Chapter 24 Measures to Assist Public Transport

24.1 Introduction

High quality, road–based public transport services are vital to achieve maximum effectiveness from the road network and to offer an acceptable alternative to non-essential use of private cars. Policies and measures should assist effective operation and enable a high quality service to be provided but, since 1985, the major responsibility for providing and operating bus services in the UK rests with the private commercial sector [Wa].

Bus systems

Most urban public transport is provided by buses. Buses can transport large numbers of people while occupying relatively little road-space, thus offering a highly cost-effective use of resources. Buses also, crucially, provide mobility to those who do not have the use of a car. Specially equipped public transport vehicles can also provide accessible transport for people whose mobility is impaired.

Buses can be flexible in operation and can respond rapidly to changing patterns and levels of demand but are adversely affected by urban traffic congestion. If the inherent advantages of bus systems are to be realised, buses must have a good on–street operating environment. There is often a strong case for providing buses with priority over, or complete segregation from, other road vehicles, to protect bus services from the effects of traffic congestion and to improve route–frequencies, speeds and reliability. Speed and reliability of a bus service is also affected by ticketing arrangements and bus design. Vehicle and staff availability, bus route–planning and good on–the–road management of the service further influence reliability.

Guided Buses, Trams and LRT Systems

Conventional buses can be protected from the effects of traffic congestion by their segregation on sections of carriageway or track but it is possible also for buses to be automatically 'guided' on the track. Guided buses retain some, if not all, of the flexibility advantages of normal bus systems, whilst promoting a technologically–advanced image. They provide a 'bridge' between ordinary buses and tracked forms of public transport.

Trams or light rapid transit (LRT) (see Chapter 34) can transport large numbers of people, although the need for a fixed track means that network–wide passenger accessibility, without interchange, will be at a lower level than for a bus system. Trams/LRT are perceived by the public generally as modern, high quality and environmentally–acceptable modes of transport. Essentially, trams/LRT face the same on–street operating problems as buses but, unlike buses, tram/LRT systems introduced into British cities have been provided with a high degree of segregation and priority over other traffic. This has been achieved either through construction of purpose–built track and bridges, as in Sheffield, or through the use of redundant railway lines, as in Manchester, in combination with preferential traffic management and control [Wb].

24.2 Legislative Framework and Responsibilities

The Transport Act 1985 (HMG, 1985) [Sa] established a competitive market for the provision of bus services outside London, with road service licensing and a deregulated system based on bus service registration [NIa]. Within Greater London, the majority of bus services are privately supplied under contract with London Transport Buses, which plans and regulates the network of services.

While the intention of the 1985 Act was to promote competition, the Act included, *inter alia*, provisions to ensure safe and acceptable standards of operation (so called, 'quality licensing'). The Act enables local authorities to apply to the Traffic Commissioner for Traffic Regulation Conditions, to prevent danger to road–users and/or to reduce severe traffic congestion, by limiting the number of buses using particular roads. Highway authorities still retain wide powers under the Road Traffic Regulation Act 1984 (HMG, 1984) to control the use of individual roads and routeing of all classes of vehicles [NIb]. However, if they consider that undue constraints are imposed on their operations, bus operators can, under certain circumstances, appeal.

In planning and designing measures to assist buses, the Traffic Regulation Orders (TROs) and signs should recognise that, from 31 December 1996, buses are defined as:

- ❑ motor vehicles constructed or adapted to carry

more than eight passengers; and
- ❑ local buses not so constructed or adapted (HMG, 1994) [NIc].

A 'bus' is a public service vehicle used for the provision of a local service as defined in the Transport Act 1985 (HMG, 1985) [Sa] and not being an excursion or tour bus [NId].

Traffic signs with the word 'bus', or the bus symbol, thus apply to this very broad definition. Permitted variants allow for the word 'local' to be added to appropriate signs, which then refer to the more specific definition of 'local bus'.

Outside Greater London, responsibility for the bus system and the infrastructure on which it operates rests with:
- ❑ 'bus operators', who operate commercial services and/or provide non–commercial services under contract to local authorities;
- ❑ 'Traffic Commissioners', who license operators, register services and enforce standards;
- ❑ 'Passenger Transport Executives (PTEs)', where they exist;
- ❑ 'The Vehicle Inspectorate Executive Agency', which is responsible for the annual testing and spot testing of buses [NIe];
- ❑ 'the Department of Transport and Government Offices', who provide grants to assist funding of bus priority and other measures [NIf];
- ❑ 'the police', who enforce most of the associated traffic regulation measures; and
- ❑ 'local authorities', whose responsibilities are:
  - ❑ to provide, maintain and manage the road and traffic systems on which buses operate;
  - ❑ to promote on–street parking regulations, which heavily influence many bus operations;
  - ❑ to apply to the Traffic Commissioner for traffic regulatory conditions on bus services, to ensure safety and/or to reduce severe bus–based congestion; and
  - ❑ to contract 'socially–required' bus services not provided commercially;

Although bus services in London are operated under contract by private companies, London Transport Buses administers a system of service licensing. Local Borough councils in London also have extended powers to manage on–street parking and loading.

Two legislative regimes exist in relation to services using guided buses. These are based either on a TRO or a Transport and Works Order (TWO), as follows:
- ❑ a scheme may be introduced under a Traffic Regulation Order where:
  - ❑ the guided busway is built on land forming part of an existing public highway;
  - ❑ the buses are not electrically–powered from an external source; and
  - ❑ the operation can be controlled adequately by normal traffic signs and signals; or
- ❑ a Transport and Works Order (England/Wales) or private legislation (Scotland) is needed, where a guided busway involves [NIg]:
  - ❑ equipment which restricts public rights of passage;
  - ❑ bus operation with electrical power derived from an external source;
  - ❑ operation outside the existing highway limits; and
  - ❑ planning permission.

The legislative background to trams/LRT systems is similar to that for Guided Buses (see Chapter 34).

24.3 Government Policies and Guidance

The Government supports improvements to all forms of urban transport through Transport Policies and Programmes (TPPs), which are submitted annually by local highway authorities (see Chapter 4) [NIh]. TPP guidelines recognise the scope for encouraging a shift in travel–demand between modes, such as from cars to public transport, and may provide resources for a wide range of urban public transport related facilities. Bus–priority measures, for example, are eligible for Department of Transport (DOT)/Government Office funding, as part of bids for Supplementary Credit Approval (SCA) [NIe].

Planning Policy Guidance Note PPG13 (DOE/DOT, 1994) [Sb] emphasises the importance of bus– priority schemes and is supported by PPG6 (DOE, 1996) [Sc], which stresses the importance of a high level of bus service in relation to new developments [NIi] (see also Part IV).

24.4 General Approach to Bus–Priority

Bus–priority measures have several aims, as follows:
- ❑ to reduce delays to buses arising from traffic congestion and thus save bus operating costs, passengers' travel–time costs and bus–fleet requirements;
- ❑ to improve the reliability of bus services, so as to make bus travel more attractive;
- ❑ to increase mobility for those members of the community who do not own or have use of a car;

❑ to increase accessibility to major traffic generators, like shopping centres and inter–modal transport interchanges; and
❑ to make a contribution to traffic restraint and the management of congestion, by the provision of efficient and high quality alternative services.

Bus–priority measures vary in scale, from simple traffic management measures, such as exemptions for buses from a manoeuvre prohibited to other traffic, through to area– or route–based schemes, where buses are provided with priority over complete routes, using a comprehensive package of traffic management and control measures [Wc].

Planning and Design of Bus–Priority Measures

The basic approach to bus–priority scheme planning, design and evaluation is described in the DOT guide LTN 1/91 [Sd] Keeping Buses Moving (DOT, 1991). The design process involves a standard approach, consisting of a feasibility study (including 'before' surveys), consultation, detailed design, implementation and 'after' surveys/monitoring. A typical study project brief is described in the London Bus–Priority Network Design Brief (LTB, 1994).

As part of the feasibility study, bus–priority measures should be subject to operational and economic evaluations. The operational evaluation should determine that the proposed scheme can function safely and effectively and will include consideration of layout, junction capacity, bus stop design and the loading/unloading needs of frontage premises. The economic evaluation should determine the benefits to bus operators and passengers, any disbenefits which may arise to other road–users and the capital costs of the scheme. The evaluation should also take account of wider issues, such as increased bus regularity (and thus reduced passenger waiting time), environmental impacts and policy considerations, such as when the transportation strategy is to encourage transfer of passengers from car to bus (see also Chapter 9).

Road–based public transport is supplied by a variety of vehicle–types but bus–priority measures can be used by all vehicles defined as a 'bus' or by 'local buses' only. Other classes of vehicle permitted to use bus–priority measures can be specified in the relevant Traffic Regulation Order. Bus–priority schemes should concentrate on assisting buses but it may be appropriate to permit some other categories of vehicle to use the priority measures, provided that:
❑ road safety is not jeopardised;
❑ effective and efficient operation of the bus–priority measure is not compromised;
❑ the legal definitions of the vehicle classes are clear; and
❑ the other vehicles are sufficiently distinctive for unequivocal enforcement.

Typically, the other vehicle categories which may be permitted to use bus–priority measures are:
❑ emergency vehicles (police, fire and ambulance);
❑ pedal cycles; and
❑ taxis.

Vehicle categories not generally permitted to use bus priority measures include:
❑ private cars;
❑ motor cycles ;
❑ goods vehicles; and
❑ high occupancy cars (see Section 24.13).

However, there are examples where HGVs and motor cycles are also permitted to use bus–priority measures (eg in the access–control scheme for Newcastle's central area).

24.5 Comprehensive Route–Length Bus–Priorities

Bus–priority measures, combining physical traffic management measures, such as bus–lanes and bus–advance areas, and traffic control systems, such as active bus–priority at signals, are most successful when implemented along bus–route corridors and linked to other improvements, such as passenger information at bus stops, improved waiting facilities, more frequent services, a review of waiting and loading requirements, bus stop clearways and cages, easily accessible buses and park–and–ride facilities. In combination, the measures not only improve bus operations but also the image and public perception of the service, in a way that could encourage higher patronage and hence a transfer from other modes.

