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16. Abstract

This report presents guidelines for use by the Texas State Department of Highways and Public Transportation (SDHPT) in incorporating provisions for buses into the Department's street planning, design, and operation processes. The guidelines presented in this report were derived from a nationwide survey of transit/transportation agencies and address the following aspects of bus-related street improvements: 1) bus service planning; 2) bus facility design; and 3) bus service operations. The guidelines presented in this report should be useful to SDHPT and other state and local transportation agencies in developing a cooperative bus planning process in Texas.

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GUIDELINES FOR PLANNING, DESIGNING, AND OPERATING BUS-RELATED STREET IMPROVEMENTS

by

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Research Report 1225-2F

Research Study Number 2-18-89-1225

Sponsored By

Texas State Department of Highways and Public Transportation
in cooperation with the
U.S. Department of Transportation
Federal Highway Administration

Texas Transportation Institute
The Texas A&M University System
College Station, Texas 77843

August 1990

METRIC (SI*) CONVERSION FACTORS

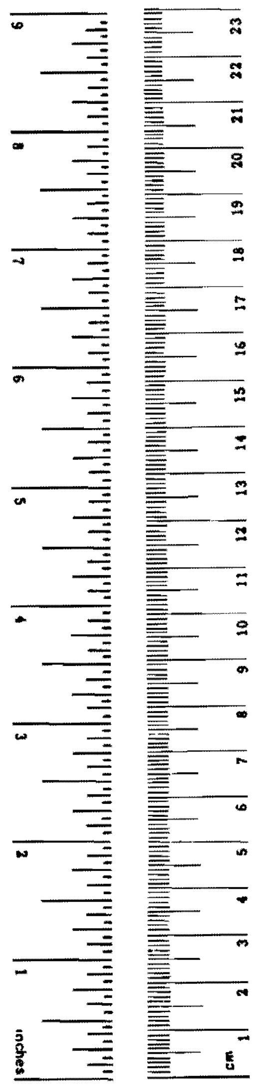
APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	2.54	millimetres	mm
ft	feet	0.3048	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
		AREA		
in^2	square inches	645.2	millimetres squared	mm^2
ft^2	square feet	0.0929	metres squared	m^2
yd^2	square yards	0.836	metres squared	m^2
mi^2	square miles	2.59	kilometres squared	km^2
ac	acres	0.395	hectares	ha
		MASS (weight)		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		VOLUME		
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft^3	cubic feet	0.0328	metres cubed	m^3
yd^3	cubic yards	0.0765	metres cubed	m^3

NOTE: Volumes greater than 1000 L shall be shown in m^3.

TEMPERATURE (exact)

Symbol	When You Know	Multiply By	To Find	Symbol
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

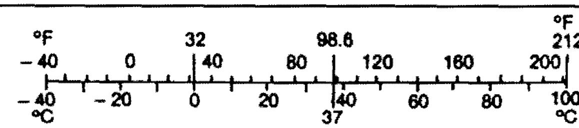


APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
		AREA		
mm^2	millimetres squared	0.0016	square inches	in^2
m^2	metres squared	10.764	square feet	ft^2
km^2	kilometres squared	0.39	square miles	mi^2
ha	hectores (10 000 m^2)	2.53	acres	ac
		MASS (weight)		
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T
		VOLUME		
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m^3	metres cubed	35.315	cubic feet	ft^3
m^3	metres cubed	1.308	cubic yards	yd^3

TEMPERATURE (exact)

Symbol	When You Know	Multiply By	To Find	Symbol
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



These factors conform to the requirement of FHWA Order 5190.1A.

* SI is the symbol for the International System of Measurements

ABSTRACT

This report presents guidelines for use by the Texas State Department of Highways and Public Transportation (SDHPT) in incorporating provisions for buses into the Department's street planning, design, and operation processes. The guidelines presented in this report were derived from a nationwide survey of transit/transportation agencies and address the following aspects of bus-related street improvements: 1) bus service planning; 2) bus facility design; and 3) bus service operations. The guidelines presented in this report should be useful to SDHPT and other state and local transportation agencies in developing a cooperative bus planning process in Texas.

Keywords: Bus-related street improvements; Bus service planning guidelines; Bus facility design guidelines; Bus service operations guidelines; Transit planning; Interagency cooperation/coordination; Geometric design; Traffic control; Surface streets; Urban streets.

IMPLEMENTATION STATEMENT

This report presents guidelines for use by the Texas State Department of Highways and Public Transportation (SDHPT) in incorporating provisions for buses into the Department's street planning, design, and operation processes. The guidelines presented in this report should be useful to SDHPT and other state and local transportation agencies in developing a cooperative bus planning process in Texas.

DISCLAIMER

QUICK REFERENCE SUMMARY

Following is a summary of the information presented in this report on bus service planning, facility design, and service operations guidelines. These pages can serve as a quick reference to the Department's personnel when considering bus-related street improvements.

BUS SERVICE OPERATIONS GUIDELINES	
Frequency of Bus Stops:	• 0.25 mile apart (general rule) • 0.125 mile apart (areas of high intense development)
Bus Priority Measures:	• Consider if a reasonable concentration of bus services, a high degree of bus and auto congestion, and community willingness to support public transportation is present.
Bus Stop Signs	• May be either a standard traffic control sign (see Texas Manual on Uniform Traffic Control Devices) or a transit agency sign.
Bus Stop Sign Placement:	• Bottom of sign must be 7 feet above ground level. • Locate no closer than 2 feet from curb face. • Locate no further than 6.5 feet from curb face. • Locate at desired bus front door boarding location.
Traffic Signals:	• All bus passengers become pedestrians upon leaving the bus. • Include WALK and DON'T WALK indications at signalized intersections. • Install pedestrian push buttons if the signal is actuated. • If the near-side stop area is between the advance detector for the signal, consider installing an additional detector for the bus to obtain or extend the green light.
Capacity:	• See Transit Capacity Chapter in the Highway Capacity Manual.

BUS SERVICE PLANNING GUIDELINES

Service Criteria:	• population density > 2000 persons/sq mi • ridership (anticipated peak period) > 20-25 passengers per bus hour on a weekday 15 passengers per bus hour on Saturday 10 passengers per bus hour on Sunday
Service Area:	• Normally defined by legislation. • When population density is 4000 persons/sq mi or 3 dwelling units/acre, 90 percent of the population should be within 0.25 mile of a bus line. • When population density is 2000 to 4000 persons/sq mi, 50 to 75 percent of the population should be within 0.5 mile of a bus line.
Route Structure and Spacing:	• 0.5 mile in urban areas • 1.0 mile in low-density suburban areas
Route Directness and Length:	• Desirable to have routes not more than 20 percent longer than the comparable trip by car. • Routes deviation should not exceed 8 minutes per round trip. • Routes should generally not exceed 25 miles or 2 hours per round trip (except for Park & Ride service).
Bus Turnouts:	• Bus parking in the curb lane is prohibited. • Traffic in the curb lane exceeds 250 vehicles during the peak hour. • Passenger volumes exceed 20 to 40 boardings an hour. • Traffic speed is greater than 40 mph. • Accident patterns are recurrent.
Shelters:	• Contact local transit agency concerning local warrants and policies. • Transit agencies usually determine whether to install a bench/shelter at a particular location.
Route Planning Procedures:	1. Review characteristics of the service area. 2. Estimate ridership. 3. Estimate revenues. 4. Simulate travel times by car (consider bus requirements). 5. Schedule preparation. 6. Estimate costs. 7. Assess economic performance.
Pedestrian Accessways:	• Should be direct and minimize unnecessary meandering. • Should be paved, wheelchair accessible, and, whenever possible, lighted. • Should extend from development to bus stop to avoid passengers walking through landscaping or parking lots.

BUS FACILITY DESIGN GUIDELINES

Bus Design Vehicle Dimensions:	• Length: 40 feet (60 feet for articulated buses) • Width (including mirrors): 10.5 feet • Height: 11 feet • Heaviest Axle Weight: 25,000 lbs
Acceleration Rates:	• 3.0 to 3.5 mph/sec are upper limits when standing passengers are not able to hold onto a hand grip.
Jerk Rate:	• Preferred maximum jerk rate is 2.0 mph/sec/sec.
Deceleration Rates:	• 2.5 mph/sec is commonly used for typical urban transit buses.
Bus Turning Radii:	• Path of Overhang: 47.1 feet (40-foot bus) and 42 feet (60-foot articulated bus). • Path of Left Front Wheel: 42 feet (40-foot bus) and 38 feet (60-foot articulated bus) • Path of Right Rear Wheel: 23.2 feet (40-foot bus) and 21 feet (60-foot articulated bus).
Corner Radius:	• 50 feet for buses turning into single traffic lane with minimal encroachment. • 35 feet adequate when turning into two or more traffic lanes.
Bus Clearance:	• Overhead obstructions: 12 feet minimum above street surface. • Obstructions greater than 2 feet from edge of street curb.
Lane Width:	• Curb lane: 11 feet (12 feet on urban arterials) minimum, 14 feet desirable. • Other lanes: 11 feet (12 feet on arterials) minimum, 12 feet desirable.
Grades:	• 6 to 8 percent maximum.
Grade Change:	• High Volume Driveways: 3 percent maximum. • Low Volume Driveways on Major or Collector Streets: 6 percent maximum.
Bus Stop Lengths:	• Mid-block: 150 feet minimum. • Near-side: 100 feet minimum. • Far-side: 90 feet minimum. • For articulated bus stop zones, increase zone by 20 feet.
Bus Turnout Dimensions:	• Stopping area length consists of 50 feet for each standard 40-foot bus and 70 feet for each 60-foot articulated bus expected to be at the stop simultaneously. • Stopping area width excluding gutter is 12 feet minimum for speeds over 30 mph. • Tapers and acceleration and deceleration lane lengths are dependent on design speed.
Passenger Shelters:	• Contact transit agency to determine if a standard shelter design exists. • Basic considerations include: - Canopy is 7 feet minimum above sidewalk and 2 feet minimum from curb face. - Shelter is 5.5 feet minimum to 8.5 feet desirable from curb face. - Back of shelter is less than 4 inches or greater than 1.5 feet from wall or fence. - Clearance of 6 inches minimum under shelter to avoid collection of waste and debris. - Allowances for elderly and handicapped individuals, provision of adequate lighting, presence of street furniture, transparent material for shelter walls, waterproof canopy, presence of sidewalk or pad of adequate size, and others.

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CHAPTER 1
INTRODUCTION

1.1 Background

In recent years, it has become increasingly evident that the economic and social vitality of many of the state's urban areas will be closely tied to the quality of their transportation systems. The transportation problems facing Texas cities, however, cannot be solved by simply building more streets and highways. Likewise, transit is not the solution to all urban transportation problems. A balanced transportation system, that makes the best use of the advantages of all available transportation modes, will be needed to efficiently serve the state's transportation needs.

The Texas State Department of Highways and Public Transportation (SDHPT) has responded to this need for a balanced transportation system by expanding beyond its traditional highway orientation to a role that now places increased emphasis on public transportation systems. The recent creation of a new division of public transportation within the SDHPT, and an increasing level of support for transit-related research, are clear indications of the Department's commitment to public transportation in Texas. As a result of this expanded multimodal approach to transportation planning, there is a need to incorporate provisions for transit vehicles and services into the Department's roadway planning, design, and operation guidelines.

