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Hard Shoulder Bus Priority Measures on Motorways and Type 1 Dual Carriageways

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DN Design

Technical

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1. Introduction

1.1 General

This interim guidance outlines the design principles and factors to be considered by design organisations when incorporating hard shoulder bus priority measures, either to an existing or new Motorway or Type 1 Dual Carriageway. The process of design is described together with an approach to developing options.

1.2 Background

Improving the performance of public transport on the National Road Network can increase the social and economic benefits of the network. Solutions which achieve modal shift towards public transport away from private car use have the potential to reduce the cost and impact of upgrades required in response to existing congestion and future population growth. They also have the potential to reduce the cost of new schemes with greater emphasis placed on the people carrying capacity as opposed to vehicle carrying capacity.

There is no doubt that decarbonising transport is one of the most urgent and complicated challenges facing the global transport sector and it is a critical piece of the jigsaw in the fight against climate change. If the country is to achieve the target of net zero by 2050 as set out in the Government's *Climate Action Plan 2019*, there is an urgent need to reduce carbon emissions in this sector. TII adopted a Sustainability Statement in 2018 with a commitment to embed sustainability principles at all levels across our organisation and sustainability is now one of the critical strategic objectives of TII's Statement of Strategy 2019–2023. Schemes promoting a modal shift to more sustainable modes of transport will support the policy demands of smarter travel and the climate adaptation plan, by encouraging increased public transport usership and as a result reducing carbon emissions from private car usage.

This interim guidance provides detail on the geometric and other technical aspects, alongside the design considerations for scheme implementation. The document provides a guide for scheme development and the need for the organisational collaboration of both road authorities and transport bodies.

Any proposals to implement Hard Shoulder Bus Priority Measures on national motorways and dual carriageways should be investigated through the Phase 1 Concept and Feasibility Report. The Feasibility Report should be submitted to the Senior Engineering Inspector for review and approval.

1.3 Scope

This interim guidance gives details of the requirements and development considerations for the implementation of hard shoulder bus priority measures on Motorways and Type 1 Dual Carriageways on the National Road Network. This document specifically applies to schemes implementing the measures on new roads, or where the provision is being added to an existing Motorway or Type 1 Dual Carriageway.

1.4 Implementation

This interim guidance should be used forthwith on all schemes where it is planned to implement hard shoulder bus priority measures on the National Road as either part of an online or offline improvement, except where the scheme has received, prior to publication of this document, its statutory approvals to allow it to proceed.

Where this exception is to be used, design organisations shall confirm this by e-mail to the Standards Section of Transport Infrastructure Ireland (TII) at infoPUBS@tii.ie.

1.5 Definitions

The following terminology has been adopted when discussing hard shoulder bus priority measures within this document:

- Within this document the term, **hard shoulder bus priority measure** refers to the general allocation of road space to buses on either a periodic (specified hours) or permanent basis. In the case of periodic usage, the period of operation shall be indicated on a traffic sign or information plate.
- Hard shoulder bus priority measures shall either be used by buses only (such use will require a specific Statutory Instrument for each scheme) or shall function as a Bus Lane as defined in section 32 of the 1997 Road Traffic Regulations (as amended).

Particular terms used in this Publication are defined as follows:

a) A **Bus Lane** is an area of road cross-section given over to users as set out in SI 332/2012. The legislation sets out the permissions for the lane to be used by any bus or pedal cycle. In addition, taxis and wheelchair accessible taxis are permitted to use bus lanes during their course of business.

b) **"Bus"** means a mechanically propelled vehicle designed for travel by road having seating accommodation for more than 9 persons (including the driver) and providing a public bus service as defined in section 46 of the Public Transport Regulation Act (2009).

c) **Central reserve**: The area which separates the carriageways of a motorway or dual carriageway. This includes any offside hard strips.

d) **Clear zone**: The clear zone is the total width of traversable land on the nearside or offside which is to be kept clear of unprotected hazards. This width is available for use by errant vehicles. The zone is measured from the nearest edge of the trafficked lane: i.e. the hard shoulder or hard strip forms part of the clear zone.

e) **Cross-section**: The road cross-section incorporates all elements between the boundaries including carriageways, the central reserve, separation zones, hard shoulders, hard strips, verges including any footway, cycle track, bridleway, fences, barriers, ditch, cutting or embankment slopes, berms and maintenance strip. All dimensions are measured square to the centreline of the road.

f) **Design Organisations**: organisations responsible for undertaking and/or certifying the design.

g) A **Dual Carriageway** is a divided all-purpose road with a central reserve. There are three types of Dual Carriageway as defined below:

   i) **Type 1 Dual Carriageway**: A divided all-purpose road with a central reserve and a minimum of two lanes and hard shoulder in each direction constructed to the geometric standards of *DN-GEO-03031* and *CC-SCD-00006*.

   ii) **Type 2 Dual Carriageway**: A divided all-purpose road with a central reserve and two lanes and hard strip in each direction constructed to the geometric standards of *DN-GEO-03031* and *CC-SCD-00005*.

iii) **Type 3 Dual Carriageway**: A divided all-purpose road with a central reserve and two lanes in one direction of travel and one lane in the other direction, constructed to the geometric standards of *DN-GEO-03031* and *CC-SCD-00004*. The side which has the two-lanes alternates at intervals of approximately 2km.

h) A **hard shoulder** is a surfaced strip, 1.5m wide or greater, adjacent to the nearside traffic lane to offer a place to stop in emergencies, clear of mainline traffic. It also provides access for emergency vehicles and additional road space during temporary traffic management.

i) **ITS Systems**: Intelligent transport systems (ITS) are systems in which information and communication technologies are applied in the field of road transport including infrastructure, vehicles and users, and in traffic management and mobility management, as well as for interfaces with other modes of transport.

j) **Managed Network Environment**: A road network with enhanced controls such as additional technology to control the flow of traffic or additional restrictions.

k) **Motorway:** A public road as defined in Section 43 of the *Roads Act (1993).*

l) A **National Road** is a public road or a proposed public road which is classified or is intended to be classified as a national road under Section 10 of the *Road Act (1993)*.

m) **Nearside**: left-hand side of vehicle when viewing a forward moving vehicle from behind, typically the front-seat passenger side of the vehicle in Ireland.

n) **Offside**: right-hand side of vehicle when viewing a forward moving vehicle from behind, typically the driver side of the vehicle in Ireland.

o) **Slip road**: A connector road within a junction between a dual-carriageway or motorway mainline carriageway and the adjacent road network, or vice versa, which meets the adjacent road network either via a merge/diverge or at an at-grade junction. Slip road connections to dual-carriageway or motorway mainline are via merge/diverge.

p) **Verge**: The part of a road cross-section alongside a carriageway but not including embankment or cutting slopes. This includes hard strips but not hard shoulders.

1.6 Adherence to the Interim Guidance

This interim guidance sets out the best practice processes, operation and layout for schemes implementing hard shoulder bus priority measures, developed from experience and review of similar schemes in other jurisdictions. Designers should aim to meet the minimum recommendations as set out in this document to ensure the best outcome for the project and safe operation of the scheme. In some cases, sufficient advantages might justify going below the minimum recommendations, in more constrained locations. Non-adherence should be assessed in terms of the effects on the economic worth of the scheme, the environment, and the safety of the road user.

To assess the merits of the design approach taken and evaluate where designers are unable to meet the minimum recommendations of this document within the context of the scheme as a whole, the designer should follow the Design Report submission process set out in Section 5 of DN-GEO-03030 Design Phase Procedure for Road Safety Improvement Schemes, Urban Renewal Schemes and Local Improvement Schemes. The Design Report should be submitted to TII for review as a Departure application using the TII Web-based Departures database. Guidance on the development and contents of the Design Report is provided in the TII Publications (Standards) DN-GEO-03030. Sample Design Reports have been uploaded to https://www.tii.ie/tiilibrary/. See TII Publications (Standards) GE-GEN-01005 for information on how to submit a Departure.

Statutory and/or Procurement Procedures should not commence prior to the review and satisfactory responses to any comments from TII on the Design Report, and receipt of a Gateway Approval.

1.6.1 Relaxations and Departures from Existing Standards

This interim guidance makes reference to requirements of other TII standards which contain various criteria and maximum/minimum levels for achieving a desirable level of performance in terms of road safety, operation, economic and environmental effects and sustainability. Where the requirement cannot be met a departure is required. In some cases, the referenced standard may also permit relaxations.

All departures and relaxation must be submitted with Appendix E of the Design Report for the scheme. Further information in relation to departures and relaxations, including the process for submitting an application for a departure can be found in *GE-GEN-01005 Departure form Standards and Specifications*.

In specific relation to this document, where relaxations and departures are proposed the additional relationships with the minimum recommendations of this document should be considered.

2. Roles and Responsibilities

To achieve a successful outcome for a scheme it requires organisational collaboration to ensure all elements of the scheme are coordinated. Collaboration of organisations is essential, independent of the source of scheme funding.

The following roles and responsibilities are likely to be required:

- **Design Organisations** are responsible for coordinating the design of the scheme with the other organisations, applying the design principles set out in this IAN and delivering a design that meets the objectives of the scheme. They are responsible for notifying TII as the standards and IAN owner of any cases of non-adherence as well as any departures from referenced standards, including seeking approval for these in advance of them being implemented into the design. In developing the design there is a need to ensure the proposal provides good value for money, by optimising new and existing infrastructure and reducing cost without compromising on safety. Early understanding of the existing issues and constraints can reduce risk of cost increase at a later stage of the project.
- **Transport Infrastructure Ireland (**TII) has overall responsibility for the planning and supervision of works for the construction and maintenance of national roads. As such TII is the standard's owner and is responsible for approval of the network design and any departures. TII may also be the funding agency for the project, responsible for controlling costs and ensuring the project is progressed in line with TII's Project Management Guidelines. As the network operator, TII's input into the design and future operation of the scheme is important and their input should be sought at all stages. The level of ITS provision associated with these measures will need to be coordinated carefully with Motorway Operations Control Centre (MOCC) and their resource capacity to monitor and control the network.
- The **National Transport Authority (NTA)** is responsible for overseeing the provision of bus, train, tram and taxi services in Ireland. The designers of all hard shoulder bus priority schemes on Motorways and Type 1 Dual Carriageways should coordinate with the NTA to ensure the design achieves the desired strategic outcomes and meets the future needs of the bus service operators in order to maximise usage
- **Bus Service Operators** are the ultimate end user of schemes. To maintain safety on the network, it is recommended that they deliver driver training on how to use the new scheme layouts.
- **Local Stakeholders:** There are potentially many interested stakeholders adjacent to the scheme who may provide valuable input into the development of the design, and may also be impacted through construction (including pedestrians and cyclists, and disabled user groups). They should be consulted throughout the scheme's development.
- **Local Authorities** should be consulted by the Designers to ensure the enhancements to the network are integrated with the wider local transport objectives and other projects for the areas the scheme passes through. Local Authorities may play an important role in the development and funding of complimentary infrastructure remote from the mainline of the motorway / Type 1 Dual Carriageway to ensure seamless end to end journeys which are key to making the bus an attractive alternative.

At the outset of a scheme organisations involved should work to coordinate and understand each other's roles and responsibilities within the remit of this IAN.

3. Need, Benefits and Justification

This Publication supports the Government's *Climate Action Plan 2019*, which sits alongside the *Project Ireland 2040 (National Planning Framework).* Prioritising buses on the strategic network can support the following objectives outlined in the plan:

- Ensure growth plans focus on the reduction and need for private transport and increase the use of public transport
- Improve air quality through reducing CO2 emissions per passenger km and limiting congestion
- Encourage active travel as part of end-to-end journeys
- Contribute to the government target of the country being net-zero by 2050

The integration of hard shoulder bus priority measures onto Motorways and Type 1 Dual Carriageways provides the opportunity to realise the benefits of modal shift into higher occupancy vehicles thus increasing road capacity at relatively low cost, without providing additional traffic lanes. Modal shift has the potential to relieve traffic congestion and is in accordance with government policy. This option should therefore always be considered early in the consideration of Alternatives and Options as laid out in the *Project Appraisal Guidelines for National Roads Unit 4.0*.

The use of hard shoulder bus priority measures, where an existing road has reached capacity, should be considered as an option for resolving congestion alongside active travel measures and alternative forms of transport.

It is important in developing a project to engage with existing bus operators on the current provision of public transport as well as future operations. As part of this consultation, design organisations should consider the opportunity for private sector bus operators increasing operations along the relevant routes, due to the priority infrastructure delivered and future proof the scheme for this growth. The frequency of service is considered a key differential for scheme benefits, with schemes needing to prioritise improvements to journey time reliability and service frequency to maximise the infrastructure investment. When developing the objectives, the design organisation should ensure a clear set of objectives are established considering stakeholder input to allow a range of options to be marked using SMART (Specific, Measurable, Achievable, Realistic and Timely) objectives.

3.1 Assessment Methodology

3.1.1 Selecting and Assessing the Appropriate Scheme

Guidance on developing scheme options is set out in *PE-PAG-02013 - Project Appraisal Guidelines for National Roads Unit 4.0 - Consideration of Alternatives and Options*. The guidance sets out the steps and methodology for robustly assessing options and developing the business case for schemes. Hard Shoulder Bus priority schemes can be stand-alone improvements or can be part of an overall road improvement scheme involving junction enhancements and lane modifications. In the case of stand-alone hard shoulder bus priority measures, limited options are generally available. These will include the location of the measures along the road.

In addition to hard shoulder bus priority measure scheme options, the guidance requires design organisations to ensure a 'Do-Nothing' option and a 'Do-Minimum' option is considered as well as alternative options to bus prioritisation. These can be assessed as part of the wider road improvement scheme.

At the assessment stage, it is important to select the optimum operating type to ensure the case illustrates a strong need.

Availability of lanes, prioritisation level given and location of scheme terminuses will have a large influence on the improvements to bus journey time reliability, service frequency and passenger demand increase.

3.1.2 Approach to Assessment

The *TII Project Appraisal Guidelines (PAG)* and *Department of Transport (DoT) Common Appraisal Framework* make recommendations that objectives are established based on the following criteria:

- Economy
- Safety
- Environment
- Physical Activity
- Accessibility & Social Inclusion
- Integration

The following sections set out considerations that schemes should make regarding how hard shoulder bus priority schemes can meet these criteria.