Bus–priority measures, particularly when linked along a route, may form an important part of an overall strategy for dealing with urban congestion. Examples include projects along the Wilmslow Road in Manchester, in South and West London and Uxbridge Road in London, as well as long established schemes in Oxford. Linked bus–priority measures, ie a comprehensive approach to bus–priority along a route, have been shown to be highly cost–effective. Packages of measures have been shown to result in First Year Rates of Return (FYRR) in excess of 100%.

London's Priority (Red) Routes

In London, the Road Traffic Act 1991 (HMG, 1991) designated a network of roads as Priority 'Red'

Routes (see Section 13.14). These routes are subject to special parking controls, which are applied on an end–to–end to basis, traffic management and bus–priority measures with clear objectives:

- ❑ to improve the movement of all classes of traffic on the Priority Red Route Network, so that people and goods can reach their destinations in London more easily, reliably and safely;
- ❑ to provide special help for the efficient movement of buses;
- ❑ to reduce the impacts of congestion;
- ❑ to improve the local environment;
- ❑ to provide better conditions for pedestrians and cyclists; and
- ❑ to discourage car–commuting into central London and traffic from crossing the central area.

Park–and–Ride Schemes

City centres provide the focus for a wide variety of trip purposes from surrounding areas and many trips will commence by car because of the widespread distribution of origins. Park–and–ride can be an effective policy to assist in reducing central area traffic congestion, by intercepting these car trips and encouraging people to complete their journey by public transport. Out–of–town park–and–ride schemes using bus services to the central areas are operated in many cities including Oxford, York, Chester, Norwich, Exeter, Shrewsbury and Bristol (EHTF, 1993) and are planned in many more. Similarly, park–and–ride may be operated with tram, LRT and local train systems (Noble *et al*, 1993). For example, the Metro system on Tyneside has four major park–and–ride interchanges [Wd].

Oxford provides an example of a successful park–and–ride system, introduced as part of an integrated city centre traffic policy. Typically, in 1992, over 3,600 cars (about 4,500 people) entered four parking sites daily with 4,500 cars (about 8,500 people) on Saturdays. However, traffic flows into the city centre remained broadly constant, as trips which transferred to buses tend to be replaced by other car trips. While some of the bus services required revenue support, other services were commercially registered and claimed to be profitable.

Key criteria for a park–and–ride scheme are that the site should be:

- ❑ close to an interchange with a major highway to provide easy and safe access for car–users;
- ❑ near the edge of a built–up area and beyond the usual limits of congestion;
- ❑ capable of offering a direct bus, tram, LRT or train service to the city centre, with priority or segregation where necessary;
- ❑ capable of accommodating about 500 parking spaces, the minimum needed to support a financially viable dedicated bus service;
- ❑ accessible by regular bus, tram, LRT, or train services, if special park–and–ride services are not operated all day;
- ❑ of compact layout, to limit the walking distance (especially when it is raining) from parked cars to the public transport stop;
- ❑ furnished with relevant, up–to–date information, attractively displayed;
- ❑ equipped with good lighting and good surfacing; and
- ❑ designed to provide a high degree of personal and vehicle security.

Enforcement

Bus–priority measures and parking regulations are liable to violation by other drivers and require rigorous enforcement. New methods, such as the use of camera technology, to improve enforcement of bus–priority and compliance with traffic regulations can reduce the need for intense police effort (TDL, 1995).

Roadworks

Bus services tend to suffer disproportionately from roadworks, with services often disrupted along route–lengths where other vehicles find alternative routes. Highway engineers and police can assist in minimising problems for bus passengers, by ensuring that bus services are given special consideration and by adopting temporary bus–priority measures, wherever feasible (LTB, 1996).

24.6 With–flow Bus–Lanes

A with–flow bus lane (see Photograph 24.1) is an area of carriageway reserved for the use of buses and, occasionally, other permitted vehicles for all or part of

Photograph 24.1: With–flow bus–lane in London.

the day, in which the buses operate in the same direction as the general traffic flow.

With–flow bus lanes enable buses to bypass traffic queues, usually on the approaches to signal–controlled junctions or roundabouts. With–flow bus lanes:

❑ are usually located at the kerbside, in order to serve bus stops, but some off–side bus lanes exist, for example, to assist right–turning buses;
❑ give buses priority at the locations and times most needed;
❑ minimise disruption to normal traffic patterns;
❑ need only be part–time, thus allowing reasonable access to frontage properties; and
❑ are relatively inexpensive to implement, with the capital cost often repaid by benefits in less than one year.

Times of Operation

Bus–lane operating periods should be determined, primarily, by the times and duration of traffic congestion. Thus, bus–lanes may operate during peak periods, am or pm or both, or all day or weekday or all week but times and days of operation in any one urban area should be standardised to avoid confusion to road–users. Bus–lanes which operate all day, say 07:00 hours to 19:00 hours or 24 hours, are more readily understood by other road–users and are consistent with a general policy of encouraging public transport. However, all day lanes materially affect frontage access for loading and off–loading and, where frontage loading requirements are intense, peak–period only bus–lanes may be unavoidable.

Where all day bus–lanes exist, the loading issue may be resolved by:

❑ servicing frontage premises from nearby side–streets; or
❑ loading 'out of (07:00–19:00) hours'; or
❑ direct frontage service–access, notwithstanding the all day bus–lane.

Permitted Use by Other Traffic

Pedal cyclists are usually permitted to use with–flow bus–lanes for safety reasons, since otherwise they would be required to ride in the main traffic stream outside the bus–lane.

Taxis are sometimes permitted to use with–flow bus–lanes, on the grounds that they perform a public transport service, provided that:

❑ taxi volumes and set–down/pick–up behaviour does not interfere with bus operations (off–line taxi–stop bays may be possible); and
❑ taxi–use does not encourage infringement of bus–lane regulations by other vehicles, ie taxis should be easily identifiable vehicles, such as London 'black' cabs, or should carry a prominent taxi sign.

Motorcycles are not normally permitted to use bus–lanes, as they travel at the same speed as general traffic and should not be encouraged to weave or overtake on the inside of a queue, by incursion into a bus–lane. However, there are examples where motorcycles are permitted to use bus–lanes.

Layout

The location and design of the start and finish of with–flow bus–lanes are crucial. Lanes must start upstream of the end of the predicted traffic queue and the bus/other traffic diverge at that point should be carefully designed to ensure a safe distance for non–priority vehicles to merge. With–flow bus–lanes should normally be at least 3.0m wide, but, where there are significant numbers of cyclists, a width of 4.25m – 4.6m is preferable. Above 4.25m, a designated cycle–lane (1.0m) may also be provided alongside the kerb by carriageway marking.

Most with–flow bus lanes are terminated, ie 'set–back', before the traffic signal stop–line of the junction they approach. The set–back ensures that the full width of the stop–line is available to all vehicular traffic during the green signal period and thus the capacity of the junction is maintained and left turns made possible. The length of the set–back should be such that buses entering from the bus–lane can clear the traffic signal stop–line on the first available green phase. As a general guide, the set–back length, in metres, should normally be twice the green time, in seconds. A shorter set–back can be used, if the junction approached is not the constraint on the capacity of the route or if the bus–lane continues downstream of the junction. In these cases, a short set–back will allow 'left turns and buses only'.

A with–flow bus–lane may be extended right up to the signal stop–line under four conditions:

❑ if a reduction in the traffic capacity of the junction is acceptable, as part of an overall traffic restraint strategy for the area;
❑ if the junction is not the critical constraint on the capacity of the route;
❑ if safe provision can be made for left–turning traffic; and
❑ if right–turning traffic can be accommodated in such a way that it does not restrict flow in the other non–priority lane(s).

Signing and Road–Marking

Signs and road markings must convey sufficient information to drivers to enable them to obey the

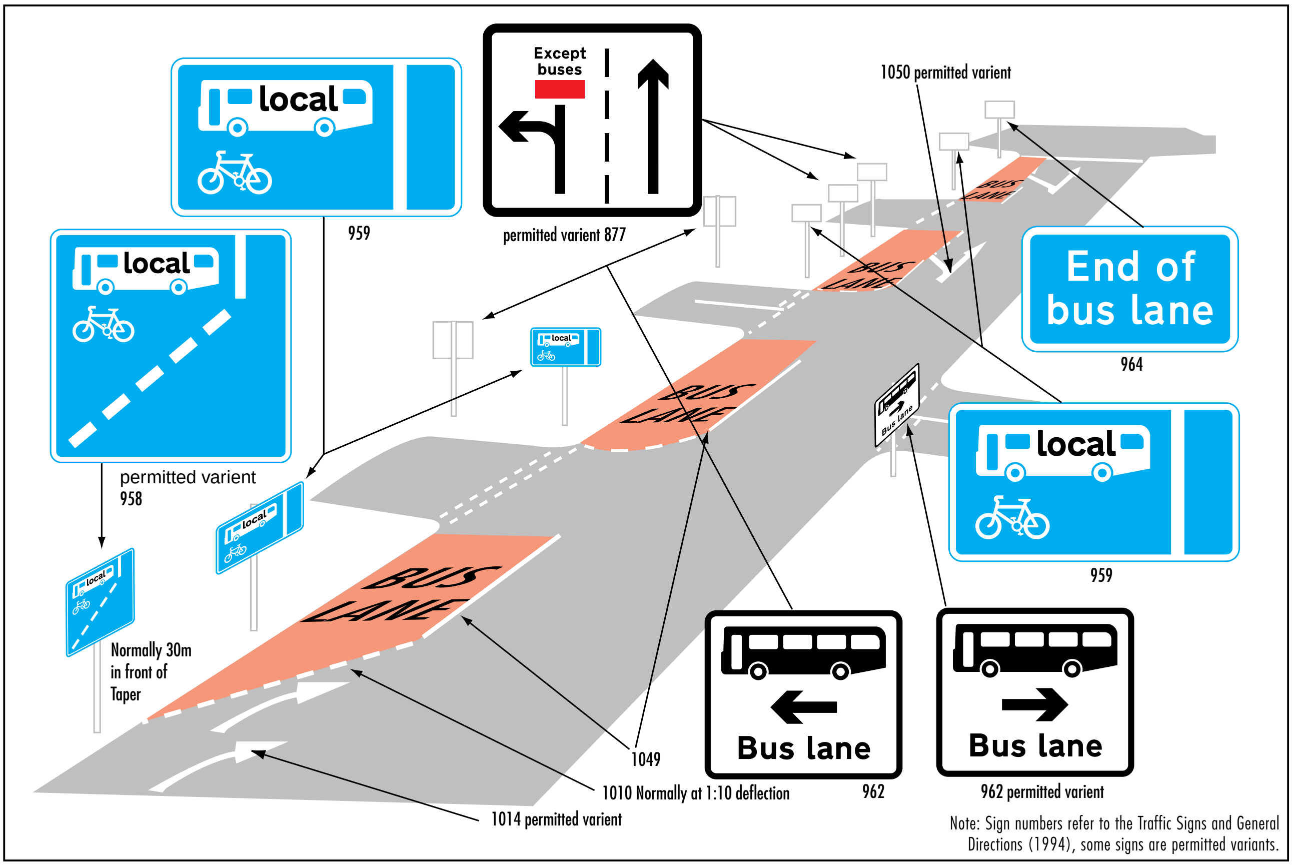


Figure 24.1: Schematic layout of a with–flow bus lane in a one–way street.

regulations applying to the scheme. Signs should be in accordance with current regulations (HMG, 1994) [NIj] and a typical signing layout is shown in Figure 24.1.

