

LRT

**LIGHT RAIL TRANSIT  
SERVICE GUIDELINES**





## LIGHT RAIL TRANSIT SERVICE GUIDELINES

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## 1. VISION STATEMENT

Light Rail Transit (LRT) provides high-quality, high-speed, and environmentally friendly public transit service on established trunk corridors linking major trip generators, regional centers, and county cores. Successful LRT service generates high levels of ridership, is time-competitive with the automobile, accommodates higher capacity needs than Bus Rapid Transit (BRT), and costs less than heavy rail transit. LRT is a premium, accessible, and convenient service capable of attracting and promoting development and investment around stations and along corridors.

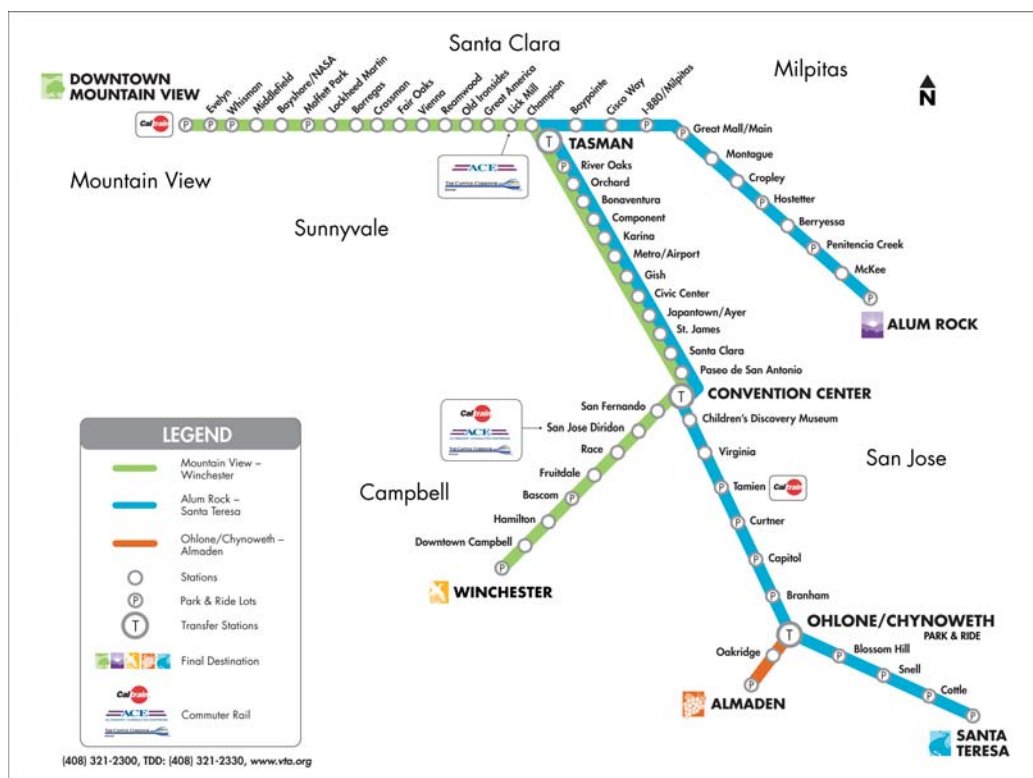
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## 2. MODAL OVERVIEW

Light Rail Transit (LRT) is the modern version of early streetcar lines that influenced the development of cities and communities during the last two centuries. LRT embraces a wide range of electrically powered vehicles operating on steel rails. LRT can operate on mixed-flow streets or in its own semi- or fully-separated right-of-way, including on freeway medians or shoulders, railway right-of-ways, pedestrian malls, drained canal beds, in tunnels and on overhead viaducts. Transit signal priority is employed for LRT at-grade crossings to minimize delay and waiting time at intersections, which also improves safety

and operating speeds. In some cases, grade-separated crossings are provided. LRT generally provides lower carrying capacity than heavy rail, but higher capacity than community shuttle, local bus, or BRT service due to its ability to add cars to the train and increase unit carrying capacity. LRT is demand-responsive in that the length of trains and the service frequency can be easily adjusted when required.

VTA has two primary LRT lines and one spur line. The primary network length is approximately 42 miles with a total of 62 stations. A network map is shown in Figure 1.

**Figure 1** VTA LRT Route Network

### 3. PLANNING AND IMPLEMENTATION PROCESS

The design, implementation, and operation of all LRT service shall result from a comprehensive planning process. Prior to implementation, all potential new lines or service changes will be subject to an initial planning study to determine the feasibility, structure, identify necessary local commitments, and funding availability. The following Service Design Guidelines are part of this process for planning, designing, implementing and monitoring new service. Specific steps to evaluate existing and proposed service are as follows:

#### EXISTING SERVICE EVALUATION

Step 1 – Assess existing service versus established service standards

Step 2 – Devise and implement an Improvement Plan, if necessary

#### IMPLEMENTATION OF NEW SERVICE

Step 1 – Conduct market research and estimate ridership and revenue potential

Step 2 – Evaluate the new service with the Transit Sustainability Policy (TSP) methodology<sup>1</sup>

Step 3 – Identify and design route alignments

Step 4 – Establish LRT station location

Step 5 – Design stations, facilities, and street improvements

Step 6 – Develop an operating plan and implementation schedule

Step 7 – Develop a marketing plan and brand management strategy

<sup>1</sup> The TSP evaluation may result in the following recommendations: (i) the proposed new service is to be implemented (and the process proceeds to Step 2); (ii) the development and adoption of a Corridor Improvement Plan is necessary; (iii) Bus Rapid Transit is recommended as either the interim or preferred mode over LRT; and (iv) LRT service is not recommended on the given route/corridor.

Step 8 – Monitor service performance (see Existing Service Evaluation)

## 4. LRT POLICIES

### 4.1 LRT SYSTEM PERFORMANCE STANDARDS

This section identifies a set of performance thresholds needed to ensure that LRT routes and stations contribute to productive and efficient service.

New LRT lines shall be evaluated according to three standards, as shown in Table 1 below. The primary evaluation standard is:

- **Boardings per Revenue Vehicle Hour.** This measures the number of boardings during a given revenue hour of vehicle service. It has served as VTA's long-established evaluation criteria to assess productivity of transit services. This indicator shows how well service is utilized given the hours of service provided. It also indicates whether the transit capacity offered is appropriate, and how well capital and operating resources are deployed to provide service.

Secondary evaluation standards are discussed below. These standards are calculated based on the primary standard (average boardings per revenue vehicle hour). As the primary standard changes, the secondary evaluation standards will also change.

- **Boardings per Station.** This measures the number of daily boardings at a given LRT station and gauges how well a station is being utilized. This is important given operating and maintenance costs associated with keeping a station operational. An under-used station impacts LRT operating performance, as well as farebox recovery and cost efficiency. This is especially true for larger LRT stations designed to handle high passenger and transfer volumes. Highly utilized stations can be considered for additional station amenities. *Existing LRT service is evaluated by this standard only.*

- **Boardings per Route Mile.** This compares the number of daily boardings to the total length of an LRT route or the entire LRT network. This standard shows whether a route is effectively designed given its length. Furthermore, it can be used to identify route segments with higher demand, which allows the operator to best tailor service and capacity to serve this ridership.

At present, VTA's LRT system has two primary lines: Alum Rock to Santa Teresa Station, and Mountain View to Winchester Station. In 2006, these two lines handled an average of 29,500<sup>2</sup> daily boardings per day, equating to some 45 boardings per revenue hour or 700 boardings per route mile, assuming a network length of 42 miles.

<sup>2</sup> Based on December 2006 summary of operating statistics.

**Table 1** Ridership Standards for Existing/New LRT Service<sup>A</sup>

Performance Standard	Study Area	Existing LRT Service	New LRT Service
Average Boardings per Revenue Hour	Line	—	87
Minimum Boardings per Station	Station	559 <sup>B</sup>	1268
Average Boardings per Route Mile	Segment/Line	—	1489

Table Notes:

<sup>A</sup> All standards are based on existing VTA performance and those of similarly sized LRT systems and stations in cities with comparable land use patterns (Denver, Sacramento, St. Louis, and Salt Lake City).

<sup>B</sup> Based on existing VTA performance and the desire to improve daily utilization of less patronized stations.

### Performance Standard Policy Notes

- The goal of LRT is to achieve a 20 to 25% farebox recovery ratio consistent with VTA's Board adopted objective for all routes in the system.
- A new or proposed line or station not meeting any of the standards in Table 1 shall be subject to an Improvement Plan (IP) to increase ridership and to improve operating performance and efficiency.
- An existing line not meeting the weekday boardings per station standard shall be subject to an IP to increase ridership and to improve operating performance and efficiency.
- Line segments that consistently perform below the noted standards may be subject to service and operational changes that may include:
  - » Reducing operating frequencies, especially during the off-peak;
  - » Skipping unproductive segments or stops, especially during the off-peak; and
  - » Shortening service hours.
- Stations that consistently perform below the noted standards may be subject to service changes that may include:
  - » Shifting to peak hour operations;
  - » Shortening service hours;
  - » Skipping unproductive stations; and
  - » Closing particularly unproductive stations.
- Any service modifications shall be designed to comply with the performance standards.
- Stations consistently failing to meet the daily boarding per station standard may still be warranted, on a case-by-case basis, if they provide:
  - » Links to key transfer points and connecting routes.
  - » Service to nearby hospitals and other social welfare facilities.
  - » Service to other special trips generators such as schools, stadiums, and shopping malls.
  - » Service to new or proposed developments with high potential for transit use.
- Those stations that are partially or fully privately funded (i.e. not by VTA) may be subject to relaxed standards upon agreement between VTA and the private funding source.

## 4.2 MARKET RESEARCH AND REVENUE/ RIDERSHIP FORECASTS

Prior to the implementation or initiation of new service, VTA shall undertake market research to: (i) comprehend market needs and ridership potential, based on major trip generators and origin and destination patterns within the community; and (ii) identify the type of infrastructure improvements needed. Market research will also assist in identifying optimal route design and desired service characteristics (i.e. acceptable travel times, service span, and days of operation).

Even though a market may exist for a given route, the performance may not be sufficient to satisfy VTA standards as given in Table 1, and established by the Board requiring a minimum fare recovery of 20 to 25% for the entire system. Thus, VTA shall conduct ridership and revenue analyses on potential new routes and service segments to assure they meet existing standards. In addition, the analyses will help to identify potential locations along the route that generate maximum ridership and revenues.