The initial report (1) from this project presented findings from a nationwide survey of transit/transportation agencies concerning current practice in planning, designing, and operating transit-related street improvements. The report presented discussions of the various factors considered in developing the bus guidelines contained in this report. It also included a summary of the physical and operating characteristics of light rail transit (LRT) vehicles and services that are pertinent to the design of transit-related street improvements. A list of the agencies which responded to the survey of current practice is included in the initial report; the assistance of these agencies is gratefully acknowledged.

This report is intended to facilitate the development of a cooperative bus service planning process in Texas by 1) outlining a general procedure for incorporating bus considerations into the Department's street planning, design, and operation processes, and 2) providing guidelines for use by Department personnel in planning, designing, and operating street improvements that incorporate provisions for bus operations.

1.2 Organization of this Report

Bus guidelines in this report are presented in the following three chapters:

- Chapter 2 - Bus Service Planning Guidelines
- Chapter 3 - Bus Facility Design Guidelines
- Chapter 4 - Bus Service Operations Guidelines

The planning guidelines (Chapter 2) focus on bus route and service planning considerations, and guidelines for locating bus service support facilities. The review of planning guidelines is intended to acquaint SDHPT personnel with current bus service planning practices. These guidelines should be of use to the Department in identifying roadway segments and travel corridors where street and highway designs should include provisions for bus services. The bus facility design guidelines (Chapter 3) address geometric and structural issues that should be considered in the design of roadways and support facilities to insure safe and efficient bus operations on surface streets. The chapter on bus service operations guidelines (Chapter 4) summarizes information regarding capacity, signs, traffic signals, bus priority measures, and maintenance for bus-related street improvements.

Preceding this report is a Quick Reference Summary. It contains a summary of the information presented in Chapters 2, 3, and 4. A designer can use this "quick reference" when selecting bus-related street improvements.

1.3 Incorporating Bus Service Considerations Into the Street Planning, Design, and Operation Processes

Several large cities in Texas are currently implementing major transit improvement programs and it appears that transit will become increasingly important in serving the state's transportation needs. However, there is more to good transit services than choosing the appropriate technology and providing high levels of service frequency and reliability. While the responsibility for providing safe, comfortable, and reliable transit vehicles rests with the local transit agency, the means for assuring that transit vehicles can easily access major service areas and that patrons can safely walk to stops and wait comfortably for transit vehicles is generally beyond the control of the transit agency. The provision of quality transit services, then, requires a cooperative effort involving local transit service providers, local and state highway agencies, and private developers.

Figure 1 illustrates a general procedure for incorporating bus service considerations into the Department's street planning, design, and operation processes. As indicated in Figure 1, the guidelines presented in this report apply to urban streets. If a roadway project is not an urban street project, then the planning, design, and operation process should proceed in accordance with the Department's Operations and Procedures Manual (2). If the improvement project is for an urban street, the Department's design staff should consult the local transit agency (if one exists) and review the general planning guidelines in Chapter 2 to determine if the project should include provisions for bus services. If the street project should include provisions for bus services, the guidelines presented in Chapters 3 and 4 should be reviewed to insure that the planning, design, and operation process considers the needs of buses and bus service support facilities. The Texas Public Transit Reference Manual (3) can provide information on the planning, designing, and implementation of public transit systems if the information is desired.

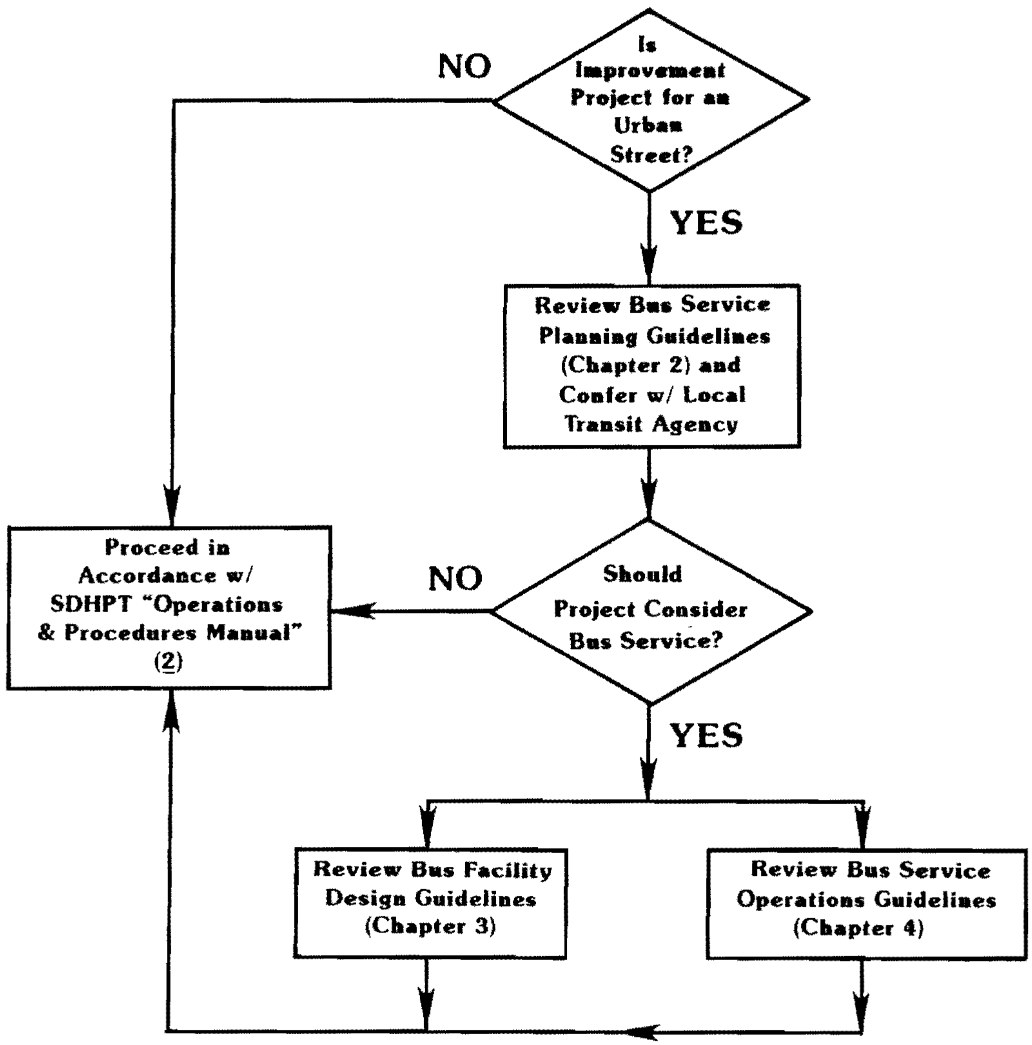


Figure 1. Procedure for Incorporating Bus Service Considerations Into the Street Planning, Design, and Operation Processes

CHAPTER 2
BUS SERVICE PLANNING GUIDELINES

2.1 General

Most transit agencies have developed guidelines and policies for use in assessing whether a transit market exists and whether that market can be served by existing or proposed transit services. Population densities, trip generation potentials (i.e., land uses) and characteristics of the street network are the primary factors considered by transit agencies in planning new or improved services. This chapter presents a brief overview of these basic service planning factors for buses. These factors should be useful in identifying roadway segments and travel corridors where street designs should include provisions for buses and bus service support facilities.

While the basic factors outlined in this chapter are commonly used by transit agencies in planning transit services, specific factors and threshold values may vary from city to city. **Therefore, it is recommended that the local transit agency be consulted concerning specific local service planning guidelines.**

2.2 Bus Service and Route Planning

The following service and route planning guidelines are representative of practice in the United States (4):

- Service Criteria. Bus service should be considered where 1) population density exceeds 2000 persons/sq. mile and 2) anticipated peak period ridership exceeds 20 to 25 passengers per bus hour on weekdays, 15 on Saturdays, and 10 on Sundays. Route continuity and transfer requirements may lower these factors.

- Service Area. The transit service area is normally defined by legislation. Where population density within this area exceeds 4000 persons/sq. mile, or 3 dwelling units per acre, 90 percent of the residences should be within 0.25 mile of a bus line. Where population density ranges from 2000 to 4000 persons/sq. mile, 50 to 75 percent of the population should be within 0.5 mile of a bus line.

- Route Structure and Spacing. Bus routes should fit major street patterns. Basic grid systems are appropriate where streets are in a grid pattern; radial or radial-circumferential systems are applicable where radial or irregular street patterns exist. Bus routes should be spaced at approximately 0.5 mile in urban areas and 1 mile in low-density suburban areas. Closer spacing should be provided where terrain inhibits walking.

- Route Directness and Length. Circuitous or "off-route" routings (deviations from a direct and simple route) should be avoided. A route not more than 20 percent longer than the comparable trip by car is desirable. Route deviation should not exceed 8 minutes per round trip (based on at least 10 additional customers per round trip). Routes should be as short as possible to serve their markets, and generally should not exceed 25 miles or 2 hours per round trip (except for Park & Ride service).

- Route Planning Procedures. Key steps in planning route changes include: 1) a review of characteristics of the service area, including physical feasibility for bus operations; 2) an estimate of ridership (often by comparison with similar areas); 3) an estimate of revenues; 4) a simulation of travel times by car, considering bus requirements; 5) schedule preparation; 6) an estimate of costs; and 7) an assessment of economic performance.

2.3 Bus Stops and Turnouts

In transit service planning it is generally assumed that most patrons will not walk more than 0.25 mile to a transit stop. As a result, bus stops should be placed no more than

0.25 mile apart, as a general rule. In areas of high density development, transit stops may be necessary as frequently as every two blocks (0.125 mile apart).

The determination of the proper location of transit stops involves choosing between far-side, near-side, and mid-block stops. Advantages and disadvantages of each bus stop type are compared in Table 1. The following factors should also be considered when selecting the type of bus stop:

- potential patronage
- passenger origins and destinations
- pedestrian access including accessibility for handicap/wheelchair patrons
- adjacent land use and activities
- intersection geometrics
- parking restrictions and requirements
- traffic control devices
- physical roadside constraints (trees, poles, driveways, etc.)
- intersecting transit routes

A turnout is a specialized bus stop where the transit vehicle can pick up and discharge passengers in an area separated from the main lanes. A turnout allows through traffic to flow freely without being impeded by stopped buses. Many transit planners and engineers believe the most appropriate use for bus turnouts is on roadways that experience high volumes of traffic. Although this appears to be an accurate assessment, frequently a bus turnout can be counter-productive in high volume situations if inadequate acceleration and deceleration distance is provided. Many times, high traffic volumes will not allow sufficient gaps for the bus operator to safely and comfortably return the vehicle to the main lanes. The provision of an acceleration lane in a turnout design enables a bus to obtain a speed that is within an acceptable range of the through traffic speed and to more comfortably merge with the through traffic. The presence of a deceleration lane enables buses to decelerate without inhibiting through traffic. Turnouts without acceleration or deceleration lanes should be considered only at locations where buses may be stopped for long periods of time.