Bus and other traffic lanes are separated by carriageway markings comprising a solid white line 250mm–300mm wide. The application of coloured road surfacing also assists with compliance. Bus–lane throughput is a function of bus flow, the number of

Photograph 24.2: Extra bus–lane width for overtaking.

Photograph 24.3: A contra–flow bus–lane in London.

bus stops and passenger demands at stops but bus flows and passenger demands do not usually impose capacity constraints on the design of bus–lanes. Research has shown that a single–lane bus–lane, with 'normal' passenger demand at stops, can cater for about 120 buses/hour, without special measures (NATO, 1976). Above this level, special measures, such as provision for overtaking at stops through the use of bus stop bays or variation in the bus–lane width, are likely to be necessary (Photograph 24.2).

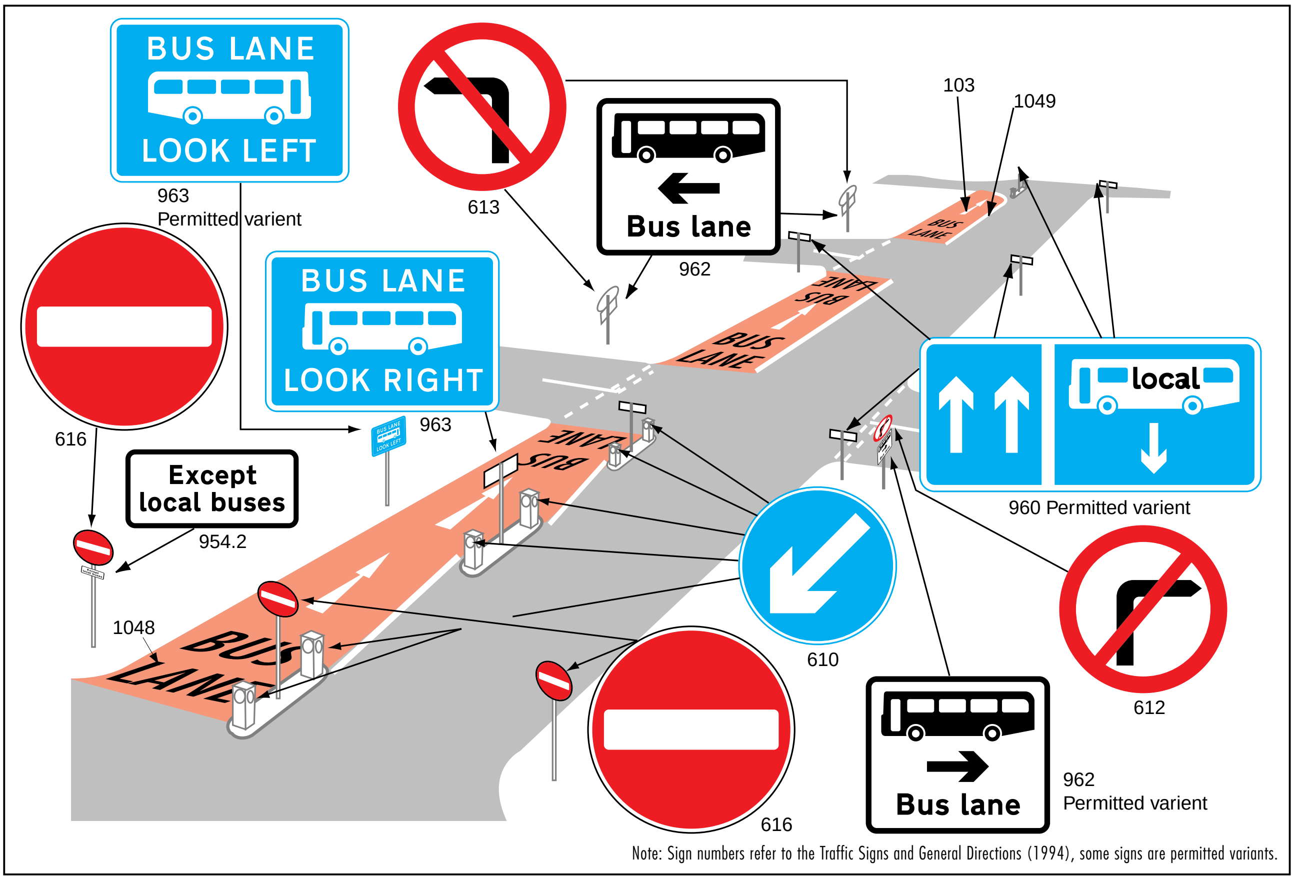


Figure 24.2: Schematic layout of a contra–flow bus lane.

24.7 Contra–flow Bus–Lanes

A contra–flow bus–lane (see Photograph 24.3) is a traffic lane reserved for the use of buses travelling in the direction opposed to the general traffic flow. Contra–flow lanes usually operate on a 24–hour basis.

Contra–flow bus–lanes are usually introduced in area–wide one–way traffic systems, where the effect is to create a two–way road with 'buses only' allowed, in one direction, and all types of vehicle including buses, in the other. By allowing buses to travel against the direction of traffic flow, contra–flow lanes enable

buses to avoid unnecessary diversions and thus save both journey distance and time and often improve access for buses to passengers' destinations. The main characteristics of contra–flow bus lanes are:

- ❑ that buses follow the same route on outward and return journeys in one–way systems, resulting in convenience and benefits to passengers;
- ❑ that savings are achieved in bus–kms and bus–hours;
- ❑ that reductions occur in bus–passengers' walk–times to main destinations; and
- ❑ that, if well–signed, they are easily understood and respected by other drivers.

Permitted Use by Other Traffic

Pedal cyclists may be permitted to use contra–flow bus–lanes, where a minimum lane–width of 4.25m can be provided. However, cyclists can experience difficulties at entry/exit points and at side–roads, where traffic crosses the lane.

Layout

Contra–flow bus lanes should not normally be less than 3.0m wide. Pedestrians' safety may be an issue and the design of pedestrian crossing facilities and pedestrian protection, such as short lengths of guardrailing to channel pedestrians to suitable crossing facilities, should receive special attention.

Signing and Road–Marking

Signing and road–markings should be in accordance with the current regulations (HMG 1994) [NIj]. Physical separation, either a continuous island or a series of long islands, is normally used. While ensuring that other vehicles do not enter the lane, this may introduce potential difficulties, such as:

- ❑ reducing the perception by pedestrians of 'two–way operation';
- ❑ causing tracking damage if the lane is narrow;
- ❑ creating difficulties for buses having to take avoiding action in emergency or breakdown; and

Photograph 24.4 A bus–advance lane.

❑ creating difficulties for loading/unloading to frontage premises.

Contra–flow lanes may be delineated, instead, by a solid white line, 250mm–300mm wide, supplemented by traffic islands and/or double white lines with hatching between them. Coloured surfacing reinforces the special nature of the lane.

At the entry, a 'No Entry Except Local Buses' sign should be used wherever possible (HMG, 1994) [NIj]. However, if cyclists are permitted to use a contra–flow bus–lane, then current regulations do not permit the signing of an exemption for cyclists to 'No Entry' signs. Thus, either a separate 'cycle–gate' must be provided or all motor vehicles could be prohibited with an exemption for buses and cycles, although the general level of compliance by other vehicles may be reduced. Figure 24.2 shows typical entry–signing.

Loading and Unloading

If traffic flow in the opposing direction is heavy, and if loading is allowed in the lane, it may be difficult and unsafe for buses to overtake stationary vehicles.

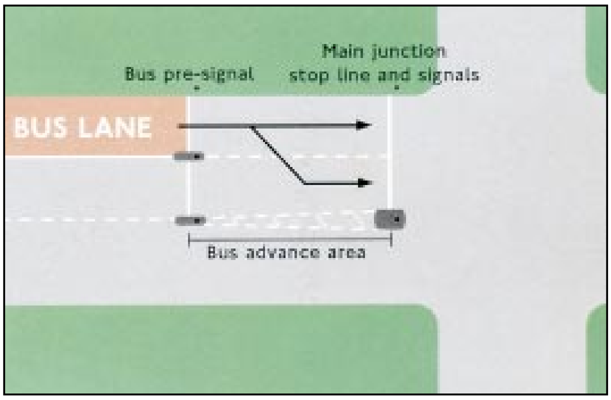


Figure 24.3: Layout of advance–area for buses, with pre–signals.

In these circumstances, possible remedies include:

❑ a double width contra–flow bus–lane;
❑ servicing from nearby side–streets;
❑ delivery vehicles permitted to park, whilst loading/unloading, along the off–side kerb of the bus–lane, where it is physically segregated or partly–segregated; and
❑ the provision of loading–bays, within the curtileges of buildings fronting the contra–flow lane.

Particular care is needed at pick–up points on a contra–flow bus–lane and special traffic islands may be required.

24.8 Bus–Priority Using Traffic Signals

A 'Bus–Advance Area' (see Photograph 24.4) is a traffic management measure which permits buses to advance into an area of road, clear of traffic, before a signal–controlled junction. Pre–signals, in advance of the junction, always control traffic entry to the advanced area, with a bus–lane provided up to the pre–signals (see Figure 24.3). The objective of the pre–signals and advance area is to re–order vehicles, so that buses may be given priority to reach the junction first. The maximum traffic throughput of the junction is unchanged.

