# Standards and Guidance Documents

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| **Document Title** | Control and Communications Technology Appraisal |
| **Reference** | TA 121 – Ramp Metering |

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| **Date** | 2020 |
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**The small print:**

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Design Manual for Roads and Bridges

Control & Communications Technology
Appraisal

# TA 121
# Ramp metering

(formerly IAN 103/08, IAN 121/09)

Revision 0

**Summary**
This document contains appraisal requirements for ramp metering.

**Application by Overseeing Organisations**
Any specific requirements for Overseeing Organisations alternative or supplementary to those given in this document are given in National Application Annexes to this document.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

**This is a controlled document.**

# Contents

# Release notes

| