successive cars. The number 2 indicates the headway between cars 1 and 2, and 3 indicates the headway between cars 2 and 3. Figures 3 and 4 show that sufficient headway exists between cars to detect individual cars and to throw the switch in all switch segments.

FURTHER WORK AND CONCLUSIONS

Further work is in progress to enhance the interactive capability of the PROFILE program. Specifically, simplifying the user input procedures and increasing the amount of graphical output are being considered. In addition, more work is required to characterize and quantify the nature of car rollability. Freight-car rolling behavior, which is essentially an input to PROFILE, is a critical determinant of the final profile design.

This paper has shown that PROFILE can be used to eliminate the tedious manual process of evaluating hump profile designs by using scale drawings. In addition, PROFILE gives a precise prediction of catch-up problems between cars. The program allows the yard designer to evaluate many more design alternatives than it was previously possible to evaluate, thus ensuring production of the most cost-effective design.

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Conflicts Between Urban Areas and Railroads: A Status Report

Richard G. McGinnis

The development of conflicts between urban areas and railroads in the United States is examined, and the nature and magnitude of the current problems and present and past efforts to resolve them are described. Many American cities developed primarily as a result of the railroads, but changes in urban activities and transportation operations have altered somewhat the relation between the cities and railroads. Continuing expansion of urbanized areas and increases in vehicle travel have intensified the conflict. Cities have reacted by pushing for elimination of railroad-highway grade crossings and, in some cases, for consolidation, relocation, and/or removal of railroad tracks from the center city. Many city planners see the railroads as a hindrance to rejuvenation efforts. In some cities, underutilized railroad properties are in strategic locations that could be important in urban redevelopment plans. High-volume rail lines that pass through congested downtown areas can cause massive traffic jams and delays unless crossings are grade separated. Railroad-highway grade crossings pose safety problems to the motorist and restrict mobility, which is particularly important for emergency vehicles. In addition, the slow train speeds mandated by local municipalities, frequent grade crossings, and large numbers of trespassers are not compatible with efficient railroad operation. But new rail routes are difficult to locate and expensive to build, and there are many implementation problems involved in other, less expensive solutions, such as consolidation or abandonment.

Conflicts between U.S. railroads and urban communities have existed, to varying degrees, ever since railroad operations began in 1830. Initially, most of the concerns about urban railroads had to do with safety. Safety problems included dangers associated with grade crossings, runaway trains, and derailments. However, since train speeds through towns were relatively slow and vehicle traffic crossing tracks was of low volume, the safety of rail operations in urban areas

was of relatively minor importance during the 19th century.

Although concerns about conflicts between urban areas and railroads were articulated frequently during the early development of the railroads, most cities realized the great economic advantages inherent in railroad development. Thus, community leaders often competed fiercely to entice railroads to locate in their communities rather than in neighboring towns. Towns located at railroad terminals and transshipment points grew rapidly in population.

Initially, inefficient means of overland transport encouraged most new urban development to occur close to the rail lines and to form linear and radial types of development patterns. The desirability of being close to railroads began to decrease as train operations increased in speed and frequency and highway transportation improved. By the early 1900s, conflicts between motor vehicles and trains at grade crossings were becoming a major safety problem. Rail lines were physical and sometimes psychological barriers that separated one type of a neighborhood or land use from another type, and residents were becoming less tolerant of the adverse environmental impacts of the trains.

By 1920, the railroads' dominance of the transportation market was beginning to wane. The near-monopoly enjoyed by the railroads during their first 90 years of operation was being threatened by the truck and the automobile while government was imposing tighter controls on railroad operations. Cities were reacting to their growing conflict with the railroads by planning for grade separations, studying possibilities for railroad relocations, and implementing ordinances to control train operations through towns.

Between 1929 and 1970, railroad consolidations and abandonments resulted in a 17 percent decrease in kilometers of railroad lines, to 332 685 km (206 265 miles). More efficient freight operations, because of longer trains with higher-capacity freight cars, permitted a 30 percent reduction in train kilometers, although ton kilometers of freight increased by 71 percent (1).

Much of the new urban development that has taken place since 1920 has occurred at population densities lower than those that prevailed before 1920. The greater flexibility provided by automobiles allowed residents to move farther away from established employment centers and rail transportation facilities. Expansion of the urban street system and concomitant increases in volumes of motor vehicle traffic resulted in an intensification of the problem of highway-railroad grade crossings.