'Traffic metering', also termed 'queue relocation' or 'gating', involves a bus–lane running right up to the upstream stop–line of a congested junction or section of road and alters, by adjusted signal–timings, the volume of traffic which can enter the congested section. The objective of traffic metering is to control the flow of traffic at the upstream junction by reducing capacity at the metered junction, so that it, rather than the downstream junction, becomes the critical junction in the network. The bus–lane enables buses to by–pass the relocated traffic queue.

Combined bus–advance areas and traffic metering can be installed, using pre–signals to manage and relocate queues to areas where bus–lanes will still allow buses to be protected from congestion.

Design of Advance–Areas for Buses

Conventional with–flow bus–lanes generally terminate with a 'set–back' from the signal stop–line and are designed to ensure that buses clear the stop–line on the first green, where the buses are mixed with the platoon of general traffic within the set–back area. Greater priority may be given to buses by the use of pre–signals, to create a bus–advance area between the pre–signal and the junction.

Pre–signals control traffic upstream of the junction. A bus–lane taken up to the location of the pre–signal, enables buses to overtake the traffic queue. When the pre–signal is red for other traffic, buses may proceed to the main junction signal, taking their preferred lane in the advance area. They may either proceed into the advance area with no control or be subject to a 'give–way' where the road narrows or be under signal–control throughout. Pedestrian crossings can be incorporated with a separate bus–lane stop–line, although this is not generally favoured. Specific site circumstances will determine the best form of layout. Thus, the pre–signals do not always control bus movements, whereas they always control non–bus traffic movements.

Shortly before the junction signal turns green, general traffic is released from the pre–signal and enters the advance area (if there is space) to make full use of the green–time at the junction. Detailed monitoring in London and elsewhere indicates that the benefits of schemes of this type are high and scheme costs can often be recovered in less than one year (Astrop *et al*, 1994). The concept can be extended to provide a segregated lane for buses right up to the signal stop–line of the junction, if space permits or can be created. Buses can then be given a separate signal stage or an early start from the main signals. Generally, overall junction capacity will be reduced. The bus–lane must also be long enough to enable buses to enter the lane freely and so overtake the whole traffic queue. If their entry to the bus–lane is blocked, total throughput at the junction may be impaired.

Traffic Metering
Traffic metering on a main route requires the linking of two or more sets of traffic signals and a system for measuring congestion in the critical section of road between those signals. Traffic signal–timings are adjusted at the upstream signals, to meter traffic flow to the level which can be accommodated by the downstream road section. A bus–lane is provided to enable buses to overtake the traffic queues on the approach to the upstream traffic signals. Traffic metering provides journey time and reliability benefits for buses over a congested route section, where it may not be possible, for operational or physical reasons, to provide bus–only lanes.

Examples of traffic–metering schemes can be found at Bitterne Road, Southampton (DOE, 1970 to 1976) and Dewsbury Road, Leeds (Fox *et al*, 1995).

The technique of combining bus–advance areas and pre–signals with traffic metering is particularly applicable on approaches to town centres where,

Photograph 24.5: Uxbridge Road/Park View Road, Ealing.

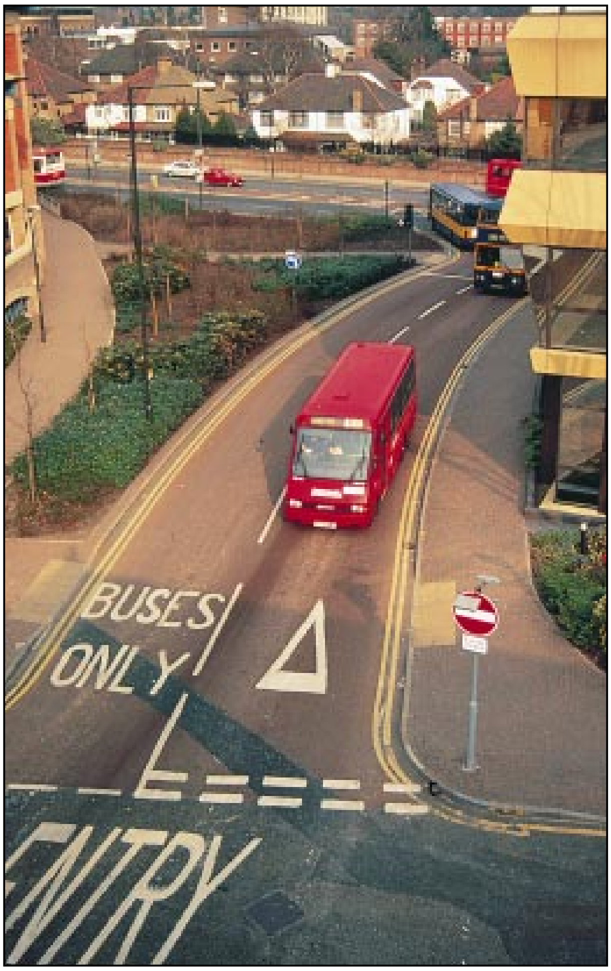
because of constraints such as narrow road widths and loading requirements, bus–lanes cannot be introduced. The Uxbridge Road/Park View Road (Southall) scheme in Ealing (see Photograph 24.5) has shown a significant reduction in bus journey times throughout all periods of the day. The technique showed these benefits on all seven days of the week, with overall savings to general traffic as well (LBE, 1995).

Exemptions from Prohibited Turns
Allowing buses to make turns prohibited to other traffic can give buses a considerable advantage, as journey distance can then be shorter than for other traffic. Clear, well–located signs are necessary to prevent other vehicles making the turns intended for buses only. Any scheme involving selective turns for buses must take into account the number of buses involved, their occupancy and the implications for junction capacity and road safety.

24.9 Junction and Network Bus–Priority at Traffic Signals

Traffic signal bus–priority can utilise Selective Vehicle Detection (SVD) within various traffic control strategies, such as vehicle–actuation, fixed–time Urban Traffic Control (UTC) and SCOOT (see Chapter 41) to provide 'active' bus–priority. Alternatively, bus volumes and passenger numbers, plus bus stop dwell– and cruise–times, can be used as inputs into traffic signal–timing calculations, with the aim of minimising delays and stops to passengers rather than vehicles, and thus provide 'passive' priority. Bus–priority at signals is relatively inexpensive to implement, with the capital cost generally balanced by benefits in months rather than years. Moreover, it is complementary to other bus–priority traffic management measures, such as bus–lanes and advanced areas.

Buses can be given priority at traffic signals by making signals respond to the arrival of a bus utilising an SVD system. Buses fitted with transponders, or other types of electronic device, are able to communicate with the traffic signal controller. As buses approach the signals, they are detected and the traffic signal–timings can be altered in their favour. The transponder is interrogated either via a roadside beacon or detector–loop buried in the road and a coded signal is sent to the signal controller, which then alters the traffic signal–settings in one of two ways. Either the green–time for the approaching bus is extended (extension) or, if the bus is approaching lights which are red, other green phases in the signal–cycle are shortened or omitted to bring forward the next green phase for the bus (recall). In the latter case, the time lost to other phases may be compensated during the next signal–cycle. Where bus flows are heavy, an 'inhibit' facility can also be set. Where buses are turning right, communication via a beacon or a detector loop can be used to call the next stage, enabling that bus to make the turn.



Photograph 24.6: An example of a buses–only road link.

SVD for buses has been applied, for example, in Oxford, Swansea (linked to SCOOT) and widely in London, where, by 1996, around 350 vehicle–actuated signal junctions had been installed outside the UTC/SCOOT controlled area and about 4,500 buses had been fitted with transponders. The system has paid for itself, typically, in about 15 months, with bus delays at most junctions reduced by around one–third and with a reduction in variability of around one–fifth.

In most large urban areas in Britain, traffic signals are controlled by some form of computer–based UTC system. Active and passive bus–priority can be provided within UTC systems. Active bus–priority, giving an extension or recall, has been incorporated into Version 3.1 of the traffic responsive SCOOT UTC system (termed BUS SCOOT) (Bowen *et al*, 1994) and is also available within fixed time UTC, using the SPRINT (Selective Priority Network Technique) algorithm. Results from the PROMPT trial in Camden Town, London, indicated that BUS SCOOT gave bus delay–savings that averaged 22% (ie five seconds per bus per junction). Overall, the benefits repay about 72% of system costs within the first year (Hounsell *et al*, 1995). Passive bus–priority can be provided within SCOOT and fixed–time UTC (BUS TRANSYT).

24.10 Bus–Only Roads (or Links) and Bus–Only Streets in Town Centres

A road or link restricted to bus–use usually allows buses to take a more direct route than other vehicles, for example between a new housing area and the existing road network, or to by–pass congested junctions (Photograph 24.6). The use of a bus–only street in a town centre is, typically, restricted solely to buses, although limited access by other categories of vehicle, such as taxis, may be allowed or the street may be accessed during limited time–periods for servicing.

Bus–only roads or links enable buses to maintain their route–patterns and to avoid needless detours where road systems have changed; thus, services can continue to provide long–established access for passengers to business and shopping areas, where such access may be denied to other vehicles. They also improve the environment of shopping streets by restricting traffic while, at the same time, maintaining accessibility.

Bus–only roads or links usually require a 'bus–gate' at the point(s) of access, to ensure compliance by other vehicles. These could be traffic signals, actuated by the buses, or physical barriers, surmountable only by buses, or signs, such as ‘No Entry Except Local Buses’, often coupled with local road–narrowing.

A bus–only street is often used by pedestrians and, thus, the bus ‘track’ should be emphasised by the use of different running levels or materials or colours to increase pedestrians’ awareness and safety. Their alignment should discourage high speeds (James *et al*, 1991). Kerbs are not always necessary but may be considered (at a minimum height), to facilitate drainage on curved alignments and, at stops, to prevent buses overrunning and to help passengers boarding and alighting.

Bus–only roads or links should not cause loading problems, since they are generally purpose–built without frontage access. For bus–only streets, servicing is a key planning constraint, as the streets are generally located in existing shopping areas. The conventional solutions apply, ie access limited to certain specified times of day and provision of facilities in nearby side–roads or at the rear of premises.