Considerations in these analyses are as follows:

- Ridership estimates shall be developed through a comprehensive planning process using VTA's Countywide Transportation Model, Transit Service Planning Tool (TSP), and other Direct Demand Models.<sup>3</sup>
- Revenue projections shall assume that fares will be consistent with VTA's fare policy.

## 4.3 IMPROVEMENT PLAN

As part of the Transit Sustainability Policy (TSP), an Improvement Plan (IP) may be developed for those LRT corridors

and stations that do not meet Table 1 standards to incrementally improve transit ridership, and therefore operating efficiency and productivity. IPs are envisioned as a partnership between VTA and local jurisdictions. They are a part of the planning and evaluation process and shall occur prior to implementation of any service changes or route modifications.

In instances where an IP is not desirable or practical, provision for service reduction and/or service modifications shall be considered. IPs shall include corridor and station recommendations for: (i) Land Use Policies; (ii) Urban Design; and (iii) Roadway Improvements. In addition, local jurisdictions may undertake Community Outreach efforts to promote transit ridership.

The following sections identify local jurisdiction and VTA actions that fall under the Implementation Plan.

### 4.3.1 LOCAL JURISDICTION ACTIONS

It is the policy of VTA to work with local jurisdictions on an ongoing basis to develop land uses and other supporting policies to increase ridership on existing lines and usage of LRT stations. The primary mechanism for this effort is through the Community Design and Transportation (CDT) Program, and station and corridor area development plans. Land use and other supporting policies are discussed below.

#### Land Use Policies

There is a reciprocal relationship between diverse, higher-density land uses and transit ridership. These factors are primary inputs to ridership estimation models. Land use policies that encourage denser mixed-use

<sup>3</sup> Local jurisdictions will have access to these tools through the *Improvement Planning Process*.



developments built to a pedestrian scale are much more likely to generate transit riders than dispersed communities that are designed around arterial streets. Figure 2 shows an example of high-density development around a VTA station. Actions to promote densification and mixed-use may include:

- Adopting land use plans and strategies to promote higher densities.
- Adopting TOD policies and overlay zones to promote mixed-use development.
- Developing TOD design guidelines, Specific Plan overlay, and corridor plans.

Table 2 summarizes residential and commercial land use policies and urban design recommendations around LRT stations.

The Community Design and Transportation (CDT) Manual has established recommended residential densities (Dwelling Units per Acre — DUA) and commercial development (Floor Area Ratios — FAR) along LRT corridors and stations to promote conditions that facilitate transit utilization. Optimal densities for LRT have been formulated based on these

CDT recommendations as well as industry research.

LRT corridor and station densities have been broken into three categories as follows:

- **Minimum Densities.** Areas meeting the minimum densities or those corridor or station areas that have phased approach plans to increase density, development, and land use shall be considered for LRT service or a station.
- **Target Densities.** Areas meeting the target densities shall be considered suitable for LRT service or stations.
- **Preferred Densities.** Areas meeting the preferred densities shall be given the highest priority for LRT service or stations.

Tables 3 through 6 present the residential and commercial density targets along new LRT corridors and stations.

#### Policy Notes

- Recommended minimum densities and FARs do not apply in areas along major established corridors that link key activity nodes and regional centers or in areas along roads that link a major corridor with a

**Table 2** Various Design/Development Requisites of LRT

Urban Design Guidelines	Land Use	Ideal Service Area/Points	Transit Policies
<ul style="list-style-type: none"> <li>• Building form and scale</li> <li>• Building orientation</li> <li>• Parking</li> <li>• Station area access</li> </ul>	<ul style="list-style-type: none"> <li>• Higher density residential</li> <li>• Higher density commercial</li> <li>• Employment nodes</li> <li>• Mixed use</li> </ul>	<ul style="list-style-type: none"> <li>• Urban corridor</li> <li>• Mixed use</li> <li>• Employment nodes</li> <li>• Downtown</li> </ul>	<ul style="list-style-type: none"> <li>• TOD policies/overlay zones</li> <li>• TOD design guidelines</li> <li>• Specific Plan overlay</li> <li>• Station area plans</li> </ul>



**Table 3** Residential Density Targets along New LRT Corridors

Line Type	Optimal Densities (DUA) (within 1-2 blocks or 330-660 feet of corridor)		
	Minimum	Target	Optimal
LRT	20	35	65

Table Note:

Source: CDT Manual, 2005, Appendix D-1 Minimum and Average Building Density Recommendations

**Table 4** Residential Density Targets around New LRT Stations

	Optimal New Residential Project Density (DUA — within 1/3 mile of LRT station)		
	Minimum <sup>A</sup>	Target <sup>B</sup>	Optimal <sup>C</sup>
LRT Station (Regional)	20	55	75
LRT Station (Local)	10	30 <sup>C</sup>	45

Table Notes:

<sup>A</sup> Source: City of Portland Bureau of Planning (for Portland TriMet LRT), 2006.

<sup>B</sup> Source: CDT Manual, 2005, Appendix D-1 Minimum and Average Building Density Recommendations

<sup>C</sup> Interpolated.

**Table 5** Commercial Density Targets along New LRT Corridors

Line Type	Target Floor Area Ratio (within 1–2 blocks or 330–660 feet of corridor)	
	Train Station or Transit Corridor	Major Bus Stations
LRT	3.0	1.5

Table Note:

Source: CDT Manual, 2005, Appendix D-1 Minimum and Average Building Density Recommendations

**Table 6** Commercial Density Targets around New LRT Stations

	Target Floor Area Ratios (FAR — within 1/3 mile of LRT station)		
	Minimum <sup>A</sup>	Target <sup>B</sup>	Optimal <sup>B</sup>
LRT Station (Regional)	2	3	4
LRT Station (Local)	0.5	1.25 <sup>C</sup>	2

Table Notes:

<sup>A</sup> Source: City of Portland Bureau of Planning (for Portland TriMet LRT), 2006.

<sup>B</sup> Source: CDT Manual, 2005, Appendix D-1 Minimum and Average Building Density Recommendations

<sup>C</sup> Interpolated.

**Figure 2** Transit-Oriented Development Around LRT Stations (Diridon Station)



major multimodal transit center or a major trip generator node.

- Recommended minimum densities and FARs do not apply at stations that are funded by a non-VTA source, at stations that serve specific social functions (such as hospitals and schools), and at stations serving as key transfer or intermodal stations. However, operational considerations and the impact to riders will still be factors considered in the analysis.
- These standards will apply until the corridor and/or station usage increases from further residential and commercial development and TOD supportive policies and measures to exceed noted performance standards.
- Those corridors that exhibit growth potential and/or approved projects to

achieve preferred densities shall have higher priority consideration.

- For those station areas requiring an Improvement Plan (IP), explicit policy language or approved plans that encourage residential and commercial densities around station areas shall be detailed.

#### URBAN DESIGN

Integrating sound urban design practices around transit stations is critical for transit riders to make the last-mile connection from the station to their destination. In the IP, potential urban design improvements that local jurisdictions can undertake include<sup>4</sup>:

- **Pedestrian and Bicycle Access Enhancements.** This may include the provision of contiguous sidewalk and bicycle lanes on both sides of the street, as well as the removal of barriers that

<sup>4</sup> The CDT Manual provides a comprehensive set of transit improvements and urban design elements available for the last mile connection around stations. Refer to CDT Manual sections 3 through 5 for more examples.

prohibit pedestrian and bicycle traffic from accessing surrounding station areas.

- **Appropriately Designed and Sized Parking Facilities.** An appropriate parking supply may be necessary based on the rider profile and demand for service, although parking facilities need to assure that pedestrian and bicycle access is unimpeded to both the station and surrounding destinations. In addition, the design and location of parking facilities must assure that transit operations are not disrupted.
- **Creation of Origin-Destination Pairs.** High-quality mixed-use developments along a corridor can encourage transit use as well as encourage additional transit-supportive development.
- **Design Guidelines.** Design guidelines may include placing parking behind buildings, providing human-scale details at the street level, and providing interesting architecture within public spaces.

## PHYSICAL IMPROVEMENTS

Various physical measures can be undertaken to improve transit travel speeds and reliability along a corridor. Local jurisdictions can work with VTA to provide transit preferential ROW treatments and implement policies and projects that improve transit speeds and increase service efficiency.

### Physical Improvements Policy Notes

Within the IP, VTA shall identify potential service enhancements, while the local jurisdictions shall identify the physical and policy actions needed to implement and achieve these enhancements. Improvements may include the following:

- Providing right-of-way (ROW) to construct double track sections, stations, and multimodal interchange stations.
- Restricting turn movements to minimize conflicts with LRT vehicles.
- Assuring that all traffic signals in a corridor are equipped with signal priority.
- Providing sufficient sidewalk width for new ADA compliant LRT stations.
- Encouraging or raising parking fees in urban cores to promote transit use.
- Reducing the parking supply, capping the parking capacity, or instituting parking charges along a corridor, in key areas, or at select stations to provide opportunities for high-density development around stations and to encourage commuters to use public transit.

## COMMUNITY OUTREACH

In addition to the improvements mentioned above, local jurisdictions can actively promote and support transit through community outreach efforts. These may include:

- Offering free trial and tourist passes.
- Conducting transit specific marketing and/or branding campaigns to provide access to transit information and other useful promotional materials.
- Building partnerships with area associations, such as downtown business associations, to promote transit ridership.

### 4.3.2 VTA EFFORTS

VTA can improve or modify service to better meet corridor and station performance targets. For routes and stations failing to meet the performance standards, VTA can:

- Restructure the operating plan and services to improve ridership and reduce operating costs.

- Reduce service hours and revenue miles operated (particularly during the off-peak), or service frequency until service meets the standards.
- Introduce peak hour service only.
- Introduce skip stop service to bypass unproductive stations on scheduled runs.
- Temporarily close particularly unproductive segments or stations.

## 5. SYSTEM AND ROUTE DESIGN

The effectiveness and efficiency of LRT is impacted by three factors: (i) route design, (ii) right-of-way; and (iii) track layout and configuration. Guidelines for these factors are discussed below.

### 5.1 ROUTE DESIGN

In order to be attractive and at the same time provide competitive travel times, LRT routes shall directly connect downtown hub and core areas with regional activity centers along major arterials, corridors, and highways. While operations on urban streets can slow LRT and reduce safety, those operating on semi- or fully-separated ROW can operate more quickly, reliably, and safely. Figure 3 shows a typical LRT route network.

