Overview of Light Rail At-Grade Crossing Operations in Central Business District Environments

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Light rail transit (LRT) agencies from 15 cities in the United States and Canada were asked to summarize existing and future light rail at-grade crossing operations issues, existing interjurisdictional relationships, block length constraints, and planned strategies to address both future LRT demand and at-grade crossing operations in the central business district (CBD). The study found that critical negotiations and planning issues exist if LRT systems will be expanding significantly or are newly implemented. For these systems, good interjurisdictional relationships are important in order to resolve current and future at-grade crossing issues; political commitment to LRT helps this process. Block-length constraints drive efforts to reduce headways to meet future demand. Overall, growing systems have turned to headway reductions, plus new LRT lines and line extensions, to satisfy future demand. These are costly strategies and will push at-grade crossings to their capacity limits in many cities. Advocated is local consideration of LRT at-grade crossing upgrades in CBD environments that will increase system efficiency and safety, perhaps delaying or obviating some capital and operating cost increases. A federal funding initiative in partnership with states and local governments is proposed that will provide a monetary incentive for local LRT agencies and cities that implement state-of-the-art at-grade crossing improvements.

This paper is intended as an overview of current and future at-grade operations issues being addressed by light rail transit (LRT) agencies in 15 cities in the United States and Canada, where at least a portion of downtown service is provided at-grade. LRT agencies were asked about the nature of the intersection conflicts and whether they have been able to resolve these issues. LRT agencies were asked about future at-grade crossing issues and what strategies were planned to address these issues.

These responses provided background information on system characteristics that may contribute to both existing and future at-grade crossing constraints. The effects of increased service levels and LRT construction programs on future LRT at-grade crossings were evaluated. The authors conclude by proposing methods for agencies and cities to seriously consider LRT at-grade crossing strategies, discussing their capacity and safety enhancement potential at the most preliminary stages of LRT planning efforts.

METHODOLOGY

Telephone interviews were conducted with operations staff from LRT agencies in 15 cities in the United States and Canada.

The following 11 agencies were asked to summarize existing and future light rail at-grade crossing operations issues and existing and planned strategies:

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- Baltimore: Maryland Mass Transit Administration (Maryland MTA),
- Boston: Massachusetts Bay Transportation Authority (MBTA),
- Buffalo: Niagara Frontier Transit Metro System (NFT Metro),
- Calgary: Calgary Transit,
- Los Angeles: Metropolitan Transit Authority (MTA),
- Pittsburgh: Port Authority of Allegheny County (Port Authority Transit),
- Portland: Tri-County Metropolitan Transportation District (Tri-Met),
- Sacramento: Sacramento Regional Transit District (RT),
- St. Louis: Bi-State Development Agency (Metro Link),
- San Diego: San Diego Metropolitan Transit Development Board (MTDB), and
- San Jose: Santa Clara County Transportation Authority (SCCTA).

Four other agencies [with no existing central business district (CBD) at-grade crossings] were asked to summarize future LRT at-grade operations issues and planned strategies:

- Philadelphia: Southeastern Pennsylvania Transportation Authority (SEPTA),
- Edmonton: Edmonton Transit,
- Cleveland: Greater Cleveland Regional Transit Authority (RTA), and
- San Francisco: San Francisco Municipal Railway (Muni).

STUDY FINDINGS

Interjurisdictional Relationships

Interjurisdictional agreements between LRT agencies and cities regarding at-grade crossing maintenance, operations, and other issues were discussed with LRT agency staff. In locations with low traffic growth and stable LRT systems, contact with the city department of transportation is routine, centering on operations and maintenance issues. For those systems that are newly built or expanding, basic implementation and design issues are also being discussed.

Locations with Stable LRT Systems

Many LRT systems that operate at-grade in downtown are located in regions with relatively low growth, more established systems, and little or no plans for LRT system expansion. Agency staff in these locations generally worked with the city during initial traffic signal design. Generally the LRT agency built the system and entered an agreement with cities to maintain the traffic signals, signage, and so forth. The operations and maintenance agreements that came out of these initial discussions (whether formal or informal) are operating satisfactorily, according to LRT agency staff.

