Ramp Metering

Technical Design Guidelines

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Executive Summary

This document details the necessary design processes required to implement the typical functionality of a Ramp Metering (RM) system, sometimes referred to as a motorway access management system (MAM). The document is aimed at the design of RM sites using equipment to MCH1965 issue C5. The document provides an insight into the pre-design considerations, design requirements and future considerations that need to be taken into account for efficient RM operation. This document is put together from the experience gathered during the provision of 30 RM sites in 2006-2007 and describes the design of various RM components for a typical site, and any additional site requirements the Designer needs to take into account.

The document forms part of a suite of RM guidelines and details the various design considerations of RM systems. The document explains the causes of congestion and how the issue of flow breakdown is addressed by RM systems.

The guidelines provided in this document shall be used in conjunction with the Design Manual for Roads and Bridges (DMRB), current specifications/ regulations and site dependant requirements to enable the design of an effective RM site.
1. Introduction

1.1 Ramp Metering (RM) Background and Concept

Ramp Metering is a traffic management technique, which manages the number of vehicles joining a motorway at peak periods. The purpose of RM is to prevent or delay the onset of flow breakdown on the main carriageway by a combination of:

♦ Managing the flow on the entry slip road to avoid large platoons of vehicles entering the main carriageway and causing flow breakdown; and,
♦ Restricting the flow onto the motorway of additional traffic that, if unrestricted, would trigger flow breakdown.

By preventing or delaying flow breakdown, the system provides the following benefits:

♦ Less congestion and improved traffic flows on the main carriageway;
♦ Higher throughput during peak periods on the main carriageway; and,
♦ Smoother and more reliable journey times on the main carriageway.

The current RM system uses part-time traffic signals on the slip road which come into operation when traffic sensors on the main carriageway indicate heavy traffic. The loops on the mainline along with queue detection loops on the slip road enable the system to determine the required flows from the slip to keep the mainline flowing close to critical occupancy. The full system operation is described in Section 3.4 of this document and in MCH1965, ‘Ramp Metering System Requirements Specification’.

The Highways Agency undertook a project to deliver 30 RM systems in 2006 to 2007. The RM systems are located in the West Midlands and the North of England. The 30 sites have been installed in the following Highways Agency Areas:

♦ Area 9;
♦ Area 10;
♦ Area 11; and,
♦ Area 12.

These sites are currently operational and overall are showing good benefits.

1.2 Document Scope

This document provides guidance for preliminary and detailed design of the system specific aspects of a RM installation. This document is a guideline and not intended as a specification detailing all of the standard procedures required for Highways Agency (HA) schemes.
Care should be taken when referring to a “typical” or “generic” RM site, as each site is different in both layout and traffic flows. Various site specific aspects shall be considered during the design phase. This document gives guidance on the considerations to be made and their impacts upon successful operation of the system.

The benefits associated with a RM installation, have been found to be directly connected to three main aspects: site selection; design; and calibration. This document gives guidance on the overlap between the three areas.

1.3 RM Scheme Overview

A typical RM scheme can be split into sections as detailed in Figure 1.1. Each section can be defined individually, but aspects from each overlap and impact on the next. The Designer shall be aware of the RM scheme life cycle and the impact of the different areas of the design process. Below is a brief description of each of the sections. A more detailed description can be found in additional RM documentation (see Section 1.5 related documentation).

1.4 Site Selection

This is primarily based on the traffic flows in and around each junction, with considerations being made to junction layout and topography. This can be initiated by a Highways Agency Area team looking for a solution to a particular congestion problem or a major RM implementation scheme. The site selection produces an output specifying a junction or junctions, which may be suitable for RM.

1.4.1 Operational Strategy

This section of the scheme involves inputs from the site selection, design and calibration teams to formulate an operational strategy for the site. This includes, determining the cause of flow breakdown, analysis of slip road flow rates and taking into account the slip road layout. From this information the design and calibration teams are able to target their work towards giving the greatest possible benefits to the conditions at that particular site. Section 2.3 of this document details some examples of congestion problems to be considered.

1.4.2 Design

Given the operational strategy the Designer can start the siting of the RM components to allow maximum benefits from the RM system. The processes are described further in this document. Typically the RM specific aspects of the design process should take under ten weeks; this is not inclusive of any geotechnical, environmental and structural design.
1.4.3 Configuration

As part of the design process the Designer shall set up the initial configuration file for the site. The configuration file contains all the site specific settings to allow the system to operate at that junction. Details such as selected Motorway Incident and Automatic Detection (MIDAS) sites, ramp loops, passwords and access levels shall be set during this phase.

1.4.4 Installation and System Commissioning

This phase of the works includes the installation, by the Contractor, of the infrastructure and the system specific aspects including commissioning by the System Supplier. At the end of this phase of the works the site shall be able to operate using the default configuration values loaded to enable commissioning, but not metering traffic as this requires careful setup.

1.4.5 Calibration

During this phase, the system is calibrated to give maximum benefits. This is a balance between slip road delays, queue length and mainline journey time reduction. Calibration is a two stage process:

♦ Initially, from the operational strategy generated during the design phase, values for the numerous parameters are derived to give an initial setup; and,
♦ Secondly, this initial setup is then finely tuned whilst the system is live and metering traffic. At the end of this phase the system shall be fully operational.

1.4.6 Operation and Maintenance

As the RM system is designed as a stand alone system the operational impacts are negligible. The RM system adapts to normal changes in traffic flows during summer and winter and operates automatically only when the mainline conditions require.

1.4.7 Evaluation

The detailed configuration at each site shall be evaluated to ensure it gives the optimum benefits available, and not causing detriment. Continuous evaluation and re-calibration may be required if the traffic flows around the area of a particular junction change. This could be due to a Highways Agency scheme in the vicinity of the junction or increased traffic on the slip road due to changes in the local road network.
Figure 1.1 - RM Scheme Life Cycle
1.5 Related Documents

A more detailed technical specification of the RM system can be found in MCH1965. The Designer is advised to become familiar with the other aspects of the RM scheme delivery, outlined in the following documents:

- Site Selection – Interim Advice Note 103/08.
- Ramp Metering Installation Guidelines – MCH 2471.
- Ramp Metering Configuration Setup and Management – MCH 2472.
- Ramp Metering Calibration Guideline - MCH 2473.
- Ramp Metering Maintenance Handover Procedures – MCH 2474.
- Ramp Metering Operational Procedures – MCH 2475.

This document is to be followed in conjunction with the associated sections of the Design Manual for Roads and Bridges (DMRB) to enable the reader to adhere to all of the necessary procedures required, producing a full and comprehensive design package.

1.6 Document Limitations

This document is aimed as a guideline for the RM specific aspects of design, and does not detail all of the design processes required to produce a full final scheme design. Aspects such as geotechnical and environmental procedures are not described in detail; however the document does highlight any RM considerations in such areas. All HA standard design requirements and processes apply but are not detailed in full in this document.

Due to the nature of the RM system and its aims, RM Designers need to have a thorough understanding of motorway communication devices and design, traffic flows, and motorway traffic behaviours, before attempting to successfully design a RM site.
2. RM Overview

2.1 Introduction

Before starting the design process it is essential to have a thorough understanding of the congestion problem and what RM can achieve. The congestion problem should have already been identified prior to design, through the operational strategy stage. Design engineers shall consider the following design considerations and have a thorough understanding of congestion.

2.2 RM Aims

The principal aim of RM is to regulate flow from the slip road on to the main carriageway at a level that maximises through put on the main carriageway. An overview of the RM concept is provided below.

Occupancy is the amount of time a vehicle detection loop is covered by a vehicle expressed as a percentage.

When traffic flow on the main carriageway is high this means that the traffic occupancy is also high. A high occupancy directly equates to smaller distances between vehicles or a low headway, in such conditions the road’s capacity is close to being reached, and small changes in the nature of the traffic flow cause it to become volatile and susceptible to flow breakdown.

The introduction of traffic from the slip road can cause vehicles to change lanes and bunch leading to higher occupancy and lower headways. These shorter headways can be unsustainable at speed on the main carriageway; therefore for comfort and safety, drivers adjust their speed to account for the short stopping distances available.

Often this adjustment of headway causes following vehicles to brake, propagating a “wave” of braking vehicles in the traffic stream. Traffic occupancy in the wave becomes even higher. To compound the problem more vehicles enter the main carriageway from the slip road, thereby boosting occupancy even higher. If vehicles continue to join, ultimately the main carriageway speed drops to a point where flow breakdown occurs. In this situation vehicles are stopping at the back of a queue and then driving off the front of the queue. When flow breakdown is directly due to the merge, this stationary traffic can typically be seen between the merge area and approximately 2km downstream.

Weather conditions, daylight, vehicle mix and gradients amongst other things can all affect the maximum throughput of any section of motorway.

To address this problem, RM aims to maximise throughput on the main carriageway without disrupting the local road network. It does this by controlling the discharge of
traffic from the slip road to reduce the interference of merging traffic on the main line flow, thereby maintaining speeds at a higher level. Maintaining higher speeds postpones the onset and duration of flow breakdown on the main carriageway. To do this, the RM system relies on the measurement of traffic conditions on the main carriageway and attempts to maintain traffic on the road at ‘target occupancy’ by restricting the flow from the slip road.

2.3 Examples of RM Congestion Problems

This section details three examples of RM congestion problems, and how they can be identified and treated by the Designer.

Figure 2.1 shows an MTV plot M6 J25 to M6 J21a southbound.

