Use of Railroad Rights-of-Way for Light-Rail Transit Systems

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This paper describes the conditions that are required for railroad rights-of-way to be usable for light-rail transit. Some of the locational characteristics of desirable rights-of-way are described. A method for analyzing railroad use and physical characteristics is presented. Several solutions to problems in using railroad rights-of-way are outlined. The design parameters for joint use of rights-of-way are explored.

There are many potential locations for construction of low-cost light-rail transit (LRT) systems that use railroad rights-of-way. Recent railroad mergers and the decline in railroad passenger service have led to the downgrading or partial abandonment of many once important urban rail lines. In addition, shifts in the characteristics of freight handling have changed the manner in which the urban rail network is used. Such factors as the increased use of piggyback shipping and containers and the relocation of industries to outlying facilities have increased the number of rail lines available in urban areas.

Obtaining railroad rights-of-way may require one or more of the following: (a) relocation of through movements to other routes, (b) abandonment of railroad service, (c) provision of separate trackage within the same right-of-way, (d) joint use of trackage, and (e) provision of rail freight service by the LRT system. The applicability of each of the solutions depends on individual circumstances. Factors that must be considered in analyzing various solutions include the density of rail freight traffic, the number and rail-use levels of on-line industries, and the availability of other routes.

The locational characteristics of a railroad right-of-way that are most generally desirable are (a) access to a central business district (CBD) and (b) penetration of an area of sufficient population to provide an adequate level of use. Access to a CBD does not necessarily require a right-of-way that goes into the center of the commercial area. It is more likely that the right-of-way will reach the edge of the CBD, and only a short section of subway construction or street operation is needed to reach the commercial center. In many cities, this distance is less than 1.6 km (1 mile).

While it is not within the scope of this paper to address the issue of the level of use necessary to support LRT operations, it must be pointed out that many rail corridors that have access to a CBD are not suitable for LRT development because they largely serve industrial areas or undeveloped parts of an urban area or are isolated from residential development by terrain or natural barriers. For example, a right-of-way may lie along the edge of a river in a relatively narrow valley. Often access to one side is blocked by the river, and access to the other side is made difficult along much of the tributary area because of the slope of the terrain.

Feeder service, using either buses or park-and-ride lots, can sometimes be used to overcome locational disadvantages if the length and speed of the line (and thus the amount of time advantage that the line provides) are sufficient to offset the circuitous routing. Travel distances must be of sufficient length that a somewhat circuitous route is still competitive with other modes in total travel time. This condition is likely to occur only in the largest urban areas.

In addition to providing direct access to a CBD, railroad rights-of-way may be useful for LRT service in the largest urban areas in two other ways. LRT may serve as a feeder to an existing rail transit service, as on the Ashmont-Mattapan line in Boston. This type of feeder may, in some situations, be less costly to construct and operate than an extension of heavy-rail transit (HRT) service. In a very few situations, nonradial or crosstown routes may be desirable in the largest cities. However, these routes are likely to be useful only where they serve as feeders to other rail lines as well as provide crosstown service.

To sum up, a railroad right-of-way is valuable for LRT service if it serves a corridor with a high volume of current or potential transit use. In many situations, the existence of high-volume bus routes will indicate the presence of such a corridor. Railroad rights-of-way that are not located in potential high-volume corridors will not be useful for successful LRT routes. The temptation to regard a right-of-way as suitable simply because it is easily available should be strongly resisted.

RAILROAD USE AND TRACK REQUIREMENTS

Use

Analysis of rail-line use requires a thorough knowledge of the type of train movements that travel the line, the volume of train movements, and the magnitude and frequency of car spottings on individual sidings along the line. Gathering data at this level of detail is a necessary first step in determining the feasibility of using a particular railroad right-of-way.

Several types of train movements may be used on a given line, e.g., through freight and passenger train movements between points remote from the line under consideration, local or way freight movements that traverse the line but may also set out and pick up cars along the line or switch cars for major customers, switching movements that operate exclusively to pick up and set out cars on a given line or within a given switching district, and transfer movements to exchange freight cars between railroads or between nearby yards on the same railroad. Knowing which movements are used permits categorization according to which simply traverse the line and which use the line to switch cars to on-line rail facilities or customer sidings. It should also be determined whether these movements are attributable to one or several carriers. The owning road may grant access to other roads. The line might also represent joint trackage, i.e., it may be owned by several roads.

