4. Design Guidelines for Transit Facilities on Streets

In the arterial street setting, the provision and design of transit facilities is fully integrated with the provisions for passenger service. This Chapter reflects the integration of in-street and curbside infrastructure in the design of urban transit facilities.

This Chapter deals specifically with provisions for the operation of rubber-tired public transit buses within a street environment. Neither light rail, trolley, or other fixed rail modes are addressed here. Busways and transitways in their own rights of way are addressed in Chapter 3. Provisions related to High-Occupancy Vehicles on arterials are addressed in greater detail in NCHRP Report 414, HOV Systems Manual [2].

This discussion concentrates on the transit arrangements that most directly affect roadway design, and vice versa. Buses can operate in mixed traffic or under various degrees of preferential treatment over - or segregation from - other vehicles. In mixed operations, the key transit facilities are at the curbside, where transit vehicles and their passengers (customers) interact. Where transit preferential treatment is under consideration, specific guidelines are provided for the various methods of providing that.

4.1. General Planning And Design Considerations

The general approach to planning and implementing transit facilities on streets is to recognize the role of public transit in providing mobility to both transit-dependent and “choice-of-mode” passengers within the urban transportation network, and where appropriate to assign a higher priority to transit operations over general traffic movement.

The vast majority of surface transit operation occurs in mixed traffic. The applicability of preferential treatment (dedicated lanes and stations) for transit reflects the fact that a single bus can carry as many people as forty or fifty automobiles, and that urban transportation systems should be focused on the efficient movement of people and goods rather than of vehicles.

Those facilities may take the form of either bus-only facilities or High-Occupancy Vehicle facilities. The latter provide preferential treatment for carpools along with transit vehicles and in many cases are physically identical to a bus-only version. The special provisions related to operating an HOV lane on an arterial (over and above those necessary to provide preferential treatment for transit alone) are addressed separately, in NCHRP Report 414, HOV Systems Manual [2]. This Chapter focuses on bus-only measures.
4.1.1. TYPES OF ON-STREET TRANSIT SERVICES AND FACILITIES

There are two general categories of arterial-related transit priority treatments:

- Those which give transit exclusive use of the roadway or of designated lanes (i.e. concurrent and contraflow reserved lanes, reversible median or center lanes, transit malls, etc.); and
- Those which give preferential treatment or special privileges to buses through traffic control measures (i.e traffic signal pre-emption systems, transit-oriented traffic signal timing, special exemptions from turn prohibitions, etc.).

Note that there is considerable – but not complete - overlap between transit priority and HOV priority in this context.

Arterial streets which are reserved for the exclusive use of transit, or which have specific lanes reserved for buses, can have many combinations of physical and operating characteristics. These are illustrated in Table 4.1.

Regardless of the type of treatment, the geometric design and traffic control features should adequately and safely accommodate all vehicles which might ultimately use the facility. If it can be ensured that a facility will always be limited to bus-only use, for example, some design features could be modified from those that would apply for general traffic use. Even so, the needs of maintenance, service, and emergency vehicles must always be considered in the design criteria.

Consideration should also be given at an early stage as to whether there is potential or possibility for ultimate conversion of the general traffic or bus priority facility to a light rail mode. This is critical because many light rail design parameters differ from those for rubber tired transit facilities – a few examples include pavement depth and structure, superelevation, drainage, passenger stops, power/communications provisions, grade, and horizontal and vertical clearances. If light rail conversion potential exists, or the bus facility is being implemented as an interim step towards rail, the design criteria will need to combine the most restrictive aspects of both bus and light rail modes.

4.1.2. PLANNING AND DESIGN PROCESS

Groups Involved

A project aimed at improving bus operations on an arterial road will undergo a planning process similar to any road improvement project, and will need to include the involvement of the same stakeholders. The participation of the appropriate agencies and individuals is key to ensuring that all groups are involved in discussing the different design elements, that potential issues are identified and resolved prior to implementation, and that all groups have a common understanding of the project intent and outcome.

The key agencies to be involved in the process are the Transit Agency and the road owner (City / Town / County or State Department of Transportation). If the Transit Agency is essentially an operating body and has limited planning and design responsibilities or capabilities, the City / State will take the lead role in planning and design. If, on the other hand, the Transit Agency has the necessary in-house expertise it will drive the project.
Close co-operation between the road owner and the transit agency is required in all aspects of the work, from agreeing on the function of the roadway in achieving the mobility objectives for the corridor to deciding on the design details that affect safety and capacity for all road users. The Metropolitan Planning Organization (MPO) may play a key role in ensuring the necessary co-ordination and co-operation between agencies. Every agency with a funding role will have a stake in the project’s outcome and will need to be consulted with throughout the planning process.
An arterial project is likely to generate considerable interest within the community through which it passes, from both commercial property owners / tenants and residents of adjacent properties. Aspects such as property requirements, congestion, cut-through traffic, noise, on-street parking, accessibility, and aesthetics are of direct interest to the community.

Major trip generators (schools, medical centers, shopping centers, public buildings, large employment complexes, etc.) may have a direct interest in enhancing transit accessibility, service, and attractiveness. Representatives of the disabled community also have a direct and specific interest in the design aspects of the project.

Appropriate mechanisms should therefore be used to involve interested community members and representatives in the planning and design process.

Other stakeholders that should be considered for inclusion in the process (as appropriate to the corridor under study) include:

- Police / enforcement agency
- Federal agencies (FHWA, FTA)
- Rideshare agency / Transportation Management Association
- Local municipalities (Planning and Engineering departments)
- Emergency service providers
- Maintenance services
- Property Developers

Bus passengers and drivers possess perhaps the most intimate knowledge of the corridor and its day-to-day problems; since they are the “customers” for the improvement project, it is vital to obtain their input and to communicate with them throughout the planning and design process.

**Planning and Design Steps**

The design process for any transportation project normally involves a number of steps. These include:

- review the results and recommendations from the planning process;
- consider operational issues and opportunities;
- obtain input from the public and local organizations;
- assess the specific characteristics of the freeway or corridor;
- develop a preliminary design;
- review the preliminary design with the public and local organizations;
- finalize the design plans; and
- implement a performance monitoring program.

The steps are discussed in more detail below.

- **Review Recommendations from Planning Process.** The first step in the design process usually involves reviewing the results or recommendations from the planning process. Any changes in the corridor, project objectives, funding mix, stakeholders, or other features during the period since the planning study should be reviewed. The outcome of the planning process will usually be a recommended alternative or a limited number of alternatives. These recommendations will form the basis for the start of the design process.
Consider Operational Issues and Opportunities. The operating characteristics associated with the recommended application should be considered early in the design process. Reviewing the operational issues and the opportunities related to the selected alternative(s) can assist in identifying critical elements that may need to be addressed in the project design. Approaches to address these concerns can then be incorporated into the facility design.

Obtain Input from the Public and Local Organizations. The public involvement process started in the planning phase of a project should continue through the design process. Providing the public, business and neighborhood groups, and other organizations with the opportunity to participate early in the design process will help identify any issues and concerns that will need to be addressed. Techniques used to involve the public at this point in the process may include meetings, focus groups, surveys, and individual interviews.

Assess Specific Characteristics of Arterial or Corridor. The characteristics of the roadway being considered for the transit project are examined in this step. Possible activities include detailed assessment of traffic volumes, available right-of-way, intersection spacing, existing bus services, and adjacent land uses. Although many of these items will have been examined in the planning stage, a more detailed analysis is usually needed in the design process.

Develop Preliminary Designs. This step includes the development of the preliminary designs for the specific project. Although the complexity and level of detail will vary depending on the type of treatments considered, the design should be completed to a stage that allows all groups to understand the key components of the facility, to develop realistic cost estimates, and to outline an implementation schedule.

Review Preliminary Designs with the Public and Local Organizations. The preliminary designs should be reviewed by the public, business and neighborhood groups, and other organizations along the affected corridor. Techniques for public involvement at this stage may include hearings, meetings, workshops, outreach efforts, newsletters, and other approaches.

Select and Finalize Preferred Design. The comments received through the public involvement process should be reviewed, the preferred design selected, and any needed modifications should be made to the design plans. The design can then be finalized and used to develop the plans and specifications for the project. The actual construction and implementation process can then be initiated.

Operational Monitoring and Refinement. A monitoring program that establishes the pre-existing baseline conditions (congestion, bus delays, unreliability, etc.) and quantifies the improvements due to the project will likely make a considerable contribution to maintaining community support through the disruptive construction process. It will identify any areas for further improvement and will also be useful in similar work in other corridors. The Monitoring program thus needs to be set out and initiated well before construction begins. Once a facility is in operation, close attention should be paid to the comments of bus passengers, bus drivers, motorists, disabled users, fronting commercial property owners, and the community. A mechanism for their input should be maintained and special effort made to respond quickly to any concerns that arise.
4.1.3. NEED AND JUSTIFICATION FOR BUS PRIORITY TREATMENT

Within the physical confines of a busy mixed-flow arterial street, it is physically impossible to maintain free flow conditions for all users at all times. Transit users may experience their share of delay (or even a disproportionate share), and they may themselves create delays to other users of the road.

Arterial bus or HOV lanes are designed to increase the potential person-capacity of a roadway by reserving one or more lanes, either part-time or full-time, for the use of vehicles with multiple occupants. When the regular (general traffic) lanes experience congestion, vehicles in the reserved lane should still travel freely. As a result, persons in the reserved lane are provided a time-savings benefit compared to persons driving alone. This time-savings and service reliability benefit can both optimize the efficiency of the existing bus operation and attract new users from general traffic modes.