Table 1. Comparative Analysis of Bus Stop Locations

Near-Side		Far-Side		Mid-Block	
Advantages	Disadvantages	Advantages	Disadvantages	Advantages	Disadvantages
Minimizes interferences when traffic is heavy on the far side of the intersection. Passengers access buses closest to crosswalk. Intersection available to assist in pulling away from curb. No double stopping. Buses can service passengers while stopped at a red light. Provides driver with opportunity to look for oncoming traffic including other buses with potential passengers.	Conflicts with right turning vehicles are increased. Stopped buses may obscure curbside traffic control devices and crossing pedestrians. Sight distance is obscured for crossing vehicles stopped to the right of the bus. The through lane may be blocked during peak periods by queuing buses. Increases sight distance problems for crossing pedestrians.	Minimizes conflicts between right turning vehicles and buses. Provides additional right turn capacity by making curb lane available for traffic. Minimizes sight distance problems on approaches to intersection. Encourages pedestrians to cross behind the bus. Requires shorter deceleration distances for buses. Gaps in traffic flow are created for buses re-entering the flow of traffic at signalized intersections.	Intersections may be blocked during peak periods by queuing buses. Sight distance may be obscured for crossing vehicles. Increases sight distance problems for crossing pedestrians. Stopping far side after stopping for a red light interferes with bus operations and all traffic in general. May increase number of rear-end accidents since drivers do not expect buses to stop again after stopping at a red light.	Minimizes sight distance problems for vehicles and pedestrians. Passenger waiting areas experience less pedestrian congestion.	Requires additional distance for no-parking restrictions. Encourages patrons to cross street at midblock (jaywalking). Increases walking distance for patrons crossing at intersections.

Source: Adapted from Reference 5 and Reference 6.

Generally, bus turnouts should be considered when at least one of the following conditions is met:

- Bus parking in the curb lane is prohibited.
- Traffic in the curb lane exceeds 250 vehicles during the peak hour.
- Passenger volumes exceed 20 to 40 boardings an hour.
- Traffic speed is greater than 40 mph.
- Accident patterns are recurrent.

Where appropriate, the right-of-way for a future turnout should be obtained or reserved to satisfy projected needs.

2.4 Waiting Areas and Shelters

Comfortable and secure passenger waiting areas need to be provided at transit stops. These consist of spaces apart from the normal sidewalk for passengers to congregate, sit, and be protected from the weather. A paved landing area located immediately adjacent to the stopped bus for boarding and alighting passengers is also very important. Generally, bus stops should work efficiently and provide passenger comfort, safety, and personal security.

In the central business district area where buildings are near sidewalks, a shelter may be created by attaching a canopy to the building. In addition to requiring less space than a stand-alone shelter, the canopies may increase pedestrian traffic for the businesses.

A sheltered waiting area is important to the transit patron because it provides relief from adverse weather. However, resources may not exist to provide a shelter at every bus stop. Therefore, many transit agencies have established guidelines to determine which bus stops should include shelters. These guidelines are generally based on the number of boarding and/or transferring passengers at each stop and the frequency of service at each stop. It is suggested that the roadway designer contact the local transit agency concerning local warrants and policies for waiting areas and shelters.

2.5 Pedestrian Access

One of the factors affecting transit use is accessibility. Land use activities should be arranged to facilitate the movement of people from their origins (residence) to local transit services and back again. This can be achieved through pedestrian walkways (accessways) between transit stops and adjacent land uses.

The primary considerations relative to maximizing accessibility to transit services are:

- Accessways should be direct, and should minimize unnecessary meandering.

- Accessways should be paved, wheelchair accessible and, whenever possible, lighted.

- Accessways should extend from the development to the bus stop, to avoid bus passengers walking through landscaping or parking lots to access buses.

While it is recognized that the Department has little direct control over these factors, the designer should be sensitive to these factors in dealing with local transportation agencies and property owners/developers.

CHAPTER 3
BUS FACILITY DESIGN GUIDELINES

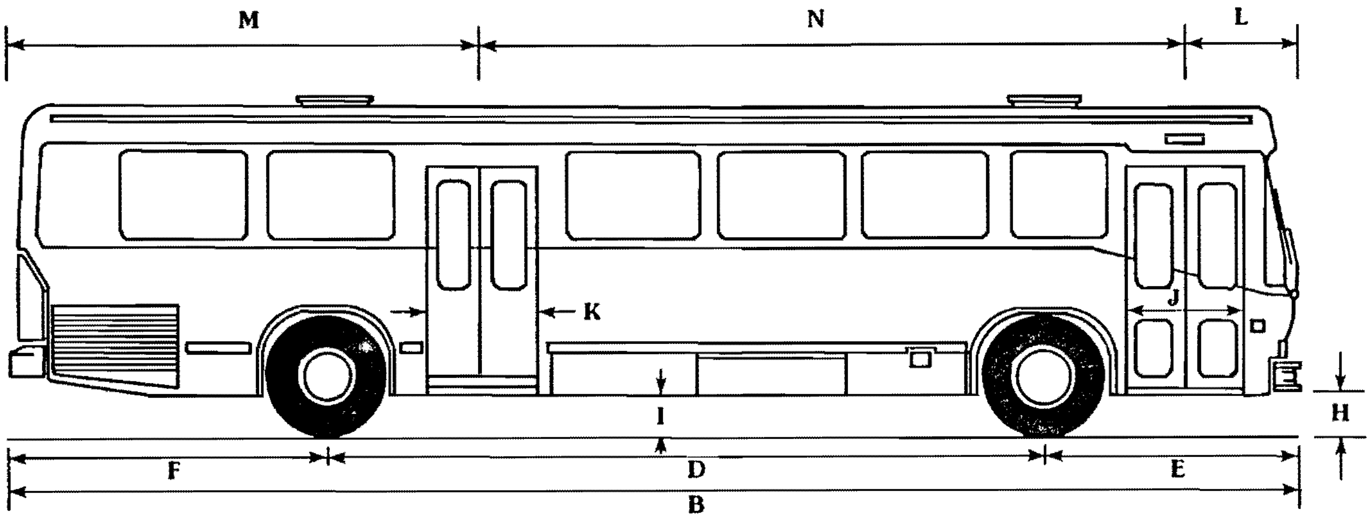
3.1 General

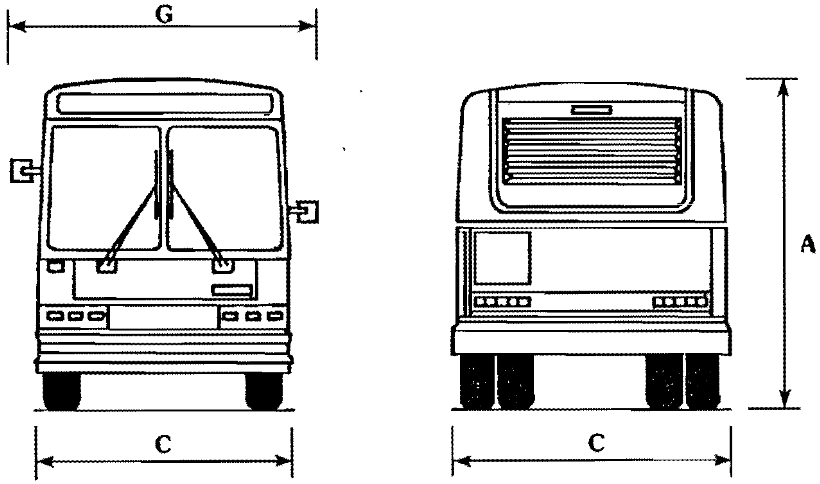
This chapter presents recommended guidelines for the design of transit-related street improvements. Topics include vehicle characteristics, roadway geometrics, and shelter area design. Additional information on geometric design is available in the SDHPT Operations and Procedures Manual (2) and the American Association of State and Highway Transportation Officials (AASHTO) A Policy on the Geometric Design of Highways and Streets (commonly referred to as the Green Book) (7). Information on park-and-ride facilities is available in the Revised Manual for Planning, Designing and Operating Transitway Facilities in Texas (8) publication.

3.2 Vehicle Characteristics

For the purpose of designing facilities for buses, it is important to define a design vehicle, which represents a compilation of critical dimensions from those vehicles currently in operation. The following two basic bus types are commonly used by transit service providers: 1) 40-foot "standard" bus; and 2) 60-foot articulated bus. (Currently, some manufactures are investigating the production of 65-ft buses.) Figures 2 and 3 show typical design vehicle dimensions and weights for these two basic bus sizes.

The standard 40-foot bus and the 60-foot articulated bus are generally the largest vehicles in a transit fleet and represent the most common design cases. Key roadway design features such as lane and shoulder widths, lateral and vertical clearances, vehicle storage dimensions, and minimum turning radii are typically based on the standard 40-foot bus. The articulated bus, while longer, has a "hinge" near the center of the vehicle which allows maneuverability comparable to the 40-foot bus. Design templates for minimum turning paths for single unit (40-foot) and articulated (60-foot) buses are shown in Figures 4 and 5, respectively. The templates are usable for either left turn or right turn designs depending





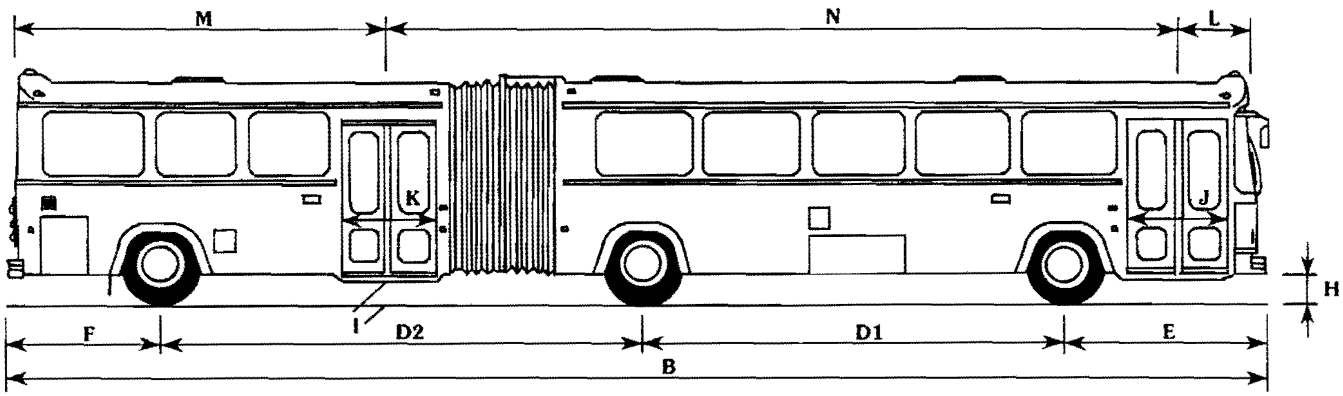
	ITEM	
A	Overall Height	10'9"
B	Overall Length	40'0"
C	Overall Width	8'6"
D	Wheel Base	23'9"
E	Front Axle to Bumper	7'3-3/4"
F	Rear Axle to Bumper	9'4-3/4"
G	Edge Mirror to Mirror	10'2"
H	Step to Ground, Entrance	1'5"
I	Step to Ground, Exit	1'4-1/2"
J	Clear Door Opening, Entrance	2'6"
K	Clear Door Opening, Exit	2'2-1/2"
L	Centerline Door to Front	3'0"
M	Centerline Door to Rear	17'11-1/4"
N	Centerline Door to Door	19'8"

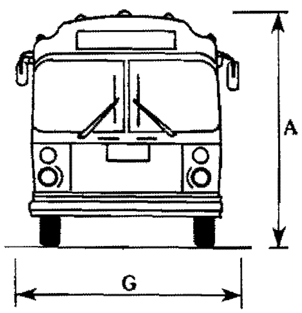
NET/GROSS VEHICLE WEIGHT*

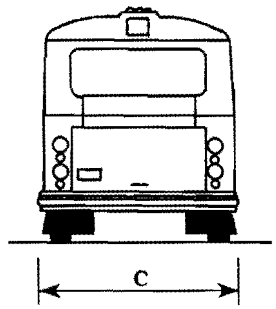
Front Axle	7,420/11,980
Rear Axle	18,060/24,660
Seating Capacity	51
Standing Capacity	25

* Net Weight is "Road Ready" Without Passengers. Gross Includes Passengers.