Interpretation of this MTV plot shows three distinctive sites that suffer from congestion, which include a primary site and a secondary site:

The congestion downstream of the M6 J22 filters back upstream and affects the merge at M6 J23. At a similar time the congestion at the M6 J23 merge filters back and affects the M6 J25 merge area. Each site has a merge area problem, which is severe enough to filter back to the upstream junction.
2.3.1 Primary Sites

Junction 22 shows congestion just downstream of the merge (shown by the grey shading of the MTV plot). Further downstream of the merge the speed represented on the MTV plot is higher. This shows the merge area at M6 J22 is the head of the congestion.

This type of site is referred to as a primary site and can typically be identified by a regular flow breakdown occurring in the vicinity of the merge of the junction. Primary sites show flow recovery almost immediately downstream of the merge, as the flow breakdown is attributable to the merging traffic at that junction. Traffic and RM systems operate in the following way at primary sites:

♦ Flow breakdown occurs at a primary site as occupancy slowly builds up at the merge until critical occupancy/capacity is exceeded and flow eventually breaks down;
♦ RM is activated and regulates slip road flow as critical occupancy is approached at the merge;
♦ RM helps to keep flow at or below critical occupancy for as long as possible to delay the onset of flow breakdown;
♦ RM also prevents large platoons from entering the motorway and causing flow breakdown; and,
♦ When flow breaks down RM prevents more vehicles from entering the motorway to aid flow recovery.

Primary sites should be treated by Designers in the following way:

♦ At critical occupancy, the speed of approaching vehicles is relatively low so this site is likely to have a relatively low safe merging speed \(V_{in}\);
♦ Speed of approaching vehicles is relatively low as critical occupancy is reached, vehicles do not require a long acceleration distance to the merge from the stop line during times of congestion. Therefore the distance from the stop line to the merge can be relatively short; and,
♦ Downstream loop locations shall be in the vicinity of the merge, which is typically just downstream of the on-slip.

In addition to classic primary sites with over-capacity-at-the-merge, there are other types of congestion sites that can be categorised as primary sites, which suffer from very specific congestion problems.

2.3.2 Weaving Sites

This type of congestion occurs at sites with a significant amount of weaving vehicles downstream of the junction for reasons other than merging traffic from the slip road. At sites that suffer from traffic weaving at the merge area, RM has proven to provide particularly good benefits, when designed, installed and configured correctly. A typical example of a weaving site is:
RAMP METERING

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A site at which there is an off-slip directly after an on-slip; and,
A site at which there is a motorway diverge occurring shortly after an on-slip.

Weaving sites exhibit the following traffic/driver behaviour:

- Vehicles wishing to get off at the downstream junction move into the left hand lane, before the on-slip, causing an unusually high occupancy in the left hand lane;
- Vehicles merging into the main carriageway from the on-slip therefore have to adjoin a highly occupied left hand lane to get into the main carriageway. This causes an initial merging problem; and,
- Vehicles from the right hand lanes continue to move into the left hand lane after the on-slip, to get off at the downstream junction, whilst adjoining vehicles attempt to move right from the left hand lane into the freer faster moving right hand lanes, leading to flow breakdown and shockwaves.

Typical MTV plots showing a weaving site include the following characteristics:

- High occupancy in lane 1 in the approach to the on-slip, relative to other lanes with flow breakdown building up very quickly;
- Free-flowing conditions in right hand lanes;
- Recovery of flow after the off-slip; and,
- Flow breakdown periods can be longer than at other non-weaving sites, due to the excess occupancy in the left hand lane causing flow breakdown before the critical occupancy across all of the three lanes is reached.

2.3.3 Signalled Roundabout Sites

A slip road with a signalled feed from a roundabout usually promotes congestion typical of a primary site. Signalled roundabouts have a tendency to release large platoons of vehicles from local roundabouts that reach the motorway cyclically and cause flow breakdown due to capacity being exceeded on the mainline.

RM is known to give large benefits at sites where congestion is caused by a signalled feed into the slip road. This is due to the RM system breaking up the large platoons from the signalled roundabout into smaller platoons that can merge onto the main carriageway more easily.

2.4 Secondary Sites

From Figure 2.1, Junction 25 shows increased congestion occurring as a result of tailing back congestion from Junction 23. Deploying RM at Junction 25 in this type of situation can help to delay the onset of flow breakdown further down at Junction 23, and help recover flow at Junction 25 at the end of the peak period. This type of site is referred to as a secondary site. A secondary site usually has the following identifiable features:
It is a site that contributes significantly to flow breakdown at a location further downstream by increasing the occupancy on the mainline, therefore it usually has a significantly high level of flow on the slip road; and,

A secondary site typically suffers from flow breakdown itself when traffic tails back from a bottleneck location downstream.

The downstream bottleneck may not necessarily be another ramp metering junction, but could be another type of bottleneck. Examples of typical bottlenecks that a secondary site can be used to alleviate against can include the following:

- A downstream merge or diverge problem;
- Road layout such as a hill, bend or narrow lanes; and,
- A speed restriction, leading to an increase in occupancy.

The following shall be considered by the RM Designer for a secondary site:

- Set the downstream detector loop at the location of the bottleneck. The secondary site therefore can restrict traffic on its slip road to delay flow breakdown at the downstream bottleneck;
- This method of operation means that mainline traffic at the merge will not have broken down when RM is to be in operation and the safe operating speed of traffic upstream of the merge ($V_{in}$) will be high. Therefore acceleration distance from the stop line to the main carriageway needs to be long enough to allow for safe merging; and,
- Good publicity and driver education is also required as traffic in the queue at a secondary site will not witness the downstream bottleneck, but will see a free flowing carriageway, and will not see an obvious reason for waiting in a queue.

Benefits can also be achieved when a secondary site is designed to switch on after flow breakdown has occurred locally (Due to a tailback of congestion from the downstream bottleneck). Operating the RM system in this way means that benefits are only achieved by attempting to keep traffic flowing on the main-carriageway and helping flow recovery. Unfortunately when operating in this way the onset of flow breakdown on the main carriageway is not delayed or prevented. Typically a site will be designed in this way when there are restrictions on the available acceleration distance and the following shall be considered:

- Configuring in this way means there will be a slower $V_{in}$ and therefore acceleration distances from the stop line can be shorter; and,
- The choice of downstream detector is local and not remote.

## 2.5 Site Selection Information Summary

Typical information that the Designer shall understand from the evaluation of the traffic statistics, which influence the operational strategy, includes the following:
The determination of the exact point, or points of flow breakdown;
The expected operating times of the RM system and how long the congestion lasts;
The downstream road layout;
The most suitable locations for mainline detection loops;
Whether occupancy and flow breakdown are affected by bends/ hills/ visibility issues;
Whether the site is a primary site, or secondary site, or a weaving site;
The magnitude of the slip road flows. These need to be considered by the Designer, in respect of length of slip road and queue capacity; and,
The safe operating speed, \( V_{in} \) at times when the RM system shall be active.

### 2.6 RM Limitations

There are some congestion problems, for which RM systems can not provide effective benefits. Typically these are congestion problems (often present through a merge area) caused by a downstream bottleneck and not caused by merging traffic from the slip road.

Situations like this are particularly relevant when:

- Flow from the slip road is low compared to main carriageway flow. If flow from the slip road is low then whether restricted or not, it is unlikely to have a significant impact on the traffic flowing through a downstream bottleneck; or,
- A bottleneck problem causes a large congestion problem, where capacity of the road is greatly exceeded.

Large bottleneck problems would typically include a large change in capacity on a road for example:

- Reduction of road capacity due to lane loss;
- Traffic backing up from an off-slip and blocking a lane of the main carriageway;
- Diverging tailbacks at motorway intersections; or,
- Roadwork traffic management/ accident causing lane loss.

Designers need to be aware that a site may be designed, installed, commissioned and handed over perfectly at time of commissioning, however significant changes to local flows could greatly alter its impact, should the conditions at the site significantly change in the future.

Before starting the design process it is essential to have a thorough understanding of any current schemes and future schemes that are taking place that can have any impact on flows through a ramp metering junction. Local schemes likely to have an impact on the traffic flows could include any of the following non exhaustive list:

- Changes to local road layout and feed into slip road;
2.7 Maximising RM Effects

The Designer shall use the opportunity of the design and associated investigation to maximise the benefits of RM, through optimisation of non-RM features. Typically, this can include consideration of changes to the road layout.

2.7.1 Slip Road Lanes Change Considerations

Changes to the slip road layout, require factors such as the consistency and number of slip lanes, merge area, queue storage capacity and slip road flow to be evaluated.

In the case of a single lane slip road, if the number of lanes on a slip road is increased to include two lanes, this would increase the ramp storage and reduce any traffic overflow problems caused to local link roads or roundabouts. This is particularly effective solution if the slip road is not long enough for sufficient vehicles to be stored within only one lane, without compromising the acceleration distance to the merge.

Alternatively, in the case of a double lane slip road, a reduction to a single lane slip road, where possible, can provide greater control at the ramp metering site, by enabling very small platoons of traffic to enter the merge. This is particularly effective for segmenting traffic where medium platoons entering the main carriageway cause flow breakdown, e.g. at a weaving site.

Designers should be aware that many slip roads without RM feature a double lane slip road merging into a single lane slip road. Such a change in lane layout within the storage area confuses drivers who become inconsistent in their approach to the stop line. Some drivers approach as they would if there were two lanes, whilst some drivers approach in single file as they would if there were only one lane. This inconsistency makes controlling release rates nearly impossible and therefore compromises the integrity of the system.

In situations where the slip road merges from double lane to single lane, upstream of the proposed stop-line, then the lane layout and associated markings shall be modified to be consistent throughout the length of the queue storage area.
2.7.2 Merge Area Modifications Impacts

In some instances the hard shoulder along the main carriageway and the on-slip may be modified to extend the merging area. This gives the advantage of spreading the area at which cars merge, and increasing visibility for merging vehicles.