Six agencies in low-growth regions stated that their contact with the local city staff concerned maintenance and routine operations issues: Baltimore, Pittsburgh, St. Louis, Buffalo, Boston, and Calgary. Of these agencies, only Baltimore has a formal agreement with the city; all other agency-city arrangements were characterized by LRT agency staff as informal. Table 1 provides details on these agreements, which have generally proven adequate.

TABLE 1 Interjurisdictional Relationships

LRT System Location/Agency	Agency/City Agreement Type	At-grade Crossing Issues Covered
Baltimore (Maryland MTA)	Formal	Routine maintenance and signal operations facilitating LRT progression.
Boston (MBTA)	Informal	Routine maintenance and signal operations. Initial meetings on xing signal design were satisfactory.
Buffalo (NFT Metro)	Informal	Routine maintenance and signal operations. Formal agreement has been pending for 8 years; informal arrangement is working.
Calgary (Calgary Transit)	Informal (LRT agency is part of City of Calgary DOT)	Routine maintenance and signal operations. Initial interdepartmental staff work on xing signal design was satisfactory.
Los Angeles (MTA)	Formal (with Long Beach and Los Angeles DOT's)	Interjurisdictional contacts are very active. Still resolving basic issues of LRT priority and crossing safety. ATSAC signal operation at xings is part of agreement, but is not yet operational. City of Long Beach grants LRT priority at minor CBD crossings, but priority is not given at three major arterials. Consultation on future LRT plans is also ongoing.
Pittsburgh (Port Authority Transit)	Informal	Routine maintenance and operations; train length and frequency mutually determined by agency and city staff.
Portland (TRI-MET)	Formal	Maintenance and operations; particularly strong relationships with local cities result in swift resolution of issues due to regional commitment to operations and expansion of LRT system. Portland uses a short-term (one month) "demonstration project" strategy to convince cities that LRT signal priority is workable. Ongoing consultation on future LRT plans.
Sacramento (RT)	Informal	Routine requests for city work crews to maintain signals, signage, tree trimming, etc. Regular contact, "about every other week". Also work with Caltrans when required.
San Diego (MTDB)	Informal	Routine maintenance and operations; also signal modifications and other improvements "of a minor nature", and future planning issues. Meetings occur as needed, usually every 1-3 months. Initial meetings on signal design was satisfactory.
San Jose (SCCTA)	Informal	Routine maintenance and operations, future planning issues. Initial consultation regarding design of xing signal system was satisfactory.
St. Louis (Metro Link)	Informal	Routine maintenance and operations; recently resolved gate down-time issues.

Locations with New or Expanding LRT Systems

One of the significant survey findings was that systems in growing urban areas, with significant LRT extensions in the works, or systems in the initial years of revenue operation discuss many more basic and critical issues than the systems described in the previous section. Contacts between the city and LRT agency can be contentious, as participants are attempting to solve fundamental issues. Sacramento is an exception to this rule; though RT plans significant LRT system growth, agency staff currently characterize their contacts with the city of Sacramento as being of a routine nature, centered on maintenance and operations.

SCCTA worked closely with the city of San Jose to design the signal system for the at-grade crossings in the downtown transit mall and elsewhere. During this process, critical safety and operations issues were resolved; now contacts with city transportation staff are more informal and center on maintenance and operations. However, as future signal modifications need to be discussed at crossings in downtown, another critical round of negotiations with city transportation staff will occur.

San Diego MTDB staff also worked regularly with the city to design the traffic signal control system for LRT priority on the existing downtown line. However, there are concerns on the part of MTDB staff and city transportation staff that are still being discussed at meetings conducted on an as-needed basis, usually every 1 to 3 months. Significant at-grade crossing improvements, as well as those of a minor nature, are discussed. Future LRT expansion plans also require essential consultation with traffic engineering staff.

The Portland and Los Angeles cases provide an interesting contrast of the effectiveness of negotiations between LRT agencies and cities. What makes negotiations in Portland more effective than in Los Angeles is not only a matter of negotiating style. It appears that a regionwide political commitment to transit service and infrastructure is a critical factor in determining the ease with which the issues related to at-grade crossings are resolved.

