Considerations for Effective Light Rail Street Operation

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Mention street operation to designers of new light rail systems, and many of them wince and conjure up visions of slow, rumbling, clanking streetcars edging their way through crowded vehicular traffic. Street operation today, however, can be not only effective, but desirable under certain conditions. When initial consideration is given to street operation, planners and designers should keep in mind that future upgrading is possible. With the availability of future year funding, street operation can be replaced by tunneling (for short or long stretches) or by constructing a median if the street is widened. In this paper, street operation includes mixed traffic, partial segregation, and complete separation on the street. These various treatments will be discussed later.

The primary point of this paper is not to convince the reader to use street operation in a proposed system but to discuss those considerations that should be addressed to maximize overall operation when street operation has been selected as an option for all or part of the system.

INTRODUCTION

Three constraints may make street operation desirable or necessary, or both: funding limitations, especially when they preclude subway construction, the lack of private right-of-way (PROW), and the political need to minimize disruption by avoiding property acquisition.

As opposed to PROW and subway, street operation has the following benefits:

1. Lower initial costs
   - No right-of-way acquisition; existing streets can be used;
   - No signal system is needed for light rail transit (LRT) car spacing because traffic signals and other controls will limit speeds;
   - Simpler and less expensive overhead can be used;
   - Extensive grading requirements are unnecessary because, again, existing streets are used; and
   - No grade-crossing gates are needed because that function will be served by traffic signals and stop signs.
2. Easier accessibility for passengers
   - Closer stop spacing;
   - More convenient access to the stops, especially for elderly and handicapped patrons; and
   - Passengers can be more closely distributed to more sections of shopping areas.

Conversely, street operation can have the following negative impacts on both LRT and vehicular traffic:

1. Capacity. Through-put may be lower but can be partially offset by train operation;
2. Dwell time. Passenger handling is more time consuming because of the low-level boarding unless self-service fare collection and safety islands are used;
3. Average speeds. Additional running time will be necessary because of traffic and pedestrian interference;
4. Reliability. Because street operation takes place in an environment over which the transit operator has less control, the service provided may be less reliable (delays and accidents); and
5. Track cost. Initial installation cost of the track structure will generally be higher.

DISCUSSION

The following considerations are meant to maximize street operation. All reflect the experiences of the authors and are the result of extensive visits by both authors to many light rail properties worldwide. These considerations are also lessons learned from 10 years' experience in the light rail operations of a major U.S. city system by one author and extensive consulting by the other.

Car Design

Performance

An early decision must be made about whether the car will be used only in street running with mixed traffic or also on exclusive right-of-way. If the latter is the case, the car must incorporate features for both environments, but this will of necessity involve compromise.

Performance requirements must be based on the type of environment in which the car will predominantly operate. High balancing speeds are not as valuable for predominantly street operation because of the relatively frequent stops for either passengers or cross streets and traffic lights. Here it is operationally desirable to have the highest possible acceleration and braking rates consistent with safety and comfort. Over the life of the car this will translate into considerable operational savings, both in terms of running time and operators and cars required. The PCC car set a high standard for acceleration and braking, which has not been met by many of the recent light rail vehicles (LRVs).

Stopping

Mixed traffic requires more frequent use of emergency braking, and track brakes and truck mounted sanders are essential. A slip/spin detector will prevent excessive wheel spinning or locked wheel sliding during acceleration and nonemergency braking. This not only reduces wheel wear but keeps the car under control.

Car Shape

A square-ended car may not be feasible in mixed traffic, especially on short-radius turns. Articulation may also be necessary. Tapered ends will present design problems for front door on-board fare collection because of the location of the doors in reference to the operator and fare box. Tapering will also result in the loss of some passenger seating capacity. Installation in older cities with narrow streets requires clearance considerations not only for passing other light rail cars, but curbs, other fixed obstructions, and possible sidewalk overhang.