At some existing slip roads the markings are restrictive, such that the movement of traffic from the slip road to the main carriageway is not a smooth merge. The addition of RM to such a junction would result in unproductive use of the road and a poor time to accelerate into the merge. By modifying the road marking, to extend the length of the merge, traffic can reach the main carriageway at higher speeds, and over a greater distance allowing for better merging with the main line and increased visibility for both the mainline vehicles and the slip road vehicles.

2.7.3 Ghost Islands

A ghost island is an area of the carriageway suitably marked to separate lanes of traffic travelling in the same direction on both merge and diverging layouts. The purpose of a ghost island at a merge is to separate the points of entry of two slip road traffic lanes.

A ghost island splits the slip road flow into lane 1 and lane 2 and identifies separate merge areas for both. A problem encountered here, is that RM breaks up slip road flow in a far more controlled way by releasing limited number of vehicles at any time, which works less efficiently with ghost islands.

The difficulty experienced at RM sites that have ghost islands, is caused by merging traffic leaving the stop line in the offside/outer lane. The ghost island forces drivers in
the outer lane to merge early with the main carriageway. This results in the drivers using only a small fraction of the potential acceleration and merge area that would be available if the ghost island was removed. Due to the reduced acceleration distance the RM system will only be able to meter traffic at lower mainline speeds. This greatly reduces the effect of RM as it can only operate after flow breakdown.

During design of a RM site, the Designer shall consider removing ghost islands, or modifying road markings to improve traffic flow/ reduce confusion. The removal of ghost islands is preferred to ensure only the RM system controls the entry of vehicles from the slip road to the motorway. The decision to remove or modify ghost islands is site specific and hence any changes need to be approved.

As RM is not on continuously, when considering ghost island modification or removal, the behaviour of merging traffic without the operation of RM shall be fully considered.

Merge layout designs shall be made in accordance with the following specifications, which detail design principles for a range of lane and merge layouts.

♦ DMRB, Volume 6, Section 2, Part1 TD22/06 Chapter 2; and,
♦ DMRB, volume 6 section1, TD39/93. ‘Designing Major Merges’.
3. RM Components

3.1 Introduction

This section provides an insight into the hardware and software requirements for RM implementation. The hardware includes all road side installations and software includes the system algorithms for the ramp metering controller. Further details can be found in MCH1965, ‘Ramp Metering System Requirements Specification’.

The key components of Ramp Metering system are:

♦ Fixed warning signs;
♦ High friction surfacing;
♦ Road markings;
♦ Signal heads (traffic signs incorporating light signals);
♦ Slip road traffic sensors;
♦ Upstream and downstream MIDAS traffic sensors on the main carriageway;
♦ Ramp metering outstation;
♦ Communications to and from ramp metering outstation (RMO);
♦ Safety fencing and safe area;
♦ Cabinets;
♦ System algorithms; and,
♦ Advance warning signs (electronic) where applicable.

The following sections explain the main RM components.
3.2 System Components

The components required to carry out the minimum functional requirements of RM are described in this section. Figure 3.1 shows a generic site overview detailing the RM components. This is a typical diagram and RM installations may vary dependant on site specific layouts.

![Figure 3.1 - Generic Site](image)

3.2.1 Fixed Warning Signs

Warning signs are to be used, where applicable, to warn drivers of queues, and to alert drivers of the temporary traffic signals. Typical installations include ‘Queues Likely’ and ‘Part Time Signal’ signs located along the slip road.
3.2.2 High Friction Surfacing

High friction surfacing is typically required upstream of the stop line and on the lead up to the override loops. This anti-skid surface serves as a protection for the queue, and assists vehicles stopping for the signal heads at the stop line.

3.2.3 Road Markings

Road markings shall include the installation of the stop line and modifications to the lane identifiers on the approach to the signals. Further road markings may include clarification of lane layout and modification to merge layout.

3.2.4 Signal Heads

Part time signal heads are used to regulate traffic flowing from the slip roads onto the motorway. The signal heads are fitted with a yellow backing board to distinguish them from standard traffic signals. The varying signal cycles are controlled by the ramp metering outstation.

3.2.5 Slip Road Traffic Sensors

Slip road loop detectors monitor traffic on the slip roads and regulate the queue formation. The slip road loops currently employed are one loop per lane per loop array. Slip road loops consist of:

- Release loops at the stop line, which indicate when a vehicle has left the stop line;
- Presence loops at the stop line, which indicate when a vehicle is present at the stop line;
- Queue override loops at the back of the vehicle storage area which indicate when a queue has reached the back of the storage area; and,
- Queue detection loops, which detect the length of the queue between the presence and override loops.

3.2.6 Upstream and Downstream Traffic Sensors (MiDAS Loops)

Upstream and downstream (of the merge) traffic is detected using the Motorway Incident Detection and Automatic Signalling (MiDAS) outstations. These outstations use arrays of induction loops in the motorway lanes to calculate speed, flow and other statistical information at the various sites, which is passed to the MiDAS subsystem. The MiDAS outstation is housed in a type 600 cabinet.

Information on individual vehicles gathered by the MiDAS outstation is passed to the RMO via the MiDAS outstation’s ‘Outstation Auxiliary Link’ OAL, which the RMO processes into speed, flow and occupancy values.
3.2.7 Ramp Metering Outstation

The Ramp Metering Outstation (RMO) consists of the Ramp Metering Controller (RMC) and a Traffic Signal Controller (TSC) co-located in a nineteen inch rack within a dedicated type 600 cabinet. Also contained within the RMO cabinet is a communications modem with power provided from a local power cabinet.

The role of the RMO is to provide control functionality for the system this is principally the calculation of the release rates and resultant variation the signal timings based on real time traffic data. This is achieved through the functionality of the RMC and TSC as follows:

- The RMC is continuously gathering information from all of the various loop detectors (Slip road loops and MIDAS), and performing a series of ramp metering algorithms to calculate suitable release rates. The RMC uses RS485 ports to communicate with the MIDAS outstations, via the MIDAS outstation’s Outstation Auxiliary Link (OAL). The slip road loops are connected directly to loop interface cards on the RMC. The RMC performs data filtering of the slip road loop and OAL MIDAS data. The RMC then runs the algorithms (Using a range of site specific calibration parameters) to control the displayed signal sequences, in addition to other functionality including system logging, and fault reporting; and,

- The TSC functionality includes providing control and power to the signal heads. This also includes determining red light failures, ambient light levels and preventing the display of incorrect aspect combinations. It also provides dimming of the signal heads in response to the levels of ambient light.

The RMO has a remote communications link, with suitable security arrangements, so that supervisory functions can be carried out over the internet.

The remote communications link is an internet protocol link and has previously been provided by a variety of different methods depending on the communications available at the site. Some of the options used in the 2006-2007 RM project included:

- BT broadband line with associated cabling and cabinets;
- Satellite installation with associated cabling and mounting arrangements;
- Link to another local site that already has internet access via the longitudinal cabling; and,
- Link to a transmission station or RCC via an ADSL modem and a copper pair on the longitudinal cabling.

3.2.8 Safety Fencing and Safe Working Area

Consideration shall be given to safety fencing where required. Safe working areas shall be taken into account in early stages of design and consideration shall be given to the safety requirements for maintenance staff on site.
3.2.9 Cabinets

The cabinets for RM sites currently include type 600 communications cabinets and type 609 power cabinets.

3.2.10 Advance/ Electronic Warning Signs (where applicable)

The Designer shall take into consideration the requirements for electronic/ variable message signs provision for future installations. These would typically be required where the layout will result in reduced sight lines. Requirements for these are to be designed out wherever possible.

3.3 System Algorithms and Operation

The RMO operates in one of 4 operational modes listed below and in accordance with the system algorithm specification:

♦ Standby;
♦ Switching On State;
♦ Steady State; and,
♦ Switching Off State.

The RMO continually receives traffic data from the slip road loops and MIDAS outstations on the mainline. The system operation relies on this continuous stream of traffic data and varies the vehicle release flow over the stop line via the RM signal sequences.

In standby mode, the RMO continuously collects, filters and analyses input data from all traffic detectors and regularly evaluates the switch on/off algorithm. When preset levels are met the system switches to the ‘switching on state’ where it displays its first signal aspect. This is full green for a minimum period set during calibration, to indicate to the road user the activation of the system.

Upon completion of the ‘switching on’ state, the RMO enters normal operation which is the ‘steady state’ condition. In steady state operation, the RMO continues to collect, filter and analyses input and also regularly evaluates all algorithms in order to activate the signal aspects accordingly.

When the main carriageway traffic flows are returning to normal the RMO switches to ‘switching off’ state. In this state the RMO gradually increases the number of vehicles released from the stop line to dissipate any stored traffic in a safe and controlled manner. The RMO then returns to ‘standby’, deactivating the signals with a prolonged green period.

A detailed explanation of the system operation and explanation of other system algorithms is available in MCH1965, ‘Ramp Metering System Requirements Specification’.
4. RM Design

4.1 Introduction

The following section provides the RM-specific-only, guidelines and fundamental steps required to design a RM site. The Designer should note that the guidelines pertain to a generic RM site and several variations of design are possible as each site requires a large number of design considerations to be carried out prior to locating infrastructure.

The section demonstrates typical distances and specifications for design, however the Designer shall recognise that all RM sites are different and that the design considerations outlined shall be taken into account at every site.

Due to the nature of RM and the complex nature of the aims that RM Designers are trying to achieve, RM Designers need to be HA Communications Designers, with a thorough understanding of ITS system configuration of the HA system, in addition to having an understanding of traffic flows and motorway traffic behaviour.