The rationale for designing and operating the street such that buses are given priority over other vehicles (notably the private car) may stem from three principles:

- delay inherent in street use should be allocated proportionally among all users (i.e. bus passengers should not experience any greater delay than the equivalent trip by private car);
- the public investment in transit service should be protected by ensuring that buses can maintain reliable, efficient schedules; and
- as a matter of public policy, priority may be granted to those users of the transportation system that choose the least polluting, most space-efficient, most energy-efficient, and least costly modes.

While there is considerable flexibility in the application of these principles, it must always be considered that any advantage to transit is usually coupled with an actual or perceived (relative) disadvantage to other street users. There are both technical and qualitative aspects to this equation. If a lane is converted from general traffic to exclusive bus use, for example, it will not necessarily be obvious to the motorist in the adjacent lane that the use of that lane by one bus every few minutes is actually the key to maximizing the person-moving capability of the street. Similarly, a major investment in transit signal priority could be cost-effective yet imperceptible to the motorist and even the bus passengers.

The need and justification for bus priority treatment is therefore a complex, corridor-specific or jurisdiction-specific mix of policy, technical, and public perception factors. To state that “a bus lane should be used by at least \( X \) buses per hour” or “converting a general purpose lane to exclusive bus use is warranted if it is used by \( X \) buses per hour” can be a risky oversimplification.

A priority facility can, however, be assessed on its technical merit as an input to the policy / public perception deliberations.

A bus lane should only be provided only where it can be demonstrated that the person-moving capacity of a roadway would be improved, and that it would not be better to open the lane to general traffic. A comparison of the “with bus priority” and the “without bus priority” alternatives can be made using the analytic procedures in Chapter _ of the Highway Capacity Manual. Benefit / Cost analysis is another useful justification technique, since it puts all options on an equal footing, can address both positive and negative impacts together, and can apply to everything from signal priority systems to bus lanes. Another approach is to simply limit bus lanes to
situations where the benefiting buses would carry at least as many people as if the lane were used by autos.

Implementing transit priority by way of establishing High Occupancy Vehicle lanes can often boost the “benefit” side of a benefit / cost analysis at little incremental cost, and may be considered as long as the operational integrity of the bus service is not compromised. Similarly, where a bus-only lane enjoys only marginal technical or public support, an HOV 3+ lane (or in some cases a 2+ facility) may be considered as an alternative mechanism to provide bus priority over single-occupant vehicles. HOV lanes, however, can raise significant issues of policy, public support, enforcement and transportation strategy, and should be considered carefully in that context.

4.1.4. SELECTING TYPE OF APPLICATION

There are two general types of arterial settings where transit facilities are considered:

- High-standard, high-speed (40 – 50 mph) multilane suburban roads, generally with limited access (see Figure 4-1); and

- Lower-speed, short-block, urban streets generally found in or around centers of concentrated employment like Central Business Districts (see Figure 4-2)

Spot treatments (signal priority, queue jumps, etc.) can be applied on either a standalone basis or in conjunction with either of the on-road treatments noted above.

Where bus service frequency and demand is such that, during peak periods, buses carry at least as many people as the autos in a typical adjacent lane, there is some rationale for dedicating a lane to transit. This typically corresponds to a bus volume of at least 20 buses per hour but, as noted earlier, a usage threshold should be corridor-specific and locally-developed. At lesser demand levels, bus lanes or other priority measures can be rationalized on the basis of Benefit / Cost analyses or local circumstances and opportunities.
In either case, as Figure 4-3 demonstrates, implementation of transit facilities is often a difficult proposition, due to the need to balance sometimes-competing requirements:

- overall efficiency of the road system (i.e. by not unduly penalizing auto users);
- transit operational and passenger needs;
- requirements of streetfront commercial and residential users;
- frequency and spacing of cross streets and traffic signals;
- road safety;
- the objectives held for transit; and
- cost / funding issues.

More often than not, transit facilities are needed to resolve operational problems on an existing roadway rather than a brand new street, accentuating the above issues.

The interface between buses and passengers occurs at bus stops or off-line stations (see Chapter 5). The general location of bus stops is largely dictated by patronage and by the locations of intersecting bus routes and transfer points. Convenience and safety are the primary needs of bus stop users; bus stops that are not convenient or safe will not be used.

**Bus Lane Hours of Operation**

If a bus or HOV lane designation is required in order to preserve the operational integrity of the bus service or to establish bus priority over general traffic, the hours of the restriction must also be defined. The choices are:

- peak period (peak direction or both directions)
- daytime (e.g. 7 AM - 7 PM)
- full time (24 hours per day)

Factors influencing the outcome include:

- precedent (local or regional);
- the time, extent, magnitude, and consistency of recurring traffic congestion;
- bus service frequency and peaking characteristics;
- demand for use of the lane by others (particularly the curb lane);
- corridor or systemwide consistency;
- enforceability and degree of commitment to enforcement; and
- local or project-specific circumstances.
Peak period or daytime bus lanes usually apply on weekdays (Monday – Friday) only, since both bus volumes and traffic congestion are often reduced on weekends. However, some corridors or circumstances may require Saturday or 7-day designation. The need for extended hours will be determined through local study.

4.1.5. BUS STOP DESIGN BASICS

Bus Zone Location

The location of bus stops on the near side vs. the far side of a major intersection is the subject of a long and complex debate and specific preferences typically exist within each locale. While there are adherents to both positions, on balance, a far-side location (particularly in combination with signal priority for buses) generally provides the best service to passengers and the fastest, most reliable path for bus operations. Table 4-2, adapted from TCRP Report 19, Guidelines for the Location and Design of Bus Stops [3], summarizes the general advantages and disadvantages of each:

Bus Zone Length

A bus zone is a designated road space for loading and/or unloading passengers. A zone accommodating one bus is normally from 25m (80 ft) to 50m (160 ft) in length. In business districts, during peak periods, this length may be extended. If a bus zone is located in an area where parking is permitted, the zone length is marked to keep the area free of parked or stopped cars at all times. Parked vehicles in a bus zone should be towed away immediately. Basic bus bay dimensions are summarized in Table 4-3.

Platform Geometry

The basic bus platform takes the form of a flat concrete pad adjacent to the roadway, large enough to accommodate a passenger shelter, benches, or other facilities without interfering with the through movement of pedestrians on the sidewalk (if present). The pad should be at least 2.5m (8’) deep and 3 m (10’) long. Specific dimensions will depend on the size, shape, and orientation of passenger shelters, and on the number of waiting passengers.

The curb line and sidewalk should extend the full length of the platform (see below) to allow safe and efficient passenger alighting (and, in a proof-of-payment system, boarding) at the rear doors.

The bus stop should be located such that oncoming buses are clearly visible early enough for waiting passengers to react and move to the stopping door and/or flag the bus operator.
<table>
<thead>
<tr>
<th>Far-Side Stop</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimizes conflicts between right turning vehicles and buses</td>
<td>May result in the intersections being blocked during peak periods by stopping buses</td>
</tr>
<tr>
<td>Provides additional right turn capacity by making curb lane available for traffic</td>
<td>May obscure sight distance for crossing vehicles</td>
</tr>
<tr>
<td>Minimizes sight distance problems on approaches to intersection</td>
<td>May increase sight distance problems for crossing pedestrians</td>
</tr>
<tr>
<td>Encourages pedestrians to cross behind the Bus</td>
<td>If signal priority not in use, can cause a bus to stop far side after stopping for a red light, which interferes with both bus operations and all other traffic</td>
</tr>
<tr>
<td>Creates shorter deceleration distances for buses since the bus can use the intersection to decelerate</td>
<td>May increase number of rear-end accidents since drivers do not expect buses to stop again after stopping at a red light</td>
</tr>
<tr>
<td>Results in bus drivers being able to take advantage of the gaps in traffic flow that are created at signalized intersections</td>
<td>Could result in traffic queued into intersection when a bus is stopped in travel lane</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Near-Side Stop</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimizes interferences when traffic is heavy on the far side of the intersection</td>
<td>Increases conflicts with right-turning vehicles</td>
</tr>
<tr>
<td>Allows passengers to access buses closest to crosswalk</td>
<td>May result in stopped buses obscuring curbside traffic control devices and crossing pedestrians</td>
</tr>
<tr>
<td>Results in the width of the intersection being available for the driver to pull away from curb</td>
<td>May cause sight distance to be obscured for cross vehicles stopped to the right of the bus</td>
</tr>
<tr>
<td>Eliminates the potential of double stopping</td>
<td>May block the through lane during peak period with queuing buses</td>
</tr>
<tr>
<td>Allows passengers to board and alight while the bus is stopped at a red light</td>
<td>Increases sight distance problems for crossing pedestrians</td>
</tr>
<tr>
<td>Provides driver with the opportunity to look for oncoming traffic, including other buses with potential passengers</td>
<td></td>
</tr>
</tbody>
</table>
### Table 4-3

**Bus Bay Dimensions**

#### Metric

<table>
<thead>
<tr>
<th>Through Speed (km/h)</th>
<th>Entering Speed (km/h)</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Entrance Taper (m)</td>
</tr>
<tr>
<td>&lt;50</td>
<td>&lt;30</td>
<td>5:1 min</td>
</tr>
<tr>
<td>60</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>70</td>
<td>50</td>
<td>65</td>
</tr>
<tr>
<td>80</td>
<td>60</td>
<td>70</td>
</tr>
<tr>
<td>90</td>
<td>70</td>
<td>75</td>
</tr>
<tr>
<td>100</td>
<td>80</td>
<td>80</td>
</tr>
</tbody>
</table>