Passenger Stops

If front door fare collection is required, low-level steps may have to be incorporated in the taper. Safety islands built up to the first step height (as in The Hague) can help speed boarding and alighting but may present a gap (and safety problem) at the front taper. Boarding and alighting from street level may also require high or low steps and an on-board lift for elderly and handicapped patrons. Lifts should be avoided wherever possible because of the high incidence of maintenance problems. Floor-level loading platforms with ramps are preferable if sufficient space is available.

Visibility

The presence of pedestrians, especially children, means the operator's view to the front and sides is critical. His seat position and the height of the console top must give him a view as close to the car as possible to guard against people crossing directly in front of the car. Corner post widths must be narrow enough to minimize blind spots. Windshield glare reduction is also important because of the short reaction time in mixed traffic at night.

Mirrors are needed in mixed traffic operation, but the car taper may result in left and right mirrors that provide vision only as far as the clearance points on the car side. An alternative is to have the bottom edge of side windows low enough to give some view of small cars traveling alongside through use of a cab-mounted inside rearview mirror. As a minimum, an outside mirror is needed when the front doors are open to spot passengers running for the car from the side rear.

Outward folding doors will also hinder the operator from seeing any clearance points on the car side while edging past parked automobiles or other close clearance obstacles.

Warning Devices

A car operated in mixed traffic has a much greater need for both audible and visual warning devices. Audible devices should include an automatic repeating gong in addition to a horn because the latter may not be allowed in city operation. A rear gong is also helpful as a warning for car overhang during turning movements. An alarm and a light for reverse movements are advisable.

Visual warnings should include side, rear, and front turn signals, preferably the attention-getting alternately flashing type. Front marker lights should be a color (blue?) distinctive from those used by general automotive traffic. Rear tail and marker lights are needed in addition to brake lights, and brake lights that alternately flash will help reduce rear-end accidents. Flashing red lights on the car side behind the passenger doors that are activated whenever doors are unlocked or open will enhance safety for middle-of-the-street boarding or alighting where automobiles might pass. Four-way hazard lights are necessary for cars disabled in traffic. A warning sign on the rear of the car aimed at alerting motorists to car swing during turning movements should be placed at the motorist's eye level.

Door Operation

Passenger-activated doors (from outside and inside) are useful in street operation, especially with self-service fare collection. The operator unlocks the doors, and the passenger simply pushes a button to open them. In both hot and cold weather, only the doors that need to be opened are opened, thus conserving both heat and air-conditioning.

Wheels

Because of the greater track bed rigidity involved with street laid rails, resilient wheels are highly desirable to reduce the impact of vibration on the track and through the street to wayside structures.

Water Protection

Street-running cars are much more susceptible to water damage to underfloor components from water splash, slush, salt, and snow. Component protection and air intake positions must be examined in this light.

Passenger Concerns

Along the Wayside

Safety and security are important at transit stops. Considerations include access to the stop, crosswalk protection, lighting for night boarding and alighting, and pavement markings and signs alerting motorists to the stop. These signs, when hung from the overhead facing motorists, will alert them to curbside stops. Red stop lights supported from the overhead and aimed at motorists can also be effective. Give careful attention to the placement of passenger stops and position them at regularly marked pedestrian crossings where possible and, where street width allows, use safety islands. Include passenger-activated pedestrian signals where you can.

Although safety islands decrease dwell time and improve passenger safety, they can be an accident hazard to oncoming motorists and provide an ongoing maintenance and insurance expense when hit. The end facing traffic should be tapered, distinctively lit, and equipped with double amber flashing warning lights. Safety islands should also include splash guards to protect waiting passengers. Shelter roofs must clear the car side if the air suspension bellows are down and the car leans.

On Board

Inside the car, include stepwell deicers to minimize slipping hazards where snow and ice are a possibility. Additional stanchions and seat grab handles are needed because of the higher acceleration and braking rates. Adequate window visibility should be given to the passenger because many stops may be made only when requested. A stop-requested chime and a light system are helpful. A door closing warning alarm, sensitive edges and alarm, and brake interlock will all enhance passenger safety.