Appendix A includes site design drawings produced for the installation of one of the sites of the 2006-2007 RM project. This is included as an aid to the design process and should not be taken as an ideal site design. The concept of a generic, or typical, site should be approached with caution as each site needs to take into account the individual layout and site specific congestion issues to produce an effective RM installation.
4.2 Generic Site

**Figure 4.1 - Generic RM Site Showing Typical Dimensions**

**Figure 4.2 - Signal Heads and Stop Line**
4.3 Process

The typical process for RM design is outlined in the following flow chart.

![Design Activities Flow Chart](image)

**Figure 4.3 - Design Activities Flow Chart**
4.4 Location of Stop Line

The location of the stop line is the most critical feature in the design of RM site. This requires finding the best balance between a location far enough down a slip to provide sufficient vehicle storage, versus the requirement to allow vehicles enough acceleration distance to merge safely. The location of stop line has an impact on the safety aspects and governs visibility for drivers approaching the queue.

Locations of stop lines used in the 2006 to 2007 RM project were typically 45m upstream from the soft nosing.

In assessing the location of the stop line, the Designer shall assess the following requirements:

- The minimum and maximum required distance from the stop line to the merge;
- The minimum and maximum storage requirements on the ramp; and,
- Visibility for vehicles approaching the stop-line.

The above factors need to be considered in conjunction with the local environment which may include:

- Gradients of the slip road;
- Gradients of the merge area;
- Gradients of main carriageway;
- Speed of vehicles on the main carriageway; and,
- Bends and visibility of slip road.

The materials used to white line the stop line shall be in accordance with Specification for Highway Works - Series 1200 (Traffic Signs). The size for the stop line shall be in accordance with Traffic Signs and Regulations and General Directions (TSRGD) diagrams 601.1, 1002.1 and 1022.

4.4.1 Minimum Stop Line Distance to Merge

The Designer shall locate the stop line, to allow for the safe merging of traffic at the anticipated operating speed of the system. The operating speed of the system must be decided during the formulation of the operational strategy and can be derived from the relevant speed flow curves.

When determining the minimum distance from stop line to merge, the Designer shall consider the following:

- The stop line distance to merge shall be as long as possible (without exceeding the maximum stop line to merge distance detailed in section 1.4.2) without compromising storage area on the ramp;
- The Designer shall consider uphill gradient of on-slip;
The Designer shall consider gradients of merge area;

- The Designer shall consider any speed characteristics of road (e.g. any mandatory 50 mph limits);
- The Designer shall need to consider flow breakdown characteristics; and,
- Uphill gradients reduce acceleration and require longer slip roads. Conversely downhill slip roads aid acceleration and require shorter slip roads.

4.4.2 Maximum Stop Line Distance to Merge

In the case of extremely long slip roads, it is not always beneficial to increase the acceleration distance to the maximum possible value. This is because an extremely long distance in which to accelerate (from the stop line to the merge) can in fact enable individual vehicles (segmented by a small release rate) to catch up with each other whilst accelerating to the main line. This has the impact of allowing vehicles to develop/ redevelop into undesirably large platoons before adjoining the motorway. This situation is particularly relevant to vehicles following a slow accelerating Heavy Goods Vehicle (HGV).

Therefore Designers shall ensure that the acceleration distance from the stop line is long enough to prevent vehicles released at separate intervals, from being able to regroup before merging.

4.4.3 Minimum Ramp Storage Requirements

Storage on a ramp needs to be sufficient to allow vehicles to be stored on the ramp without vehicles flowing back on to the roundabout or junction adjoining the slip road.

One of the functions of RM (beyond segmenting adjoining traffic platoons to ease merging) is to hold back traffic to delay the onset of flow breakdown on the main carriageway. If this function is required at a site then a large storage area is required.

Factors influencing the storage areas requirements include:

- Slip road flow rates (high slip road flows require large storage areas);
- The rate at which vehicles join the storage area (this can be very cyclic in the case of signalled roundabouts);
- Presence of heavy goods vehicles;
- Speed at which vehicles move along the ramp/ speed limit on ramp; and,
- Visibility for drivers joining the storage area, in case of curved slip roads/ uphill/ downhill.

An example problem could be a site where the cause of flow breakdown could be due to long platoons of vehicles arriving from a signalled roundabout in bursts, without having a high average hourly flow. In this circumstance a short storage area would suffice, with RM being used to break up the large platoons of traffic, and not being used necessarily to hold large flows of traffic back. If however such a site had
large average hourly flows (e.g. during rush hour) then such a site would be required to have a large storage area in order to hold back traffic to delay flow breakdown and hasten flow recovery.

4.4.4 Maximum Ramp Storage Requirements

In some instances, storage on exceptionally long slip roads could have capacity for a very large number of cars. Whilst this could potentially have great benefit to the users of the main line (by holding large flows back), such a system would cause excessive and extended delays for drivers waiting on the slip road. Maximum storage capacity can be dictated through the location of the override loops.

Typically in the 2006-2007 RM project, the maximum length of the slip road storage area was 200m to 250m.

4.5 Location of Signal Heads

Signal heads shall typically be installed 2m downstream of stop line. Signal heads typically consist of a pair of signal heads on a passive pole located on either side of the slip road. Distance from each kerb is typically 1.5m or more.

The alignment of the lower signal head used on each pole, and the location of the pole 2m downstream of the stop line, allows visibility of the signal heads from vehicles waiting on the stop line.

In all sites of the 2006-2007 RM project, passive poles were used, allowing the poles to be erected without requiring safety fences. In the case of a 'non standard' installation whereby the stop line and signal heads are under 25m from the soft nosing, with the passive pole located within the area of the nosing or behind barrier, a HA departure in accordance with TA 89/05 may be required to overcome clause 2.5 of the DMRB Volume 8 Section 2.

The Designer shall also ensure that authority to use a ramp metering sign incorporating traffic signals is obtained and complies with the ‘road traffic regulations act 1984 – section 64’.

Backing boards for ramp metering traffic signals shall comply with GT 46/5/190 (see Appendix B). This authorises the use of the ramp metering backing board on slip roads. Note that the Authority dictates that only the sign arrangement specified to drawing 5053147_20_02_1503 may be used on slip roads, and only for the purpose of Ramp Metering.

Specifications used to determine the type of signal poles that are used are detailed in TSRGD diagram 3000.

Adequate safety measures shall be in place for the signal heads, conforming to Series 300 and 400. The electrical installation shall be in compliance with Series 1400 of Specification for Highway Works.
Alignment of signal heads shall be in accordance with 5053147_20_02_025, ‘Ramp Alignment of Signal Heads’. Where no hard shoulder is present, the nearside traffic signal alignment shall be the same as the alignment for the offside signal head. The lower signal shall be orientated in order to be seen by a driver waiting at the stop line. Traffic signal poles shall typically be 6.5m high.

Designer shall make note of the requirements of Traffic Signal Pole drilling from the drawings ‘Jerol Traffic Signal Pole Detailed Drilling Overview’. A hard standing area or a platform for the purpose of maintenance shall be allocated depending on site layout and shall comply in accordance with MCX drawings and BS5395.

4.6 Location of Detectors

The detectors required to implement RM consist of:

- Release and presence loops;
- Override loops;
- Queue detection slip road loops; and,
- Loops on main carriageway.

The locations of all loops on the slip road, shall comply with the MCX 1011 (sheet 2 of 2) ‘Installation Drawing NMCS2 – Ramp Metering Two Lane Loop And Chamber Configuration’ for a two lane slip road and MCX 1011 (Sheet 1 of 2) ‘Installation Drawing NMCS2 – Ramp Metering Single Lane Loop And Chamber Configuration’ for a single lane slip road.

The induction loops shall be in accordance with MIDAS specifications detailed in TD 45/94 and HD 20/05 within the Design Manual for Roads and Bridges – Volume 9. They shall conform to SHW – Series 1200 detailing the installation and layout of induction loops. The layout and installation details of detector loops are as detailed in Drawings G1 to G32 of the Highway Construction Details (HCD) (MCHW Vol.3). The detector cables shall comply with specification TR2029 and Designer shall include sufficient ducts to accommodate the number of feeder cables required at a particular location.

In the case of all loops on the slip road, only a single loop per lane per array is required.

4.6.1 Location of Release and Presence Loops

Presence and release loops are used by the RMC to identify when a vehicle is waiting at the stop line (using the presence loop) and when a vehicle has just left the stop line (using the release loop):

- Typical location of presence loops is 2m upstream of the stop line; and,
- Typical location of release loops is 2m downstream of the stop line.
Refer to Figure 4.1– Generic RM Site, showing typical dimensions for details.

### 4.6.2 Location of Override Loops

The purpose of the override loops is to ensure that the queue is flushed when it reaches a certain length. When override loops are triggered with a specific occupancy, the RMO detects this state and forces a queue override algorithm to flush the queue by forcing a high release rate. Flushing the queue at a specific length achieves the following functions:

- The queue is prevented from reaching the local roundabout/junctions;
- The back of the queue is prevented from reaching dangerous locations, e.g. a corner of a bend; and,
- The maximum queue length is controlled thereby preventing an excessive waiting time.

The locations of the queue override loops at the majority of the 2006-2007 RM rollout sites were typically at a distance of 39 meters from the start of the slip road. This distance was selected because it would allow room for two heavy goods vehicles to approach the back of the queue before slip road queuing could be allowed to spill onto any roundabouts. In the 2006-2007 RM project, where slip roads were extremely long without significant curvature, the location of override loops were located a distance of 200m from the stop line.

### 4.6.3 Location of Queue Detection Loops

Queue detection loops are required by the RM system in order to identify the approximate length of the queue. During the 2006-2007 RM project, length of queue was controlled by the RMC by taking data from the loops on the slip road (queue detection loops and override loops). The RMC controller can accommodate seven sets of queue detection loops in addition to the override loops, release loops and presence loops.