Figure 2. Dimensions and Weight for A "Standard" 40-Foot Bus Design Vehicle



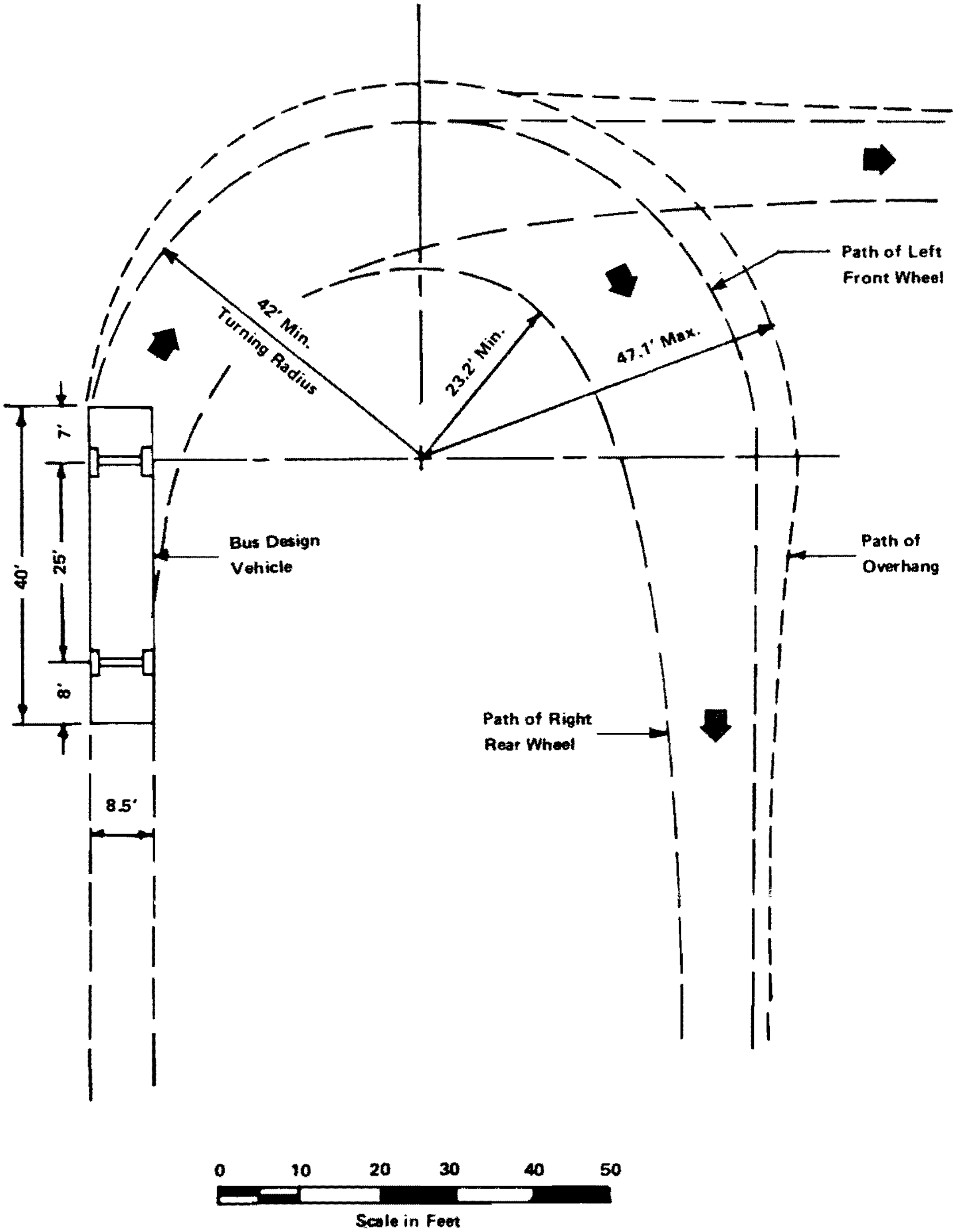




ITEM	
A Overall Height	10'4"
B Overall Length	59'10"
C Overall Width	8'6"
D Wheel Base (D1/D2)	18'7"/24'0"
E Front Axle to Bumper	8'8"
F Rear Axle to Bumper	8'8"
G Edge Mirror to Mirror	10'6"
H Step to Ground, Entrance	1'2"
I Step to Ground, Exit	1'2"
J Clear Door Opening, Entrance	3'8"
K Clear Door Opening, Exit	3'6"
L Centerline Door to Front	3'6"
M Centerline Door to Rear	21'4"
N Centerline Door to Door	35'0"
NET/GROSS VEHICLE WEIGHT*	
Front Axle	11,800/16,420
Rear Axle	12,130/16,420
Center Axle	14,970/24,250
MAXIMUM BEND ANGLE	
Horizontal	± 36 deg
Vertical	± 11 deg
Seating Capacity	70

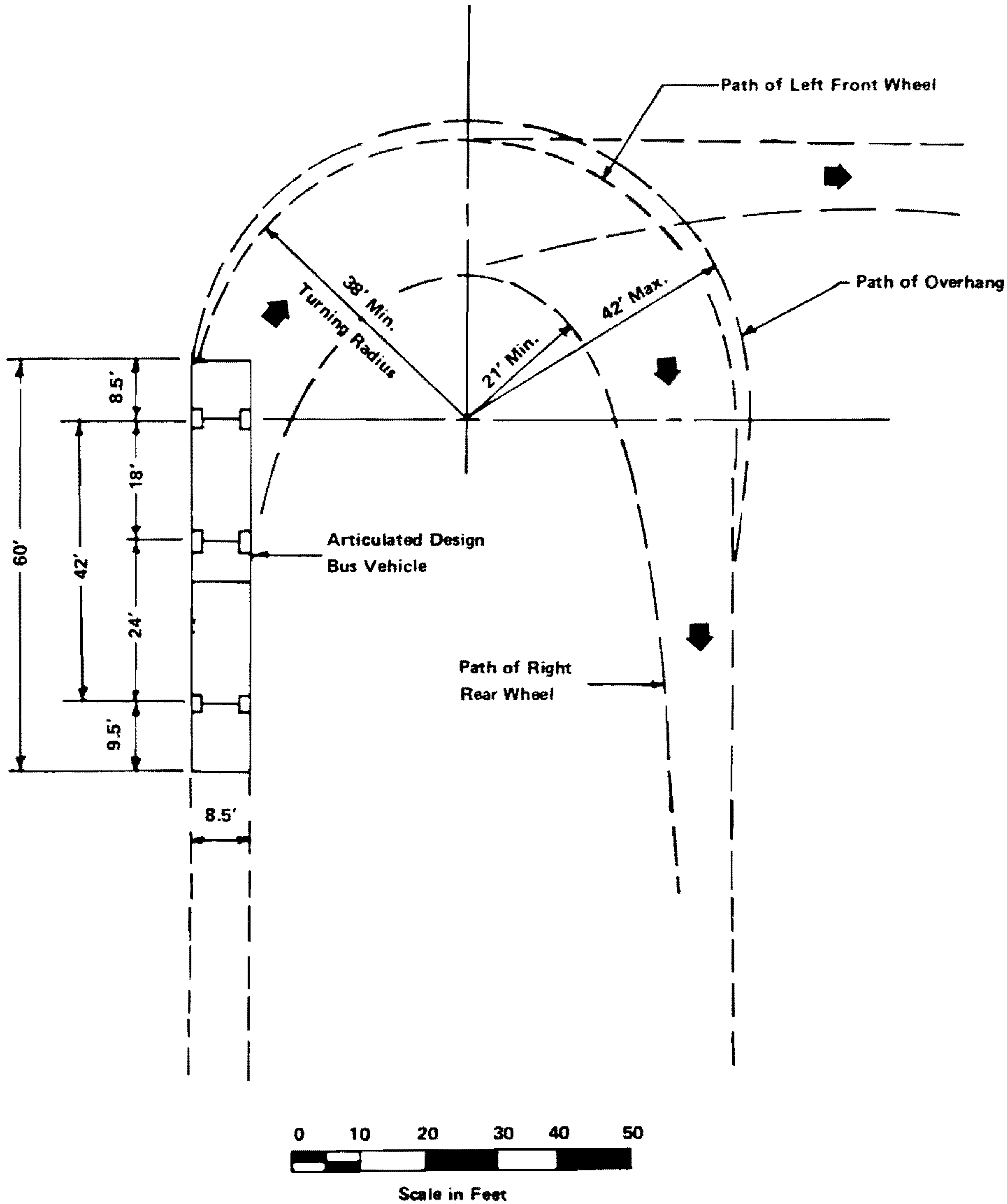
* Net Weight is "Road Ready" Without Passengers. Gross Includes Passengers.

Figure 3. Dimensions and Weight For An Articulated Bus Design Vehicle



Source: Reference 7.

Figure 4. Minimum Turning Path Design Template for 40-Foot Bus



Source: Reference 7.

Figure 5. Minimum Turning Path Design Template for Articulated Bus

on how the template is oriented (i.e., either face-up for right turn design or face-down for left turn design).

The maximum rate of acceleration, deceleration, and rate of change of acceleration and deceleration (jerk) is related to the tolerance of a standing passenger who is not able to hold onto a hand grip. This condition occurs when passengers have both hands full (e.g., with bundles), when they cannot reach a hand grip, or when a hand grip is not available. The jerk rate is more critical to passenger comfort, however, the rates of acceleration and deceleration are also important. Acceleration and deceleration rates from 3.0 to 3.5 mph/sec are usually considered appropriate upper limits for the conditions described above. A deceleration rate of 2.5 mph/sec is commonly used for typical urban transit buses. A preferred maximum jerk rate is 2.0 mph/sec/sec; an allowable maximum jerk rate is about 50 percent above this value (9).

3.3 Clearances, Lane Widths, and Grades

Because of the need to make frequent stops, buses generally travel on the traffic lane closest to the curb. Therefore, it is important to consider bus clearance requirements in roadway design. Obstructions should be located greater than 2 feet from the street curb to avoid being struck by a bus mirror. Because the maximum bus width (including mirrors) is about 10.5 feet, a traffic lane used by buses should be no narrower than 12 feet in width. These lane widths are consistent with the preferred lane widths recommended by AASHTO for various urban street classifications (see Table 2). Desirably the curb lane width (including the gutter) should be 14 feet to allow buses freedom of movement and to avoid sideswipe accidents. Overhead obstructions should be a minimum of 12 feet above the street surface.

Grades should be selected to provide uniform operation throughout the roadway segment. Selection of the roadway grade is related to topography and the potential to balance quantities of cut and fill material, while still providing a roadway that can be traversed safely and economically. Table 3 shows recommended maximum roadway grades as a function of roadway classification. Typically the recommended maximum grade for 40-foot buses is in the range of 6 to 8 percent.

The maximum grade change from the travel lane to a driveway is determined by the clearance of the vehicle undercarriage and the wheelbase length. If this grade change is too steep the front bumper, rear bumper, or midsection may scrape the pavement causing damage to the bus, the pavement, or both. Recommended grade changes are shown in Figure 6.