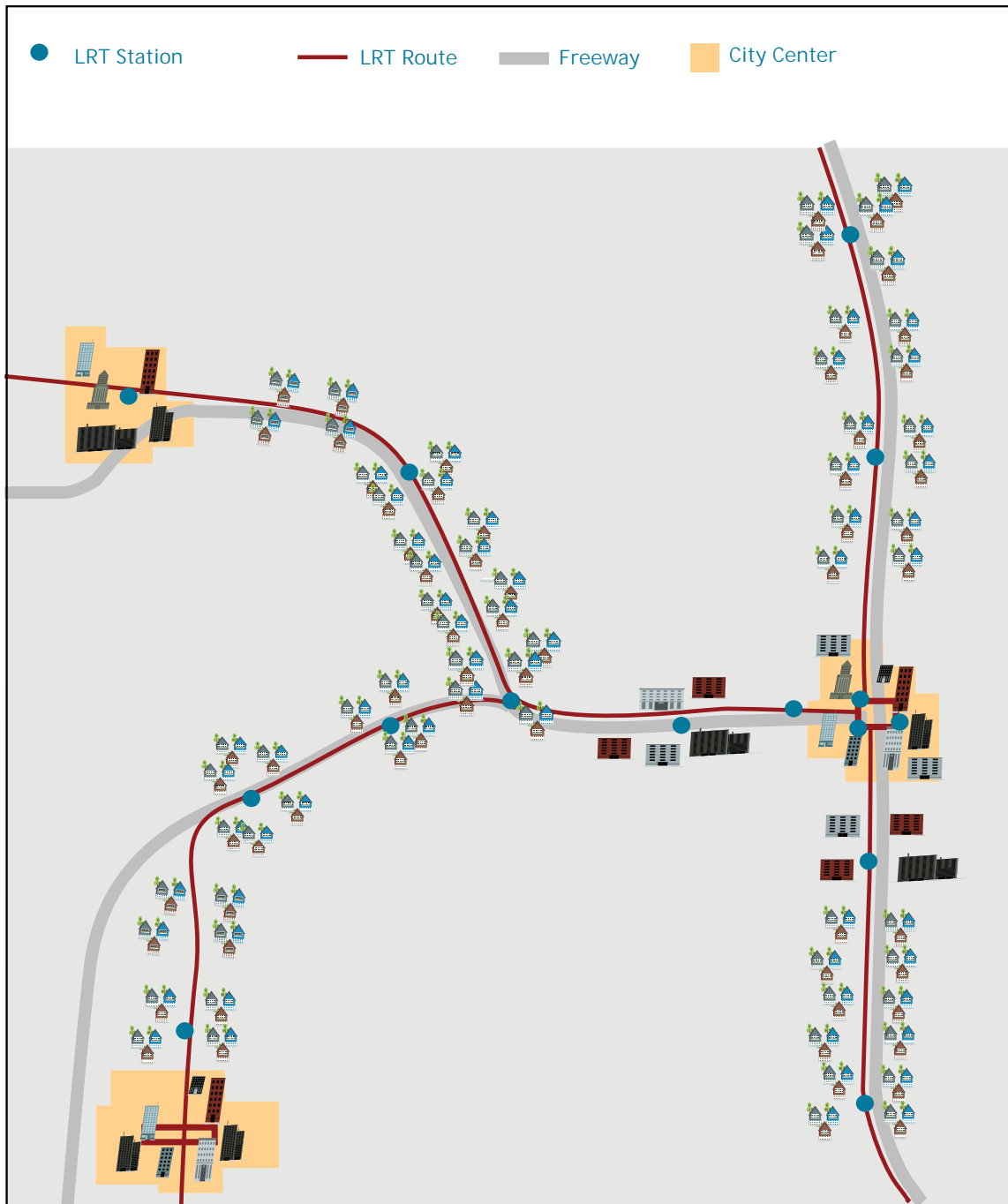
The following policy guidelines shall govern the development of VTA's LRT service network:

#### Route Design Policy Notes

- All new LRT line segments shall undergo a system analysis to assess the operational impacts to the existing system, and identify the improvements needed to maintain system speed and operational flexibility. These improvements shall be incorporated into line/segment cost estimates.
- LRT lines shall serve and operate in established or planned corridors serving major trips generators, such as airports, civic and employment centers, mixed-use districts and high-density residential areas, colleges and universities, and shopping centers. These corridors shall have the potential for future development and densification to improve conditions for transit utilization.
- LRT lines shall be designed to be as direct as possible, avoiding circuitous route deviations unless it is to serve a major activity node and the addition of new riders offsets the impacts of increased travel times.
- LRT lines shall operate bi-directionally within the same ROW, unless the routing serves a one-way street, in which case couplet service is acceptable (where the line operates in one direction on one street and the opposite direction on a parallel or nearby street).
- LRT lines shall be integrated into the community with pedestrian-oriented and transit-friendly developments around the station area.
- LRT lines shall operate with transit signal priority (TSP) at all at-grade crossings throughout a corridor/ROW. Figures 4a and 4b show an example of TSP for an intersection serving LRT.
- LRT lines shall be designed to complement future heavy rail transit systems.
- New LRT lines shall intersect with existing LRT lines to the extent possible, to create multiple transfer opportunities.
- LRT lines shall be well integrated with the regional transit systems and have multiple transfer opportunities to local buses, BRT, commuter rail, and heavy rail, where possible.

- All new LRT extensions shall include the development of a Parking Management Plan (PMP) that will document:
  - » Park & Ride demand;
  - » Shared parking opportunities;
  - » Public-private partnership opportunities;
  - » Security issues and measures, including high-tech solutions such as video monitoring and SmartCard control entry and exit systems; and
  - » Proposed parking fees, if any.

**Figure 3** Typical LRT Route Network





**Figure 4a** LRT Transit Priority Signal**Figure 4b** Example of a LRT signal

## 5.2 RIGHT-OF-WAY

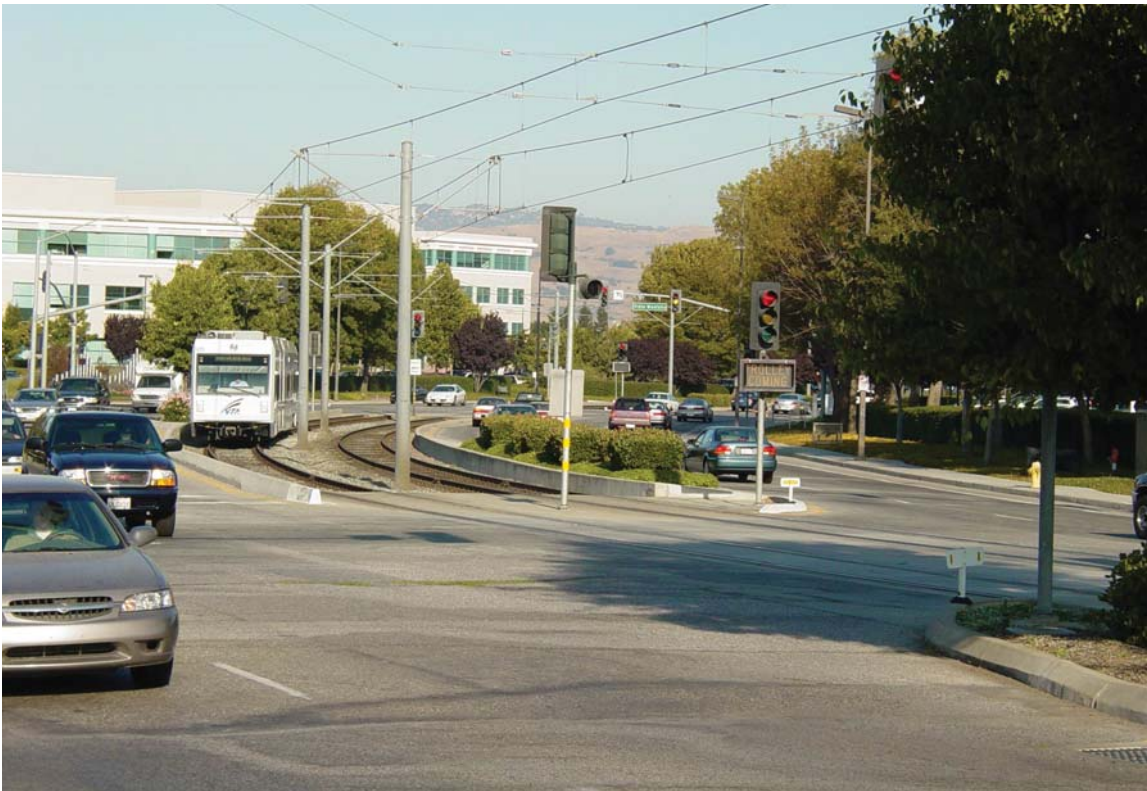
The type of right-of-way (ROW) an LRT system operates in has a significant impact on the operating speeds it can attain. Policy guidelines for VTA LRT ROW are as follows:

- All new lines shall include an analysis of potential improvements, such as grade-separations and double-tracking single line segments, which will improve overall system performance.
- LRT lines shall operate on existing ROW to the extent possible to reduce capital costs. Figure 5 shows LRT operating in the center median of an arterial road.
- LRT lines shall operate within semi- or fully-exclusive ROWs, to the extent possible, to improve operating speeds and reliability, and enhance safety when crossing intersections. Figure 6 shows an example of a track on semi-exclusive ROW.
- LRT shall operate on fully exclusive ROW, alignment and operations to allow the vehicle to reach maximum vehicle design speeds.
- For shared street ROW operation a combination of station spacing and signal timing shall allow LRT travel time to remain competitive with automobiles traveling in the same corridor. This includes urban as well as suburban streets.
- Urban street operations shall be adopted only when a street is designated as transit preferential, which includes the provision of necessary ROW for stations, preferential movements at intersections, and transit preferential signal timing and priority (i.e. transit signal priority). Figure 7 shows LRT operating in a single-track urban transit mall.

**Figure 5** LRT Operations on Arterial Street



**Figure 6** LRT Operations on a Semi-Exclusive ROW





**Figure 7** LRT Operations in Transit Mall<sup>5</sup>

### 5.3 TRACK LAYOUT AND CONFIGURATION

For all rail transit systems, double tracking is considered the optimal operational environment. Double tracks permit bi-directional lines to operate simultaneously along the same segment of track, while also permitting bypassing of disabled trains at crossovers and switches. Bi-directional double tracks also allow LRT maximum operational flexibility and the ability to operate at shorter headways, faster speeds, and with greater reliability.

#### Track Layout and Configuration Policy Notes

Policy guidelines for VTA LRT track layout and configuration are as follows:

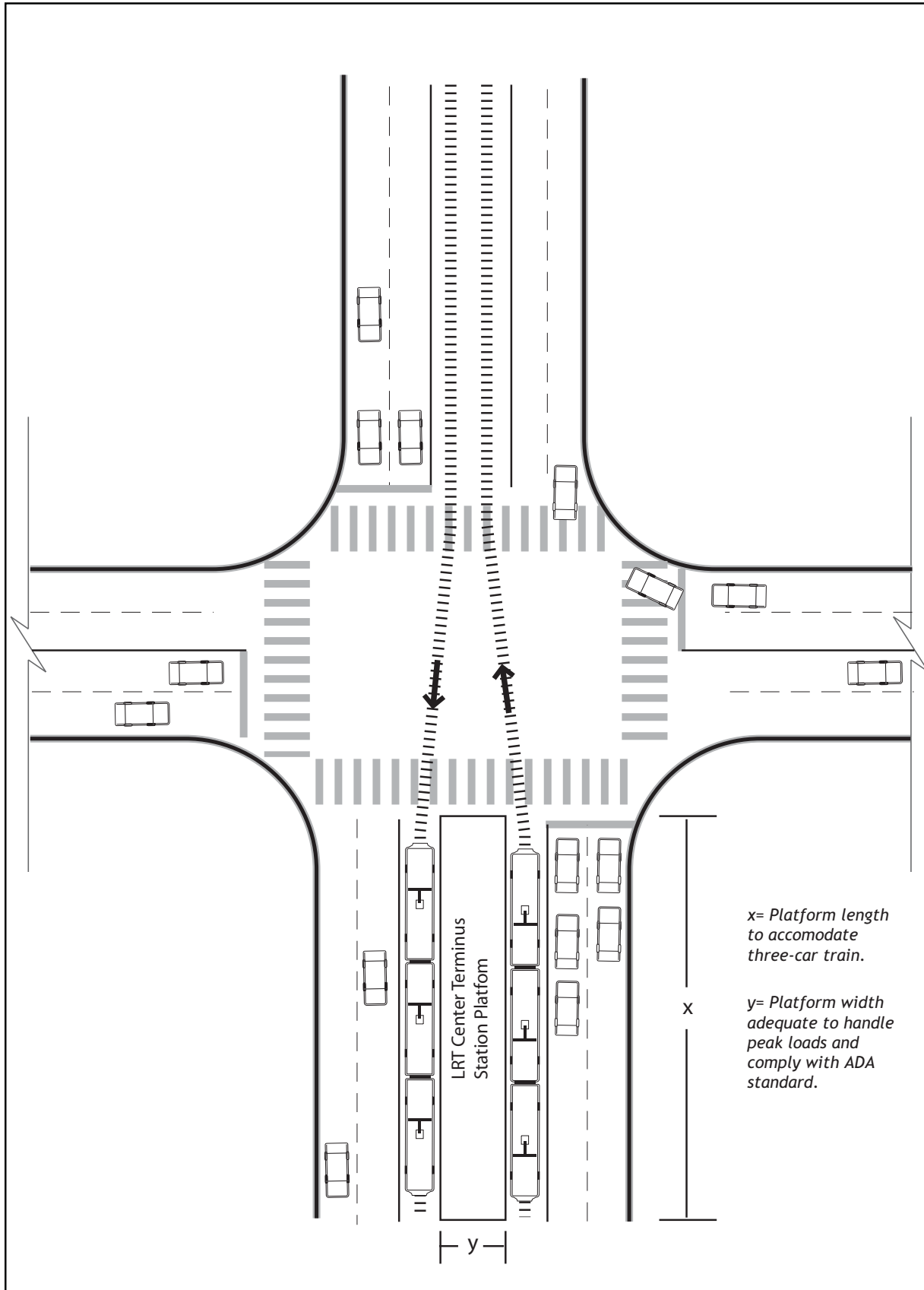
- All new line segments shall provide double-tracks unless the proposed LRT route operates on a one-way street, in which case a track couplet is acceptable (as described in section 5.1 Route Design). A loop route

through a downtown transit mall may be one such example. Figure 8 through Figure 12 show platform configurations around stations. Figure 13 and Figure 14 show double track and single track configurations on VTA's LRT system, respectively.

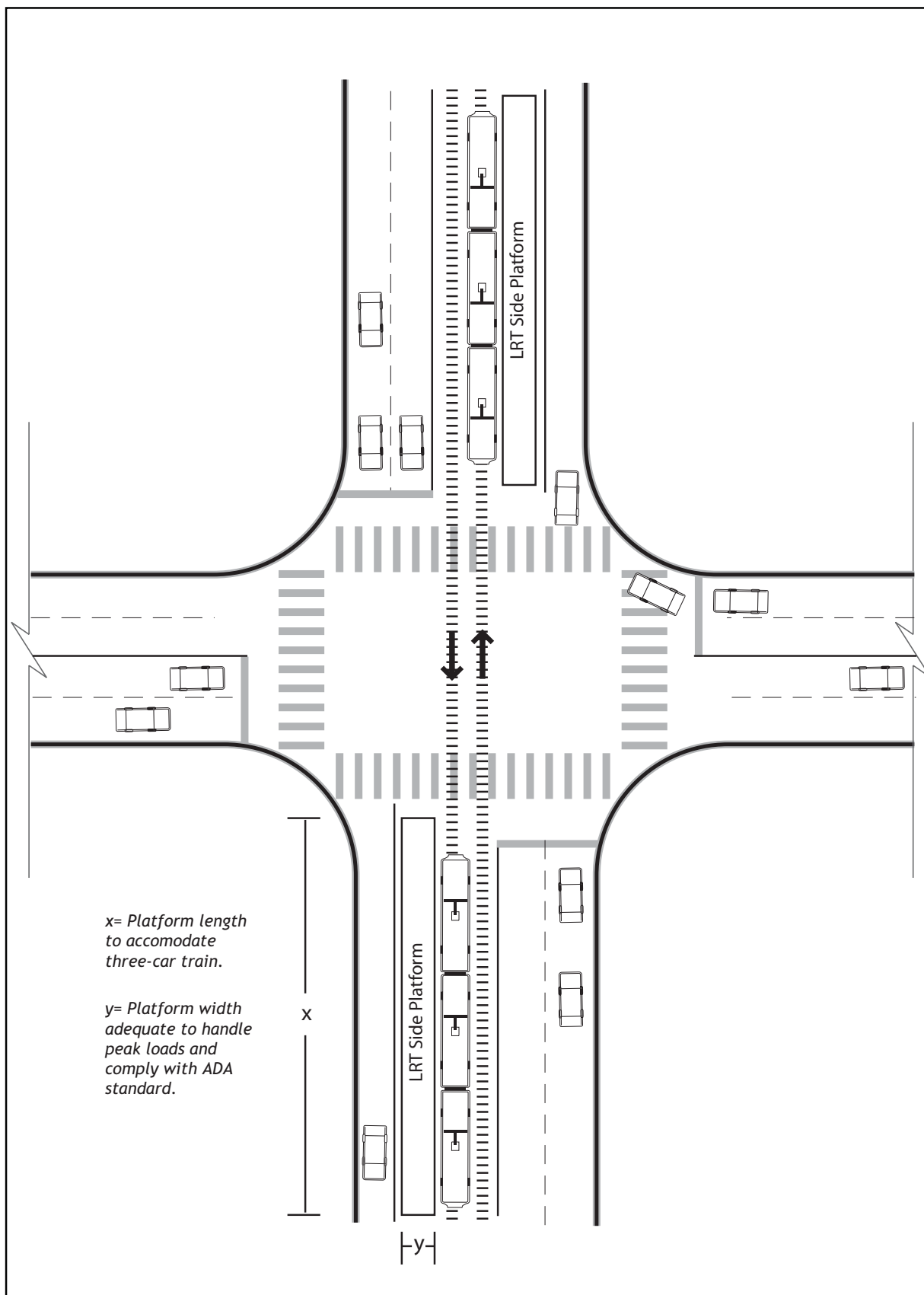
- All terminal (end-of-line) stations shall have double tracks. In addition, all terminal (end-of-line) stations shall have tail tracks to provide sufficient storage to meet the LRT systems operational needs, as shown in Figure 15.
- Connection points between all new segments or lines and existing track shall allow for all turning movements. Figure 16 through Figure 21 show how connecting lines intersect at four-way and T-intersections.
- Crossover tracks shall be provided at intervals that achieve optimal systems operating flexibility.

<sup>5</sup> Photo taken by Peter Beeler from Metropolitan Transportation Commission; Oakland, CA.

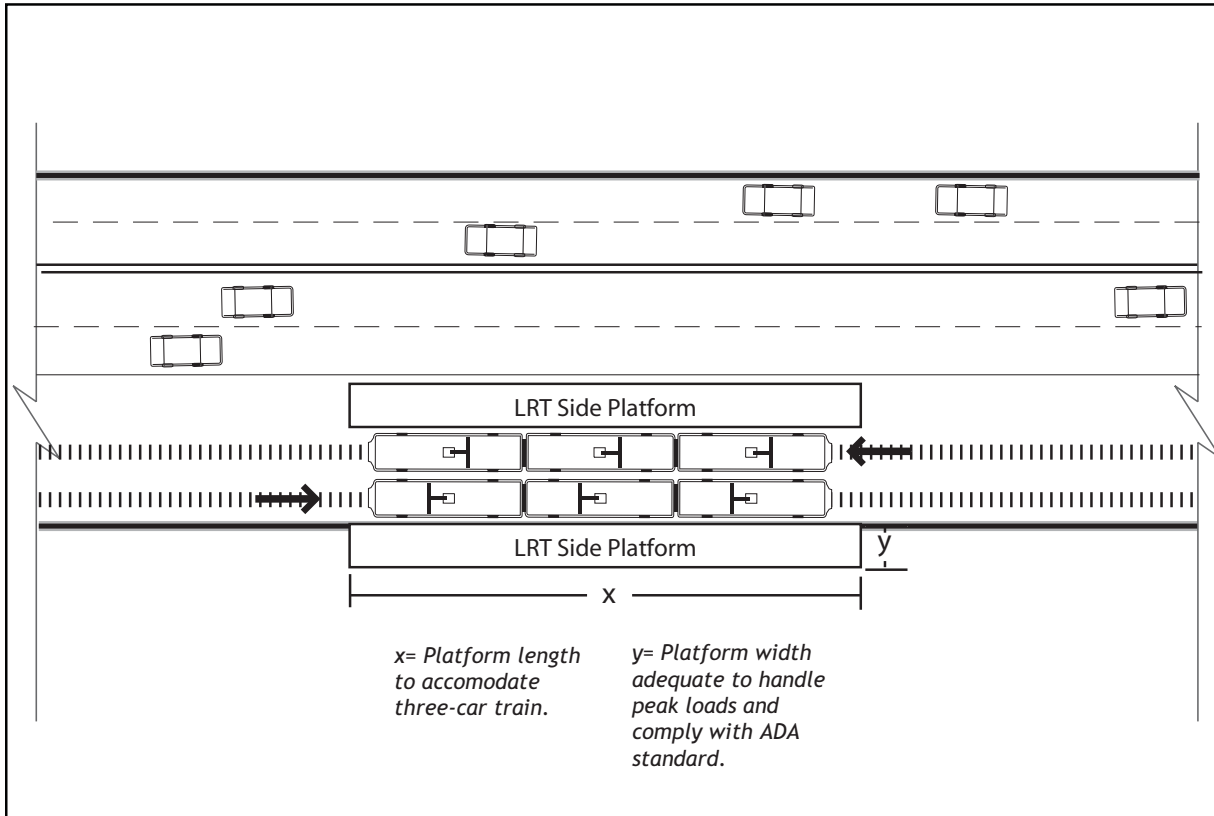
**Figure 8** Bi-Directional Median Platform Configuration