CURRENT PROBLEMS

The nature and magnitude of conflicts between railroads and urban areas vary widely among communities but can usually be classified into one of five categories: safety problems, mobility constraints, environmental problems, land use conflicts, and railroad operational problems.

Safety Problems

Concern about the safety of railroad operations in urban areas is probably the most common problem aired in discussions of railroad relocation projects. Most safety problems arise from conflicts involving railroad-highway grade crossings, fears about train accidents involving rail cars that are carrying hazardous materials, or dangers to pedestrians and trespassers.

Concern for safety at railroad-highway grade crossings has resulted in the construction of grade separations or installation of gates and/or flashing lights at some of the more dangerous crossings. However, of the 95 102 grade crossings in urban areas, 65 228 still have only passive warning devices, such as crossbucks and stop signs (2).

Current accident statistics do not provide for breakdowns between urban and rural accidents. It has been estimated, however, that 60 percent of accidents at highway-railroad grade crossings occur in urban areas (3). Estimates for 1977 (4) are that 7375 accidents occurred at urban railroad-highway grade crossings, including 375 fatalities and 2775 injuries. If we use values established by the National Highway Traffic Safety Administration for the societal costs of fatalities and injuries (5) and update these values to 1978 dollars by using a 6 percent annual inflation rate, the total economic cost to society of railroad-highway grade-crossing accidents in urban areas is estimated to be about $150 million/year.

Seventy percent of the ton kilometers of transportation of hazardous materials in the United States is by rail. During 1975 and 1976, railroads were responsible for only 2 fatalities involving hazardous materials and trucks for 43 (6). Of the 1977 fatalities that involved hazardous materials, 4 were caused by railroads and 30 by trucks (7). Because of the safety advantage that railroads have over trucks in the movement of hazardous materials, it is likely that railroads will continue to transport major quantities of hazardous materials in the future.

Hazardous materials, which include toxic materials, explosives, flammable products, corrosive substances, and radioactive materials, present potentially catastrophic dangers to the urban areas through which they must pass during transport. Because the main lines of many railroads pass through urbanized areas, it is very difficult, if not impossible, to route these materials around cities. Extensive precautions are taken by the railroads when they move hazardous materials; however, the tremendous volumes of these materials that are being moved by rail increase the probability that some accidents will occur, although this probability is significantly lower than it would be if movement were by truck.

During 1977, 525 pedestrians and trespassers were killed on railroad facilities. Trains and railroad yards have always been an attraction, especially to children. Seven-eighths of the people killed were illegally trespassing on railroad property (7). Applying the values used in the grade-crossing analysis for societal costs of fatalities, a societal cost of $185 million/year can be placed on railroad-pedestrian casualties.

Mobility Constraints

Non-grade-separated railroads in urban areas act as barriers to highway and pedestrian transportation, and delays are experienced at grade crossings whenever a train occupies the intersection. Furthermore, street networks are often distorted so that drivers must travel a circuitous route to get from one side of the tracks to the other. Travel delays are especially detrimental to emergency vehicles, and some communities have had to build additional police stations and firehouses to ensure that essential services are available to both sides of the track at all times. The annual cost of time delays and additional operating costs attributed to urban grade crossings in the United States is estimated to be about $1 billion in 1978 (8).

Railroads have historically created psychological barriers in urban areas, often separating neighborhoods

of differing ethnic or socioeconomic characteristics, which sometimes leads to designations of certain areas as the "right" side or "wrong" side of the tracks. Some city planners also feel that railroads that limit access to a central business district (CBD) are preventing, or at least inhibiting, revitalization of the center city. Few data exist to show whether or not removal of a railroad would eliminate the psychological barriers that have developed over long periods of time. However, most studies have concluded that railroad relocation is not a panacea for revitalizing urban areas.

Environmental Problems

Most railroads were designed and constructed at a time when function rather than environmental compatibility was the primary design criterion. This philosophy carries over today in freight car design, right-of-way maintenance procedures, and the architecture of many railroad facilities and generally has a negative effect on the aesthetics of bordering neighborhoods.

In addition to negative impacts on the visual quality of an area, railroads produce noise, vibrations, air pollution, and, in some areas, water pollution.