Portland LRT agency staff indicated that their institutional relationships with local cities are very strong, with swift resolution of at-grade crossing issues, not only for current operations and maintenance but also for planned LRT extensions. The region has made a long-term commitment to transit and has abandoned any policy to increase highway capacity. This allows multijurisdictional agreements to take place more smoothly than might otherwise be the case because local jurisdictions are largely in agreement on regional rail transit goals.

Portland has also successfully overcome the objections of cities resistant to granting LRT priority by convincing local staff to accept very short term LRT traffic signal priority demonstrations at selected crossings. Such projects can last no more than a month. Usually after the priority system is in operation, the local jurisdiction observes no negative effects on intersection operations and approves a permanent LRT traffic signal priority system.

By contrast, Los Angeles MTA contacts with the city of Los Angeles and the city of Long Beach, where street running segments are located, have not yet achieved successful implementation of planned LRT signal priority; issues of crossing safety are also under review. The city of Los Angeles has been working actively with MTA. However, the Automated Traffic Surveillance and Control (ATSAC) system installed at Blue Line crossings is still only in testing by the city of Los Angeles and is not yet operational. The city of Long Beach has given priority to LRT trains at many minor downtown crossings, but priority is not given at three major arterial cross streets. Issues are currently being resolved by direct consultation between MTA and affected jurisdictions; similar work is being undertaken on planned LRT extensions.

Because cities and MTA staff do not necessarily share the same regional commitment to LRT over automobile traffic considerations, critical issues still remain. Portland enjoys this regional commitment to LRT. Even though this fundamental difference is much more important than any single negotiating technique, the Portland strategy of installing 1-month signal priority demonstration projects could be tried in Los Angeles and Long Beach to help overcome city objections.

Existing At-Grade Crossing Strategies

LRT agency staff were asked whether they implement signal preemption and priority for light rail trains at downtown at-grade crossings and, if so, how it is accomplished. In most cases LRT agencies were satisfied with their choice of signal technology and the degree of LRT priority at at-grade crossings. Agencies tend to advocate their chosen technology as more cost-effective than others. Table 2 presents an outline of at-grade crossing strategies employed by each LRT agency.

Some cities that grant train priority have chosen to use a vehicle identification system that uses vehicle tagging known as VETAG, developed in the Netherlands. VETAG is best described as a system for the selective detection, identification, and location of vehicles. Other LRT systems have instituted or are trying to institute an ATSAC or similar type of traffic signal control system. Such systems control at-grade crossings using a computerized central traffic signal control system.

Buffalo and Portland use VETAG systems. These systems operate with standard signal controllers. LRT operators transmit a signal to the downstream signal controller when the train is ready to leave the station. The controller adjusts green and red times for opposing traffic and the train to allow the train to pass through the crossing without stopping.

VETAG or similar systems accommodate light rail vehicles (LRVs), essentially, by creating windows in signal timing during which LRVs can clear intersections without stopping and by actually accommodating trains within these timing windows so that street traffic is affected minimally.

Calgary and Los Angeles use ATSAC or similar systems. This system links intersections and uses a computerized optimization program to achieve the most efficient signal timing. The system detects the LRV's approach to a downstream intersection, and if LRT priority is programmed into the system, it will adjust the signal progression so that LRT trains can pass through the next crossing without stopping.

All other LRT systems operate at-grade crossing signals with standard controllers and detectors; timing is adjusted for extended green time on the LRT approach. San Diego has adopted a creative approach to using standard signal controllers to provide more efficient LRT priority using its signal phase countdown device for drivers, so that the LRV can cease boarding passengers and disembark in time to catch the green "wave."

No LRT systems were found to have true signal preemption capability at at-grade crossings in their CBDs. However, most downtown systems had instituted LRT train priority at crossings.