#### U.S.

<table>
<thead>
<tr>
<th>Through Speed (mph)</th>
<th>Entering Speed (mph)</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Entrance Taper (ft)</td>
</tr>
<tr>
<td>&lt;30</td>
<td>&lt;20</td>
<td>5:1 min</td>
</tr>
<tr>
<td>35</td>
<td>25</td>
<td>170</td>
</tr>
<tr>
<td>40</td>
<td>30</td>
<td>190</td>
</tr>
<tr>
<td>45</td>
<td>35</td>
<td>210</td>
</tr>
<tr>
<td>50</td>
<td>40</td>
<td>230</td>
</tr>
<tr>
<td>55</td>
<td>45</td>
<td>250</td>
</tr>
<tr>
<td>60</td>
<td>50</td>
<td>270</td>
</tr>
</tbody>
</table>

**NOTES:**

- Entering speed to be within 15 km/h (10 mph) of through speed at end of taper.
- Tapers based on standard 3.65m (12 ft) bus bay width. 3.0m (10 ft) minimum is acceptable for traffic speed under 50 km/h (30 mph). Add 6m (20ft) to length of stopping area if it is to be used by 18m (60 ft) long articulated buses.
- Deceleration rate 4 km/h/sec (2.5 mph/sec)

**Reference:** [3]
**Accessibility Features**

An appropriate curb height for efficient passenger-service operation is between 0.15 m (6 inches) and 0.22 m (9 inches). If curbs are too high, the bus will be prevented from moving close to it and the operations of a wheelchair lift could be compromised. Low-floor buses may have difficulty operating where high curbs are present. If there is no curb or the curb is too low, elderly persons, persons with mobility impairments, or passengers with child strollers may have difficulty boarding and alighting.

The urban design, lighting, visibility, grade, and accessibility of both the stop and of approach pathways should be carefully considered. All bus stops should be accessible by hard-surfaced sidewalk or pathway that is cleared and maintained in all seasons. Sidewalks at bus stops need to be relatively level, in addition to being wide, so that lifts will properly deploy.

The bus stop/bay surface should be a durable, stable material able to resist the heavy bus stopping loads (12,000 kg / 25,000 lb) and avoid pavement failure or rutting and ponding which can lead to buses splashing waiting customers. Reinforced concrete pavement pads are the most common design approach to this problem.

In the case of a bus bay, if a curb and gutter (urban) drainage system is in place, the bus bay should drain to a continuous gutter at the edge of the traveled lane, rather than to the curb.

### 4.2. Bus Operations in Shared Lanes (Mixed Traffic)

#### 4.2.1. ACCOMMODATIONS FOR SHARED LANE USE

**Part-Time Uses**

*Parking*

Bus routes often pass through commercial areas where on-street parking is seen as vital to the economic health and/or pedestrian-oriented nature of the area. Removal or relocation of established on-street parking can be a contentious issue, and often a compromise must be struck between the needs of bus/traffic operations and local parking requirements. This normally takes the form of prohibiting on-street parking during peak periods and allowing it at other times.

When parking is prohibited, local transportation needs will define whether the lane is reserved for bus use, HOVs, or opened to general traffic. As a general rule, it is easier to convert a lane to bus or HOV use if it is used for parking during the day than it is to convert a general traffic lane to restricted use, since the lane is not being "removed" from general use.

When a lane has a "no parking" designation on it, it is essential that it be enforced as such; a single parked vehicle in a congested location can pose significant delays to several buses at a time as they try to merge into the adjacent general traffic lane to skirt the stopped vehicle. Signage and parking meter notices should be very clear as the hours of parking availability, and the cooperation and support of adjacent merchants should be sought. The restriction should be backed up with a towing
program, with all vehicles stopped or parked in the lane during the “no stopping” period removed immediately. In particular, a sweep should be made of the lane shortly after the start of the “no parking” period to ensure it operates effectively through the peak period.

**Shoulder**

If a shoulder is used by buses during peak periods, a substantial signing effort is required to ensure that parked vehicles are not left on the shoulder during bus lane operation. A “sweep” of the lane by tow trucks at the start of the bus lane period may be required. “No Parking” / “No Stopping” restrictions will apply during the period of bus operation.

**Mixed Traffic**

The bus clearance requirements for the lane in which the bus travels are:

- Overhead obstructions should be a minimum of 3.65 m (12 ft) above the street surface;
- Obstructions (posts, signs, vegetation) should not be located within 0.6 m (2 ft) of the edge of the traveled lane to avoid being struck by a protruding bus mirror; and
- A traffic lane used by buses is desirably 4.25 m (14 ft) wide and should be no narrower than 3.65 m (12 ft) in width, since a bus with mirrors is typically 3.2 m (10’ – 6”) wide.

**Turning Traffic And Driveways**

Vehicles may enter a right curb bus or HOV lane in order to complete a right turn into or out of a crossing street or driveway; they should not turn directly to or from the second lane. A distance of 100 m (300 ft) upstream and downstream of the entrance is adequate and appropriate.

Alternatively, if the reserved lane passes through several short city blocks, the turning vehicle may be allowed to use the lane within one block of the turn. Enforcement is eased in that case by the fact that any ineligible vehicle passing straight through an intersection can be automatically cited (although lenience is required if there are entrances (e.g. a service center) immediately downstream of the intersection).

Motorists and the public should be made aware of the appropriate legislation.

**Bicycles**

Unless specifically banned from the road, bicycles are required to travel adjacent to the curb unless there is on-street parking. If the lane is not wide enough to provide a dedicated bicycle lane at the curb, the shared use of a narrow lane can pose a safety hazard to bicyclists, decrease the comfort of both bicyclists and bus operators in the lane, and reduce the operational efficiency of the lane.

Buses operating in other than the curb lane do not experience (or generate) such bicycling conflicts.
Loading / Deliveries

There is an inherent conflict between a bus operating in a curb lane and stopped loading / delivery vehicles. In a street where conflicts arise between bus operations and the commercial needs of fronting businesses, a consultative approach is recommended, so that all parties can work towards a solution that is mutually agreeable.

Where conflicts exist, the two functions must be separated either physically or temporally:

- Loading / delivery functions can be prohibited during peak bus operating periods;
- Loading / delivery functions can be relocated to side streets or laneways or underground docks;
- Buses can operate in a lane other than the curb lane;
- Buses can operate on alternative routes.

If loading / delivery functions share the curb lane with bus operations but are prohibited during peak periods, enforcement should be rigorous and the appropriate regime of fines, towing, and penalties applied. Signage should be direct and clearly visible.

4.2.2. BUS OPERATIONS AT INTERSECTIONS

Intersection Approach

Turning Geometry

At an intersection where buses make or have the potential to make right turns, careful consideration must be given to the corner curb radius. A properly designed curb radius produces:

- Less bus/auto conflict at heavily used intersections (since buses can move quickly and smoothly through the turn);
- Higher bus operating speeds and reduced travel time; and
- Improved bus passenger comfort.

A trade-off in providing a large curb radius is that the crossing distance for pedestrians is increased. This greater crossing distance increases the pedestrians’ exposure to on-street vehicles and can influence how pedestrians cross an intersection, both of which are safety concerns. The additional time that a pedestrian is in the street because of larger curb radii should be considered in signal timing and median treatment decisions.

The design of the corner curb radius should be based on the following:

- Design vehicle characteristics, including bus turning radius (noting that where semi-trailer trucks are present, a bus may not be the critical design vehicles);
- Width and number of lanes on the intersecting street;
Allowable bus encroachment into other traffic lanes (including the potential to set back the stop bar on the intersecting street to allow a turning bus to swing into the opposing lane in order to complete the turn – no right turn on red allowed);

On-street parking;

Angle of intersection;

Operating speed and speed reductions; and

Pedestrian crossing patterns.

For a right turning bus with no encroachment into the opposing lane on the intersecting street, no parking, a 90 degree turn, and no truck use, the basic corner curb radius is tabulated in Table 4-4.

Table 4-4

Recommended Corner Radii

<table>
<thead>
<tr>
<th>Width of Approach Lane</th>
<th>Width of Entered Lane</th>
<th>Recommended Curb Radius</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>m</td>
<td>ft</td>
</tr>
<tr>
<td>3.65 m (12 ft) (i.e. 1 lane)</td>
<td>3.65</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>4.9</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>6.1</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>7.3</td>
<td>24</td>
</tr>
<tr>
<td>4.9 m (16 ft) (i.e. 1 lane with 1.2 m (4 ft) shoulder)</td>
<td>3.65</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>4.9</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>6.1</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>7.3</td>
<td>24</td>
</tr>
<tr>
<td>6.1 m (20 ft) (1 lane with parking)</td>
<td>3.65</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>4.9</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>6.1</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>7.3</td>
<td>24</td>
</tr>
</tbody>
</table>

Reference: [3]

Transit Lane Termination

The simplest, and often most effective, means of terminating a bus or HOV lane on an arterial is to bring it to the stop bar at a signalized intersection, then drop the designation at the other side of the crossing. The curb lane on the exit may then continue in general use or be dropped downstream. This technique works for a bus lane in the right, inner, or left lane.
Another strategy is to make the right lane turn right at the signal, while allowing buses to go straight through; the bus lane can drop and buses merge into the rightmost general traffic lane downstream of the intersection.