3.1.2.1 Economy

Evaluation of current network flows should consider the vehicle carrying capacity and current utilisation of this capacity. When full, the high occupancy of buses makes optimal use of the available road space, increasing the number of people moved per vehicle. This leads to an improvement in flow due to the modal shift reducing the number of private cars. Schemes should therefore consider current flows, bus patronage and routes in assessments.

When developing future growth scenarios, in addition to private vehicle increase, the achievable modal shift driven by the introduction of a scheme and therefore the potential for increase in bus service frequency should be considered. Design organisations should consult with the NTA on options for future bus routes, linkages and frequency of service. The scheme should also consider the potential for private operators to utilise the new infrastructure where hard shoulder bus priority measures are being considered.

Journey time is an important economic factor, a priority for users and is heavily influenced by congestion. Without priority for buses, their journey time reliability is impacted by the same congestion as private vehicles. Through prioritising buses, the desirability of this mode of transport therefore increases. When considering journey times for public transport, it is important to consider the service frequency, stop locations and the end-to-end trip time when assessing desirability. A well-integrated scheme will provide increased benefit for investment.

Careful consideration of the existing road layout and constraints should be made to understand the potential to modify the current infrastructure to accommodate a new layout. This may result in a lower capital expenditure through the reuse of existing infrastructure, but the constraints posed may also lead to increased cost if not identified at an early stage.

3.1.2.2 Safety

When developing options, design organisations should review the current safety baseline for the scheme extents to identify road safety issues and how future options may address these issues. As part of the review, the existing road condition and existing departures should be identified.

Hard shoulder bus priority schemes introduce new layouts and prioritisation, together with the likelihood of deployment of ITS control infrastructure, all of which may potentially lead to driver confusion.

Any solution should consider how driver confusion and lane misuse can be addressed through training, driver engagement through early and regular liaison with the NTA, the operation and management of the network by TII Network Operations and MOCC, and through the design process to ensure a safe scheme. Hard shoulder bus priority measures also change the arrangements for places of refuge and emergency access. The design process has to consider whether there are any hazards that might make these layouts inappropriate.

As part of any safety review design organisations should assess the existing provision and safety issues associated with non-motorised users (NMUs). Along Type 1 Dual Carriageways there is the potential that cyclists use the existing hard shoulder for cycling. Where hard shoulder bus priority measures are to be introduced the provision for cyclists should be replaced to avoid conflict with vehicles using the lane. To reduce the risk to this user group schemes should consider how parallel infrastructure can be provided away from the Motorway or Type 1 Dual Carriageway hard shoulder bus priority measures or verge located NMU facilities can be provided.

Away from the Motorway or Type 1 Dual Carriageway hard shoulder bus priority measures, safe routes for NMUs to access bus stops should be identified and schemes should work with local governments to recommend improvements to existing infrastructure to provide greater connectivity and protection for NMUs.

3.1.2.3 Environment

Hard shoulder bus priority measures, where possible, utilise existing road space more efficiently. In some cases, this may provide the opportunity to limit the extent of widening outside of existing road corridors. However, an environmental assessment of any design is required, as in some cases repurposing of the existing road cross-section may require works to the carriageway and verge needing additional land. However, this does pose the potential to reduce the environmental impact compared with alternative options.

Prioritisation of buses with high occupancy also benefits the efficient use of road space, a reduction in congestion consequently, reduces C02 emissions per passenger km. This reduction in emissions will contribute to an improvement in air quality on the network and is an important contribution to reducing the carbon outputs associated with the operation by users of the network.

3.1.2.4 Physical Activity

Scheme options should consider optimising patronage through optimisation of bus stops and additional linkages by working with local authorities. When developing a hard shoulder bus priority scheme for a Motorway or Type 1 Dual Carriageway the location of bus stops off the network is important and may determine layouts at junctions to ensure optimum priority access for buses onto the network. When consulting with local government, consideration should be made as to how non-motorised users may access sites to increase accessibility for walkers, cyclists or other public transport modes. This should include an assessment of the existing infrastructure for NMUs and where there may be requirements to upgrade this or add in new provision to enhance the connectivity to the scheme.

3.1.2.5 Accessibility & Social Inclusion

Hard shoulder bus priority measures promote the use of public transport. The ability to travel is heavily linked to the ability to work and access to education. The ownership of a private car is generally more expensive than public transport meaning lower and middle income sections of society typically have a greater reliance on public transport modes. As well as being considered more sustainable than private vehicle usage due to their high occupancy nature, public transport is more widely accessible as a result of being cheaper. Pricing strategy and stop locations however, require careful consideration to ensure potential passengers consider the option accessible both physically and financially.

3.1.2.6 Integration

It is important schemes meet and consider the latest national, regional and local policies and the future aspiration of the Government and TII in developing the National Road Network. Schemes must consider the critical importance they will play in achieving TII's sustainability targets and the Government's target of net zero carbon by 2050.

The scheme should consider how it supports not just end-to-end trips but the local journeys along the transport corridor. Any scheme changes should recognise the existing provision of public transport linkages and the trips they support.

The construction of schemes has a short-term impact on the existing road network and local community due to construction traffic and traffic management. Hard shoulder bus priority schemes have the potential to reduce works on and outside of the existing network boundary. However, the use of traffic management and works on the network will still impact both the users of the networks and also the network's neighbours.

4. Early Design Considerations for Implementing Hard Shoulder Priority Measures on Existing Roads

To minimise and control scheme risk, the design team should fully consider, at an early stage, the potential constraints of an existing road when assessing the implementation of an upgrade scheme involving the implementation of hard shoulder bus priority measures. Unidentified constraints of the existing road network may lead to scheme delays and cost increase at a later stage. Consideration must be given to existing relaxations and departures along the length of network under consideration. A review of the latest RSI undertaken and high collision locations assessments for the route should be undertaken with an aim to address items raised in those reports.

To identify potential constraints of the existing road, the designer is required to undertake a detailed topographic survey of the corridor at an early project stage. The following is a list of common design constraints which will need to be reviewed and accounted for in any scheme design and cost:

- **Structures –** Existing structures can present a constraint on the headroom, visibility, nearside offset and cross-section width of the future scheme. The designer should consider whether modification will be required to accommodate a revised cross-section on or through an existing structure and the potential limits the structure may also place on the design. Changes to the cross-section may also mean traffic is running closer to the existing parapet or piers. The designer should check to ensure adequate stopping sight distance is provided, and the existing containment and loading capacity provided by the structure is sufficient for the proposed design and if additional protection measures are required.
- **Crossfall –** Conversion of an existing hard shoulder may require modification to the existing crossfall of the hard shoulder to ensure that a consistent crossfall is maintained between the hard shoulder bus priority measures and adjacent lanes. This may have subsequent impact on the level of the edge of pavement. Changes to the carriageway and drainage may require works to the verge to install drainage assets or to modify the level to match the revised pavement level. Where the pavement level is being lowered reconstruction may be required. Changes in the elevation of the verge may require changes to earthworks slopes. Where the crossfall is being extended or carriageway surface area increased the designer will need to review the impact on surface water drainage, including minimising long drainage paths.
- **Verge Signage and Furniture –** The designer must consider how the placement of new ITS equipment, signage and Emergency Refuge Areas (ERA) will be incorporated around existing signage, verge furniture and communications ducts. The modification or rationalisation of existing equipment may require additional verge width and add additional cost if not identified and considered at an early stage. The designer should take cognisance of the requirements of the TII Traffic Signs Approval Procedure, DN-TSM-03082 Appendix A, B and C.
- **Junction Layouts –** The type of existing junction layout will constrain the potential options for upgraded hard shoulder bus prioritisation junction layouts. It is likely that existing space will be required around the junction to upgrade any new layout and the designer should consider current constraints around the junction which may further limit the options available to the designer when selecting a new layout.
- **Pavement Construction –** The designer should obtain data on the design of the existing pavement to assess the existing condition and residual design life available.

Hard shoulders can be designed to accommodate a reduced loading and therefore additional strengthening of the pavement may be required to accommodate additional loading. The designer should also consider how modification of the cross-section may also redistribute lanes leading to the wheel path position aligning with existing joints, potentially leading to increased wear.

- **Drainage –** The existing drainage may require modification or relocation due to an increase in pavement area, or change in use of the hard shoulder to ensure all lanes are sufficiently drained and water is removed from within the wheel path of buses using the hard shoulder. A change in crossfall may also require a change in the position of the drainage. Where French drains are used the designer should consider the additional risk of stone scatter, with vehicles running in closer proximity to the edge of pavement when using the hard shoulder. Based on an assessment of risk it may be appropriate to retrofit concrete channel drainage.
- **Vehicle Restraint System (VRS) –** Due to the re-allocation of lanes and the use of the hard shoulder for buses, it is likely that the nearside running lane will move closer to the existing VRS or require it to be moved/set back all together. The designer should consider what the likely impact a future cross-section will have on the existing VRS provision and the need to upgrade or make modifications. The designer must also factor in the likelihood that the VRS may limit forward visibility for a revised cross-section. Assessment and design should be in accordance with *DN-REQ-030134*.
- **Non-Motorised Users –** Hard shoulder bus priority measures on dual carriageways should exclude the use of cyclists at avoid conflict. At an early stage, the designer should consider what alternative provision should be provided for NMU's to by providing either parallel segregated provision along the existing road network or along a parallel route corridor. In addition, design organisations should consider how NMUs can safely access the bus stops away from the mainline of the Motorway or Type 1 Dual Carriageway and whether new or upgraded infrastructure will be required to facilitate the safe connectivity for NMUs.
- **Elements of the road listed in the Motorway Order –** It is essential that where hard shoulder bus priority measures are proposed on a Motorway that specific Order(s) for the section or road under consideration are reviewed for what elements of the carriageway are and are not listed as being included in the Motorway. This may have impacts of the merge and diverge slips and components of junctions and interchanges. The classification of the road elements may have an influencing factor on the design and statutory processes adopted for the scheme.
- **Network Management and MOCC Operations** – Operational efficiency and safety of the existing network will be a key consideration in the type of scheme proposed and adopted. The level of existing ITS equipment will influence the potential management of the hard shoulder bus priority measures.

The above have the potential to further require additional land outside the existing scheme boundary, and the designer needs to consider the impact additional land may have on programme and cost.

5. Type of Operation

This interim guidance covers the provision of non-physically segregated hard shoulder bus priority measures. These are schemes which are not physically separated by kerbs or vehicle containment barriers from the main carriageway. Typically, these schemes will differentiate the provision via signage and road markings. These schemes are typically preferred due to their reduced land requirements, option to be used on a periodic basis only, ability to retain the availability of the hard shoulder for emergencies when vehicles cannot reach an emergency refuge area (ERA) and ease of access at junctions.

Non-physically segregated schemes have the benefit of being typically cheaper to implement, requiring less linear infrastructure and provide increased flexibility in operation. The lack of physical segregation means driver education and clear messaging is required to prevent misuse.

The implementation of hard shoulder bus prioritisation in this document is either provided by the periodic or permanent use of the hard shoulder as a bus priority measure. Where the hard shoulder is to be used on a periodic or permanent basis, or it will necessitate new arrangements to provide for places of refuge and emergency access. The design process should therefore carefully consider any hazards that might make this layout inappropriate and include other measures including Emergency Refuge Areas and CCTV to provide alternative refuge areas and enhanced monitoring of the network.

5.1 Types of Schemes

5.1.1 Periodic Hard Shoulder Bus Priority Measures

Periodic Hard Shoulder Bus Priority Measures are provided solely for use by buses. The hard shoulder will be opened to approved buses providing a public bus service, with drivers that have undertaken an approved NTA course of driver training. There are two types of periodic opening:

i. **Critical Flow –** hard shoulder opened for buses only when a critical mainline flow or speed is reached, requiring flow monitoring equipment for operation. This type of scheme benefits journey time for bus services even when there is congestion outside of peak times.

ii. **Peak Hours –** hard shoulder opened for buses during fixed AM or PM peak periods only. This type of scheme does not provide bus priority during congested periods outside of peak times, meaning journey time reliability is not always maintained.

5.1.2 Permanent Usage Bus Lanes or Permanent Hard Shoulder Bus Priority Measures

Provision of permanent facilities involves the continuous use of a hard shoulder as a permanent hard shoulder bus priority measure (for buses only) or a newly constructed permanent Bus Lane, to give priority to approved buses. The Bus Lane operates at all times of day regardless of levels of congestion. Bus Lane provision as set out by SI 332/2012 provides access for a wider range of permitted vehicles including any public service vehicle or pedal cycle. In addition, taxis and wheelchair accessible taxis are permitted during their course of business. Consideration should be given to the appropriate use of the lane given the aims and objections of the scheme before a decision is reached on whether a Bus Lane or permanent hard shoulder bus priority measure is provided.

5.2 Selecting a Periodic or Permanent Implementation

The objectives of the scheme should be used when determining the most appropriate operation for a scheme, with the following factors considered:

- **Speed differential** between buses using the priority measures and the traffic in the adjacent lane is a primary factor in the safe operation of schemes and is a particular consideration at decision points. Use of the nearside of the carriageway for the measures permitted by this document reduces the potential for speed differential. Designers should consider limiting the maximum speed differential when modelled to 20km/h by use of ITS. During periods of heavy congestion speed differential is likely to be highest.
- **Impact on capacity** will be a major perception factor for a scheme. Instead of introducing new private vehicle capacity the scheme improves carrying capacity by prioritising high occupancy buses. Therefore, to be successful the scheme needs to achieve a modal shift. Periodic schemes have the benefit of only operating when required therefore allowing the hard shoulder to be used for emergency purposes where present.
- **Layout** – A permanent scheme has the potential to reduce driver confusion due to less uncertainty of the operational layout currently active. However, well designed markings/ signing can mitigate this. Periodic schemes reduce the time the hard shoulder bus priority measure is in use, meaning the road operates in its more conventional layout for greater periods of time. Where peak hour schemes are in operation, the fixed nature of the opening hours can reduce the amount of ITS equipment required to operate a scheme and also reduce driver uncertainty.
- **Journey time reliability** for buses is key to a successful scheme. To achieve this, buses must be prioritised in times of congestion. The peak hour implementation is disadvantaged in this regard as it cannot operate when congestion occurs outside of peak hours.
- **Existing emergency access and places of refuge** will be impacted by the re-provision of the hard shoulder and the choice of how the scheme operates will impact on how the network is used.
- **Operational efficiency and safety of the network** are important to ensure minimisation of impact on the road network. Network Operations and the motorway operators should be consulted on the existing situation over the length of network being considered.

