESEARCH INSTITUTE
GRUEN ASSOCIATES



EAST WHEELING ALTERNATE LAND RE-USE
REGIONAL SHOPPING
COMPATIBLE WITH ALTERNATES 1 AND 2
RAILROAD RELOCATION STUDY
Prepared For: Wheeling, West Virginia

0 400 800 1200
Scale in Feet
North

FIGURE 3
STANFORD RESEARCH INSTITUTE
GRUEN ASSOCIATES

The eventual benefits of the employment and taxes would be greater than the cost of moving the railroad, or of leaving the railroad in place and developing an industrial park.

Many of you will undoubtedly see a lot of proposals for railroad relocation over the next few years, and you will be involved in designing studies to determine the best course of action to pursue for the improvement of the community, the railroad, and the highways. Let me urge you to include in your studies a sufficient consideration of the community benefits in levels of detail that are commensurate with the engineering descriptions of the trackwork and street construction.

Session V

Research And New Developments

"A presentation of on-going and recently completed railroad-highway safety research and development projects."

Moderator: Jack B. Stauffer, Director,
High Speed Ground Test Center
Federal Railroad Administration

National Crossing Inventory and Numbering Project Status Report

Daniel M. Collins
Industry Economist
Office of Policy, Plans and Programs
Federal Railroad Administration

Since most of the people present at this conference are basically familiar with the origin and techniques of the national crossing inventory and numbering project, I will not spend much time on these aspects. However, for the sake of those unfamiliar with the process, I will quickly summarize the inventory beginning.

In August, 1972, the US Department of Transportation submitted a report to Congress entitled, "Railroad-Highway Safety, Part II: Recommendations for Resolving the Problem." The primary goal of this report was tc provide recommendations for alternative courses of action which would lead to a significant reduction in accidents, fatalities, personal injuries and property damage at railroad-highway grade crossings.

One of the reports major recommendations was development of an adeuqate information system. Although information regarding railroad-highway grade crossings is collected and maintained by various local, state and federal agencies and by individual railroad companies, it was recognized by the D.O.T. policy makers that most of these crossing information systems are fragmented, uncomparable, and incomplete.

Following submission of the report, the Federal Railroad Administration assumed principal responsibility for the development of the national railroad-highway grade crossing information system. The Federal Railroad Administration entered into a contract with the Association of American Railroads to develop a "Comprehensive National Railroad-Highway Crossing Information and Numbering System."

The railroad companies with direction and guidance from the Association of American Railroads and the American Short Line Railroad Association, would make a site-specific inventory of each railroad-highway grade crossing and would install a unique identifying number at each location.

The project was initiated in June of 1972. The work plan called for a 3-phase effort with project completion scheduled for mid-1975. Phase I, completed in November of 1972, included the design of the numbering system, number boards, inventory forms and procedures, and the design of the test phase. Phase II, completed in August of 1973, included the testing of the number boards, inventory forms and procedures. It also provided an account of field work cost as well as an opportunity to design and test computer files and data handling procedures. Phase II consisted of an actual inventory of 19,000 crossings in five states — Colorado, Florida, Nevada, Virginia, and Connecticut. Many bugs were worked out in this Phase II test phase.

Phase III, is the phase we are presently in. It is called the Implementation Phase, consisting of the inventorying, numbering and data processing of the crossings in the remaining 44 states.

Between the pilot phase and implementation phase a significant financial hurdle was crossed when the Federal Highway Administration, who had been providing technique assistance all along, contributed approximately a million dollars toward the project. With this increased funding, and with the agreement of the United States Railroads, the project was broadened in scope to include an inventory and numbering system of not only public crossings, but also private, pedestrian and all types of separated crossings.

It is at this time that the Federal Highway Administration declared that this inventory fulfilled the requirements of Section 203 of the Federal Aid Highway Act of 1973 which called for a survey of *all* crossings.

Project Status

As of the end of July 1974, some 200,000 number boards have been posted by railroads at crossings. This represents 45 percent of the total estimated number of crossings, some 505,000. The Texas Transportation Institute, subcontractor to the Association of American Railroads has knowledge of over 26,000 forms presently in the hands of the state highway departments which will soon be transferred to TTI. As of July 31, 1974, TTI had 45,000 crossings on the computer in Texas. As the chart indicates a considerable amount of the inventory activity is taking place during these summer months. To date, 39 states have received forms from the railroads.

The total number of railroads over 75 percent complete is 110. The expected number of railroads to be 100 percent complete by the end of calendar year 1974 is 205, which represents 63 percent of the estimated total number of crossings. However, when we include the railroads which will not be completed by the end of the year, but have inventoried some of their crossings, this brings the total estimated crossings expected to be inventoried to 455,000, or 90 percent of the total estimated crossings by year end 1974.

The estimated completion date for the entire project is June 30, 1975. At that time we expect to receive the national tape from the Association of American Railroads and then correspondingly deliver tapes to railroads and highway departments. It will be a policy, however, to deliver upon request to railroads and highway departments, those tapes completed before June of 1975.

As my earlier numbers indicate, there is a tremendous backlog between actually hanging the number boards and receipt of complete forms at TTI. If this continues, which is primarily attributable to slow office work, the project may be even further delayed. The contractor and the project sponsors have a meeting scheduled for September 12, 1974, to discuss methods of moving this office work along.

At the present time there are three very fundamental associated tasks ongoing. I will explain the first two, Mr. Mueller will elaborate on the third task.

1. Development of a permanent numbering system
2. Inventory Update Procedures
3. Creation of the National Crossing Information Center

Permanent Numbering System

The contract between the Department of Transportation and the Association of American Railroads has been amended to include a 4-month study of a system for permanently displaying a number at crossings. This effort is to include an analysis of:

1. Whether a permanent number is needed,
2. If so, at what crossings,
3. If so, what type and how best to display the number.

The investigating team will be interviewing various railroad and highway personnel in this intense research effort. We expect recommendations to be delivered to the Department of Transportation in late fall. In this effort we have no intention of developing or displaying another number. We are investigating possible methods for permanently displaying the number presently assigned to the crossing.

Permanent Numbering System Questions

1. What should be the specifications of the numbering system?
2. If a permanent sign is necessary, what type of material should be used in its manufacture?
3. Should the signing system conform with current railroad facility signing practices?
4. Who should be responsible for the installation and maintenance of the system?
5. Should a central agency produce the signs or should they be manufactured individually by railroads or public agencies?
6. What maintenance, labor or procedural problems will be involved?
7. Should the signing system be a mandatory requirement of DOT?
8. Who will pay the cost of any selected signing system?

Expected Completion

Year	Month	Number of Crossings	Percent Complete
1974	July	189,000	37
	August	303,000	60
	September	373,000	74
	October	414,000	82
	November	439,000	87
	December	455,000	90
1975	June	480,000	100

Status of Implementation Phase As of July 31, 1974

States	Confirmation From Railroads	Forwarded To Texas A&M	At State Highway Dept.
Alabama	985	––	985
Arizona	650	650	––
Arkansas	856	35	821
California	2,103	40	2,063
Colorado	166	166	––
Florida	23	23	––
Georgia	1,323	716	607
Idaho	223	114	109
Illinois	1,251	1,129	122
Indiana	2,944	462	,2,482
Iowa	2,838	595	2,243
Kansas	5,136	1,364	3,772
Kentucky	1,111	––	1,111
Louisiana	424	320	104
Maine	145	––	145
Michigan	2,507	2,259	248
Minnesota	2,261	1,502	759
Mississippi	776	246	530
Missouri	4,411	3,440	971
Montana	2,057	992	1,065
Nebraska	1,463	211	1,252
New Hampshire	74	––	74
New Jersey	157	157	––
New Mexico	1,376	1,230	146
New York	384	152	232
North Carolina	195	195	––
North Dakota	2,006	1,166	840
Ohio	158	––	158
Oklahoma	2,969	––	2,969
Oregon	406	406	––
Pennsylvania	466	355	111
Tennessee	489	121	368
Texas	6,243	5,744	499
Utah	3	3	––
Vermont	108	––	108
Virginia	426	420	6
Washington	1,496	1,396	100
Wisconsin	1,132	405	727
Wyoming	7	7	––
	51,748	26,021	25,727

Proposed National Railroad-Highway Crossing Inventory Update Procedures

Norman C. Mueller
Chief, Methods Branch
Office of Highway Planning
Federal Highway Administration

I am very pleased to be with you today to share present thoughts regarding update procedures for the National Railroad-Highway Crossing Inventory.

First, I would like to point out that both the state highway departments and the railroad companies have been most cooperative and have made much progress toward the successful completion of the national inventory. They are to be commended for their accomplishments. However, much remains to be done. Both the states and the railroads must continue their efforts to assure the successful completion of the inventory.

We have just heard about the current status of the national inventory project. Now, I would like to spend the next few minutes describing what is expected to take place after the inventory is completed: update procedures to maintain the data base in a current status.

Purpose of Update

The major goal of the entire effort is to increase safety at railroad-highway crossings by reducing the potential for accidents. A considerable amount of information is required to accomplish this. That is why the inventory is being conducted. Such information is needed by the Federal Government to provide a national perspective in:

FEDERAL (FHWA, FRA, NHTSA)
- **Accident Research**
- **Identification of Accident Causes**
- **Establish Preventative Measures**
- **Development of Legislative Proposals**

The States need information for:

STATE (SHD, PUC, ETC)
- **Crossing Deficiency Analysis**
- **Development of Priorities**
- **1973 Highway Act**

(Meeting requirements of Sections 203 and 230 of the 1973 Highway Act.)

Finally, the railroad companies must have information to establish their own:

RAILROADS
- **Crossing Deficiency Analysis**
- **Establish Improvement Priorities**

Railroad-highway safety is a continuing process, rather than a one time effort. As such, there will be a continuing need for information, and that information must be current. Procedures for updating the inventory and keeping the data base current are presently being developed. Three levels of data files are presently envisioned:

- **National File – FRA**
- **Individual State Files – Each State**
- **Individual Railroad Company Files – As Desired By Each Railroad Company**

Objectives Of Update Procedures

The update procedures are being designed in a manner that will provide file updates to each entity via a common data flow process. The objectives of the update procedures are:

- **Maintain Quality Of Data**
  - **Continued Use Of Established Lines Of Communication**
    - **Maintain Currency of Data**
      - **Minimize Data Handling**
        - **Continuing Use Of a Uniform Data Base On A Nationwide Basis**

The need to update a data base is created when changes occur at the crossing. There are three obvious causes of change in the data contained in the railroad-highway crossing inventory files. They are:

- **New Crossing**
  - **Crossing Closed**
    - **Change**

The data elements in the inventory data base have been categorized into three groups:

- **Administrative**
  - **– Management and Jurisdiction of Crossing (Periodic)**

- Physical
  - Crossing Configuration (As They Occur)
- Operational
  - Utilization (Periodic)

Within each of these categories, specific data elements have been designated as state or railroad company responsibilities. The assignment of data element responsibilities was based on expected awareness of change. Data responsibilities are as follows:

ADMINISTRATIVE DATA ELEMENTS

STATE

- State
- County
- City
- Nearest City
- Highway Number
- Street Name
- Highway System
- State System
- Functional Class

RAILROAD

- Railroad Co., Div., Sub.
- Railroad I.D. Number
- Timetable Station
- Branch or Line Name
- Railroad Milepost

REGULATORY

- Private Crossing
- Public Crossing
- Pedestrian Crossing

PHYSICAL DATA ELEMENTS

STATE

- Crossing Angle
- No. Traffic Lanes
- Truck Pullout Lanes
- Is Highway Paved
- Pavement Markings
- Advance Warning Signs
- Type of Development

RAILROAD

- Type and Number Tracks
- Separate Track Owned By Another Railroad
- Type Of Protection
- Speed Selection Provided
- Signals For Train Control
- Crossing Surface

OPERATIONAL DATA ELEMENTS

STATE

- ADT
- Percent Trucks

RAILROAD

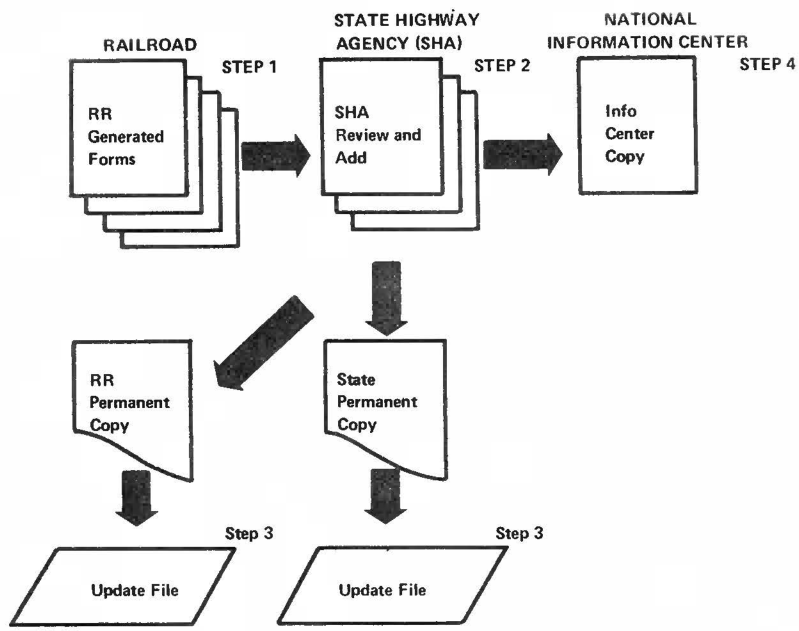
- Daily Train Movements
- Train Speed At Crossing

All changes (updates) will be reported via a form that is similar to the original inventory form – the form has been modified slightly to provide a strictly numerical identification of the items and to indicate the reason for the update. The form will remain as a 4-copy set and will be handled in much the same way as is being done now.

