overcome that problem, but that may not be a concern if transit operations are fairly consistent on the intersection approach.

An "area" detection system (e.g., using GPS to continuously track buses through the roadway network) provides better information to the TSP system. A "zone" system is a smaller version of an area system, limited to the immediate approaches of the intersection. When the system detects a bus in the zone, the system alerts the controller that priority is needed.

In any case, the detection system must be tied to a bus schedule/route database to determine if a particular bus is delayed and actually requires signal priority. The detection location must be far enough in advance of the signal that there is time to adjust the signal timing and allow the bus to approach the site without dropping speed and momentum. This distance will vary according to the operational speed of the road and the technology used.

After a bus is detected, the bus detection system must communicate its presence to the traffic signal controller. If the signal is in a green phase, the controller typically will extend the green phase until the bus has passed. If the signal is showing red, the controller will truncate the green on the cross street and move to green on the bus approach as early as possible. Changes are limited by minimum length for cross-street pedestrian phases. The cycle length may change or selected phases skipped to accommodate the bus.

If the signal is located within a progression, any transit priority changes should be designed carefully so as to maintain the integrity of the progression. In a heavily traveled corridor, the benefits of maintaining signal progression for general traffic may outweigh the benefits of providing signal priority to buses that require independent operations.

It is desirable to install an "exit detector" immediately downstream of the signal, to register the passage of the bus and advise the signal controller to return to "normal" phasing. This minimizes the delay imposed on other traffic. If there is no downstream detector, the signal controller should be set to return to "normal" phasing after a specified period.

5.8.1.6 Communications System

Communications links between the various TSP elements are important but may have little impact on infrastructure design. If the communications system is based on radio or wireless links between the bus and the control center or between the bus and the traffic signal controller, the issue is more one of system design and electronics, rather than roadside infrastructure. If the communications system is based on vehicle detection by in-pavement loops or pole-mounted beacons, then the specific design parameters for those technologies must be followed.

5.8.2 Passenger Information Systems

If buses are tracked throughout the roadway network, or even on just one street/route, the information provided to the bus operator also can be provided to passengers at stops. Information also can be disseminated on the Internet, monitors in retail/office centers, closed-circuit television, telephone, cellular (mobile) telephone, pagers, and other media.

The most common means of providing real-time passenger information at bus stops is to display the anticipated time of arrival of the next bus on an illuminated sign (Figure 5-56). Signs may be elaborate or

Figure 5-56. Real-Time Passenger Information

simple, and can use various technologies. For a stop hosting just one route, a simple "countdown to next bus" display is adequate. For a stop used by several express and local routes, a multi-line display may be needed that details the next buses on each route and their destinations, or the order of arrival of the next four or five buses. A multi-line display is particularly useful if buses tend to arrive in platoons or so closely spaced that passengers have a hard time picking up the route numbers of following buses. If passengers know the order of arrival, they can move to an appropriate spot on the platform to board.

If the display is a countdown type (e.g., "Next Bus in 4 Minutes"), there is no need for a clock display as well. If the display shows the anticipated arrival time (e.g., "Route 324 at 4:42"), a system-synchronized clock display should also be provided.

Passenger information displays can take many forms. They can be attached to a pole at the stop, incorporated within a bus shelter, or be in a stand-alone kiosk. The displays should, if possible, be located upstream of and oriented toward the stop, so that a waiting passenger can view the sign at the same time as seeing an approaching bus.

Designers should carefully consider the requirements of visually impaired customers. The size, color, shape, and brightness of the information displays in all weather conditions (especially full sunlight) should be tested in the field before committing to a particular style or technology. Designers should consider providing a supplementary audio loop for visually impaired users. See "Building a True Community—Final Report" (*4*) for more information.

Another key consideration is protection from vandalism. Displays should be enclosed in a protective case and located high, out of direct reach of vandals. Designers may consider monitoring and videotaping signs and stops by closed-circuit television.

Signs may be turned off overnight or left on with a note to the effect that "Service Resumes at _ a.m."

The decision to use the signs and to prioritize their implementation at locations within a system or corridor will be a function of:

- Passenger needs;
- Funding;
- Cost of acquisition and maintenance; and
- Transit system image-building/marketing.

Real-time passenger information systems can be implemented in coordination with other system upgrades (for example, new bus shelters or a BRT system). Opportunities may exist for cost reduction or quality improvement through commercial sponsorship, particularly with respect to using the signs for advertising messages. If the signs are used for marketing, the primacy of their intended use for transit information must not be affected.

5.8.3 Other ITS Provisions

A wide range of ITS applications emerging in the United States and abroad could influence roadside design for bus operations. Some applications are safety-oriented, such as warning of an approaching bus at a stop or busway intersection or guidance technologies built into a busway to improve vehicle and driver safety. Most such provisions are targeted at system performance, efficiency, and communication between end-users and operations management. For example, a growing number of regions are adopting "511" information systems which provide a wealth of information in real-time for a wide range of transit and transportation services. ITS provisions can promote improved service reliability, schedule adherence, dispatcher monitoring, and enhanced passenger communication.