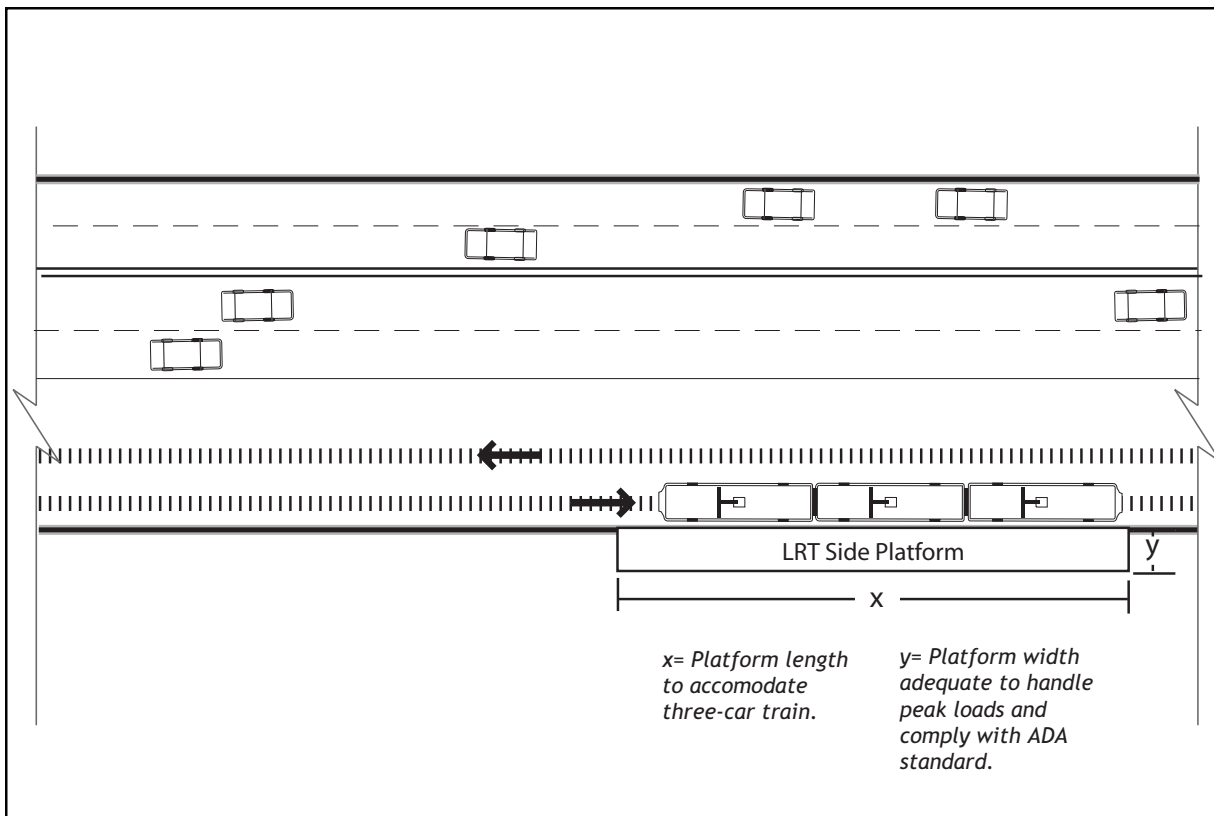
**Figure 9** Offset Median Platform Configuration



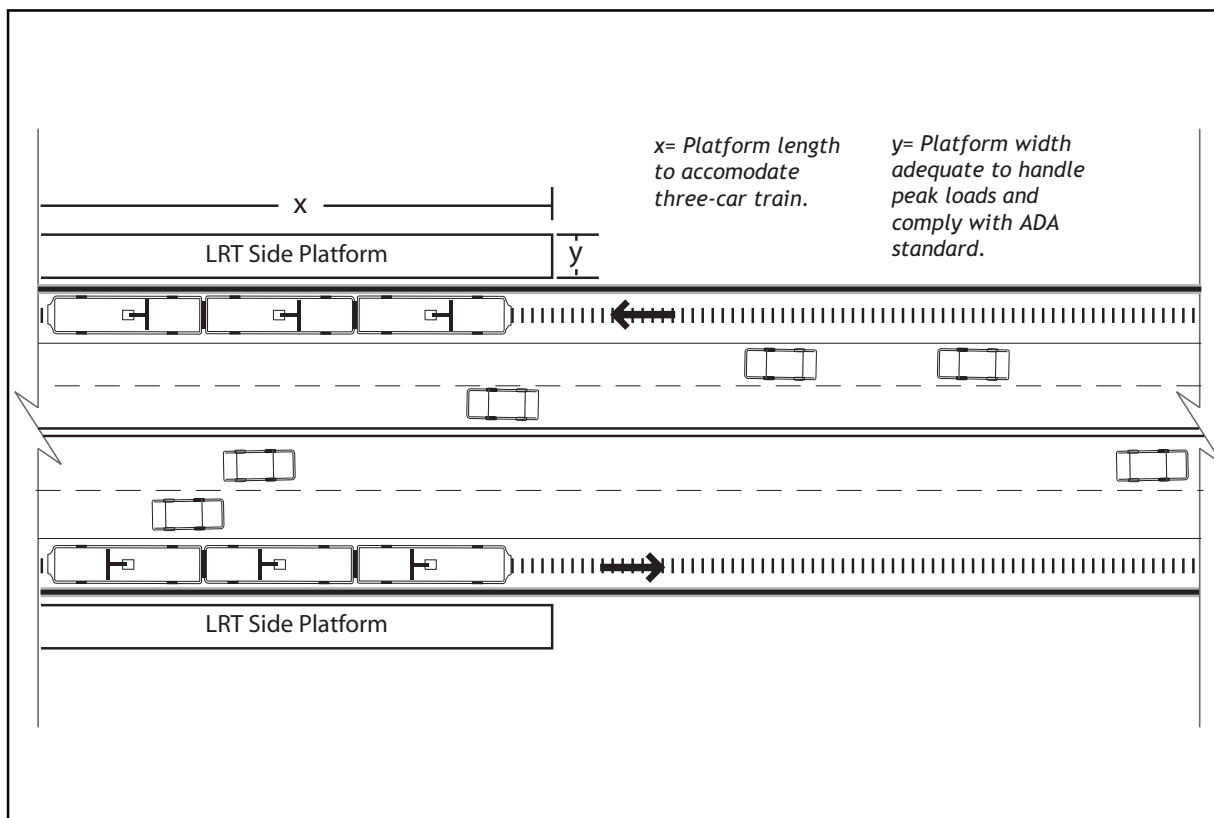
**Figure 10** Parallel Streetside Platform Configuration