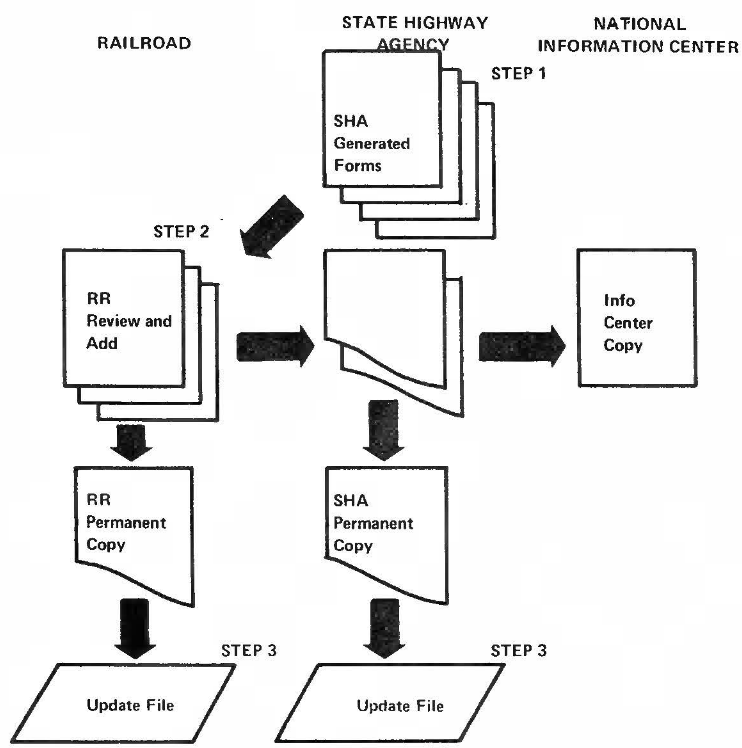
Four basic steps are required to process an update. In all cases the responsibility for submitting data changes to the national information center lies primarily with state highway agencies. Either a state or a railroad may initiate an update form. In the first, case, RAILROAD INITIATED UPDATE, a railroad completes a form set, retains a copy, and forwards three copies to the appropriate State Highway Department. That agency reviews the form and adds to it any changes it has made to that crossing, if that is appropriate. The agency then returns a copy of that form set to the railroad, keeps a copy, and forwards a copy to the National Information Center.

In the second case, STATE INITIATED UPDATE, the state highway agency will complete a 4-copy set, retain one copy and send the others to the railroad involved. Once the railroad has reviewed and made their additions, they retain a copy and return three to the state highway agency. Assuming all information is correct, a copy is kept for permanent files and the fourth sent to the Information Center.

RAILROAD INITIATED UPDATE



STATE INITIATED UPDATE



As in the present inventory, any conflict between the railroad review and the state highway agency review must be resolved before the forms are sent to the Information Center.

NATIONAL RAILROAD-HIGHWAY CROSSING INFORMATION CENTER

- **Maintaining Agency**
  - **Federal Railroad Administration**
- **Reports**
  - **Crossing Inventory And Accident Data By:**
    - **Individual Railroad Company (Company Use)**
    - **State (Use Of All Concerned State Agencies)**
- **Input Data Flow**
  - **State Agency To FRA "Center"**

The update procedures are presently in draft form. Final update procedures will result via the following review process:

- **Initial Drafts Prepared By FHWA/FRA/AAR/TTI**
  - **Review Comments By Advisory Committee**
- **Intermediate Draft** — **Present Status**
  - **Review Comments By State Agencies, Railroad Companies, And Others**
- **Final Draft**
  - **Advisory Committee Review**
- **Publish And Distribute**

We presently anticipate that the update procedures will become effective about the first of the year.

In order to assure maximum benefit from railroad/highway safety improvement programs, improvements must be based on current data. The update procedures I have discussed represent our efforts to assure the continued availability of an up-to-date data base for this purpose.

Accident and Accident Severity Prediction Equations

Janet Coleman and Gerald Stewart
Office of Research
Federal Highway Administration

Background

Railroad Highway Grade Crossing Safety has been the subject of special interest over the past 7 to 8 years and there have been many attempts over the years to develop methods of ranking crossings into some order of priority for improvement. These have been variously labeled hazard index formula, priority index formula, or accident prediction formula. While many states use one of these methods, none has been generally accepted. Also, some of these methods still in use were developed many years ago and there have been many changes in warning devices, in highway design, and in motor vehicle characteristics. Both the 1970 Railroad Safety Act and the 1970 Highway Safety Act contained requirements for a study and a report to Congress on the grade crossing safety problem together with recommendations for any merited improvement program.

An economic analysis was used to evaluate the accident reduction and nationwide losses and the increase in net benefits that would result from various levels of improvement at public grade crossings. That analysis indicated that grade crossing warning devices would return greater overall benefits and greater safety benefits for given levels of investments than would grade separation. The report recommended that any new federal initiative should concentrate on installation of grade crossing warning devices. Grade separations and similar elimination type projects should continue to be included in other highway programs. Based on the results of the economic analysis, the report indicated that at least 3,000 installations of grade crossing warning devices could justifiably be made annually for the next 10 years at an expenditure of about $75 million dollars per year. Refining the accident data used in the 1972 Report to Congress, the federal highway staff prepared and presented at the 1972 Conference on Grade Crossing Safety a paper on warrants for safety improvements at rail highway grade crossings. Recognizing that some of the current warrants in use in selecting projects for improvement programs are rather subjective and make little use of the quantifiable factors which appear to be related to accident potential, the study endeavored to establish through multiple linear regression some usable relationships between such factors and the actual accident experience in groups of crossings stratified by area type, by type of warning devices and by ranges of highway volumes and train volumes. The resulting equations can be used to predict the number of accidents for groups of crossings within certain ranges of traffic volumes. They can also be used to predict the number of accidents at individual crossings. Limitations in the data used, particularly in the higher ranges of both the vehicle traffic and the train traffic, limited the usefulness of these prediction equations.

The 1973 Highway Act specifically authorized the expenditures of funds for grade crossing improvements. This is the first time highway trust funds were authorized specifically to be used on grade crossing projects and for crossing projects off the federal aid system.

A Federal Highway Administration study was initiated because recently completed work did not completely fulfill the needs of states and political subdivisions for use as a guide in evaluating and selecting grade crossing improvement projects. The main objective of this study is to refine and extend the existing techniques for assessing accident potential and accident severity at grade crossings for different types of warning devices. Additional grade crossing accident and inventory data were requested from 45 states and 7 railroads. At present, FHWA has assembled an accident-inventory data base from 15 states of approximately 173,000 accident-inventory records of from 1 to 7 years of train-involved accident data at public crossings. FHWA also has assembled about 17,000 records of non-train accident data representing 1 to 5 years of accident experience from four states. This is the largest grade crossing accident-inventory data base assembled so far and will be used in research efforts until the Nationwide inventory data are available and a few years of FRA accident data are assembled.

Accident data representing 10 years of accident experience on both public and private crossings have been received from three railroads. Approximately 6,800 railroad accident records are being used in the accident severity analysis.

Status Of Work

At this time the train involved accident analysis and accidents severity analysis are in progress. The non-train involved accidents analysis will begin sometime in the fall. Work to date has concentrated on analyzing data for crossing with crossbucks, flashing lights and automatic gates.

The train-involved and non-train accident inventory data base was assembled under contract by the National Bureau of Standards which also did preliminary work on developing the accident prediction equations, development of the accident severity prediction equations and the development of the non-train involved accident prediction equations are being done by the Federal Highway Administration staff.

Accident and inventory data were received from approximately 35 states. Due to problems in matching accidents to the inventory data, we were able to use data from only 15 states. Approximately 9,000 of the accident-inventory records representing three states are being reserved for validation purposes.

Development Of Accident Prediction Equations

The accident inventory data were stratified into groups by type of area, urban vs. rural, and by the 6 types of warnings, none, stop signs, crossbucks, automatic gates, flashing lights and other devices. The other active category includes wigwags, bells, and watchmen. The numbers of crossings and accidents that fell into each of these stratifications are summarized in Table 1. The crossings within each group in Table 1 were then separated into several ranges of highway volume and train volume. Various highway traffic volume ranges and train volume ranges were tested to obtain the most advantageous spread of crossings and accidents for use in regression analysis. The two variables which were present in all of the data were highway traffic volume and train traffic volume. We limited our analysis to using these two variables as independent variables. Based on the analysis of the raw data, a number of transformations were performed in the interest of obtaining a linear relationship between the dependent variables and each of the independent variables.

Previous work both by federal highway staff and under contract to the Federal Highway Administration led to the conclusion that regression applied to individual crossings was not to be recommended. This led to regression analysis with group means in the desire to overcome the effects introduced by the large number of crossings having no accidents. Group boundaries were determined empirically. In previous work a minimum of 30 crossings for any group mean to be

Table 1

SUMMARY OF ACCIDENT-INVENTORY DATA USED TO DEVELOP THE ACCIDENT PREDICTION EQUATIONS

	Urban		Rural		Total	
Passive	Crossings	Accidents	Crossings	Accidents	Crossings	Accidents
None	1,427	157	1,133	61	2,560	218
Crossbucks	7,714	1,676	14,729	1,908	22,443	3,584
Stop Signs	353	215	954	266	1,307	481
Total Passive	9,494	2,048	16,816	2,235	26,310	4,283
Active						
Gates	1,747	680	1,030	294	2,777	974
Flashing Lights	3,084	1,479	2,278	694	5,362	2,173
Other Active[1]	662	297	224	68	886	365
Total Active	5,493	2,456	3,532	1,056	9,025	3,512
TOTAL	14,987	4,504	20,348	3,291	35,335	7,795

[1] The other active category includes wigwags, bells and watchmen.

used in the regression was selected to insure that the estimate of the true group mean by the sample group mean was statistically valid. NBS performed a similar analysis on a limited portion of the data base to test the restriction of a minimum sample size of 30 to see if this restriction could be relaxed. It was found that in some cases, but not all, that the number of crossings per cell could be reduced and result in slightly better fits.

After examining several functional forms it was also found that the following three functional forms were the most promising:

$$\log_{10}\overline{WA} = C_0 + C_1 \log_{10} \overline{V} + C_2\sqrt{\overline{T}} \quad \text{Equation 1}$$

$$\log_{10}\overline{WA} = C_0 + C_1 \log_{10} \overline{V} + C_2 \log_{10} \overline{T} \quad \text{Equation 2}$$

$$\overline{WA} = C_0 + C_1 \overline{V} + C_2 \overline{T} + C_3 \overline{V}\overline{T} \quad \text{Equation 3}$$

where $\overline{WA}$ = Average number of accidents per crossing year

$\overline{V}$ = average daily traffic for highways

$\overline{T}$ = average daily train traffic

C_i are the regression coefficients.

Analyses were made using the above functional forms and using all cells with 10 or more crossings as well as cells with 30 or more crossings. Comparisons were made between the two sets of output and a minimum sample size of 10 was found to be satisfactory to be used in all further analyses. A tabulation program was set up to calculate the following information for each type of warning device, for each area type, stratified by different ADT and train volume ranges:

N* = the number of crossing years of data;
A = the total accidents reported on the N* records;
WABR = the average number of accidents per crossing year;
NREC = the number of unique crossings reported in that particular cell;
VBAR = average ADT value for the cell;
SDV = standard deviation of VBAR;
TBAR = average daily train volume for the cell;
SDT = standard deviation of TBAR

Regression analyses were done utilizing the OMNITAB program, a computer package developed by NBS and available for use on many different computer configurations. Based on output from the OMNITAB regression program, a number of different terms were added to the preliminary functional forms mentioned above. From the preliminary regression runs, Equation 2 was shown to be the most promising for the following types of warning devices: urban other active, urban crossbucks, rural crossbucks, urban stop signs, rural stop signs, urban automatic gates, urban flashing lights and rural flashing lights. The coefficient of determination, R^2, has the interpretation of the proportion of variation in the dependent variable explained by the fitted relationship among the independent variables. Initial analysis concentrated on crossbucks, flashing lights, and automatic gate warning devices. The FHWA staff continued the analysis initiated by NBS and attempted to use different ranges of ADT and train volumes to obtain a better spread of the data to utilize more of the data in our regression fits. Each of the regression surfaces developed many be improved by the admission of new and additional terms into the regression such as V^2 T^2, $(\log V)^2$, or $(\log T)^2$. Additional analyses with these new terms were performed resulting in significantly improved fits for the following types of equations: urban and rural crossbucks, urban and rural flashing lights and urban gates. Additional work is needed on rural gates. The fit for rural gates was poor and this may be due to a lack of data in this area. Coefficients for the equations developed and the R^2 are given for urban and rural crossbucks, flashing lights, and gates in Table 2. At this time, work is still continuing on the rural gates. Shown in Table 3 are the ranges of the ADT and train volumes used in developing each of the equations. Confidence intervals about these equations for use in predicting accidents at individual crossing will be developed as soon as the equations are finalized.