5.3 Hard Shoulder Bus Priority Measures Scheme Management

The following sections provide an overview of elements of scheme management that should be considered. Details of the requirements for each element can be found in *Sections 7 to 10*.

5.3.1 Operational Monitoring and Control

Designers should refer to the TII Guidance Note ***Operational Control Provisions and Deployment of Supporting ITS Infrastructure for Motorway and Type 1 Dual Carriageway Bus Priority Measures.*** Effective design and implementation of ITS control measures will necessitate close collaboration with the MOCC Senior Manager.

Careful consideration needs to be given to the initial infrastructure cost and space requirements at an early project stage, together with the operational costs and resource commitments. The need for future proof systems and space within the road cross-section should also be considered.

In addition to the above, ITS systems can provide the following services:

- Provide journey time passenger information and live bus operation updates at bus stops and when the system is in operation to road users via signage
- Detection of obstructions and incidents impacting the operation of lanes and provide advance warning to drivers, e.g. stranded vehicles
- For periodic usage schemes specifically, ITS systems may be used to determine and communicate periods of opening through vehicle detection systems and variable message signs. This is essential for critical flow schemes.
- Provide control over the operational speed of lanes to reduce speed differential (See Section 7.1.3)
- Provide enhanced prioritisation for buses, for example at junctions
- Monitor the safety and operation of the scheme

5.3.2 Engagement

To ensure safe and effective operation of the scheme, it is important that road users are made aware of the way the scheme operates. In advance of the scheme opening, awareness campaigns are advised and information signs should be used to communicate the new road layouts and the meaning of any new regulatory signage.

Once open, there should be continued engagement with road users through good public information and signage, to ensure that the road user is aware of the new system and how it operates. Road users' interaction with the scheme should be monitored and messaging tailored accordingly based on lessons learnt from reviews within the Phase 7 Closeout Report following the Stage 4 Road Safety Audits. A workshop should be held with TII Network Operations and MOCC prior to the completion of the Phase 7 Closeout Report.

5.4 Junction Layouts

Junctions provide potential conflict points between buses and other road users and a potential delay to journey times. Careful consideration should therefore be given when selecting a layout, whilst assessing what is feasible within the existing constraints. When making a decision, the following should be considered:

- The frequency of bus services required to leave at each junction to access park and ride facilities or bus stops versus the proportion of less frequent stopping services which may just travel through the junction, will influence the decision as to whether to implement through junction running
- Where existing structures for the junction dictates the arrangement (location of bridge abutments / piers, roadside infrastructure, etc.)
- The space adjacent to the junction available to provide additional land where required to facilitate an updated layout
- Whether the existing layout contains multiple auxiliary lanes

Further details of layouts are found in *Section 7.6*.

5.4.1 Through Junction Running

Through Junction Running (TJR) is where buses will not leave the mainline carriageway at the junction, and instead carry on past the diverge nose on the mainline using the hard shoulder bus priority measures (typically permanent or temporary use of the hard shoulder). Subsequently, buses will continue around the back of the merge to continue in the hard shoulder bus priority measure.

To avoid conflict with joining vehicles that are potentially queuing, traffic modelling should be undertaken to identify any blocking issues, and in those circumstances bus gates can provide a solution to prioritise buses. Where a diverge or merge has more than one auxiliary lane TJR should not be used, due to the increased conflict points.

5.4.2 Non-Through Junction Running

Non-Through Junction Running (Non-TJR) requires buses to exit at the junction. Buses wishing to re-join the mainline carriageway will re-join via the hard shoulder bus priority measures on the merge slip road, which will transition into the mainline hard shoulder bus priority lane.

5.4.3 Compact Grade Separated & Left-in, Left-out Junctions

In order to reduce conflict points and assist vehicles in navigating junctions, compact grade separated and left-in, left-out junctions should be upgraded to have full merge and diverge layouts as detailed in *Section 7.6*. Where space does not permit this, design organisations should carefully consider how the design will minimise the risk of vehicle conflict. Design organisations should review what measures can be implemented to improve the safety of the existing junction and its interaction with the scheme.

In line with the guidelines set out *in DN-GEO-03060,* the overriding principle is that direct vehicular access onto national roads should be avoided as far as practicable. Hard shoulder bus priority schemes should not contain direct accesses as per DN-GEO-03060. Where a hard shoulder bus priority measures scheme is being undertaken on a Type 1 Dual Carriageway all existing accesses should be closed. Where it is not possible to remove a direct access, a departure is required as set out in DN-GEO-03060.

5.4.4 Roundabouts and Signalised Junctions

Roundabouts and signalised junctions either as part of the mainline or at the end of a slip road have the potential to introduce journey time delay and conflict points.

As part of the scheme development existing junctions should be reviewed to ensure conflict points are removed. This can be achieved through one of the following options:

- Signalisation of junctions to provide prioritisation of buses through the junctions and to ensure there is no conflict movements between mainline traffic turning and the buses travelling through the junction
- Buses to merge back into the mainline in advance of the junction. Following the junction buses will merge back into the hard shoulder bus priority measures.

In order to optimise journey time reliability of buses, the first option should be selected where possible, so junctions and signals prioritise buses. This avoids the potential for journey time delay caused by buses being caught in congestion on the mainline. When selecting an option the design organisation should model the potential journey time impact between buses and normal traffic to optimise the system. Where it is anticipated that there will be frequent bus services the repeated stoppage of normal traffic may not be practical.

6. Scheme Development / Delivery Approach

This section provides advice for design organisations on best practice and considerations when developing a scheme.

6.1 Scheme Development and Options

Schemes should be developed in accordance with *PE-PMG-02041 – Project Management Guidelines*.

During scheme development, design organisations should consult with local and relevant stakeholders and organisations to ensure the scheme is designed to meet the current and future needs of all road used users, integrated into the wider network and meets the scheme objectives. Regular engagement with interested parties should be maintained throughout the scheme life cycle.

A range of options of varying levels of ITS provision should be considered and discussed with Network Operations. Factors that will influence the level of ITS provision required to provide the most appropriate outcome will include;

- Current operational arrangements and management structure,
- MOCC resource availability and capabilities,
- Methods of scheme enforcement,
- Existing ITS provision and potential future ITS expansion,
- Cost and anticipated benefits, and
- Environmental and land constraints.

6.2 Construction Phase Considerations in Design

Hard Shoulder bus priority schemes are likely to require works in the verge and hard shoulder to upgrade and add to existing infrastructure. The design may also require changes to road markings, restraint barrier, pavement and drainage in the central reserve due to changes in pavement levels or lane redistribution. There is also likely to be works to grade separated junctions to alter layouts.

Where schemes are upgrading existing roads the design and construction organisations should carefully consider the sequencing of works to minimise disruption to the flow of traffic. During the design process it is essential to consult with TII Network Operations to understand the likely future maintenance interventions and incorporate them into the works to avoid disruptive maintenance once the scheme opens.

It is likely that the implementation of hard shoulder bus priority schemes will be within the Motorway Maintenance and Renewals Contract (MMaRC) or PPP controlled sections of the network, and therefore associated procedures and protocols should be followed and incorporated into the development and planning of the scheme implementation.

6.3 Opening & Review

When developing a scheme, projects should follow the procedure set out in *TII Road Safety Audit GE-STY-01024.*

Following the scheme's opening, design organisations should monitor the performance and safety of schemes over time to assess its effectiveness. This should include a Stage 4 Road Safety Audit 2-4 months after opening as set out in *GE-STY-01024.*

It is recommended that the areas of compliance and operability form part of the review as they are likely to have a large influence on the safety of a scheme. To undertake this, TII Network Operations and motorway operators, recovery firms and An Garda Síochána should be consulted alongside a review of scheme data monitoring compliance with the use of the scheme as intended. Where non-compliance is identified as having an impact on the schemes operation and therefore safety, proposals should be developed on how compliance can be improved and included in the Stage 4 Road Safety Audit. This may be in the form of driver awareness campaigns, additional roadside infrastructure or a form of enforcement.

It is recommended that additional reviews are undertaken of the scheme effectiveness. These reviews should be made at 1, 3 and 5 years after opening to monitor the change in usage over a longer period of time.

7. Geometrical Requirements

This section sets out the geometric and design recommendations of hard shoulder bus priority measures.

7.1 Design Speed

Buses (which are neither designed nor adapted for the carriage of standing passengers) are limited to an operational speed of 100km/h on a motorway or dual carriageway in line with *S.I No. 546/2008*. As the primary vehicle type using hard shoulder bus priority measures there is consequently the opportunity to lower the design speed of lanes used by buses versus the mainline design speed. This reduced design speed recognises the reduced speed of the buses using the hard shoulder priority measures and in the cases of permanent facilities, the training which will be provided to drivers by the NTA.

7.1.1 Design Speed – Permanent Hard Shoulder Bus Priority Measure Schemes

The designer is recommended to use a 100km/h design speed for the design of the permanent hard shoulder bus priority lane only, where the design speed of the mainline running lanes exceeds 100km/h. Where the mainline design speed is 100km/h or less, the permanent hard shoulder bus priority lane design speed should be designed to the same design speed as the mainline.

Any further reduction in design speed may impact on the sightlines of bus drivers and the comfort to passengers. The permitted combinations of design speeds are set out below in *Table 1*.

Table 1 Permitted Design Speeds of Permanent bus facilities Lanes

Mainline Design Speed (km/h)	Bus Facility Design Speed (km/h)
120	100
100	100
85 or less	Match the design speed of the mainline

7.1.2 Design Speed – Periodic Hard Shoulder Bus Priority Measures

The designer is recommended to use an 85km/h design speed for the design of the hard shoulder bus priority measure only, where the design speed of the mainline running lanes exceeds 85km/h. Where the mainline design speed is 85km/h or less, the hard shoulder bus priority measure design speed should be designed to the same design speed as the mainline.

Any further reduction in design speed may impact on the sightlines of bus drivers and the comfort to passengers. The permitted combinations of design speeds are set out below in *Table 2*.

Table 2 Permitted Design Speeds of Part-time Hard Shoulder Bus Priority Lanes

Mainline Design Speed (km/h)	Bus Facility Design Speed (km/h)
120	85
100	85
85	85
70 or less	Match the design speed of the mainline

7.1.3 Operational Speed

Buses (which are neither designed nor adapted for the carriage of standing passengers) are limited to an operational speed of 100km/h in line with *S.I No. 546/2008.* It is therefore recommended that where the use of dynamic speed limits is proposed and agreed with TII Network Management and the MOCC, the upper posted operational speed limit matches that of the mainline posted speed limit. Where buses are designed or adapted for the carriage of standing passengers, the speed limit prescribed is 65 km/h. Where static speed limit signs are required and posted, consideration should be given to the use of an 80km/h (or less) speed limit on the bus priority measure. All special speed limits on national roads and motorways require the written consent of TII.

When congestion occurs on the mainline there is likely to be an increase potential for a large speed differential between the mainline and the vehicles in the hard shoulder bus priority measures. The use of ITS technology such as monitoring and lane control and dynamic speed limit measures (see Section 11) provides the opportunity to control the signed speed of both the hard shoulder bus priority measures and the mainline in response to traffic conditions. To limit journey time delay during congestion there is the opportunity to run the hard shoulder bus priority measures at a higher speed than the mainline signed speed.

7.2 Geometry and Visibility

The proposed horizontal and vertical alignment, geometry and visibility of the hard shoulder bus priority measures should align to the relevant design speeds, set out in *Section 7.1*. The sight distances for the scheme should be measured in accordance with the requirements of *DN-GEO-03031.* For a scheme that is modifying the existing cross section, the designer should reassess the geometry and visibility of the scheme and the impact of any additional signage, VRS and change of layout for the scheme. Where a scheme is utilising the existing hard shoulder, it is likely that the designer may incur more difficulty in achieving the visibility requirements and there may be a need to increase the verge width to accommodate this. Any reduction in geometry or visibility from the requirements of DN-GEO-03031 will be a departure. It is advised that relaxations as permitted in *Sections 2.4 and 2.6 (including Tables 2.1 and 2.2)* as set out in *DN-GEO-03031* should not be permitted.

7.3 Types of Operation

This interim guidance permits the use of the following types of operation. All other types of implementations should first be discussed with and approved by TII. All layouts recommended in this document make use of the nearside lane:

- Periodic Critical Flow Nearside Lane Implementation
- Periodic Peak Hours Nearside Lane Implementation
- Permanent conversion of the Nearside Lane

7.4 Cross-Sections on Open Roads

7.4.1 General

Table 3 gives detailed dimensions for cross-sectional elements. The information covers urban and rural Motorways and Type 1 Dual Carriageways. *Table 4* gives detailed dimensions for cross-sectional elements covering interchange links, loops and on and off slip roads. These cross-sections have been graphically represented in *Appendix A*. The designs as set out in the tables represent the minimum recommended dimensions and any reduction in widths should be discussed and approved by TII in advance of implementation.