Field observations may be a useful source of this data if a sufficient number of observations are made. Rail activities can fluctuate enough that it could be misleading if only one or two observations are made. Rail records are the best source of use data once the type of movement is known. Some common sources include the following.

1. A timetable for employees provides a list of all scheduled trains. Generally only a portion of the total freight movements will be shown. Within the timetable is a section (special instructions) that details the type of signal rules governing the line, speed limits, and other operational features.

2. Train sheets are kept by a dispatcher and log all through train movements over the line. If the line is totally or partially within area switching (yard) limits, these sheets will not constitute a log of all train movements.

3. Block office records detail all train movements that have passed an office by a given time of day.

4. A yardmaster controls movements within a specified territory, subject to the railroads' operating rules. Most railroads require that a log of these operations be maintained, but through movements are not likely to be shown.

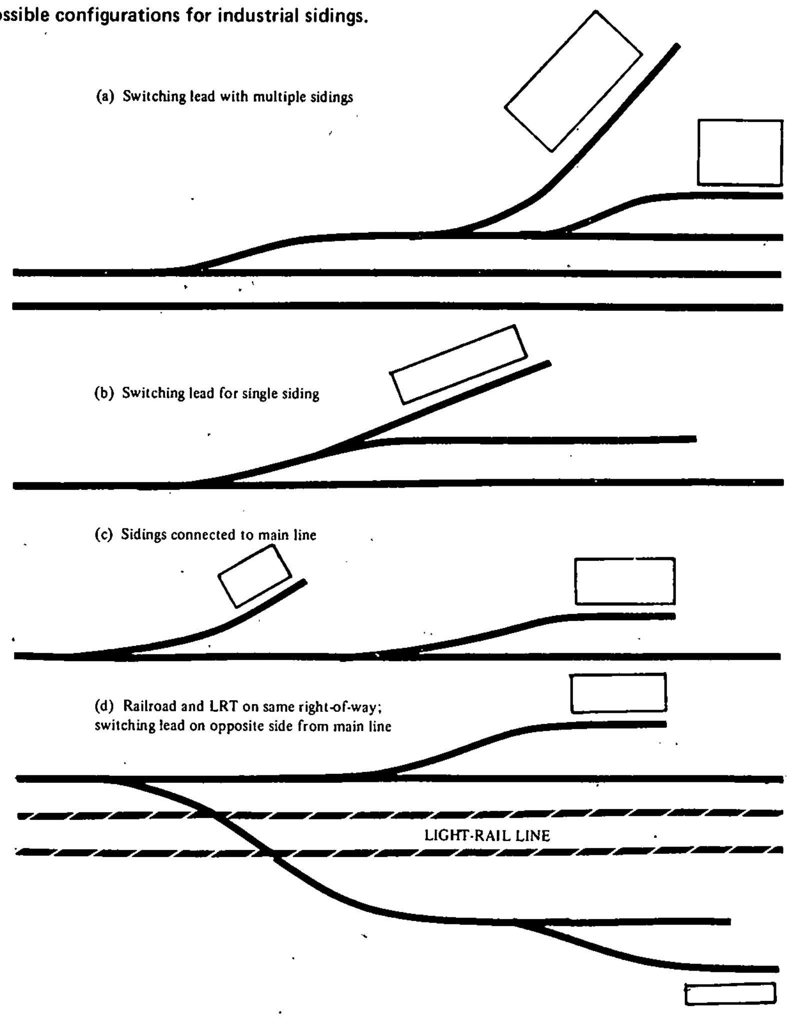
Railroads also maintain records from which the frequency and number of railroad cars that use a given siding or group of sidings can be determined. Sources of this information include the car accounting records, which are maintained primarily to support per diem and demurrage charges but can also be used to determine the magnitude and frequency of use of sidings, and waybills, since an analysis of waybills for customers on a given line specifies rail use and when it occurred. At least two sources of information, one on movements information and the other on siding use should be employed.

Track Requirements

The review of use will provide a preliminary indication of the current track requirements and which track facilities may be classified as excess. Through movements that are either frequent or random in occurrence will require retention of main-line tracks or relocation of the movement to another line. These movements must be able to traverse the line at any time without delay and generally require that tracks for on-line switching activity be segregated. For example, switching tracks should be designed to allow switching activities that do not foul main tracks. In areas where there are numerous rail customers, a parallel switching lead is often a practical solution, as is shown in Figure 1A. A switching lead intended to serve one customer should have two stub tracks of sufficient capacity to avoid fouling the main tracks during switching movements, as in Figure 1B. The absence of through movements or minimal siding activity will allow switching to be accomplished by using the main track, as in Figure 1C.