Table 2

REGRESSION EQUATIONS FOR GROUPS OF CROSSINGS TO PREDICT EXPECTED ACCIDENTS PER CROSSING YEAR

Area - Protection	Equation Form and Coefficients	R^2*	N*
Urban - Automatic Gates	$\log_{10}\overline{WA} = C_o + C_1 \log_{10}\overline{V} + C_2 (\log_{10}\overline{T})^2 + C_3 \log_{10}\overline{T}$ $C_o = -2.61239$ $C_2 = -.22067$ $C_1 = .23998$ $C_3 = .96516$	.6945	47
Urban - Flashing Lights	$\log_{10}\overline{WA} = C_o + C_1 \log_{10}\overline{V} + C_2 (\log_{10}\overline{T})^2 + C_3 \log\overline{T}$ $C_o = -2.53756$ $C_2 = -.16075$ $C_1 = .30726$ $C_3 = .77665$	.7102	48
Urban Crossbucks	$\log_{10}\overline{WA} = C_o + C_1 (\log\overline{V})^2 + C_2 \log_{10}\overline{T} + C_3 \log_{10}\overline{V}$ $C_o = -3.99567$ $C_2 = .42379$ $C_1 = -.20265$ $C_3 = 1.47000$	.7409	41
Rural - Flashing Lights	$\log_{10}\overline{WA} = C_o + C_1 \log_{10}\overline{V} + C_3 \log_{10}\overline{T} + C_3 (\log_{10}\overline{V})^2 + C_4 (\log_{10}\overline{T})^2$ $C_o = -5.18631$ $C_2 = 1.91167$ $C_1 = 1.74150$ $C_3 = -.21923$ $C_4 = -.93909$	.6333	36
Rural Crossbucks	$\log_{10}\overline{WA} = C_o + C_1 (\log_{10}\overline{V})^2 + C_2 \log_{10}\overline{T} + C_3 \log_{10}\overline{V}$ $C_o = -4.05504$ $C_2 = .41623$ $C_1 = -.21282$ $C_3 = 1.52211$	.7764	43

$^*R^2$ = Multiple correlation coefficient squared
N = Number of groups used

Table 3

ADT AND TRAIN VOLUME RANGES USED TO DEVELOP ACCIDENT PREDICTION EQUATIONS

1. Urban - Flashing Lights and Gates

ADT	Train Volume
0	0.0-0.1
1-500	0.2-2.0
501-1000	2.1-5.0
1001-3000	5.1-10.0
3001-6000	10.1-15.0
6001-10000	15.1-25.0
10001-15000	>25.1
15001-20000	
>20001	

2. Urban - Crossbucks And Rural - Flashing Lights And Crossbucks

ADT	Train Volume
0	0.0-0.1
1-300	0.2-2.0
301-600	2.1-5.0
601-1500	5.1-10.0
1501-4000	10.1-15.0
4001-8000	15.1-25.0
8001-15000	>25.1
15001-25000	
>25001	

Development Of Accident Severity Prediction Equations

Severity data was obtained from accident reports supplied by three railroad companies. Basic information to be used in the accident severity prediction included type of warning device, nature of collision, train speed in the accident, vehicle speed in the accident, number of injuries and number of fatalities. The types of warning are the same six classifications of devices used in the accident analysis. Approximately 6,800 accident records were supplied by the railroad companies. The number of accidents, injuries and fatalities for each classification of warning device and nature of collision are indicated in Table 4. Accident severity prediction equations have been developed for flashing lights and crossbucks. Work is continuing now on prediction equations for automatic gates.

Table 4

SUMMARY OF ACCIDENT SEVERITY DATA

Type of Warning Device	No. Of Accidents	No. Of Injuries	No. Of Fatalities
Automatic Gates	284	182	60
Flashing Lights	2,031	1,012	262
Other Active	327	149	38
Crossbucks	3,598	1,658	473
Stop Signs	59	29	6
None	525	95	16
Unknown	51	0	2
Total	6,875	3,125	857

Nature of Collision	No. Of Accidents	No. Of Injuries	No. Of Fatalities
Train Strikes Auto	4,055	1,860	555
Train Strikes Truck	1,107	308	127
Train Strikes Other	183	218	52
Auto Strikes Train	1,240	604	101
Truck Strikes Train	223	96	17
Other Strikes Train	39	39	5
Other	28	0	0
Total	6,875	3,125	857

Accident severity is described in terms of rate of injury and rate of fatality representing the number of injuries per accident and the number of fatalities per accident, respectively. Accident severity prediction equations are developed in terms of characteristic of accidents, thus the mean rate of injury and the mean rate of fatality for similar accidents are predicted from data which reflects the relationship between accident severity and accident characteristics (train speed and vehicle speed). Accident severity prediction equations have the basic form:

Mean number of injuries in similar accidents	=	Mean rate of injury for these accidents	×	Number of accidents of this kind
Mean number of fatalities in similar accidents	=	Mean rate of fatality for these accidents	×	Number of accidents of this kind

Accident severity prediction for different classifications of accidents involves prediction of the mean severity rate as well as the number of

Table 5

ACCIDENT SEVERITY ANALYSIS SUMMARY
Sequence of Numbers in each cell

1. Proportion of accidents in speed class
2. Predicted rate of injury for speed class
3. Predicted rate of fatality for speed class

1. Crossbucks

Train Speeds

		0-12 mph	13-24 mph	25-36 mph	37-48 mph	>48 mph
	0 mph	.1262 .3320 .0393	.0635 .4279 .0471	.0879 .4365 .0804	.0557 .3725 .1288	.0269 .2962 .2094
Vehicle Speeds	1-14 mph	.1690 .3500 .0564	.0518 .4459 .0673	.0616 .4545 .1132	.0395 .3905 .1777	.0173 .3141 .2790
	15-29 mph	.0716 .5193 .0551	.0375 .6152 .0658	.0386 .6238 .1109	.0241 .5598 .1743	.0084 .4834 .2743
	30-44 mph	.0361 .6256 .0608	.0165 .7215 .0726	.0193 .7301 .1216	.0067 .6661 .1898	.0036 .5898 .2955
	>45 mph	.0171 .5326 .1156	.0070 .6286 .1364	.0084 .6372 .2184	.0028 .5731 .3211	.0031 .4968 .4585

2. Flashing Lights

Train Speeds

		0-12 mph	13-24 mph	25-36 mph	28-48 mph	>48 mph
	0 mph	.1433 .2896 .0693	.0699 .5249 .1436	.0739 .5174 .1882	.0352 .4261 .3031	.0179 .2604 .3890
	1-14 mph	.1594 .3995 .0475	.0393 .6348 .1008	.0485 .6273 .1343	.0225 .5359 .2254	.0087 .3703 .2986
Vehicle Speeds	15-29 mph	.0976 .5540 .0659	.0306 .7893 .1371	.0485 .7818 .1801	.0168 .6905 .2918	.0058 .5248 .3762
	30-44 mph	.0555 .7634 .1411	.0202 .9987 .2700	.0347 .9912 .3384	.0098 .8999 .4896	.0052 .7342 .5840
	>45 mph	.0191 .6242 .1485	.0098 .8595 .2819	.0150 .8520 .3519	.0058 .7607 .5046	.0069 .5950 .5984

the mean severity rate as well as the number of accidents for which the rate applies.

The accident data were stratified according to various accident characteristics (train speed and vehicle speed) and the total number of injuries and the total number of fatalities were computed for each classification. The ratio of the number of injuries in a classification to the number of accidents in the classification is a measure of the rate of injury for this particular classification. Similarly the ratio of the number of fatalities to the number of accidents is a measure of the rate of fatality. From the tabulated data, severity ratios were obtained and arranged for statistical analysis. Results from the tabulated data were examined to determine the statistical properties so that appropriate methods could be used to produce estimates of the mean rate of injury and mean rate of fatality for each classification. Statistical methods for this type of data included the two-way classification analysis of variance with unequal numbers and proportions, and multiple linear regressions. The regression work has not proved promising. In each case, the dependent variables are the severity ratios, the observed rate of injury and observed rate of fatality and the independent variables are the average train speed and the average vehicle speed.

In the two-way classification data, the following were tabulated for each class:

number of accidents in the class;
number of injuries in the class;
number of fatalities in the class.

For each class, the rate of injury, the rate of fatality, and the proportion of accidents occurring in the class were also calculated. Table 5 shows this information for crossbucks and flashing lights.

If P is the estimate of the proportion of accidents occurring in a class, and if N accidents are predicted for a group of crossings, then P x N is an estimate of the number of accidents which will occur in the class for which the injury and fatality rates are appropriate.

The total number of injuries or fatalities predicted for the N accidents may be estimated using the overall severity rates for each warning device. The overall injury and fatality for crossbucks and flashing lights follow.

Warning Device	Injury Rate	Fatality Rate
Crossbucks	.5129	.1463
Flashing Lights	.6402	.2522

Use Of The Equations

Use of the prediction equation for groups of crossings entails the following steps. First, stratify the crossing data into the same ADT and train volume categories used to develop the equations and obtain a V (Vbar = mean ADT) and T(Tbar = mean number of trains per day) for the group to be considered. Using the V and T values, calculate the predicted number of accidents for a given group of crossings. The predicted number of accidents should also be calculated for the next higher level(s) of warning devices. Once the predicted number of accidents are known, the severity of the predicted accidents can be calculated. By using the overall injury and fatality rates developed for each of the warning devices, the predicted number of injuries and fatalities can be obtained. Once this is done, costs of the predicted accidents can be calculated for a given level of warning device and the next higher level(s).

The use of the prediction equations for individual crossings involves calculating the predicted number of accidents using the actual ADT and train volume values for the particular crossings. The predicted number of accidents can be calculated for the present level of warning device and for the next higher level(s). By using the vehicle speed limit and the train speed limit for the crossing, the number of predicted injuries and fatalities can be obtained using the injury and fatality rates developed for the appropriate vehicle and train speed classes.

Summary

The FHWA study is expected to be completed by the end of 1974. The final report will contain a detailed description of the type of analyses used to develop the prediction equations and suggested guidelines for using the equations.

New Passive Devices (Pooled Fund Research Project)

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It is estimated that there are about 223,000 public railroad-highway grade crossings in the

United States with an additional 35,000 grade intersections separated by structures. On these public railroad-highway grade crossings, 48,000 are protected by "active" types of protection which provide the driver with a positive indication of the approach of a train. The remaining 175,000 public crossings and some 140,000 private crossings have some type of "passive" protection.

Static signs and markings constitute the usual form of passive protection. These inform the motorist on the existence and location of a crossing but in the absence of some form of active protection, the driver must determine independently whether a train is approaching and whether it is safe to cross.

With more than three-fourths of the public grade crossing nation-wide protected only with static signs, it is most important for the signs both approaching and at the crossing to be effective. Furthermore, at the 70,000 or more crossings in the lowest classification for both highway and railroad traffic volumes—two or less trains per day—and 500 or fewer vehicles per day, economic justification for other than minimum protection of the static sign type does not appear possible.

A solution to the railroad-highway grade crossing safety problem would be to construct grade separation structures at each location. The cost for implementing this solution is, of course, prohibitive. It might also be desirable to protect all grade crossings with "active" warning devices, but here again the installation and operation costs limit the number of locations at which these devices are generally installed.

The majority of railroad-highway grade crossings will continue to be protected only by signs and markings which provide "passive" warning to drivers to proceed with caution at railroad-highway grade crossings.

The Manual on Uniform Traffic Control Devices (MUTCD) is the national standard for the signs and pavement markings at and approaching railroad-highway grade crossings. The standard existing *advance* warning sign consists of a 36 inch reflectorized yellow sign with a black "X" and the letters RR, which advises of the crossing ahead but gives no other information. Pavement markings are required in advance of some crossings and consist of a distinctive "X" and the letters RR. The crossbuck sign which consists of a set of crossarms with the words "Railroad Crossings" written on the arms is the standard device for use *at* the crossings. The crossbuck form of railroad-highway crossing has been standard for many years. Recent research indicates that improvements may be possible by providing more effective types of signs and markings at the crossing and on crossing approaches. Before new signing and marking procedures can be adopted for general use, these new "passive" warning systems must be installed in substantial numbers and at a variety of locations in order to obtain a thorough evaluation of their effectiveness.

Project Objective

The purpose of this research project is to evaluate the effectiveness of new passive signing systems to warn drivers of the potential hazard of railroad-highway grade crossings in the interest of greater safety to motorists crossing the railroads.

Research Organization

This research study is a cooperative effort among 25 state highway agencies, the Federal Railroad Administration and the Federal Highway Administration. Each of these agencies have contributed funds for the conduct of the study, as well as the states providing sites for testing the new signing systems.

A project advisory committee was formed at the initial stages of this project. This advisory committee consists of representatives from each of the participating states, the Federal Railroad Administration, the Federal Highway Administration and the Association of American Railroads. The advisory committee's functions are to:

- Develop technical prospectus to be included in the Request for Proposal (RFP) for this project. (This was accomplished at a meeting of the committee on June of 1972).
- Review and select a contractor responding to the RFP to conduct the field evaluation studies at all the sites (This was accomplished at the February 1973 meeting).
- Participate in the selection of the signs to be tested (This was accomplished at the December 1973 meeting).
- Follow the progress of the contractor during the study.
- Review the contractor's technical reports on the effectiveness of various systems; and,
- Prepare a committee report to initiate the adoption of new signing standards for railroad-highway grade crossings if the evaluation results warrant such action.

In addition to serving on the advisory committee, the state representative has additional responsibilities which primarily concerns the studies to be conducted in his state. Each state representative is to ensure that the following functions are provided for this study.

• Select possible study sites and supply information to the contractor about the site characteristics, traffic volumes, accidents etc;

• Ensure that the existing traffic control devices at the sites selected are up to MUTCD Standards before the contractor makes his initial study;

• Either install detector loops or provide flagging for the contractor while the contractor installs temporary loops and picks-up the loops before and after each study period;

• Purchases, installs and obtains the necessary clearances for the installation of the new experimental signs: and,

• Returns the standard signs to their proper location after the studies have been conducted.

The contractor, the System Development Corporation (SDC), has been retained by FHWA acting in behalf of the Advisory Committee to conduct the field studies in the various states. The contractor is responsible for the following tasks:

• Recommend the traffic control devices to be tested;

• Formulate an experimental design and select field test sites from those submitted by the states to fit the experimental design;

• Develop a data collection system and conduct a pilot test,

• Conduct a review meeting of the advisory committee;

• Arrange for the manufacture of the sign faces;

• Conduct the field studies;

• Analyze the data;

• Report the results; and

• Hold a final meeting of the advisory committee.

Research Approach

A. *Sign Systems Selected*

Miniature version of the 50 sign candidates were mailed to every member of the Advisory Committee for ranking of the railroad-crossing signs. This was done in a two-phase evaluation process, where the weighting of the goals for sign selection was done in the first phase and ranking of the railroad-crossing signs were done in the second phase. The following three general goals that the signs must meet were established in the first phase.

Goal I – Gain and Hold the Driver's Attention

Goal II – Convey the Information needed for Correct Response

Goal III – Present the Information Clearly and Unambiguously

For each of the basic goals, several subgoals were established to answer the respective questions of: *How* to best get attention; *what* information is most important; and *which* communication technique will be most successful and unambiguous. Each member of the Advisory Committee was asked to review the various goals and subgoals and then assign relative weights to them to indicate their opinion in the relative importance of each goal and subgoal. Results of the national average as represented by the participants were sent to every member, who were then asked to rank the various railroad-crossing signs within the framework of the weights assigned for each goal and subgoal.