Table 2. Recommended Urban Street Lane Widths

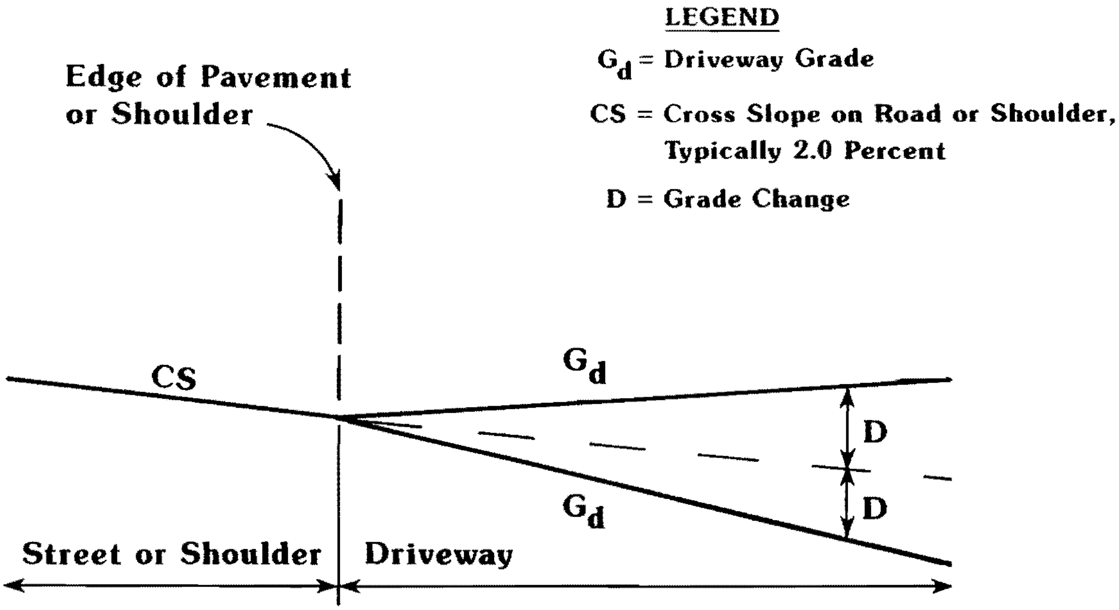
Road Classification	Lane Width (ft)	Additional Auto Parking Width (ft) (As Needed)
Local	11 (Minimum) 12 (Preferred)	7 (Residential Areas)[a] 9 (Commercial & Industrial Areas)[b]
Collector	11 (Minimum) 12 (Preferred)	7-10 (Residential Areas)[a] 8-10 (Commercial & Industrial Areas)[b]
Arterial	12 (Minimum)[c]	Restricted

[a]Provided as needed on one or both sides of roadway.
[b]Usually provided on both sides of roadway.
[c]An additional 2 feet (including gutter) is desirable for curb lanes.

Source: Reference 7.

Table 3. Recommended Maximum Roadway Grades for 40-Foot Buses

Roadway Classification	Maximum Grades (%)
Local	8
Collector	7
Arterial	6



	Recommended Grade Change (D)	
	Desirable	**Maximum** *
High Volume Driveway	0%	±3%
Low Volume Driveway on Major or Collector Streets	0 to ±3%	±6%
Low Volume Driveway on Local Streets	0 to ±6%	Controlled by Vehicle Clearance

* Grade changes greater than the maximum should use a vertical curve to transition from the street to the driveway

Source: Adapted from Reference 10.

Figure 6. Recommended Grade Changes for Driveways

3.4 Intersection Design

Corner curb radii at street intersections are a common bus-related design problem. Some of the advantages of a properly designed corner curb radius are:

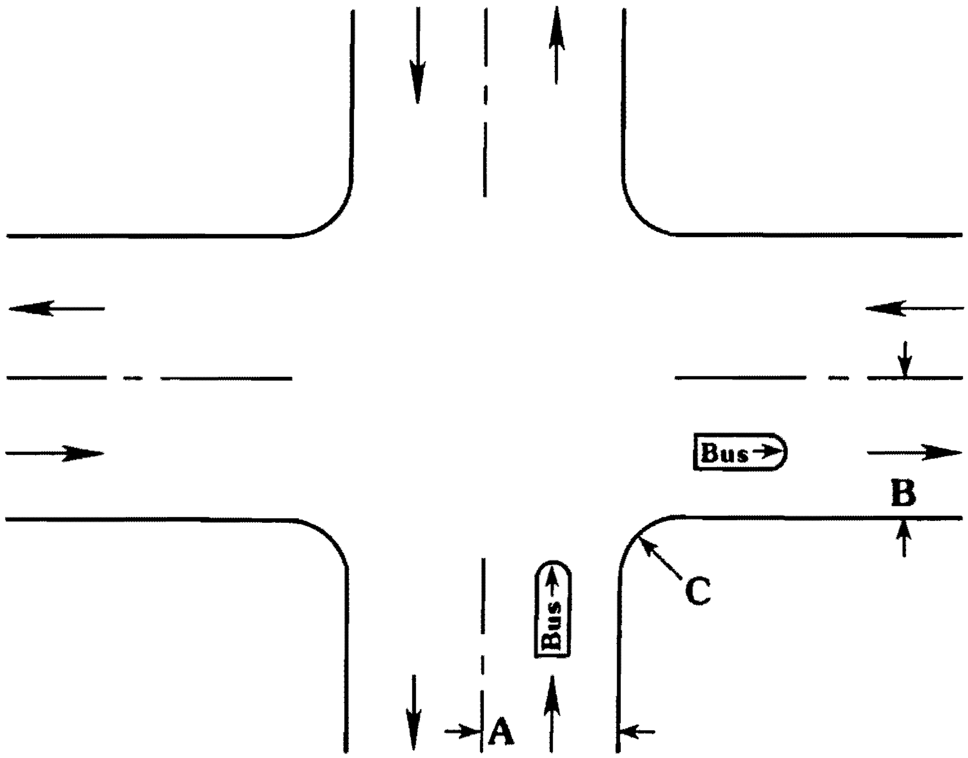
- Less bus/auto conflict at heavily used intersections
- Higher bus operating speeds and reduced travel time
- Improved bus rider comfort

The design of intersection radii should be based on the following elements:

- Design vehicle characteristics
- Width and number of lanes on the intersecting street
- Allowable bus encroachment into other traffic lanes
- Bus turning radius
- On street parking
- Right-of-way/building restrictions
- Angle of intersection
- Operating speed and speed reductions
- Pedestrians

Figure 7 shows appropriate corner radii for transit vehicles and various combinations of lane widths. This figure should be used as a starting point; the radii values should be checked with an appropriate turning radius template before being incorporated into a final design.

If parking is allowed on either the approach street or the cross street, parking restrictions should be enforced to avoid conflicts and facilitate bus turning movements. On the approach, parking should be prohibited a minimum of 15 feet prior to the point of curve of the radius. On the cross street, parking should be prohibited a minimum of 40 feet from the point of tangent of the curb radius (5).



A Approach Width (feet)	B Entering Width (feet)	C Radii* (feet)
12 (1 lane)	12 16 20 24	50 45 40 35
16 (1 lane with 4-foot shoulder)	12 16 20 24	45 40 30 25
20 (1 lane with parking)	12 16 20 24	40 35 30 25

* Assumes no parking on cross street and minimal lane encroachment on opposing travel lanes.

Source: Houston Metro Bus Templates (11) were used to determine radii values.

Figure 7. Recommended Corner Radii

Sight distance at intersections should consider vehicles that utilize the facility with reasonable frequency. When significant bus traffic exists, intersection sight distance design should consider their characteristics, for example, their slower acceleration rates and longer vehicle lengths. Intersection sight distance procedures are discussed in the Green Book (7).

3.5 Pavement Design

The pavement design for roadways used by buses is similar to normal pavement design. The following factors are important in designing an adequate pavement structural section:

- Bus axle weights
- Projected bus volumes
- Pavement material strengths
- Subgrade soil conditions

Roadway pavements used by buses need to be of sufficient depth to accommodate bus axle loads approaching 25,000 pounds. The detailed design of pavement sections will depend upon site specific soil conditions and should follow local pavement design practices.

Pavements in bus stop areas and layover locations, especially in areas of high bus volumes, should be given special consideration. While pavements at bus stop areas or layover locations can be either asphalt or concrete, a concrete pad has the advantage of resistance to shoving, rutting, and petroleum deterioration.

3.6 Bus Stops, Turnouts, and Turnarounds

Bus stops should consider passenger loading and unloading that is occurring adjacent to the street curb. Sidewalks and wheelchair access ramps should be provided at all stops.

Bus stop zones for near-side and far-side stops should be a minimum of 100 and 90 feet, respectively, and mid-block stops should be a minimum of 150 feet. When articulated buses are used, the zone should be increased by 20 feet. Additional length should be provided for multiple buses as indicated in the following paragraph. Representative dimensions for bus stop zones are illustrated in Figure 8.

At some bus stops, more than one bus may be at the stop at a given time. The number of bus-loading positions required depends upon 1) the rate of bus arrivals, and 2) passenger service time at the stop. Table 4 presents suggested bus stop capacity requirements based on a range of bus flow rates and passenger service times. Bus stop zones should increase by 50 feet for each additional standard bus and 70 feet for each additional articulated bus.

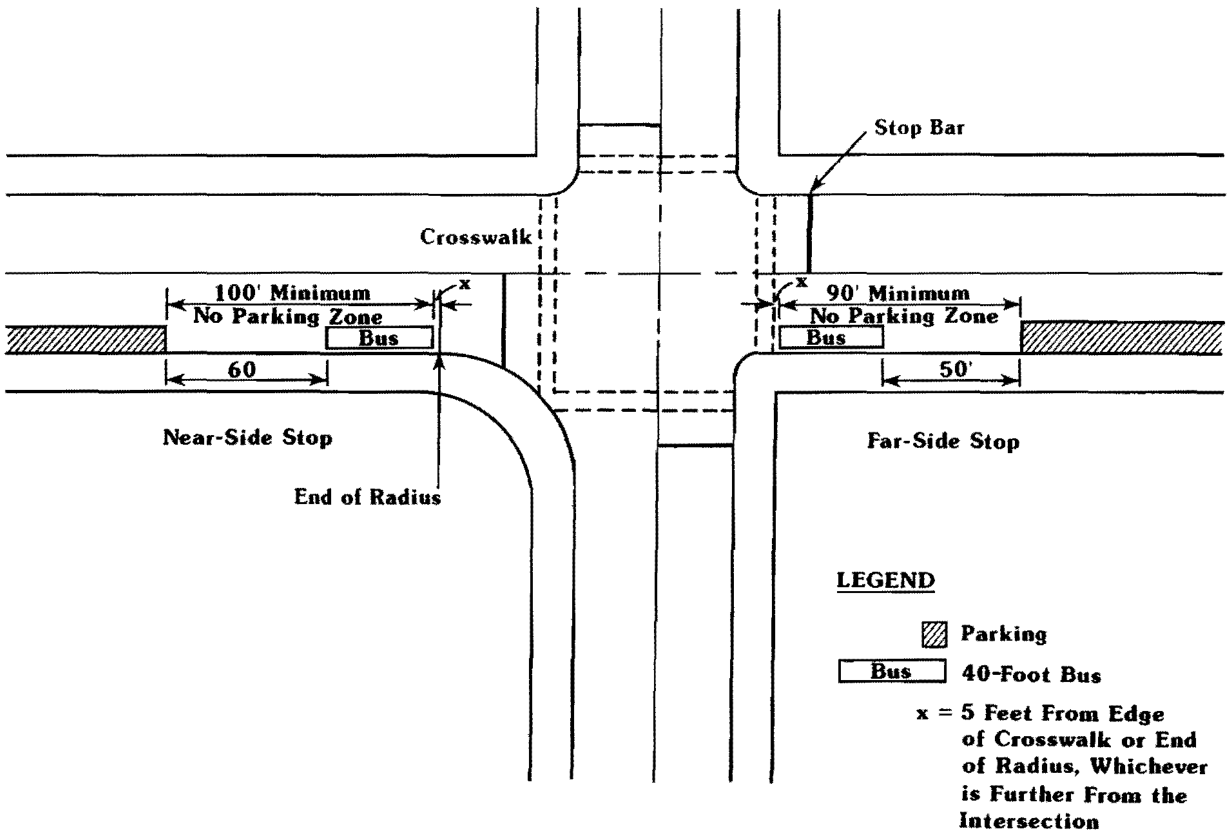
Bus stops can conflict with driveways. At least one driveway should be open to vehicles accessing the property. Figure 9 shows acceptable and undesirable alternatives for bus stops/driveway arrangements.