The number of main tracks that must be retained is generally a function of the volume of through train movements and the type of signalization that is used. For example, if there is no signalization or if the existing signal system is unidirectional, a railroad may chose to retain two main tracks, even in traffic of moderate density. The LRT project may be able to reduce the railroad's track need by improving the signal and control system and thereby increasing the capacity of the remaining tracks.

Figure 1. Possible configurations for industrial sidings.



The location and number of sidings that must be retained will be determined by the waybill analysis or car accounting records. If sidings are randomly located on both sides of the right-of-way, it will be necessary for the LRT line to be crossed. The track arrangements must be such that railroad switching activity does not take place on the crossing. A possible configuration is shown in Figure 1D. The operational aspects of such a crossing are further discussed in a following section.

CONSTRAINTS ON THE USE OF RAILROAD RIGHT-OF-WAY

The level of use is the major determinant of the availability of a railroad right-of-way for an LRT system, but there are other areas of consideration that are also important, particularly the issues of whether the physical characteristics of the line are suitable to accommodate an LRT operation, what institutional constraints might be encountered, and how they will affect operation of the line.

Physical Characteristics

The physical characteristics of a railroad right-of-way that are important for potential LRT use include width of the right-of-way, number and location of rail customers, number and type of highway and railroad crossings, and barriers to right-of-way expansion.

Right-of-Way Width

An inventory of right-of-way widths can be compiled by obtaining Interstate Commerce Commission (ICC) evaluation maps from the railroad engineering department or tax maps from the local government body. A simple field check is recommended as part of the preliminary planning to determine whether there are incursions of nonrailroad buildings or structures and to check the locations of railroad structures, such as bridges, fills, and cuts.

The right-of-way must at least accommodate two tracks and be approximately 9.14 m (30 ft) wide. The need to provide for continued railroad operation will require a wider right-of-way. The exact width will depend on the number of tracks and the use to which they are put. The maximum number of tracks a railroad is likely to require is four, two main tracks and two parallel sidings that will accommodate switching activity without fouling the main tracks. The railroad may need only one track to accommodate switching activity. The nature of track use also has an effect on the required width. Main tracks designed for high-speed operation may require greater width to accommodate perimeter fencing.

The right-of-way width in areas of cuts or fills is also important if additional tracks are required to segregate railroad operations. The need to increase the size of these structures to accommodate segregated trackage can also require wider rights-of-way. Since railroads use a great deal of off-rail maintenance equipment, vehicle access roads may be required if the rail line is a major route. Right-of-way width is also critical in areas where it may be advantageous now, or in the future, to have grade separations.

Number and Location of Rail Customers

The use survey will provide a list of all active customers. The likelihood that inactive sidings will become active in the future may also need to be investigated. Some sidings may be inactive because the facilities they serve are temporarily vacant. Others may be inactive because users switched from rail service to truck or piggyback service. A survey of the owners or tenants of inactive sidings is recommended to permit estimation of the future use of these facilities.

Barriers to Right-of-Way Expansion

The railroad right-of-way cannot be expected to supply all the land needs associated with the LRT line. Stations may require land outside the right-of-way to accommodate parking and in certain cases to facilitate access. Platform areas can usually be accommodated within the right-of-way, but the need for continued railroad operations may require additional width at stations.

Grade-separation structures can have two effects. Additional land may be required for the structure approaches, particularly where a street grade is changed and the railroad grade remains the same. Also, land may be needed for both rail and highway traffic detours during construction.

The ability to expand the right-of-way can be estimated by taking an inventory of all structures that border or are near the existing rail line. This is especially important near proposed station sites or where grade-separation structures are required.

Number and Type of Highway and Railroad Crossings

LRT operations have the flexibility to tolerate grade crossings as long as they do not present severe operating impediments. Traffic volumes by time of day should be obtained for all highway crossings to determine possible trouble spots. The presence of a large number of heavily used highway crossings that would require grade separations could push costs up to the level of rail rapid transit. Heavily used highway crossings that are not grade separated will probably require the installation of traffic signals that are tied into the street signal system. Such signals would reduce interference with street traffic but would lower the quality of LRT service by increasing running time. If railroad grade-crossing signals are acceptable from the point of view of traffic control, then LRT service would be relatively unimpeded. The interconnection of grade-crossing signals with traffic signals at nearby intersections to minimize both LRT and street traffic delay has been proposed for Edmonton, as noted by O'Brien, Schnablegger, and Teply in their paper elsewhere in this Report.