Advisory Committee members were also asked to rate the various candidate signs subjectively where no formalized constraints, weights, goals, and subgoals were placed.

At the Advisory Committee meeting in Sacramento, summaries of the results of the subjective sign rating from the general sign opinion poll and the results from the objective rating scores submitted by the Advisory Committee members were displayed and passed out to each attendee. Miniature scale models of the road-surface, railroad crossing, and miniature sign posts were also developed and displayed at this meeting. Slides were shown of a road-way scene with some possible signing systems.

The candidate sign systems were developed by asking committee members to break into four subcommittees and each develop a candidate signing system using one of the four top ranked "at crossing" signs which were assigned to each subcommittee. The subcommittees then developed other candidate systems using one of the top ranked advance warning signs. The systems were compared and discussed at length and general agreement was reached with the resulting seven systems.

System #1 included the standard advanced warning sign with a yellow crossbuck with a black border.

System #2 is the same as System #1 except both signs are to be in bright yellow green (BYG).

The systems will automatically record the following data for each vehicle:

a. Vehicle number

b. Length of vehicle

c. Time of crossing

d. Location in feet from crossing for each detector

e. Arrival time at each detector

f. Velocity at each detector

g. Acceleration at each detector

h. Relative velocity at each detector to preceding vehicle

i. Headway at each detector related to preceding vehicle

In addition to the detector data which are automatically recorded, a manual observer will be stationed in a position to observe the approaching vehicle. Through a push-button device, the manual observer will record the following information in the computer which will be stored on the punched paper tape.

a. Local or out-of-state vehicle
b. Vehicle type - car, bus, truck, or farm
c. Vehicle age - old or new
d. Vehicle condition - good or poor
e. Window status - open or closed
f. Windshield clarity - good, fair, poor, or can't tell
g. Sex of driver- male or female, or can't tell
h. Number of passengers - none, one two, can't tell
i. Passing vehicle or not passing
j. Visual search - good, fair, none, or can't tell
k. Driver's age - under 25, 25 to 60, over 60, or can't tell
l. Train whistle (when it occurs)
m. Train arrival at and departure from the crossing
n. Train speed to the nearest 5 mph.

At least 100 complete vehicle crossing observations will be collected for each system at each site on one approach to the crossing.

In addition to the contractor collecting data at the 56 sites located in 23 states, it is planned that data will be collected at a railroad crossing located in Maine for all seven of the signing systems as well as the standard system. The data will be collected by the personnel operating the "Maine Facility" which is a 15 mile instrumented two-lane rural highway which has a railroad grade crossing located in it. Data are to be collected during inclement weather and at night for each sign system as well as during daylight hours.

Data Analysis

There are five different data types that are expected to be analyzed by this project. These are:

- Day time state site data;
- Night time state site data;
- Day time Maine Facility data;
- Night time Maine Facility data; and,
- Inclement weather Maine Facility data.

The three important site parameters selected for the experimental design which are: sight restriction, speed limit, and exposure factor (average daily traffic multiplied by the number of trains per day) along with the other site parameters mentioned in the experimental design are the primary variables which have been balanced to avoid biased effects on any particular system. The measures of effectiveness which will be analyzed consist of the following:

Speed Profile of each vehicle will be analyzed to determine if the vehicle could stop in time on its approach in the event that a train did suddenly appear.

Speed Reduction will be determined from the change in the vehicles speed between the first and the last loop which will indicate the cautiousness of the driver as he responds to the different signs.

Deceleration smoothness analysis will provide information on the potential hazard of collision between a leading vehicle and following vehicles.

Speed Differential measurements will also provide information on the potential collision between vehicles.

Visual Search is the human factor parameter to indicate the drivers awareness of the potential hazard of a possible train crossing.

Standard statistical tests will be applied to the data to determine differences in the effectiveness of the signing systems. The effect of the site variables will be studied and the systems will be ranked in the order of their measured effectiveness for typical conditions.

The result will be reported in a final report submitted to the advisory committee. If the one or more of the experimental systems prove to be superior to the current standard, the committee will prepare a recommendation to the National Advisory Committee for Uniform Traffic Control Devices to change the standard signs for railroad-highway grade crossings.

Problems Experienced

The contractor initially outfitted a van with the surveillance equipment. During the pilot test of the equipment, it was found that this vehicle was inadequate. At the current time a larger motor-home type of vehicle is being modified to hold the surveillance equipment and to allow the field crew living accommodations.

Some of the sites submitted by the states which were included in the experimental design have had to be withdrawn for various reasons. These reasons include: the installation of activated devices, finding that the railroad flags the crossing, the tracks have been abandoned, etc. Thus, the experimental design sites have to be modified.

Some state laws require the legend "Railroad Crossing" to appear on the sign at the crossing. Thus, the design of the experimental signs are being reconsidered.

Since the bright-yellow-green is a new color, the reflective sheeting for these signs is not fully developed. It may be that the signs being tested will not appear as they should under nighttime conditions.

Current Status

At this point in time the contractor is preparing to begin conducting the field studies. Some problems have been experienced with obtaining the proper surveillance equipment and developing the field procedures. It is hoped that the field data collection will start in September of this year and the project should be completed by July of 1976.

The states involved in this research project are listed below:

California	Minnesota	Texas
Colorado	Mississippi	Utah
Connecticut	Montana	Washington
Georgia	Nebraska	West Virginia
Iowa	New Mexico	Wisconsin
Kansas	North Dakota	
Kentucky	Ohio	
Louisiana	Pennsylvania	
Maryland	Rhode Island	
Michigan	Tennessee	

In-Vehicle Warning Systems For Railroad Grade Crossing Applications — A Review Of National Highway Traffic Safety Administration-Sponsored Research

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The purpose of this presentation is to briefly describe some of the work performed by Tracor Jitco, Inc under contract to the National Highway Traffic Safety Administration (NHTSA) on a study entitled, "Feasibility Study of In-Vehicle Warning Systems." The final report will be available to the public from the National Technical Information Service when it is published in a couple of months. Before the details of the project are reviewed, the background of how NHTSA became involved with this program area will be described.

NHTSA has the responsibility for reducing accidents caused by vehicle-related factors as well as those caused by driver-related factors. Because both of these factors play a role in grade crossing accidents, NHTSA has been concerned with determining how human behavior can be modified and vehicle factors improved to prevent such crashes. Preventive measures to date have focused on active warning devices at the crossing, passive warning signs, driver education and traffic law enforcement.

One approach that has not been tried that relates to NHTSA's interest in the vehicle and driver is to put a device inside the vehicle that would sound an alarm to warn the driver when a train is approaching at a grade crossing. This concept is not new. A number of such "in-vehicle warning systems" (IVWS) have been conceptualized and developed in the past. However, no systematic analysis had been performed to determine the feasibility of the concept as an accident countermeasure; nor had there been any rigorous analysis of the grade crossing environment, driver needs, accident data and other relevant information to determine what kind of equipment performance would be required to make an IVWS a viable, cost-effective accident countermeasure. To fill these gaps, the NHTSA and the FRA jointly sponsored a program to study these issues. The study also considered the application of IVWS's to emergency vehicles because of the potential of these devices for improving the detection of emergency vehicle sirens and because of the a prior assumption that any IVWS would have to be justified on a total system basis and not as an individual solution to a specific problem. This presentation, however, will cover only the railroad grade crossing aspect of the problem.

One of the first questions to be addressed by the study was whether an IVWS could perform a useful function as a railroad grade crossing accident countermeasure. A number of casual factors associated with these accidents were identified and the role of an IVWS in preventing them was examined. The causal factors identified included driver inattention, driver stress, poor judgment of when to cross, acoustic isolation of motor vehicle interiors, and inadequate sight distance at crossings. Driver inattention brought about by distraction, familiarity with crossing, daydreaming, etc., could be overcome with an IVWS which alerts the driver to the approach of a train. Driver stress from fatigue and alcohol impairment often results in unsafe driver looking behavior, similar to tunnel vision. An IVWS could aid the driver under stress by advising him of the need to search for an approaching train. The driver's misjudgment of safe crossing time could be helped by an IVWS which provides a constant warning time before the train reaches the grade crossing. Similarly, an IVWS could help to eliminate problems arising from the driver's inabilitv to hear train horns because of vehicle soundproofing and problems from crossing site defects, such as poor sight distance and inadequate signs. In considering the nature and extent of these casual factors, the study reached the conclusion that approximately 60-75 percent of the train-vehicle collisions at grade crossings have casual factors that can be influenced by means of an IVWS.

Given that an IVWS had significant potential as an accident countermeasure, the next question to be addressed was what system requirements need to be satisfied to make an IVWS a feasible approach to the problem. One of these requirements was that the system provide a realiable warning over its operating lifetime under all environmental conditions. Poor reliability can result in the driver missing a warning signal. Such missed signals could result from a component breakdown or from an inadequate system design that does not take all environmental factors into consideration. For example, some system designs cannot provide reliable warning signals because of sharp curves that often precede crossings, trackside buildings, and background acoustic and electromagnetic noise.

Another system requirement is for a low false alarm rate. A false alarm occurs when a driver receives an indication of the presence of a train when there is no train that presents a hazard to the driver. Repeated false alarms could cause him to ignore a true alarm in the belief that it was another false one. In addition to this credibility problem, repeated false alarms could prove to be an annoyance to the driving public.

The study also identified the need for an IVWS to provide a constant warning time to the driver. A constant warning time would assist the driver in making the judgment of when it would be safe to cross the tracks and would help reduce the risk taking associated with the crossing decision. Closely related to the constant warning time requirement is the need to provide a warning signal to the vehicle at a distance sufficient to allow the driver to take appropriate action. For example, for a train velocity of 68 mph and a warning time of 20 seconds, this distance extends for 2000 feet in front of the train.

With a knowledge of the type of performance needed by an IVWS, the study explored various system configurations to determine what kind of system would meet the necessary performance requirements. One of the least complex configurations examined uses a radio frequency transmitter in the locomotive that broadcasts directly to a receiver in the motor vehicle. The receiver would actuate a warning display panel and an audio alarm when the vehicle is within a danger zone of the train. Although this system has relatively low cost and complexity, some of its features may lead to false alarms and missed signals. Because the radio frequency signal is non-directional, drivers not approaching the grade crossing will receive false alarms. Line of sight obstructions, such as trackside warehouses, would reduce signal strength and result in missed signals. Missed signals would also occur because of variations in the signal to noise ratio brought about by the varying electromagnetic noise backgrounds at different crossings.

More complex radio frequency transmission systems that correct for some of the defects in relatively simple configuration were also analyzed. In addition, systems using other operating principles, such as acoustic detection of train horns, were studied. The general conclusion from these analyses was that only the more complex systems could provide a reliable warning to the driver. These more complex systems, however, still possessed a number of drawbacks, a chief one being high cost.

In order to obtain a quantitative estimate of cost-effectiveness, an analysis of the simple, direct radio frequency transmission configuration was conducted to determine the potential savings from accidents reduced and expected costs. For this computation, the emergency vehicle application of IVWS was included in the calculations of accidents reduced and system costs. The analysis found that even the most optimistic estimates for costs and benefits result in an unfavorable cost-benefit ratio of $3 spend fo each $1 saved.

The overall conclusions of the study can be expressed as follows: In-vehicle warning systems have the potential for prevention of a significant percentage of grade crossing and emergency vehicle crashes. The cost of achieving reliable warnings is not, however, offset by savings in accident reduction for an IVWS dedicated only to the grade crossing and/or emergency vehicle problem. The more complex IVWS's require that certain hardware be installed at the railroad crossings in order for them to satisfy the necessary performance requirements. This technology might be better spent on a program of active crossing protection. There may be some benefit if the functions provided by such an IVWS were included as part of a total intervehicular communication system which performs many functions in addition to grade crossing and emergency vehicle warning.

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Model For Evaluation Of Alternative Grade-Crossing Resource Allocation Strategies

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Introduction

Effective formulation of grade-crossing protection programs requires the capability to estimate with reasonable accuracy the costs, potential benefits and implementation implications of alternative resource allocation decisions. One of the special difficulties of orderly planning in the area of railroad-highway crossing safety is the diffuseness of the subject. The crossings can range from lightly travelled, with a mean time between accidents of hundreds of years, to high-traffic-density situations where collisions occur several times annually. Protection options are based upon the choice of flashing lights, lights plus automatic gates, or grade separations, with costs ranging from less than $20,000 to greater than $1 million. Basic decisions concerning the type of protection to be used at each class of crossing depend not only upon the costs and effectiveness of the warning systems, but also on overall program objectives, available resources, and implementation strategy. This paper describes a computer-aided analytical approach which can aid significantly in the planning/decision-making process, and presents preliminary results (based upon data of limited precision) which should illuminate both the approach and the problem area.

The methodology and concomitant computer program described here provide no magic circumvention of the limitations of inadequate information concerning crossing population, inherent hazard, or costs; nor do they indicate unambiguously the protection to be used at a particular crossing. Both input data and "answers" obtained represent only gross averages. However, these average values can make possible a relatively accurate understanding in terms of program alternatives, of overall characteristics (magnitude and nature of required investment, number of crossings affected, potential safety benefits, etc.). In addition, examination of the sensititions, hardware cost, warning effectiveness, etc., can be most useful in development of policy for both implementation and research programs.

The Basic Approach

The most effective expenditure of crossing protection funds is determined largely by two incremental factors. If one categorizes crossings by hazard – the probability of an accident during a particular unit of time – a distribution such as that shown in Figure 1 is found. There is clearly greater "leverage" – more lives saved for a given percentage reduction in accident probability – for the higher-risk crossings. In addition, even the relatively small number of crossings characterized by high hazard ratings are found to contribute a large total number of accidents. Thus, effective protection at these crossings is an obvious component of any viable overall strategy.

However, one has a discrete (but very broad) spectrum of protective systems and devices to choose from. These range from passive systems with a price in the range of a few hundred to a few thousand dollars, through active devices of greater effectiveness which typically cost (installed) $15,000 to $75,000, to grade separations which reduce train-vehicle collisions to zero but may cost $500,000 to $1 million. This spread is illustrated qualitatively in Figure 2. Optimal selection of the protection appropriate to each crossing category thus requires a matching of the protection effectiveness to the potential hazard in a manner which optimizes the overall result.