Terminating a bus lane in a mid-block location is simply a matter of signage denoting “Bus Lane Ends” and allowing general traffic to move over and use the lane from that point on.

**Right Turn Provisions - Shared Lane Use for Right Turns**

Allowing right-turning vehicles to use the curbside bus lane on the approach to an intersection effectively terminates the bus lane at whatever point non-buses can use the lane. There is little benefit to implementing a curb lane bus lane if the right turn lane approaching an intersection is regularly blocked with queued vehicles.

To minimize the disruption to through movement of buses, the following options are available:

- Ban right turns during the period of bus lane operation
- Direct right turning vehicles to unsignalized cross streets (for example, in a grid network, turns can be made one street in advance of a major crossing arterial then through the grid to the desired cross street, thereby allowing right turns to be banned at the major arterial)
- Allow right turns on the red phase of the signal
- Use a short signal cycle, to provide frequent opportunities for right-turning vehicles to enter the cross street
- Provide a free lane away from the turn on the cross street, so right-turning vehicles can move easily into the cross street
- Avoid a double left turn in the opposing direction on the main street, so that right turns and opposing lefts can occur simultaneously

Where pedestrians are present, consideration should be given to minimizing the conflict between turning vehicles and pedestrians crossing either street.

**Right Turn Provisions - Separate Lane for Right Turns**

In light of the conflicts inherent in sharing the curb lane between buses and right turning vehicles, it is desirable (physical and operational conditions permitting) to provide a separate right turn lane for right-turning vehicles and allow buses an unimpeded approach to the intersection.

Allowing vehicles to turn right from the rightmost general purpose through lane (i.e. the second lane) is not recommended, unless it is on a protected phase and the turning vehicles can queue without disrupting the flow of through traffic. In practice, this approach has rarely been taken due to the safety concerns related to vehicles crossing the bus lane. It is common, however, for motorists to make such an unsafe turn from the second lane where the curb lane is designated for bus use; they can feel uneasy using the bus lane approaching the intersection or they may be bypassing a bus at a near-side stop. Signage, pavement marking, and driver education should be used to clearly direct turning motorists as to the appropriate course of action.
The more common – and preferred - approach is to provide a separate right turn lane to the right of the bus lane. The length of the lane should be adequate to store the maximum queue so that it doesn't spill back into the bus lane. A break in the pavement marking, supplemented by advance guide signs, should be provided to direct turning vehicles safely across the bus lane and into the turn lane.

The effect of a separate right turn lane can also be achieved by operating buses in the second lane, as described above.

**Advance Stop Bar for Bus Left Turns**

In some situations, a high volume of buses must make a left turn at a signalized intersection. It is very difficult to combine this requirement with the provision of effective service at a right curb bus stop before the intersection. If the bus must weave from a right curb stop across a busy multi-lane arterial to a left turn lane, the bus stop must be set so far back from the intersection that passengers transferring to or from a bus route on the cross street are presented with a long and inconvenient walk. Furthermore, the weaving movement has the potential to be both difficult for the bus operator and disruptive to the flow of through traffic.

**Figure 4-4**

**Advance Signal And Stop Bar**
**For Bus Left Turns From Right Lane Bus Stop**

Reference: [2]
It is not always possible to avoid that situation by rerouting buses or by shifting the bus stop to the far side of the cross street (after the left turn). An effective solution can be provision of a signal and stop bar in advance of the intersection to allow the bus to move across the arterial and make the left turn freely and with minimum disruption to through traffic (see Figure 4-4). As a consequence, the right curb bus stop may be located closer to the cross street, providing more convenient transfers.

The stop bar should be located back from the intersection stop bar and at the head of the bus stop or bus bay. The advance signal to bring through vehicles to a stop should be triggered by either the bus moving forward over an in-pavement detection loop or by another electronic means (e.g. bus-mounted transponder, side-mounted radar beam, or similar). The trigger would be located just downstream of the bus stop; the bus should move clear of the bus stop to avoid the risk of a following bus not being able to access the stop while the turning bus awaits its go-ahead. The signal would only operate for the few seconds required by the bus, and would revert to green until a red light for through traffic is triggered by the next bus.

The signal should be coordinated with the left turn signal, such that the bus moves freely through the intersection after receiving the advance green. To minimize the risk of motorists “jumping the light”, the signal to allow the bus to move ahead while other vehicles remain stopped should be a transit-only signal head (i.e. a two-phase signal showing a vertical white bar on a black background) rather than a conventional three-head green-amber-red signal. It should be located within the bus driver’s field of view and not necessarily clearly visible to all motorists.

The advance signal should be far enough back from the cross street signal that motorists do not confuse the two. The advance signal may be signed as such.

The warrant for implementing an advance signal will be based on a benefit-cost analysis, considering transit delays, safety issues, passenger transfer impacts, and net delay to general traffic.

**Bus Movement Across Intersecting Streets**

The street along which a bus travels will typically have a 2% crossfall to the curb as part of the drainage system. Where a street intersects the bus street, the crossfall on the perpendicular street can generate a slight “bump” in the profile of the bus street. This is most obvious in the curb lane, along which the bus typically travels. The effect is sharper the narrower the cross street is. This “bump” can be uncomfortable for sitting bus passengers and hazardous for standees, with the impact on comfort magnified for bus passengers on a street with frequent minor street intersections.

Careful attention should therefore be paid to the details of the pavement grades through each intersection, the intent being to make travel in the curb lane of the bus street as smooth and comfortable as possible while protecting the functionality of the drainage design. Normally, the gradeline of the major road should be carried through the intersection and that of the minor road should be adjusted to it. This design involves a transition in the crown of the minor road to an inclined cross section at its junction with the major road by introducing a sag vertical curve on the intersecting street.

Since superelevation transition lengths for safety and comfort are based on the relative grade differential between the edge of pavement and the centerline profile (see AASHTO Green Book 2001 [4], Exhibit 2.7) the same principle can apply to the intersecting street situation. For example, for a 55 km/h (35 mph) design speed on a
two lane road, the maximum permissible relative grade is 0.63%; the intersection crown transitions at the curb line should therefore adhere to this criterion.

**Bus Stops**

*Near Side – Channelized*

If the right turns at a signalized intersection are channelized, there will be a triangular island between the through curb lane and the turn lane at the approach to the intersection. There can also be a separate right turn lane to the right of the through lane, for storage and deceleration of right-turning vehicles.

A bus stop should not be located within the separate right turn lane, in order to preserve its functionality and to avoid the difficulty in pulling out into the busy through lane. There may be an opportunity, however, to use the island as a bus platform. To do so, the island curb face needs to be long enough (18 m / 60 ft in front of the stop bar) to accommodate a stopped bus and adequate protection provided for waiting passengers against stray vehicles. It can be an exposed, harsh, busy environment, so some form of passenger shelter should be considered.

*Near-Side – Unchannelized*

A near side bus stop at an unchannelized intersection should be located as close as possible to the intersection, in order to minimize walking distance for transferring and boarding passengers. The front of the stopped bus should be 1.5 m (5 ft) from the edge of the crosswalk or end of the curb radius, whichever is further from the intersection.

If the curb lane is used for parking during parts of the day, a No Parking zone should extend at least 30 m (100 ft) back from the stop, to allow the bus to enter the bus stop from the second lane and stop with the rear wheels close to and parallel to the curb.

*Far Side*

A far side bus stop can use a conventional curbside position or an open-ended bus bay. In either case, the number of stopping positions should be carefully assessed in deciding on the length of the stop, to avoid buses queuing back into the intersection or blocking right turns from the cross street.

The rear of the stopped bus should extend no closer than 1.5 m (5 ft) from the edge of the crosswalk or end of the curb radius, whichever is further from the intersection. If the curb lane is used for parking during parts of the day, a No Parking zone should extend at least 15 m (50 ft) downstream from the stop, to allow the bus to re-enter the second lane.
4.3. Bus Lane Design

4.3.1. BUS USE OF SHOULDERS

Between Intersections

A high-standard multilane arterial road in a suburban setting may be provided with paved shoulders. There may be a significant advantage to allowing the use of the shoulder by buses during congested periods (see Figure 4-5) even if that shoulder is used for other purposes (e.g. bike path, parking, etc.) during off-peak periods.

If a shoulder is to be used by buses, it must be structurally and geometrically adequate. The shoulder pavement strength must be designed to reflect regular use as a traveled lane; this generally means the shoulder pavement should be consistent with that of the adjacent general traffic lanes. The traveled portion of the shoulder should be no less than 3.0 m [10 ft] wide and preferably 3.5 m [12 ft] wide. Beyond the traveled portion, an additional paved “shoulder” of at least 1.0 m [3 ft] width should be provided as a buffer between the edge of the lane and any obstructions, piers, sign supports, walls, ditch edges, or guiderails.

All specifications in terms of sight lines, illumination, offset from obstacles, and so on must be met by the shoulder lane just as if it were a normal traffic lane. Retrofitting protection within the Clear Zone may be an important part of a Shoulder Lane project.

The shoulder should revert to its normal function as a breakdown facility during non-congested periods, while buses use the general traffic lanes. In the event of an incident or a stopped car blocking the shoulder during times of Bus Lane operation, buses are required to merge into the rightmost general traffic lane to skirt the obstacle, then re-enter the shoulder downstream of the blockage.

Care must be taken with signing and pavement marking for any lane such as a shoulder Bus Lane that changes function by time of day.