Railroad crossings can pose similar problems. Crossings of railroad main and branch lines can create service-delay problems because of the randomness of train operation. This situation is even more acute if it is the railroad that controls the crossing, since the controlling party has the right to hold or stop any movement on the other line in order to protect movement on its own line. If control is exercised from a remote location, waiting time will be even greater. Such situations could not be tolerated, and a grade separation would be required. Crossings that have railroad switching leads can be tolerated if they are infrequently used and activity can be confined to nonpeak periods. In addition, all switching would have to be done outside the limits of the crossing.

Operating Issues

The need for continued rail access to all or a portion of the right-of-way requires either operational or physical separation of railroad and LRT activity.

Operational Separation

Railroad and LRT operations can use the same track if railroad operation is restricted to periods that would not interfere with LRT operation. Railroad operation would typically be restricted to the late evening hours, during which its impact would be negligible or nonexistent. In most instances, railroads would not tolerate such restrictions on through freight movements but might be inclined to accept them on switching movements. The feasibility of restricting switching movements depends largely on the needs of the rail shippers affected. If the shipper requires early morning delivery at some destination, the siding will have to be switched in the late afternoon, and a restriction could not be tolerated. In this instance, physically separate rail facilities would have to be provided.

The joint use of tracks without this form of separation would present a variety of problems, not the least of which could be the effects on LRT service reliability. Other problems would include incompatibility of signal and other train-control systems used for railroad and LRT operation and the incompatibility of operating rules of the two systems. Joint use without operational separation is not recommended.

Physical Separation

Railroad and LRT operations may use separate track facilities within the same right-of-way, scheduling movements so that they have minimal impact on each other. It is quite likely that situations will arise in which the railroad will require access to both sides of the right-of-way (Figure 1D), necessitating one or more crossings at grade. Such crossings will require interlocking facilities that protect movements on both lines. Understandings will have to be reached as to the hours that the railroad can use the crossing and the length of time the crossing can be held by the railroad.

Institutional Constraints

It is impossible to list all institutional problems that might arise, since many are based solely on local considerations. However, federal agencies or regulations will have significant impact on LRT operation; this is discussed below.

The Federal Railroad Administration (FRA) exercises control over railroad safety matters, including track standards and equipment design. The FRA has no jurisdiction over rail transit operations that do not provide interchange freight service. An LRT line would have to adhere to FRA track standards in areas of joint use. However, those standards are generally less stringent than normal LRT operating practice. If joint operations did not have positive time separation, the FRA might insist on compatible car-design specifications. These specifications would rule out the use of light-rail vehicles (LRVs) because of the differences in floor and coupler height. There have been numerous examples of mixed railroad and LRT operations in the past, but unfortunately no examples have survived to form a precedent today.

LRT operations linking two states would fall under the jurisdiction of the ICC in matters of rates and service. Lines that handle short-haul passenger traffic exclusively are classified as suburban electric railways and are thus now subject to ICC control only in regard to rates.

If an LRT line were to assume direct responsibility for freight operation over its lines and participate in joint tariffs, the ICC would have jurisdiction over the freight service and could possibly claim jurisdiction over passenger service on the basis of some rather ancient precedents (1). The one transit operation that also provides rail freight service, the New York City Transit Authority, has used a subsidiary company, the South Brooklyn Railway, for its freight operations in order to avoid the problems of ICC jurisdiction. Operation of freight service by an LRT system under contract to a railroad would most likely remove the LRT system from ICC jurisdiction, since there would be no participation in freight tariffs. This was true for the freight service that the Chicago Transit Authority operated for many years for the Chicago, Milwaukee, St. Paul and Pacific Railroad Company.

RELOCATION OR ABANDONMENT OF RAILROAD SERVICE

Relocation or abandonment of railroad service is often a means for making a right-of-way available for LRT use. As mentioned previously, many rail lines in urban areas have become surplus as a result of railroad mergers and changes in patterns of use.