Definition of the "best" solution is, to some degree, a matter of judgment and policy. If resources are fixed, one may seek the allocation which achieves maximum accident reduction. Alternatively, the means to an explicit goal – perhaps a specified reduction in death toll – can be chosen for minimum cost. Further, given specific criteria, there may be a number of alternative strategies with similar overall characteristics, but rather different implications for implementation.

FIGURE 1
BREAKDOWN OF ACCIDENT STATISTICS
(CROSSINGS WITH PASSIVE PROTECTION)

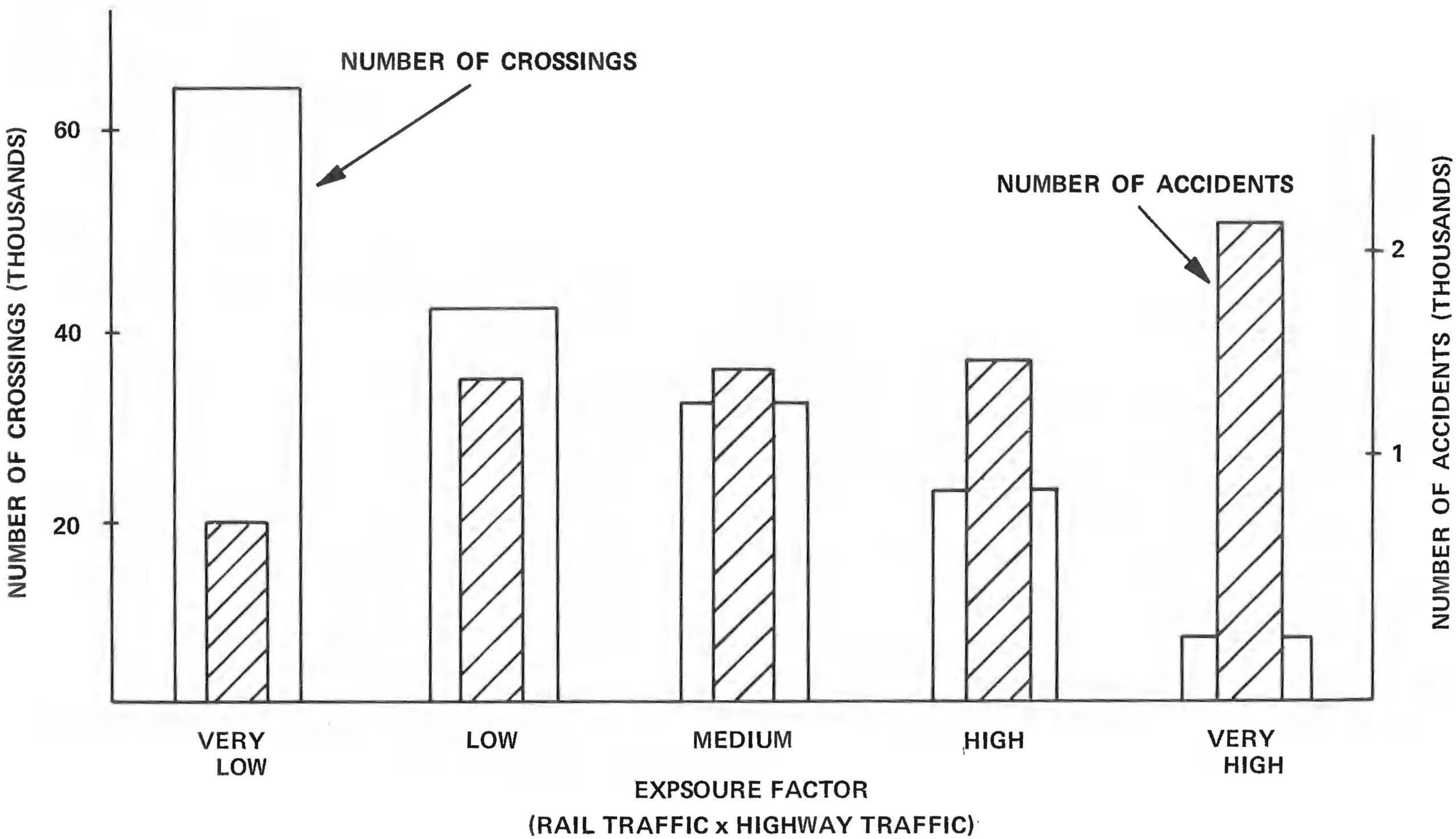
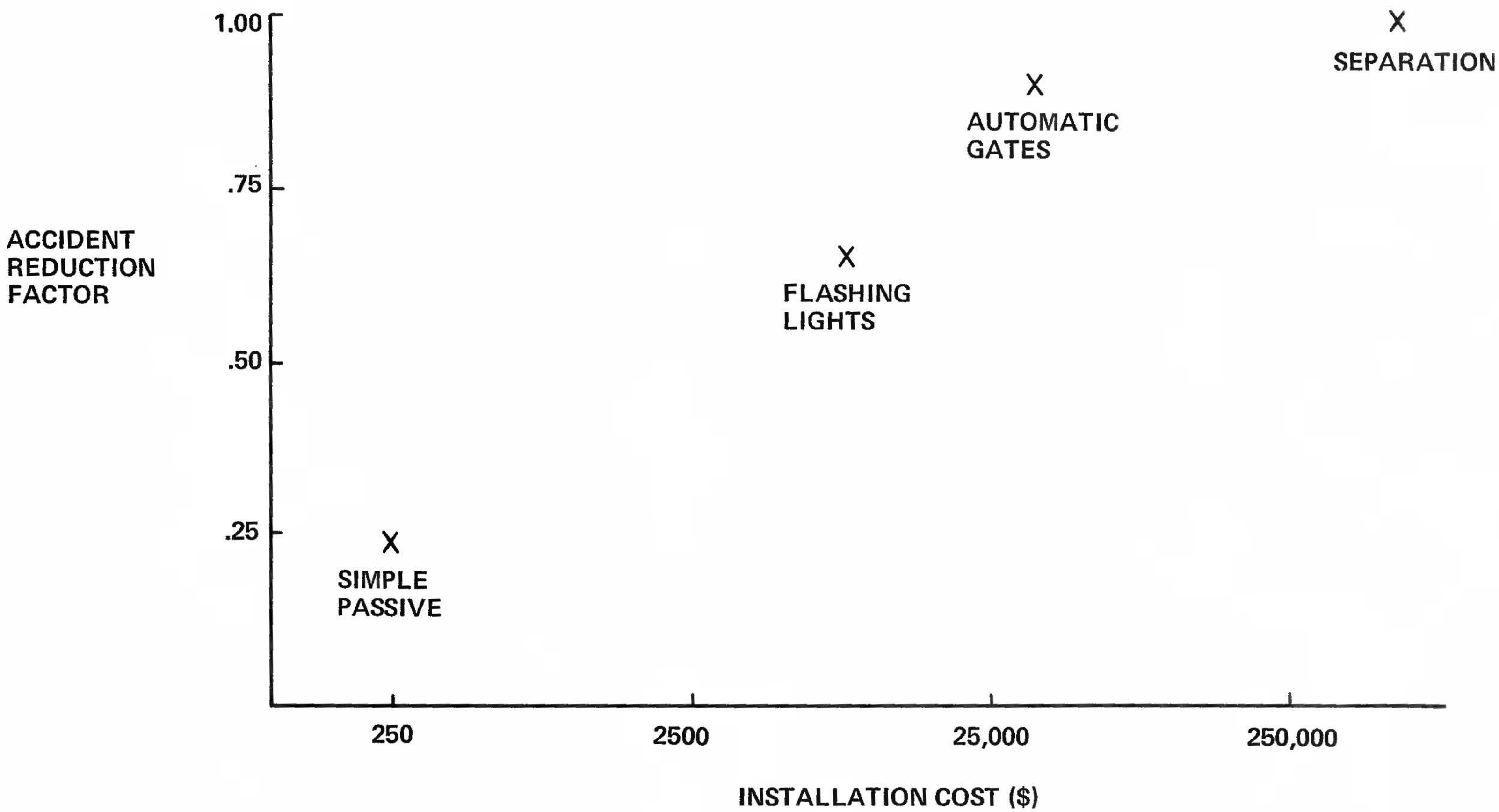


FIGURE 2
EFFECTIVENESS AS A FUNCTION OF COST FOR TYPICAL GRADE CROSSING WARNING SYSTEMS
(HYPOTHETICAL)



Thus, the means chosen to analyze crossing resource allocation should provide not a single "best" answer, but rather must present a variety of possible variations, within acceptable constraints. Only then are fully informed decisions possible. This result can be obtained in a conceptually simple manner; one can merely consider all possible combinations of protective systems or devices (as in Figure 2) and the actual crossing population, categorized by hazard (Figure 1). For the case indicated in the figures, this involves four protection alternatives, and five crossing categories. This implies that 625 combinations (protection strategies) are possible, although most can be eliminated immediately as being either ineffective or unnecessarily costly. More realistic analysis involves many more alternatives.

Fortunately, consideration of a very large number of alternatives can readily be carried out by use of a digital computer with automatic rejection of the vast number of strategies not meeting specified criteria – total cost, lives saved, cost per life saved, net societal benefits, etc. It is this methodology which has been implemented at the Transportation Systems Center. In use it not only permits convenient evaluation of alternatives, based upon available data, but also allows immediate evaluation of the policy options resulting from a hypothetical change in either cost or effectivenss of any protection system, new or conventional.

Table 1
Categorization of Crossing Population for Purposes of Illustration

Category Number	Number of Crossings	Hazard	Description
X01	104798.	0.015320	Very Low Density
X02	10207.	0.054260	Low Density
X03	5800.	0.091770	Medium Density
X04	2440.	0.165120	High Density
X05	573.	0.582360	Very High Density
	123818.		Total Rural

The criterion most often applied previously[1] is that each crossing category must be protected in the manner which achieves maximum net benefit (or maximum benefit-cost ratio), and allows installation of protection only if this parameter is above a set threshold. A given array of possible protection devices and crossing population leads then to only *one* possible strategy. There is no provision for a "graceful degradation" of the constraints to permit estimation of the costs of attaining a different, possibly somewhat more or less expensive, policy goal.

Another widely used approach is to rank all crossings in a given jurisdiction according to some specified hazard rating. A program can then be generated by defining the degree of hazard which warrants a given class of protection, and simply working down the list each year until funds are exhausted. The weakness in this method is that careful analysis shows the warranted protection to be in part determined by the overall program funding level and implementation process.

On the other hand, the method described here makes possible tailoring to specific safety objectives, funding limitations, implementation constraints, or policy guidelines. The approach is intended to provide immediate information, through a highly-interactive computer program, as to the characteristics of overall, "macroscopic" protection programs associated with particular policy decisions or protective systems. Conceptually, the computations involved are very simple. Input information of two types is required: The population of grade crossings, categorized in terms of hazard (accident potential), and the alternative protective systems to be considered. Hypothetical data of this type is given in Tables 1 and 2 for purposes of illustration. The values indicated are not to be taken as highly accurate, but do represent a reasonable approximation to the actual case for rural, passively protected crossings. "Hazard," H, the anticipated accident probability per year per crossing, is typically determined from rail and

Table 2
Categorization of Protection Systems for Purposes of Illustration

Protection System Number	Cost ($)	Effectiveness	Description
W0.	0.	0.0000	Crossbucks (Existing)
W1.	25000.	0.7000	Flashing Lights
W2.	40000.	0.9500	Automatic Gates
W3.	400000.	1.0000	Grade Separation

highway traffic density, although the computations to follow are independent of the definition of hazard, and more sophisticated approaches may easily be substituted. "Effectiveness," E, is the factor by which the protective system in question is expected to reduce accidents and deaths; it normally can range from zero (no effect) to unity (perfect protection). "Cost," C, is the total expense of installation.

For any given crossing category, installation of a specified protection system at all crossings within that category will have an associated total cost of N x C, where N is the number of crossings. In the computations here described, the resultant cost values calculated are divided by a factor of ten. This permits two (approximate) interpretations: (1) the *annual* total installation cost of a 10-year program to achieve the protection specified at all crossings, or (2) the steady-state annual societal cost, including both amortization and maintenance. Although the 10 percent value is not precise in either case, it represents a useful approximation, at least as accurate as the basic effectiveness, hazard, and cost data.

Similarly, one can readily calculate the potential saving of life, and accident prevention, associated with a particular class of protection for a specified crossing category. As used here, hazard represents the annual probability of an accident at the crossing in question. Thus, the number of lives saved by installation of given protection at all crossings in a category will save N x H x E lives per year; other benefits – reduction of injuries, property damage, etc – are readily incorporated.

Given the categorized crossing population and a set of protective systems, one can readily generate a "cost/lives" matrix, as seen in Figure 3. From it, one may read cost (as defined above) and lives saved for each possible combination of crossing category and protection. In Figure 3 cost per accident prevented, and benefit/cost ratio, are also displayed for each cell.

Each Cell Contains: **Total Cost ($Millions)**
Total Lives Saved Annually
Cost Per Accident Prevented ($10000's)
Benefit/Cost Ratio

Protection System

Crossing Categories	W0	W1	W2	W3
X01	0.0	262.0	419.2	4191.9
	0.0	187.2	254.1	267.5
	0.0	233.1	274.8	2611.0
	1.00	0.26	0.22	0.02
X02	0.0	25.5	40.8	408.3
	0.0	64.6	87.7	992.3
	0.0	65.8	77.6	737.2
	1.00	0.93	0.79	0.08
X03	0.0	14.5	23.2	232.0
	0.0	62.1	84.2	88.7
	0.0	38.9	45.9	435.9
	1.00	1.57	1.33	0.14
X04	0.0	6.1	9.8	97.6
	0.0	47.0	63.8	67.1
	0.0	21.6	25.5	242.2
	1.00	2.82	2.39	0.25
X05	0.0	1.4	2.3	22.9
	0.0	38.9	52.8	55.6
	0.0	6.1	7.2	68.7
	1.00	9.94	8.43	0.89

Figure 3
"Cost/Lives" Matrix for Hypothetical Crossing Population and Protection System Array Tables 1 and 2

Protection Strategies

A total grade crossing protection policy requires a decision as to the type of protection to be installed at each class of crossing. In terms of the cost/lives matrix, this consists of selection of one cell for each crossing category. Possible overall choices will be referred to as "protection strategies"; two such strategies are illustrated in Figure 4. As displayed in the figure, each strategy has associated with it a total cost and saving of life, consisting of the summation of these factors for each cell comprising the strategy.