The magnitude of these environmental problems increases with the density of train operations and the population density of the areas adjacent to the railroad. Noise problems emanate from such factors as train horns, locomotive noises, the squeal of brakes and steel wheels on sharp curves, grade-crossing warning bells, and classification yards. Noise problems are worse in the vicinity of grade crossings because of the legal requirement in most states that trains sound their horns before each grade crossing as a warning to motorists.

The environmental intrusion of the railroad is reflected in the value of land ajacent to the right-of-way. The negative impact of railroad operations on property values is greatest for residential areas; thus, decreases in property values close to railroads are a measure of the "cost" of the environmental degradation caused by the presence of the railroad.

Land Use Conflicts

Railroad facilities, particularly in urban areas, often restrict higher-value land use. Many cities have CBDs that contain sizable tracts of land owned by railroads, and in some cases these facilities are abandoned, out-of-service, or underutilized by the railroads. Freeing this land for other land uses could be an important first step in revitalizing the CBD.

Even if the railroad facilities are currently being fully used, restructuring of rail operations, including relocation of some facilities, may prove to be cost-beneficial for community development reasons. Over the years, changes in railroad operations may have obviated the need to have certain operations in downtown business districts.

Railroad Operational Problems

Railroads are not able to operate as efficiently in urban areas as they do in less congested rural areas. Most operational problems associated with urban operations can be attributed to two causes: slow running speeds and large numbers of grade crossings.

Grade-crossing accidents, in addition to killing and injuring many people, inflict time and money costs on the railroads. These costs result principally from disruptions in operations, filing of accident reports, damages to equipment, and liability suits. In addition, most states require the railroads to maintain grade-crossing warning devices and crossing surfaces.

Many local municipalities have ordinances that set maximum running speeds for trains through urbanized areas. In some cities, the tracks actually run right down the middle of busy downtown streets and trains are restricted to maximum speeds of 8 km/h (5 miles/h). These low speeds, while necessary for safety reasons, delay train movements, increase labor costs, and decrease equipment utilization, all of which leads to inefficient operation. In 1970, the annual cost to the railroads associated with low-speed operation in urban areas was estimated to be approximately $75 million-$100 million (8).

PRESENT AND PAST EFFORTS TO RESOLVE CONFLICTS

Conflicts between railroads and urban areas can be ameliorated in either of two ways. The most common way, and usually the less expensive one, is to modify the railroad-urban area interface so that the conflict is either eliminated or minimized. Warning devices and/or grade separations at grade crossings, elevation or depression of rail lines, and installation of buffer zones or barriers along rail lines are examples of methods that can be used to reduce conflicts between urban areas and railroads. A second approach is to remove the railroad by either abandoning it or relocating it. These solutions are usually considerably more expensive than the above method, but they do entirely eliminate the conflict.

Grade-Crossing Protection and Elimination Programs

Background

From 1920 to 1930, the railroads carried out an extensive program of grade separations and grade-crossing protection. During this period, the casualty ratio [(injuries + fatalities) × 10^{18}]/(train kilometers × vehicle kilometers) dropped almost 70 percent, from 98.3 to 30.4. After 1930, there was a four-year period when the railroads stopped spending and almost nothing was done to improve grade crossings. Starting in 1935, some special federal programs to improve safety at railroad-highway grade crossings were initiated and carried forward to the war period. After the war, grade-crossing work was again resumed, and substantial amounts of money from federal-aid highway programs were used (9).

The Federal-Aid Highway Act of 1944 amended the law to provide special funding ratios for projects that would eliminate railroad-highway grade-crossing hazards on the federal-aid system. Under the provisions of this law, as much as 100 percent of the construction cost and 70 percent of the cost of right-of-way acquisition of such projects can be paid from federal funds. As much as 10 percent of the total federal-aid highway system funds apportioned to each state in any year can be spent by using the above ratios. Additional grade-crossing projects can be undertaken at the regular (usually 70 percent) funding ratio (9).

Increased congressional interest in railroad-highway safety and in the urban railroad problem led to the Railroad Safety Act of 1970 and the Highway Safety Act of 1970. These acts required the Secretary of Transportation to make a comprehensive nationwide study of railroad-highway grade-crossing safety (3) and report his recommendations to Congress (10).

The Highway Safety Act of 1973, as amended by the

Highway Safety Act of 1976, provides funding at a 90:10 ratio for grade-crossing safety improvements. Projects for crossings on the federal-aid system can be financed with Highway Trust Fund money, whereas off-system projects must be financed from general fund appropriations. At least half the funds authorized and expended must be for protective devices. In addition, the states are required to conduct and maintain a survey of all grade crossings that may require separation, relocation, or protective devices and implement a schedule for this purpose (9).