**Figure 11** Offset Streetside Platform Configuration



**Figure 12** Single Track Platform Configuration



**Figure 13** Double Tracks



**Figure 14** Single Track Operations (Downtown Campbell)

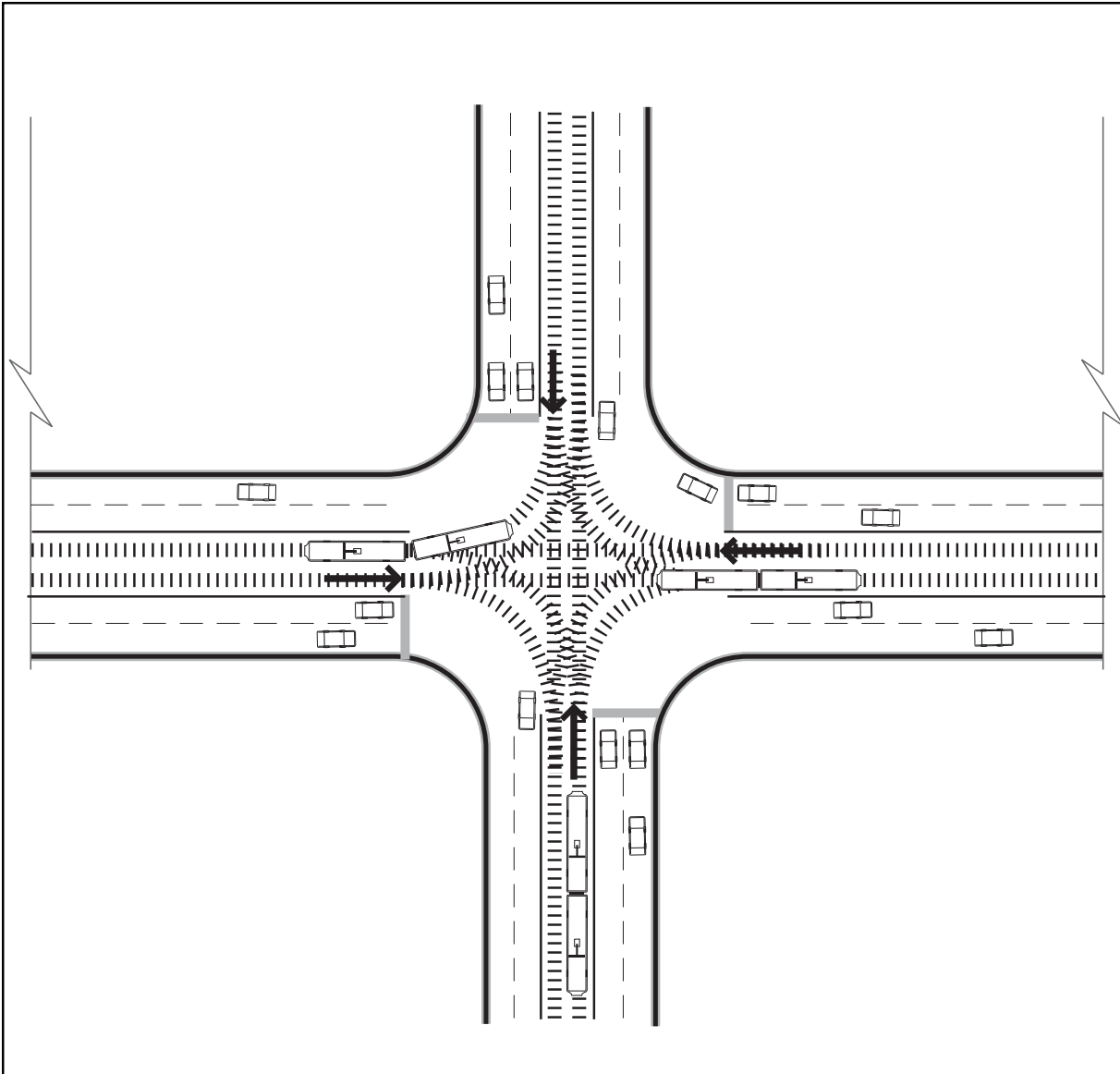


Note: Left track is designated for freight trains

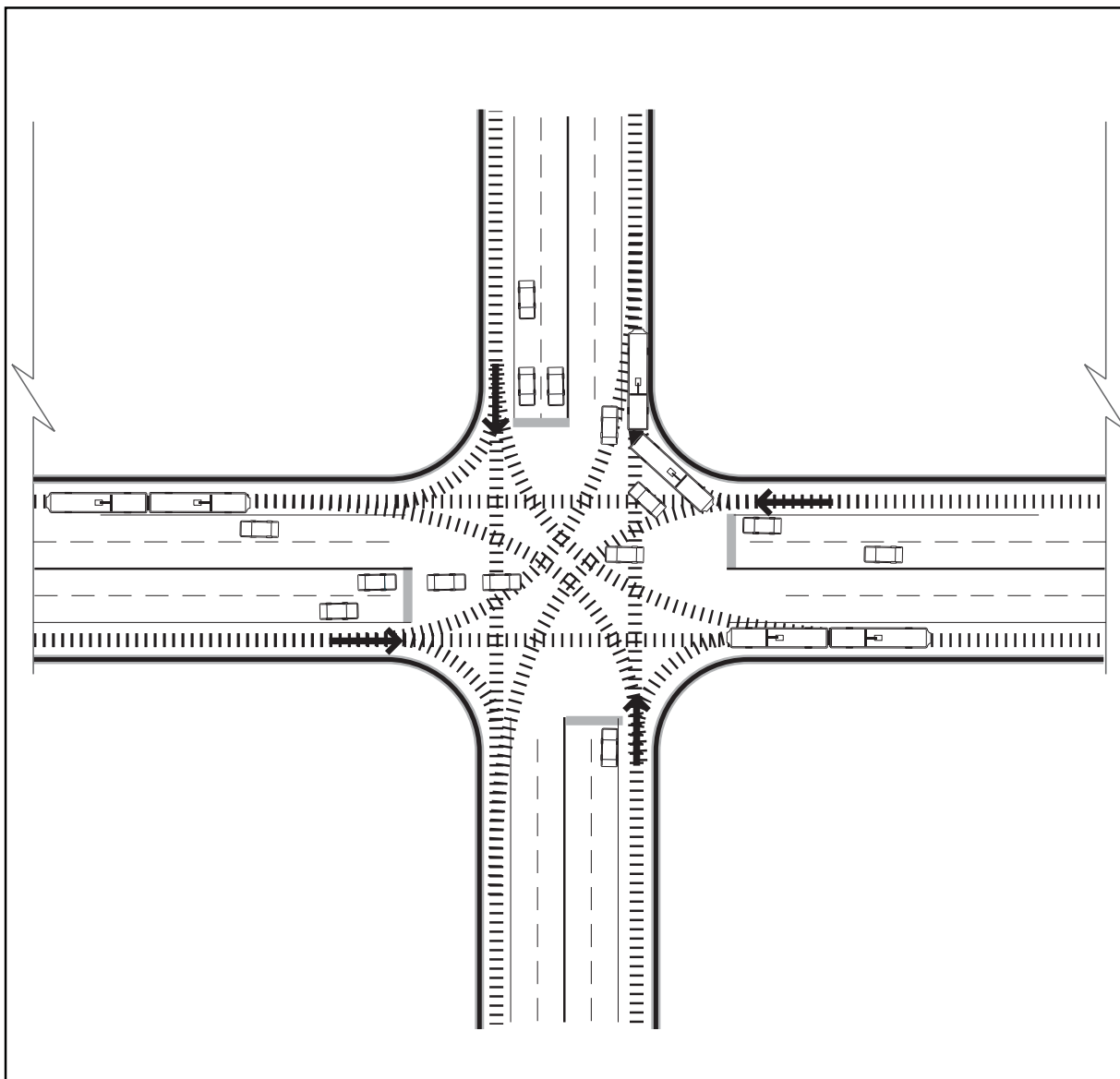
**Figure 15** Tail Tracks for Vehicle Storage at Alum Rock Station