TABLE 2 Existing At-Grade Crossing Strategies

LRT System Location/Agency	Signal Control System	Agency Strategies Addressing LRT Movements
Baltimore (Maryland MTA)	Standard	Signals are timed to facilitate LRV progression at 5 mph. Bids being solicited to install signal preemption on Howard Street corridor to allow faster operation.
Boston (MBTA)	Standard; testing trolley indicator	No preemption, testing a "trolley indicator" which detects train at on-street station, triggers red phase at upstream signal to minimize auto conflicts with alighting passengers; early indications of low safety benefits, high street traffic disruption.
Buffalo (NFT Metro)	Standard; with VETAG	No congested CBD intersections; VETAG working satisfactorily to ensure LRV priority. Staff considers VETAG to be highly cost-effective for their system as opposed to an ATSAC-type system.
Calgary (Calgary Transit)	ATSAC	Satisfactory operation; ATSAC adjusts timing to facilitate LRT progression using its signal optimization function.
Los Angeles (MTA)	ATSAC operational in Long Beach segment; test phase in Los Angeles	Long Beach ATSAC facilitates LRV priority at minor CBD xings; no LRV priority at three major arterials, occasionally trains must stop (and some indications are that LRT operators may not be slowing as they encounter a yellow phase at these locations in order to maintain schedules). ATSAC not operational in Los Angeles segment.
Pittsburgh (Port Authority Transit)	Standard	No LRV priority or preemption. Actuators alert signal controllers on LRV approach; signals treat LRV movements the same as auto traffic.
Portland (TRI-MET)	Standard; with VETAG	VETAG seen as "win/win" strategy--train only affects signal timing upon departure from station. VETAG seen as cheaper, more reliable than ATSAC-type system.
Sacramento (RT)	Standard	Trolleys detected at intersection pavement loop; depending on the location, timing may give LRV priority. Where there are gates, trains must leave the station before they lift. Fire trucks can cancel LRT priority if needed.
San Diego (MTDB)	Standard, with "green wave" LRV progression	In "C" Street corridor, "countdown" device at initial xing allows LRV to depart at the early part of a green phase. Downstream signals are timed to allow an LRV "green wave" provided the train initially departs as planned. The countdown device also alerts the operator to lock the LRV doors to ensure on-time departure.
San Jose (SCCTA)	Standard	As LRV approaches downstream at-grade xings in the CBD transit mall, trains are detected approximately one block prior to their arrival at the xing. Signal controllers adjust timing to allow LRT to proceed without stopping.
St. Louis (Metro Link)	Standard railroad xing gates	Standard controllers detect LRT and close railroad xing gates upon approach.

Block Length and Other On-Street Issues

Most cities with constraints on train length due to short block lengths were able to increase capacity by increasing headways and avoid obstructing intersections by locating stations in those blocks that are of adequate length, as well as by granting priority to trains so that stopping at short blocks is unnecessary (Table 3).

However, at-grade operations are affected by CBD block length in three cities: Sacramento, San Diego, and Los Angeles. In Sacramento, four-car trains are deployed, even though incidents in which trains overhang into intersections occur. In Los Angeles, there is also a situation of overhanging trains at several intersections, even though train length is limited to two cars. Three-car trains will be necessary soon, which may cause more significant concerns with overhanging trains. San Diego designed its stations to accept overhanging trains; during peak hours MTDB must run a three-car configuration, and because since blocks fully accommodate only two-car trains, the three-car train extends into pedestrian crosswalks.

Shorter trains could mean capacity problems for LRT agencies facing anticipated growth in patronage and block length constraints on operations. In the short term, many systems intend to use shorter headways to cope with this problem, despite increased operating costs. In addition, some systems stated that both short- and long-term growth in transit patronage will be handled by increases in bus transit service.