Problems with Current Programs

Possibly the greatest problem in improving safety at grade crossings has been in increasing the rate of installation of active warning devices. Although reliable figures on the rate of installation of these devices are difficult to obtain, it appears that the current rate is somewhat higher than that of the early 1970s. However, it continues to fall short of achieving the goal of 3000 active warning devices/year recommended by the 1972 report to Congress.

Active warning devices have traditionally been regarded as an effective means of significantly reducing the number of accidents at grade crossings. A study of the number of accidents at 1552 crossings in California before and after active warning devices were installed (11) supports this view. The study found that, in California, the relative accident expectancy at similar crossings that have standard devices is as follows: 1.00 for crossings with crossbucks, 0.33 for crossings with flashing lights, and 0.13 for crossings with automatic gates. For example, if 100 accidents were expected at a crossing where the warning device used was crossbucks, the installation of flashing lights would reduce the expected number of accidents to 33 and the addition of automatic gates would reduce it to 13. Other studies have shown that train-activated devices reduce accident severity in addition to reducing accidents.

Rates of accident severity by type of warning device [according to data given in Federal Highway Administration (FHWA) Notice N5120.3 of November 1975] are given below:

	Fatalities per Accident		Injuries per Accident	
Device	Rural	Urban	Rural	Urban
Crossbucks	0.32	0.13	0.82	0.55
Flashing lights	0.19	0.10	0.42	0.45
Automatic gates	0.09	0.04	0.27	0.28

Relocation and Consolidation Programs

A joint report written by FHWA and the Federal Railroad Administration (FRA) in 1976 (12) discussed the nature of conflicts between urban areas and railroads and estimated the magnitude of the problem in the United States. By using an analysis performed by the Stanford Research Institute, estimates of $1.8-1.9 billion were given for the cost of consolidation and relocation projects in which benefits could be expected to exceed costs.

As part of its study, FHWA conducted a survey of the states and railroads to determine the number of projects that had been completed since 1950 and the number that are currently in some stage of planning. The results of this survey are given in Table 1(8, p. 52).

Section 163 of the Federal-Aid Highway Act of 1973 authorized 12 cities to develop demonstration projects for relocation of railroad lines and/or elimination of railroad-highway grade crossings. The Federal-Aid Highway Amendments of 1974 and the National Mass Transportation Assistance Act of 1974 each added one additional city. Four more cities were added by the Federal-Aid Highway Act of 1976, and the 19th and final city was authorized by the U.S. Department of Transportation and Related Agencies Appropriation Act of 1977. As of December 1978, $548.4 million had been authorized for the demonstration cities.

Table 2 (13) gives the cities that are currently included in the demonstration project and their share of obligated federal funds as of December 31, 1978. The table also includes 1978 cost estimates for each of the projects.

HINDRANCES TO FUTURE PROGRESS

There are many obstacles to implementing solutions to conflicts between railroads and urban areas. These obstacles can be grouped into four categories: financial, institutional, statutory, and operational.

Financial Obstacles

High Cost of Projects

Perhaps the single most important obstacle to relieving conflicts between urban areas and railroads is the high cost associated with these types of projects. Estimates of implementation costs for individual projects in the FHWA demonstration program run as high as $114 million.

If relocation must be accomplished by establishing a new railroad corridor, the cost will be high, particularly if new right-of-way must be purchased. In addition to the high cost of land for right-of-way in urban areas, construction costs of approximately $465 000/track-km ($750 000/track mile) are not uncommon. If other structures and facilities are required, costs can be even higher. To get full benefit from the relocation, it is usually necessary to provide for grade separation of the highways that cross the railroad right-of-way. One grade separation can cost as much as several million dollars. Additional costs arise from the use of track and signal devices required to connect the new corridor to the existing rail lines.

When railroad relocation is carried out by consolidating several railroads into an existing railroad corridor, costs are usually lower. Costs, in this case, are determined in part by the amount of connecting track needed, the sophistication of the signalization required, and the capacity and level of classification of the upgraded track.