Wayside Concerns

Track Systems

The greatest amount of attention must be given to the design of the track system. The success or failure of a light rail street operation is directly dependent on the efforts to integrate the track system into the street environment. Location of the track system must take into consideration traffic flow and movements, street geometry, pedestrian movements, and the general environment in which it is to be placed. There is no standard design that can be recommended for all locations. Local street and traffic departments should be involved in the design phase to ensure that their concerns are taken into account.

Segregated Track Areas

This configuration can be considered for streets and wide boulevards where the loss of two lanes will not severely affect traffic or where automobile traffic can be diverted. Narrow streets can also be considered depending on traffic densities, the ability to prohibit parking, or, again, the ability to divert automobile traffic to other streets. In certain situations extra street width may be achieved by cutting back sidewalks. Pedestrian volumes and the presence of sidewalk basements will dictate the feasibility of this approach. The principal separation methods include:

- Complete separation. The track structure is open and not paved. Automobile access is prohibited by standard curbs and center fencing eliminates pedestrian intrusion. This configuration allows for higher speeds, improves safety, and minimizes pedestrian and automobile conflicts. This type of separation is generally not suitable for commercial areas where it is not desired to have highly constrained pedestrian movements. Its more appropriate location is where pedestrian densities are lower and lateral street crossings can be limited to fewer than eight per mile.

In some cities there are median strips that could be easily converted to light rail use. Treatments similar to those in New Orleans can also be employed to minimize the visual impacts. In this case, the entire track structure has been sodded to enhance its appearance. Consideration should also be given to the use of far-side stops to decrease conflicts with general traffic turning movements.

- Raised texture pavement. Segregation can also be achieved by raising the pavement surface in the track area. The slight height difference in conjunction with a rough pavement surface would inhibit automobile intrusion but would not prevent it from occurring. Rough pavement could be used to limit intrusions by installing "Belgium Block" or similar material or texturing a concrete surface. This configuration lends itself to most street environments and also allows crossings by emergency vehicles. It also improves drainage in the track area.
- Marked or painted segregation. Segregation here is achieved simply by marking the pavement surface and erecting the appropriate enforcement signage from the overhead. The track area should be crosshatched with a long-life marking material to minimize maintenance efforts. In this situation the degree of separation achieved is directly dependent on the level of enforcement activity. Clearly this is the least effective level of separation, but it may represent a necessary compromise. It can also be the first step in achieving a more positive segregation. If this approach is adopted, an agreement must be reached about who will maintain the markings.

The ability to segregate light rail operation is also dependent on the frequency of intersections. Closely spaced intersections inhibit higher speed operation thus limiting one of the major advantages of segregations. This problem is compounded if left turns are allowed at these intersections unless steps are taken to limit or prohibit their use. Access to streetfront properties is also a consideration. The roadway area between the track and the curb line must be wide enough to accommodate turning and automobile backing movements so that traffic flow is not significantly impeded. Figure 1 shows some of the segregation treatments discussed.

Mixed Traffic Locations

Guidelines for the placement of tracks in a variety of mixed traffic locations are provided next:

- Tangent track. The best location is still

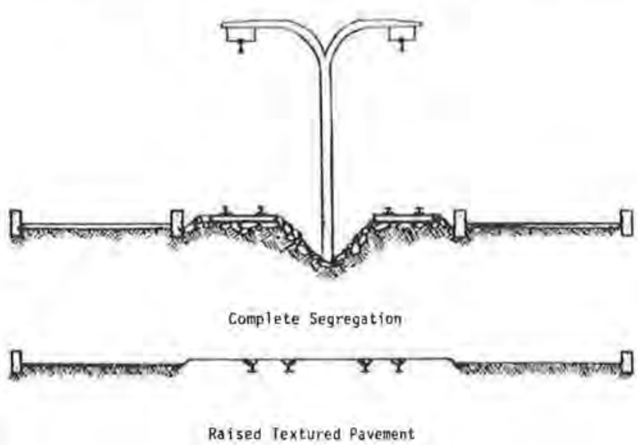

FIGURE 1 Segregation treatments.

generally the traditional location, the center two lanes in the roadway if the street accommodates two-way mixed traffic. If the running lanes are adjacent to a parking lane, it may be desirable to indicate clearance lines on the pavement.