TABLE 3 Existing Block Length Constraints

LRT System Location/Agency	Block Length Constraints?	Agency Strategies Addressing Block Length Constraints
Baltimore (Maryland MTA)	Yes	CBD block length limits LRT train length to 3 cars; current system operates 3-car trains.
Boston (MBTA)	No	Agency staff indicated no block length constraints.
Buffalo (NFT Metro)	No	Agency staff indicated no block length constraints.
Calgary (Calgary Transit)	No	No block length constraints; train platforms not located on short blocks in CBD. Train length is constrained by platform length to 3-car trains.
Los Angeles (MTA)	Yes	Block lengths are a problem for at least five xings in the Los Angeles street-running segment and two xings in Long Beach. Trains overhang intersections at these locations. At xings near Washington station, train overhang occurs. This situation is occurring with 2-car trains.
Pittsburgh (Port Authority Transit)	No	Agency staff indicated no block length constraints.
Portland (TRI-MET)	No	Some short blocks exist in CBD but trains do not stop; does not affect train length with current operations.
Sacramento (RT)	Yes	Block length a concern in some CBD locations, where 4-car trains do overhang intersections; peak train length is 4 cars. This situation is tolerated. Accidents have become a concern at other xings, however, due to on-street configuration. Staff has used curbs and median channelization, as well as signing and striping to alert auto drivers.
San Diego (MTDB)	Yes	Train length is limited in several CBD locations by block lengths of approximately 200 feet (can accommodate 2-car trains). Peak train length is 4 cars; prior to entering CBD, trains are shortened to 3 cars at a transfer station. Trains overhang intersections; pedestrian crosswalk traffic is blocked.
San Jose (SCCTA)	No	Agency staff indicated no problem with block length constraints; trains operate with 2 cars, station length limits trains to a maximum of 3 cars.
St. Louis (Metro Link)	No	Agency staff indicated no problem with block length constraints.

In the long term, many systems anticipate building new LRT lines to increase capacity, although this may create further pressure on at-grade crossing signals due to increased patronage on trunk lines.

Future At-Grade Crossing Issues

This section outlines the views given by agency staff on whether at-grade crossing issues would be an important consideration in the future and what, if any, actions they plan to take to resolve these issues (Table 4).

Whether shorter headways will cause future at-grade crossing traffic congestion appears to be a function of the level of new transit demand that will need to be accommodated. The following systems expect either short- or long-term pressure on existing at-grade crossings. Demand is expected to rise either solely on existing lines or because planned new feeder lines will place more pressure on existing CBD trunk lines.

The Los Angeles Metro Blue line is currently operating at capacity, running at a minimum headway of 6 min with two-car trains. Increased capacity is an imminent need. There are plans to go to 5-min headways within the next few years, and cars have been ordered that will allow trains to be extended to three cars. Without LRV priority at major Long Beach crossings and the Los Angeles street-running segment (where ATSAC is installed but not operating), this configuration could cause even more serious problems with overhanging trains than the current situation.

Pittsburgh LRT is also operating near capacity. The transit agency has issued a request for proposal for a consultant to analyze current demand and project future capacity and demand. Depending on results and new projections, at-grade crossing issues will be examined.

San Diego staff were concerned that on the C Street Line, feeder line extension plans could result in headways that degrade at-grade crossing operations in some CBD locations. The authors note that block lengths in the CBD on the C Street Line restrict train length to three cars in the peak hour (and this configuration results in trains blocking crosswalks). In the future, MTDB might have no choice but to run very short headways that would increase pressure on CBD at-grade crossings.

For San Francisco Muni, LRT at-grade crossing issues will begin with the opening of future Embarcadero (Muni Metro) and Market Street (F Line) LRT lines. Five-minute headways with preemption are initially planned. However, Muni officials stated that potential future operations may see 2- to 2.5-min headways, which would render at-grade intersection operations very tight and preemption difficult.

Similarly, Edmonton staff anticipate that in the long term, demand might affect at-grade crossings on the planned university area extension, which is located downtown.

Sacramento RT also plans significant growth in its LRT system. RT staff indicate that although the Phase 1 South Line extension will pose no problem, Phase 2 of the expansion plan includes the Natomas Line to the Sacramento Airport, which will further reduce headways and may increase pressure on the at-grade crossing traffic signal system downtown.

Portland staff indicated that in the future, the current LRT system may reach the capacity limits at at-grade crossings (this would occur when 3-min headways are running). This situation will arise because of planned downtown lines and line extensions (eight planned LRT lines in all).

Future At-Grade Crossing Strategies

As indicated, Los Angeles, Pittsburgh, San Francisco, Edmonton, San Diego, and Portland anticipate at-grade crossing problems in future because of anticipated increases in demand and system expansion plans.

Pittsburgh and Sacramento have not begun to discuss specific strategies. Pittsburgh intends to draft its plans soon, and Sacramento will wait until the Phase 2 Natomas extension to the Sacramento Airport, which is anticipated to degrade at-grade crossing operations, is closer to implementation.