Relocation of Railroad Service

Relocation of transiting movement to other routes is often possible in areas that have a high density of railroad facilities. Relocation of transiting movements may be used to permit total abandonment of a line that does not have significant local traffic, to permit reduction in the number of railroad tracks required for freight operation so that right-of-way is available for LRT use, or to reduce the level of use so that joint use is possible. Figure 2 shows how the relocation of through movements to an alternate route could be arranged. The connections required for the relocation of service are indicated. In many situations, new connections will be required. In some of these situations, lines belonging to more than one railroad will be used, and agreements on trackage rights will be needed. In other situations, the lines to be used will belong to one railroad. However, new connections will still be required, particularly if common ownership of parallel routes is the result of a fairly recent merger.

Abandonment of Railroad Operations

Abandonment of railroad freight service is possible where a route is not required for through movement and there is insufficient on-line traffic to justify its retention. Abandonment of a railroad line requires ICC approval. The ICC has established minimum use criteria for abandonment at 54 car movements/route km/year (34 car movements/route mile/year). In many cases, however, abandonments of significantly more heavily used lines have been permitted; each abandonment case may require a unique decision. Alternative uses for rights-of-way are given consideration in abandonment decisions. Most such decisions, however, have resulted from the need to provide an expensive grade separation between an interstate highway and a little-used railroad.

In abandonment procedures there is no requirement for compensation to affected industries. However, the relocation of on-line industry may be a means of reducing the level of use of a rail line so that abandonment is feasible. Such a policy has never, to our knowledge, been formally developed. Thus, the legal requirements of publicly financed industrial relocation, where rail access is being discontinued but there is no condemnation of property, remain unexplored.

The discontinuance or reduction of railroad operations

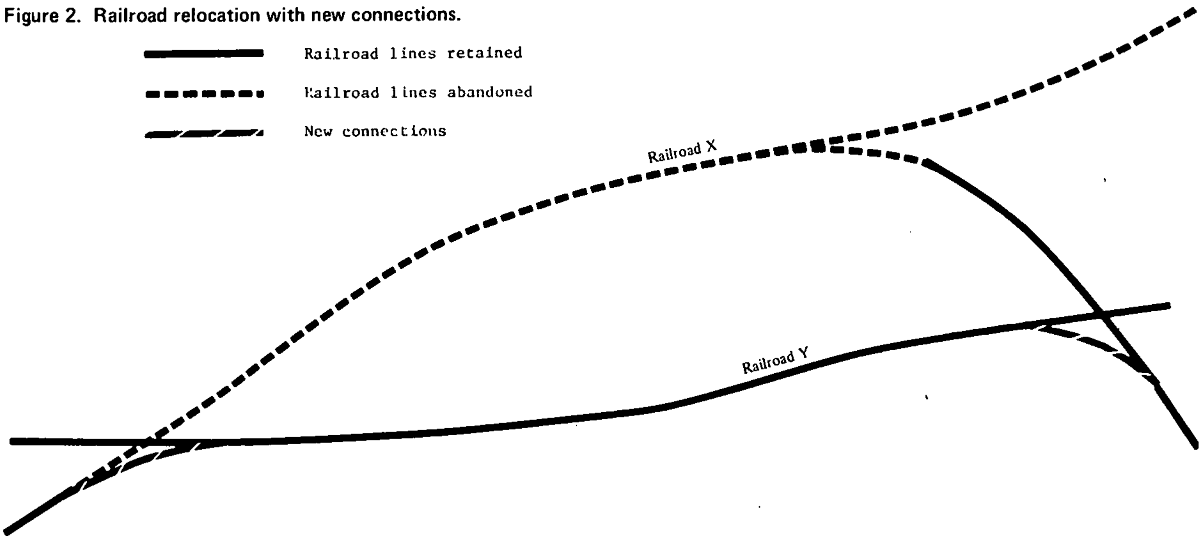


Figure 2. Railroad relocation with new connections.

to accommodate a federally-funded LRT operation could give rise to labor protection claims under section 13c, which is designed to give job protection to workers affected by federally supported mass transit projects. However, ICC decisions in railroad abandonments usually require employee protection as a condition of abandonment where only a portion of a railroad is affected.

Most railroad abandonment situations would involve only a small number of employees, and thus could probably be resolved by the normal railroad employee protection procedures at low cost. However, where a large number of employees would be affected, such as in the discontinuance of a railroad commuter service, there could be substantial costs that would have to be assumed by the LRT operating agency. It is suggested that, if possible, railroad abandonment procedures be completed substantially in advance of the acquisition of railroad property, in order to minimize the employee protection liability of the LRT operator.