Placing the two running tracks side by side instead of separating them by automobile traffic is more advantageous because (a) track maintenance and replacement are less expensive when both tracks are colocated; (b) portable crossovers can be used to repair one track while maintaining service; and (c) there is less disruption to light rail operation.

If two-way light rail and one-way mixed traffic are provided on the same street, it may be advantageous to place one track near the curb line. This arrangement can possibly provide more lanes for mixed traffic use and, to some extent, reduce conflicts between light rail cars and general traffic. Contraflow light rail lanes can also be employed when it is advantageous to use one-way street pairs. Such a lane also constitutes another variety of segregation.

The need to change lanes should be avoided if at all possible. If lane changes are necessary, they must be protected by signalization or other means to avoid accidents.

- Curve alignments. Curves should be laid out to minimize the amount of car overhang. Excessive overhang is a significant source of traffic accidents for light rail cars. It may be necessary in some instances to realign the roadway to ensure gentle curves. In those instances where curves cannot be eased, clearance lines should be placed on the pavement to show the limits of the overhang. In all instances curves should be laid out to permit clearance for opposing light rail movements.
- Turning movements. Turns should be placed where they can be made with general traffic turning movements or where they can be protected with traffic signals. Right turns are the most vulnerable turns if a traffic lane exists between the track area and a parking lane. Automobile traffic should be held to allow a protected light rail car turn. If the light rail turning movement also involves a switching movement, consideration should be given to placing the actual switching points several car lengths in advance of the turn through the use of gauntlet tracks. This will allow the operator to take fuller advantage of green time available without the necessity of pausing at the intersection to select his route. Additionally, the operator can direct his full attention to the turning movement and more car turns per traffic signal cycle are permitted.
- Grades. Light rail cars can be designed to climb grades in the range of from 11 to 12 percent (Henderson Street and Grandview Avenue in Pittsburgh are two examples). In most instances, this is well above the grades that will be encountered on a new operation. Designers should be cognizant of the flexibility afforded in this area.

Street Track Construction

System designers must be aware of several problems that must be dealt with when designing street trackage. These problems include

- Noise. The interaction of track and the wheels of the light rail vehicle can produce objectionable noise. There are numerous track construction techniques to minimize this problem. One example is the use of macadam instead of concrete paving material.
- Vibration. The same interaction can also produce vibrations in adjacent structures. This impact can be controlled through design of the track subgrade and the type of paving employed.

When in operation, street trackage will tend to corrugate, which further exacerbates noise and vibration problems. This situation can be mitigated by periodic rail grinding and proper wheel maintenance.

Location of Passenger Stops

Passenger stops should be spaced at the greatest intervals possible to facilitate higher speeds. A good rule of thumb is four stops per mile. In actual practice, the location of stops will be dictated by intersecting transit lines, major load generators, street geometry, and so forth. Stops may also be frequently tied to the interval used on the non-street-running portion of the line. Some typical considerations for stops follow:

Four-Lane Streets (two travel lanes and two parking lanes)

Passenger stops in this environment can be simple and require little or no construction. The parking lane protects passengers who are boarding or alighting from the car. Parking should be restricted for a distance equal to two car lengths. Appropriate signage should be installed to identify the stop and prohibit parking.

Six-Lane or Wider Streets

Streets configured with multiple traffic lanes offer greater flexibility in the type of stop facilities that can be provided. Safety islands with shelters can be constructed to provide a secure place for passenger activity. Typically these islands are built at curb height and should be 6 to 7 ft wide. Their length is approximately two car lengths. The island can be made accessible by ramping one end of the facility. The platform is made secure by installing standardized warning lights and barrier protection at the leading end. A typical configuration is shown in Figure 2. If sufficient street space is available, it may also be possible to construct high-platform stations that match the car floor height. The platform should have sufficient width to contain all passenger activity with a length to accommodate all doors that will open at these locations on the longest train length. Additional length will also be required for an access ramp. A typical configuration is shown in Figure 3.