Several installations during the 2006-2007 RM project, had long slip roads and override loops were located 200m upstream of the stop line. In this situation, all seven sets of queue detection loops were spread evenly between the presence loops (at the stop line) and override loops (at the back of the storage area), with exact spacing between these loops of 25m.

Most installations during the 2006-2007 project, had distances of less than 200m between the queue override loops and the stop line. In this situation, the sets of queue detection loops were evenly distributed between the presence loops (at the stop line) and override loops (at the back of the storage area) with the number of sets selected, to enable the length between these loops to be as near as possible to 25m.

During the siting of the queue detection loops, any existing MIDAS loops located on the slip road may clash with the desired RM loop locations. In this case, the Designer shall, if possible arrange for the MIDAS loops to be relocated to avoid
clashes. The distance between the queue detection loops needs to be constant for the queue management algorithms of the RMC to operate efficiently. If relocating of MIDAS loops is not possible, then the number of queue detection loops could be reduced and the spacing increased to avoid clashing.

Given a limitation of 200m from loops to the RMO, and the restriction of maximum queue length during the 2006-2007 RM project, all of the slip road loops were within 200m of the RMC. However during future installations, there is potential for local traffic or physical constraints to create requirements of over 200m of cabling between override loops and the RMC. Installing any slip road or override loops at distances greater than 200m from the stop-line shall require the use of an induction loop interface unit. Depending upon the design put forward by the Contractor, the loop interface unit shall either derive power from the RMO or be provided with mains power.

4.6.4 Selection of Main Carriageway Loops

From the operational strategy, the Designer shall be able to identify and specify which main carriageway MIDAS loops shall be used for traffic detection by the system to provide the maximum benefits.

The upstream MIDAS loop is required by the RMO to identify speed and flow of vehicles approaching the merge area. The choice of upstream MIDAS loop needs to be the first upstream MIDAS loop, for the following reasons:

♦ There shall be no off-slips between the upstream loop and the RM junction. If the upstream loop is incorrectly selected upstream of the off-slip, then the flow of traffic over the loop would give a flow reading higher than the flow into the merge from the main carriageway; and,
♦ The upstream loop is required to provide an accurate speed of lane 1 prior to the merge area; it should therefore be as near as possible to the merge.

The downstream MIDAS loop is required by the RMC to identify speed, flow and occupancy on the main carriageway in the vicinity of the merge area. The RMC has the capability of linking to four downstream sites, and the RMC can then be programmed to utilise any one of these sites as its downstream MIDAS loop.

Vehicle data is received by the RMC from the MIDAS outstations using the Auxiliary Outstation Link (OAL), over the RS485 connection provided by NRTS.

To document and record the configuration of MIDAS outstations to the RMC on the OAL, the Designer shall:

♦ Produce OAL diagrams detailing which MIDAS outstations shall be connected; and,
♦ Modify each MIDAS outstation information card to clarify the connections made to the OAL port.

Dedicated traffic monitoring outstations may be required for the following reasons:
♦ Sites at which there is not already MIDAS available in the road side; or,
♦ Sites at which flow is known to breakdown in regions between MIDAS loops (where a better sited MIDAS loop would detect flow breakdown more efficiently).

In this situation, there would be a requirement to locate the exact point or points of flow breakdown (if flow regularly breaks down at regular locations). Detectors shall be installed at these locations of flow breakdown where possible. The requirement for dedicated traffic monitoring outstations shall be designed out wherever possible.

4.7 High Friction Surfacing

High Friction Surfacing (HFS) is required in the lead up to the stop line and in the lead up to the queue over ride loops to help protect the back of queues.

On a typical site with good sightlines of the signal heads the HFS is to be installed for fifty metres on the approach to the stop line.

On a typical site with good sightlines of the likely back of the maximum queue and enough distance from the start of the slip, the HFS is to be installed for fifty metres on the approach to the override loops. With the queue override loops installed at the minimum 39m from the start of the slip the HFS shall be installed from the start of the slip to the queue override loops.

Sites with poor sight lines (e.g. due to road curvature) or poorer stopping distances (e.g. due to a downhill slip road), shall require a more extensive deployment of HFS than the requirements outlined for a ‘generic’ site and shall be considered by the designer.

Antiskid surfacing shall comply in accordance with HD 28/04 of the DMRB (Volume 7.3.1) and SHW – Series 900 detailing standards for HFS.
### 4.8 Location of Fixed Warning Signs

In the typical 2006-2007 RM project installations, fixed warning signs were used to warn drivers of queues and to alert drivers of the temporary traffic signals.

![Figure 4.4 - Locations of fixed warning signs](image)

Location of the ‘Queues Likely’ sign shall be before the queue and therefore before the queue override loops. Therefore on most 2006-2007 RM project sites, the signs were located as near as practically possible to the start of the slip road.

Location of the ‘Part Time Signals’ needs to be prior to the signal heads. On most 2006-2007 RM project sites this needed to be sited in accordance with fixed signage/TSRGD diagram 543, 584 and 584.1. The detail of fixed signs is specified in TA 12/81 of the DMRB (Vol. 8.1.1.) The standards are specified in SHW – Series 1200 and 1400.

In the case of fixed signage the following rules shall be applied:

- Fixed warning signs shall be arranged in a non clutted way;
- All fixed warning sign locations shall be agreed with the Highways Agency; and,
- Fixed warning signs shall be sighted in locations that enhance visibility of the signs.

In addition to the signage requirements applicable to the generic sites, there are a number of signage considerations for sites which deviate from the generic design. Typically these sites may include:

- Sites at which the location of a fixed sign in the ‘generic’ location for a sign is not possible (geotechnical reasons, environmental reasons, structures);
♦ Sites that have exceptional curvature;
♦ Sites that are cluttered with other signs or other roadside furniture; or,
♦ Sites that benefit from the use of a variable message sign, in conjunction with fixed signing.

Signage at locations that deviate from the generic-site shall be located in accordance with the following regulations and specifications:

♦ Road markings shall comply with Clause 1212 of SHW. Road markings shall also comply in accordance with the Traffic Signs Regulations and General Directions 2002 and Chapter 5 of the Traffic Signs Manual, 1985 or any later amendments. In particular lane markings on approach to the traffic signals shall be in accordance with drawing number 1004.1 detailed in the Traffic Signs Manual. White line marking shall be in accordance with Chapter 5 of the traffic signals manual, diagram 1005.1 (road markings on approach to signal stop line). Road studs might be required depending on site requirements;
♦ All plate signs shall be sheet aluminium as described in BS 873. Where reflective material is required it shall have a photometric performance complying with the requirements of BS 873, Part 6. Passive posts shall be in accordance with TA89/05. Fixed signing shall be in accordance with drawing 5037856_20_01_03_1220 (‘Fixed Signing Details’). Appropriate lighting shall be provided for signs;
♦ The standard of reflectivity for sign faces shall be Class 1. Each new sign post located on motorway slip roads shall be identified by up to 6 vertical digits. The letters and numbers shall be black self adhesive vinyl mounted on a plate constructed from 3mm thick aluminium, faced with Class 1 reflective yellow with 100mm high characters at a minimum height of 1.5m above ground level. The numbers shall be detailed by the Overseeing Organisation; and,
♦ All passively safe posts shall comply with BS EN 12767. Passively safe posts may satisfy any of the four occupant safety levels specified in Table 3 of BS EN 12767.

4.9 Location of Cabinets

To locate the cabinets, the Designer needs to take into account the various site specific requirements.

The following cabinets are required for a RM site:

♦ Type 600 Cabinet for locating the RMC and signal head controller; and,
♦ Type 609 Cabinet providing power to the site.

The location of cabinets shall comply with SHW – Series 1500 and TA 77/97 of the DMRB (Vol. 9.5.1.).

The following guidelines shall be followed for siting cabinets:
For the purpose of commissioning and installation, it is advisable that the power 609 cabinet and communications type 600 cabinet are located in the same immediate vicinity as the RMC controller, ideally with a safe pull in area (enclosed if necessary) to allow for ease of validation, commissioning and maintenance; and,

- Alternative cabinet positions may be necessary dependant on the site layout. If installed between the ramp and the main carriageway, the preferred access shall be from the main carriageway.

### 4.10 Safety Fencing

Safety fencing shall comply in accordance with TD 19/06 of the DMRB (Vol. 2.2.8.) and SHW –Series 300 and 400.

In the 2006-2007 RM project, fencing was not required for signal heads placed upon passive poles, however a HA departure in accordance with TA 89/05 was required to overcome clause 2.5 ‘Use in nosing’ of the DMRB Volume 8 Section 2.

In sites where safety fencing already exists, RMC cabinets can be installed behind the fencing, should this be an option after considering the remaining design factors. The outstation design shall comply in accordance with the drawing MCX 0582. Road restraint systems adjacent to cabinet sites shall be of normal containment level N2 with a maximum working width of W4 (i.e. 1.3m) plus 1m additional working width from the safety fencings in accordance with MCX 0160.

Where modifications are required to existing safety barriers to incorporate a type 609 cabinet, design shall comply in accordance with MCX0146 and 0153 series drawings.

### 4.11 Location of a Safe Area for Calibration and Maintenance

Providing a safe area for validation of the RM system (e.g. site acceptance testing, calibration and maintenance) enables the validation exercise to be carried out in a safe and convenient way without any requirement for traffic management. The Designer shall take into consideration use of existing CCTV for calibration purposes.

The Designer shall comply with current CDM regulations and advise a safe area for calibration and maintenance depending on the site layout. Road safety audit assessments must be incorporated in to the design of a safe area.