Another possible claim by railroad labor unions is for jurisdiction over the employees of a new service on the grounds that it replaces the railroad service. This claim has been advanced in a few cases in which commuter service has been replaced by rail transit service, but it has never been successful.

DESIGN CONSIDERATIONS FOR JOINT USE OR JOINT OPERATION

Clearances

Sufficient horizontal and vertical clearance for freight equipment must be provided in all cases in which rights-of-way are shared or trackage is jointly used for freight and LRT operation. The source for all data on railroad equipment referred to in this section is the Car and Locomotive Cyclopedia (2).

Substantial differences exist between recommended railroad practice for new construction and clearances on existing railroad lines. Recommended practice calls for 6.7 m (22 ft) of vertical clearance and 2.4 m (8 ft) of horizontal clearance for fixed structures as measured from the track centerline at the top of the rail. However, the standard clearance diagram for rail freight equipment, as is shown in Figure 3, is significantly more restrictive: maximum height of 4.8 m (15.5 ft) and maximum width of 3.3 m (10.7 ft), 1.6 m (5.3 ft) from track centerline. Cars built to this standard are acceptable for operation on more than 95 percent of the railroad trackage in the United States.

However, although this is the nominal standard, much of the railroad equipment in service exceeds the vertical clearances of this standard. Car heights of 5.2 m (17 ft) are not uncommon. Loaded trilevel automobile carriers are almost 5.8 m (19 ft) high. A few special cars for aircraft assembly shipment have been built with a maximum height of 6.0 m (19.7 ft). Table 1 gives the typical dimensions of various types of rail freight equipment.

The clearance requirements affect the design of LRT systems that have joint use of right-of-way or shared trackage in three areas. Vertical clearance requirements may present problems in relation to wire height. Horizontal clearances are a problem if platforms at the car-floor level are to be used in joint operation. Clearance requirements for railroad operation may require that the clear height of grade separations be increased.

Vertical clearance for jointly used trackage or for crossings of railroad lines at grade may increase the wire height beyond the 5.8-m (19-ft) maximum operating height of the pantograph specified for the standard LRV (3). However, for most industrial trackage a wire height of 5.5 m (18 ft) is acceptable. This height will allow a 0.3-m (1-ft) clearance for high-cube boxcars. Railroads will generally insist on 6.7 m (22 ft) of vertical clearance on main lines, on trackage that serves automobile-loading facilities, and for access to industries that are likely to originate or receive oversized loads. In these situations, two solutions are possible. Where a 4.6-m (15-ft) minimum wire clearance on the LRT line is practical, the pantograph base can be elevated to provide a 6.7-m (22-ft) maximum wire height. If the problem exists only at a small number of railroad crossings at grade, wire bridges may be used, as is done in Cleveland (a wire bridge is a lift mechanism that raises a section of wire from the normal operating height to a height sufficient for railroad clearance requirements).

Horizontal clearances present a significant problem only if platforms at the level of the car floor are desired. Although a railroad freight car is significantly wider than the standard LRV, the standard design practice of using 3.7-m (12-ft) or 4.0-m (13-ft) track centers and 2.1-m (7-ft) side clearance is sufficient for almost all freight movements. Three means are available to provide for freight operation on LRT lines that have high-level platforms: gauntlet tracks, car-door sill extensions, and hinged platform edges. However, none of these meets the test of being both operationally simple and low in cost. If extensive joint use of an LRT line is under consideration, it is probably better to avoid platforms at car-floor level entirely.

Gauntlet tracks are relatively expensive, since they require a switch at each end of the gauntlet. In addition, remote-controlled power switches are necessary if freight trains are not to stop at each end of the gauntlet for a crew member to manually operate the switches, which increases costs substantially. Car-door sill extensions are feasible only if all stations have high platforms, since the extension must be below the bottom of the door. In addition, a gap of approximately 0.3 m (1 ft) would exist between the car side and the platform except at the doors; this would create a hazard for passengers, particularly during boarding. Hinged platform edges are time consuming for a freight-train crew to operate, since they must be hinged in short sections to be lifted manually. Gauntlet tracks have been the most commonly used and are probably the most satisfactory solution.

Vertical clearance requirements for grade separations are similar to those for wire height. The 6.7-m (22-ft) clearance standard should be adhered to if practical. An examination of the individual railroad line is necessary to determine existing clearance restrictions and thus to determine acceptable vertical clearances. As was pointed out above, a 5.5-m (18-ft) clearance is often sufficient.