Should it be desirable to have high-level platforms in open track areas but impossible to have them when street operation is necessary, modifications to the car will be required. Cars will have to be equipped with entrances that can be configured to accommodate either step or high-level entrance. Slide-and-glide doors will also be required.

Light Rail Car Movement Control

It is general practice to install signal systems to protect light rail movements. Such systems are not necessary in a street environment and could hinder free flowing traffic movement. Due principally to the lower speed of operation, "line-of-sight" control is adequate. General traffic conditions also require that cars follow one another at reasonable intervals. In addition, cars must be able to close up at locations other than passenger stops if they are operating in dense traffic areas.

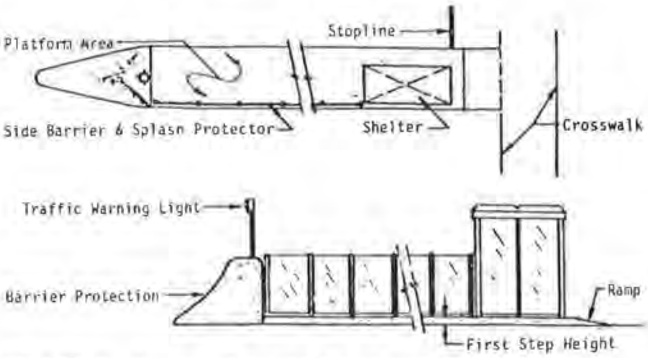

FIGURE 2 Typical safety island configuration.

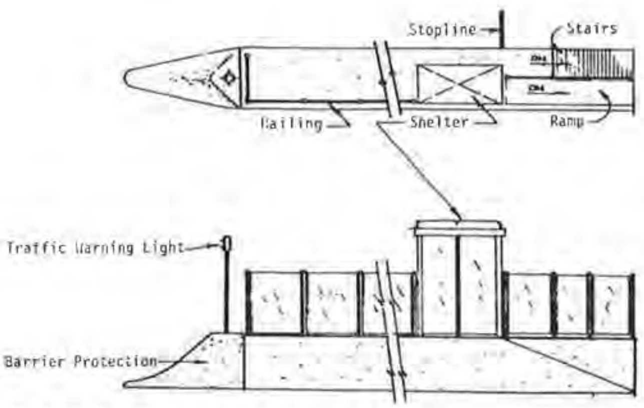

FIGURE 3 Typical high-level street station.

Utility and Street Environment Interface

The addition of electrified rail service to a street environment will affect other utilities that were there first. In the layout of the track structure, it may be necessary to relocate manholes outside the track area to ensure access at all times. This is especially true for telephone, electric, and cable utilities. The presence of an electrified rail operation also introduces or increases electrolysis problems for underground utilities. The electric power designers must work with the utilities to provide appropriate protection. Local traffic departments must also be made aware that traffic lanes will be out of service to accommodate emergency track repairs. In general, routine track maintenance should be scheduled for the night hours. It is necessary to establish appropriate communication links with local traffic departments to ensure coordinated responses to such situations.

Traffic Signal System Interface

This subject has already been briefly touched on. There is a need to establish traffic separation when turning movements are involved. Protection is required for light rail cars when making left turns in front of opposing traffic. Protection is also required when right turns cross an adjoining lane of traffic. An interface should be provided with the traffic signal system so that the car's presence is detected and the appropriate protection provided. In certain instances it may be desirable to allow cars to preempt green time at certain intersections to ensure uninterrupted light rail movement. An alternative to the outright preemption mode is one that influences the signal system. In this situation green times are advanced or retarded for light rail movements. At major intersections it may be desirable to provide a separate cycle and signaling to accommodate light rail movement. Separate signal heads with visually distinct aspects to avoid motorist confusion can be used wherever preferential treatment is given to light rail operation. A complete traffic analysis is required by the designers to ascertain where preferential treatment can be provided without materially impacting general traffic flows.

