INTRODUCTION

Presented in this third chapter are the criteria that were used to locate and design bus stops, prototypical bus stop designs that were used in laying out the proposed bus stops, examples of bus shelters from other locations, and specific bus/rail interface improvement plans for each of the six Pasadena to Azusa stations.

BUS STOP LOCATION AND DESIGN CRITERIA AND PROTOTYPES

Bus Stop Location and Design Criteria

As part of the Bus Interface Project, a technical memorandum was prepared that compiled criteria for locating bus stops and preparing concept designs for the safe and convenient interface between these bus stops and the Pasadena to Azusa Metro Gold Line Foothill Extension stations (*Task 4.1 Design Criteria and Prototypical Bus Stop Treatments Technical Memorandum,* prepared June 8, 2010). Since the Metro Gold Line Foothill Extension Construction Authority (Construction Authority) will not be the implementing agency for the bus stop improvements, the criteria, guidelines, and prototypes contained in the technical memorandum are intended to be sufficiently generic so that they can be further refined by each city and/or bus operator for detailed design under their supervision.

Contained in the Design Criteria Technical Memorandum are excerpts from the following documents:

- Federal Transit Administration (FTA) Transportation Cooperative Research Program (TCRP) Report 19 – Guidelines for the Location and Design of Bus Stops, 2007
- Los Angeles County Metropolitan Transportation Authority (Metro) Transit Service Policy Guidelines, November 2007
- Metro Rail Design Criteria, January 2010
- Omnitrans Bus Stop Design Guidelines, October 2006
- California Building Code, 2007 edition

Bus Stop Location Criteria

Recommendations regarding bus stop locations and the capacity of each bus stop are based on bus stop and layover space requirements identified in the technical memorandum. Positioning and sizing of bus stops are based on specific criteria developed or adopted by the appropriate public agencies and transit operators that will be servicing the bus stops. For the purposes of this project, bus stop location and design criteria are consistent with those adopted by Metro.[1] These guidelines also incorporate by reference a report published by TCRP that includes specific details and recommendations regarding bus stop locations, spacing, and design guidelines.[2] The TCRP guidelines have also been adapted by the FTA. Standards and guidelines presented in these two documents are used as the basis for recommendations presented herein.

Three primary criteria were used in the process of determining bus stop locations:

- Convenience and Safety – Route of Access between bus stop and light rail station platform access points
- Spacing – Distance between bus stops
- Capacity – Number of buses that should be accommodated at stops located adjacent to the light rail stations

Parameters and guidelines used for each criterion are summarized below.

[1] Metro, Transit Service Policy Guidelines, November 2007

[2] TCRP Report 19 – Guidelines for the Location and Design of Bus Stops, 2007

Convenience and Safety

Identifying specific locations for bus stops adjacent to the six Pasadena to Azusa light rail stations involved coordination with staff from Metro and Foothill Transit, as well as with staff from each of the five cities located along the Pasadena to Azusa alignment. Discussions with these transit agencies and local jurisdictions focused on making potential transfer between bus and rail services (as well as the reverse) as simple and safe as possible within each station area. Specific considerations included the following:

- Minimize distance traveled – Bus stops have been located as close as possible to the pedestrian access points for light rail station platforms in order to minimize the amount of time and distance involved for riders to make the transfer between modes.
- Minimize street crossings – When possible, bus stops have been located on the same side of the street as the light rail station to minimize the need for riders to cross streets when traveling between bus stops and light rail station platforms.
- Safety – The paths traveled by riders between the bus stop and the light rail station platform were selected to provide a safe path of travel, avoiding as much as possible conflicts with automobile, bus, and light rail and other train traffic.
- Minimize impacts to traffic – Bus stops have been located to minimize potential impacts to automobile traffic traveling in the vicinity of light rail stations. Bus stops are located off-street or within bus turnouts where feasible. On-street bus stops have been located to minimize impacts to parallel automobile traffic.
- Minimize impacts to bus travel times – Bus stops have been located to minimize adding to on-board passenger bus travel times. As much as possible bus locations seek to minimize circuitous travel routes, unsignalized turning movements, and diversions from the main bus routing.

Bus Stop Spacing

Determining spacing between individual bus stops is important for several reasons and typically involves finding balance between providing convenient walking access to bus lines by individual passengers while minimizing impacts to bus travel times and speeds that may result from a high frequency of stops. Too many stops can increase travel times and discourage ridership. Attracting riders and providing the right number of stops increases the accessibility of the transit service and minimizes the distance that potential riders must walk to access a bus stop.

To address these competing objectives and to ensure that various types of bus services operate as efficiently as possible, Metro and other bus operators have guidelines related to bus stop spacing for specific types of bus services. Table 3-1 summarizes the guidelines for bus stop spacing as adopted by Metro.