At Intersections

Most suburban arterials where there is enough congestion for shoulder bus lanes to be considered would also have dedicated right turn lanes at intersections. The shoulder therefore typically becomes the right turn storage lane as the intersection is approached and is not continuous across the intersection. Since the shoulder is already structurally capable of accommodating traffic loads, the only issue is the determination of the point at which the lane becomes available to right turning vehicles. Standard right turn queue length analysis procedures will define this point, which should be shown to motorists via pavement marking and (optionally) signage. Buses approaching that point can either continue through in the right lane or merge left to bypass any queue that may develop in the turn lane. A channelized free-flow right turn is one mechanism available to minimize the amount of queuing in the bus / turn lane (see Figure 4-6).
At the intersection, all vehicles other than buses should be required to turn right, and provision should be made for buses to proceed through to a far side bus stop.

**Bus Stops**

If a mid-block bus stop is required for a shoulder bus lane, buses will usually stop in the lane. The shoulder bus lane is normally a peak-only operation, so a mid-block bus stop functions as a bus bay during off-peak times. The bus stop zone should be painted as such, with no parking permitted within the zone at any time.

Since shoulder bus lanes transition to general right turn lanes in advance of intersections, bus stops at intersections become conventional right (curb) lane stops, as described below.

### 4.3.2. RIGHT (CURB) LANE

**Between Intersections**

The most common form of arterial Bus Lane is a right curb lane reserved for bus use during weekday peak periods in the peak direction. This reflects the need for buses to service curbside bus stop. Bus acceleration and deceleration characteristics being slower than that of general traffic, isolating them from autos minimizes the impact of bus operations on the remaining traffic lanes.

The Bus Lane width should be no less than 3.3 m [11 ft] and preferably 3.6 m [12 ft], even if that requires re-allocation of width from other lanes. The curb lane width should be reviewed, however, if the lane is also to be used by bicycles. The AASHTO Bicycle Design Manual [5] should be referred to for appropriate lane widths in that shared situation.

The main concern with curb lane use by buses is the competition for use of that lane by others. This can reach the point where the curb lane is rendered ineffective as a bus priority facility. Demands for the curb lane use, particularly in a congested urban / CBD environment, can come from:
general traffic;
- parking / stopping (see photo);
- deliveries;
- taxi ranks;
- bicycles;
- right turns and queues (both at intersections and mid-block);
- service / maintenance vehicles; and/or
- bus stops.

Fronting retailers, in particular, are often concerned about the provision and retention of on-street parking.

It can be a challenge to keep the curb lane clear of stopped or parked vehicles for uninterrupted bus movement. For that reason, it is common to lift the bus lane designation during off-peak periods and allow other uses of the curb lane. Prime consideration must be given, however, to the need for buses to stop and serve passengers throughout the day.

Signing, regulations, effective penalties, and an active towing strategy are needed during the period of bus lane operation. A periodic review of the entire affected corridor is recommended, to ensure that adequate provisions are being made for accommodating all the parking, delivery, service, and operational needs of the street while preserving the functionality of the bus lane.

At Intersections

A bus lane can either extend to the stop bar, with right turns allowed from the lane or from a separate right turn bay, or the bus lane designation can be terminated in advance of the intersection. The latter is a common approach outside North America.

The length of the set-back of the end of the bus lane from a signalized intersection is an operational and design issue that has been studied in some detail in the U.K., where curbside bus lanes are common. There is a fine balance to be struck between providing bus priority and accommodating the right-turn needs of autos without overly penalizing either. The guideline established by Oldfield et al (1977) is that the bus lane should end (and right-turning vehicles should be allowed to enter the right lane) approximately 2.5 m (8 ft) per second of green time at 95% saturation. The set-back can be reduced to 1m (3 ft) per second of green at 70% saturation.

Bus Stops

Curb Stop

The right lane curbside bus stop is the simplest, most convenient, and by far the most common arrangement for collecting and distributing passengers in an urban area. At its simplest, the stop can be designated by a small post-mounted sign, to which a bus pulls up and stops to allow passengers to get on or off. More elaborate stops are possible, ranging up to fully-enclosed bus shelters with real-time passenger information displays and provision for two or three buses using it simultaneously.
No matter what the provisions are on the curb, the length of curb space designated for bus use will be dictated by the number and size of the design vehicles to use the stop. The first bus at the stop should move to the head of the stop. Only a single stopping position at the head of the stop is defined; if a second or third bus arrives while one bus is stopped at the head, they pull up tight to the rear of the preceding bus. Passengers then move down the stop to the appropriate vehicle.

**Bus Bay**

The critical issue with bus stop provisions in a curb bus lane arrangement is often the blockage of the lane by a stopped bus. In a heavily-traveled corridor, not all buses will necessarily need to use every stop. If the lane is used by right-turning vehicles, a queue can build up behind a near-side bus stop. This can be very disruptive to the function of the bus lane, and a single stop can negate whatever travel time savings the lane is intended to provide. When a bus must merge into the adjacent general traffic lane to bypass a stopped bus, not only does it have a disruptive impact on traffic flow and bus operations, but it presents an image to the motoring public that the bus lane is poorly-designed, little-used, and ineffective. This in turn may translate into a call to open the lane to general traffic.

One solution to this problem is to provide an indented bus bay (turnout) so that through buses can bypass a stopped bus. The design parameters are stated in *AASHTO – Geometric Design of Highways and Streets* [4]. The length of a two-bus turnout provision in a 3.0 m [10 ft] wide curb lane should be about 55 m [180 ft]. An entry taper of no less than 5:1 and exit taper of no less than 3:1 are recommended.

Guidance as to when to provide bus bays and when not to is subject to local operating conditions, but general indications (Texas Transportation Institute TCRP 19, 1996 [8]) are:

- At least 250 veh / peak h in curb lane
- Traffic speed greater than 64 km/h (40 mph)
- Bus volume greater than 10 bus / peak h
- Passenger volume greater than 20 boardings / h
- Average peak period dwell time greater than 30 seconds / bus

All of these conditions are aimed at minimizing unnecessary delay to through traffic in the curb lane. If the curb lane is a bus or HOV lane, the risk of express buses being delayed by stopped buses (particularly if merging into the adjacent general purpose lane is problematic due to congestion) will be the key consideration in assessing the need for a bus bay.

The common bus drivers’ concern about the use of bus bays – that it is difficult for stopped buses to re-enter the traffic lane – should not apply in when the buses are re-entering a bus or HOV lane, where there are many long gaps between vehicles in the lane.

More problematic is likely to be the provision of the physical space required, particularly in a built-up CBD setting. It is sometimes possible, in a downtown street, to “fill in” the curb lane (for example, on a four-lane one-way street) with pedestrian amenities and expanded sidewalk / streetscaping, while leaving room for indented bus bays as needed.
**4.3.3. INNER LANE**

**Between Intersections**

A bus lane may occupy the second lane from the curb, leaving the curb lane free for general traffic, parking, deliveries, bicycle use, right turns and storage, and/or bus stops. This arrangement can thus overcome many of the drawbacks of a curbside bus lane (see Figure 4-9).

![Figure 4-9](image1)

Bus Lane in Second Lane, Ottawa

An inner bus lane is more applicable in the urban / CBD setting rather than in a suburban environment; curb lane conflicts in the latter are usually limited to right turning vehicles and queues, which can be dealt with by providing turn lanes as described under curb lane above. A bus lane through a suburban commercial strip with frequent entrances and a high volume of mid-block right turning vehicles might, however, operate best in the second lane.

At least two lanes should remain available for general traffic under an inner lane bus lane arrangement. Assuming the curb lane has little functionality for through traffic, this implies limiting the application of inner lane bus lanes to an eight lane two-way roadway or a four lane one-way street. For this reason, inner lane bus lanes are most common on one-way street pairs in CBD settings.

![Figure 4-10](image2)

Dual Bus Lane (New York City)

A special case of an inner lane bus operation is a dual bus lane. This can be used where extremely large bus volumes and a mix of express and stopping buses exceed the capacity of a curb bus lane and the second lane is also given over to bus use. New York City offers some examples (see Figure 4-10).

For a inner bus lane width should be no less than 3.3 m [11 ft] and preferably 3.6 m [12 ft], even if that requires re-allocation of width from other lanes. The width of the curb lane could be reduced to 3.0 m [10 ft] as a first step.

Allowance must be made for motorists to have access to the curb lane. For curb lanes serving through traffic, this may be limited to allowing autos to cross the Bus Lane to make right turns at intersections; for mid-block driveways and parking, autos can be allowed to cross (but not drive in) the Bus Lane. Designated zones for vehicles to cross the Bus Lane and gain access to a right turn lane can be marked in advance of the intersection (see Signage and Pavement Marking, below). It is important that the legal framework is in place to allow the regulation and enforcement of such movement.
At Intersections

Reservation of an inner lane for bus or HOV use poses few restrictions on movement at intersections. Buses will move straight ahead in the lane, or shift to other lanes to make turns.

Bus Stops

When buses operate in a reserved inner lane, particular consideration has to be given to passenger service. This discussion addresses mid-block bus stops; stops at or near intersections are dealt with in a subsequent text. Three types of mid-block stops are used: curb stops, bus bulbs, and islands.

Figure 4-11

Line Diagram Of Three Different Mid-Block Bus Stops For Second Lane Bus Lanes

Curb Stop

With through buses operating in the second lane, stopping buses can move to the curb and serve passengers at conventional curbside stops. This arrangement maintains the bus lane for unobstructed use. Since non-bus traffic is banned from the second lane, bus drivers can easily re-enter the Bus Lane from a stop.