Los Angeles, San Francisco, Portland, San Diego, and Edmonton are considering specific at-grade crossing strategies to address the at-grade crossing issues that will arise from operations expansion and line extensions. The following section outlines their planned approaches.

In Los Angeles, a working ATSAC system in the street running the Los Angeles segment is needed. In this segment, LRV priority is essential, especially at crossings where trains block intersections. At minor crossings in Long Beach, LRV priority is provided. However, at major crossings in Long Beach, there is no LRV priority and trains must stop; because of this, some LRT train operators are inclined to try to beat the red signal indication in order to meet operating schedules. Long Beach and MTA are discussing the need for some form of LRV priority at these crossings to solve this issue.

In San Francisco, with a strong local mandate to build traffic signal timing around transit, a VETAG system will be built. This may become obsolete after the first years of LRT at-grade operations. To replace it, Muni is considering an optical or infrared transmission system for buses and potentially for LRT. In Portland, Tri-Met staff stated that an aggressive rail-building program will increase the number of direct downtown rights of way by constructing new radial lines from the CBD; plans include eight new lines regionally. As lines reach capacity, there may be at-grade crossing concerns. They will run minimum headways using the current signal system and accommodate excess transit demand on the bus system.

Given their long-range LRT system extension plans, San Diego staff are looking into every possible option for the C Street Line operating in the CBD. Another look at how LRV priority is implemented or at a new CBD LRT crossing are possibilities.

In Edmonton the need for priority traffic signal systems for the university extension (which passes through the CBD) has not been finally determined, but LRV priority is a likely outcome. A decision will be made after the current phase of system expansion predesign is complete.

CONCLUSIONS AND PROPOSED POLICY CHANGES

Interjurisdictional Relationships

Good interjurisdictional relationships and agreements between cities and transit agencies are important for all of the LRT systems contacted.

TABLE 4 Future At-Grade Crossing Issues and Strategies

LRT System Location/Agency	Future At-Grade Crossing Issues	Future At-Grade Crossing Strategies
Baltimore (Maryland MTA)	Ridership may exceed current system capacity	Build more LRT line segments and absorb some transit ridership onto conventional bus system.
Boston (MBTA)	No anticipated future operations issues.	n/a
Buffalo (NFT Metro)	No anticipated future operations issues.	n/a
Calgary (Calgary Transit)	No anticipated future operations issues.	n/a
Edmonton (Edmonton Transit)	Future xing impacts anticipated on planned University area extension due to congested CBD intersections.	May consider LRV priority for this new line. Decision will be made after system predesign is complete and engineering work has begun (one year away).
Los Angeles (MTA)	Current system is at capacity (2-car trains, 6-minute headways). Increased capacity is an imminent need. Shorter headways will create further pressure on existing xings; 3-car trains are anticipated, however, short block length and lack of signal priority will create concern in Long Beach.	A working ATSAC system in the street-running Los Angeles segment is anticipated to assist with this near-term situation, extending priority to trains--this is critical at xings with trains overhanging. Train priority must be worked out with Long Beach at major xings to avoid trains stopping in short blocks; otherwise, passenger transfers from 3-car to 2-car trains may occur at Long Beach city limits.
Pittsburgh (Port Authority Transit)	As yet undetermined by agency; future LRT plans will be drafted in near future and strategies will be developed at that time.	n/a
Portland (TRI-MET)	Future system may reach capacity limits of at-grade xings (at 3-minute headways). This is due to planned downtown LRT lines and extensions (8 projects).	Aggressive LRT building program will increase system capacity, but may degrade operations at at-grade xings. Agency will run minimum possible headways, and anticipate that bus transit will absorb excess LRT demand.
Sacramento (RT)	Phase I South Corridor extension will reduce headways, but not enough to degrade xing operations. There is a possibility that headways may decrease further with the Phase II expansion (Natomas Line to airport), which may cause pressure on at-grade xings.	At one location on the future extension, underground operation may be necessary as site conditions preclude at-grade running. No other measures are planned.
San Diego (MTDB)	Ridership increase anticipated on CBD "C" Street line; staff feels that to operate at headways short enough to degrade xing operations would increase LRT operating costs unrealistically.	Headways will be shortened but constrained by available operating funds. 3-car trains will continue to operate despite overhanging at some intersections. Given LRT expansion plans, various options are being considered.