Some accepted communication strategies that provide schedule updates at transit stations, for example, are now being delivered externally to personal computers, cell phones, personal digital assistance devices, and other devices targed at helping potential and regular transit patrons make informed choices about specific transit services and their status. The specific application is likely to require some form of in-vehicle and roadside detection or monitoring capability which, in turn, can be relayed through various channels. Technology is changing rapidly, so no specific guidance is presented in this chapter. The goals and objectives of each project and service likely will dictate the unique ITS needs and provisions for a specific street or roadway along a corridor.

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6 Light Rail and Streetcar Facilities on Streets and Highways

In This Chapter:

This section provides guidelines for light rail and streetcar facilities within arterials and highways. It covers operations in mixed traffic, in reserved lanes, and in segregated rights-of-way, and for shared-bus facilities in separate transit alignments. The guidelines cover roadway design, traffic controls, and stations. More thorough guidelines for the design of light rail transit (LRT) facilities in segregated rights-of-way can be found in various references (*4, 9*).

Light rail transit is defined as a metropolitan railway system characterized by its ability to operate single cars or short trains along shared rights-of-way at ground level, on aerial structures, in subways, or on streets in exclusive rights-of-way, and to board and discharge passengers at track or floor level. (*11*)

A streetcar is an electrically powered rail car that typically runs singly in mixed traffic on a track on city streets. Its motive power is derived through a trolley (a wheeled device running on top of wires). In earlier times, "streetcars" referred to vehicles in local urban service, and "trolleys" reached points beyond the built-up area. In Europe, the streetcar is referred to as a tram.

6.1 HISTORICAL CONTEXT

Light rail transit is reminiscent of the streetcar and interurban electrical railway systems that operated throughout the United States and Canada a century ago. Most of these systems were replaced by buses before World War II. Early examples of light rail lines include the Boston Green Line system, the Shaker Heights Rapid Transit, and the Pittsburgh South Hills Rail Lines that

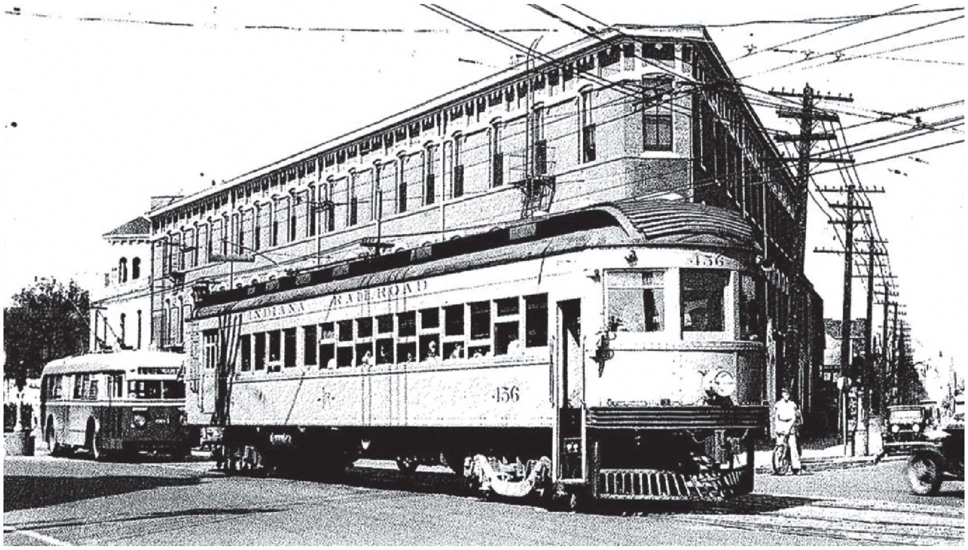

Figure 6-1. Street Running Interurban, Indiana (1937) (*2*)

are still in service. Many other cities once had some form of light rail lines—Los Angeles, Milwaukee, St. Louis, Portland, and Seattle are just a few examples. Most cities with populations of over 100,000 in the 1920s had streetcars in operation.

The interurban electric railways extended beyond cities into outlying communities. Most accommodated passengers with little freight service. Some were streetcar extensions into the surrounding countryside; others were built to railroad standards and became high-density, high-speed carriers. Most remaining systems, however, served commuter markets by 1940.

Most interurban railroads and streetcar lines operated on city streets, but a few had elevated or subway access into the city center. They operated in the centers of streets within built-up areas (Figure 6-1) and along the side of the road in outlying areas (Figure 6-2).