Financial Condition of Cities and Railroads

According to the report of the Stanford Research Institute on urban railroad relocation (8), not more than 10 percent of cities that experience serious conflicts with railroads would be willing (or able) to contribute more than 10-20 percent of project costs. Much of the U.S. railroad system is suffering from problems similar to those of the cities. Maintenance and operating costs are increasing faster than revenues. The past practice of many railroads of deferring regular maintenance has contributed substantially to the problem. Poor track conditions, undependable motive power, and car shortages have also led to a general decline in service. Many railroads have been

Table 1. Summary results of survey of completed and proposed relocation projects.

Type of Project	Completed Projects			Proposed Projects		
		Cost ($000s)[a]			Cost ($000s)[a]	
	Number	Average	Total	Number	Average	Total
Relocation	69	3385	233 565	32	6 912	221 184
Consolidation	27	927	25 029	35	2 804	98 140
Combination relocation and consolidation	32	5554	177 728	45	12 659	569 655
Elevation	22	9716	213 752	15	9 887	148 305
Depression	20	5117	102 340	7	10 081	70 567
Relocation of yards and terminals	50	5637	281 850	21	17 069	358 449
Unspecified	7	4518	31 626	30	10 196[b]	305 867
Total	227		1 065 098	185		1 772 167

[a]In 1973 dollars.
[b]Average cost for all planned projects was used.

Table 2. FHWA Railroad-Highway Demonstration Program projects.

Type of Project	City	Federal Funds Obligated[a] ($000s)	Estimated Project Cost[b] ($000s)[c]
Relocation	Elko, Nevada	8 851	26 000
	Lincoln, Nebraska	1 998	31 600
	Wheeling, West Virginia	96	24 800
	Carbondale, Illinois	2 263	63 200
	East St. Louis, Illinois	2 881	21 100
	Springfield, Illinois	3 579	114 300
	New Albany, Indiana	2 575	2 700
	Brownsville, Texas/ Matamoros, Mexico	1 210	24 400
	Lafayette, Indiana	360	61 800
	Hammond, Indiana	589	57 000
	Metairie, Louisiana	251	40 000
	Augusta, Georgia	306	97 000
	Pine Bluff, Arkansas	255	55 400
Grade separation	Blue Island, Illinois	230	5 900
	Dolton, Illinois	210	4 500
	Anoka, Minnesota	2 987	3 600
	Greenville, Texas	353	6 200
	Sherman, Texas[d]		
	Terre Haute, Indiana	285	6 000
Total		29 279	645 500

[a]As of Dec. 31, 1978.
[b]Federal share is now 95 percent for all cities in the program.
[c]In 1978 dollars.
[d]Withdrew from the demonstration program.

forced into bankruptcy, and others are only marginally solvent.

Even the financially strong railroads are unable to provide much support for relocation projects. The poor condition of the industry as a whole [an average 1.26 percent rate of return on investment in 1977 (1)] has generally made it difficult for railroads to raise cash in the equity markets. Even if the railroads are able to regain the confidence of the private investment community, it is not likely that they would be eager to finance railroad relocation projects. Dollar benefits to the railroads from urban railroad relocation are generally small and can even be negative. (Railroad benefits average about 20 percent of total benefits for the FHWA demonstration cities that have filed financial reports. However, railroad benefits are as low as 1 percent of total benefits for one city.) There are benefits to be derived from improving the public image of railroads, but these benefits contribute little to financial integrity. Furthermore, if new equity became available to the railroads, they would be interested in funding projects of their own that would produce much higher rates of return than relocation projects.

Limited State and Federal Funding

A 1975 survey of several states indicated an unwillingness on the part of the states to finance urban railroad relocation projects (8). Most states reported that they were not even able to handle their current highway needs with existing funding and that additional funding sources would be needed for railroad relocation. Since 1975, the increased maintenance requirements of the aging Interstate and federal-aid highway systems have worsened the financial condition of most state highway departments and left little, if any, money for rail-related projects.

The federal government is seen by most officials to be the only entity capable of funding urban railroad projects. Congress has authorized the current Railroad-Highway Demonstration Program, but there is some question as to whether there will be sufficient funds to complete the demonstration program.

Inflation

Since the inception of the Railroad-Highway Demonstration Program in 1973, the United States has been in a period of high inflation, particularly in the construction industry. The Federal-Aid Highway Act of 1973 authorized a total of $90 million for its 12 designated demonstration cities. As of December 1978, FHWA estimated the costs of these projects to be more than $300 million. The current estimated total cost of the entire 18-city demonstration project is $646 million (in 1978 dollars). At current rates of inflation, this price tag could increase by as much as $60 million each year the projects are delayed.