Use of a curb stop is more valuable when there is a mix of stopping and through buses; if all buses need to stop, the bus lane's function is limited to allowing a bus to jump ahead of a stopped bus from a rear stop. If buses operate in a platoon, all buses would stop and few or none would “jump the queue”, hence there would be little merit to a curb stop in a second lane bus lane configuration.

The curb stop / inner lane bus lane configuration is not compatible with the curb lane being used by through traffic, since curb lane users would be completely blocked by a stopped bus. The arrangement is more suited to a curb lane that is used primarily for parking, deliveries, and right turns.

As stated in AASHTO – Geometric Design of Highways and Streets [4], the length of a two-bus turnout provision in a 3.0 m [10 ft] wide curb lane should be about 55 m [180 ft]. An entry taper of no less than 5:1 and exit taper of no less than 3:1 are recommended. Parking and stopping must be banned or physically prevented within that envelope.
**Bus Bulb**

Rather than moving the buses to the curb line, the curb line can extend out to meet the buses in a second lane Bus Lane. This obviously precludes use of the curb lane for through traffic, but retains its functionality for parking, deliveries, and turns. The bulb provides a well-defined waiting area for bus passengers, out of the way of pedestrians moving along the sidewalk and away from shop entrances, and has enough room to provide a bus shelter, transit information displays, and/or streetscaping features.

Where most or all buses stop, where buses operate in platoons, where space in the curb lane is limited, and/or where curb bus stops are made unusable by illegally parked or stopped vehicles, the bus bulb can provide an effective solution. The length of the face of the bulb can be limited to the length of the number of buses using it; a single-bus bulb would be 12 m [50 ft] long and a two-bus bulb 24 m [100 ft] long. The bulb tapers to the curb line at a 1:1 ratio.

**Island**

If the curb lane is to be maintained for moving traffic, buses in an inner lane can employ a streetcar-style island platform. The width, shelter, and protection specifications are identical for the two modes, but a bus-only island need only be as long as the design vehicle (nominally 18 m (60 ft). For safety reasons, it is not recommended to provide in-street bus boarding without an island platform.

### 4.3.4. LEFT (MEDIAN) LANE

**Between Intersections**

On a multi-lane high-standard arterial, a Reserved Bus Lane may occupy the leftmost lane against the center island (see Figure 4-12). This arrangement provides conflict-free movement for express buses and avoids the demands by other vehicles for use of the right curb lane.

At least two adjacent lanes should remain available for general traffic, which limits this application to a six-lane or an eight-lane arterial.

The bus lane width should be no less than 3.3 m [11 ft] and preferably 3.6 m [12 ft], even if that requires re-allocation of width from other lanes. The width of the curb lane could be reduced to 3.0 m [10 ft] as a first step.

The bus lane can operate on a permanent (24 hour per day) basis or during weekday peak periods only.

Unless there is no demand for left turns or left turns are banned during the period of bus lane operation, allowance must be made for left turning vehicles. Either the left turning vehicles cross the bus lane via a designated break in the lane into a protected
left turn slot (which can be signalized or non-signalized) or a left turn lane must be inserted between the bus lane and the leftmost through lane. In the latter case, left turns must occur on a protected signal phase. For a peak-only bus lane operation, the bus lane can be used for left turn storage at other times.

**At Intersections**

With the leftmost lane reserved for buses or HOV’s, left turns in either direction to or from the arterial have to be controlled (using protected phases at signalized intersections) or eliminated. Special signage and pavement marking is appropriate to guide vehicles turning left into the arterial from crossing streets into the general traffic lane rather than the bus lane. Left turning vehicles on the arterial may be allowed to cross the reserved lane and turn from median left turn bays; under no circumstances should left-turning vehicles (cars or buses) block the reserved lane to through traffic.

Right turns from the left-side reserved lane are similarly prohibited. If a high volume or right turning buses uses the lane, an advance signal and/or a dedicated right turn bay may be worthwhile.

**Bus Stops**

A center bus lane is targeted towards express or through buses that have little need to weave across to a bus stop at the curb. If there is a need to serve passengers at stops in the corridor, normally a lower-frequency local bus would continue to operate in the (mixed flow) curb lane using conventional curbside stops.

At a major intersection or transfer point where express buses need to board or disembark a high volume of transferring passengers, bus stops can be provided either on in-street island platforms or on a central (median) island platform. In-street island platforms are described under second lane bus lanes above. Use of a single central island platform either requires the buses to cross over the median to a contraflow position, or, to avoid the crossover, the exclusive use of buses with double-sided doors.

**Figure 4-13**

Line Diagram Of In-Street Island and Center Island Bus Stops For Left Side Bus Lanes
The crossover allows use of an island platform by conventional buses but may require special measures to minimize the risk of a head-on collision and to prevent its use by unauthorized vehicles. The arrangement puts buses in a contraflow position at the platform; consideration may be given to the degree of separation provided between stopped buses and oncoming traffic, as to whether paint, delineators, raised curbing, or a physical barrier is appropriate.

The single island provides the benefits of consolidating passenger shelter, information, and access in one place. It can be wider and more comfortable than a typical in-street island, and is buffered somewhat from the flow of traffic. It provides greater opportunity than narrow in-street platforms to contribute to the streetscape and to function as a landmark or gateway. If the left lane functions as a permanent (24 hour per day) bus lane, this may be preferred; if the bus lane is only a peak period / peak direction operation, investment in in-street facilities will likely be a lower priority.

The island will normally be located at or very near a signalized intersection; the signal timing, phasing, and bus priority features should be carefully designed so as to optimize the movement of passengers and buses to and from the platform.

4.3.5. RIGHT SIDE OR LEFT SIDE CONTRAFLOW (ONE WAY STREET)

Between Intersections

Figure 4-14
Right Side Bus Lane On One-Way Street, Honolulu

On a one-way street in a CBD, bus lanes can be provided in the direction opposite to the main flow. This is an effective means of eliminating bus lane violation problems. If the one-way pair has been changed from a two-way system, contraflow bus lanes may be desirable or necessary to maintain traditional bus stop or routing patterns.

Careful consideration must be given, however, to the planned or potential operational strategy for bus operations, since there is little or no opportunity for a bus in a single contraflow lane to pass a stopped or disabled vehicle. If several buses are operating in a platoon, the last bus is governed by the “worst case” of the preceding stopped buses; if there are heavy boarding volumes or disabled passengers to be served, the risk of a following platoon backing up across the cross street should be considered. If curb space is available, an indented bus bay can be used to minimize such conflicts and provide operational flexibility. For a contraflow bus lane to be effective, there should be a minimum of 20 to 30 buses using it during the peak hour.

Delivery vehicles may use the lane in some cases during off-peak periods if the introduction of one-way streets has restricted access to mid-block businesses. Under no circumstances should vehicles be allowed to block the lane at any time. A No Parking / No Stopping regime is required. The contraflow lane should be designed for permanent use, not temporary or peak-only operation.
A right side bus lane on a one-way street is simply a restriction on the use of what is functionally a two-way system. There are therefore no special requirements to physically separate the bus traffic from opposing traffic flow. If desired, however, the opposing lanes may be physically separated by a raised concrete strip, flexible delineators, or pylons. Buses may operate with headlights on or parking lights flashing while in a contraflow lane, to alert oncoming motorists of the opposing traffic on what might otherwise be expected to function as a one-way street. The lane width will be the conventional 3.6m (12 feet), with a narrowing by 0.3m (1 foot) permitted in short constrained areas.

A left side contraflow bus lane on a one-way street does require physical separation, however, because it is on the “wrong side” in terms of motorist expectations. If possible, the bus lane should be wider – up to 4.3m (14 feet) – if the separation takes the form of a concrete wall, pylons, or cones.

Careful consideration should be given to pedestrian safety. In a busy pedestrian environment where people are in the habit of crossing the street mid-block, there is considerable risk that they will step off the curb into the bus lane while concentrating on finding a gap in the “one way” flow of auto traffic. This is a particular risk where the bus lane has been retrofit to what was once a one-way street. In such a situation, it is recommended that a physical barrier be placed at curbside to channel pedestrian crossings to signalized crosswalks, and to prevent mid-block crossings. Careful consideration should be given to the design of the barrier, so that it is safe and attractive and fits into the streetscape plan.

### At Intersections

A contraflow lane of any type violates the expectations of the motorist and pedestrian. The risk that motorists will turn without looking at the bus lane, and either inadvertently enter the bus lane in the wrong direction or cross the lane while heading for a gap in the main flow, can have serious consequences. Channelization, turn restrictions, signage, line and pavement marking, streetside guidance, and public education all have a part in ensuring that this risk is minimized.

### Bus Stops

If conventional right-door buses are used, a contraflow bus lane is restricted to the right side curb lane. Conventional curbside stops may be used. As noted above, there may be a need for locating stops at an indented bus bay, so that a stopped bus doesn’t block the lane for following vehicles.
A left side contraflow lane might be used as a peak period route for express buses but either double-sided bus doors or in-street island platforms (see Figure 4-16) would be needed to serve any stops.

### 4.3.6. MEDIAN CONTRAFLOW (TWO WAY STREET)

#### Between Intersections

In a suburban arterial setting where there is a directional imbalance between flows during peak periods and there is little opportunity to assign one of the peak direction lanes to bus priority use, it may be possible to “borrow” the inner lane from the counter-peak direction for use as a peak period bus lane. In another case, a brief segment of contraflow lane could be used in the vicinity of a median island platform or bus stop in a single reversible lane corridor.