**Figure 16** 4-Way Intersection – Center Track Configuration

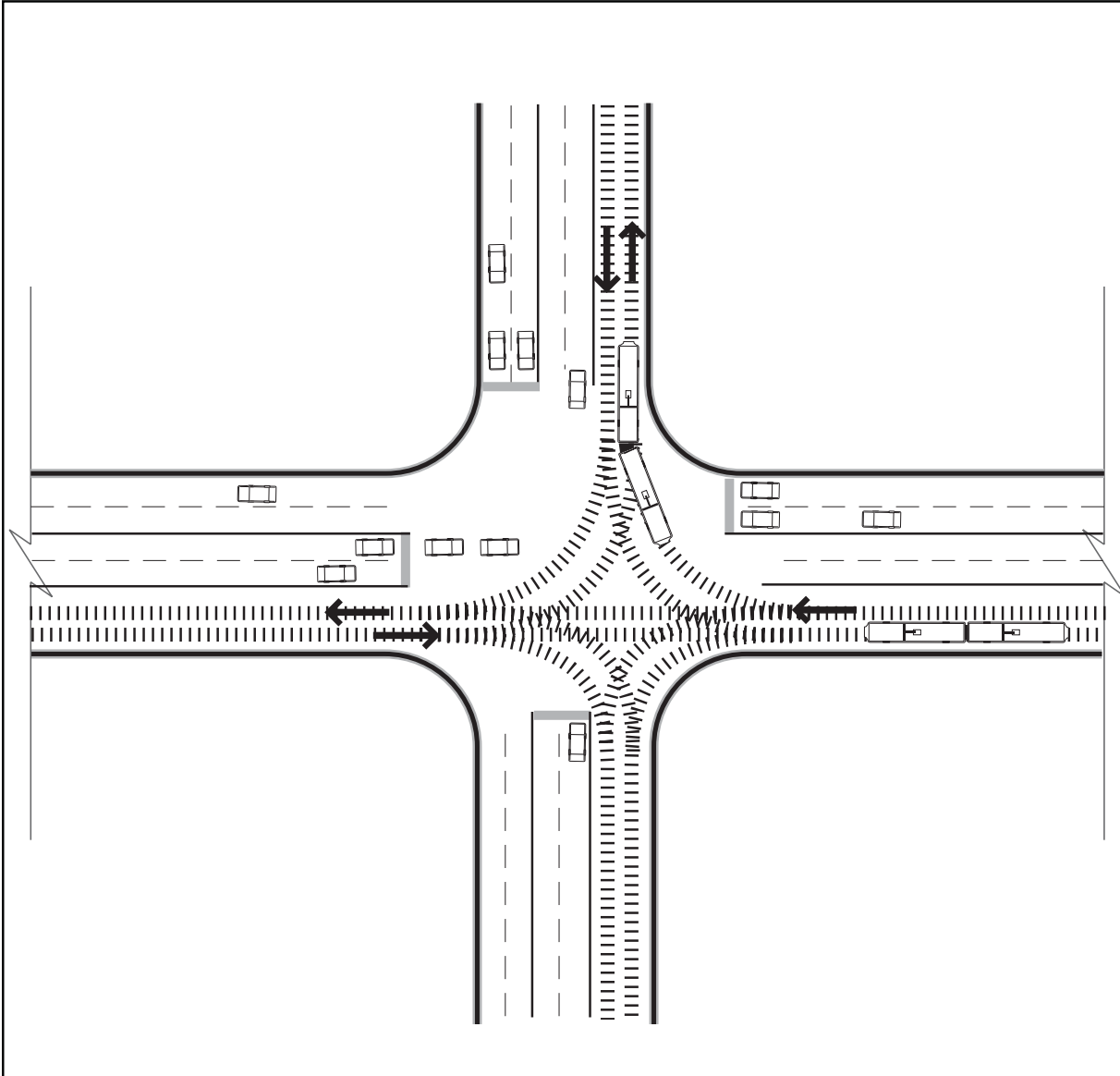


**Figure 17** 4-Way Intersection – Single Track Configuration

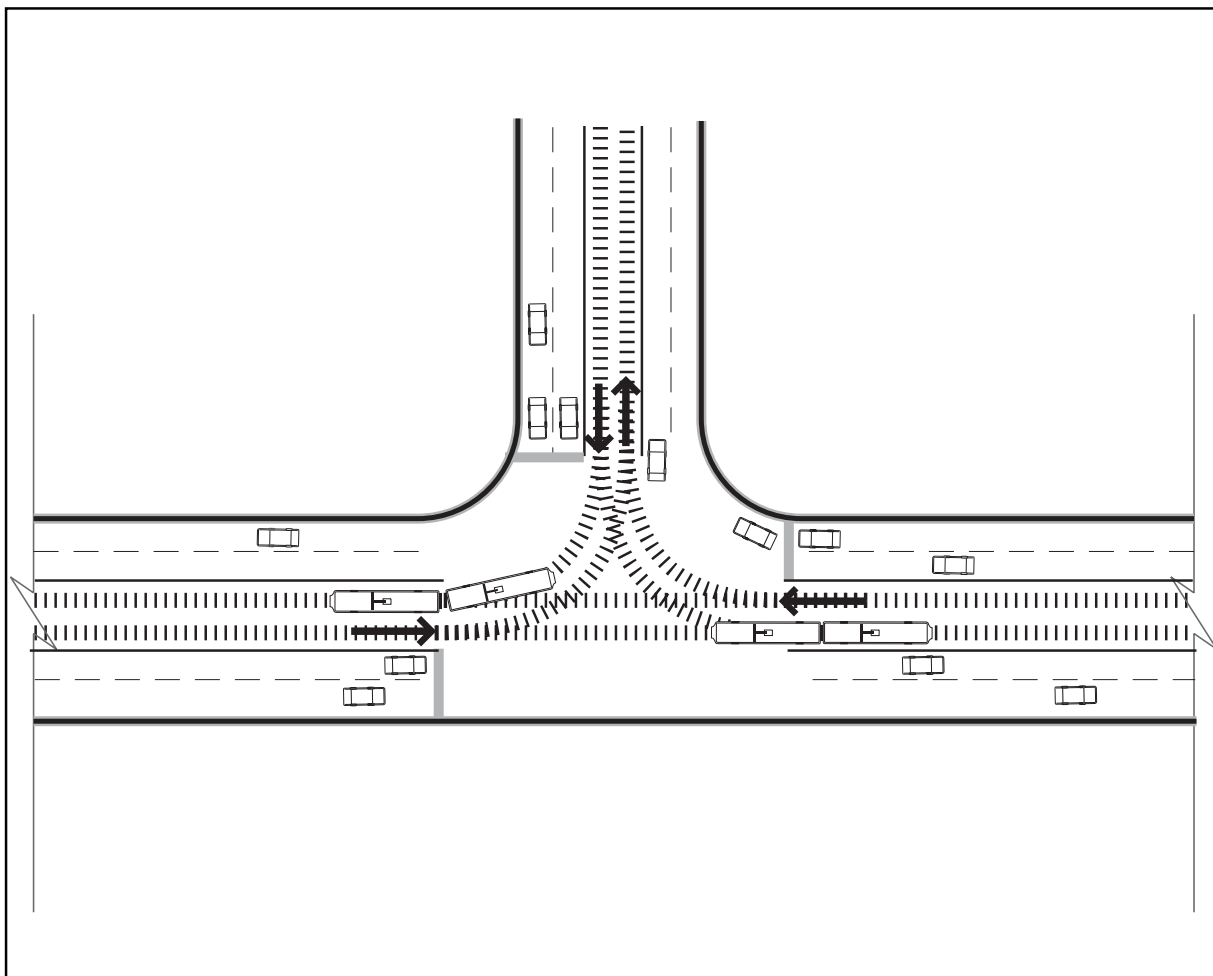




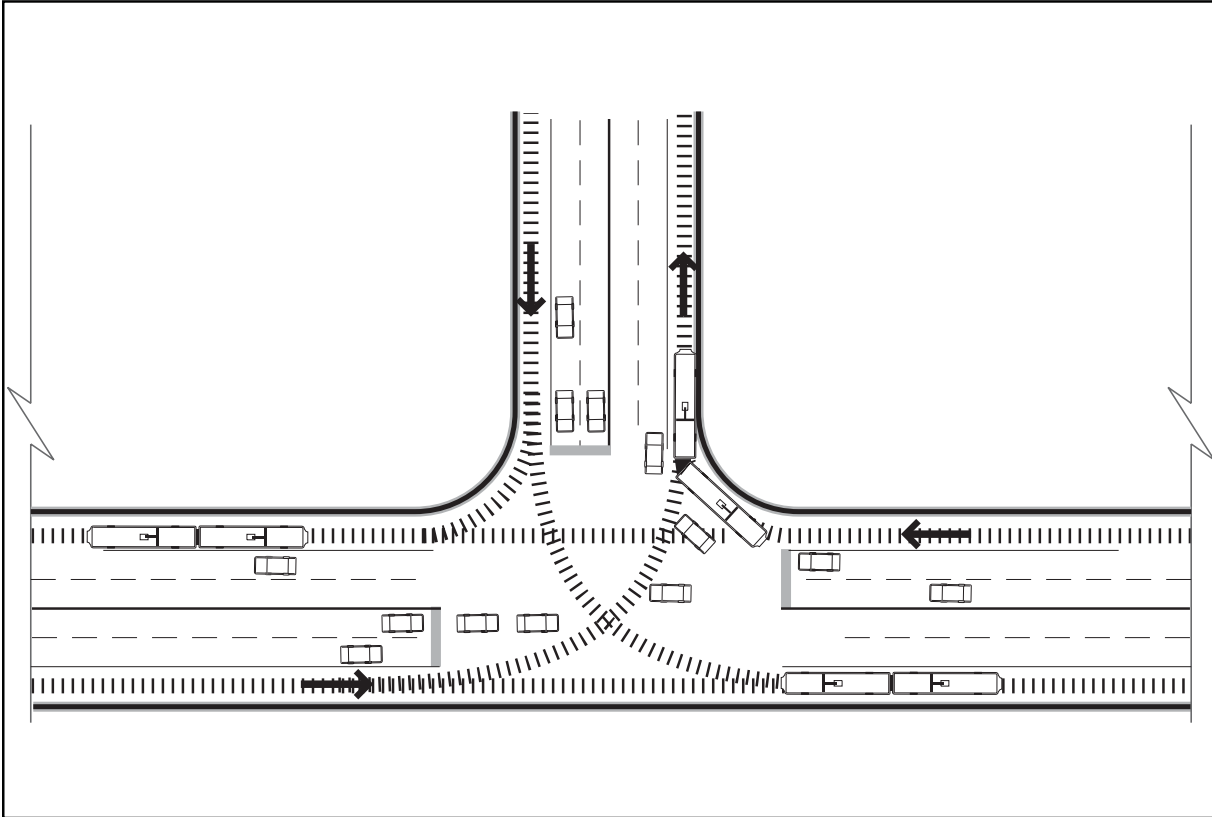
**Figure 18** 4-Way Intersection – Streetside Track Configuration



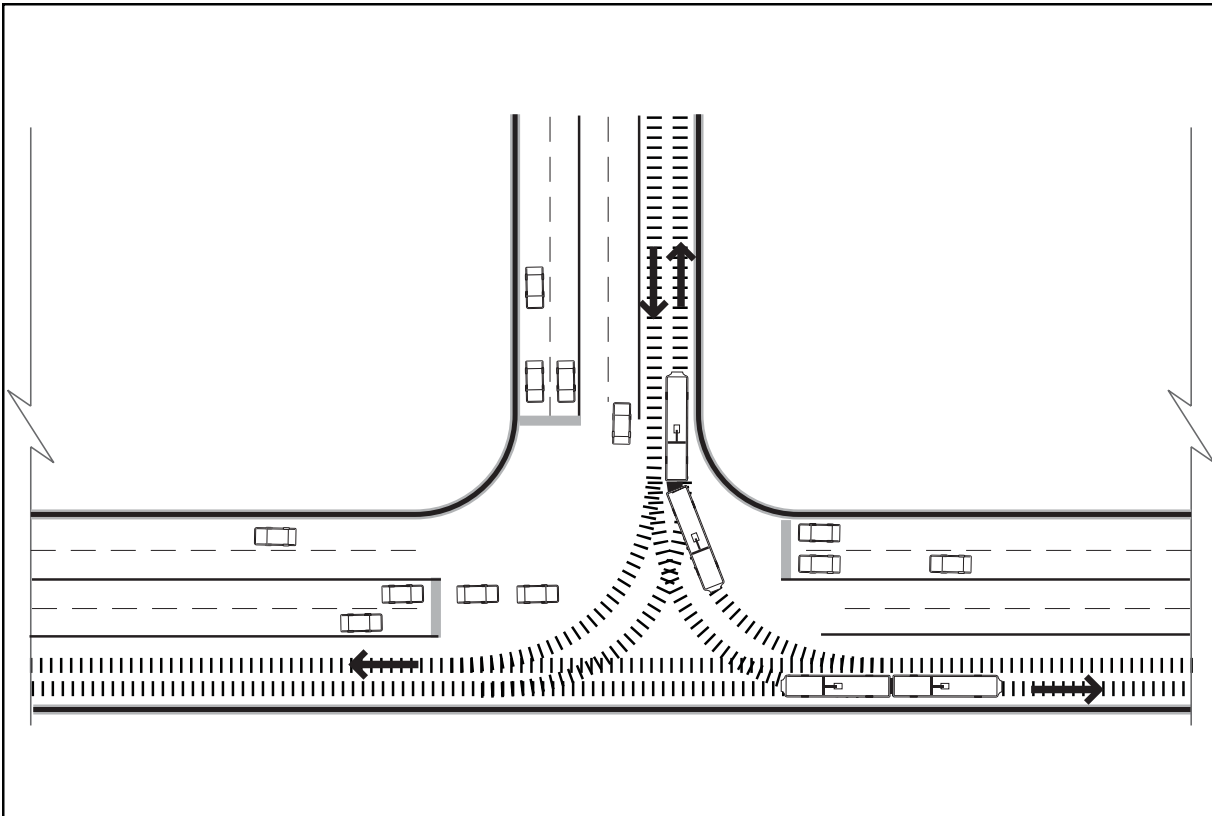
**Figure 19** 3-Way Intersection – Center Track Configuration



**Figure 20** 3-Way Intersection – Single Track Configuration



**Figure 21** 3-Way Intersection – Streetside Track Configuration



## 6. STATION LOCATION

LRT stations are the primary interface between the riders and the system. Stations need to be attractive, well designed, and above all, well located and placed to provide convenient and easy access.<sup>6</sup>

VTA LRT station placement guidelines are as follows:

- In general, stations shall be located every 0.75 to 1.00 mile. Specific station placement shall be based on planning studies that identify the location of key activity generators along the corridor and/or demand at particular locations along the corridor.
- Stations shall be located in close walking distance to, if not directly serving, major trip generators, such as civic and employment centers, downtown business districts, mixed-use districts and high-density residential areas, colleges and universities, and shopping centers.
- Stations shall be placed at locations with potential for development and densification to encourage transit use.
- Station usage forecasts shall satisfy ridership standards for new stations as outlined in Table 1.
- Specific station location shall depend on surrounding safety conditions and physical constraints.
- Where a station is to be located at an intersection with transit signal priority (TSP), the stops shall always be located at the far side.
- Stations shall be provided in locations with sufficient ROW for related facilities

and amenities, including passenger shelters, benches, bike storage, lighting, poles, informational signage, and trash receptacles.

- Station locations shall allow for full ADA compliance.

## 7. STATION AND FACILITY DESIGN

Stations provide riders with a sense-of-place and permanence, and create a link between their trip and their community. Although placement and location is a paramount issue, a station must also be well integrated into the surrounding areas, well designed, large enough to meet peak capacity demands, easily accessed, attractive, comfortable, and safe. Amenities such as real-time passenger information systems, route maps, transfer connection information, and ticket machines add to the functionality and usefulness of the station. Figures 22 and 23 show the different station designs based on the surrounding communities.