Institutional Obstacles

Multijurisdictional Problems

In most railroad projects of any magnitude, the operating and environmental impacts generally extend to more than one locality. In some cases, project limits extend beyond state boundaries and even national boundaries (the Brownsville, Texas, demonstration project, for example, is a joint U.S.-Mexico undertaking). Agreement on a final plan can be difficult when individual jurisdictions have different goals, priorities, and resources. Local jealousies, unequal distribution of project benefits and negative impacts, and conflicting objectives can hinder the acceptance of a unified plan of action.

Governmental Conflicts

Localities not included in the FHWA Railroad-Highway Demonstration Program must compete for other limited federal and state funds. One of the most likely sources of funds for railroad relocation is the federal funds available for eliminating hazards at railroad-highway grade crossings both on and off the federal-aid highway system. These funds are administered by FHWA and are given to the state highway and/or transportation departments for allocation to specific projects. The selection criteria used at the state level in disseminating these funds may make it very difficult for an urban railroad project to qualify for these funds on a priority basis.

Intraindustry Competition

Railroads are private enterprises that operate in a regulated, but nonetheless competitive, environment. Railroads compete with other railroads as well as with other modes of transportation. Competitiveness between railroads often surfaces in relocation projects. Some of these projects involve the consolidation of rail lines of more than one company into a single corridor, which may require joint use of a right-of-way or even joint use of track. When two railroads share the use of the same track, one usually assumes the responsibility for operational control and maintenance while the other pays trackage-right fees to cover its share of the costs. Satisfactory agreements between railroads are sometimes difficult to negotiate.

Railroad-Labor Relations

Railroad-labor conflicts usually emerge in relocation projects that involve the elimination of a railroad yard or restructuring of a terminal area. Union contracts generally have written into them a specific reporting location for the employees. If a railroad yard is relocated or its use changes, it will probably be necessary to negotiate new contracts with the unions involved, particularly if the reporting location is changed.

Local Conflicts

In most railroad relocation projects, some segment of the population will be adversely affected. It is virtually impossible to relocate a railroad in an urban area without some dislocation. Residents who are close to the project but not close enough to be displaced may also be adversely affected.

Negative impacts can evolve from the visual intrusions, vibration, noise, air pollution, and dangers associated with the higher volumes of highway traffic that result from altered travel patterns. Increased volumes of train traffic because of rail-line consolidation can have similar impacts on homes and businesses in the vicinity of the tracks. Bridges and other structures associated with relocation projects can affect the aesthetics of an area and, in doing so, lower property values. Strong neighborhood opposition to relocation plans may develop and result in the slowing down or termination of the project. In many cases, the philosophy is, "Let's get the railroad out of downtown, but don't put it in my neighborhood."

Lack of Lead Agency

Railroad relocation projects have no strongly unified proponents at the state or federal level. The existing congressionally sponsored demonstration program has been criticized for its special-interest orientation.

One of the main reasons for the lack of unified support for railroad relocation has to do with the nature of project benefits. Most railroad relocation projects are characterized by a wide dispersion of benefits and low benefit/cost ratios (0.65-1.55 for the FHWA demonstration cities). The benefits include savings in highway-user travel time, reduced potential of highway-railroad grade-crossing accidents, improved mobility for emergency vehicles and other highway users, reduction or elimination of the frustrations associated with waiting for trains to clear grade crossings, removal of rail facilities that are contributing to urban blight, removal of barriers between neighborhoods, improvement of area aesthetics, release of urban land for redevelopment, increased tax base, opportunity for economic development and urban renewal, improvement in railroad operations and in the public image of railroads, and a reduced probability of major catastrophies resulting from accidents involving hazardous materials. In most relocation projects, the benefits that accrue to any one segment of the population are not sufficient in themselves to justify funding the project. Although the total aggregated benefits may justify project costs, the disaggregated benefits are not great enough to get the attention of special-interest groups.

Statutory Obstacles

Statutory Limitations of Local Governments and Authorities

Local government units receive their legislative and operating authority from the state. Therefore, the statutory abilities of local governments to carry out railroad relocation projects vary from state to state. The problems that typically arise in connection with relocation projects are problems of debt limits and taxing abilities.