TABLE 3-1: BUS STOP SPACING GUIDELINES

Service Type	Population Density (Persons per Square Mile)			Route Average
	Over 20,000	10,000 to 20,000	Under 10,000	Distance Between Stops (miles)
Metro Liner	1,500 to 4,000 ft	1,500 to 4,000 ft	2,600 to 5,200 ft	1
Express	500 to 2,600 ft	1,500 to 4,000 ft	2,600 to 5,200 ft	1
Rapid Express	800 to 1,500 ft	1,000 to 4,000 ft	2,600 to 5,200 ft	1+
Rapid	800 to 1,500 ft	1,000 to 4,000 ft	2,600 to 5,200 ft	0.7
Limited	750 to 1,000 ft	750 to 1,500 ft	1,000 to 4,000 ft	.5
Local	500 to 800 ft	500 to 1,000 ft	500 to 1,300 ft	.25
Shuttle	TBD	TBD	TBD	TBD

Source: Los Angeles County Metropolitan Transportation Authority, Transit Service Policy Guidelines, November 2007

The six Pasadena to Azusa light rail stations will primarily be served by local bus and shuttle services. However, stop spacing recommendations presented below would not preclude operation of other bus service types identified in Table 3-1.

Bus Stop Bay Capacity

The third criterion in determining bus stop locations and size addresses the appropriate capacity of bus stops to accommodate the anticipated number of buses that would be using the stop during peak-service time periods. Table 3-1 gave the total number of buses anticipated to service the stops located closest to the Pasadena to Azusa stations. There are two main categories into which these buses can be placed. The first category includes buses that are stopping adjacent to a light rail station only to board and disembark LRT passengers. These buses would be stopping for short periods of time (typically only as long as it takes to board and disembark passengers) before continuing their route. In these cases, several bus routes can typically share the same space within a single bus stop. Table 3-2 presents guidelines for the bus bay size requirements for an individual stop based on the frequency of service.

TABLE 3-2: BUS STOP BAY SIZE RECOMMENDATIONS

No. of Buses Per Peak Hours	Capacity Required (Bays) When Service Time at Stop is				
	10 Seconds	20 Seconds	30 Seconds	40 Seconds	60 Seconds
15	1	1	1	1	1
30	1	1	1	1	2
45	1	1	2	2	2
60	1	1	2	2	3

Source: Transportation Cooperative Research Program, TCRP Report 19 – Guidelines for the Location and Design of Bus Stops, 2007

Initial Bus Stop Needs

The second category involves buses that will lay over adjacent to a particular light rail station. Buses stopping to lay over typically stop for durations of 10 to 15 minutes, allowing for short breaks for bus operators or shift changes between operators. Layovers typically occur at the terminus of an individual bus route. In these cases, a dedicated bus stop space or bay is usually required for each bus line, depending on the frequency of service for that individual bus line. Layover spaces are typically located completely outside of traffic lanes, either off-street in a bus bay or parallel to existing traffic lanes in a bus turnout or wide curb lane.

Using the recommendations presented in Table 3-2, bus stop capacity needs have been estimated for each of the Pasadena to Azusa stations by analyzing the bus frequency information presented in Chapter 2, Table 2-1. Table 3-3 summarizes the bus bay needs by station for the Gold Line opening year, based on existing bus service levels. The table identifies bus frequency at each bus stop at each Gold Line station, along with the corresponding bus stop capacity needs and layover space needs. The combined total of bus stops and layover positions is the need for each particular bus stop.

Future Bus Stop Needs

Estimating future bus stop capacity needs can be difficult as most transit agencies develop detailed service plans and route headway proposals only for short-term time periods (1-5 years). This short-term planning horizon allows agencies sufficient time for the acquisition of additional buses, if needed, and allows for flexibility to adjust service schedules to changing travel demand patterns. Even with these constraints, it is possible to make a conservative assumption regarding future bus service increases. Metro's 2009 Long Range Transportation Plan (LRTP) calls for substantial investments in expanding local bus services, both by Metro and by municipal operators, as well as by Foothill Transit.

TABLE 3-3: BUS STOP BAY NEEDS BY STATION (GOLD LINE OPENING YEAR)

Station	Bus Stop Location	Stop Designation	Peak Hour Bus Flow AM	Stops Needed	Layover Spaces Needed	Peak Hour Bus Flow PM	Stops Needed	Layover Spaces Needed	Total Bus Bay Capacity Required
Arcadia	WB Santa Clara Street	A	8	0	3	8	0	3	3 layover
	SB 1st Street (n/o Santa Clara Street)	B	2	1	0	2	1	0	1 stop
	NB 1st Street (n/o Santa Clara Street)	C	2	1	0	2	1	0	1 stop
	NB 1st Street (n/o Huntington Drive)	D	10	1	0	10	1	0	1 stop
	SB 1st Street (n/o Huntington Drive)	E	2	1	0	2	1	0	1 stop
	SB Santa Anita Avenue	F	5	1	0	5	1	0	1 stop
Monrovia	SB Myrtle Avenue	B	1	1	0	2	1	0	1 stop
	WB Duarte Road	C	1	1	0	1	1	0	1 stop
	EB Duarte Road	D	1	1	0	1	1	0	1 stop
	NB Myrtle Avenue	E	1	1	0	2	1	0	1 stop
Duarte	SB Highland (n/o Duarte Road)	A	5	1	0	4	1	0	1 stop
	NB Highland Avenue	B	5	1	0	4	1	0	1 stop
	SB Highland Avenue (n/o Business Center Drive)	C	5	1	0	4	1	0	1 stop
	WB Duarte Road	D	5	1	0	4	1	0	1 stop
	EB Duarte Road	E	2	0	2	2	0	2	2 layover
	EB Duarte Road	F	3	1	0	2	1	0	1 stop
Irwindale	WB Avenida Padilla	A	4	2	0	4	2	0	2 stops
Azusa-Alameda	EB Santa Fe Avenue	B	11	1	2	11	1	2	1 stop/ 2 layover
	NB Azusa Avenue	C	11	1	0	11	1	0	1 stop
Azusa-Citrus	WB Foothill Boulevard	A	6 - 7	1	1	11	1	1	1 stop/ 1 layover
	NB Citrus Avenue	B	8	0	3	8	0	3	3 layover

Notes:

- Stops identified as zero are locations where all buses utilizing this stop will be layovers.
- n/o stands for north of.

For the Year 2035 buildout condition, the following bus service improvements are assumed for the bus routes serving the Pasadena to Azusa stations. Again, these are conservative assumptions for service increases.

- Bus routes operating at 15-minute headways or less would maintain those service frequencies.
- Bus routes operating at 20- to 30-minute headways would change to operate at 15-minute headways.
- Bus routes operating at 35- to 60-minute headways would change to operate at 30-minute headways.

Table 3-4 identifies bus stop and layover, needs assuming the future growth in transit service frequencies identified above for the buildout condition (year 2035).

TABLE 3-4: BUS STOP BAY NEEDS BY STATION (BUILDOUT YEAR)

Station	Bus Stop Location	Stop Designation	Peak Hour Bus Flow AM	Stops Needed	Layover Spaces Needed	Peak Hour Bus Flow PM	Stops Needed	Layover Spaces Needed	Total Bus Bay Capacity Required
Arcadia	WB Santa Clara Street	A	11	0	3	11	0	3	3 layover
	SB 1st Street (n/o Santa Clara Street)	B	3	1	0	3	1	0	1 stop
	NB 1st Street (n/o Santa Clara Street)	C	3	1	0	3	1	0	1 stop
	NB 1st Street (n/o Huntington Drive)	D	14	1	0	14	1	0	1 stop
	SB 1st Street (n/o Huntington Drive)	E	3	1	0	3	1	0	1 stop
	SB Santa Anita Avenue	F	8	1	0	8	1	0	1 stop
Monrovia	SB Myrtle Avenue	B	4	1	0	4	1	0	1 stop
	WB Duarte Road	C	2	1	0	2	1	0	1 stop
	EB Duarte Road	D	2	1	0	2	1	0	1 stop
	NB Myrtle Avenue	E	4	1	0	4	1	0	1 stop
Duarte	SB Highland (n/o Duarte Road)	A	10	1	0	8	1	0	1 stop
	NB Highland	B	10	1	0	8	1	0	1 stop
	SB Highland (n/o Business Center Drive)	C	10	1	0	8	1	0	1 stop
	WB Duarte Road	D	10	1	0	8	1	0	1 stop
	EB Duarte Road	E	6	0	2	6	0	2	2 layover
	EB Duarte Road	F	4	1	0	3	1	0	1 stop
Irwindale	WB Avenida Padilla	A	8	2	0	8	2	0	2 stops
Azusa-Alameda	EB Santa Fe Avenue	B	14	1	2	14	1	2	1 stop/ 2 layover
	NB Azusa Avenue	C	14	1	0	14	1	0	1 stop
Azusa-Citrus	WB Foothill Boulevard	A	12	1	1	12	1	1	1 stop
	NB Citrus Avenue	B	12	1	0	12	1	0	1 stop

Notes:

- Using the criteria identified above, recommended bus stop locations for each Pasadena to Azusa station are identified.
- n/o stands for north of.
- Does not consider M270 diverted to Primrose Avenue.

Bus Stop Design

Figure 3-1 compiles elements and requirements that are either necessary or desirable features to include in the design of a typical bus stop. Clearances at the bus shelter and sidewalk are based on requirements in the California Building Code. Inclusion of the bus pad in the street is derived from Metro Design Criteria Civil Section 3.7.5 for bus stops adjacent to transit stations. The width is derived from the bus stop guidelines in the TCRP Report 19 – Guidelines for the Location and Design of Bus Stops. These standards are used by both FTA and Metro for their bus stop standards. The bus shelter features listed consist of items common in bus shelter and other features that could be included for sustainable design or advanced technology.

Prototypical Bus Stop Configurations

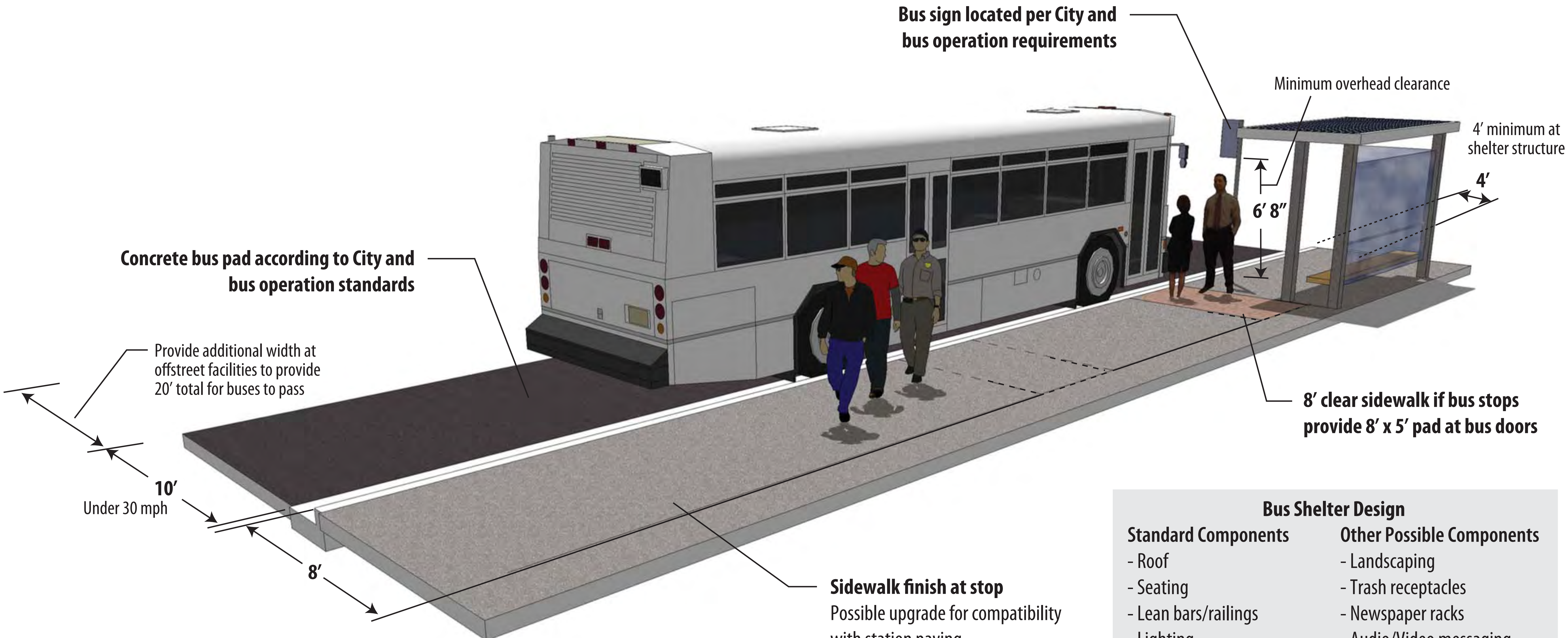
Various bus stop configurations were developed as prototypes or templates for applying to the potential bus stop locations at each station site to ensure that the design criteria contained in the FTA TCRP Report 19 would be met. There are four conditions that apply: a bus stop on the near side of an intersection (before crossing it)(see Figure 3-2), the far side (after crossing it) (see Figure 3-3), mid-block (Figure 3-4), and mid-block in a turnout to be out of the traffic lanes (Figure 3-5). The location of the bus stop relative to the corner for the "far side" case when the bus has made a left or right turn needs to be further away from the intersection than if the bus is traveling in a straight path.

A sawtooth arrangement is not shown since there are none proposed for the bus stops at the Pasadena to Azusa stations. There are standards by Metro and others that would be applicable if a sawtooth arrangement were found to be desirable for any of the proposed stations. The advantage of a sawtooth arrangement is in minimizing the curb length requirements for bus maneuvering. This, however, requires additional street or bus traffic lane widths.

Figures 3-2 to 3-5 enhance the visualization of bus stop impacts on the streets where they occur. Each figure shows the length along the curb required for the bus stop and what is required in approaching and leaving the bus stops. The curbs and crosswalks at intersections are shown with the clearances required from them. The mid-block turnout requirements do not include long acceleration and deceleration distances called for in the TCRP report, since these are applicable to bus turnouts on high-speed highways. Additionally, the long deceleration and acceleration distances required on highways are not typically available at the station locations. Street traffic, the need for on-street parking, and access to adjacent property would make their inclusion impractical and not always necessary because of the relatively slow traffic speeds.

Examples of some existing bus shelters in the corridor cities are shown in Figure 3-6. Examples of some innovative bus shelter prototypes that contain sustainable features such as solar power, recycled materials, and touch screen displays are shown in Figure 3-7. Additional sustainable features that could be incorporated into the design of the bus stops and walkways connecting the stops to the LRT stations are shown in Figure 3-8. These include sustainable approaches to lighting, benches, and other street furniture typically found at bus stops, as well as landscaping and drainage.

As depicted in Figure 3-6, another approach to bus shelter design is to mimic the Gold Line station canopies. A bus shelter design that mimics the Gold Line station canopies is one way to extend the station "branding." Bus stop continuity with the stations could also be achieved by extending pavement materials, colors, detailing of fixtures such as railings or trash receptacles and lighting, etc. Extending the station materials and/or detailing would provide for visual association and recognition of the bus stop as the one where the passenger transfers to the LRT.