### 4.12 Location of Lighting

The Designer shall provide detailed drawings for lighting signs and shall include details such as sign lighting illumination and switching requirements (lamp type and wattage), sign lighting cable length, trenching requirements and sign lighting power source. The positions of the illuminated signs and associated supply pillars shall be shown in the contract drawings and detailed in the Specification for Highways Work (SHW) document.
4.13 Cabling and Ducting

The design of cabling and associated infrastructure shall follow the current HA procedures and consist of, but not be restricted to the following:

- Loop installations and cabling;
- Loop feeder cables;
- Power cabling RMO to P and P to EI;
- Remote communications cabling;
- OAL cabling;
- Traffic signal cables; or,
- Breakaway cables in passive poles.

The system supplier is responsible for the traffic signal cabling as it is product specific and the system specific internal cabinet wiring. Cable routes shall be fully ducted for cabling between RMO and signal heads to allow for system specific cable installation after infrastructure provision.

NRTS are responsible for the national transmission network, including the longitudinal cabling, transmission equipment and local cabling to pre-defined interfaces (see Figure 4.5).

NRTS are responsible for providing the following:

- Links between the RMO and the MIDAS outstation (i.e. the RS485 OAL); and,
- Remote communications services, to allow supervisory connection over IP to the RMC.

Provision of remote communications shall be through an application to NRTS and current NRTS processes shall need to be followed with consideration of the associated lead times.

The provision of telecommunications and the allocation of responsibilities between the Contractor and NRTS Co shall be in accordance with the Table of Responsibilities from NRTS Guides 'MCH 1144 – Project Managers Guide'.

The Designer shall be aware of site specific aspects such as distance from nearest transmission station or telecommunications company availability, and any other local communications cabling requirements when making applications to NRTS.

The Designer shall prepare design drawings to indicate the locations of all RM components for the installation. The Designer shall prepare MCH1286 (‘Bulk Purchase Equipment Order’). The Designer shall identify remote communications required and shall indicate in communications drawings for installation purposes.
Figure 4.5 - Cabling Responsibilities
5. Additional Design Considerations

5.1 Road Safety Audit

HD 19/03 - Road Safety Audit Advice Note (DMRB Vol5, Section 2, and Part 3) details the requirements for Road Safety Audits which are mandatory. It contains information on the stages at which audits shall be carried out, the procedures to be followed and the requirement for monitoring of Highway Improvement Schemes after opening.

RM specific considerations for the road safety audit include but are not restricted to:

♦ Stopping vehicles on a high speed road;
♦ Protection of the rear of the queuing traffic;
♦ Safe operating speed of the system; or,
♦ Visibility of signal heads and associated signing.

5.2 Ecological

Beyond typical ecology surveys, ecology surveyors shall be aware of the following features associated with RM:

♦ Increased use of the slip road including queuing back to override loops;
♦ Increased emissions due to waiting traffic on the slip road;
♦ Decreased overall emissions on the main carriageway as a result of reduced congestion; and,
♦ Works affecting ecology could include civil work such as ducting and chamber installation.

Permanent changes to the area shall include a safe area for calibration/maintenance, new cabinets, signal heads and warning signs in the vicinity.

5.3 Infrastructure/Pavement/Geotechnical

This survey shall be carried out to identify the locations of relevant infrastructure, their orientation and related information. This shall include the following:

♦ Location of existing MIDAS loops on the main carriageway;
♦ Site clearing associated with installation of roadside equipment;
♦ Location of existing longitudinal cabling or alternative, for communication to MIDAS loops on main line and communication from RMC to LAN/WAN;
♦ Location of any power cabinets;
♦ Location of any communication cabinets;
Location of cross carriageway ducts;
Location of any obstacles/ suitable locations for communications/ power routes;
Location of cable joints;
Verify pre-existing diagrams CAD/ As-built;
Compare site selection information to real site;
Ensure storage on slip road is accurate;
Measure and verify distances between the tip of the chevrons/ back of chevrons (soft nose start) to local marker posts;
Explore potential to realign merge area (extend merge area) using a white lining exercise;
Explore the cable routes for communication/ power requirements and routes available; and,
Consideration of a pavement survey prior to the installation of anti skid surfacing.
6. Future Enhancements

6.1 Introduction

This section aims to draw the Designer's attention to the requirements and likely developments of future RM systems, which shall be taken into consideration during the design phase.

The future works are likely to involve enhancements to the existing systems to achieve better and more efficient solutions to traffic merging onto the motorways. Consideration and knowledge of the following future enhancements shall enable the designs of RM sites to have provision to make any kind of enhancements in the future. Such future-proofing, where possible, shall make it easier and more cost effective to implement these solutions in the future. Some of the considerations are listed below:

♦ Impact of infrastructure/layout;
♦ Impact of control algorithm development;
♦ Additional enforcement to ensure drivers adhere to red lights at RM signals;
♦ Installation of variable message sign (VMS) in RM sites;
♦ Impact of implementing Integrated Traffic Management (ITM);
♦ Impact of implementing Active Traffic Management (ATM);
♦ Ramp meter status sharing, shared information for incident management and detection;
♦ Requirements for altering signal timing plans along alternate routes during an incident or event to alleviate congestion and move traffic efficiently;
♦ Linking to local roundabouts to enable further traffic control; and,
♦ Linking RM with controlled motorway and variable motorway speed limits.

6.2 RM Carriageway Detection

Main carriageway detection on RM sites currently uses MIDAS for upstream and downstream detection. It is likely however that in the future there are sites that will be selected where MIDAS is not located at the correct location for the identification of flow breakdown.

Installing MIDAS loops can be an expensive operation requiring lane closures, considerable planning and modifications to the NMCS in-station site data. For these reasons a variety of alternatives to the MIDAS system could be deployed for upstream and downstream vehicle detection. These may include some of the following:
ANPR technologies, radar technologies that do not require lane closures to install, and are independent of the NMCS COBS in-station and site data; and,

Deployment of dedicated RM traffic detectors and associated outstations for use on the main carriageways that are independent of the NMCS COBS in-station and site data.

The Designer shall take into account additional infrastructure requirements, power requirements, communication requirements between alternative technology and RMO/ operator interface setting facility from RCC, NRTS requirements/approvals etc.

Changes to the algorithms and capabilities of RMCs are also likely to influence the choice of RM carriageway detection. Currently the RMC can be connected to four downstream carriageway loops, however the RMC is only able to utilise one of these at any one time (the RMC is set during configuration to use one of the four detection points). Future the algorithm capabilities of the RMC are likely to be extended to enable a larger variety of downstream detection points to be utilised simultaneously. This development will enable a large range of flow breakdown locations to be monitored by a range of detectors simultaneously.

6.3 Development and Deployment of Merge Loops

Merge loops may be deployed in the future to overcome the following merging issue.

Current RM systems suffer with an issue whereby drivers leaving the stop line prefer to queue at the earliest section of the merge area, where the outer lane of the slip road meets the main carriageway. By doing this the vehicles do not utilise the full length of the merge area. The problems caused by one long large platoon queuing at the earliest part of the merge include:

- A large platoon entering the main carriageway at one location causes flow breakdown of the carriageway; and,
- The large platoon of queuing vehicles located at this earliest part of the merge blocks emergency vehicles attempting to drive down the hard shoulder and across the junction.

This issue is particularly common when the main carriageway is forced to a standstill (for example following an accident).

To overcome the problem of allowing a queue to build on the slip road before the merge area, merge loops are likely to be developed (refer to Figure 6.1).

Merge loops will be an array of loops sited at a location on the slip road typically half way between the soft nosing and the start of the merge (refer to Figure 6.1). These loops will be used to detect a queue of traffic from the merge. The RMO on detecting a merge queue will reduce or stop flow from the stop line until this queue is cleared.
To configure a site using the existing RM system to utilise merge loops will require the following features to be designed:

♦ A merge loop array will need to be located at a point on the slip road approximately halfway between the merge and the soft nosing. The exact location will need to be determined at site based on the traffic issue and site layout; and,

♦ To accommodate use of a slip road loop as a merge loop, one less loop will be used as a queue detection loop behind the stop line. This would ideally be achieved by spreading a smaller number of queue detection loops across the storage area, but could also be achieved by reducing the storage area and bringing the override loop nearer to the stop line.

![Example Merge Loop Layout](image)

**Figure 6.1 - Example Merge Loop Layout**

### 6.4 Linked Sites

There are many sites that can use RM to reduce occupancy on a road to alleviate the problems at other junctions down stream. These sites are referred to as secondary sites, and can be metered to alleviate a bottleneck downstream. Sites suited to this kind of ramp metering tend to be close to the area of the bottleneck.

Using the existing RMC to reduce traffic on the mainline at sites downstream is already possible. This can be facilitated through the RMC’s functionality that enables a downstream loop (up to 4 loops downstream) to be selected. However, should a situation arise in which a number of RM sites are deployed to solve a bottleneck downstream, there will eventually be a requirement for the RM systems to coordinate with each other. Coordination is likely for the following reasons:
♦ To ensure release rates are coordinated for the control of occupancy at the bottleneck; and,
♦ To ensure queue control may be coordinated between the sites, such that queue waiting times are balanced in a favourable way.

The design parameters at secondary sites are different to typical primary sites, mainly because the merging speed is much higher at secondary sites. This is due to the fact that secondary sites are metered to aid occupancy at points of flow breakdown further downstream of the junction. It is highly likely that there will not be congestion at the secondary site, when RM is required. This means that the merging speed will be high and queuing metered road users will not appreciate why they are being held up on the slip road. Designers will therefore be required to consider the following:

♦ A long acceleration distance for the drivers to reach the high merging speed; and,
♦ Potential signs and good publicity to overcome the problems that drivers will have due to waiting in a queue, with apparent free flowing traffic passing locally.