When selecting between a rural or urban cross-section the designer should apply the following principles:

- 60kph or less design speed – Urban section
- 80, 100 and 120 kph design speeds – Rural section

Table 3 Dimensions of Cross-Section Elements for Urban and Rural Motorways and Dual Carriageways

	Nearside						
	Verge [3]	**Hard strip [4, 6]**	**Hard Shoulder Bus Priority Measure [1]**	**Edge Line [2]**	**Carriageway**	**Hard strip [4, 6]**	**Central Reserve [3]**
Rural							
Type 1 Dual Carriageway	2.00	0.50	3.50	0.50	3.50 (Lane 1) 3.50 (Lane 2)	1.00	2.60
Rural Motorway	2.00	0.50	3.50	0.50	3.50 (Lane 1) 3.50 (Lane 2)	1.00	2.60
Wide Dual Carriageway Motorway[7]	3.00	0.50	3.50	0.50	3.50 (Lane 1) 3.50 (Lane 2)	1.00	8.50
Urban							
Dual Carriageway Urban 3 lane[1]	Varies	-	3.35	0.30	3.65 (Lane 1, if retained)[1] 3.70 (Lane 2) 3.65 (Lane 3)	-	1.80
Dual Carriageway Urban 2 lane	Varies	-	3.35	0.30	3.65 (Lane 1) 3.65 (Lane 2)	-	1.80
Urban Motorway	Varies	-	3.35	0.30	3.50 (Lane 1) 3.50 (Lane 2)	-	1.80

Notes

1. *Where an existing carriageway has no hard shoulder the hard shoulder bus priority measures will be provided by adding an additional lane on the outside of the existing paved area to ensure the existing capacity is not reduced. The exception to this is for urban dual carriageway 3 lane sections where there is the option to repurpose the existing lane 1 for the measures where land may be constrained.*

	Nearside						
	Verge [3]	Hard strip [4, 6]	Hard Shoulder Bus Priority Measure [1]	Edge Line [2]	Carriageway	Hard strip [4, 6]	Central Reserve [3]

2. *To increase separation and provide a clear delineation between the lane types, an edge line should be provided between the hard shoulder bus priority measure and the permanent nearside running lane (see Section 7.4.5 below)*
3. *Verge and central reserve dimensions are minimum values*
4. *Where a hard strip is present, the corresponding verge or central reserve dimension includes the hard strip. However, where a hard shoulder is present, the corresponding verge dimension does not include the hard shoulder.*
5. *All dimensions are in metres.*
6. *Additional width for Wide Dual Carriageway Motorway cross-sections can be accommodated by reducing the central reserve width. Further reduction of the central reserve may be considered to provide an adjacent hard shoulder or provide space in the verge for ERA's by moving over lanes.*

Table 4 Dimensions of Recommended Cross-Section Elements on Merges and Diverges

SLIP ROADS, INTERCHANGE LINKS AND LOOPS: MERGES AND DIVERGES							
	Nearside					Offside	
	Verge	Hard strip	Hard Shoulder Bus Priority Measure	Edge Line	Carriageway	Hard strip	Verge
1 Lane	4.50	1.50	3.25	0.30	4.00	0.50	3.50
2 Lane	4.00	1.50	3.25	0.30	3.65 (Lane 1) 3.65 (Lane 2)	0.50	3.50
SLIP ROADS: DIVERGE ONLY							
2 lane	4.00	1.50	3.25	0.30	3.00 (Lane 1) 3.00 (Lane 2)	0.50	3.50

Notes

1. *All dimensions are in metres*
2. *To increase separation and provide a clear delineation between the lane types an edge line should be provided between the hard shoulder bus priority measure and the permanent nearside running lane (see Section 7.4.5 below)*
3. *The verge width should be increased as necessary to accommodate the mandatory pedestrian/ cyclist facilities in accordance with DN-GEO-03-036 as well as other usage and clearance requirements. The introduction of parallel NMU provision will help to discourage cyclists from using the hard shoulder bus priority measures where previously permitted too.*
4. *Verge dimensions are minimum values*
5. *Where a hard strip is present, the corresponding verge dimension includes the hard strip.*
6. *For guidance on the selection of the appropriate cross-section of slip roads and link roads please refer to table 7.4 of DN-GEO-03060 for the design of grade separated junctions which sets out the recommended cross-section based on the anticipated flows.*

7.4.2 Verges

Minimum recommended verge widths are given in *Table 3 and Table 4*. Further requirements for the design of verges are set out in *DN-GEO-03036 Cross-Sections and Headroom and DN-REQ-03034 Design of Road Restraints.*

Where the scheme involves an existing section of road with a verge wider than the minimum, the designer may consider reducing the width of verge to accommodate additional paved width to provide the required lane widths. Where doing this, the designer should maintain the minimum verge width as set out in this interim guidance.

The implementation of a hard shoulder bus priority measures will require additional signage and equipment to be added to the verge. To avoid a congested verge which can lead to driver confusion or maintenance issues, the designer should consider ways of minimising equipment and rationalising equipment location. For both new and upgrade schemes, verges should be designed to provide a forgiving environment for errant vehicles. This can be achieved through the provision of a clear zone to the side of the carriageway. Clear zones are obstacle free areas with generally flat or gently graded ground. This provides motorists room and opportunity to regain control of errant vehicles. Objects that cannot be eliminated should be relocated outside the clear zone where practicable. A clear zone should be designed in accordance with *DN-REQ-03034* and considered at an early stage when developing the road cross-section.

The designer should also consider the possibility that the verges need to be widened to achieve new sight stopping distance visibility splays due to the reallocation of lanes across the road cross-section.

7.4.3 Hard Strip

A hard strip provides a surfaced strip that abuts on the traffic lanes. Hard strips should be as detailed in *Table 3 and Table 4*.

7.4.4 Hard Shoulders

For many schemes the hard shoulder will be used as a periodic hard shoulder bus priority measure. For permanent schemes the hard shoulder will be permanently dedicated to the hard shoulder bus priority measure. Where the hard shoulder is temporarily or permanently taken out of use, the designer should consider how the safety of vehicles who stop in an emergency can be ensured. See requirements in *Section 10*.

7.4.5 Edge Line

The edge line width should be in accordance with the requirements of Chapter 7 of the Traffic Signs Manual. The edge line is required to provide separation and delineation between the different lane types created by hard shoulder bus priority measures.

7.4.6 Traffic Lane and Hard Shoulder Bus Priority Measure Widths

Traffic lane widths as detailed in *Table 3 and Table 4* are measured between the trafficked side of carriageway edge marking (or edge line where a hard shoulder bus priority measure is present) and the centre line of lane lines. The hard shoulder bus priority measure width is measured from the trafficked side of the carriageway edge marking to the to the nearside of the edge line.

Where more than two traffic lanes are required in either direction, the middle traffic lane(s) widths are measured between the centre line of the adjacent lane lines.

Traffic and hard shoulder bus priority measure should be widened on curves of low radius to allow for the swept path of long vehicles. See *DN-GEO-03031* for details of curve widening.

7.4.7 Central Reserves

Minimum central reserve widths are given in *Table 3*. Greater dimensions may be used as set out in *DN-GEO-03036 Cross-Sections and Headroom*.

7.4.8 Road Markings

The edge line (*see Section 7.4.5*) between the hard shoulder bus priority measure and existing traffic lanes shall be in the form of a continuous solid white line of width as set out in *Table 3 and Table 4* to discourage vehicles crossing over. The edge line should have a raised profile. Drainage gaps should be included for drainage in the continuous line to prevent surface water ponding and the presence of road markings should be considered in the design of scheme drainage.

The designer is advised to use additional road marking in the form of painted 'LÁNA BUS' markings part of RRM024 of *TSM chapter 7* on permanent sections of hard shoulder bus priority measures only. No other additional road markings are to be provided.

All other road marking should follow the existing design requirements as set out in the Chapter 7 of the *Traffic Signs Manual* and this Publication.

7.4.9 Paved Width

The width of the paved elements of the cross-section, i.e., carriageways, hard shoulder bus priority measures, hard shoulders and hard strips, should be in accordance with those advised by this interim guidance. Any reduction or increase in the width of these elements requires a departure, unless the increase results from the requirements for pavement widening on curves as detailed in *DN-GEO-03031*.

7.4.10 Changes of Carriageway Edge Treatment

Where slip roads, interchange links and loop roads join or leave main carriageways, the edge detail may change from hard shoulder to hard strip or carriageway edge.

Transitions between different edge details should take place over the length of the taper as set out in *DN-GEO-03036*.

7.4.11 Crossfall and Superelevation

In the case of upgrade schemes, the designer should assess the existing superelevation and crossfall to ensure that the hard shoulder bus priority measure matches the mainline superelevation and crossfall.

Appropriate levels of surface water run-off shall be achieved across all lanes including the hard shoulder bus priority measure. The designer should make modifications to the existing road to ensure consistency where required. The design should be in accordance with Chapter 11 of *DN-GEO-03031 Rural Road Link Design*.

7.4.12 Emergency Crossing Points

DN-GEO-03031 provides requirements on the design of Emergency Crossing Points.

7.4.13 Vehicle Restraint System

Where an existing hard shoulder is being repurposed or lane width being redistributed the new cross-sectional arrangement may result in the nearside running lane becoming closer to the existing restraint system. This may affect the design of the system and may also require the VRS to be relocated to achieve required sight stopping distances.

The designer should undertake a review as to whether the existing barrier provision is appropriate based on the new cross-section. The protection and setback of any verge or median assets should be achieved by complying with *DN-REQ-03034 and DN-GEO-03036.*

7.4.14 Provision of Lay-bys

The design of a scheme involving Bus Lane or hard shoulder bus priority measures must provide for the removal of any existing laybys on the sections of dual carriageway in question. When removing laybys, they should be returned to verge or blocked off with appropriate restraint systems. When considering the closure of laybys, the designer is advised to check if there is a requirement for using the layby for maintenance. In cases where laybys are required for maintenance, the layby should be converted using the layout in *figure 3/5 of DN-GEO-03046*.

7.5 Cross-Sections and Headroom at Structures

The requirements for cross-sections and headroom at structures are set out in *DN-GEO-03036*.

To accommodate hard shoulder bus priority measures, there will in most cases be a requirement to widen the existing carriageway cross-section to maintain suitable mainline widths and an appropriate width for the hard shoulder bus priority measures. The designer should consider the impact of lane redistribution on the position of the edge of traffic lane relative to the structure. Any reduction in cross-section may require a departure as set out in *DN-GEO-03036*. The designer should consider mitigating factors on a structure specific basis.

Where widening or modification of camber of the carriageway is needed beneath an existing structure, the headroom for the existing structure should be checked for compliance with *DN-GEO-03036*. Where pavement levels are to be reduced in the vicinity of a structure, the designer should assess if the pavement reduction or reconstruction works will impact the structure's foundations.

The containment level of the existing structure and parapet should also be reviewed where carriageway redistribution has changed the proximity of the traffic to the structure. Where identified, modification and upgrade should be made to existing structures to meet the recommendations of this interim guidance.

Where a traffic lane is modified the designer should re-assess the impact on visibility through structures as set out in *DN-GEO-03031 and DN-GEO-03036*.

7.6 Junction Layout

The following section provides details of the layouts for junction merges and diverges for both periodic and permanent schemes, including Through Junction Running (TJR) and Non-Through Junction Running (Non-TJR) configurations.

Where an existing compact grade separated junction, left-in junction or left-out junction is present these should be upgraded to an appropriate merge/ diverge layout as set out in *DN-GEO-03060*. Where space does not permit, the designer should take steps to provide a layout which minimises conflict points.

Where a scheme is upgrading an existing road, where practicable direct accesses should be relocated to connect to an existing regional or local road. Where they can't be removed, design organisations should review what measures can be implemented to improve the safety of the existing junction and its interaction with the measures being implemented.

For merges, there are 5 options:

- **Non-TJR** – Hard shoulder bus priority measures are added to the nearside of the slip-road and to the nearside of mainline downstream of the junction (can be applied to Type A, B, C, D and E merges)
- **TJR Type A (Parallel Merge) with bus gates** – buses cross slip-road traffic upstream of back of merge nose under the control of bus gates
- **TJR Type A (Parallel Merge) without bus gates** – buses cross slip-road traffic downstream of tip of merge nose
- **TJR Type B (Lane Gain) with bus gates** - buses cross slip-road traffic upstream of back of merge nose under the control of bus gates
- **TJR Type B (Lane Gain) without bus gates** – buses cross slip-road traffic downstream of tip of merge nose

For diverges, there are 2 options:

- **Non-TJR** – Hard shoulder bus priority measures are added to the nearside of mainline upstream of the slip-road and to the nearside of the slip-road approaching the junction (can be applied to Type A, B, C and D diverges)
- **TJR Type A or B (Single Lane Parallel Diverge) –** buses cross the slip road upstream of the back of the diverge

7.6.1 Non-Through Junction Running Merge layout

To minimise vehicle conflict users of the hard shoulder bus priority measures will enter the measures on the merge slip road in advance of the merge. The typical layout is shown in *Figure 1* and can be applied to Type A, B, C, D and E merges as set out in *DN-GEO-03060*. Buses travelling along the mainline should exit at the previous diverge and join via the merge slip road, instead of moving into Lane 1 and passing through the junction on the mainline.

Where an existing junction merge is part of a junction where there is not a proceeding diverge, the designer may make provision for vehicles to enter the hard shoulder bus priority measures after the end of the merge taper by use of broken Bus Lane line (*TSM Chapter 7 M 129*). The broken line should be of length equivalent to the merge taper length as set out in 7.1 of *DN-GEO-03060* for the selected layout.

The designer should adopt one of two options for enabling access to the hard shoulder bus priority measures:

i. The measures commence as a lane gain at the commencement of the slip road and then continues down the nearside of the slip road to join the mainline. The measures and lack of hard shoulder will be indicated to drivers at the junction.

ii. A broken Bus Lane line (*TSM Chapter 7 M 129*) shall be provided over the length of the slip road up to, but not extending past a point perpendicular to the start of the nose to allow vehicles to enter the measures. A sign at the start of the slip road and at the start of the nose will indicate to users the start of the hard shoulder bus priority measures. The recommended sign faces are shown in *Figure 2.*

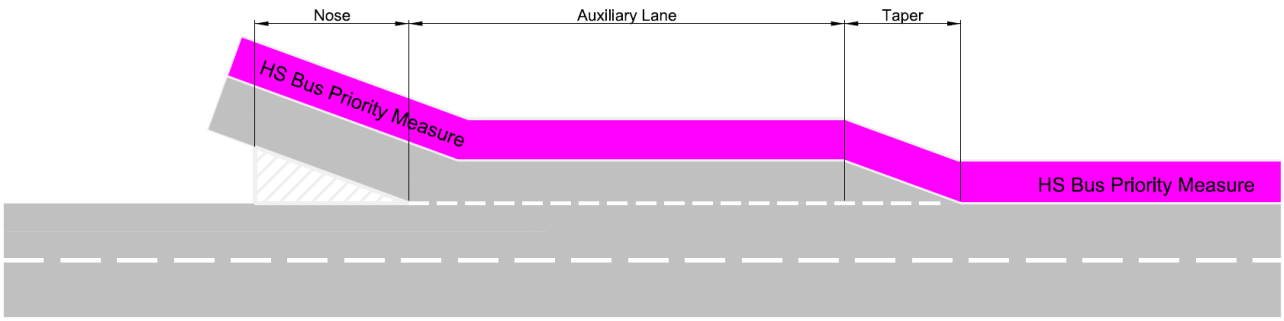
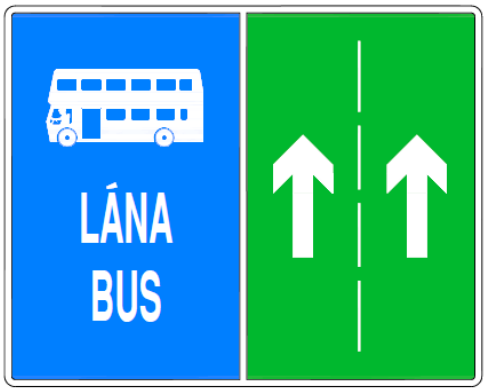
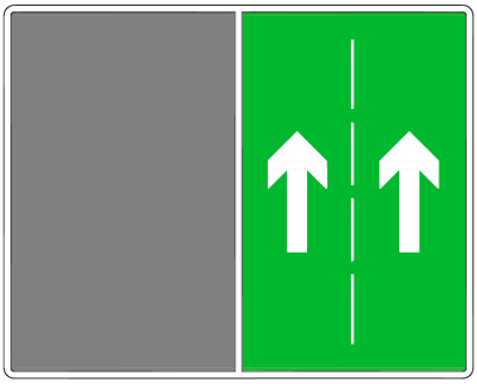


Figure 1 Non-Through Junction Running Merge layout



Hard Shoulder Bus Priority Measures in Operation



Hard Shoulder Bus Priority Measures Closed

Notes:

1. *Dimensions: 537.5 (645) mm High, 675 (810) mm Width, the larger bracketed size may be used if greater prominence of the sign is necessary.*
2. *The signs are to be amended as required by the designer to represent the layout of an individual scheme*
3. *For permanent schemes the appropriate above signs should be accompanied by a 24-hour operation sign below as per P055 in the Chapter 5 of the TSM*
4. *For peak period temporary schemes, where a fixed sign is being used the appropriate above signs should be accompanied by a period of operation sign as per P051 in the Chapter 5 of the TSM. For temporary hard shoulder bus priority schemes that are using rotary or variable message signs to display the above signs, the period of operation is not required.*

Figure 2 Bus Facility Sign Faces

7.6.2 Through Junction Running Type A (Parallel Merge) with Bus Gates

This merge layout is applicable for configurations using Through Junction Running and have a merge layout Type A as set out in *DN-GEO-03060*. Type C, D and E are not compatible with Through Junction Running due to ghost islands or multiple lanes increasing potential conflict points.