The total number of possible strategies can be very large, even in a simple case: $N_X N_p$, where N_p is the number of protection alternatives and N_X is the number of crossing categories. For $N_X = 5$ and N_p = (including "no change"), the total is 3125. In addition, the possibility of installing protective devices (lights, energy-management structures, etc) on locomotives is an additional parameter to be considered, and each candidate generates an additional array in the cost/lives matrix. A more realistic case, with more crossing categories and the possibility of upgrading existing protection, implies a very large number of possibilities.

	W0	W1	W2	W3
X01	0.0	262.0	419.2	4191.9
	0.0	187.2	254.1	267.5
	0.0	233.1	274.8	2611.0
	1.00	0.26	0.22	0.02
X02	0.0	25.5	40.8	408.3
	0.0	64.6	87.7	92.3
	0.0	65.8	77.6	737.2
	1.00	0.93	0.79	0.08
X03	0.0	14.5	23.2	232.0
	0.0	62.1	84.2	88.7
	0.0	38.9	45.9	435.9
	1.0	1.57	1.33	0.14
X04	0.0	6.1	9.8	97.6
	0.0	47.0	63.8	67.1
	0.0	21.6	25.5	242.2
	1.0	2.82	2.39	0.25
X05	0.0	1.4	2.3	22.9
	0.0	38.9	52.8	55.6
	0.0	6.1	7.2	68.7
	1.00	9.94	8.43	0.89

Figure 4 a
Sample Protection Strategy for
Matrix of Figure 3
Cost: $146 M
Lives Saved: 216

	W0	W1	W2	W3
X01	0.0	262.0	419.2	4191.9
	0.0	187.2	254.1	267.5
	0.0	233.1	274.8	2611.0
	1.00	0.26	0.22	0.02
X02	0.0	25.5	40.8	408.3
	0.0	64.6	87.7	92.3
	0.0	65.8	77.6	737.2
	1.00	0.93	0.79	0.08
X03	0.0	14.5	23.2	232.0
	0.0	62.1	84.2	88.7
	0.0	38.9	45.9	435.9
	1.00	1.57	1.33	0.14
	0.0	6.1	9.8	97.6
	0.0	47.0	63.8	67.1
	0.0	21.6	25.5	242.2
	1.0	2.82	2.39	0.25
X05	0.0	1.4	2.3	22.9
	0.0	38.9	52.8	55.6
	0.0	6.1	7.2	68.7
	1.00	9.94	8.43	0.89

Figure 4 b
Sample Protection Strategy for
Matrix of Figure 3
Cost: $422.5 M
Lives Saved: 437

Evaluation Of Alternative Strategies

The object of this model is calculation, sorting, and ranking of the possible alternative strategies, applying specifically stated (and readily changed) constraints and criteria to eliminate all but those sufficiently close to basic policy objectives. In the present form of the program, several such constraints are applied:

1. Total Cost. All strategies exceeding a specified total cost are eliminated.

2. Minimum Lives Saved. All strategies which fail to save a required minimum number of lives are eliminated.

3. Cost/Benefit. Acceptable strategies must provide a specified cost/benefit ratio. Two limits, different if desired, are imposed; one on each element of the matrix (each crossing category), and one on the total strategy.

Calculations are carried out in a manner intended to reduce computation time. For example, the more expensive cases are examined first: in Figure 4, for example, if one examines the X01, W4 case first, and finds that it alone already exceeds the total cost constraint, there is no need to consider further any of the 5^4 = 625 strategies of which it forms an element.

Information Output

The focus of the computation is listing of the costs and benefits associated with the more desirable alternatives. (However, the basic cost/lives matrix is readily displayed). In operation, after all input data has been supplied and constraints (maximum total cost, minimum lives saved, etc.) specified, acceptable strategies are selected, and each is characterized in terms of cost, lives saved, cost per accident prevented, and net benefit – benefits minus cost. A specified number of "acceptable" alternatives is then ranked on the basis of any of these characteristics desired. In the resulting list, all parameters are printed, including the total number of installations of each type of wayside protection.

The program is highly interactive, providing frequent opportunity for modification of input data, injection of new constraints, or choice of alternative output information. Running time is primarily determined by these interactions, with typical runs requiring only minutes.

Sample Results

The illustrative examples presented here, based upon the assumed values for crossing population, hazard ratings, and protective system characteristics must be viewed as hypothetical. That data has been generated from currently available sources, and appears to be a good approximation to reality. The qualitative form of the results presented here, and their sensitivity to various factors, should be quite valid. However, quantitative details – such as the number of lives to be saved by a program of given magnitude – are highly sensitive to inventory data, accident prediction equations, and warning system cost and effectiveness values. Thus the numbers shown here should be taken only as gross approximations, subject to substantial revision in the future. Improved data generated by FRA, FHWA, TSC, and others will be incorporated into this formulation as available.

The crossing population for this sample analysis is drawn primarily from Part II of the FRA/FHWA Report to Congress[2], from which various accident subtotals are taken, and supporting inventory data[3], which provided an approximation to the crossing population categorized by location (urban /rural), protection class, and rail and highway traffic densities. Hazard was estimated using an accident prediction equation and coefficients also provided by FHWA[4], with constants adjusted to produce subtotal and total accident figures for various classes which correspond to the actual national experience. The categorization used is such that the number of casualties occurring annually for each element is a small part of the whole, with a relatively uniform distribution. The ratio of fatalities to accidents and average accident costs, taken separately for urban and rural locations, are those of the Part II Report to Congress, with costs arbitrarily increased by 15 percent as a very approximate adjustment for inflation. Protective system costs and effectiveness represent a composite developed largely through studies carried out by Consad Research Corp. under a TSC contract.* The input data is summarized in Tables 3 (crossing population) and 4 (protection system characteristics). Use of national figures in these examples is merely for convenience. The methodology, and the TSC application guidelines computer program (AGCP) can be applied with equal facility to any state or locality for which adequate data is available. The maximum prevention of fatalities ("lives saved") attainable is graphed as a function of annual program cost (assuming a 10-year implementation program) in Figure 5, which also shows the associated degree to which one quickly "uses up" the high-traffic-density, high-hazard crossings, for which active protection yields substantial benefits. At this point, further investment of protection resources can be made only at crossings for which hazard, and potential benefits, are significantly lower. Eventually the point is reached at which the *incremental* benefit/cost ratio is less than unity (or any other threshold which may be selected), implying that funds are more beneficially expended in other areas. Thus, there is a natural limitation on the total amount which can optimally be spent upon crossing protection, although in practice this point has seldom been reached. (It is, of course, dependent upon policy decisions concerning evaluation of "benefits" and the required benefit-cost ratio threshold.)

Several alternative cases are also shown in Figure 5. Curve 3 is drawn under the assumption that costs of active protection are 25 percent less than the values of Table 4, both to indicate the effect of uncertainty in those values, and to suggest the impact which lower cost protective systems could have on crossing safety programs. Similarly, curve 2 has assumed enhanced system effectiveness; .8 for lights and .98 for gates, as opposed to .7 and .95 used for the basic case, curve 1. Note that these two alternative cases allow a somewhat greater expenditure before the incremental benefit/cost ration prevents further investment.

Because of the limitations of time and available data, no lengthy analysis of results such as these will be presented here. However, a full report of this research, including preliminary conclusions where justified, is in preparation and should be available within a few months. As an example of the detailed information which can be obtained directly, a summary of two alternative strategies, each costing approximately $75 million is shown in Table 5. These are calculated for the 25 percent cost-reduction-case, and each results in a prevention of 356 deaths annually. They differ significantly, however, in the means used to

*Final reports are in preparation.

Table 3

ASSUMED BASIC GRADE CROSSING POPULATION

Deaths Per Accident: 0.1666 Rural 0.0517 Urban
Cost ($Thousands) Per Accident: 61.010 Rural 26.335 Urban

X01	C01	0R	76708.	0.01969	Rural, Passive, Exposure 1
X02	C02	0R	40227.	0.03502	Rural, Passive, Exposure 2
X12	C03	1R	6000.	0.08932	Rural, Flashing Lights, Exposure 2
X13	C04	1R	3448.	0.15500	Rural, Flashing Lights, Exposure 3
X07	CO5	0U	24112.	0.06743	Urban, Passive, Exposure 2
X03	C06	0R	6232.	0.06553	Rural, Passive, Exposure 3
X16	C07	1U	10363.	0.12366	Urban, Flashing Lights, Exposure 2
X08	C08	0U	9429.	0.12427	Urban, Passive, Exposure 3
X17	C09	1U	4114.	0.21230	Urban, Flashing, Lights, Expsoure 3
X11	C10	1R	7613.	0.03522	Rural, Flashing Lights, Expsoure 3
X06	C11	0U	15471.	0.03786	Urban, Passive, Exposure 1
X24	C12	2U	2024.	0.24299	Urban, Auto, Gates, Exposure 3
X15	C13	1U	7664.	0.06203	Urban, Flashing Lights, Exposure 1
X09	C14	0U	1737.	0.23024	Urban, Passive, Exposure 4
X23	C15	2U	2342.	0.13157	Urban, Auto, Gates, Exposure 2
X04	C16	0R	676.	0.12716	Rural, Passive, Expsoure 4
X14	C17	1R	235.	0.29774	Rural, Flashing Lights, Expsoure 4
X20	C18	2R	918.	0.05216	Rural, Auto, Gates, Exposure 2
X21	C19	2R	510.	0.09230	Rural, Auto, Gates, Exposure 3
X22	C20	2U	1511.	0.06291	Urban, Auto, Gates, Exposure 1
X19	C21	2R	1542.	0.01886	Rural, Auto, Gates, Exposure 1
X18	C22	1U	147.	0.37940	Urban, Flashing Lights, Exposure 4
X05	C23	0R	57.	0.25363	Rural, Passive, Exposure 5
X10	C24	0U	114.	0.38256	Urban, Passive, Exposure 5
X25	C25	2U	96.	0.44311	Urban, Auto, Gates, Exposure 4
			223291.		Total

Table 4
ASSUMED SET OF
PROTECTIVE SYSTEM ALTERNATIVES

NO.	COST	PROT.	IMPROVEMENT
W0.0	0.	0.0001	Crossbuck (Existing)
W1.0	25000.	0.7000	Flashing Lights
W2.0	40000.	0.9500	Automatic Gates
W2.1	25000.	0.9500	Automatic Gates (Upgrade From f.l.)
W3.0	400000.	0.9999	Separation
W3.1	400000.	0.9999	Separation (Upgrade From f.l.)
W3.2	400000.	0.9999	Separation (Upgrade From a.g.)

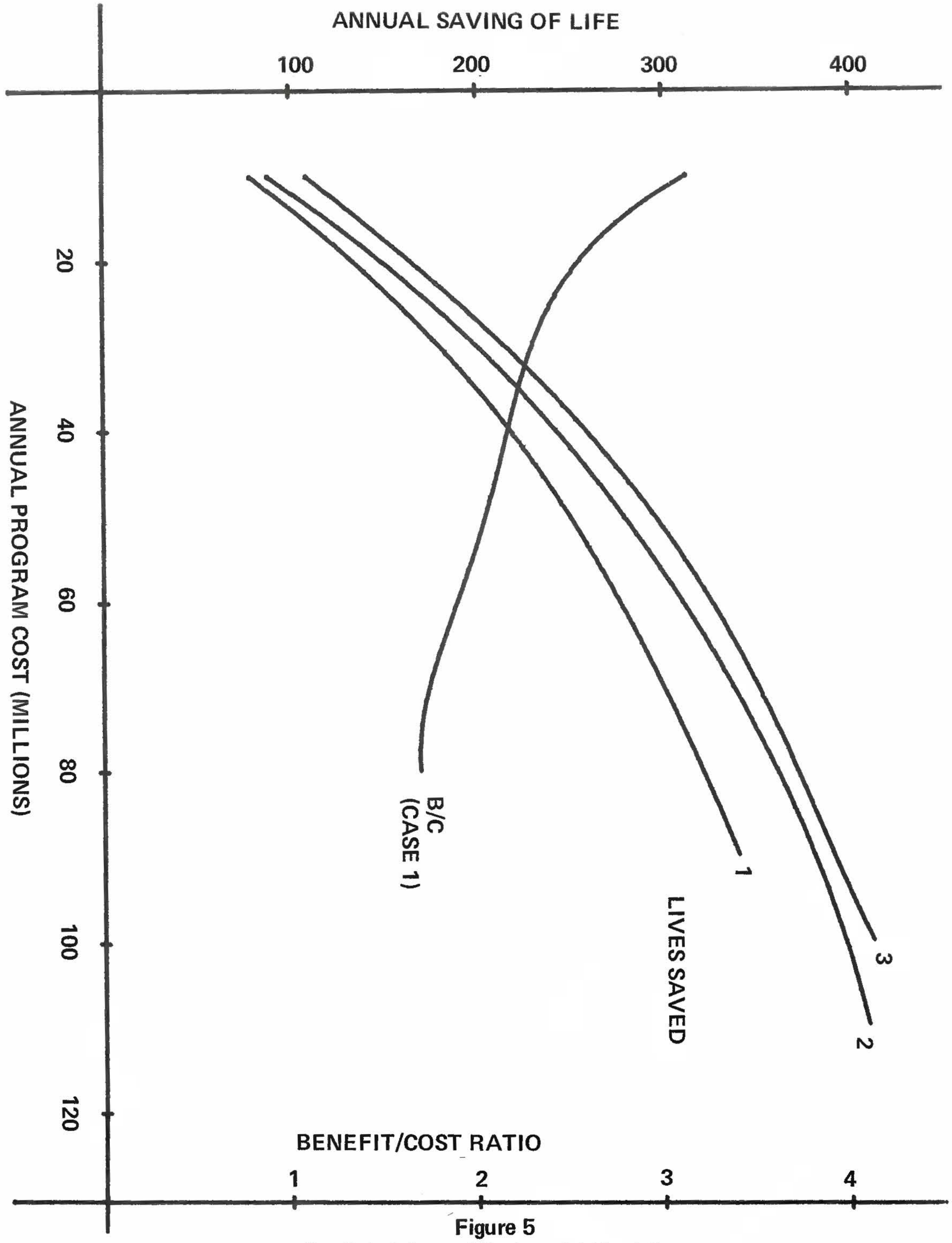


Figure 5
Predicted Annual Saving of Life at the Conclusion of a 10-Year Crossing Protection Program, as a Function of Annual Program Cost
1: Basic Case; 2; Improved Effectiveness Case;
3: Low-Cost Case

achieve this result: one utilizes only automatic gates, installed at approximately 33,000 crossings (24,000 of which represent upgrading from existing flashing lights); the other includes use of flashing lights alone in almost 18,000 cases, and involves upgrading or installation of new protection at almost 41,000 crossings. This sample, in the real world, would reveal the requirement for a policy decision: good protection at a large number of crossings, or very good protection at a smaller number. (At present, analyses typically carried out in practice are not sufficiently complex to bring out the choices which exist, so that such decisions are made by default.)