Designers will also need to consider that there will potentially be a requirement for the RMC to intercommunicate with a variety of other sites requiring the following considerations at sites that could potentially be linked:

♦ Potential communications paths required between sites; and,
♦ Possibility of updates to RMC equipment at sites to modify algorithms running on software and potential hardware updates.

Where the arriving traffic volume is greater than the capacity of the road, a bottleneck occurs. A bottleneck can be identified by the queue of vehicles that form upstream of it. Temporary bottlenecks occur when a lane is closed due to an incident.

At sites such as M6-M62 (which has closely located slip roads leading to a main junction), congestion at the main junction could be reduced by linking RM systems to regulate traffic joining the motorway from the tributary slip roads. The linking of sites enables regulation of traffic from any of the slip roads contributing a high volume of traffic. Due to the fact that the bottleneck is downstream of the slip roads, the main carriageway traffic, at these sites is likely to be free flowing when RM is required and therefore travelling at higher speeds than downstream traffic nearer to the main junction. At such slip road sites, Designers shall take into account the merge speed, and location of stop line (which needs to be further from the merge area, enabling greater acceleration distance), and alternatively the setting of speed restrictions on the main carriageways to enable safe merging.

The overall aim of linked RM site aims at balancing the entering and exiting traffic volumes over a stretch of the motorway. Based on this objective, the flow rates are calculated taking into consideration further operational constraints such as capacity of motorway, the importance of each ramp in the network traffic and local traffic conditions.
6.5 Motorway to Motorway Sites

During the 2006-2007 RM rollout project, all sites were non-motorway-slip-road to motorway sites. However, many of the most suitable sites for RM are motorway to motorway sites.

There are three different types of motorway to motorway merges. They are:

- Motorways which have a roundabout. These present the least problems as they are similar to sites which have a roundabout on the local road;
- Sites which have a free-flow link between two motorways (M62 J10/M6 J21a). There will be issues here such as sight lines, as traffic may be travelling at higher speeds; and,
- Direct motorway to motorway (such as the M5 to the M6). Where one motorway ends as the merge into another. These will be the most difficult to design as there are serious safety implications and signalling issues. There could be issues regarding approval also which might require a departure.

The risks involved in having a queue on a main line motorway due to RM need to be considered. These risks can be minimised at the design stage, through the following considerations:

- Ensure the system does not switch on until the speed on both main carriageway and joining carriageway are low enough. Designers need to take into account \( V_{in} \) and minimum occupancy on the slip road/joining motorway as well as on the main carriageway;
- There is a need to protect all parts of the queue so queue warning message signs shall be used on the higher speed slip roads. Good sight lines to all parts of the queue shall be required. Apply high friction surfacing to the queue storage area and its approach for such sites; and,
- As RM controls the queue on the slip road/joining motorway Designers would need to measure the effects of the upstream queue on both motorways to balance the queue density or even queue length on each upstream main line section.

6.6 Integrated Traffic Management

Integrated Traffic Management (ITM) is a technique used at traffic signal controlled motorway intersections aimed at reducing overall network delay. The length of a queue on an on-slip is constantly monitored, and the status this is passed to the traffic signal controller controlling the gyratory feeding the slip road. When a certain size of queue exists on the slip road, the traffic signal controller will adjust its control in an effort to reduce the traffic sent to the slip road.

In terms of design considerations, there needs to be a mechanism to transfer data between the RMC and the traffic signal controller. Most RM sites currently utilise a 609 cabinet at the top of the slip road which is the most appropriate location to connect into the traffic signal ducted network. There are many considerations for the ITM link as follows:
There needs to be sufficient capacity in the existing ducted network to route cables to the traffic signal controller; and,

A large signal controlled gyratory often uses two traffic signal controllers, working as a pair. In this situation, one controller acts as a master to issue commands to the other controller, the slave. The ITM link will need to be interfaced at the master controller. If the controllers are configured in this way, there will be a cable between the two controllers to issue the commands. If the controller nearest the RM site happens to be the slave controller, then, subject to availability the cores within that cable they can be utilised to input the data to the master controller.

At M42-M3 Junction 3 Eastbound on-slip, the slip road is fairly small and connected to local roundabout. When a large platoon of vehicles join the slip road (released by the local traffic lights), it usually fills the slip road immediately and triggers the override loops. This results in the RMO flushing the traffic onto the motorway leading to a large merge problem on the main carriageway. In future, if RM systems could be linked to detect platoons of vehicles joining local roundabouts, then the overfilling of slip roads could be avoided by trickle release of the entire slip road queue, in anticipation of a release of vehicles from the roundabout traffic lights. Such a system of operation would make space on the slip road for each platoon of vehicles.

This system will require additional software development to enable an RMC to communicate with the traffic light systems, in order to detect the size of platoons of vehicles at local roundabout waiting to join the slip roads. The main requirement is for the RMC to determine when to be operational and to detect a developing bottleneck.
7. **Summary**

The Designer will receive information from the site selection process such as:

- Site listings;
- Flow data; and,
- Site suitability records.

From this information, site visits, existing as-built records, the Designer is responsible for the delivery of outputs to enable:

- The infrastructure installation phase; and,
- The configuration setup phase.

To progress the installation phase the Designer, typically needs to output a documentation package to the Contractor that should include but is not limited to:

- Works order packages containing designs, specifications, bill of materials etc;
- Health and safety/ Geotechnical information/ Ecological information;
- CAD drawings of the design proposals based on the design considerations outlined in this document;
- Departure from standards information;
- MIDAS OAL documentation for the NRTS Contractor; and,
- Calculations for cabling requirements.

To enable the completion of the configuration process, the Designer is responsible for:

- Compilation of the MIDAS outstation information (pertaining to the MIDAS outstations selected for main carriageway detection);
- Preparation of amendments to the MIDAS site data; and,
- Operational strategy records including flow data.
8. **References**

8.1 **Traffic Sign Regulations General Directions**

543 – Traffic signals ahead

584 – Traffic queues likely on road ahead

584.1 – Queues likely

601.1 – STOP sign (hexagonal)

1002.1 – Stop line painted on the road surface

1022 – ‘STOP’ written on the road surface

3000 – Light signal

8.2 **Specification for Highway Works**

Series 300 – Fencing

Series 400 – Road Restraint system (Vehicle and Pedestrian)

Series 900 – Road Pavements – Bituminous Bound Materials

Series 1200 – Traffic Signs

Series 1400 – Electrical Works for Road Lighting and Traffic Signs

Series 1500 – motorway Communications

8.3 **Design Manual for Roads and Bridges**

TD 19/06 (2.2.8) – Requirement for Road Restraint Systems

HD 28/04 (7.3.1) – Skidding Resistance

TA 12/81 (8.1.1) – Traffic Signals on High Speed Roads

TD 45/94 (9.1.1) – Motorway Incident Detection and Automatic Signalling (MIDAS)

HD 20/05 (9.3.1) – Detector Loops for Motorways

TA 89/05 (8.2.2) – Use of Passively Safe Signpost, Lighting Columns and Traffic Signal Posts to BS EN 12767.
9. Glossary

**Active Traffic Management**

Systems which give the motorist information and advice on the road network ahead. The aim is to improve the performance of the network by redistributing traffic efficiently when congestion occurs with in certain links whilst spare capacity is available on others.

**Asymmetric Digital Subscriber Line (ADSL)**

A data communications technology that enables faster data transmission over copper telephone lines than a conventional system. This is done by utilising frequencies that are not used by a voice telephone call.

**Advance Warning Signs**

Signs that warn drivers of queues or part-time traffic signals at entry to slip roads.

**Armoured Cable**

A cable which incorporates a layer of steel wire wrapped helically around the cable to provide mechanical protection from damage. The armour wire is protected from moisture by a polyethylene sheath. The sheath is coated with graphite - this graphite coating is used when testing the integrity of the sheath.

**Automatic Number Plate Recognition (ANPR)**

A surveillance method that uses optical character recognition on images to read the licence plates on vehicles. Systems can scan number plates at around one per second on cars travelling up to 100 mph (160 km/h). They can either use existing closed-circuit television or road-rule enforcement cameras, or ones specifically designed for the task.

**Cabinet type 600**

Standard motorway equipment cabinet, for use on motorway verges, to house equipment such as Standard Transponders, MIDAS Transponders and Routers. Also used as a Marshalling Cabinet.

**Cabinet type 609**

Standard motorway cable connection cabinet, for use on motorway verges, to house connection boxes for data, and also used to house (separately) electrical power supply distribution and isolation equipment.
Cantilever

An overhead structure which extends from the verge. It has only one leg which is located in the verge. Often used to support Enhanced Message Signs (EMS) and Enhanced Matrix Indicators (EMI).

Chambers

Underground structures of a standard size used to house cable joints and to facilitate cable installation. Chambers may be constructed from brick, plastic or concrete.

Closed Circuit Television (CCTV)

A system using remotely controlled television cameras to monitor traffic patterns at sites susceptible to traffic congestion such as tunnels, junctions and interchanges. The images are transmitted from the camera to the Control Office (CO) over the fibre optic cable infrastructure.

Construction Design and Management (CDM)

These are regulations that integrate health and safety into management of the project and to encourage everyone to work together to improve planning and management of projects, identify hazards earlier and reduce risks.

Controlled Motorway

Main features of controlled motorway are mandatory speed control, automatic signal setting in response to traffic conditions, speed enforcement using automatic camera technology and driver information using enhanced message signs.

Design Manual for Roads and Bridges (DMRB)

This provides a comprehensive manual system which accommodates, within a set of loose-leaf volumes, all current standards, advice notes and other published documents relating to design, assessment and operation of trunk roads including motorways.