24.11 Bus–Stopping Places

Siting

Bus stops must be sited to allow passengers to board and alight, safely and conveniently, with minimum disruption to other road–users. Stop locations should be convenient for main shopping and business areas, right beside stations and as close to other main passenger origins and destinations as possible. The needs of elderly and disabled people should be recognised. Provision of new bus stops, or re–siting of existing stops, occurs when bus services change or new developments open. Wherever new bus stops are proposed, or an existing stop is to be moved, discussions should be held between the bus operators or PTE (in London, LT Buses), the local Highway Authority and the police, in order to determine the most suitable location. The criteria for new bus stops are that, ideally, they should be located:

- ❑ near pedestrian routes to and from the main generation points of bus trips;
- ❑ close to pedestrian crossing facilities;
- ❑ close to main junctions, to facilitate passenger interchange with other buses, but without interfering with junction capacity or compromising road safety;
- ❑ to minimise walking distances between interchange stops and cross roads;
- ❑ ’tail–to–tail’, where possible on opposite sides of the road for safety reasons and allowing sufficient space between the rear–ends of bus stop markings for other vehicles to pass;
- ❑ away from residential and other sensitive frontages, where noise and disturbance are undesirable; and
- ❑ never between a signal detector and a stop–line, where Selective Vehicle Detection (SVD) is in use.

In practice, these criteria may not all be achievable, in every instance, in which case safety considerations must dominate.

Spacing

Typical bus stop frequency is between two and three stops/kilometre. In densely populated areas, town centres and residential developments, bus stops should preferably be no more than 300m apart. Stops may be split so that buses on different routes, but using the same street, stop at different points, because of high frequency (more than 25 buses/hour) and/or lengthy stop–occupancies. A balance should be sought between the advantages of splitting stops, to reduce bus–on–bus delays and traffic congestion, and the disadvantages of reduced convenience for passengers. Bus routes with common destinations should share the same stop.

Layout

Buses should be able to approach and leave stops without delay or obstruction. Vehicles parked close to or at bus stops prevent buses from reaching the kerbside and force buses to stop in the carriageway. This causes difficulties for passengers trying to board or alight, especially for elderly or disabled people and people with children or shopping who have to walk on the road and negotiate a higher step onto the bus. Preferred bus stop layouts are shown in Figures 24.4(a) to 24.4(e). The layouts apply to urban conditions, ie roads with speed–limits up to 40 miles/h, and for 12m buses with doors at both front and centre. If other buses are used, the designs may have to be adjusted. The overall aim is to permit buses to stop within 200mm of the kerbside, without overhanging or over–running the footway. Other bus stop and bus–bay designs have been developed (LBPNSG, 1995).

Most stops in urban areas will be conventional kerbside stops. Figure 24.4 provides examples. However, buses often experience difficulty in manoeuvring to the kerbside, due to parked or loading vehicles. Bus stop ‘boarders’ help to resolve this problem. Boarders require less kerb–length than conventional bus stops located between otherwise continuous parked cars. They provide an effective deterrent to kerbside parking at the stop itself and

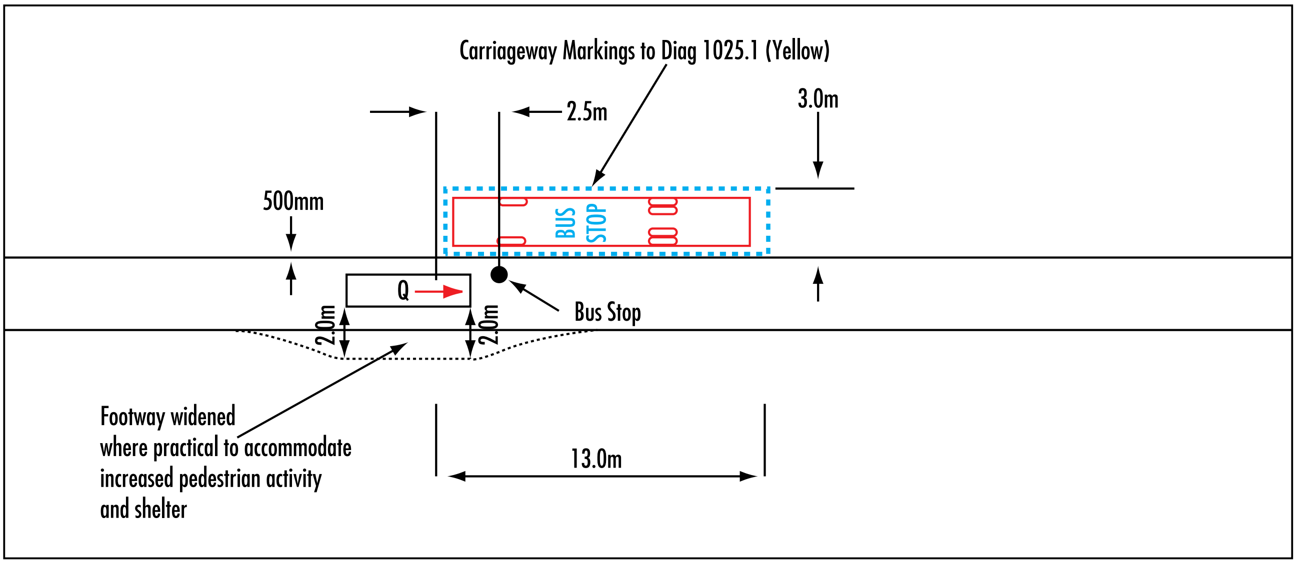


Figure 24.4(a): Typical kerb–side bus stop, unobstructed.

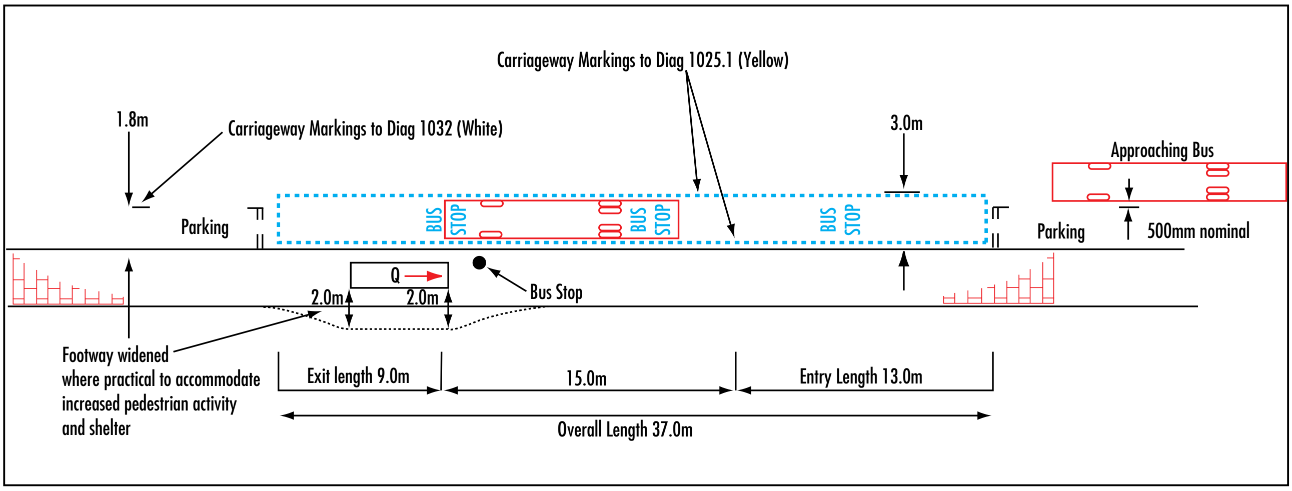


Figure 24.4(b): Kerb–side bus stop, with parking on approach and exit.

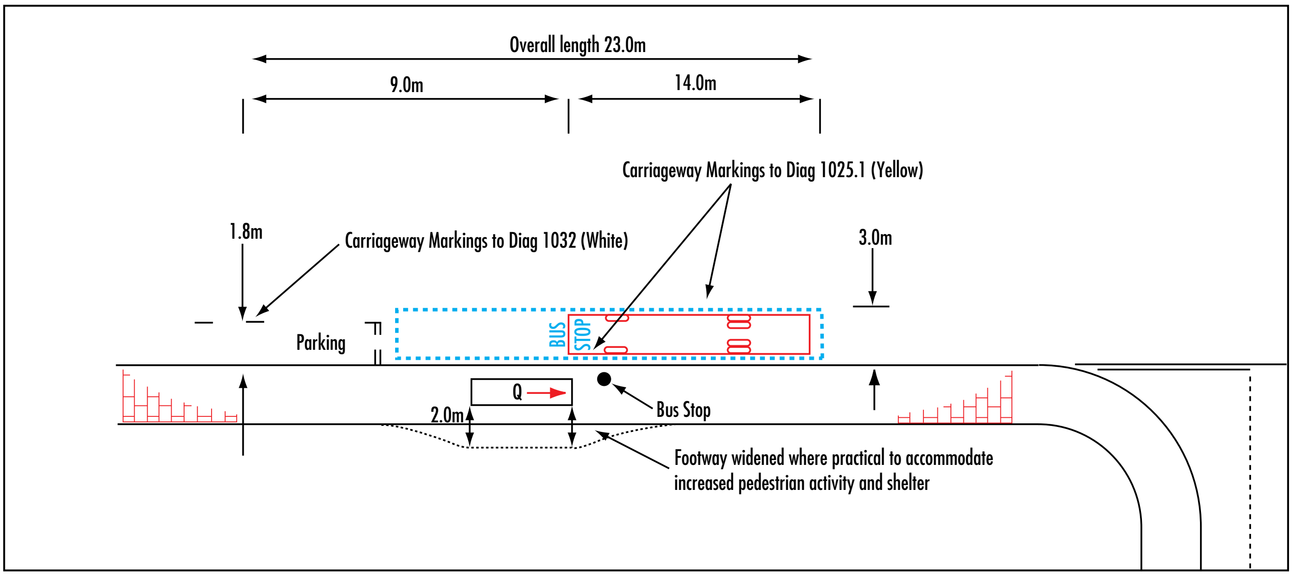


Figure 24.4(c): Kerb–side bus stop on the side of a junction.