The layout is shown in *Figure 3.* Buses travelling in the hard shoulder bus priority measures through the junction will cross the slip road merging from the back of the merge nose into the measures.

Bus gates shall be provided where this merge layout is implemented (*see Section* ***Error! Reference source not found.***). Bus gates are in the form of loop triggered signals placed in advance of the merge to detect vehicles using the hard shoulder bus priority measures.

The dimensions of the merge nose will be as per Type A layout Table 7.1 of *DN-GEO-03060*. The hard shoulder bus priority measure should diverge away from the existing carriageway over values of length and taper equivalent to the merge nose dimensions as per the mainline values in table 7.1 of *DN-GEO-03060*.

Signage and road markings should be in accordance with TSM. The design of bus gate signals and markings should be in accordance with *Chapter 7 and 9 of the TSM* and use a stop line in advance of the signals (RRM 017). Both the slip road and hard shoulder bus priority measures on the slip road will be controlled by the bus gate signals.

To ensure congestion on the merge does not inhibit the bus facility Yellow Box Markings RRM 020 of *Chapter 7 of the TSM* should be provided.

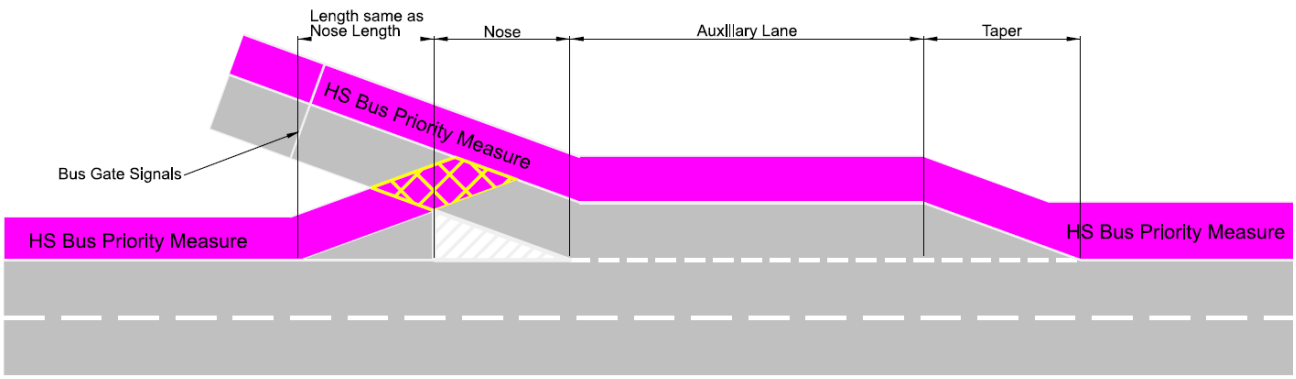


Figure 3 Through Junction Running Type A (Parallel Merge) with Bus Gates

7.6.3 Through Junction Running Type A (Parallel Merge) without Bus Gates

This merge layout is applicable for configurations using Through Junction Running and have a merge layout Type A as set out in *DN-GEO-03060*. Type C, D and E are not compatible with Through Junction Running due to ghost islands or multiple lanes increasing potential conflict points.

Where schemes are using Through Junction Running, the designer should use the Through Junction Running Type A (parallel merge) with bus gates as set out in *Section 7.6.2* unless it can be demonstrated that through modelling, congestion on the mainline will not cause queuing on the slip road which would inhibit the journey time of vehicles in the hard shoulder bus priority measures.

Bus gates provide additional prioritisation of buses, reduced land take and reduced risk of vehicle conflict.

The layout is shown in *Figure 4*. The hard shoulder bus priority measures through the junction temporarily ends at the start of the merge.

Vehicles using the measures continue in the same lane. Following the end of the junction merge, the measures recommence with permitted vehicles proceeding into the hard shoulder bus priority measures.

Merging traffic will come down the slip road and merge into the lane formed by the temporary suspension of the hard shoulder bus priority measures. Before the measures recomence at the end of the junction merge, merging traffic not permitted to use the hard shoulder bus priority measures must move over into Lane 1.

The dimensions of the merge nose, Auxiliary Lane length and Auxiliary taper length will be as per Type A layout Table 7.1 of *DN-GEO-03060*. The secondary Auxiliary Lane length and taper will have the same lengths as the initial Auxiliary Lane.

In advance of the merge nose, a sign will be provided in the verge warning hard shoulder bus priority users of the temporary end of the measures. The hard shoulder bus priority measures end sign should be of type RUS 028 of *TSM Chapter 5* with no cycle symbol as permitted by Clause 5.19.10 of the *TSM*. The sign should be accompanied by a supplementry plate displaying “Crioch/ End” of type P 010 of the *TSM Chapter 5*. To indicate the end of the hard shoulder bus priority measures the Edge line will be replaced by dashed merge line of type RRM 028. At the end of the first taper, a sign in the verge will be provided warning drivers of the need to merge and that the upcoming lane is for hard shoulder bus priority measure users only as shown in *Figure 2.*

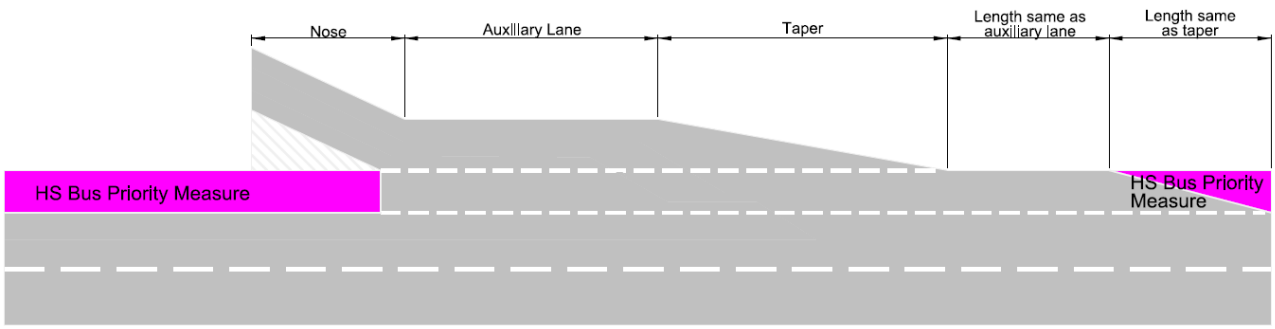


Figure 4 Through Junction Running Type A (Parallel Merge) without Bus Gates

7.6.4 Through Junction Running Type B (Lane Gain) with Bus Gates

This merge layout is applicable for configurations using Through Junction Running and have a merge layout Type B as set out in *DN-GEO-03060.* Type C, D and E are not compatible with Through Junction Running due to ghost islands or multiple lanes increasing potential conflict points.

The layout is shown in Figure 5. Vehicles using the hard shoulder bus priority measures through the junction will cross the slip road merging from the back of the merge nose into the measures.

Bus gates shall be provided where this merge layout is implemented (*see Section* ***Error! Reference source not found.***). Bus gates are in the form of loop triggered signals placed in advance of the merge to detect vehicles using the hard shoulder bus priority measures.

The dimensions of the merge nose will be as per Type B layout Table 7.1 of *DN-GEO-03060*. The hard shoulder bus priority measures should diverge away from the existing carriageway over values of length and taper equivalent to the merge nose dimensions as per the mainline values in table 7.1 of *DN-GEO-03060*.

Signage and road markings should be in accordance with TSM. The design of bus gate signals and markings should be in accordance with *Chapter 7 and 9 of the TSM* and use a stop line in advance of the signals (RRM 017). Both the slip road and hard shoulder bus priority measures on the slip road will be controlled by the bus gate signals.

To ensure congestion on the merge does not inhibit the hard shoulder bus priority measures yellow box markings RRM 020 of *Chapter 7 of the TSM* should be provided.

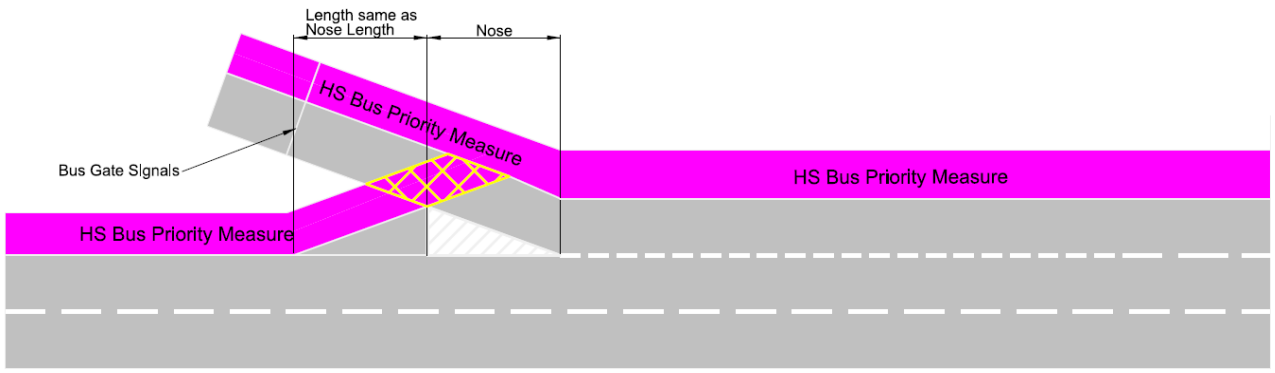


Figure 5 Through Junction Running Type B (Lane Gain) with Bus Gates

7.6.5 Through Junction Running Type B (Lane Gain) without Bus Gates

This merge layout is applicable for configurations using Through Junction Running and have a merge layout Type B as set out in *DN-GEO-03060*. Type C, D and E are not compatible with Through Junction Running due to ghost islands or multiple lanes increasing potential conflict points.

Where schemes are using Through Junction Running Merges the designer should use the Through Junction Running Type A (parallel merge) with bus gates as set out in *Section 7.6.4* unless the designer can demonstrate through modelling, that congestion on the mainline will not cause queuing on the slip road which would inhibit the journey time of vehicles in the hard shoulder bus priority measures.

Bus gates provides additional prioritisation of buses over a parrallel merge, reduced land take and reduced risk of vehicle conflict.

The layout is shown in *Figure 6*. The hard shoulder bus priority measures through the junction temporarily end at the start of the merge. Vehicles using the measures continue into the lane gain. Over the length of the parallel merge buses wanting to use the hard shoulder bus priority measures must move over into the measures. Normal traffic merging from the slip road must move over into Lane 1 over the length of the parallel merge.

To avoid additional conflict points where this layout is used hard shoulder bus priority measures will not be provided on the merge slip road.

The dimensions of the merge nose, Auxiliary Lane length and Auxiliary taper length will be as per Type A layout Table 7.1 of *DN-GEO-03060*.

In advance of the merge nose, a sign will be provided in the verge warning hard shoulder bus priority measure users of the temporary end of the measures. The Bus Lane end sign of type RUS 028 of *TSM Chapter 5* with no cycle symbol as permitted by Clause 5.19.10 of the *TSM* should be provided. The sign should be accompanied by a supplementry plate displaying “Crioch/ End” of type P 010 of the *TSM Chapter 5*.

To indicate the end of the hard shoulder bus priority measures the edge line will be replaced by dashed merge line of type RRM 028. At the end of the first taper a sign in the verge will be provided warning drivers of the need to merge and that the upcoming lane is for hard shoulder bus priority measure users only. The sign type to be used is shown in *Figure 2*.

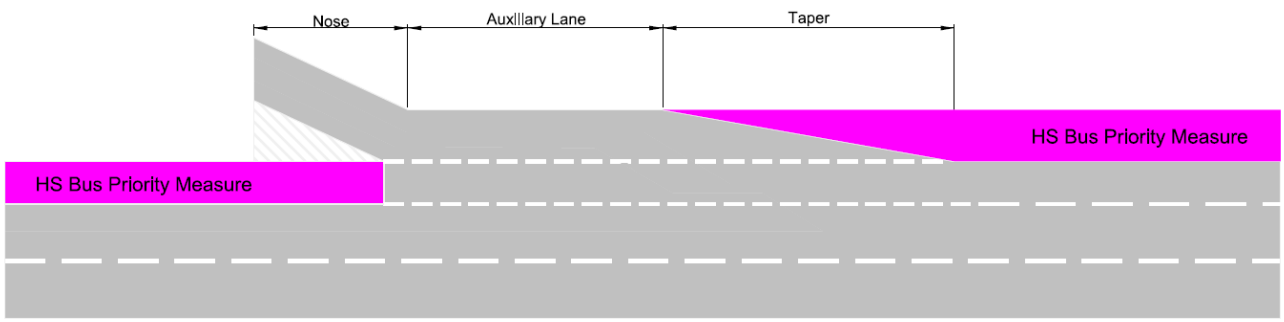


Figure 6 Through Junction Running Type B (Lane Gain) without Bus Gates

7.6.6 Non-Through Junction Running Diverge layout

To avoid the risk of conflict from buses re-emerging from the hard shoulder bus priority measures into lane 1 at the diverge and the increased risk due to speed differential the standard diverge layout hard shoulder bus priority measures require buses to leave at each diverge where Through Junction Running is not in operation. Having left at the diverge buses can re-join the mainline using the merge slip road. To minimise the journey time delay associated with this, the designer may consider ways to prioritise buses getting from the diverge back onto the merge and re-joining the mainline. The typical layout is shown in *Figure 7* and can be applied to Type A, B, C and D diverges as set out in *DN-GEO-03060* .