Duct

Provide the means by which cables may cross carriageways from one verge to the other, from one verge to the central reserve and one side of a slip to the other. The standard provision is for a group of four 100mm diameter ducts at nominal 500 metre intervals.

Flow Breakdown Characteristics

Flow breakdown characteristics indicate the pattern in which flow breaks on a road and the time periods of occurrence. MTV plots are an excellent example depicting
flow breakdown characteristics along with the speed restrictions deployed on the road.

**Ghost Island**

A ghost island is an area of the carriageway suitably marked to separate lanes of traffic travelling in the same direction for merging and diverging.

**High Friction Surfacing (HFS)**

High friction surfacing is a pavement laying method which is applied at the beginning and near the traffic signals of the slip road. HFS renders a different colouring to the pavement surface.

**Highway**

Any form of road including single carriageway, dual carriageway and motorway.

**Instation**

Those parts of the National Motorway Communications System (NMCS) which are normally located within the Control Centre. Often referred to as the building that contains the control centre and provides an office type environment for equipment sited at the instation. See also Outstation.

**Integrated Traffic Management (ITM)**

ITM is a technique used at traffic signal controlled motorway intersections aimed at reducing overall network delay.

**Local Area Network (LAN)**

Telecommunications terminology for a data communications network used to interconnect personal computers and equipment over a limited area.

**Longitudinal cable**

The 30 pair copper and 24 fibre cables (two separate cables) running parallel to the highway in the duct network, each pair and fibre is dedicated to a specific purpose. The 30 pair copper cables may be augmented by composite copper/optical fibre cables dedicated to CCTV or carrier circuits. The 30-pair copper cable is nominally jointed at intervals of 500m and the 24-fibre cable is nominally jointed at intervals of 100m.

**Maintenance**

Maintenance of equipment comprises the activities undertaken to repair an item of failed equipment and the activities undertaken to prevent items of equipment from failing (preventative maintenance).
**MIDAS Detector**

Equipment installed in a Cabinet Type 600W which processes information received from cable loops buried in the carriageway which detects the presence of vehicles. The configuration of loops allows speed to be determined.

**Motorway Access Management (MAM)**

See Ramp Metering.

**Motorway Incident Detection and Automatic Signalling (MIDAS)**

A Control Office Base System (COBS) subsystem which monitors traffic flow conditions and interacts with signal subsystems to automatically set signals without operator intervention. Signals are set when queuing traffic is detected.

**National Motorway Communications System 2 (NMCS2)**

A system using locally based distributed processing to signals, installed from 1988.

**National Road Telecommunications System (NRTS)**

National Road Telecommunications System is the Highways Agency Contractor responsible for Motorway Telecommunications.

**Optical Fibre Cable**

Cable comprising glass fibres through which light is transmitted. The light is used as a medium for the transmission of signals. Optical fibre cables allow transmission over very long lengths due to their immunity from electromagnetic interference.

**Outstation**

Site installations outside computer centres and Control Offices, set up at convenient positions along the motorway to house communications equipment, such as Responders, distributors, signal controllers, signal switches, connectors, terminal panels, and power supply units.

**Outstation Auxiliary Link (OAL)**

The MIDAS outstation auxiliary link (OAL) is used to feed data to the Ramp Metering Outstation alongside the normal data flow from MIDAS.

**Override loops**

The purpose of the override loops is to ensure that the queue is flushed from the slip roads when it reaches a certain length. When override loops are triggered with a specific occupancy, the Ramp Metering Controller detects this state and forces queue override algorithm to flush the queue by forcing a high release rate.
Port

Telecommunications terminology for a physical interface or connection between equipment or between equipment and cables. A standard transponder has one High Level Data Link Connection (HDLC) port to the Local Communications Controller (LCC) and four RS485 ports.

Presence Loops

Detector loops placed on the road to detect presence of vehicles behind the STOP line at the slip road.

Quad Cable

A 4 wire cable in which all the wires are twisted (laid) together, rather than in 2 pairs. This reduces cross pair interference where the pairs are used as the same channel.

Ramp Metering

This is a traffic management principle which regulates the number of vehicles allowed to join a motorway. The purpose of the system is to prevent or delay the onset of flow breakdown on the main carriageway. Ramp Metering is a technique that implements this principle.

Ramp Metering Controller (RMC)

It provides the functionality for filtering data from the ramp loops and OAL, running algorithms within an algorithm framework, system logging, and fault reporting, it also provides a web-based supervisory interface.

Ramp Metering Outstation (RMO)

The RMO is the roadside intelligent controller which gathers information from the sensors performs the ramp metering algorithms and controls the signal heads.

Ramp Storage

The length of slip road that is assigned to store traffic waiting to join the motorway. The storage space extends from the presence loops near the traffic signals to the queue override loops near the entry to slip road.

Release Loops

Detector loops placed on the road to detect release of vehicles from the STOP line at the slip road.
Road Safety Audit

Road safety audits are intended to ensure that operational road safety experience is applied during the design and construction process in order that the number and severity of accidents is kept to a minimum.

RS485

A data protocol (EIA RS485) and practice adopted for use by NMCS2 between the Standard Transponder and motorway devices.

Sign

A device carrying directional or other informational message e.g. route information at the approach to a junction.

Signal

A device used to give advisory or mandatory instructions, e.g. stop or 30 mph speed restriction.

Signal controller

An outstation device local to a signal dedicated to controlling a signal.

Site Acceptance Testing (SAT)

Testing carried out to verify that installed equipment is operating correctly on-site.

Site Data

The Control Office Base System data that identifies all of the outstation devices within the Control Office Area and defines the device’s operational characteristics. Site Data also encompasses Signal Sequencing Data which describes the road layout, signal positions and traffic engineering consideration to the Central Processor/Database/Control office processor base system.

Traffic Management Systems

Systems which give the motorist information and advice on the road network ahead. The aim is to improve the performance by providing supplementary information, redistributing and re-routing traffic.

Urban Traffic Control (UTC)

Urban Traffic Control is a term used to describe the technique of co-ordinating traffic signals through a centrally located computer.
UTMC

UTMC, Urban Traffic Management and Control, is a Department for Transport funded initiative leading to the next generation of open traffic management solutions.

Variable Message Sign (VMS)

A sign which can display a number of defined legends or messages.

Velocity ($V_{in}$)

The speed of vehicles on the main carriageway. This affects the merge of vehicles from slip roads and hence is a critical factor that shall be taken into account.

Wide Area Network (WAN)

A data network that covers a large area and requires specialist transmission equipment to cater for all its interconnections.
10. List of Abbreviations

ANPR - Automatic Number Plate Recognition
CCTV - Closed circuit television
CAD - Computer Aided Drawing
CDM - Construction Design and Management
DMRB - Design Manual for Roads and Bridges
HGV - Heavy Goods Vehicle
HFS - High Friction Surfacing
HCD – Highways Construction Details
ITM- Integrated Traffic Management
LAN - Local Area Network
MIDAS - Motorway Incident Detection and Signalling
NRTS - National road telecommunications services
NMCS2 - National motorway control system 2
OAL- Outstation Auxiliary Link
RCC- Regional control centre
RM- Ramp metering
RMC – Ramp Metering Controller
RMO-Ramp Metering Outstation
SAT - Site Acceptance Testing
SHW- Specification for Highway Works
TSRGD - Traffic Signs Regulations and General Directions
UTC – Urban Traffic Control
UTMC – Urban Traffic Management and Control
Vin - Speed in to ramp metering junction
VMS - Variable message sign

WAN - Wide Area Network
Appendix A

Included below are the communications design drawings for the existing RM site at M6 J22 southbound for reference purposes only.
Appendix B

Included below is GT 46/5/190 authorisation for use of the Ramp Metering backing board, and GT 46/5/190 (Pt 1)-1 backing board drawing 5053147_20_02_1503. Note that the Authority dictates that only a backing board specified to drawing 5053147_20_02_1503 may be used on slip roads, and only for the purpose of ramp metering.

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ROAD TRAFFIC REGULATION ACT 1984 – SECTION 64
AUTHORISATION OF TRAFFIC SIGNS AND SPECIAL DIRECTIONS

The Secretary of State for Transport, in exercise of her powers under Section 64 of the Road Traffic Regulation Act 1984, and all other powers enabling her in that behalf, for the purpose of introducing ramp metering schemes incorporating light signals on motorway trunk roads in England, hereby:

1. authorises the erection of a traffic sign comprising a traffic signal and a yellow surround (hereinafter referred to as 'the authorised sign') conforming as to shape, colour and character with the diagram numbered GT46/5/190(Pt 1)-1; and

2. specifies that the authorised sign may be placed only in conjunction with the road marking shown in diagram 1001 in schedule 6 to the Traffic Signs Regulations and General Directions 2002 (S.I. 2002/2313) ("the 2002 Regulations"); and

3. directs without prejudice to any statutory provision to the like effect, that it is a condition that the erection of the authorised sign shall continue to have effect only until such day as may be appointed by one month's notice given by the Secretary of State in writing to the traffic authority for the removal or alteration of the authorised sign and on that day the said authorisation shall, without prejudice to the giving of any further authorisation or direction, come to have effect.

The provisions of regulations 32, 33 and 30 of the shall apply to the authorised sign in the same manner as they apply to the light signal shown in diagram 3000 in Schedule 8 to the 2002 Regulations.
RAMP METERING

Technical Design Guidelines

Schedule 8 to the 2002 Regulations.

Dated 21 December 2007

Signed by authority of the Secretary of State

A Grade 7 Officer of the Department for Transport

CERTIFIED TRUE COPY

21 DEC 2007

DEPARTMENT FOR TRANSPORT
1. All poles to be 6.24m high

2. Lower signal to be orientated to be seen by a driver waiting at the stop line.