The amount of bonded indebtedness that a municipality can carry is usually limited to a set percentage of the municipality's tax base. For most communities, it is unrealistic to assume that relocation projects can be funded by floating municipal bonds. The report by Moon (8) estimates that the costs of railroad relocation projects, as a share of municipal outstanding debt, average from about 30 percent for communities of 50 000-100 000 to 141 percent for communities of 5000-10 000. Some areas have avoided the indebtedness limit by establishing a special-purpose authority to conduct the relocation project. Such authorities have their own indebtedness limits, which can be used entirely for their stated special purpose.

Interstate Commerce Commission and State Public Utility Commission Requirements

Because of their heavy involvement in interstate commerce, railroads are closely controlled by the Interstate Commerce Commission (ICC). Any modification of railroad operations in a community that is substantial enough to benefit that community will undoubtedly require ICC approval.

The ICC approval process can be lengthy, particularly if any opposition to the project exists. In railroad relocation projects, it is sometimes proposed that rail service to local industries located on light-density lines be eliminated. Because of the prospects of increasing freight costs, these industries may choose to plead their case before ICC, which can delay or even block the relocation project. The Railroad Revitalization and Regulatory Reform Act of 1976 attempted to speed up the ICC process by stipulating maximum time limits for the ICC approval process for railroad mergers, consolidations, and joint use of tracks or other facilities.

In addition to the ICC requirements, most relocation projects contain elements that come under the jurisdiction of state public utility commissions (PUCs) or similar organizations. Typically, highway-railroad grade crossings are controlled by the state PUC, as are railroad abandonments and consolidations.

Railroad Title Problems

In some relocation projects, railroads have had difficulty in producing clear titles for the lands that they want to sell. Sometimes the railroad holds only an easement for the property that is valid only if the property is used for railroad purposes. Sometimes the railroad's ownership of the land is subject to reversion to the previous owner's heirs if the railroad is abandoned. The problems of reversionary interest, easements, and other legal clauses in the original transfer documents add considerably to the cost and time involved in acquiring railroad rights-of-way. In some states, condemnation may be necessary in order to obtain clear title.

Another problem occurs when a railroad is not able to define clearly what land it actually owns. Conflicting deed descriptions, nonexistent deeds, and undocumented right-of-way maps add to the problem of obtaining clear title to railroad lands. Currently, much of the railroad property in the Northeast and the Midwest is, in some way, under the control of bankruptcy-court-appointed trustees. Sale of these properties must be approved by the trustees, which may be difficult. Even railroads not involved with bankruptcy procedures may have trouble disposing of land because of mortgage restrictions. In certain loans made to railroads, land has been used as collateral, and it cannot be sold without restructuring the loan agreements, which generally results in higher interest being charged to the railroads.

Operational Obstacles

A feasible plan for railroad relocation must consider the needs of both the urban area and the railroads. The general public does not adequately understand railroad operations. Professionally trained urban planners usually have little experience in railroad operations and have historically tended to plan around the railroads. On the other hand, consultants sometimes hire former employees of railroad engineering departments, whose perspective is often very narrow.

The tendency of people who are not experienced in railroad operations is to oversimplify operational needs. Problems arise when railroad officials reject community-generated relocation plans because of technical deficiencies. Community planners and engineers are unable to separate justifiable railroad operational needs from dispensable railroad demands. Thus, good, workable solutions to urban railroad problems are often difficult to achieve.

Train Speed and Length

A common complaint of communities is that trains take too long to clear a grade crossing and therefore cause massive traffic backups. In some cases, cities have passed laws that limit the time a train can block a railroad-highway intersection. Since most of these cities have also legislated maximum speeds for trains, their time restriction in fact becomes a restriction on train length, and this affects the railroad's ability to operate more efficiently by running long trains with small crews.

Joint Use of Track

Many railroad relocation plans call for two or more railroads to share the use of the same track or set of tracks. In addition to the problems that arise from railroad competition, other operating factors must be considered in planning for the joint use of track. Rail lines in a particular city represent only a small portion of a large, regional, integrated network of railroad operations. Trains are usually run on preset schedules to expedite the transfer or switching of cars from one train to another at transfer points. Changing schedules generally have systemwide effects on all railroads.

Conflicts may occur on consolidated trackage when line-haul operations are mixed with local deliveries and pickups. Stopping trains to set out or pick up locally generated traffic can cause delays to through trains. Track capacity is substantially reduced when local switching operations occupy the tracks for extended periods of time.