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TABLE 4 (*continued*)

LRT System Location/Agency	Future At-Grade Crossing Issues	Future At-Grade Crossing Strategies
San Francisco (MUNI)	LRT at-grade crossing issues in CBD will commence with future Embarcadero (MUNI Metro) and Market Street ("F" Line) lines. Potentially, headways of 2- 2.5 minutes may be necessary, which would mean "very tight" xing operations.	Because there is a strong public mandate for transit, signal timing is built around bus transit at present, and is anticipated to accommodate future LRT lines. VETAG system in place for bus priority; after the first years of LRT at-grade operation, this may be obsolete. Looking into an optical or infrared transmission system for buses and LRT.
San Jose SCCTA	Increased ridership in downtown transit mall; line extensions are being planned. Xings are not considered a severe constraint; instead, track crossings at either end of the transit mall constrain SCCTA's ability to decrease headways.	Headways to be reduced to minimum possible to meet demand, but staff anticipates that they will not need to modify the signal system to accommodate the increased demand.
St. Louis (Metro Link)	After the year 2000, demand will require adding one car to the current 2-car trains, and headways reduced to 5 minutes, resulting in slightly longer gate down-time. Staff anticipates no xing problems.	Increased demand to be served with longer trains, increased frequency; signal modifications are not seen as necessary.

Typically, where there is little anticipated growth in regional traffic or light rail and where systems have been in place over a longer period, LRT agencies and cities have resolved at-grade crossing issues in the past, and city-agency relationships concentrate on operating and maintaining the crossing system.

A significant finding was that institutional relationships are most critical for those agencies in the first years of at-grade operation and for those where growth in regional traffic or expansion of the LRT system is anticipated.

Constructive working interjurisdictional relationships in new or growing systems appear to occur if there is significant regional political support for LRT transit (and transit generally). Portland is an excellent example of what can be done if the region makes a strong political commitment to transit.

Portland's practice of working with more resistant local jurisdictions to institute a LRT priority signal demonstration could be a model strategy for many cities to secure local support for LRT traffic signal priority.

It should also be noted that European and Canadian experience, and experience in San Francisco regarding bus transit priority, has shown that LRT and city traffic engineering functions work better to resolve at-grade operations issues if they are located under one political entity (usually city government).

Existing At-Grade Crossing Strategies

Most LRT agencies have found either VETAG- or ATSAC-type systems to be the most effective ways in which to implement LRT priority. Cost appears to be the greatest factor in the choice of technology. Cities with substantial investment in ATSAC-type systems generally add the at-grade crossings to the computerized system. However, cities without ATSAC-type systems have found that VETAG appears to be very cost-effective, accommodating LRT vehicles even at congested intersections without an adverse effect on vehicular traffic conditions while allowing LRT vehicles to avoid stopping. These cities have no plans to institute an ATSAC-type system.

Block Length and Other On-Street Issues

Block length problems are most acute if the affected systems anticipate expansion and patronage growth. In the short term, the only way that these systems can solve the need for greater capacity (without overhanging trains) is to increase headways or establish signal priority, or both, so that trains do not have to stop in short blocks. This would increase labor and other operating costs for the system.

With proper funding programs in place, long-term establishment of traffic signal priority for LRV and other at-grade infrastructure improvements (e.g., traffic signals, signs, gates, and geometrics) will allow increased LRV operating speeds. This may decrease or eliminate the need to meet new demand by implementing more expensive capital improvements (new lines or grade separation) or the need to incur higher operating costs by adding more LRT trains or buses to the system.

Future At-Grade Crossing Issues and Strategies

Systems that anticipate new transit demand and overall regional traffic growth will address that future demand by either augmenting operations (by increasing headways) or building new lines and new line extensions. For many systems, this increase in service levels will degrade operations at at-grade crossings significantly. Los Angeles, Pittsburgh, San Diego, Edmonton, Sacramento, San Francisco, and Portland staff indicated that plans to augment operations and build new lines and line extensions may cause problems at at-grade crossings.