Figure 3. Outline of standard LRV and standard clearance diagram for rail freight equipment.

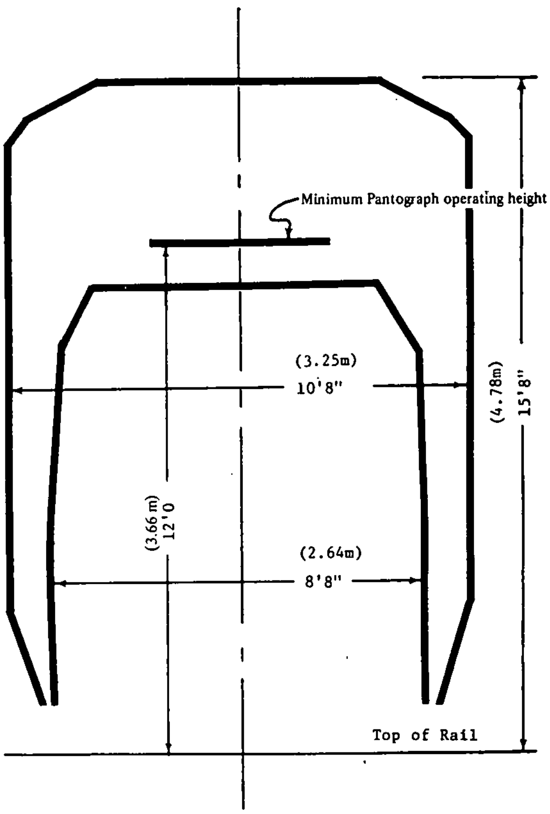


Table 1. Critical weights and dimensions of rail freight equipment.

Equipment	Gross Weight (Mg)	Truck Centers: Individual Cars (m)	Truck Centers: Adjacent Coupled Cars (m)	Car Height (m)
Locomotive				
Four-axle (EMD-GP38)	113.4	10.37	7.62	4.65
Six-axle (GE-U36C)	190.5[a]	12.5	8.08	4.73
Standard box car	99.8	12.5	4.42	4.75
High-cube box car	99.8	19.51	8.99	5.18[b]
Covered hopper car	119.3	12.15	4.12	4.57
Flat car with automobile rack	99.8	20.12	8.69	5.72[b,c]
Open hopper car	119.3	10.98	3.81	3.73
Ore car	119.3	6.1	3.81	3.51
Piggyback flat car	99.8	20.12	8.69	5.18[b,c]

Note: 1 Mg = 1.1 tons and 1 m = 3.3 ft.

[a] Maximum ballasted weight.
[b] Exceeds standard clearance.
[c] Estimated height of loaded car.

Weights

Table 1 also shows the weights of representative types of rail freight equipment, which are substantially greater than the typical weights of both LRT and HRT equipment. A fully loaded standard LRV weighs approximately 47 Mg (51.5 tons). As a result, track and structures designed for joint operation or for use of a common right-of-way will need to be capable of accommodating much higher loads than those found in LRT operation only. While it is unlikely that track design standards would change significantly, structural designs would be affected.

To illustrate the differences in carrying capacity required, the weights that would occupy a 30.5-m (100-ft) bridge span in varying operational situations are presented below (1 Mg = 1.1 tons). Among cars with a nominal capacity of 63.5 Mg (70 tons) and a gross weight of 99.8 Mg (110 tons), locomotives impose the greatest loading. Among cars with a nominal capacity of 90.7 Mg (100 tons) and a gross weight of 119.3 Mg (131.5 tons), car weight is greater than locomotive weight, except where cars with a relatively long wheelbase are used in conjunction with six-axle locomotives.

Equipment	Gross Loading (Mg)
LRVs in trains	65
Light-rail maintenance-of-way equipment	91
Freight trains	
63.5-Mg cars (four-axle locomotives)	227
90.7-Mg cars	239 to 298
Six-axle locomotives	345 to 381
Ore cars	417

Most railroad facilities should be designed to permit the operation of 90.7-Mg cars. The operation of six-axle locomotives should be allowed for on main-line trackage, but it is not a requirement for industrial lead tracks. The extremely concentrated loads imposed by 90.7-Mg open hopper cars, ore cars, and other short-wheelbase cars are present most commonly on lines that serve steel mills and coal-burning power plants.