Like the left lane concurrent flow configuration discussed above, this is more suited to express or through buses than to local services which stop on every block. Such local services should remain in the curb (mixed traffic) lane.

The bus lane should be physically separated from the oncoming general traffic lane by daily placement of pylons or pop-up flexible delineators. Buses may operate with headlights on or parking lights flashing while in a contraflow lane, to alert oncoming motorists of the (unusual) opposing traffic.

![Figure 4-17](Image)

**Figure 4-17**

Median Contraflow HOV Lane, Honolulu

Careful consideration should be given to the potential evolution of traffic patterns over time; a commitment to the median contraflow configuration (e.g. through construction of median bus platforms and shelters) is premised on the directional imbalance during peak periods being a permanent operating condition.

Access to / from the ends of the median contraflow lane can be provided by means of median crossovers. The design of the crossover will be dependent on the speed of the traffic. Where no median exists, continuous access can be provided along the length of the lane in the same manner as for concurrent flow inside lanes.

#### At Intersections

Left turns in either direction to or from the arterial have to be controlled (using protected phases at signalized intersections) or eliminated. Special signage and pavement marking is appropriate to guide vehicles turning left into the arterial from crossing streets into the general traffic lane rather than the oncoming bus lane.

#### Bus Stops

At a major intersection or transfer point where express buses need to board or disembark a high volume of transferring passengers, bus stops can be provided on a central (median) island platform. The platform would only be used during the peak
periods of contraflow operation; all off-peak boardings would occur at the right curb. This represents one drawback of the scheme – the investment in in-street platforms is only used for a few hours per day, while extra effort is needed to inform passengers as to when the in-street platform is in operation and when they must stay at the curb.

Particular attention must be given to pedestrian signing and pavement marking at crosswalks, to alert them to the operation of buses in an unconventional direction. Gates or barriers may be required to control pedestrian movement across the bus lane.

### 4.3.7. SPOT TREATMENTS FOR BUS PRIORITY

**Bus-Only Links**

There may be occasions where authorized buses can avoid out-of-way travel by taking a short bus-only link road. The design of the link will follow normal practice, and signage needs to be clear in designating the road segment for use by authorized vehicles only.

If the link has a high risk of being used by unauthorized vehicles, several options are available:

- Increased size and amount of static signage;
- Signal control or physically gate the roadway, with opening either by bus-mounted transponder, driver swipe card, in-pavement detector loop, or similar remote actuation;
- Insert a “trap” (for example, a concrete channel that can accommodate a bus axle height and wheel width but which cannot be crossed by a smaller vehicle); or
- Automated electronic enforcement is possible via a pole-mounted camera, activated by an approaching vehicle.

**Queue Jumps**

Bus queue jumps can be provided in any situation where a recurring queue of general traffic forms and affects the speed and/or reliability of bus travel. Examples include ferry terminals, toll plazas, stadia entry / exit points, and construction zones. The queue jump will normally take the form of an appropriately-signed dedicated lane. The key to the queue jump’s effectiveness is the speed, ease, and comfort of the bus re-entry into the general purpose lane.
Bus-Only Turns / Turn Lanes

Effective yet low-cost bus priority measures can sometimes be implemented by way of bus-only turn lanes or exemptions from turn prohibitions at intersections. These low-impact strategies are suitable for corridors where the volume of buses does not justify a bus lane, and where a queue jump can be implemented without significantly affecting the use of the intersection by general traffic.

Examples of bus-only turn lanes are shown in Figure 4-19.

Examples of exemptions from turn prohibitions include:

- “Right Lane Must Turn Right” / “Buses Excepted”
- “Turns Prohibited 7 AM – 9 AM” / “Buses Excepted”

Adequate physical provision must be made for the allowed bus movement. Consideration should be given to the enforceability of the queue jump.

4.4. Infrastructure and Practices Related to On-Street Bus Operation

In this Chapter, various measures that can work with Bus Lanes or in general street operations to support bus movement are addressed. The design issues associated with Bus Lane enforcement, bus-related signing and pavement marking, and Intelligent Transportation Systems infrastructure are included.

4.4.1. PROVISIONS FOR BUS LANE ENFORCEMENT

Extended Bus Turnout

A bus turnout may be extended in length to provide a clear space for enforcement activities – either for a police vehicle to sit in the turnout and observe lane usage, or to direct violators into so that ticketing can take place without disrupting the flow of buses in the lane or at the bus stop. The space may also be used for a transit inspector’s vehicle. A 15 m [50 ft] extension with a 1:1 return taper provides an adequate area for this purpose.
The location and frequency of such enforcement turnouts will depend on property availability, enforcement needs, and frequency and impact of lane violation. Consultation with the local police service is required to determine whether, where, and how to use extended bus turnouts.

**Signage**

Posting a roadside or overhead sign to emphasize the consequences of Bus Lane violation can be useful both as a deterrent and as an education device. A precedent has been set by the effectiveness of posting of fine rates for violation of freeway HOV lanes in California in reducing violations. Ottawa, Canada posts the bus lane fine rate on overhead signs (see photo); the practice has been reported to be effective in reducing violation and maintaining public respect for the facilities. For the posting of fines to be effective, however, the fine level must be substantial enough to act as a deterrent and actual police enforcement must occur on a regular basis.

**Bus-Mounted Camera**

The use of bus-mounted video or still cameras for detecting Bus Lane violators is established in London (England) and elsewhere, but requires no special infrastructure or design features on the lane.

**Bus Lane Camera**

Vehicle detector loops can be used for enforcement if the loops are equipped to read bus-mounted identification tags. Selected loops can be linked to a nearby pole-mounted camera such that any vehicle passing over the loop without registering a tag can trigger the camera to photograph the vehicle and license plate (in much the same way as red light cameras operate). Some other non-loop bus detection systems may be able to be adapted to perform a similar function.

The appropriate legal framework to allow citation by mail needs to be in place for any remote or electronic enforcement of bus lanes.

**4.4.2. SIGNING AND PAVEMENT MARKING**

Signs and pavement markings are the key methods of informing bus drivers and motorists alike of the existence of a transit facility in mixed traffic. The AASHTO Manual on Uniform Traffic Control Devices, Millennium Edition [7] has specific signage and marking standards for reserved lanes, however the majority relates to HOV and light rail facilities. Most of these standards could be applied to Bus Lanes.

The elongated diamond used on High Occupancy Vehicle lane signs is equally applicable to Bus Lane signs.
Signs

*Curbside Preferential Lane Signs (MUTCD 2000 Sec. 2B.48)*

Ground-Mounted Preferential Lane Signs should be used in conjunction with the Overhead Preferential Lane signs discussed below. Preferential Lane sign spacing should be determined by engineering judgment based on prevailing speed, block length, distance from adjacent intersections, and other considerations.

Appropriate “No Parking” / “No Stopping” signs must also be prominent at the curbside for effective curb bus lane operation.

*Overhead Preferential Lane Signs [7]*

*Intersection Lane Control Signs [7]*

Intersection Lane Control Signs should be mounted overhead unless the number of through lanes on an approach is two or less. A Transit Lane should have a supplemental “BUS LANE” plaque similar to the TAXI LANE R3-5d plaque.
Pavement Marking Between Intersections

 Preferential Lane Word and Symbol Markings [7]

**Figure 4-24**

Typical Lane Word Marking Layout

<table>
<thead>
<tr>
<th>ONLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4 m (8 ft)</td>
</tr>
<tr>
<td>1.8 m (5.9 ft)</td>
</tr>
</tbody>
</table>

Reference: [7]

Where a lane is assigned full or part time to transit vehicles, the preferential lane markings shall consist of the word marking BUS ONLY. The lettering shall be white and positioned laterally in the center of the transit lane. Marking spacing is based on the prevailing speed, block lengths, distance from intersections, and other factors and may be spaced as close as 24 m (80 ft) apart. Signs or signals shall also be used in conjunction with the lane word markings. Engineering judgment should determine the need for supplemental devices such as tubular markers, traffic cones, or flashing lights.

Consideration could be given to emphasizing the pavement message by periodic use of colored “patches”, as shown in Figure 4-25. An Australian application has been shown to be effective in reducing Bus Lane violation.

**Figure 4-25**

Bus Lane “Patch”,
Gold Coast, Australia
Preferential Lane Longitudinal Markings [7]

Preferential lane markings shown in Table 4-5 should be used in conjunction with preferential lane signs discussed above.

### Table 4-5

Preferential Lane Longitudinal Markings

<table>
<thead>
<tr>
<th>Type of Preferential Lane</th>
<th>Left Edge Line</th>
<th>Right Edge Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physically-Separated, Non-reversible</td>
<td>A single solid normal yellow line</td>
<td>A single solid normal white line</td>
</tr>
<tr>
<td>Physically-Separated, Reversible</td>
<td>A single solid normal white line</td>
<td>A single solid normal white line</td>
</tr>
<tr>
<td>Concurrent Flow – Left Side</td>
<td>A single solid normal yellow line</td>
<td>A double solid wide white line where crossing is prohibited</td>
</tr>
<tr>
<td>Concurrent Flow – Right Side</td>
<td>A double solid wide white line where crossing is prohibited</td>
<td>A single solid normal white line</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A single solid wide white line where crossing is discouraged</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A single broken wide white line where crossing is permitted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A single dotted normal white line where crossing is permitted for any vehicle to perform a right-turn maneuver</td>
</tr>
</tbody>
</table>

Note: If there are two or more transit lanes, they shall be separated with a normal broken white line.
Figure 4-26

Typical Markings for Preferential Lanes

a - Physically separated permanent lane(s)

b - Full-time concurrent lane(s) where enter/exit movements are PROHIBITED

c - Concurrent lane(s) where enter/exit movements are DISCOURAGED

Legend

⇒ Direction of travel
★★ Applicable symbol or word

Reference: [7]
Figure 4-27

Typical Markings for Preferential Lanes (Continued)

- SINGLE BROKEN WIDE WHITE
- SINGLE SOLID WIDE WHITE
- WHITE EDGE LINE IF WARRANTED
- LIMITED ACCESS EXIT SIDE STREET OR COMMERCIAL ENTRANCE
- SINGLE DOTTED NORMAL WHITE
- DOUBLE SOLID WIDE WHITE (Crossing Prohibited)
- SINGLE SOLID WIDE WHITE (Crossing Discouraged)
- SINGLE BROKEN WIDE WHITE (Crossing Permitted)

Legend:
- Direction of travel
- ** Applicable symbol or word

Reference: [7]
Colored Lane Markings

Consideration may be given to highlighting a bus lane or facility with colored lines or curbs. Many of New York’s bus lanes feature a red stripe (outlined in white) parallel and adjacent to the curb. Similar lines have been used in other jurisdictions but there are no national standards of practice.