Most systems that anticipate at-grade crossing problems due to either shortened headways on existing lines or LRT feeder line extensions are considering at-grade crossing traffic signals and other improvements. Currently no system is seriously considering grade separation of its present LRT operation where it exists in the CBD.

PROPOSED POLICY CHANGES

Improvements in at-grade crossing infrastructure (traffic signals, prioritization, gates, signage, and striping improvements) may, in many cases, be a cost-effective way to increase capacity, by increasing LRT operating speed and perhaps delaying the addition of trains or buses—at least in the short term. For a few systems, such at-grade crossing improvements might even obviate for the long term more trains or new lines. Even if at-grade crossing improvements do not delay or eliminate the need for LRT service increases and additional line segments, they may augment the capacity of the LRT system when implemented in conjunction with these strategies. The authors recommend that this potential be considered as part of the LRT system planning process.

A strong regional political commitment to transit is the key factor in implementing effective at-grade crossing infrastructure in growing LRT systems. The authors suggest that a key inducement for jurisdictions to achieve this political consensus should begin with a federal regulatory and funding commitment to at-grade crossing improvements. Modifications to the Intermodal Surface Transportation Efficiency Act of 1991 might serve as a future vehicle for a new federal funding initiative. In addition, state and local funding for these improvements should also be identified, in order to put the issue of at-grade crossing improvements on the table as LRT systems are planned.

The authors strongly suggest that LRT agencies and local cities begin to discuss seriously at-grade crossing issues in the preliminary planning process for LRT systems. A funding incentive program involving all levels of government would indicate a strong policy direction favoring consideration of at-grade crossing improvements. This could smooth the way for strong regional political commitment to, and success in, upgrading at-grade crossing infrastructure.

The authors suggest that the federal government, with its critical role in planning and funding LRT systems, should lead this initiative, with defined roles for states and local jurisdictions in the funding process. Upgrading at-grade crossings should become a vital part of the federal, state, and local discussions regarding LRT planning. If these discussions seriously consider at-grade crossing improvements in the initial planning stages, the potential exists for minimizing operating and capital costs and realizing safety benefits for the LRT system.

What could such a federal mandate look like? The authors suggest consideration of the following incentive measures:

1. A federal and/or state funding process that grants incentive funds for newly built systems that implement agreements between agencies and cities to install and maintain effective at-grade crossing infrastructure improvements. This measure is intended to promote more efficient LRT and street traffic operations. In this case, the federal incentive funds need to be granted to both city and LRT agencies and should have relatively few restrictions on transportation expenditure, in order that cities and LRT agencies subjectively consider the agreement-related incentive dollars as useful (which offers them a true incentive). This measure is designed to ensure that the LRT planning process includes consideration of at-grade crossing improvements that increase capacity and safety and reduce other operating and capital costs.
2. A federal and/or state funding process that provides the capital funding for LRT agencies to upgrade at-grade crossings to standards such as those being developed by the *Manual of Uniform Traffic Control Devices*, the California Traffic Control Device Committee, and ITE. This measure would ensure that up-to-date traffic signal systems, signage, gates, and geometric improvements are implemented, so that the highest available levels of system safety, capacity, and operating efficiency are guaranteed.
3. A federal, state, and/or local funding process that allows cities with bona fide agreements with LRT operators to maintain and operate the traffic signal system and, where the system safety record and on-time LRT performance meet a certain federal standard, to receive a subsidy for traffic signal system operations and maintenance costs. This measure is designed to ensure that cities and agencies agree on specific at-grade crossing improvements and to promote efficient system performance.

It should be noted that with federal funding programs that could be made available, concurrent state programs to secure matching funds (or primary funding, or both) for traffic signal and other at-grade infrastructure improvements should be clearly defined.

In conclusion, the authors wish to emphasize that funding incentives can place at-grade crossing infrastructure upgrades squarely within the initial planning LRT process. Availability of funding for at-grade crossing improvements would bring cities and agencies together to discuss seriously these cost-effective strategies. For successful implementation of LRT systems in the United States, leadership and a commitment to cooperation on this issue from LRT agencies and federal, state, and local government are required.

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