Table 5

SAMPLE PROTECTION STRATEGIES; LOW-COST PROTECTION STRATEGIES. TOTAL ANNUAL COST $75 MILLION; 356 LIVES SAVED ANNUALLY

Change In Protection	Number Of Crossings Receiving Indicated Protection	
	Case 1	Case 2
New Flashing Lights	0	16237
New Automatic Gates	8816	57
Upgrade From Lights To Gates	24307	24307
Total	33123	40701

Conclusion

This paper has presented a summary of a model developed at TSC to facilitate analysis of resource allocation alternatives for both research and program implementation. It has been found to be a useful tool, within input-data limitations, and promises to be increasingly valuable as improved crossing information is developed through on-going FRA and FHWA programs.

It should also be noted that this formulation is equally applicable at the state and local level; the calculations shown have utilitzed national data merely for convenience. Given categorization of the crossing population, assumed cost and effectiveness of available protection systems, and policy decisions concerning criteria for selection of strategies, this entire process is readily carried out at any level of government.

Acknowledgement

The major part of the computer programming task associated with this model was carried out by M. Hazel of TSC; the success of the effort is due largely to his diligence, skill, and ingenuity. The assistance of R. Hunter and J. Coleman, FHWA, in supplying data is also greatly appreciated. This research has been funded entirely by FRA.

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4. J. Coleman, FHWA. Private Communication.

Rail Safety/Grade Crossing Warning Research Program

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I. Introduction

The purpose of this paper is to outline a Rail Safety/Grade Crossing Warning Research Program currently underway at the US Department of Transportation, Transportation Systems Center in Cambridge, Massachusetts. This research program is sponsored by the Federal Railroad Administration Office of Research, Development and Demonstration, and includes the specific projects listed below:

1. Locomotive Conspicuity/Visibility Enhancement
2. Modularization and Standardization
3. California Grade Crossing Program Study
4. Grade Crossing Information System Requirements

5. Low Cost Barrier (Gate)
6. Innovative Warning Systems Study
7. Locomotive/Auto Impact Attenuation
8. Grade Crossing Warning Equipment Application Guidelines

Each of these research projects is described here in a manner intended to provide the reader with an understanding of objectives and status of the work.

II. Locomotive Conspicuity/Visibility Enhancement

In FY 70-71, FRA explored the benefits that would result if a locomotive were made more conspicuous to a motorist approaching a rail/highway intersection. The conclusions reached at that time were that there are likely to be significant benefits from painting locomotives with large areas of bright contrasting colors, and equipping them with flashing lights of fairly high intensity. In 1972, FRA arranged for fabrication of a variety of visually altering devices (beacons, flashlamps, illuminated panels), and in FY 73 the Transportation Systems Center undertook testing of these and other devices at the Naval Ammunition Depot, Crane, Indiana (The Crane facility has both a captive railroad and a human factors research group).

The tests demonstrated that xenon strobe lights have the highest effective conspicuity level of light sources tested. These results led to planning of a field test program to evaluate effectiveness, durability, crew factors and maintenance requirements on operating railroads in FY 74. A number of xenon strobe lights of the type shown in figures I and II were installed on locomotives of the Bangor and Aroostook, Boston and Maine, Union Pacific, Santa Fe and the Providence and Worcester railroads. Test results from many thousands of hours of operational use are beginning to show motorist alerting and maintenance cost advantages attributable to the xenon strobe light. Figure III shows a xenon strobe light mounted on a locomotive of the Bangor and Aroostook Railroad.

Operational evaluation of the xenon strobe light will continue and application guidelines will be published in FY 75.

III. Modularization and Standarization

The purpose of this study is to determine the economic and technical feasibility of modularization and standardization used to improve effectiveness and reduce cost of active grade crossing protection.

Two contracts have been awarded to industry for independent study leading to recommended modularization and standardization concepts. It is expected that the results of the study will be available in early 1975 and that promising concepts will be the subject of development and operational tests.

The commonalty of functions which can be performed in the protection of grade crossings and the similarity of equipment currently in use for this purpose, suggests that modularization of components and standardization of equipment design may increase the effectiveness of protection on a nationwide basis. Reduction in original equipment cost, moderation of the crossing protection system design burden carried by the railroad signal engineer and reduction in cost of installation, maintenance and administration are part of the benefits that many be expected from a modularized and standarized grade crossing equipment inventory.

Engineering of grade crossing protection for each new crossing site often tends to become a custom design task because of the special features that are desired and also due to a need for interface with existing railroad equipment already installed at the crossing. Use of modular construction with appropriate mechanical and electrical interface design for all grade crossing protection equipment will allow the designer substantial flexibility in combining different types of equipment. Resulting improvement in site engineering design practice, installation cost and maintenance may be expected.

The intention of this task is to study the technical and economic viability of modularization and standardization of grade crossing protection equipment. The study will establish those areas and equipments for which implementation of a standard design is feasible incorporating modular features to ease the problems site engineering design, installation and maintenance.

Modularization and standardization of grade crossing equipment is intended to deal with the geometry of external shape, dimension, mounting and electrical and mechanical input/output characteristics or other factors that will allow a standardized interface to be established between commonly interfaced subsystems or between components in a given subsystem.

The scope of this work is to include train detection, signal transmission, associated logic and motorist warning devices. That is, all equipment used in the active detection of train presence and active notification of the motorist. Combinations of available grade crossing protection equipment that form viable and currently used active

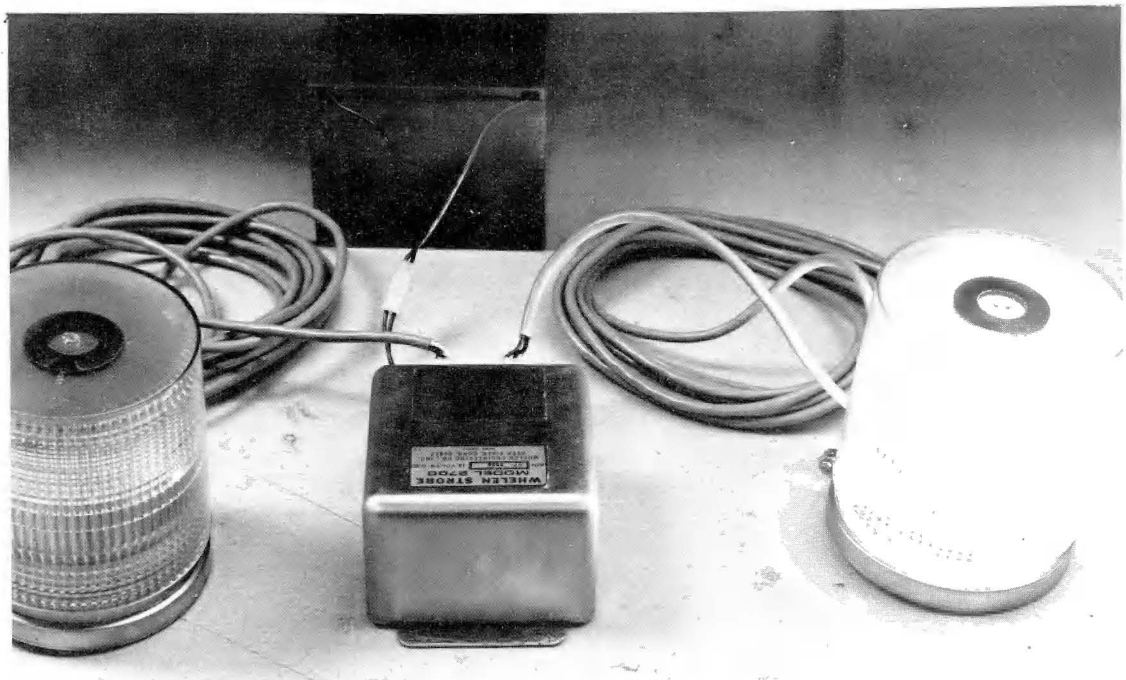


Figure I
Xenon Strobe Light

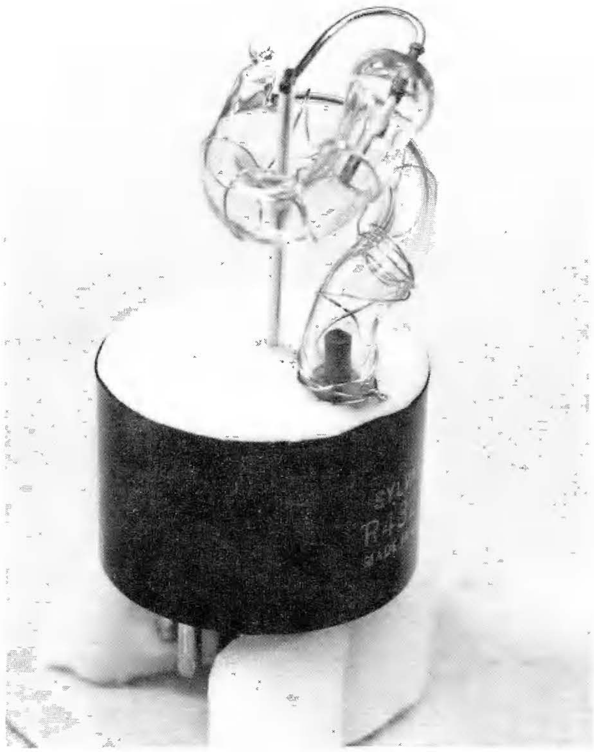


Figure II
Xenon Strobe Light

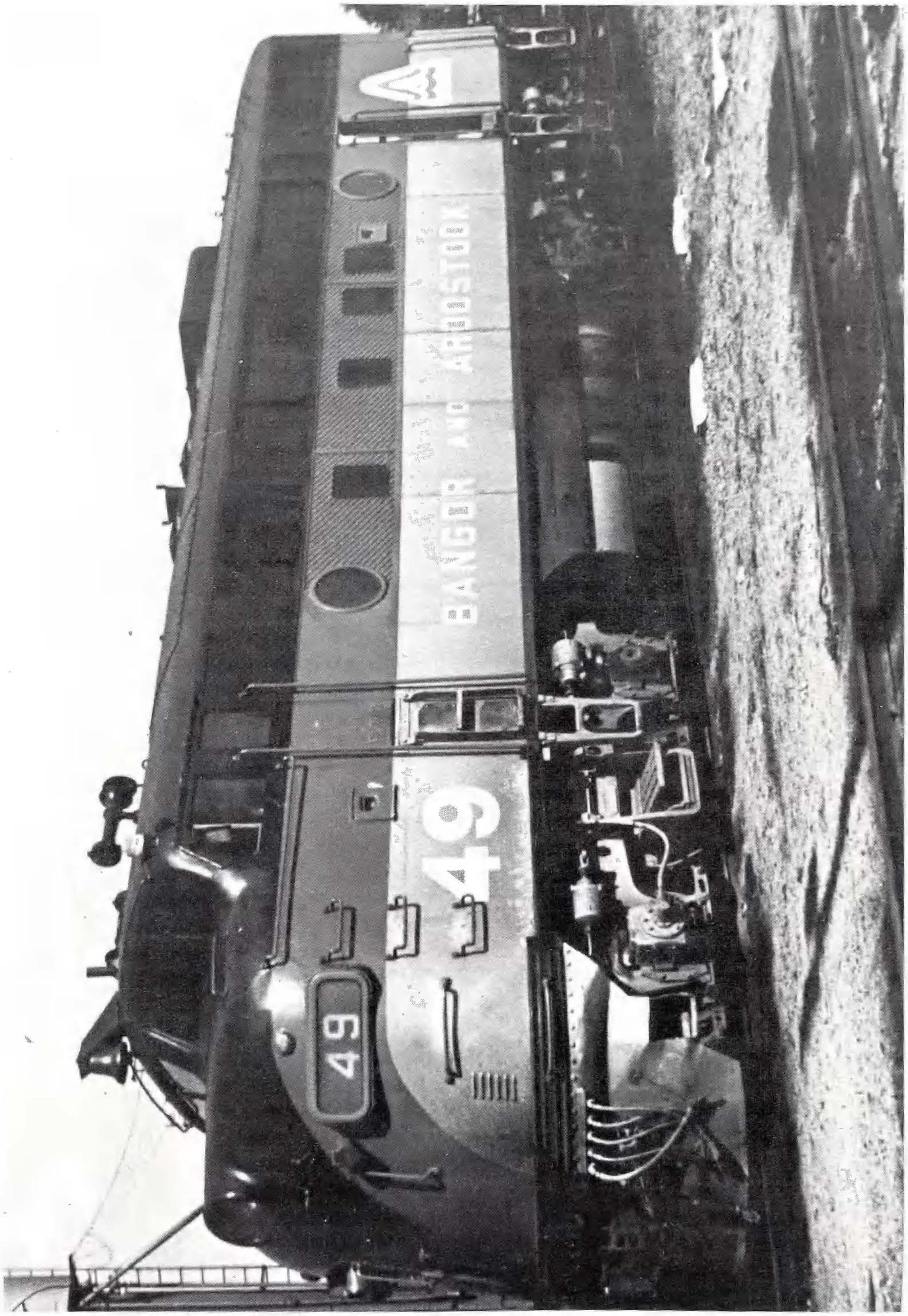


Figure III
Xenon Strobe Lights Mounted on the Bangor and Aroostook

protection systems are to be described and specified in sufficient detail to allow analysis of similarities.