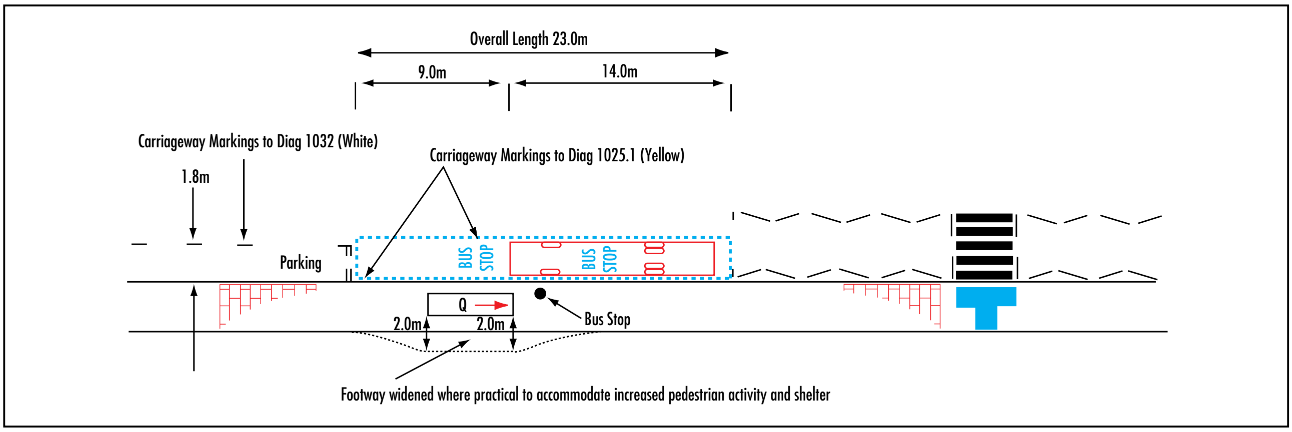


Figure 24.4(d): Kerb–side bus stop on the exit of a pedestrian exit.

they define clearly the parking areas up– and down–stream. They enable buses to align with the kerb, create passenger waiting–areas, without conflicting with general pedestrian flows, and ease bus boarding, by allowing the height of the kerb/platform area to be raised. Figures 24.5(a) to 24.5(c) show arrangements for these bus–boarders. Bus bays do not assist buses in the same way, because bus drivers can experience difficulty in re–entering a traffic stream when leaving a bus bay and the bays can attract illegal parking. The design of many existing bus bays is unsatisfactory, particularly where their geometry does not enable buses to stop close to the kerb. Preferred layouts are shown in Figures 24.6(a) and 24.6(b).

Where kerbside parking and loading is a problem in the vicinity of a stop, bus stop clearways and 'cages' should be provided (HMG, 1994). On the London Priority (Red) Route Network, 24–hour, seven days per week 'no–stopping–except–buses' arrangements are provided at all bus stops. On the London Bus–Priority Network (LBPN), in addition to the 24–hour provision, other standard hours are 07.00–midnight. At certain locations, it may be necessary to restrict the use of a stop to local buses only.

Footway Treatment

Passenger–waiting areas should be attractive, convenient and well–lit. The needs of the elderly and people with impaired mobility should be considered in the design. Where possible, bus stops should be sited on footways that are sufficiently wide to avoid obstruction to pedestrians by waiting bus passengers. Where footways are narrow, bus–boarders should be considered to enable bus passengers to wait away from pedestrian paths. If a 2.0m, full–width bus–boarder is feasible, the kerb and bus–boarder may be raised to between 160 and 180 mm at the kerb and sloped back to meet the existing kerbline. This reduces step–height to buses without impeding pedestrians on the footway. The addition of 'Kassel' kerbs (see Photograph 24.7) allows buses to stop within a few millimetres of the kerb without any damage to tyres. Bus shelters are beneficial at stops, where space permits, and high quality shelters should be used to improve passengers' comfort and convenience.

At terminus stops, at major commercial developments, at LRT/Metro interchanges and similar locations, buses may stand for some time and

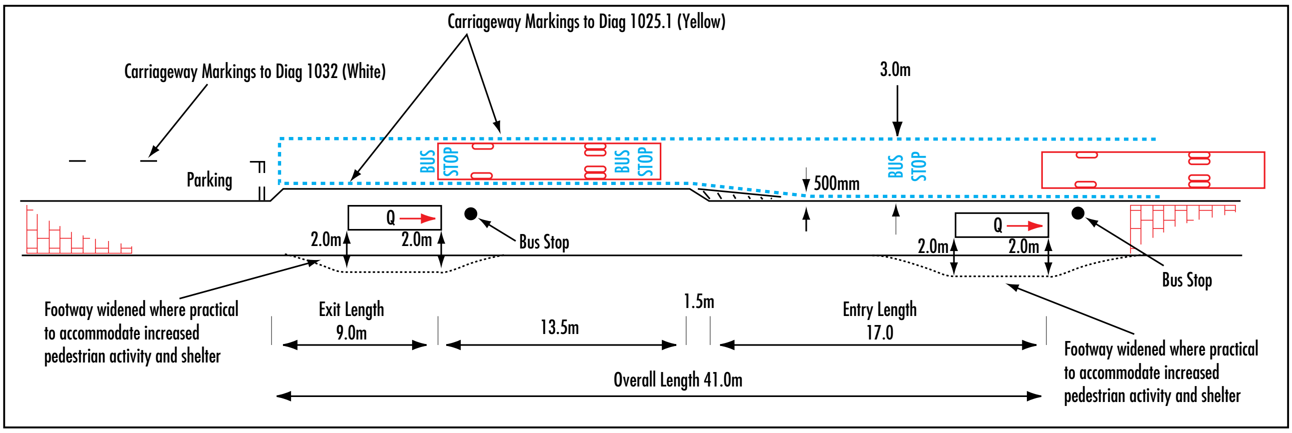


Figure 24.4(e): Multiple bus–stops, including one with a slight build–out.

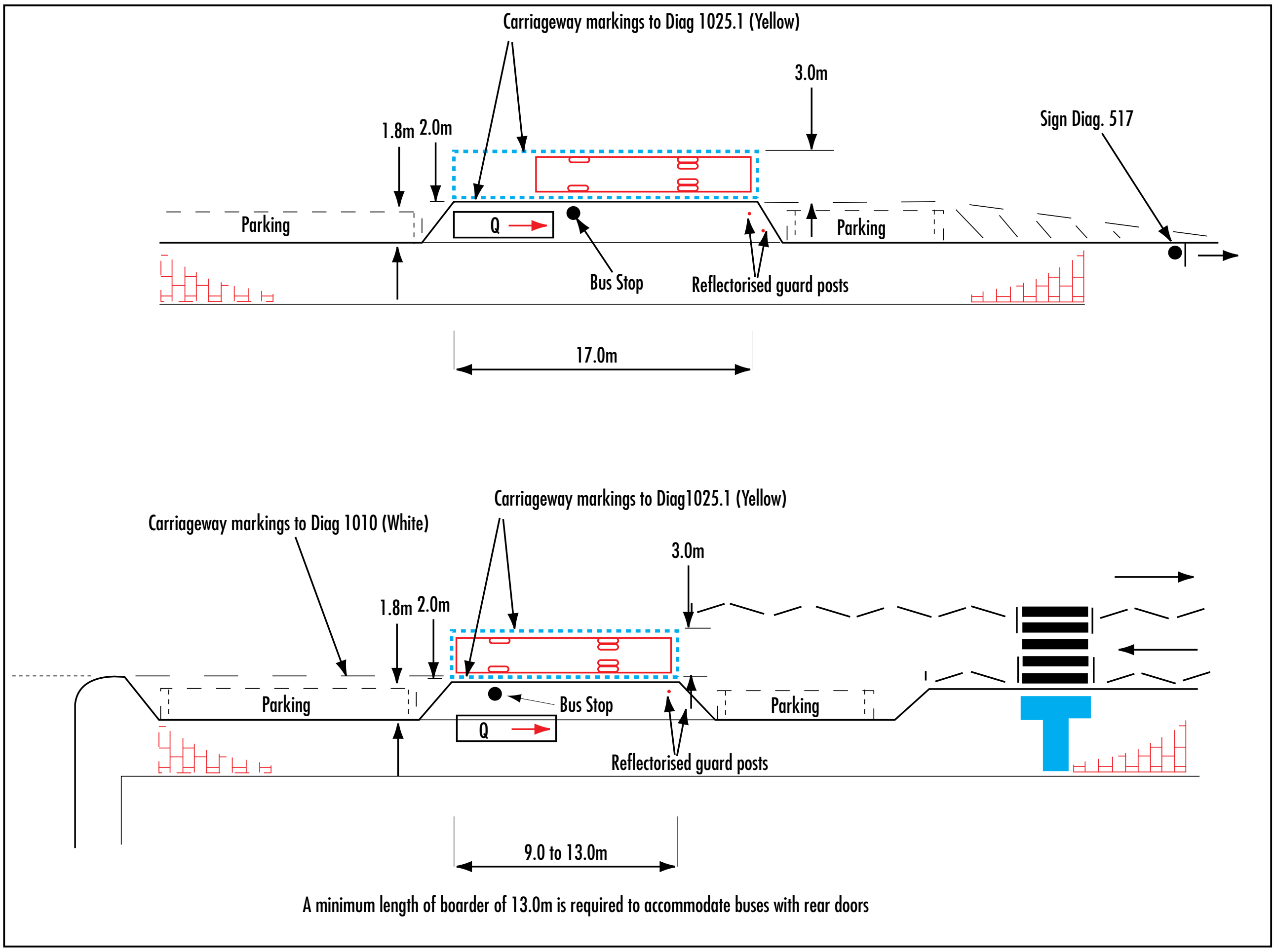


Figure 24.5(a): Examples of bus stops with full–width bus–boarders.