Table 4. Recommended Bus Stop Bay Requirements

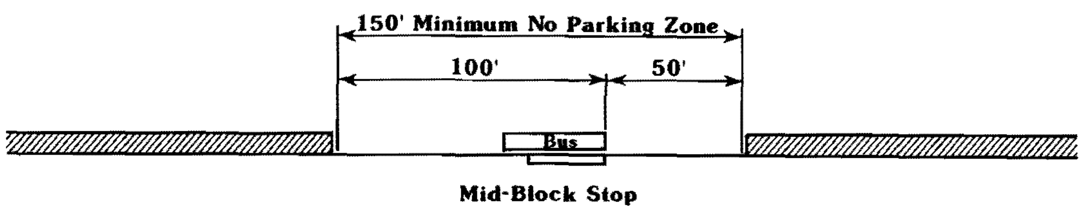
Peak-Hour Bus Flow	Capacity Required (Bays) When Service Time at Stop Is				
	10 Seconds	20 Seconds	30 Seconds	40 Seconds	60 Seconds
15	1	1	1	1	1
30	1	1	1	1	2
45	1	1	2	2	2
60	1	1	2	2	3
75	1	2	2	3	3
90	1	2	2	3	4
105	1	2	3	3	4
120	1	2	3	3	5
150	2	3	3	4	5
180	2	3	4	5	6

Source: Reference 12.

Far-Side and Near-Side Bus Stop Dimensions for Street with Parking

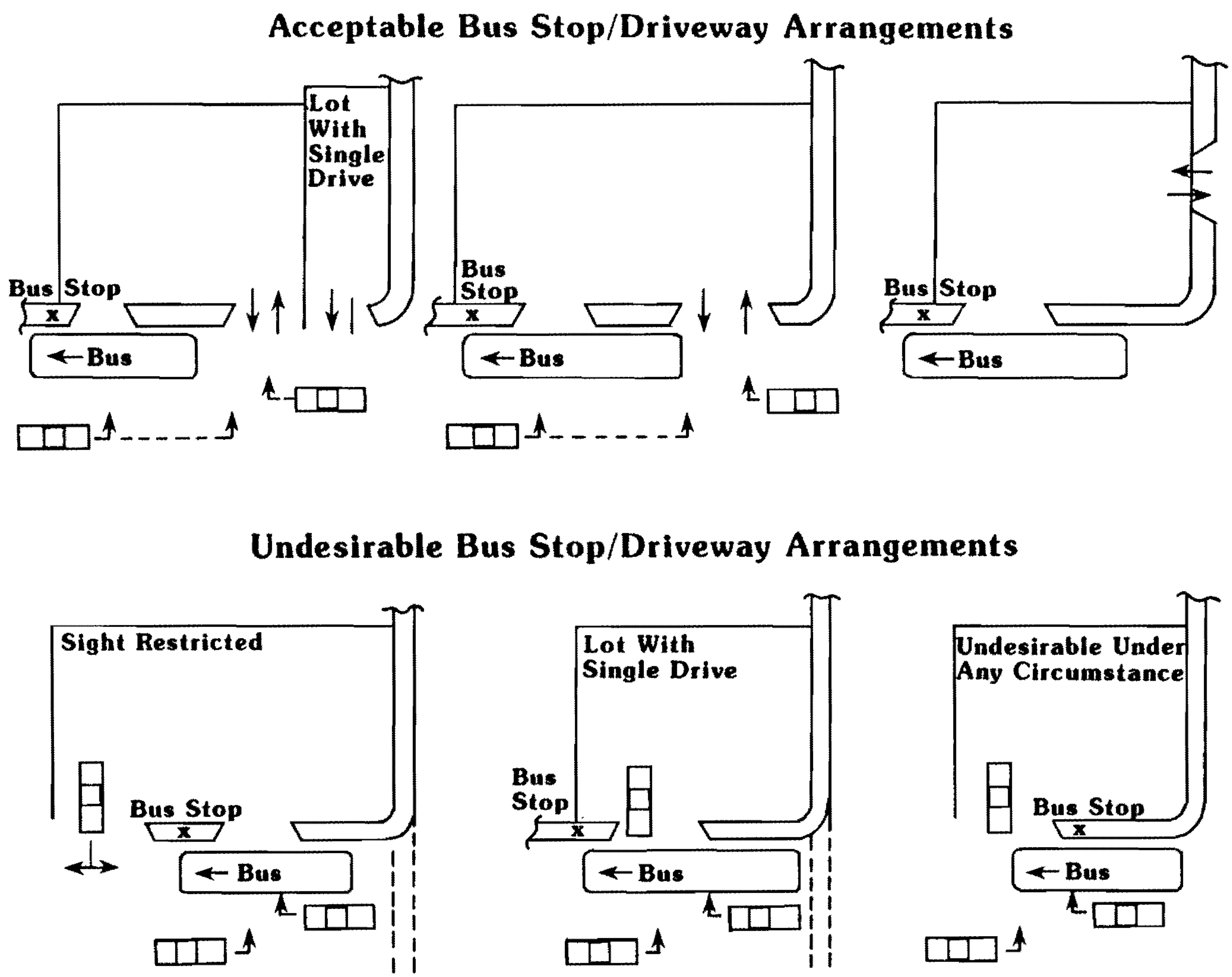


Mid-Block Bus Stop Dimensions



Notes:
1) Add 20 feet to bus stop zones for an articulated bus.
2) Increase bus stop zone by 50 feet for each additional standard 40-foot bus or 70 feet for each additional 60-foot articulated bus expected to be at the stop simultaneously. See Table 4 for the suggested bus stop capacity requirement based on a range of bus flow rates and passenger service times.

Figure 8. Typical Dimensions for On-Street Bus Stops



Source: Adapted from Reference 13

Figure 9. Bus Stop Locations Relative to Driveways.

A bus turnout is a specially constructed area off the normal roadway section to provide for bus loading and unloading. Turnouts are provided primarily on high volume or high speed roadways. Additionally, bus turnouts are frequently constructed in heavily congested downtown and shopping areas where large numbers of passengers may board and disembark. General planning guidelines for assessing the need for bus turnouts were presented in Section 2.3.

Desirably, the total length of the bus turnout should consist of entering and exiting tapers, acceleration and deceleration lanes, and a stopping area. Common practice, however, is to accept deceleration and acceleration in the through lanes and to only build the tapers and the stopping area. Provision for deceleration and acceleration clear of the through-traffic lanes is a desirable objective on arterial roads and should be incorporated in design wherever feasible. Typical bus turnout dimensions (minimum and recommended) are shown in Figure 10.

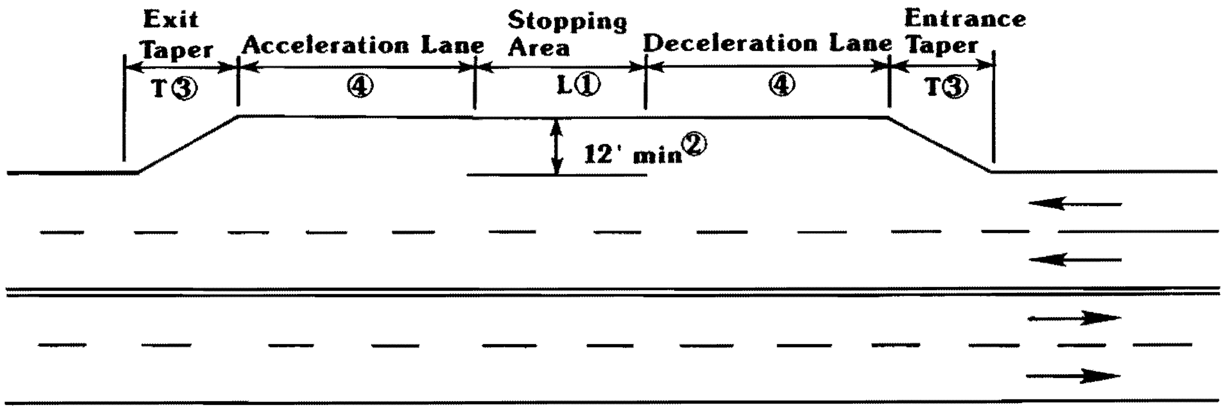
A turnaround is a roadway designed for use as a bus layover area, and to allow buses to reverse direction (turn around) at the end of a route. The following are situations where turnarounds should be considered.

- On-street layovers cannot be tolerated because the roadway does not allow for vehicle parking.

- The intersecting minor streets cannot accommodate the axle weights of a bus.

- The neighboring environment is sensitive to bus operations.

- The on-street routing necessary for the bus to reverse directions would require an unacceptable amount of unproductive mileage.



1) Stopping area length consists of 50 feet for each standard 40-foot bus and 70 feet for each 60-foot articulated bus expected to be at the stop simultaneously. See Table 4 for the suggested bus stop capacity requirements based on a range of bus flow rates and passenger service times.

2) Does not include gutter width. For speeds under 30 mph, a 10-foot minimum may be used.

3) Recommended taper lengths are listed in the table below. Desirable taper length is equal to the major road through speed multiplied by the width of the turnout bay. The Green Book states a taper of 5:1 is a desirable minimum for an entrance taper to an arterial street bus turnout while the merging or reentry taper should not be sharper than 3:1. Suggested taper design for auxiliary lanes are shown on the AASHTO Green Book Figure IX-65 (7).

4) Minimum design for a bus turnout does not include acceleration or deceleration lanes. Recommended acceleration and deceleration lengths are listed in the table below (8).

Through Speed (mph)	Entering Speed[a] (mph)	Length of Acceleration Lane[b] (Feet)	Length of Deceleration Lane[c] (Feet)	Length of Taper[b] (Feet)
35	25	250	184	170
40	30	400	265	190
45	35	700	360	210
50	40	975	470	230
55	45	1400	595	250
60	50	1900	735	270

[a]Bus speed at end of taper, desirable for buses to be within 10 mph of mainlane vehicles at the end of the taper.
[b]From Reference 8.
[c]Based on 2.5 mph/sec deceleration rate.