CONCLUSIONS

Conflicts between urban areas and railroads are widespread among cities nationally, although the nature and magnitude of the problems vary widely from city to city. Few systematic analyses of the benefits of railroad relocation have been conducted, but the few data that are available indicate that benefits are quite diverse and are usually not much greater than project costs. In some proposed projects, benefit/cost ratios have been less than 1.0. Consequently, urban railroad relocation projects have generally been given lower priority than other urban projects.

It is likely that conflicts between urban areas and railroads will intensify in the future and that this will cause an increased interest among cities in resolving these problems. The U.S. Conference of Mayors has recently become active in promoting rail relocation projects primarily aimed at economic development. To aid cities in their search for solutions to conflicts between urban areas and railroads, the conference has published a document that explains "the real story on rail relocation" (14).

New federal funding directed specifically toward urban-railroad relocation is very unlikely. The best way for cities to get federal assistance in solving railroad problems is to include railroad relocation as an element in other urban projects. For example, it could

be an important part of a downtown urban renewal project or part of a highway-transit improvement project. Thus, railroad relocation could become a means by which to solve specific urban problems rather than a panacea for urban decay.

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Addendum

Robert Schumacher

Editorial comment: The first five papers in this Record were presented in Session 3 of the 59th Annual Meeting of the Transportation Research Board. The following remarks by a participant and the presiding officer were made in the course of that session.

Instead of spending so much money running an expensive train around a test track, such as the one at the Facility for Accelerated Service Testing (FAST), why couldn't those same tests be made along some selected main-line track under normal traffic? Mention has been made that wear accumulates 5-10 times faster at FAST. First, I know of no exceptional urgency for the results, and, second, is the wear rate that much faster than it is on a heavy-traffic freight line in the Northeast, on the Santa Fe or the Union Pacific?

Controlled conditions were also mentioned. What does this mean? Of what value are controlled conditions except as they replicate the actual conditions under which North American railroads operate?

The need to make measurements does not seem to be a justification, since I know of no measurements that could not easily be made between regularly scheduled trains.

Discussion

William J. Harris, Jr.

In response to Schumacher's question about testing on main-line track instead of a test track, the more rapid accumulation of data is important. For example, rail must be tested under 181 million-272 million gross Mg (200 million-300 million gross tons) of traffic before significant trends in behavior can be established. In revenue service, this may take 5-10 years before a new set of choices is possible. During that time, the character of the traffic may change, thus altering the experimental conditions. FAST is intended to introduce 3.7 million-4.5 million gross Mg (4 million-5 million gross tons) of traffic per week. Thus, significant data are available in 1 year rather than in 5 or 10, and the test track provides much earlier information on track component behavior than can be accumulated in revenue service. If improvements and problems can be clearly shown in 1 year rather than 10, great advantages can accrue to the railroad industry. There is a need for much more rapid progress in the evaluation of new tech-

nology so that it can be applied to improve transportation effectiveness and safety.

The second question raised by Schumacher refers to controlled conditions. There are many circumstances in which one new component, such as an advanced rail material, is used by one railroad and another new component is used in revenue service by another railroad. The differences in traffic are such that comparisons within several percent are not feasible. This is another of the basic reasons why FAST was established. The railroad industry representatives responsible for the planning of FAST determined that it was essential to have uniform traffic on the test track to permit more precise comparisons of behavior. The cars and the locomotives used at FAST are identical to those in use on U.S. railroads.

The nature of the failures in car and track components is similar to that encountered in service. We know that not all conditions of service are duplicated at FAST. For example, the speed is below track hunting speed, and any effects associated with hunting are not observed at FAST. Nevertheless, there are enough similarities between revenue service and FAST operations that useful results can be obtained.

In regard to Schumacher's third question, there is no possibility that the kinds of measurements required at FAST can be made in revenue service. This would mean that the train must be stopped in daylight for about 8 h to take data on rail, ties, tie fasteners, ballast, and other components. At FAST, cars exposed to uniform operating conditions are taken out of service at frequent intervals so that measurements can be made on wheels, truck components, and other systems in the cars. There is no way in which a track can be vacated long enough to permit these kinds of measurements or that cars can be exposed to uniform operations and measured in revenue service as they are at FAST.

Railroad interest in and support of FAST are demonstrated by the willingness of individual companies to make available locomotives, cars, track components, and personnel on a continuing basis.