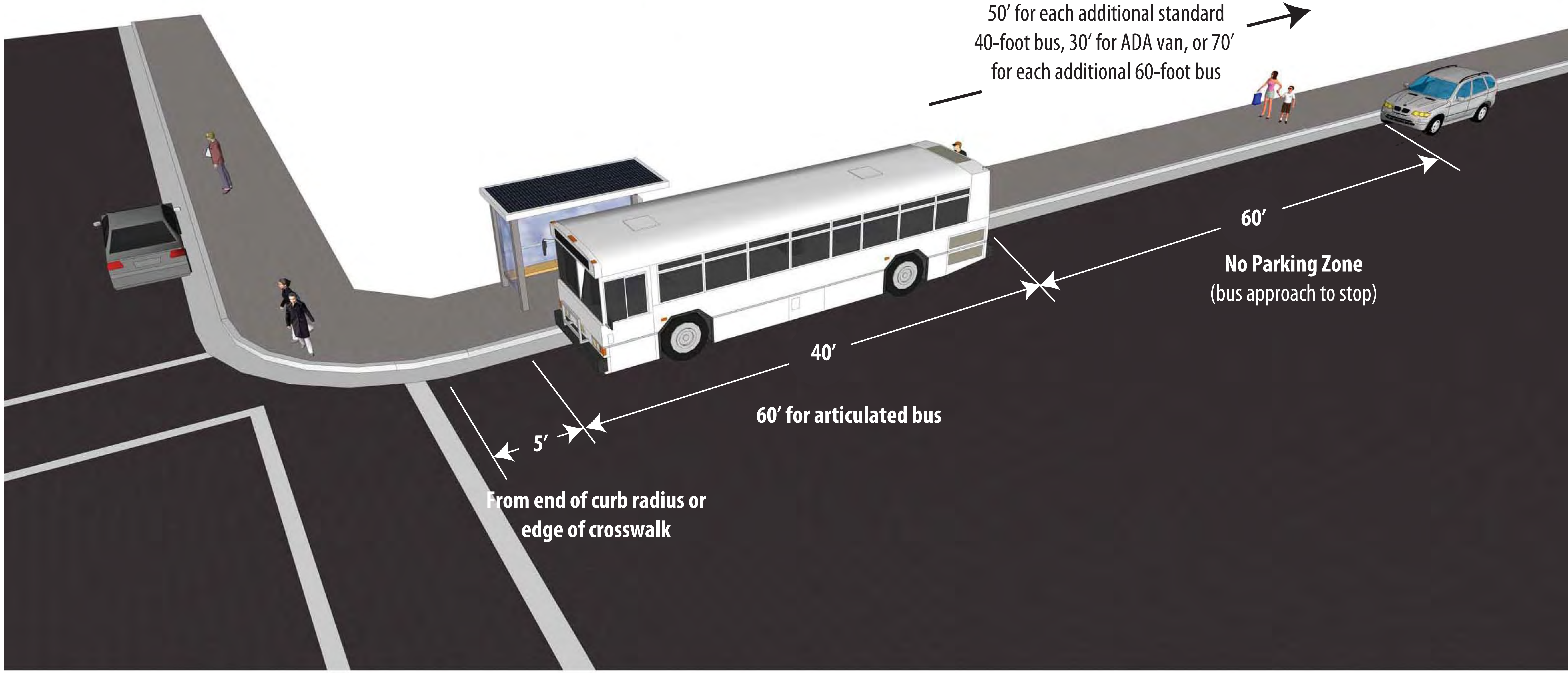


Bus Shelter Design

Standard Components	Other Possible Components
- Roof	- Landscaping
- Seating	- Trash receptacles
- Lean bars/railings	- Newspaper racks
- Lighting	- Audio/Video messaging
- Sustainable materials	- Photovoltaic power
- Pavement striping	- Wind panels
- Route map at shelter or bus sign pole	- Advertising panels
- Directional signage for LRT station	- Possible canopy design to match LRT station
	-WiFi

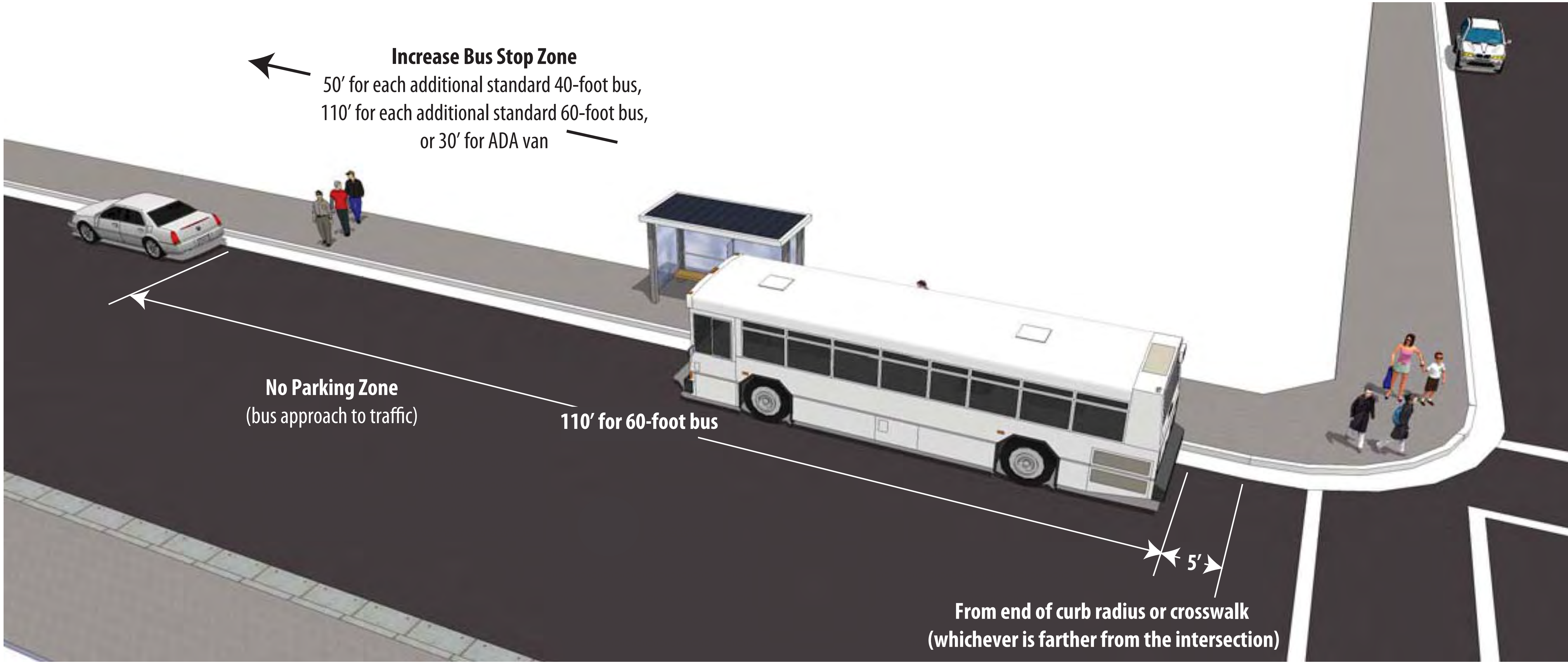
Note:
Dimensions shown are desired, but may need to be modified to fit actual conditions at each bus stop location.