Rail cars mainly ran in the center of streets in mixed traffic. In Philadelphia, for example, a single track was placed in the center of 7.8-m (26-ft) streets, and in Chicago the tracks were placed in streets as narrow

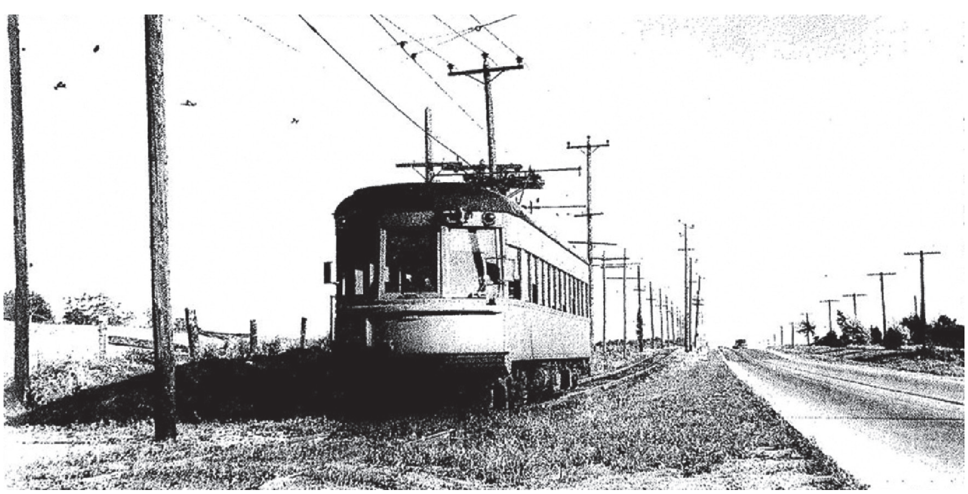

Figure 6-2. Side Running Streetcar, Indiana (1930s) (*2*)

Figure 6-3. Street Loading 63rd Street, Chicago, Illinois (1951) (*5*)

as 11.4 m (38 ft). Streetcars turning right or left conflicted with automobiles, since there was no special traffic signal protection.

Passengers boarded cars from the street (Figure 6-3). Safety islands were provided where space permitted (Figure 6-4). Today, a few large cities where long-established streetcar lines run still have this type of

Figure 6-4. Safety Island, Irving Park Road, Chicago, Illinois (1944) (*5*)

passenger boarding, but these conditions are not possible to implement today. The growth in motor vehicle traffic since the end of World War II has made it increasingly difficult for streetcars to operate reliably in mixed traffic and for passengers to board and alight from streetcars. Moreover, since 1990, at least 2.4 m (8 ft) clear width must be provided to meet ADA requirements.

Most street railway lines were converted to bus operations by the 1960s. Many of the remaining lines in Boston, Cleveland, Newark, Philadelphia, and San Francisco had, or were given, exclusive right-of-way access to central business districts.

LRT has become increasingly popular as a practical application of rail transit. LRT is a hybrid of streetcars and interurbans that can operate on a variety of rights-of-way, from on-street to grade-separated. It may use shared or exclusive rights-of-way, high- or low-platform loading, and single cars or multi-car trains. As with the interurbans before them, LRT vehicles can mix local service in city centers with express service to peripheral communities and suburban activity centers. Several light rail lines operate over former interurban rights-of-way (*12*).

Many of the LRT systems developed since 1970 have parts in a city center operating in-street, parts operating in semi-exclusive rights-of-way, and exclusive parts built in abandoned or underused freight railroad rights-of-way. In exclusive operation, conflicts with pedestrians and other motor vehicles are less frequent, average speeds can be higher, and station spacing tends to be more distant. LRT can also operate in a semi-exclusive environment within the median of a wide roadway. In this configuration, cross-streets present potential conflicts. In this setting, there are no other motor vehicles in the LRT vehicle's path between cross-streets, thus enabling faster and safer transit operations.

Light rail lines typically use articulated vehicles powered from an overhead catenary. Power is drawn from the overhead electric lines by a trolley or pantograph. LRT has "light" capacity and vehicle weight, as compared to heavy rail rapid transit which functions entirely in exclusive guideway.

6.2 GENERAL PLANNING AND DESIGN GUIDELINES

Planning and design guidelines for light rail transit on streets and highways generally are similar to those for buses. Facilities for each can be located curbside or in the center of streets. Vehicles can operate in mixed traffic, reserved lanes, or segregated running ways. Far-side stops are required for transit signal priority, as they enable station platforms and left-turning motor vehicles to share the same roadway envelope. Station platform berths are governed by ADA requirements.

Since LRT operates on fixed track, maneuverability is inhibited around motor vehicles blocking the track. LRT vehicles are usually longer than buses and run in two- or four-car train-sets. They require larger clearances and turning radii, longer stopping distances, and they must be protected from conflicting traffic whenever they turn right or left. Their proper design and accommodation can enable a community to use its limited street space for several modes and purposes, and to improve the travel options of its citizens.

This section outlines general planning and design considerations and guidelines. It identifies the need and applicability of LRT, and describes the various types of LRT running ways. It presents vehicle dimensions and geometric design requirements, basic track design considerations, and ITS applications.