The physical design of LRT stations, including platform length and width, location of vertical transport, shelters, information signs, and ticket machines, is based on, among other aspects: (i) the expected demand during the peak; (ii) the maximum operable length of trains serving the station; (iii) the role of the station in the network (whether it is a origin/destination, terminal, or transfer station); (iv) the level of connectivity to other transit modes; (v) surrounding development and community themes; and (vi) the potential for station expansion and growth.

Recommended guidelines for station and facility design are detailed in Table 7.

<sup>6</sup> Local jurisdictions that proactively work to improve the public perception of transit and access to transit stations shall receive priority considerations for service improvement over jurisdictions with competing opportunities (i.e. similar ridership and operability) or proposals that haven't worked proactively.

**Table 7** Recommended VTA Station and Facility Design Guidelines

Station and Facility Design Element	Recommended Characteristics
Shelter Design and Related Amenities	<ul style="list-style-type: none"> <li>• Stations shall consist of typical amenities as currently provided – shelters in both directions, benches, static and real-time passenger information panels, passenger signage, ticket machines, ADA accessible ramps, and other typical amenities. Figure 24 shows some amenities that are available at VTA's LRT stations.</li> <li>• Shelters shall be designed according to CDT Manual specifications such that they: (i) match with surrounding land uses and architectural design features to reflect the unique character and features of the community; (ii) provide appropriate transit information to passengers; and (iii) are oriented towards pedestrian movements and accessibility.</li> <li>• Shelters shall be designed to meet all ADA requirements.</li> <li>• Shelters shall be designed to meet peak loading volumes in both directions. Figure 25 shows the high demand at stations during peak periods.</li> <li>• Bicycle parking is required at all stations per VTA's adopted Bicycle Plan. Bike rack and locker design, placement and number of racks shall comply with the Bicycle Technical Guidelines.</li> </ul>
Platform Designs	<ul style="list-style-type: none"> <li>• Bi-directional stations shall adopt platform couplets (either center boarding or side boarding) for bi-directional boarding, whenever possible. In cases where this is not possible (a narrow road, for instance), directional stations shall be offset, so long as safe operations can be maintained and pedestrian access is not compromised. Figures 26 and 27 show examples of bi-directional platforms.</li> <li>• Depending on demand and existing ROW, stations shall adopt center platforms, to the extent possible, to reduce facility and amenity duplication and lower capital costs.</li> <li>• Platforms shall be sufficiently long to accommodate a single three-car train.</li> <li>• Platforms shall be wide and spacious enough for peak passenger flows and queues.</li> <li>• Platforms shall provide level boarding.</li> </ul>
Track Layout (discussed earlier)	<ul style="list-style-type: none"> <li>• All terminal (end-of-line) stations shall have double tracks.</li> <li>• All terminal (end-of-line) stations shall have tail tracks to provide sufficient storage to meet the LRT systems operational needs. Figures 8 through 12 illustrate track layout schematics around various station types.</li> </ul>

**Table 7** Recommended VTA Station and Facility Design Guidelines (continued)

Station and Facility Design Element	Recommended Characteristics
Transfer Facilities	<ul style="list-style-type: none"> <li>Stations shall be physically integrated with major transit facilities nearby (such as heavy rail and commuter rail stations) to the extent possible to facilitate transfers. Figure 28 shows Mountain View Station, where LRT, local bus, and commuter rail services converge.</li> <li>Stations shall possess appropriate facilities for at-station transfers to local bus and BRT, as well as other modes, where appropriate. This may include:               <ul style="list-style-type: none"> <li>» Appropriate signage and transfer information.</li> <li>» Pedestrian crossings, transfer corridors, and walking paths.</li> <li>» Passenger queuing areas.</li> <li>» Loading/unloading curb space for buses.</li> <li>» Layover bays.</li> </ul> </li> </ul>
Accessibility and Urban Design	<ul style="list-style-type: none"> <li>Stations shall be well integrated into the community with supporting land uses and densities, and pedestrian-oriented and transit-friendly developments around stations.</li> <li>Stations shall have direct pedestrian and bicycle links to nearby communities.</li> <li>Stations shall possess sufficient facilities to meet Park and Ride demand at suburban stations where there is/are: (i) available space or accommodations (such as shared use agreements) for parking spaces; (ii) appropriate access roads; and (iii) demand for auto trips.</li> <li>Suburban stations having physical constraints preventing implementation of Park and Ride facilities shall provide Kiss and Ride facilities at stations where there is/are: (i) available curbspace and sidewalk width for pickup and dropoff zones; (ii) appropriate access roads; and (iii) demand for auto trips.</li> <li>Downtown stations shall also offer Kiss and Ride facilities, if demand warrants, and existing curbspace and sidewalk areas are not physically constrained.</li> </ul>

**Figure 22** Downtown LRT Station



**Figure 23** Suburban LRT Station



**Figure 24** Passenger Information and Benches at LRT Station



**Figure 25** Platforms Must Accommodate Peak Loads



**Figure 26** Bi-Directional, Center Platform LRT Station



**Figure 27** Bi-Directional, Side-Platform LRT Station





**Figure 28** Integrated LRT Transfer Station with Bus and Commuter Rail Connections (Mountain View)



## 8. FARE PAYMENT

To lower dwell time and improve operating speeds and corridor travel time, LRT systems often adopt proof-of-payment to minimize boarding times and, therefore, travel time delays at stations. Unlike some heavy rail and BRT 2 type systems, LRT is not designed for closed fare systems, where fare turnstiles control access to boarding platforms, as this

significantly increases per station capital costs. Given the typically lower ridership volumes on LRT versus heavy rail and some high-end BRT 2 systems, closed fare systems are currently not recommended for VTA LRT.

VTA shall adopt a proof-of-fare payment approach, which is consistent with current practice for VTA's LRT network. These fare payment systems are described in Table 8.

**Table 8** LRT Fare Collection Systems

Fare System	Characteristics	Applicability to VTA LRT Services
On-Board Payment	Passengers board a transit vehicle through the front door only and either deposit money in the farebox or flash their pass/ticket to the driver for verification. This significantly lengthens boarding times and introduces additional delay into the trip. This system requires that every LRT vehicle have a farebox, but does not require additional ticketing infrastructure at stations.	Not recommended for LRT due to generated dwell time and delay.
Proof-of-Payment	Current practice for the VTA LRT system, where tickets are pre-purchased at stations or in booklets prior to boarding the vehicle (Figure 29 shows a ticket machine at a VTA LRT station). Roving inspectors check riders and fine those that are traveling without valid tickets or passes. This requires ticketing machines at all LRT stations. The advantage of this system is that dwell time and delay is minimized at stations.	Recommended for new LRT lines due to lower capital costs than closed fare system. This approach is utilized by existing VTA LRT lines.
Closed Fare System	Similar to what is done for some heavy rail and high end BRT 2 systems, a closed fare system adopts faregates or turnstiles at all stations to control access to the boarding areas. This approach requires significant infrastructure investment at every station. The advantage over proof-of-payment systems is that fare payment is assured, while dwell time and delay is reduced at stations.	Not recommended for new LRT lines due to high capital costs.

**Figure 29** Station Ticket Machines for Proof-of-Payment



## 9. OPERATING PLAN

An operating plan describes how a particular transit service shall be operated. It includes specifics on the type of route, the hours of service provided, and the stop spacing. All new lines shall include the development of operating plan scenarios as part of the planning process. LRT operating plans for VTA shall consist of, at a minimum, the following:

**Table 9** LRT Operating Plan Details

Aspect	LRT Operating Plan Details
Route Type/Structure	All-stop service on established corridors serving major generator nodes. Express routes shall be instituted if demand warrants and passing tracks exist.
Span of Service	6:00 AM to 10:00 PM — may be extended for special events or on weekdays for commuters
Operating Period	Monday through Sunday
Minimum Headways	5-10 minutes in the peak, 15 minutes in the off-peak, and 30 minutes at night.
Minimum Average Operating Speed	~25 mph
LRT Station Spacing	0.75-1.00 miles (on average) – may be shorter to serve key activity nodes
Operating Coordination with Other Transit Providers	Local feeder bus and BRT coordinated to arrive prior to scheduled LRT departures and conversely these routes depart after scheduled LRT arrivals. Especially important during the off-peak, when service is less frequent.
Fares	Consistent with VTA fare policy
Systems Integration Plan	Staff, vehicle, and funding requirements forecasted and analyzed versus existing resources and available funding. New lines physically and operationally integrated with existing network to provide seamless and well-timed transfer opportunities.
Operating Cost and Fare Revenue Assessment	Objective is to obtain a 20 to 25% farebox recovery ratio on the new lines or segments, as this is the Board approved goal. For discrete new LRT lines, operating cost and fare revenues assessed versus performance on existing LRT lines. For new extensions of existing LRT lines, performance of the extended segments assessed versus that on the original LRT segment.

## 10. VEHICLE CHARACTERISTICS

LRT systems in North America deploy a variety of electric catenary vehicles for service, with varying lengths, looks, and configurations. For LRT services operated by VTA, a standard 88.5-foot boxy articulated vehicle is deployed. The vehicles may be joined with up to two additional cars to form a

three car train consist. All VTA LRT vehicles are low-floor and have four sets of doors on each side for both alighting and boarding. Fare is on a proof-of-purchase basis and no cash is exchanged on the vehicles. Figure 30 shows a typical VTA LRT single-car vehicle, while Figure 31 shows a double-car vehicle.

Table 10 Typical LRT Vehicle Characteristics	
Aspect	Recommended Characteristics
Vehicle Type	Bi-directional, articulated vehicles
Vehicle Length	Standard (88.5')
Floor Height	Low floor (14" above pavement)
Seating Capacity	~65 (single car consist)
Seating + Standing Capacity	~230 (single car consist)
Train Consist	Up to three cars
Boarding/Alighting	Doors used for boarding and alighting
Propulsion System	Overhead catenary
Branding	Matches standard VTA branding
Bicycle Racks	Compliance with VTA Bicycle Policy required

Figure 30 VTA LRT Vehicle (Single Car Consist)





**Figure 31** VTA LRT Vehicle (Two Car Consist)



## 11. SPECIALIZED BRANDING/ MARKETING

LRT vehicles and stations, as well as marketing materials, shall be emblazoned with the traditional VTA color schemes and logos. Unlike BRT services, LRT vehicles and facilities are not branded differently than conventional VTA services.