Figure 3-1: Typical Bus Stop Design



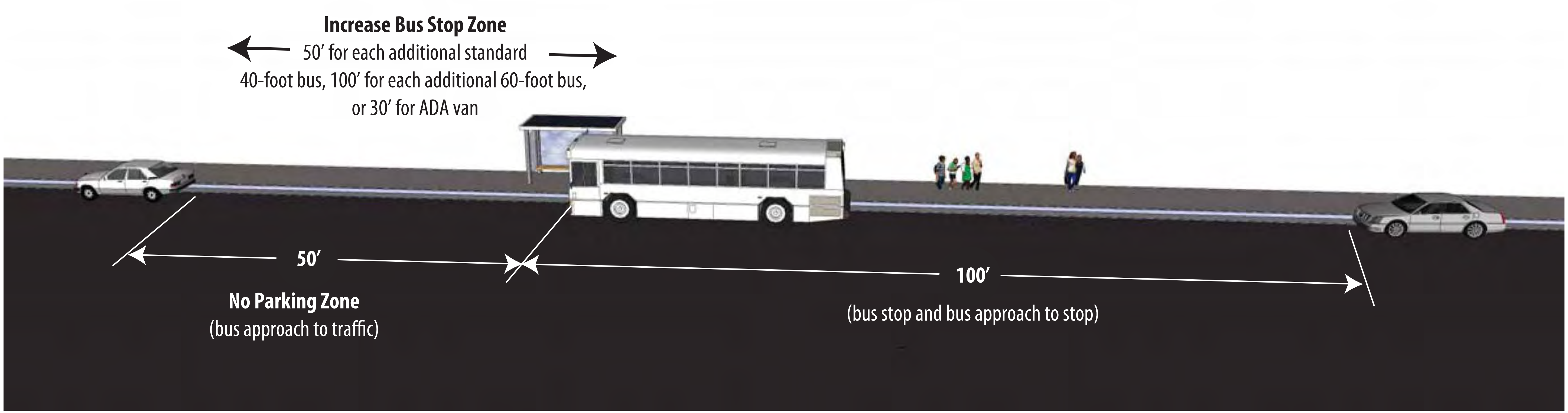
Note:
Dimensions shown are desired, but may need to be modified to fit actual conditions at each bus stop location.

Figure 3-2: Typical Near-Side Bus Stop



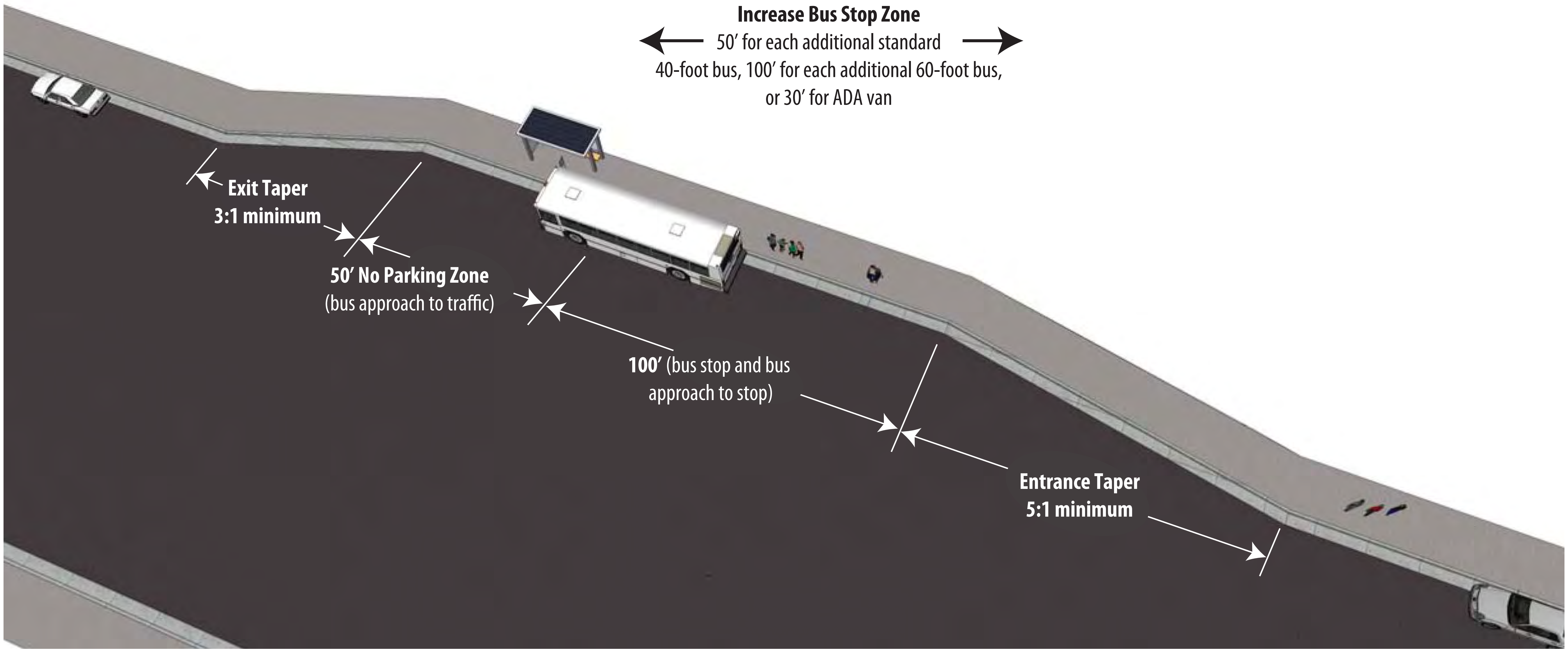
Note:
Dimensions shown are desired, but may need to be modified to fit actual conditions at each bus stop location.