Figure 10. Typical Bus Turnout Dimensions

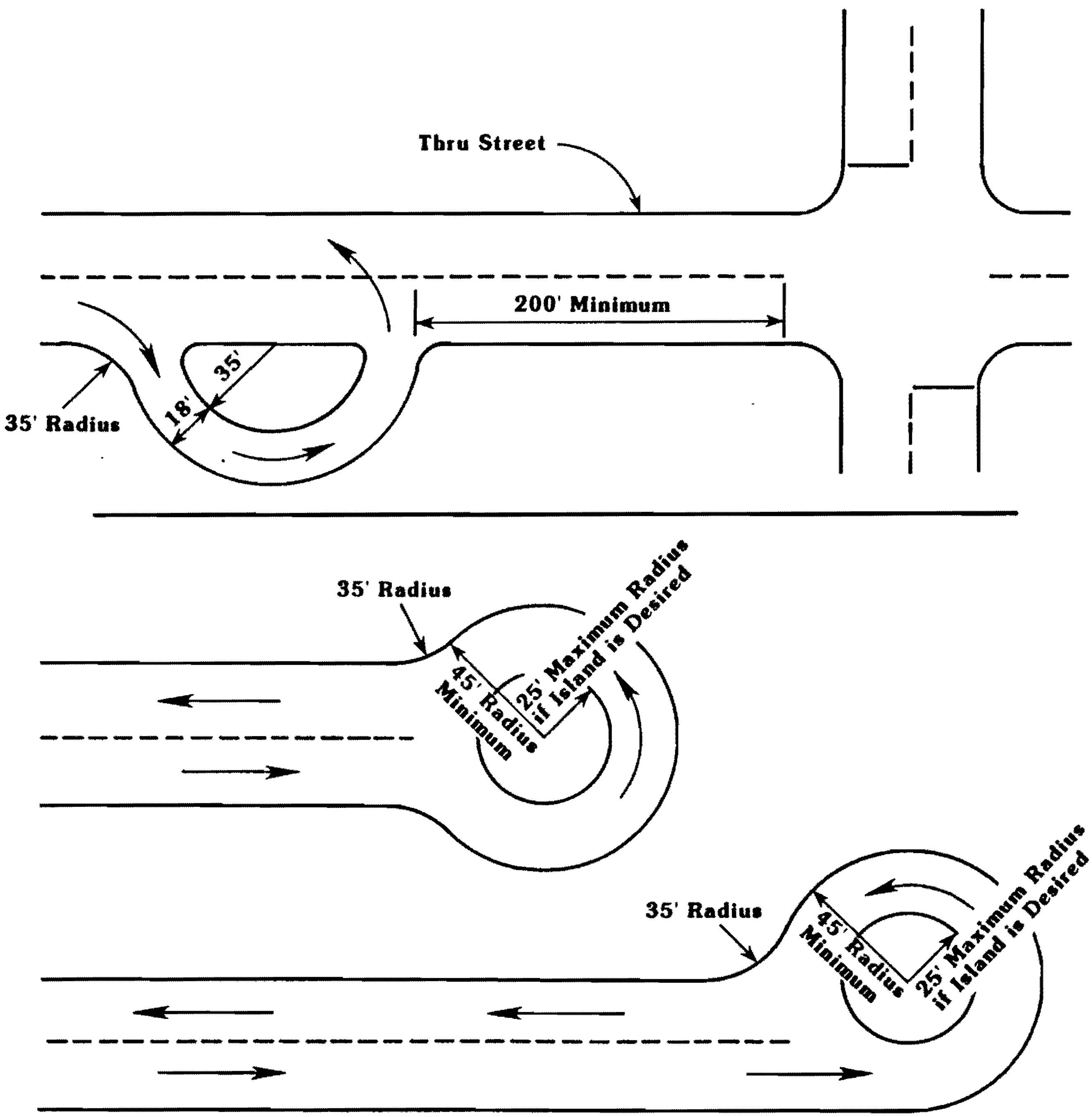
- The current layover or route reversal maneuver, though once acceptable, has become hazardous due to increases in traffic or due to other changes which have been made in the roadway system.

Bus turnarounds should be designed to discourage use by non-transit vehicles. Typical bus turnaround configurations are shown in Figure 11.

3.7 Shelter Area Design

Each transit agency may have its own shelter design. Certain basic design dimensions are shown in Figure 12 for assistance in designing the street area surrounding the shelter. Other basic considerations at a shelter include:

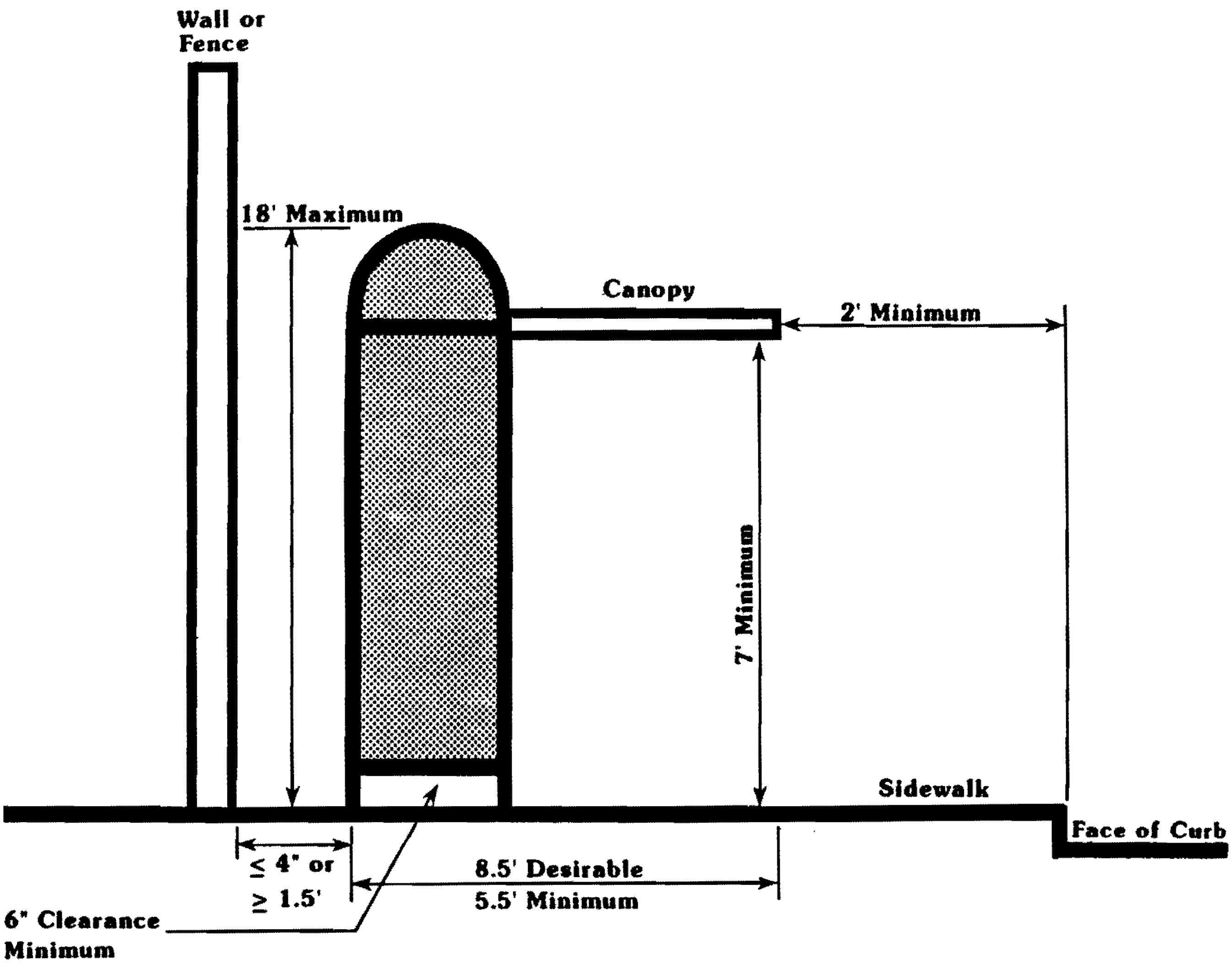
- user's safety and security
- presence of sidewalk or concrete pad of adequate size
- allowances for elderly and handicapped individuals
- provision of seating areas
- transparent material for shelter walls
- waterproof canopy
- presence of other street furniture, such as waste receptacles, information kiosks, newspaper dispensers, telephones, and postal boxes
- landscaping that provides good visibility of the shelter and minimizes the possibility of a person hiding in the shelter or surrounding area



Note: Only low, informal plantings allowed in island areas.

Source: Reference 14.

Figure 11. Typical Bus Turnaround Configurations



Source: Reference 13

Figure 12. Suggested Dimensions of Passenger Shelters

- provision of adequate lighting

- location that does not interfere with driver sightlines (see Green Book (7) for discussion on intersection sight distance procedures)

- locate a reasonable distance from storm sewer inlets

- provision for adequate drainage especially in areas of heavy boarding/alighting activities

- orient doorway away from prevailing winds

- orient at least one entrance/exit toward street

CHAPTER 4
BUS SERVICE OPERATIONS GUIDELINES

4.1 General

This chapter summarizes the effects of buses on roadway capacity and outlines guidelines and strategies for increasing the efficiency of bus operations on surface streets. Perhaps the most promising strategies for improving bus services are those relating to priority treatments for buses. These strategies include reserved bus lanes and priority treatment for buses at traffic signals. The planning and implementation of these bus priority treatments requires a high concentration of bus services, high levels of traffic congestion, and community support for transit services. Consequently, to be successful, they must be carefully coordinated with the local transportation agencies responsible for traffic control and general roadway planning and operations.

4.2 Capacity

The percentage of buses (and other heavy vehicles) in the traffic stream is an important parameter in how a road operates. The reductive effect of buses on vehicular capacity varies according to the method of operation. For uninterrupted flow, buses are the equivalent of 1.5 passenger cars. The equivalence factors of urban buses at signalized intersections depend on service time requirements at stops, the green to cycle time ratio (g/C) of the signal, vehicle flow rates, and bus volumes. Current practice is to adjust for the presence of buses in the traffic stream using the procedures and factors presented in the Transit Capacity Chapter in the Highway Capacity Manual (15). These adjustments do not, however, reflect the impact of person volume on total intersection delay and other similar measures of performance that are based on individuals rather than vehicles.

Suggested arterial street exclusive or near-exclusive bus lane capacity ranges based on actual operating experience are given in Table 5. This table gives representative service volumes for downtown streets and arterial streets leading to the city center for each level

Table 5. Suggested Bus Flow Service Volumes for Planning Purposes[a] (Flow Rates for Exclusive or Near-Exclusive Lane)

Level of Service	Arterial Streets		
	Description	Buses/Lane/Hour	MidValue
A	Free Flow	25 or less	15
B	Stable Flow, Unconstrained	26 to 45	35
C	Stable Flow, Interference	46 to 75	60
D	Stable Flow, Some Platooning	76 to 105	90
E	Unstable Flow, Queuing	106 to 135	120
F[b]	Forced Flow, Poor Operation	over 135[c]	150[c]
Main CBD Street			
A	Free Flow	20 or less	15
B	Stable Flow, Unconstrained	21 to 40	30
C	Stable Flow, Interference	41 to 60	50
D	Stable Flow, Some Platooning	61 to 80	70
E	Unstable Flow, Queuing	81 to 100	90
F[b]	Forced Flow, Poor Operation	over 100[c]	110[c]

[a]These service volumes may be used for planning purposes. More precise values for operations and design purposes should be computed from the capacity relationships and procedures set forth in Chapter 12 of the Highway Capacity Manual.