Vehicles are not permitted to leave the hard shoulder bus priority measures and enter the mainline ahead of the diverge. Where a junction diverge is not accompanied by a subsequent merge, the designer may make provision for vehicles to exit the measures before the start of the diverge taper by use of a dashed line (broken Bus Lane line M 129) of length equivalent to the merge taper length as set out in 7.2 of *DN-GEO-03060* for the selected layout.

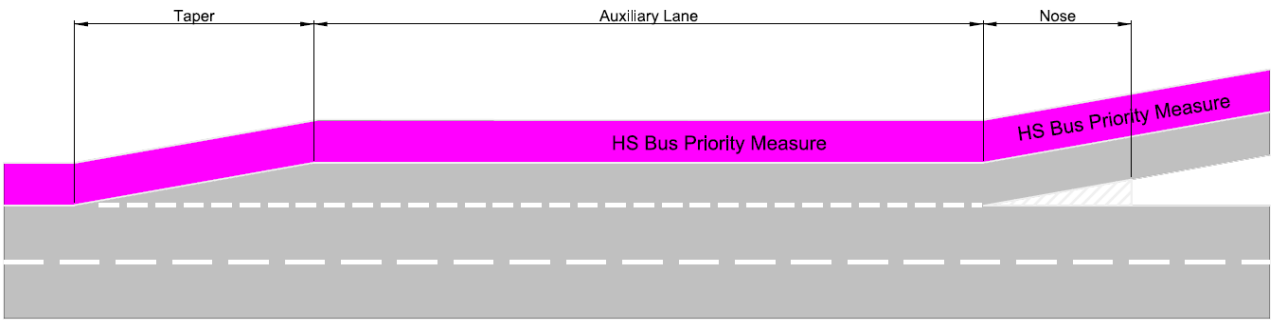


Figure 7 Non-Through Junction Running Diverge layout

The designer should adopt one of two options for enabling vehicles to exit the hard shoulder bus priority measures once diverged from the mainline and on the slip road:

i. The hard shoulder bus priority measures on the slip road cease by way of a lane drop at a subsequent junction at the end of the slip road

ii. A broken Bus Lane line M 129 shall be provided over the length of the slip road commencing from a point perpendicular to the end of the nose to allow vehicles to exit the hard shoulder bus priority measures. A sign shall be placed at the end of the measures to indicate the end. The Bus Lane end sign of type RUS 028 of *TSM Chapter 5* with no cycle symbol as permitted by Clause 5.19.10 of the *TSM* should be provided. The sign should be accompanied by a supplementry plate displaying “Crioch/ End” of type P 010 of the *TSM Chapter 5*.

7.6.7 Through Junction Running Type A or B (Single Lane Parallel Diverge)

This diverge layout is applicable for configurations using Through Junction Running and have a diverge layout of Type A or B as set out in *DN-GEO-03060*. Type C and D are not compatible with Through Junction Running due to multiple lanes increasing potential conflict points.

The layout is shown in *Figure 8*. Buses intending to travel in the hard shoulder bus priority measures through the junction will exit the measures onto the slip road. At the back of the nose they will merge back into the hard shoulder bus priority measures where the measures continue.

At the commencement of the diverge taper, the designer should provide a broken Bus Lane line M129 at 45 degrees to the running lane to indicate the end of the hard shoulder bus priority measures and the start of the diverge auxiliary lane opening to all exiting traffic.

A sign should be provided warning users of the end of the measures. The Bus Lane end sign of type RUS 028 of *TSM Chapter 5* with no cycle symbol as permitted by Clause 5.19.10 of the *TSM* should be provided. The sign should be accompanied by a supplementry plate displaying “Crioch/ End” of type P 010 of the *TSM Chapter 5*.

Following the auxiliary lane, a tapered ghost island should commence with length “Xm” where “X” is equivalent to the diverge nose length as set out in table 7.2 of *DN-GEO-03060*. The ghost island will reach a width of 0.5m over the length.

Entry to the hard shoulder bus priority measures should be provided at the end of the additional ghost island with a continuation of the solid white line extending down in line with the nose across the measures to the ghost island. All other dimensions as per Type A or B layout Table 7.2.

The designer should review the length of the diverge slip road to ensure that during times of congestion, the traffic does not impact the free-flow nature of the hard shoulder bus priority measures, which would detract from the benefit of Through Junction Running.

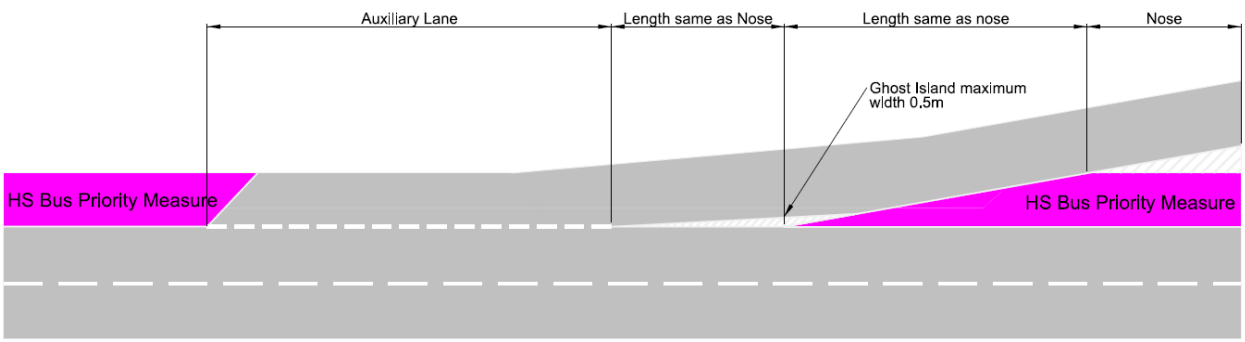


Figure 8 Through Junction Running Type A or B (Single Lane Parallel Diverge)

7.7 Bus Gates

Bus gates for Through Junction Running removes conflict at the merge by providing prioritisation to users of the hard shoulder bus priority measures. Bus gates are in the form of loop triggered signals placed in advance of the merge to detect vehicles using the hard shoulder bus priority measures.

The stop line should be positioned to allow a balance between sufficient acceleration distance to enable safe merging and sufficient storage for queuing vehicles. Vehicles approaching the stop line should have sufficient forward visibility of the signal heads. Vehicles at the stop line should have forward visibility of the hard shoulder bus priority measures, carriageway ahead and carriageway adjacent. A stationary vehicle behind the stop line needs to accelerate to reach a suitable speed and merge safely with traffic travelling in lane 1 of the main carriageway. The typical distance from the back of nose to the bus gate stop line is 40m +/- 20m.

The bus gate signals should be provided in accordance with *TSM Chapter 9 – Traffic Signals*.

Passively safe traffic signal poles should be positioned 2m downstream of the stop line, one in the offside verge and one in the nearside verge. The distance from each edge of pavement for passively safe signal poles shall be 2m +1m / - 0.8m.

In order to detect vehicles using the hard shoulder bus priority measures and therefore trigger the bus gate, a downstream detector site should be located in advance of the merge at a point after the diverge nose.

The use of signs and road marking should be in accordance with the *TSM*. Signs and road markings shall be located in accordance with *TSM Chapter 5 and 7*.

8. Other Requirements

In addition to the recommendations set out in *Section 7,* the following elements should be considered.

8.1 Driving Training & Awareness

Design organisations may be required to provide scheme data to support the National Transport Authority (NTA) in the development of relevant driver training courses for hard shoulder bus priority measure schemes. Training will ensure users under the authority of the NTA are familiar with the road layouts, types of operation, safety implications and rules.

Design organisations should also provide scheme data to support TII in developing content for the roll out of a public awareness campaign on the safe use of hard shoulder bus priority measures during the inception of the scheme if required.

8.2 Drainage

Drainage systems for schemes should be designed in accordance with *DN-DNG-03022*.

The provision of hard shoulder bus priority measures on existing roads may require significant widening of the existing carriageway and full replacement of the drainage system. Where a scheme is upgrading an existing road with no or minimal widening, the designer should take particular care in assessing the impact of converting any existing hard shoulder to a running lane. This will include ensuring sufficient drainage run off rates are provided to avoid aquaplaning in accordance with Section 11 of *DN-GEO-03031*. Where French drains are used the designer should consider the additional risk of stone scatter, with vehicles running in closer proximity to the edge of pavement when using the hard shoulder bus priority measures. Based on an assessment of risk it may be appropriate to retrofit concrete channel drainage. Where a new road is being constructed the use of French drains is discouraged where they run adjacent to the edge of the pavement.

The designer should also consider the impact of any modification to pavement camber on any drainage systems, and this does not create a future maintenance liability or safety issues for road users.

8.3 Pavement

The pavement should be designed in accordance with the principles set out in TII Publications.

Where an upgrade scheme is being undertaken for the provision of hard shoulder bus priority measures, the designer should undertake an assessment of the existing pavement condition and residual life. The designer should check that the existing hard shoulder is designed to carry the additional loading from buses.

9. Bus Stop Requirements

When locating and designing bus stops the designer should consider several different factors. Factors will differ for each type of bus stop location. Common to all bus stops is that the designer should take cognisance of the safety and security of passengers waiting and alighting buses as well as the connectivity to existing infrastructure. For this reason, bus stops are not permitted on Motorways. The designer should also consult with the NTA on their strategy for locating bus stops and park and ride facilities.

The location of bus stops has a big influence on the end-to-end journey and therefore the desirability of the service. This will impact on the effectiveness of modal shift to buses. The following types of bus stop locations may be considered:

- Offline bus stop on a local or regional road
- Dedicated park and ride facility

The provision of new online bus stops on type 1 dual carriageways (which have a speed limit of 80km/hr or greater) are not permitted. Any such proposal shall require a departure from standards involving direct consultation with TII. The Design Report should be submitted to TII as set out in DN-GEO-03030.

9.1 Offline Bus Stop

The following considerations should be made when considering an offline bus stop on a local or regional road:

- Offline bus stops may provide a safer environment for pedestrians to alight from buses with generally lower speeds than on a slip road
- There is the opportunity to utilise existing facilities reducing the cost of infrastructure investment
- Offline stops are more suited to local stopping services than long distance travelling where offline stops will lead to an increase in journey time. Offline stops, however, may reduce the connection time for people by delivering them closer to their origin or destination.
- Buses may not benefit from prioritisation when away from the hard shoulder bus priority measures on Motorways or Type 1 Dual Carriageway and therefore, are subject to impact on journey time reliability due to congestion
- Real time arrival information may provide an enhanced user confidence and experience
- The service pricing should be deemed good value when compared against other modes of transport

The design of bus stops on local or regional roads should be done in consultation with the NTA and local authority. The layout should be in accordance with the requirements of the *TSM*. The designer should ensure that new bus stops connect safely to existing infrastructure with segregation for pedestrians from vehicles.

9.2 Park and Ride Facility

The following considerations should be made when considering a dedicated park and ride facility:

- Park and Ride facilities enable users to access the bus network more easily by different modes, by allowing them to commute to a central location along the transport corridor
- These facilities are best placed outside the ring of congestion in cities and urbanised areas to avoid adding additional traffic in these areas
- When choosing a location, the facility's potential catchments for users of all modes of transport should be considered to optimise the end-to-end journey time of users. Locating the facility as close to the SRN as possible will also reduce the time for buses to complete stops helping to reduce connection times.
- Clear signage is important to and from the park and ride for vehicles and then within the park and ride for passengers to easily navigate to the bus stop
- It is important that security is provided, including lighting, to ensure passengers feel safe using the facility and comfortable in leaving their vehicle parked
- Provide well-lit bus shelters with seating
- Real time arrival information may provide an enhanced user confidence and experience
- The service pricing should be deemed good value when compared against other modes of transport
- The facility should be large enough to handle anticipated vehicle demand
- NMUs should be considered in the design and location of facilities. This should include secure bike storage and ensure NMU routes feel safe and desirable to use. In addition, the site should be connected to other local bus or rail services.

9.3 Other Considerations

The designer is advised to consider appropriate security measures to ensure the safety of passengers and their possessions at any of the bus stop types. Such measures may include but are not limited to the following:

- CCTV at stops and on connecting links to provide reassurance
- Security measures to protect users' alternative modes of transport when using the service
- Provision of emergency phones
- Lighting at stops and on connecting links

The designer should look to minimise the distance travelled between the bus stop and a passenger's onwards mode of transport or destination.

Designers should include measures to make facilities accessible to all. Measures may include but are not limited to including ramps, tactile paving, clear signage, audio announcements and laying out the facility to enhance the experience for those with additional needs.

10. Emergency Refuge Areas

10.1 General

Where hard shoulder bus priority measures are introduced the hard shoulder's primary purpose will still be for stranded vehicles.

An Emergency Refuge Area (ERA) provides safe refuge for vehicles in emergencies. ERA's should be provided on hard shoulder bus priority measure schemes where the distance between junctions exceeds 1.5km.

The following process should be followed for setting out ERA's:

- Starting from the merge, the distance a vehicle has to travel to the next ERA should not exceed 0.5km.
- ERA's should be continued to be placed at maximum 0.5km intervals until the Secondary Advance Direction sign of the next junction. ERA's should not be placed after the Secondary Advance Direction sign (typically 500m) for the junction, to avoid road users confusing the ERA diverge with the junction diverge

Between grade separated junctions the distance should be measured from the end of the merge nose tip to the start of the diverge nose tip. Where the next junction is a priority junction the distance should be measured from the stop line of the junction. The spacing to ERA's should be measured from the centre point of the ERA which represents the place of safety within the ERA.