A final report summarizing results of this work will be available in mid-1975.

IV. California Grade Crossing Program Study

The purpose of this study is to investigate the California Grade Crossing Protection Program and establish those factors that have led to an exceptionally good grade crossing accident rate in that state.

A contract has been awarded for collection and interpretation of data pertinent to the California program to determine which elements have contributed most towards the improvement of grade crossing safety. It is hoped that other states may benefit through knowledge 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 railroad grade crossings. In annual vehicle miles traveled, a common measure of highway traffic, California with its 118,023,000,000 vehicle miles is twice as large as all of the New England states combined (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont) 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. Only the New England states, and Middle Atlantic states achieved better safety records based on estimated vehicular exposure. California's growth in population, 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 in California has been great.

Recognizing the magnitude of California's problems and the results being achieved, the mechanics of the program become of vital interest to us, 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 Governor 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 efforts. However, a 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.

A final report discussing results of this study will be available in the latter part of 1974.

V. Grade Crossing Information System Requirements

The purpose of this study is to determine potential users of a grade crossing information system and their various data system needs.

A contract has been awarded to study this problem and a report identifying results will be published the latter part of 1974.

A thorough knowledge of user requirements will help to establish system characteristics and will identify possible data gaps in the current collection activity.

Data requirements will be determined by identifying data used at federal, state, local, and railroad levels. This work will provide a framework for establishing a useful information system capable of responding to the type of questions having the most value to user organizations.

VI. Low Cost Barrier

The purpose of this program is to study the technical and economic feasibility of developing a low cost automatic barrier (or gate) for active railroad-highway grade crossing protection. The study is further intended to form a base for selection of promising concept(s) that can be developed as the subject of later government procurements. It is anticipated that the most promising concept will be developed and brought through field evaluation for operational application.

Automatic gate type devices at actively protected crossings are not only the most effective warning and deterrent to drivers, but are also the most expensive to install and maintain.

In recent years, there has been a trend toward use of more automatic gates as motorist alerting devices in California and other states. However, only 7,000 to 8,000 gate installations have been made across the nation, while approximately 232,000 public grade crossings and an equally large number of private grade crossings exist in this country. One of the factors that prevents more extensive gate application is the cost of original equipment, installation, maintenance and administration. Improving this cost structure will improve benefit/cost considerations if the effectiveness of the resulting barrier remains at least as good as existing devices.

Specifications setting limitations that govern the design of automatic gates at the present time have restrictive parts that may possibly be modified without causing a major change in effectiveness. An example of one possible change is the 3,000 volt surge protection requirement applied to the drive motor winding. Investigation of each factor in the existing design specification is expected to suggest possibilities for a modified specification.

Automatic gate arms have historically been made of wood with more recent application of aluminum and fiberglass structures. Maintenance of automatic gate structures of this nature requires replacement of gate arms when these are broken by automobiles, as they often are. This replacement requirement involves both substantial expense to the railroads and results in periods of exposure of grade crossings to an unprotected condition with accident safety and legal liability issues. Although a good deal has been done to improve the performance of gate arms through use of fiberglass and shear pin design techniques, much remains to be done to increase effectiveness and reduce overall cost. Since overall costs have been identified as equipment, maintenance, installation and administrative costs, a reduction in overall cost is possible even though the original equipment cost of a gate arm is increased by redesign. As a result, imaginative redesign of the standard gate arm is encouraged in this study to improve effectiveness and reduce overall costs. Concepts that allow gate arms to move out of the way when struck by an automobile and then slowly return to their normal position may be possible within the present state-of-the art for materials and need investigation. Such investigations, however, must result in a product that will meet a realistic, though modified, gate specification.

Other considerations that require similar attention include factors that will facilitate and lower the cost of installation, maintenance and administration.

It is the intention of this project to provide industry with an opportunity to investigate concepts that will lead to an improved barrier device with potential for lowering overall cost of original equipment, installation, maintenance and administration.

Scope of the study will include development of hardware concepts that lead to new barrier designs. The new concepts must have original equipment, installation, maintenance and administration costs that, in total, are 30 percent less than those currently applicable for existing gate designs without important loss of function or reliability.

Original equipment cost refers to the manufactured cost of a complete barrier mechanism. Installation cost includes all costs associated with the installation of a barrier mechanism. Maintenance costs refer to average annual cost of repairing a barrier installation, including gate arm breakage. Administrative costs include all clerical and inventory costs involved in purchase, installation and maintenance.

The study will begin with a complete analysis of existing barrier functional requirements as established by AAR and industry specifications. From these sources a modified specification is to be established reflecting changes that will impose less restrictive requirements on barrier design, if possible, without seriously decreasing the functional capability and reliability of the device.

Based on the revised specification, new or modified concepts will be synthesized that show promise of providing the cost reduction desired. Through economic and technical analysis, that concept with the greatest potential for cost reduction while meeting requirements of the modified specification will be selected and recommended for further development. It is not intended that extensive human factor considerations will be included as part of this program. However, recommended concepts will be comparable in motorist alerting effectiveness with standard gates.

Detailed analysis and preliminary design of the recommended concept are to be completed as part of this program with planning necessary to show tasks, schedule and funding required to bring the concept through development, test and operational evaluation as the subject of new federal procurements.

A scale model of the recommended concept is to be provided to demonstrate special features used for cost reduction.

VII. Innovative Warning Systems

The intent of this study is to synthesize and analyze *new* and *innovative* techniques for the improvement of railroad-highway grade crossing safety.

The study is further intended to form a base for selection of promising concepts that can be developed as the subject of later government procurements. It is anticipated that the most promising concept or concepts will be brought through field evaluation for operational application.

Two contracts have been awarded for independent study of this problem. Study results are expected in the latter part of 1974.

Under each contract, new and innovative grade crossing protection concepts will be synthesized having potential for significant cost and effectiveness advantages over systems in current use. Concepts recommended for further development may be composed in part of protection equipment in current use but must show sufficient innovative advantage to warrant the cost of development and field test.

The grade crossing warning system to be considered for innovation is composed of a train sensor, communication link, and warning device. The interaction of these subsystems in response to an approaching train will be analytically studied and reported. Hardware components and subsystems used in each of the concepts recommended will be described in detail using drawings, artist conceptual sketches and detailed analyses to augment written description. A sound engineering analysis of hardware components and subsystems will be made to justify effectiveness in proposed applications.

A cost analysis of recommended concepts will be made considering equipment cost, installation and maintenance. Equipment costs are to be prepared in production lots of one (1), ten (10), and one hundred (100). A comparison shall be made with present systems in use to determine cost savings. A negative answer to this analysis is not necessarily undesirable, since there are conditions under which higher equipment costs are allowable. A system with 20 percent higher cost yielding a 50 percent effectiveness improvement has value.

An evaluation will be made of the effectiveness of each concept considered resulting in recommendation of *that* concept with the most overall merit for subsequent development, test, and field evaluation. The rationale and criteria used for concept evaluation will be described and a scale model of the concept will be prepared to demonstrate the principles involved.

VIII. Locomotive/Auto Impact Attenuation

In mid-1972, a contract was awarded by the government for study of the feasibility of reducing locomotive/auto accident severity by modifying the front structure of the locomotive. The resulting modification was to reduce damage to the automobile by cushioning impact forces and deflecting it off the track. Possible derailment of the locomotive due to automobile engine block entrapment under the front end was also to be prevented.

Results of the feasibility study were favorable and work has now started on study of concepts for a locomotive/automobile impact test device that can be fabricated and evaluated in a series of crash tests at the Department of Transportation High Speed Ground Test Center in Pueblo, Colorado.

A test device will be mounted on a locomotive and crashed against an automobile located on the track. Accelerometers mounted in dummies in the automobile as well as on the automobile structure will measure accelerations during the impact period.

Tests were successfully completed in early 1974 at the High Speed Ground Test Center to evaluate the same conditions outlined above without an attenuator. These tests provided baseline locomotive/auto collision data. (See figure IV for a summary of test conditions.) This baseline information will provide a "standard" reference against which tests using the attenuator can be compared. The comparison will provide a useful tool in determining effectiveness of the attenuator.

IX. Grade Crossing Warning Equipment Application Guidelines

The Grade Crossing Warning Equipment Application Guideline project will be the subject of a separate paper presented at this meeting.

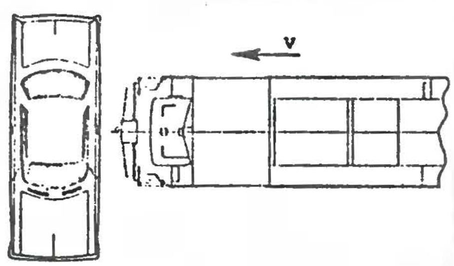
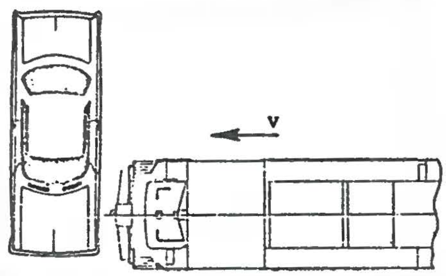
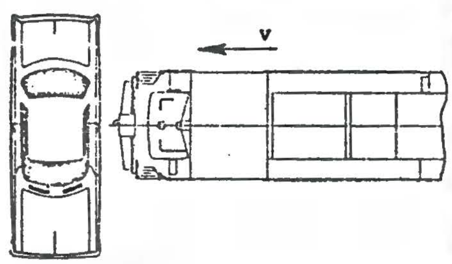
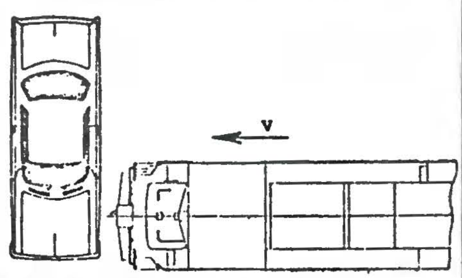
Test Number	Struck Vehicle Stationary 1973 Fury / Striking Vehicle Locomotive	Instrumentation	Speed (mph)	Orientation
1		CAMERAS ONLY	50	DIRECT SIDE
2		CAMERAS ONLY	50	OFFSET SIDE
3		CAMERAS, DUMMY, ACCELEROMETERS	50	DIRECT SIDE
4		CAMERA, DUMMY, ACCELEROMETERS	50	OFFSET SIDE

Figure IV
Grade Crossing Impact Test Matrix

The 1974 National Conference On Railroad-Highway Crossing Safety

19-22 August 1974
Interim Education Center
US Air Force Academy
Colorado Springs, Colorado

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March 10, 1975

Dear Conference Participant:

Enclosed is a copy of the Proceedings of the 1974 National Conference on Railroad-Highway Crossing Safety and a short questionnaire. The planning committee would appreciate your response to the questionnaire to aid in evaluating the Conference.

The objective of the questionnaire is to determine whether the Conference led you to initiate any changes - organizational, administrative or technical - in your organization's railroad-highway grade crossing safety activities.

Your response to the questionnaire will also provide the sponsoring agencies with direction for future conferences, if such are considered appropriate. Please return the questionnaire in the postage prepaid envelope attached to the questionnaire.

Sincerely yours,

Daniel M. Collins

Daniel M. Collins
Chairman, Conference
Planning Committee

Enclosure

CONFERENCE EVALUATION

1974 National Conference on Railroad-Highway Crossing Safety

I. Please indicate your general affiliation (i.e., railroad labor, railroad technical, railroad management, State highway or transportation department, public utilities commission, enforcement, education, supplier, city or county, Federal, consultant, other. ______________________

II. Are any of the following types of technical, administrative, or organizational changes already accomplished or under consideration by your organization as a result of your attendance at the conference:

A. Increased involvement with any of the other partners? Yes ______
No ________ Under Consideration ______________
Explain: ____
____
____

B. Action toward seeking revision of any legislation?
Yes __________ No _________ Under Consideration ________
Explain: ____
____
____

C. Revision of organizational structure to deal more effectively with grade crossing programs (such as by assigning a specific single individual overall grade crossing program responsibility)?
Yes __________ No ___________ Under Consideration ______
Explain: ____
____
____

D. An improved inventory and accident record system? Yes ______
No ___________ Under Consideration ____________
Explain: ____
____
____

E. Modified emphasis on the types of grade crossing improvements undertaken (such as greater use of gates, upgrading existing active devices, or crossing surface improvements)?
Yes ________ No ________ Under Consideration ________
Explain: ____
____
____

F. Increased consideration of railroad consolidation and relocation as a means of alleviating urban railroad-highway problems?
Yes ________ No ________ Under Consideration ________
Explain: ____
____
____

G. Steps to accelerate projects (such as use of master agreements, assigning additional personnel, stockpiling materials or modifing internal procedures to speed the flow of paperwork)?
Yes ________ No ________ Under Consideration ________
Explain: ____
____
____

H. Any other kinds of actions?
Yes ________ No ________ Under Consideration ________
Explain: ____
____
____

III.

A. Will the information contained within the proceedings serve as a useful tool in your activities associated with railroad-highway crossings?
Yes ________ No ________ Possibly ________

B. Do you anticipate that receipt and review of the proceedings will lead to any changes?
Yes ________ No ________ Possibly ________

IV.

A. Would you participate in a State oriented Conference if held in your State?
Yes ________________ No ________________

B. Would you participate in a National Grade Crossing Conference if held in 1976?
Yes ________________ No ________________

C. If you favor future conferences, what subjects should be a part of the conference program?
____
____
____
____

V.

Any additional comments you may have. ____________________
____
____
____
____
____

Thank you for your assistance.