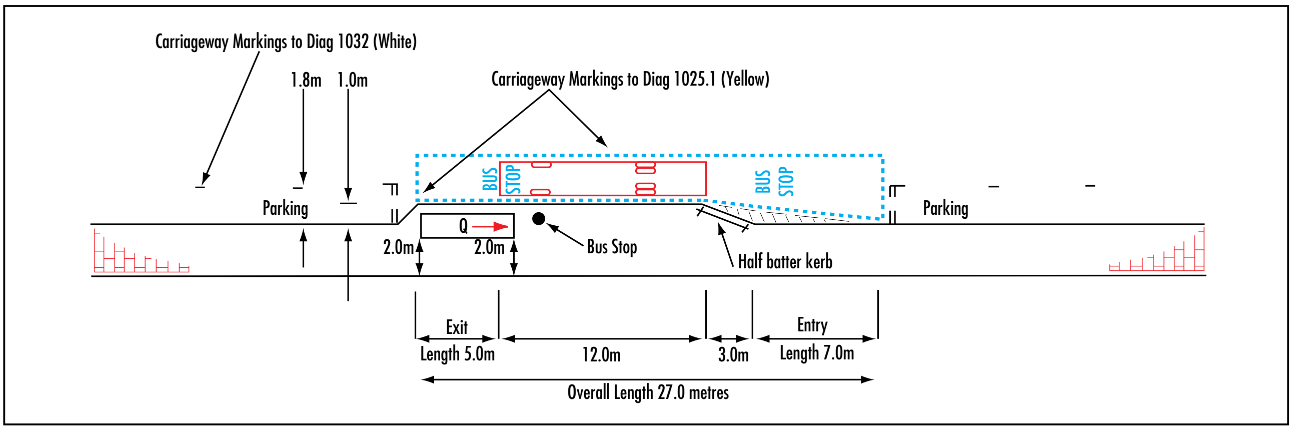


Figure 24.5(b): Examples of bus stops with half–width bus–boarder – narrow road width.

will usually need to turn round. Clearway regulations may be necessary at some stands to keep them free of other traffic. It is preferable to provide a turning–area off the highway, unless a suitable roundabout or gyratory exists nearby.

Bus Stations

Bus stations assist buses to provide good accessibility to town centres or major developments. In smaller, concentrated town centres, a well–sited bus station will be able to serve the majority of passengers' objectives. In larger town centres, a single bus station may only be able to serve a minority of passenger–trips and could impose unnecessary constraints and costs on bus operators. Bus stations should:

❑ provide a focal point for passenger–journeys to and from a town centre and allow good accessibility to town centre facilities;
❑ allow easy interchange for passengers between bus services;

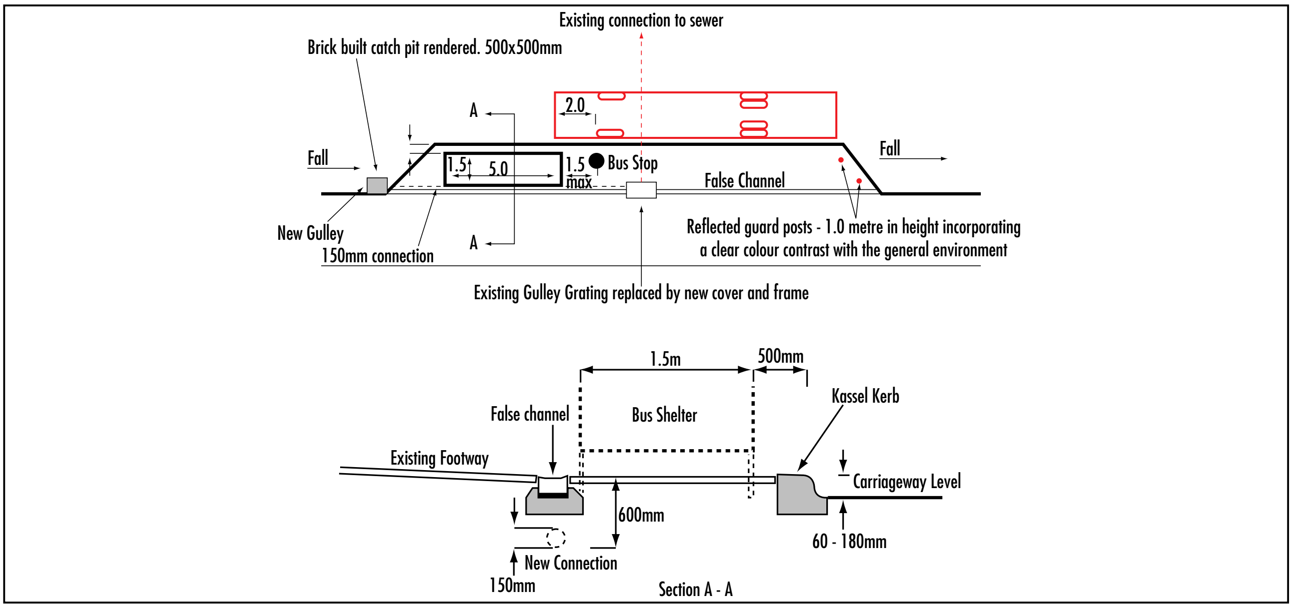
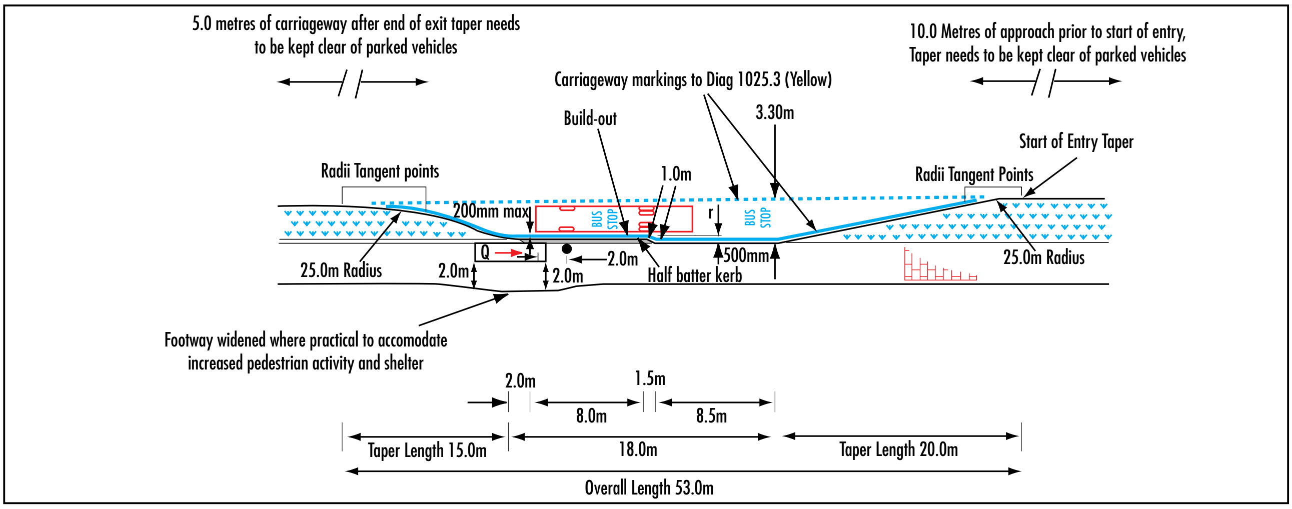
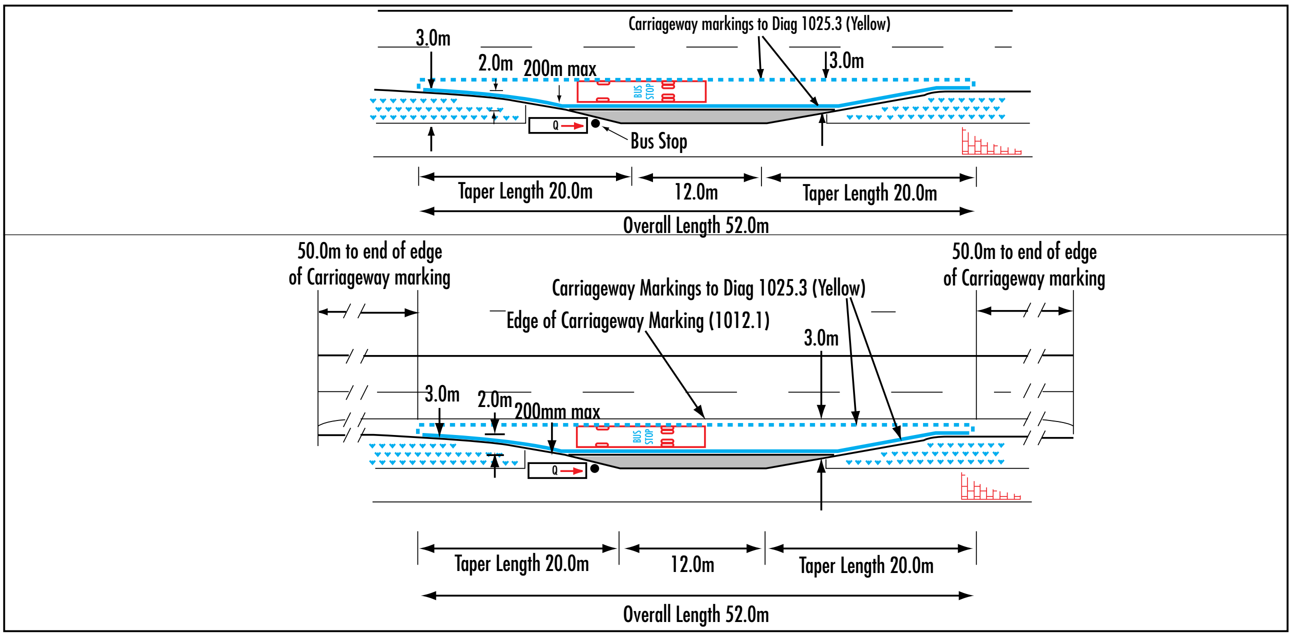


Figure 24.5(c): Construction details for bus stops with half–width bus–boarder.



Above: Figure 24.6(a): General arrangement of bus bay. Below: Figure 24.6(b): Low cost amendment to an existing bus bay.



Photograph 24.7: Bus–boarder and Kassel kerbs.

❑ provide a high quality passenger environment, including shelters, information, security and other facilities;
❑ permit operators to improve the efficiency of management of bus services, by the provision of bus–stacking and lay–over areas and crew–change facilities; and
❑ allow buses to enter and leave the bus station site unobstructed by traffic congestion and without introducing costly diversions.

Bus station design depends on the expected movement patterns of passengers and buses, as well as bus standing and lay–over requirements. Basic design objectives are:
❑ to encourage maximum passenger use;
❑ to ensure the quality, safety and security of passengers;
❑ to minimise the potential for conflict between passengers and vehicle–movements;
❑ to minimise walking distances between the main passenger origins and destinations and the bus station;
❑ to minimise the number and distance of bus movements within the station; and
❑ to provide for an efficient sequence of setting–down, standing, waiting and boarding.