The greatest potential for conflict between light rail and general traffic exists at intersections where left turns are permitted. To separate movements, a left turn can be provided as shown in Figure 4. Signalization can be used to provide separate cycles for turning movements and further reduce the potential for conflicts. Such arrangements also speed light rail operation.

Electrical Distribution Systems

The installation of overhead electrical distribution systems can be made quite compatible with street operation. Unfortunately, designers have not made great use of the design latitudes that are available to make these systems as unobtrusive as possible.

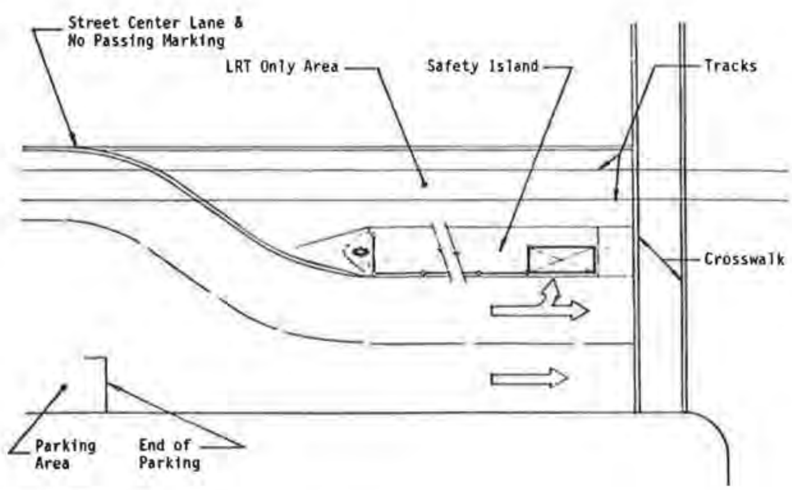

FIGURE 4 Turning movements.

This greater latitude derives from the street environment. For example, the lower speeds associated with street operation allow the use of systems that are less rigid and extremely light. The proximity of buildings and a street lighting system offer varying options for supporting the contact wire system.

Light rail planners often must consider street operation in such areas as in the central business district where all utilities have been placed underground. The reimposition of overhead electrical lines can be a sensitive subject, especially if the burial was accomplished in recent years. The design of the electrical system must acknowledge these concerns.

A simple trolley wire system may be the best solution. Such a system consists of the contact wire supported with lateral span wires spaced at intervals ranging from 90 to 125 ft. The system is light and can be supported from reasonably sized poles. System performance can be assured by proper contact wire tensioning and by selecting a current collector (pantograph) that functions as part of the system. Some useful guidelines follow:

Support System

The poles used to support the overhead system should be spaced at the intervals indicated previously. The exact spacing is dependent on street geometry, location of driveways, and so forth. Wood poles can be used but consideration of aesthetics and maintainability generally dictates the use of steel or concrete poles. Designers should take steps to eliminate "pole pollution" through joint use with utility companies. Street lighting requirements can be accommodated by overhead support poles. If electric and telephone facilities have not been placed underground, this feature could be included as part of the trolley project to improve its salability. A typical trolley support arrangement is shown in Figure 5. In general, existing street light poles will have to be replaced because they lack sufficient strength and are of "breakaway" construction. Alternately, a simple trolley system can also be supported by using building eyebolts that eliminate poles, improve aesthetics, and reduce installation and maintenance costs.

Tangent Alignment

The simple trolley wire system is supported by lateral spans. A single fitting will connect the span wire and trolley wire. Assuming that a pantograph current collector will be used, the fitting will need to provide sufficient vertical clearance to assure that the pantograph will not snag the span wire. In general, hangers are insulated and additional insulation is placed at intervals along the span. Today, spans can be made of insulating material that improves both the appearance and the serviceability of the overhead system. On narrow streets a bracket arm assembly, as shown in Figure 6, can be used to reduce the number of poles and costs for construction and maintenance.