Figure 3-3: Typical Far-Side Bus Stop



Note:
Dimensions shown are desired, but may need to be modified to fit actual conditions at each bus stop location.

Figure 3-4: Typical Mid-Block Bus Stop



Notes:
- TCRP Report 19 acceleration and deceleration lanes per traffic through speed not provided.
- Dimensions shown are desired, but may need to be modified to fit actual conditions at each bus stoplocation.

Figure 3-5: Typical Mid-Block Turnout Bus Stop

EXISTING BUS SHELTER & BUS STOP DESIGN ALONG FOOTHILL CORRIDOR

Examples at the left are samples of bus shelters found in the cities served. Passenger volumes may be larger due to train capacity than for a typical bus stop and a more substantial shelter may be appropriate. In addition, the stop may give a first impression of the community to transit riders.


Arcadia


Azusa


Azusa


Azusa


Duarte


Irwindale


Irwindale


Monrovia


Monrovia

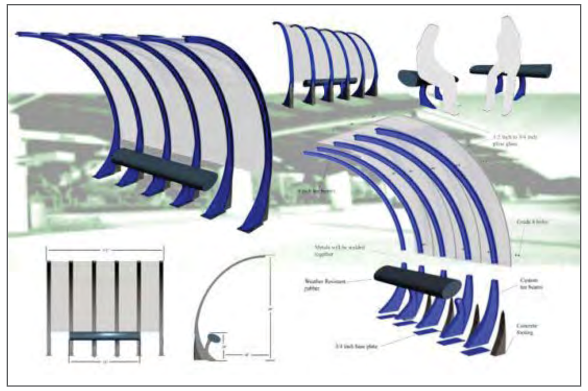

Monrovia


Monrovia

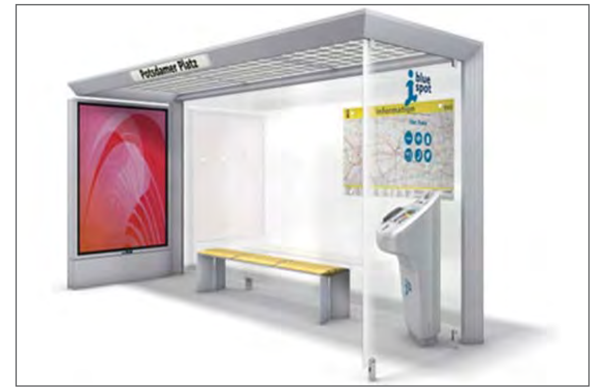

Example of shelter that mimics station canopies

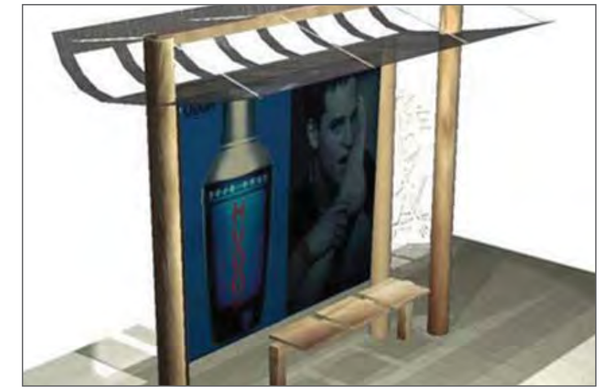
Figure 3-6: Bus Shelter Design Examples

RECENT DEVELOPMENTS IN THE DESIGN OF BUS STOPS AND SHELTERS

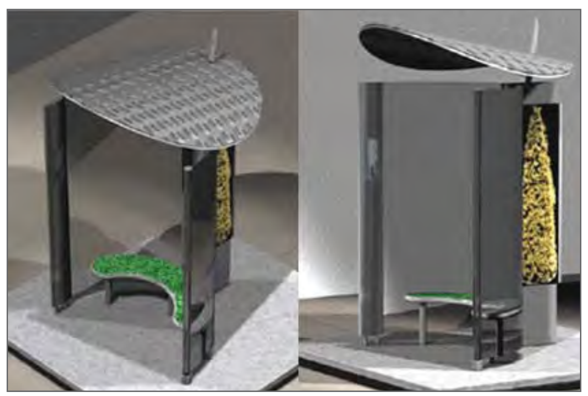

Rider Comfort


Ergonomics


Intelligent Bus Stop


Recycled Materials

Through public and academic design competitions and agency and municipality design contracts, innovative and unusual approaches to bus stop design have been developed worldwide. Many reflect thinking about how to incorporate sustainable design, alternative energy, and the newest communication and lighting technologies into the stops and shelters. Others address passenger comfort and providing relevant information.


Solar and Touch Display

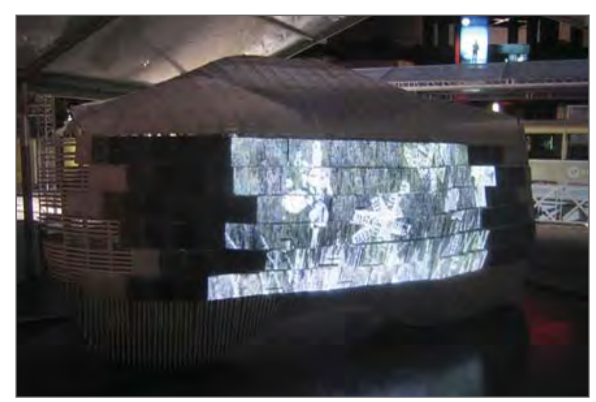

Solar Intercom, LED Lighting, and WiFi


Solar, CCTV, Audio, and WiFi


Sustainable Materials and Solar


Solar Cost-Efficient


Touchscreen Monitors Weather and Buses


LED Display Outside


Touch Screen Inside

Figure 3-7: Examples of Innovative Prototypes

SUSTAINABILITY

Weaving sustainable design components into the public realm when planning station areas will ensure not only resource conservation, but also provide another set of place-making opportunities.