Bus station design (LTB, 1995; and BRPT, 1981) depends on specific site–factors, such as available land–area, site–shape, topography, local road–pattern and access, passengers origins and destinations, the peak numbers of buses and passengers and the manoeuvring capability of the largest bus in service. Four basic layouts of bus station are shown in Figure 24.7, as follows:

❑ 'island layouts' – which are compact but have operational problems for buses and for passengers' safety, as frequent crossing of lanes is necessary;
❑ 'perimeter layouts' – where a single main passenger destination is served, such as a shopping centre or railway station. These are not recommended where main passenger destinations exist on more than one boundary, as jaywalking can occur and bus circulation between setting–down, standing and boarding requires additional empty–running kilometres for buses;
❑ 'central concourse layouts' – these are preferred to the narrow island layouts for restricted sites, since stops can be organized to ensure an efficient setting–down, standing and boarding sequence and passengers can be provided with high quality facilities and shelter in a single area; and
❑ 'reversing layouts' – which save space but are appropriate only for low frequency services, as buses cannot queue in the circulation space while waiting for a designated free bay and, for safety reasons, supervised reversing is usually necessary.

In addition to interchange at bus stations, many other facilities involve interchange between buses and other modes, including railway stations, park–and–ride facilities, kiss–and–ride facilities, ferries and airports. Design considerations similar to those for bus stations apply but, additionally, the potential for transfer between modes should be maximized. This can be achieved with:
❑ good accessibility for vehicles of all kinds (for example, combining kiss–and ride with park–and ride); and
❑ a high level of convenience (eg short walking distances) and comfort (eg weather protection) to encourage passenger interchange.

Timetables and count–down information should be displayed at all public transport stops. Local authorities and PTEs play an important role in providing timetable information at stops, for passengers, as a first priority, and also for local residents. The image of public transport and passenger services can be enhanced by the use of real–time displays based on automatic vehicle location (AVL) systems. These show the expected time to the arrival of the next bus, tram or LRT vehicle and its service number (see Photograph 24.8) (see also Chapter 15).

24.12 Busway Transit and LRT

Busway transit is defined as a public transport system which utilises buses, operating on exclusive rights of way, termed busways. Busways, provided over

Photograph 24.8: A 'countdown' display at a bus stop based on AVL

significant but not necessarily all route–sections, protect buses from the effects of traffic congestion and enable a rapid and reliable service to be offered. Busways should be segregated physically from general traffic, to the maximum extent feasible, in order to minimise violation of their right of way. Buses may be guided or non–guided. As with LRT, a properly planned busway transit system should not just consist of a busway track, the system should also incorporate high quality buses, bus stop information services, passenger facilities and 'smartcard' fare–collection systems.

Mass transit based on busways has many advantages over fixed–track systems, including:

- 'performance' – buses operating on segregated busways can provide a reliable and regular service at high operating speeds. With traffic management and signal–priority and even, in selected critical locations, grade–separation, service performance can approach that of LRT with similar segregation;
- 'flexibility in operation' – buses can join and leave a busway at intermediate points along its length. Thus, buses serving many areas of a city may use part, or all, of a busway and passengers from a wide catchment area benefit from services, without the interchange required by rail systems;
- 'flexibility in implementation' – as with any segregated track system, busways will affect other traffic, particularly loading and unloading to frontage properties. However, unlike LRT, a segregated busway may be discontinued for short lengths and some less rigid form of priority provided;
- 'lower capital costs' – costs of infrastructure and rolling stock are substantially less than for fixed–track systems of equivalent capacity, along the same route and with the same degree of segregation;
- 'scope for rapid and incremental development' – busways may be introduced and used effectively over short sections, so a system may be enhanced and expanded, as demand grows and resources permit; and
- 'passenger capacity' – busways are unlikely to offer greater capacity than LRT with equivalent degrees of segregation from other traffic. However, high capacities (ie 25,000 to 35,000 passengers/h) are not often needed in Britain. Even so, segregated busways have been recorded with 200 buses/h carrying 20,000 passengers/h at uniform headway and a constant speed of about 19 km/h (Cracknell *et al*, 1992).

In Britain, there are few purpose–designed busways, although a segregated contra–flow lane may be regarded as a basic form of busway. Examples of purpose–built schemes are the Runcorn segregated busway and Redditch, which has a part–segregated busway. In other countries, examples of busways operating include: Ottawa, with 20km of segregated bus track; Seattle, with a two kilometre bus–only tunnel, with metro–type stations and dual–powered buses; Pittsburgh, with two segregated busways, one used jointly by buses and trams; Curitiba Brazil, with the most extensive system–wide busway network in the world, having schemes on five major corridors serving a city of near two million population; Liege, with busways introduced into the existing road network, partly using ex–tram rights of way; and France, with busways in Paris, Envreaux, Montpelier and Nice.

Busways can be operated with guided buses and examples are schemes in Ipswich and in Leeds (Photograph 24.9). Various forms of bus guidance exist. The most usual form involves lateral guide–wheels, mounted on conventional buses, which

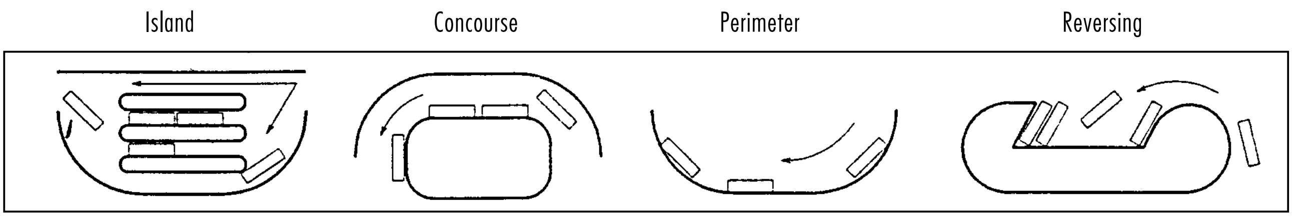


Figure 24.7: Bus station layout.

run along guide–rails or kerbs on both sides of the busway track. This system operates in Leeds, Adelaide (Australia), Essen and Mannheim (Germany). Other prototype schemes have been developed, involving buses guided by signals from cables buried in the road surface and buses guided by an arm lowered from each bus into a slot and rail cut into the road surface. The advantages of guided buses are: the reduced width required for the busway track, since it need only be wide enough to accommodate a bus and its attached guidance system – usually about 2.6m kerb–to–kerb (although the structural width of the guidance kerbs and safety clearances must be added); the smooth train–like ride (a consequence of the high quality track which forms the busway); and the enhanced public perception of a guided system. Against these factors must be set the capital costs, lack of flexibility (only specially equipped buses can use the guideway) and problems which may occur in the event of a bus–breakdown on the guided way.

Safety and ease of enforcement favour rail–based systems. Moreover, the physical presence of rails, when street–running is used, appears to deter illegal parking. The main advantage of LRT systems is the quality image they project, which may assist in attracting car–users to public transport as an acceptable alternative mode in the context of car restraint policies. This must be set against the high capital and operating costs. Design considerations for LRT systems are discussed in detail in Chapter 34.

Stops

Where buses operate on–street, details described in the foregoing paragraphs for conventional bus stops apply. For guided buses, in cases where the guidance wheels on each bus are permanently deployed, clearances and layouts of bus stop bays must take this dimension into consideration. Where stops are within a busway, whether non–guided or guided, the following apply:

- ❑ for island stops or platforms, suitable arrangements must be made for boarding and alighting passengers to cross adjacent roads to and from the stops; crossing may be combined with junction signals or may use measures such as a Pelican crossing; and
- ❑ island platforms should incorporate physical measures for safety and ease of use, such as channelising guardrails, a back shelter–wall to protect waiting passengers from the nearside traffic stream, dropped kerbs at the crossing points for access for mobility– impaired people and textured surfaces for the visually impaired. The height of the kerbs and bus stop waiting–area will depend on the type of bus and guidance system which is to be operated.

No comprehensive design standards exist for stops. Nevertheless, generally:

- ❑ stop–spacing may vary from 250m in densely–developed inner city areas to 1km in suburban areas;
- ❑ wherever possible, stops should be located on segregated sections of track, to avoid delays to other vehicles and to ensure stops are not obstructed by other road vehicles;
- ❑ dimensions of stops will reflect the sizes of rolling stock used. Platforms may range from high (915mm) to low (400mm). Most modern systems are likely to adopt low–floor vehicles and thus lower platforms will most often be used; and
- ❑ platforms should preferably be 3m wide or more (including allowance for guardrails) although, in critical cases, a minimum of 2.5m may be acceptable.

24.13 Other Facilities

High Occupancy Vehicle (HOV) lanes are traffic lanes for use by buses and other vehicles (usually cars) with three or more occupants. HOV lanes do not benefit buses alone nor do they have a great impact on modal choice. The objective is to promote higher car occupancy and, thereby, to improve the efficiency of road–use. Numerous examples of HOV lanes exist in cities in the US and other countries (Kain, 1992).

Where bus flows are too low to justify a lane exclusively for buses, allowing taxis and/or goods vehicles into the lane may justify a combined scheme.

Photograph 24.9: Guided bus in Leeds.

The introduction of disability discrimination legislation has stimulated the provision of public transport which is accessible to people with impaired mobility, including those who travel in wheelchairs. For some of these people, the journey between their home and a bus stop will be unmanageable, even if buses are accessible. Weather conditions, state of health, time of day and other factors will determine their ability to use public transport or their need instead to rely on a door–to–door services, such as community buses, dial–a–ride and accessible taxis.

To achieve a genuine door–to–door service, the vehicles should be able to get as close to the pick–up point as possible and to drop passengers off as close as possible to their final destination. The value of the services will be entirely lost if the vehicles are unable to gain access into a shopping precinct or pedestrian area, in order to drop off an elderly or mobility–impaired person, in safety and within a walking distance that can be managed (for some, this may as little as 50m). Factors necessary for a good service include: dedicated drop–off points; tactile surfaces; dropped kerbs; and, as minibuses with rear–loading passenger lifts are likely to be used, sufficient clear space behind the vehicle for wheelchair–users to manoeuvre safely.

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