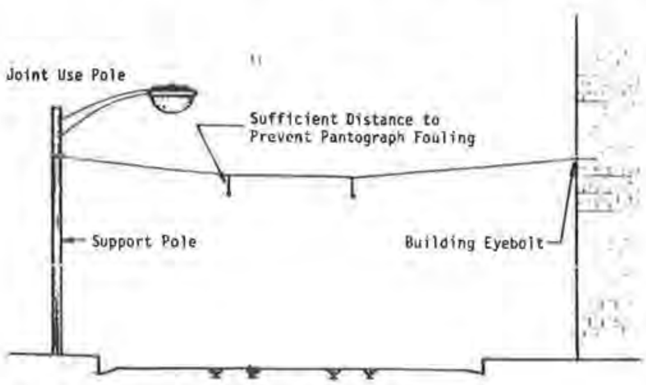

FIGURE 5 Simple trolley wire support.

FIGURE 6 Typical bracket arm assembly.

The street environment is by nature dynamic. Delivery of high loads and construction of new buildings will result in the need for temporary removal of the wire system. The simple trolley wire system can easily accommodate this requirement.

Curve Alignment

When curves are encountered, pull-offs must be installed at appropriate intervals. The exact spacing is a function of the current collector employed. A typical pull-off assembly is shown in Figure 7. It will be noted that the pull-off arm is configured to prevent pantograph fouling. It should also be noted that heavier poles will be required. In addition to supporting the weight of the overhead, the change in direction of the contact wire imparts a far greater loading. The visual impact of the heavier poles on main streets or boulevards can be minimized by locating all poles behind the building line.

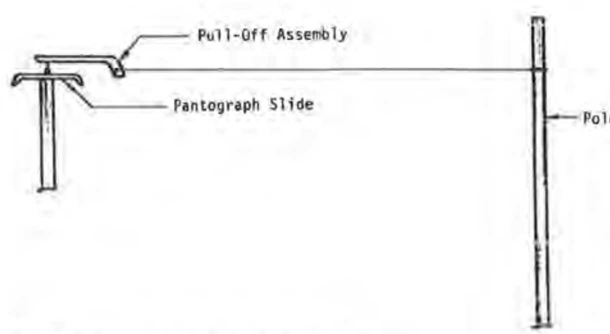

FIGURE 7 Typical pull-off assembly.

Electric Feed

The contact wire employed in a simple overhead system does not have sufficient electrical capacity to supply the correct voltage over extended distances. A feeder system is usually required with frequent taps to the contact wire. The required feeders can be aerial, but the preferred location would be underground to lessen the visual impact. Feederless systems can also be employed by increasing the size of the contact wire, from 2/0 to 4/0 wire, and by using closely spaced substations. The practicality of a feederless system is directly dependent on the proposed frequency of service and the power consumption characteristics of the light rail car to be employed. Another possible solution is to install two contact wires in close proximity over each track.

Specifications

The electrical code of most states mandates certain requirements with regard to overhead construction. For example, the height of the trolley wire above the street, the clearance necessary with lateral telephone and electric service, and distances between transit and utility attachments on poles are but some of the specifications that must be built into the design. Of greater significance is that these codes are often outdated and do not reflect current construction procedures or materials. It may be necessary to enter into negotiations with the affected boards to obtain changes.

Current Collector

It is important that a current collector be selected that functions as an integral part of the overhead system. In a simple trolley wire system, the position of the contact wire changes in the vertical direction between support points. The difference in vertical positioning is a function of wire tension, wire weight, and support spacing. It is essential that the current collector selected remain in contact with the wire at normal operating speeds. The system also designer must match current collector characteristics with those of the overhead system.

Catenary Overhead Construction

This type of construction requires a messenger catenary in addition to the contact wire. Lateral support uses multiple span wires or a structural member. Poles are much larger although spacing can be up to twice that of a simple overhead system. This system also allows for faster overall speeds. Such a system is not recommended for street operation. It offers a significant visual intrusion and provides operating characteristics that are not needed in a street environment. In addition, it is significantly more expensive than simple trolley wire construction even though fewer poles are required (i.e., stronger poles and larger foundations are needed).