Grade Separations and Crossings

Joint operation or use of a common right-of-way will require substantially different design criteria for grade-separation structures than those required for LRT use only. The difference in vehicle weights has already been described. Approach gradients will be a greater constraint where the grade level of the rail line has to be changed to accommodate a grade separation. Generally, grades of more than 1 percent are undesirable for main-line freight operation and those of more than 2 percent are undesirable for switching leads. An LRT line may commonly have long grades of up to 6 percent; short grades of up to 10 percent are feasible.

If use of a common right-of-way is planned, it may be desirable at some locations to have grade separations for the LRT line but not for the rail freight trackage. This solution is attractive if the rail freight track is used relatively infrequently and the cost of the grade separation would be substantially increased by including it. A more elaborate example of this type of design would have the rail transit route built on an elevated structure over a non-grade-separated railroad right-of-way, as was done in portions of the San Francisco rapid transit system.

The use of railroad rights-of-way for LRT routes will often require crossings of remaining railroad trackage. In designing rapid rail systems, it has usually been thought desirable to have grade separation for all such crossings. For LRT operation, crossings of railroad lines at grade are acceptable in many situations.

The design of signal protection for a crossing depends on the degree of central control that is required on both the LRT line and the railroad. The most common crossing has no signal control on the railroad and automatic block signals without central control on the LRT line. In this situation, a key-operated time-delay interlocking is sufficient protection. Normally the interlocking is cleared for the LRT route and is activated manually by a railroad crewman. A time-delay circuit prevents the signals from clearing for the railroad line until a sufficient time has passed after the LRT signals indicate STOP so that any car that has already passed the signals will clear the crossing. A short track circuit is provided on the railroad line to restore the interlocking to its normal state after the railroad train has cleared the circuit.

A somewhat more sophisticated version of this type of crossing protection is provided by the automatic interlocking, which is controlled by approach track circuits on each line. This type of interlocking has the circuit logic of the two systems interconnected so that the crossing is cleared for the vehicle or train that arrives first at the approach section. This type of protection can be used for branch lines and secondary main lines where a mandatory stop for railroad movements over a crossing is undesirable. It is also suited to railroad operation in automatic block signal territory.

CONCLUSIONS

Railroad rights-of-way have been used for transit purposes in several cities, e.g., Boston and Edmonton. HRT lines have been built on railroad rights-of-way in Boston, Chicago, Cleveland, New York, Philadelphia, San Francisco, and Washington. A hybrid system that has characteristics of both LRT and HRT also exists in Chicago.

The use of railroad rights-of-way for LRT has differed significantly from their use for HRT because both rail-highway and LRT-railroad grade crossings are acceptable. Thus, substantial reductions in construction costs are possible. Railroad rights-of-way usually provide horizontal and vertical alignment characteristics that exceed the requirements for both LRT and HRT systems. In using railroad rights-of-way, the less restrictive alignment requirements of LRT are an advantage only in transition sections.

Joint use of trackage does not present any difficult design problems, but it does present some operational problems that are inherent in mixing LRT and railroad freight service, as well as several institutional problems. These make joint use unfeasible except where positive operational separation can be provided without degrading passenger service. Such situations exist only for low-volume switching activities.

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The Design of Light-Rail Track in Pavement

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Many existing light-rail transit (LRT) networks and parts of some new ones require the construction of track in pavement. Sometimes this track is intended for joint use with street traffic or buses; in other places paved track is used in pedestrian areas or on medians. This paper describes the types of LRT track used in pavement in North America and Europe and suggests that the standards now in use in the United States may be in need of revision. There has been very little construction of LRT track in pavement in North America in the last 40 years. What little has been built has followed the traditional standards of the industry, which date from the earliest streetcar days, and has generally used girder rail, ties, and ballast set in concrete pavement. By contrast, most European LRT systems have adopted a basically different type of track for use in pavement. It is built without conventional ties and is mechanically separated from the street pavement structure. Such track is quieter and may also be less costly; it appears to warrant serious consideration for new U.S. installations.

There has been very little construction of light-rail transit (LRT) track in street pavement in North America in the last 40 years. What little has been built, for realignment or rerailing, has been constructed to standards first developed in the earliest days of streetcars; these standards are straightforward and have stood the test of time. During the recent bleak period of transit history, there was little need for better designs and no resources available to research them. Now that several existing LRT systems in North America are engaged in refurbishing their physical plants and new systems are under design, it is appropriate to pay some attention to the progress that has been made in the search for a track design that offers potentially lower costs and environmental benefits in countries in which LRT has been the