Opportunities exist within station areas to employ bioswales, biofiltration planters, and permeable paving to infiltrate or cleanse storm water in the public realm before it reaches storm drains. Planting concepts can incorporate drought-tolerant and native plant species to minimize water use and maintenance. Energy savings can be achieved through the use of solar-powered and high-efficiency lighting and furnishings. Impacts of furnishings manufacturing and transportation can be mitigated by choosing locally made furnishings and materials with locally sourced, recycled, or sustainable harvested content. Furthermore, incorporating street trees and paving materials with high reflectivity can create shade and reduce the heat island effect of paved areas.

Cleanse/Infiltrate Storm water

Bioswale

- Capture, cleanse and infiltrate storm water runoff from street or building downspouts
- Water percolates into soil below

Biofiltration Planter

- Capture and cleanse storm water runoff as it flows through planter
- Cleansed water returns to storm drain

Permeable Paving

- Allows storm water to filter into the ground instead of carrying pollutants to the storm drain

Incorporate Drought-Tolerant and Native Planting

- To conserve water, provide urban habitat for local wildlife, visual appeal and shade, incorporate drought-tolerant and native planting

Use Solar-Powered and High-Efficiency Lighting and Furnishings

Solar Powered Recycling and Trash Receptacles

Solar Powered Lighting

LED High Efficiency Lighting

Solar Powered Recycling and Trash Receptacles

- Harness sun's energy to compact items, reducing trips needed to empty bins.

Solar Powered Lighting

- Off-the-grid; reduce reliance on energy; cost savings

LED High Efficiency Lighting

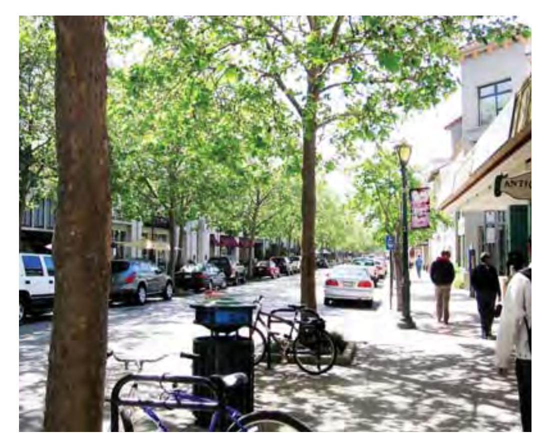
- Reduced energy needs and cost savings

Choose Locally Made Furnishings & Materials With Locally Sourced, Recycled, and Sustainably Harvested Content

Products that incorporate recycled materials, such as this bench made from recycled plastics, reduce impacts resulting from extraction and processing of virgin resources.

- Locally manufactured furnishings reduce the distance items must be shipped, which contributes to the local economy
- Locally sourced, recycled, and sustainably harvested content reduce impacts on the environment

Reduce Heat Island Effect



Closely spaced street trees with generous canopies shade pavement

High-albedo paving materials reflect the sun and reduce heat gain

- Sufficient tree canopy provides shade that also contributes to reducing the heat island effect
- Lighter-colored paving materials reflect the sun's rays more than darker materials, reducing the heat island effect

Figure 3-8: Sustainability Considerations