Environmental Considerations

Some of the items to be considered in reducing visual pollution have been mentioned. The following environmental considerations are restated for emphasis:

- Employ joint use poles to the greatest extent possible to avoid pole "pollution";
- Use simple overhead construction to the extent possible; the amount of hardware in the air is minimized making the overhead system more acceptable;
- Employ hardware that minimizes visual pollution; for example, synthetic nonconducting spans eliminate the use of insulators;
- Put all feeder lines underground;
- On curves, keep heavier poles behind building lines; and
- If a street or mall operation, use trees to hide the pole line.

Transit Malls

Light rail operation is quite compatible with a transit mall. This application of light rail operations has been witnessed in numerous European cities. A key consideration is to clearly delineate the location of the light rail line. Although the track structure provides a form of delineation, differing pavement textures, low curb lines, and other similar treatments will provide further reinforcement of the light rail line's presence.

Train Operation

Many light rail operations will have sufficient traffic volumes to require train operation. The planner-designer must incorporate this feature into station design, the layout of certain turning movements, switch activation locations, and other areas as appropriate. The locations of car stops may also be affected. Long trains can block intersections if intersections are closely spaced. Stops will have to be located adjacent to lightly used side streets where through movements can be prohibited.

Switch Control

Frequently used switches require the installation of some form of switch control. Several methods are currently available. Induction systems, which incorporate a car-mounted transmitter and wayside receiver, are available. The operator will cause the transmission of the appropriate command for the selection of the desired route. The technology is available to preprogram route selection without further operator intervention. Another means of switch control involves the installation of insulated rail sections. Route selection is accomplished by occupying the insulated section at the appropriate time. Wayside lights are used to indicate the appropriate occupancy times for various routings.

Communication and Coordination

Selling light rail operations becomes even more challenging when street operation is involved. Some of the communication and coordination needed is outlined next.

Community Input

An early community relations and education program is desirable. It should be directed not only at city officials and engineers but also at local merchants' associations, community groups, schools, and so forth. A program that incorporates an opportunity for everyone to give input will not only result in better ideas but will help ensure that the program is supported and carried out expeditiously. To this end, public relation handouts and regularly scheduled meetings should be used. Visits by key decision makers to other systems that operate similarly to that which is being proposed will provide input to help structure the program.

Street and Traffic Departments

An extra effort is required during the design phase to interface with local street departments and traffic engineers. Construction of the tracks might be tied in with improvements desired by these various agencies and disruption to the local citizens minimized.

In addition, the cooperation of local officials is essential to obtain reservations, changes in parking patterns, traffic signal preemption or influencing, and other efforts that will facilitate car movement through mixed traffic.

Procedures and points of contact must also be established with the local street and traffic departments to ensure that the maintenance needs of both agencies can proceed unhampered. There should also be an understanding about which agency will be responsible for street markings used for segregations, crosswalks for safety islands, maintenance of safety lights, and so forth.

Motor Vehicles

Most states have or had certain regulations in effect that govern the interaction among light rail cars, general traffic, and boarding or alighting passengers. Some of these regulations included the prohibition of passing a stopped light rail car or yielding the right of way for passengers traveling to and from safety islands. It may be prudent to have these regulations reintroduced or reemphasized. Inclusion of these regulations in state driver training manuals should also be considered.

Utilities

Coordination with utilities at the time of construction has been discussed. Before commencing design, a direct liaison should be established with each utility. Procedures should be established that accommodate route maintenance needs of the various agencies. It is common practice in most areas to notify all utilities before making any street or sidewalk openings. Emergency procedures should also be developed.

CONCLUSIONS

The objective has been to raise various considerations for review when street operation is being seriously considered. There is no doubt that other site-specific considerations will also surface and need to be addressed.

An in-depth exploration, evaluation, and resolution of all these considerations should result in

- A realization that LRT street operations can be practical, desirable, and effective under many more circumstances than are normally apparent;
- The development of checklist items for inclusion in both car and wayside specification preparation;
- Early involvement of both public and governmental agencies in the dialogue necessary to adequately address problems unique to street operation; and
- Adoption of a plan to ensure adequate public and passenger support and safety.