The following should also be considered when sighting ERA's. The below may result in spacing of ERA's with a frequency greater than 0.5km's:

- It is preferable for ERA's to be sighted where the longitudinal gradient does not exceed 2% to avoid vehicles rolling forward or backwards
- Where practical ERA's should be sighted on the outside of curves to assist in achieving good visibility
- Where there is a steep gradient following the ERA exit taper it may be preferable to extend the exit taper length of the ERA to assist vehicles with accelerating before existing the ERA
- It is preferable to locate ERA's opposite each other to avoid stagger and the risk of road users crossing the carriageway to reach a place of safety or ERA

To reduce misuse and to ensure awareness of the safe use of ERAs, design organisations should support TII in developing a public engagement strategy on the use of ERAs.

10.2 Layout and Visibility Requirements

The layout of ERAs should be in accordance with the layout of parking bays as detailed in Figure 8.4 of *DN-GEO-03031 – Road Link Design.*

The Stopping Sight Distances (SSD) for road users entering and exiting an ERA should be the desirable minimum for the design speed of the hard shoulder bus priority measure.

The exit SSD should be measured from the mid-point of the 20m wide section, a perpendicular distance of 1.75m from the back of the ERA to an object height of 1.05m.

The entry SSD should be measured from the centre of the hard shoulder bus priority measure to the midpoint of the 20m wide section of an ERA, a perpendicular distance of 1.75m from the back of the ERA, to an object height of 1.05m.

10.3 Signage and Road Markings

ERA's should be made visible with the application of orange coloured surfacing.

At the entry to the ERA and then at the back middle of the ERA a sign showing the emergency layby and an Emergency Roadside Telephone symbol should be used to indicate a layby for emergency use only. *TSM Chapter 4, F 805* should be used as the basis for this sign, but without the fire extinguisher symbol, unless provided. Sign dimensions should be as per the guidance in clause 4.9.9.

The following road markings shall be used within the ERA:

- Single yellow line (RRM 007) should be provided at the nearside edge of the ERA to indicate that parking is for emergencies only
- The solid nearside edge line of the hard shoulder bus priority measure should continue over the length of the ERA

10.4 Emergency Roadside Telephone (ERT)

An Emergency Roadside Telephone (ERT) should be provided adjacent to the middle of the stopping bay of an ERA to enable users to communicate with MOCC operators in the event of an emergency, breakdown or for assistance. Design organisations should consider safe access to the ERT including provision of ramps, clearances and guardrails.

CCTV cameras should be located so that they provide full coverage of the ERA. This allows Control Centre Operators to detect stationary vehicles and the opportunity to provide warning to other road users where ITS systems are in use. The design organisation should consult with TII Operations on the type and location of CCTV and how this will interface with current CCTV systems in MOCC.

The location and mounting of CCTV cameras should take coverage, environmental conditions and image stability. CCTV cameras should be co-located with other roadside technology equipment, for efficient construction and ongoing maintenance, including calibration.

11. Bus Priority Measure Operations, Intelligent Transport Systems & Signage

The use of ITS systems in the monitoring and controlling of bus priority measures can play an important role in the management of a successful scheme. The following deployments of ITS technologies should be considered:

- For critical flow implementation, flow detection via loops to determine traffic volumes and therefore opening times
- Stopped vehicle detection either through CCTV or other remote systems provide the opportunity to provide advance warning to hard shoulder bus priority measure users of stranded vehicles and communicate the hazards via variable message signs
- Use of variable message signs to enable the implementation of periodic schemes, indicating changes of hard shoulder lane use
- CCTV to provide additional assistance to MOCC operators to monitor the schemes operation
- Detection loops to allow for the implementation of bus gates
- The use of real time bus information collected from ITS systems is proven to increase confidence of passengers and reduce frustration driven by delays. These systems may be provided at bus stops and made available online or via an app.
- Use of variable speed limits can improve the flow of traffic lanes and reduce the speed differential where required between normal lanes and the hard shoulder bus priority measures
- Advance Motorway Indicators provide visual reinforcement of lane usage and variable speeds

The level of ITS deployment will be dependent upon the operational design for scheme. The following sections provide an overview of the ITS equipment that can be implemented to improve the operation and safety of hard shoulder bus priority schemes.

11.1 Designing for Maintenance

Design organisations should carefully consider the sighting of additional signs and equipment to avoid obstruction and where possible co-locate equipment to avoid verge clutter. A maintenance strategy should be developed, including how equipment will be accessed for maintenance. Consolidating equipment can help to reduce the number of maintenance access points.

ERA’s can provide a safe location for maintenance operatives to park and locating equipment that requires regular access within close proximity to ERA’s is therefore advised. Where an ERA is being used for maintenance, it is recommended the hard shoulder bus priority measures are temporarily closed to provide a buffer between the nearest live lane and workers.

New ITS infrastructure should be reviewed to ensure that it is future proofed for potential developments in technology or additional equipment. This may include providing accessible verge ducting and flexible mounting points for equipment.

Roadside technology should have the functionality to enable software to be upgraded, faults to be diagnosed and equipment reset, remotely, where possible to reduce exposure to road workers, and traffic management costs, through reducing visits to the roadside.

Where existing technology is being reused as part of the system, compatibility with the new systems should be checked and upgraded or replaced if required.

11.2 Scheme Monitoring

ITS equipment and the overall operation of the scheme should be overseen from the MOCC. Depending on the operating regime control centre operators will have the ability to control lane opening, set variable speeds and react to incidents. To facilitate this the design organisation should consider how the scheme will be connected to the MOCC and the need for additional verge side ducting to connect systems along the scheme. Designers should refer to the TII Guidance Note ***Operational Control Provisions and Deployment of Supporting ITS Infrastructure for Motorway and Type 1 Dual Carriageway Bus Priority Measures*.**

To assist the work of control centre operators, in addition to CCTV coverage of ERA's, full coverage of the network should be provided. The Cameras should be positioned to ensure they are unobstructed by other network equipment. Cameras allow operators to detect broken down vehicles and for periodic systems, undertake a check that the hard shoulder bus priority measures are clear before opening. The location and mounting of CCTV cameras should take coverage, environmental conditions, image stability and whole life costs into account. CCTV cameras should be co-located with other roadside technology equipment, for efficient construction and ongoing maintenance, including calibration.

In addition to CCTV, Automatic Incident Detection (AID) systems or Stop Vehicle Detection radar can be used to identify stranded vehicles. This can improve response times to incidents. As technology evolves, the use of non-loopbased detection technologies is desirable on the main line as maintenance of loops can require increased impact on live lanes and increase the complexity of resurfacing operations.

Information collected from monitoring systems can be used as part of a review of the systems operation, user compliance and safety.

11.3 Real-time Information

Schemes should consider the use of technology to provide journey time passenger information and live bus operation updates. Service information has been shown to increase user confidence in services. Information can be delivered to users at bus stop displays or via an app. Consultation with the NTA should be had at an early stage on the opportunity to use such systems to improve the user experience.

11.4 General Signage requirements

The designer should review signage and markings where an existing road is being upgraded in accordance with the advice in this interim guidance. Existing signage and markings should be updated in line with the guidance of this document.

It is important that road users are made aware they are entering a managed scheme. This should be communicated via fixed signs. Information on whether the system is in operation can be communicated via fixed signs or variable message signs depending on the type of operation and ITS system being used.

Hard shoulder bus priority measure signs indicating whether a measure can be used as shown in *Figure 2 and* should be provided at the following locations in the nearside verge. Alternatively, the information can be displayed on a VMS, indicating which lanes are open:

- At the start of an entry slip road and again repeated at the nose
- At the start of an exit slip road and again the end of the slip road
- Following an access, where an access has not been designed out
- On the mainline in advance of the merge where a scheme is commencing
- On the mainline following the diverge where a hard shoulder bus priority scheme is ending
- At regular spacing, as set out in *Section 11.5.4*.

At the end of any hard shoulder bus priority measures an “end” sign should be provided. The end sign should be of type RUS 028 of *TSM Chapter 5* with no cycle symbol as permitted by Clause 5.19.10 of the *TSM*. The sign shall be accompanied by a supplementry plate displaying “Crioch/ End” of type P 010 of the *TSM Chapter 5*.

Full SSD visibility to signage should be to the design speed of the mainline and not the design speed of the hard shoulder bus priority measures.

11.5 Critical Flow Hard Shoulder Bus Priority Measures

Critical flow hard shoulder bus priority measures require the greatest use of ITS monitoring and control systems, due to the need to monitor in real time the flow of the mainline and adjust the system opening accordingly. The advantage of this monitoring however is that the system is more responsive and therefore optimised to the live conditions on the road network. This can have the advantage of improving traffic flow for both road users and those using the hard shoulder bus priority measures.

In addition to the recommendations in *Sections 11.1 to 11.4*, the following ITS systems are required for this system:

- Automatic Incident Detection (AID) Loops or Radar *(Section 11.5.1),* for the monitoring of traffic flows to determine system opening and closure
- Variable Message Signs (VMS) *(Section 11.5.2),* to communicate lane operation
- Advance Motorway Indicators (AMI) *(Section 11.5.3),* to strengthen the communication of lane operation

The following ITS systems are recommended for this system:

- Variable speed limits can be communicated via VMS and AMI systems to reduce the speed differential between the mainline and the hard shoulder bus priority measures.
- Non-loop based stop vehicle detections where required to supplement the coverage of AID loops

11.5.1 Automatic Incident Detection (AID) Loops or Radar

Automatic Incident Detection (AID) Loops or Radar should be provided, to include all running lanes, to support; traffic counting, classification, queue protection and congestion management. It is recommended that the detection system should include a minimum of 1 mainline counting site per link. This site should be aligned across all lanes. Where technology allows non-loop based detection technology may provide a cost-effective solution which reduces the impact of maintenance.

11.5.2 Variable Message Signs (VMS)

Variable message signs (VMS) can be used to communicate variable speeds and which lanes are currently in operation on schemes. They can also provide information to road users on congestion or stranded vehicles. VMS signs should either be located on a verge mounted cantilever over the nearside lane or on a portal gantry over the nearside lane.

11.5.3 Advance Motorway Indicators (AMI)

Advance Motorway indicators (AMI) provide the ability to communicate variable speeds and which lanes are currently in operation on schemes. At locations where AMI's are implemented they should be mounted on a portal gantry with a signal over the centre of each lane, including that of the hard shoulder bus priority measure.

The size and design of variable message signs is outlined in *Chapter 3 and 5 of the TSM*. A speed limit sign should be shown over every lane, even if two or more are subject to the same speed limit.

On merge slip roads, a variable speed limit sign should be provided where variable speed limits are in place on the mainline carriageway to give drivers advance warning of the speed limit.

11.5.4 Positioning of ITS Signals and Gantries

The following provides guidance on the positioning of gantries and signals

Variable Message Signs (VMS)

Where VMS are being used the first VMS on a link should be placed 300m +/-100m downstream of the merge nose. Flexibility is provided to allow for positioning around constraints and to achieve SSD of the mainline design speed.

A minimum of 2 VMS signals should be provided per link. In addition, VMS signs should be positioned at regular spacing ensuring that a vehicle has to travel no more than 500m before being able to see the next VMS when measuring using the SSD for the mainline design speed.

Advance Motorway Indicators (AMI)

Where AMI's are being used, the first set of AMI's should be positioned at the same location as the first VMS sign on a link. Where the link exceeds 6km's additional AMI's should be provided so that the spacing is a minimum of one between each junction and does not exceed 6km in rural sections and 3km in urban sections.

SSD to all AMI's should be measured using the mainline design speed.

Automatic Incident Detection (AID) Loops

The objective is to position detectors where they are required to detect traffic queues. Each VMS or AMI signal site should have a detector located as close as practicable to the related signal so that the signal settings align as closely as possible to the traffic conditions. Where inductive loops are used, loops should be located 10m upstream of the reference signal. If this is not practicable due to site constraints, as a result of design optimisation, or non-loop based detectors are used, then the detector site should be provided within 50m upstream to 10m downstream of the reference signal.

11.5.5 Additional Strategic VMS

Additional strategic VMS are not required as part of a scheme. However, where existing strategic VMS are present, they should be retained or be repositioned. Where required or retained, the sequence of sign and signalling installations on the approach to a junction should be strategic VMS, VMS, and then the primary ADS.

11.6 Peak Hours Hard Shoulder Bus Priority Measures

Peak hours hard shoulder bus priority measures can be operated using fixed signage and supplementary plates only due to the static nature of the operating hours. The recommendations in *Sections 11.1 to 11.4* should however be implemented. In addition, the following ITS systems are optional but recommended to help improve the operation of the scheme. These additional systems will require additional scheme cost and the benefit should be weighed up on a scheme by scheme basis and in line with TII's ITS strategy:

- Automatic Incident Detection (AID) Loops (Section 11.5.1), for the monitoring of traffic flows to determine if variable speeds should be introduced and to aid detection of stranded vehicles. Non-loop based stop vehicle detections may be added to supplement the coverage of AID loops. Variable speed limits can be communicated via VMS and AMI (Section 11.5.3), systems to reduce the speed differential between the mainline and the hard shoulder bus priority measures.
- Variable Message Signs (VMS) (Section 11.5.2), to communicate lane closures due to incidents and compliment static signs where provided
- Advance Motorway Indicators (AMI) (Section 11.5.3), to strengthen the communication of lane closures due to incidents

11.7 Permanent Hard Shoulder Bus Priority Measure

Due to the permanent nature of these schemes the scheme can be operated using fixed signage only. The recommendations in *Sections 11.1 to 11.4* should however be implemented. In addition, the following ITS systems are optional but recommended to help improve the operation of the scheme. These additional systems will require additional scheme cost and the benefit should be weighed up on a scheme by scheme basis and in line with TII's ITS strategy:

- Automatic Incident Detection (AID) Loops (Section 11.5.1), for the monitoring of traffic flows to determine if variable speeds should be introduced and to aid detection of stranded vehicles. Non-loop based stop vehicle detections may be added to supplement the coverage of AID loops. Variable speed limits can be communicated via VMS and AMI (Section 11.5.3), systems to reduce the speed differential between the mainline and the Bus Lane.
- Variable Message Signs (VMS) (Section 11.5.2), to communicate lane closures due to incidents and compliment static signs where provided
- Advance Motorway Indicators (AMI) (Section 11.5.3), to strengthen the communication of lane closures due to incidents