Some overseas jurisdictions have made use of colored pavement, either for the entire reserved lane or in limited use at lane thresholds and intersections. Given the widespread acceptance and effectiveness of that practice, it should be given consideration, although concerns about cost, maintenance, and standardization need to be addressed.

Reversible lane signs

Conventional MUTCD signs may be used for buses operating in reversible lanes. Consideration will need to be given to the use of dynamic overhead control signals to emphasize the operational rules in place at any given time.

Contraflow lanes

In the case of a contraflow lane of any type (right curb, left curb, median) conventional signs should be used at frequent intervals, particularly at cross streets (including advance signs on cross streets approaching the contraflow corridor) and major driveways. Overhead signs, lane-use control signs where applicable, and flashing lights on preferential lane signs are recommended to emphasized the contraflow operation. Electronic signs or arrows may be placed on the front of the buses themselves, and activated while in the lane. Pedestrian crosswalks should be signal-controlled.

At Intersections

A bus lane at a signalized intersection should have a dedicated signal head, marked as such. Consideration may be given to the use of “bus” signal heads – i.e. white vertical bar as used in some light rail applications, or a “B” letter within the signal lens – as opposed to conventional three-color heads.

4.4.3. INFRASTRUCTURE DESIGN FOR INTELLIGENT TRANSPORTATION SYSTEMS

Bus operation on arterial streets is a key part of the urban transportation system. Buses are but one part, however, of a complex and dynamic system. The overall system is usually actively managed to some degree by responsible authorities. Within the urban traffic control system, bus priority systems may sit among:

- Signal systems for traffic flow progression
- Local Area Traffic Management
- Traffic conditions monitoring (via detector loops, cameras, etc.)
Incident management
Emergency vehicle priority systems

The infrastructure that is associated with all of these systems may also be used for bus priority in many cases; in other situations new or dedicated infrastructure may be needed. Key aspects of bus-oriented ITS needs are outlined below.

**Traffic Signal Operations for Transit Priority**

*Introduction*

Granting priority treatment to buses at signalized intersections can contribute significantly being able to operate buses in a fast, reliable, manner on an arterial street. This can be done as a standalone initiative (independent of whether there are Bus Lanes on the street) or as an integral part of a Bus Rapid Transit scheme for the corridor. Signal priority is in widespread usage worldwide and has proven to be cost-effective in many situations.

*Principles*

The basic principle is that a bus is detected approaching a signalized intersection and the signal timing and phasing is adjusted to provide the bus with clear passage through the intersection. This may save the bus up to one minute or more of waiting at a red light, but more importantly, contributes to the ability to adhere to schedule. When transit priority is implemented along a lengthy corridor, the cumulative travel time savings can be significant.

Active signal priority can take the form of:

- Extend green phase to allow bus to receive a green signal
- Advance green phase by reducing length of other phases
- Provide special bus phase
- Omit phases in order to advance the bus phase
- Priority phase sequences to favor the bus route
- Compensate non-bus phases with additional time following the bus priority phase
- Modify offsets in a coordinated system to favor bus operation

*Benefits*

The benefits of signal priority are maximized if the corridor is served by one or two high-frequency bus routes, such that the travel time savings and consistency of travel time allows a reduction in the number of buses to provide the same service. The combination of route length and service frequency can be analyzed to determine the travel time savings needed to eliminate one bus from the route; a 50 km (30 mile) round trip operating on 5 minute headways at an average speed of 20 km/h (12.3 mph), for example, requires 30 buses in service; that number could be reduced to 29 if the average speed could be increased to 20.7 km/h (12.8 mph) by way of a 5 minute average round trip travel time reduction. The “saved” buses may be reallocated to other routes or used to increase the service on the priority route. Ranking all city corridors by this measure can help prioritize application of signal priority systems.
The annualized savings in terms of fleet size and operating cost can be substantial. However, if the priority corridor only serves parts of routes or forms a small portion of a lengthy route, it is less able to generate substantial savings. For example, if the 5 minute headways described above are provided by six different routes, each operating at thirty minute headways, it will be much more difficult to gain enough travel time to save a bus on any individual route.

The improvement in reliability and schedule adherence, more than the actual decrease in travel time, is a strong attractor of new transit trips. Signal priority can thus increase ridership while simultaneously reducing operating cost. The key variables are the capital and operating cost of the priority system, and the degree of impact on other vehicles using or crossing the corridor.

**Methodologies**

There are various means of detecting a bus approaching an intersection – in-pavement magnetic induction loops, side-fired radar, optical strobe, ultrasonic, microwave, GPS, and photographic devices are all in use. The detection location must be far enough in advance of the signal that there is time to adjust the signal timing, introduce an amber and all-red phase, and allow the bus to approach the site without dropping its speed and momentum. This distance will vary according to the operational speed of the road and the technology used.

Detection may be “dumb” and simply look for a vehicle type or axle spacing that represents a bus, or it may be a “smart” system that can register the bus’ identification tag and check whether it is in service and whether it is ahead of or behind schedule. An intermediate approach is where the request for signal priority is made by the driver via a dashboard switch. Where the signal is also set up for emergency vehicle priority treatment, emergency vehicle requirements will override any transit priority processes.

Only buses that are behind schedule or on schedule will benefit from signal priority; buses that are ahead of schedule should not be granted priority. Furthermore, on a route where buses are able to maintain their scheduled service, or in a corridor where service is on so frequent that being “on schedule” is irrelevant to the passenger, signal priority is not likely to bring substantial benefits to the service. It is most suited to congested arterials with long signal cycles serving a variety of bus routes at moderate-to-lengthy headways. It is also useful for near-side stops, to allow the bus to clear the intersection immediately once boarding has been completed (although careful design is required to ensure that a stopping bus doesn’t trigger the signal priority system).

Once a bus is detected, the bus detection system must communicate its presence to the traffic signal controller. If the signal is already on a green phase, the controller will typically 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. Any changes are limited by pedestrian phases, which cannot be shortened. The cycle length may change or selected phases skipped to accommodate the bus needs.

Any such changes in a signal progression arrangement will need to 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.

It is desirable to install a detector immediately downstream from 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 will be set to return to “normal” phasing after a specified period.

A related approach is to provide a bus-only signal, activated in the same manner, but showing red to all approaches for a brief period during which the bus passes through the intersection or makes a turn across the intersection. This is more common in the case of median transit lanes (particularly when buses need to turn from the median) or where buses must turn left from a right curb lane.

In certain situations, a passenger may wish to hail a bus that would otherwise operate as an express service. To simplify this process and make it more reliable, consideration could be given to use of passenger-activated signals at or in advance of the bus stop advising the bus operator of the waiting customer. For example, one freeway interchange in Ottawa (Canada) has bus stops at the foot of the exit ramp, which are only served by express OC Transpo highway buses when a “request stop” sign (a simple shoulder-mounted “OC” signal) is illuminated on the highway in advance of the exit ramp. The sign is simply activated by a passenger waiting at the stop, if the sign is not lit up, the bus operator can pass by the exit without delaying the through passengers unnecessarily.

**Passenger Information Systems**

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

At bus stops, the most common means of providing real-time passenger information is to display the anticipated time of arrival of the next bus on an illuminated sign. Signs may be elaborate or very simple, and can use LED, LCD, plasma, flip-disc, or other technologies. For a stop that hosts just one route, a simple “countdown to next bus” display is adequate; for a stop used by a variety of express and local routes, a multi-line display that details the next bus(es) on each route and their destinations, or the order of arrival of the next four or five buses may be needed.

It is particularly useful to have a multi-line display if buses tend to arrive in platoons or are 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 following buses rather than rushing back and forth to figure out which bus is theirs.

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

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

Careful attention should be paid to 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. Consideration should be given to providing a
Another key consideration is protection from vandalism. Displays should be enclosed in a protective case and located high, out of direct reach of vandals. Consideration may be given to monitoring and videotaping the signs and stops via closed circuit television.

The signs may be turned off overnight, or left on with a note to the effect that “Service Resumes at _ AM”.

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 often be implemented in coordination with other system upgrades (for example, new bus shelters or a Bus Rapid Transit system). Opportunities for cost reduction or quality improvement through commercial sponsorship are often available, particularly with respect to using the signs for advertising messages. If the signs are used for marketing, the primacy of the signs’ intended use for transit information must not be affected.

### 4.5. References