[b]The values for level of service F should not be used for planning or design. They are merely given for comparative purposes.

[c]Results in more than one-lane operation.

Source: Reference 15.

of service. Where stops are not heavily patronized, as along outlying arterial streets, volumes could be increased by about 25 percent (15).

4.3 Bus Priority Measures

Planning and implementing bus priority measures require a reasonable concentration of bus services, a high degree of bus and car congestion, and community willingness to support public transport. Measures should be applied that:

- alleviate existing bus service deficiencies
- achieve attractive and reliable bus service
- serve demonstrated existing demands
- provide reserve capacity for future growth in bus trips
- attract auto drivers
- relate to long-range transit improvements and downtown development programs

General planning guidelines for assessing the applicability of various bus priority measures for arterial streets are outlined in Table 6. The guidelines generally specify that the number of bus riders in the exclusive lane be at least equal to the number of auto occupants in the adjoining lane for the period that the priority measures would apply. They are expressed in terms of peak-hour buses and passengers and should be based on future design year corridor demands to allow for generated traffic. However, approximately 75 percent of the warrants should apply to base-year (existing) conditions. This approach allows flexibility for the future, and it safeguards against unrealistic demand forecasts (4).

Bus priority measures for arterial streets include reserved lanes and streets (i.e., contraflow, concurrent flow, and reversible lanes), priority at traffic signals (i.e., bus signal preemption and special signalization), and special turn permission (i.e., "No Left Turn, Buses Excepted"). Most bus priority measures are reserved bus lanes on city streets, usually in the direction of traffic flow. Following is a brief discussion of each type of bus priority measures (16).

Table 6. Applicability of Arterial Bus Priority Treatments

Type of Treatment	General Applicability To: Local Bus	General Applicability To: Limited-Express Bus	Planning Period (Years)	Design-Year Conditions: One-Way Peak-Hr Bus Volumes	Design-Year Conditions: One-Way Peak-Hr Bus Passenger Volumes	Related Land-Use and Transportation Factors
Bus preemption of traffic signals	X		1-5	10-15	400-600	Wherever not constrained by pedestrian clearance or signal network constraints.
Special bus signals and signal phases, bus actuated	X		1-5	5-10	200-400	At access points to bus lanes, busways, or terminals; or where special bus turning movements must be accommodated.
Special bus turn provisions	X		1-5	5-10	200-900	Wherever vehicular turn prohibitions are located along bus routes.
CBD curb bus lanes, main street	X		5	20-30	800-1200	Commercially oriented frontage
Curb bus lanes	X		5	30-40	1200-1600	At least 2 lanes available for other traffic in same direction
Median bus lanes	X	X	5	60-90	2400-3600	At least 2 lanes available for other traffic in same direction; ability to separate vehicular turn conflicts from buses.
Contra-flow bus lanes, short segments	X		5	20-30	800-1200	
Contra-flow bus lanes, extended	X	X	5	40-60	1000-2400	At least 2 lanes available for other traffic in opposite direction. Signal spacing greater than 500-ft intervals.
Bus turnouts	X		5	10-15	400-600	Points of major passenger loadings on streets with more than 500 peak-hour autos using curb lane.
Bus streets	X	X	5-10	20-30	800-1200	Commercially oriented frontage

Source: Adapted from Reference 4.

Contraflow is where the high-occupancy vehicles travel on an arterial in the direction opposite the normal flow. Contraflow facilities have developed in three ways: 1) a contraflow lane is added to an existing one-way arterial, 2) a two-way street is converted to one-way flow and the high-occupancy vehicles continues to use the street in the contraflow direction, and 3) a lane is added to a divided arterial by using an off-peak direction lane (left side of median) for peak direction buses.

Concurrent flow lanes are traffic lanes reserved for high-occupancy vehicles in the same direction as the normal traffic flow and are also the most common form of priority lanes. Although the curb lane is normally used, lanes adjacent to the median or in the area previously used by streetcars are sometimes used. By far the most common form of concurrent flow lanes are reserved curb lanes in central business districts. Concurrent flow lanes allow high-occupancy vehicles to bypass waiting vehicles at traffic signals or other bottlenecks resulting in an improved level of service for the passengers in the high-occupancy vehicles. The use of the lanes for concurrent flow can be restricted to peak periods and can revert to mixed flow traffic or to parking or loading. Continual enforcement is required for success since the lane is subject to frequent violations by both moving and parked vehicles. When other than the curb lane is used as the reserved lane, it is difficult to load and unload passengers.

Reversible lanes utilize the same lane for both the A.M. and P.M. peak periods. This type of facility could conceptually be considered a form of concurrent flow or a combination of concurrent flow and contraflow, depending on the configuration. An advantage of the reversible center lane configuration is that it can revert to a continuous center lane for left turns during off-peak periods. The reversible lane concept is disruptive to normal traffic flows because it requires the prohibition of left turns if a reversible center lane is used. If the reversible lane is located to the left of the left-turn lane, the signal phasing is constrained by the need to avoid conflicts between the left-turn lane and the reserved lane.

Two types of priority at traffic signals are passive and active. Passive priority only acknowledges the presence of a bus in terms of the timing pattern; the predetermined timing pattern is not affected by the presence or absence of buses. The signal is typically timed to reflect the lowest total person-hours of delay. Active priority or preemption of traffic signals occurs when a signal from a bus overrides the existing pattern and substitutes a new signal pattern to benefit buses. Preemption can be further divided into two subsets, unconditional and conditional preemption. Unconditional preemption results if preemption is granted whenever a bus requests it, subject only to clearance intervals (pedestrian and vehicle) required for safety. Conditional preemption results if other factors (e.g., progression, or time since last preemption) are also considered to determine when or if a preemption will be granted.

Special bus turn provisions are used when vehicular turn prohibitions are located along a bus route.

4.4 Signs and Pavement Markings

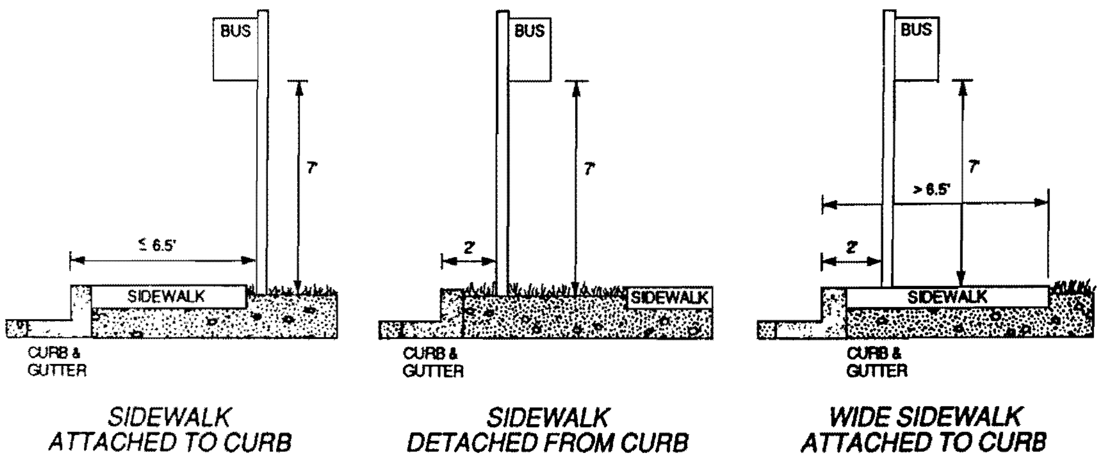
Proper signs at transit facilities are an important element of good transit service. Signs serve as a source of information to the patrons and operators regarding the location of bus stops, park-and-ride lots, and other facilities, and are an excellent marketing tool to promote transit use.

A bus stop sign may either be a standard traffic control sign (e.g., see Texas Manual on Uniform Traffic Control Devices (17)), or a transit agency sign which identifies the bus stop location and displays the name and number of the bus route(s) using the stop. The transit agency's information telephone number is also frequently displayed on the bus stop sign.

Bus stop signs should be placed at the location where people will board the front door of the bus. The bus stop sign indicates the area where passengers should stand while waiting for the bus and serves as a guide for the bus operator in positioning the vehicle at the stop. Double sided signs for visibility from both directions and reflectorized signs for night time visibility are preferred.

Bus stop signs should be installed with their own sign post and should not be obstructed by trees, buildings, or other signs. The bottom of the sign should be at least 7 feet above ground level and should not be located closer than 2 feet from the curb face. Figure 13 shows typical bus stop sign placement standards.

Pavement markings associated with bus stops are generally installed and maintained by local authorities. The most common is the yellow painted curb at bus stops. Stop lines and/or crosswalks are also desirable as most bus stop locations are at intersections. Pavement markings for priority lanes, such as for high-occupancy vehicles or buses, should be installed by local authorities.



Source: Reference 13.

Figure 13. Guidelines for Bus Stop Sign Placement

4.5 Traffic Signals

Bus stops are frequently located at signalized intersections. Generally the intersections are of two major streets which provide the potential for transfers of passengers between buses or for larger accumulations of passengers. Traffic signal design should accommodate buses and bus passengers. The following guidelines concerning traffic signals and transit operations should be considered in designing signal systems:

- Location of bus stops should be coordinated with traffic signal pole and head location. Bus stops should be located so that buses do not totally restrict visibility of traffic signals from other vehicles. (These problems can be effectively addressed by using far-side bus stops.)

- All bus passengers become pedestrians upon leaving the bus. It is very desirable that WALK and DON'T WALK indications be in place at signalized intersections at bus stops.

- When traffic actuated signals are installed, pedestrian push buttons should also be installed to activate the WALK and DON'T WALK indications.

- Near-side stop areas often are between the advance detectors for a traffic signal and the crosswalk. Location of a detector at the bus stop will enable the bus to actuate the detector and the signal controller to obtain or extend the green light. Lack of a detector will force a bus to wait until other traffic approaching from the same direction actuates the signal controller.

- Timing of traffic signals should also reflect the specific needs of buses. Longer clearance intervals may be required on higher speed roadways with significant bus traffic. Vehicle passage times must provide adequate time for a bus to accelerate from the bus stop into the intersection. Intersections adjacent to railroad tracks should have timing and detection that reflect the need for buses to stop at the railroad crossings.

4.6 Maintenance

Maintenance for bus-related street improvements generally consists of the following:

- Maintenance of pavement surfaces
- Repainting stop areas

- Snow removal/sanding of roadway and bus turnouts
- Cleaning, repair, and replacement of parking control signs
- Cleaning, repair, and replacement of bus stop signs

The majority of bus stops are at sidewalk areas within the public roadway section. Maintenance of these areas is generally the responsibility of the agency responsible for the roadway unless a separate maintenance agreement between the transit and highway agencies is instituted. Maintenance for those areas on private property, such as shopping centers, hospitals, and schools, would be the responsibility of the property owner unless a separate maintenance agreement between the property owner and the transit agency is arranged prior to initiation of transit service. Maintenance of passenger shelters is generally the responsibility of the agency that owns the shelter.

In general, the agency responsible for maintenance at bus stop areas is as indicated below:

<u>Item</u>	<u>Responsible Agency</u>
• Roadway maintenance or pavement repair	• Local roadway jurisdiction
• Bus stop signs	• Transit agency
• Repainting of painted surfaces	• Local roadway jurisdiction
• Passenger shelter and pad	• Transit agency (or property owner)
• Landscaped areas	• Property owner

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