12. References

12.1 TII Publications

a) DN-DNG-03022 - Drainage Systems for National Roads (including Amendment No. 1 dated July 2015)

b) DN-GEO-03031 - Rural Road Link Design

c) DN-GEO-03036 – Cross-Sections and Headroom

d) DN-GEO-03046 - The Location and Layout of Lay-bys and Location Markers

e) DN-GEO-03060 - Geometric Design of Junctions (priority junctions, direct accesses, roundabouts, grade separated and compact grade separated junctions)

f) DN-REQ-03034 - The Design of Road Restraint Systems (Vehicle and Pedestrian) for Roads and Bridges

g) GE-GEN-01005 - Departures from Standards and Specification

h) GE-PAV-01006 - Use of Volume 7 (Including Erratum No. 1, dated January 2016)

i) GE-STY-01024 - Road Safety Audit

j) PE-PAG-02013 - Project Appraisal Guidelines for National Roads Unit 4.0 - Consideration of Alternatives and Options

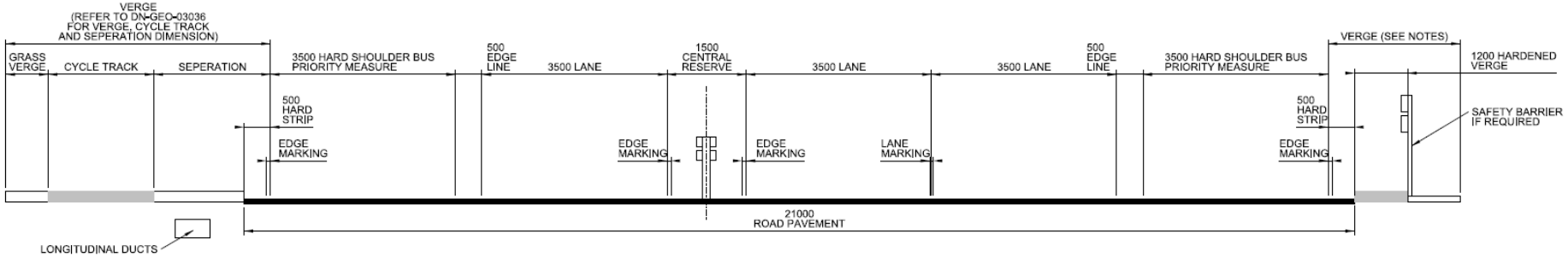
k) PE-PMG-02004 - Project Management Guidelines

12.2 Other References

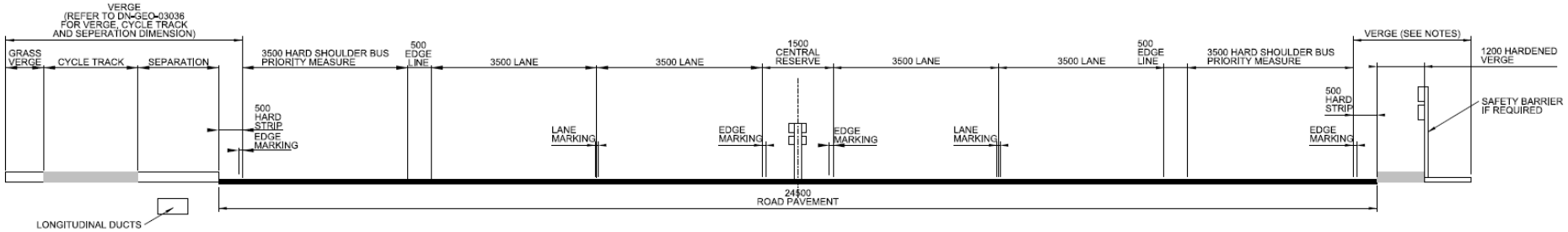
a) Irish Traffic Signs Manual as published by the Department of Transport

Appendix A:

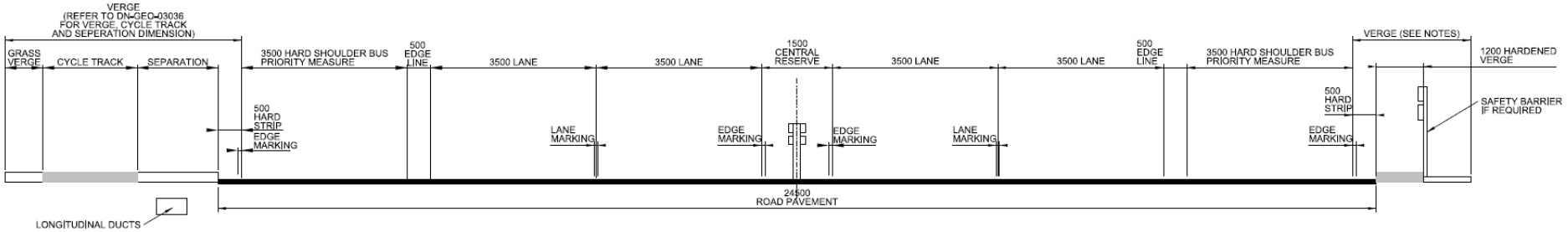
Cross-Sections



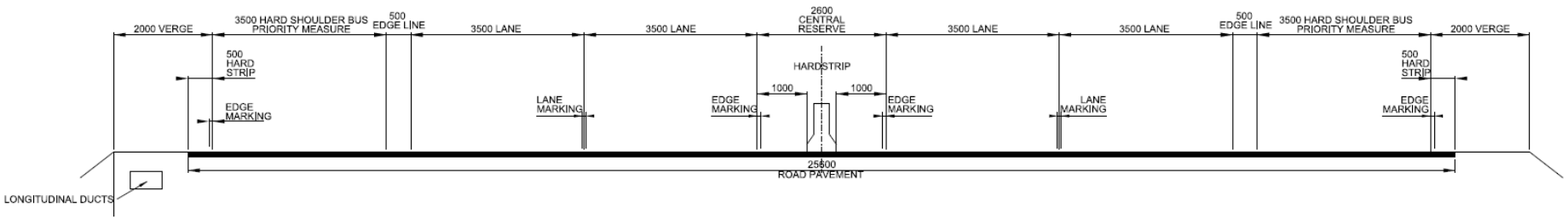
Type 3 Dual Carriageway



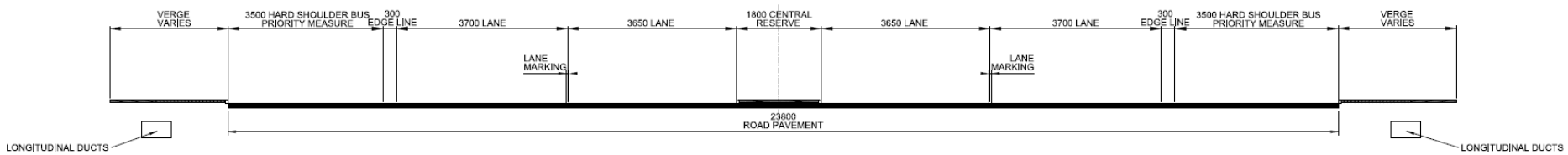
Type 2 Dual Carriageway



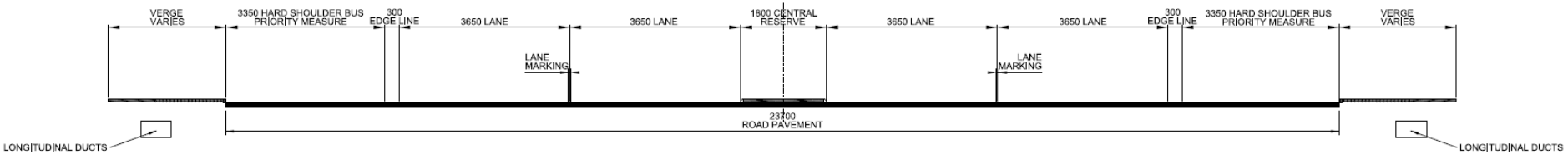
Type 1 Dual Carriageway



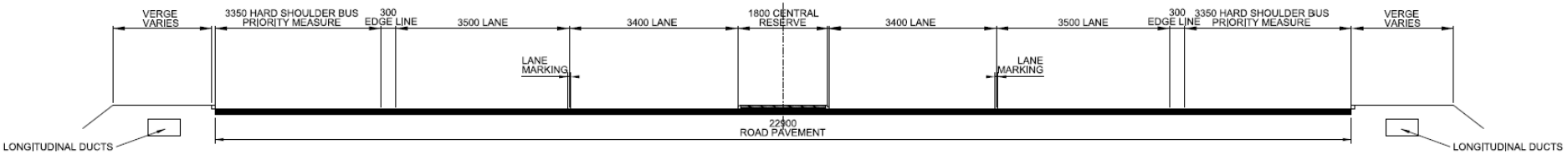
Rural Motorway



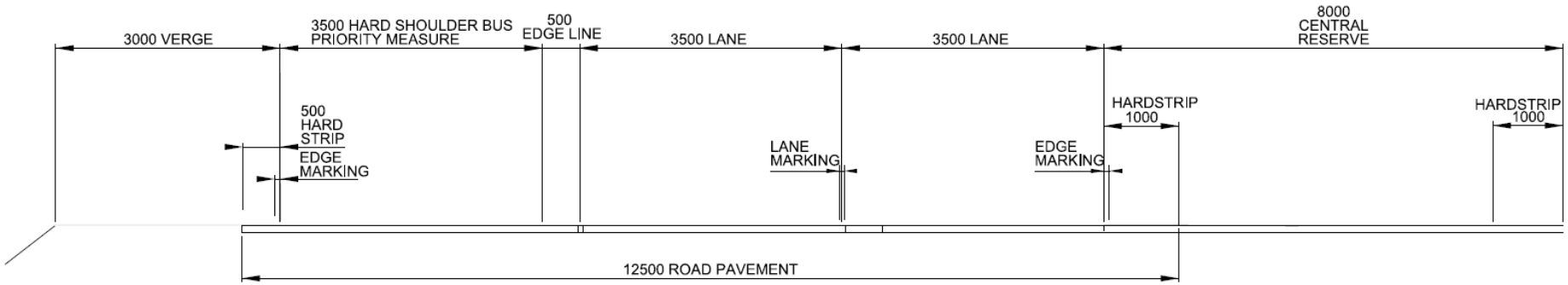
Dual Carriageway Urban 3 lane



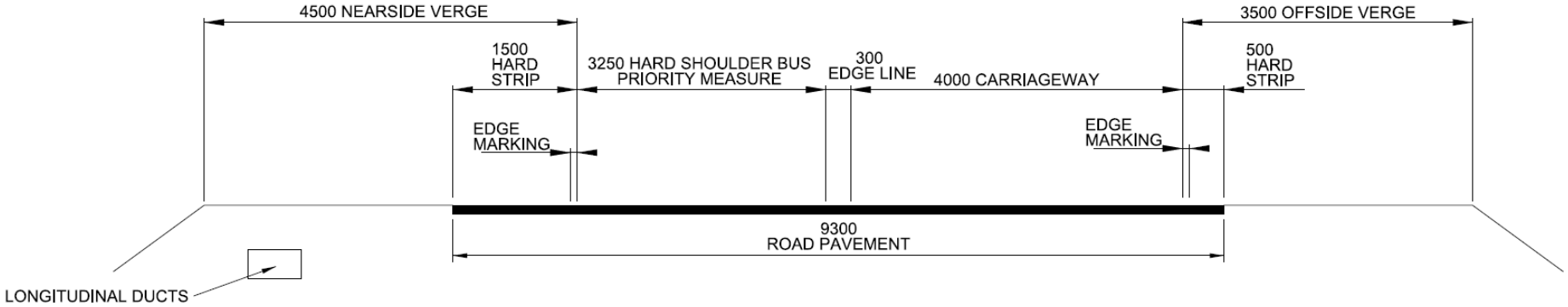
Dual Carriageway Urban 2 lane



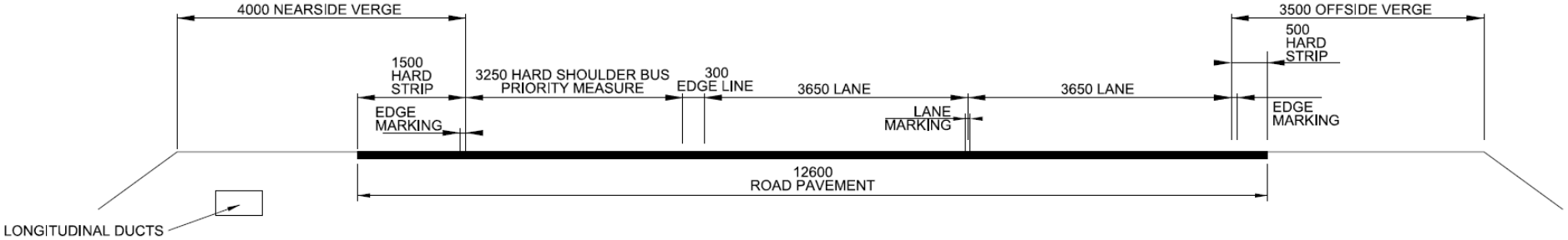
Urban Motorway



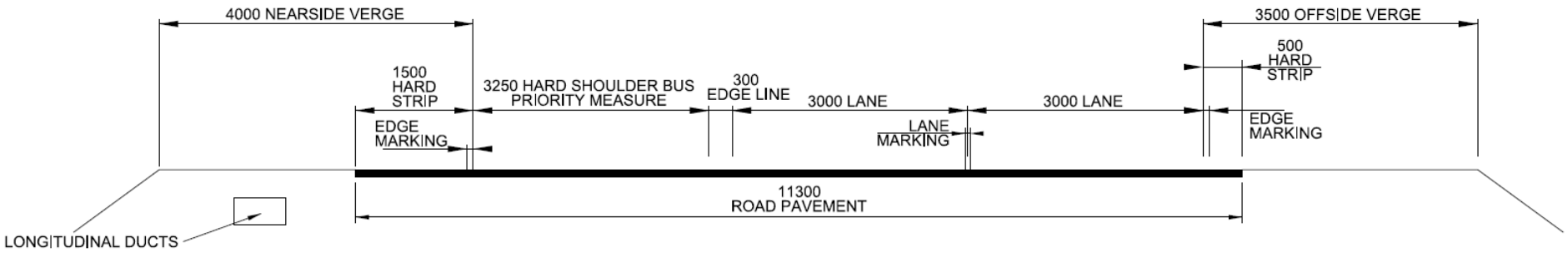
Wide Dual Carriageway Motorway



Merge and Diverge – 1 Lane



Merge – 2 Lane



Diverge Only 2 Lane

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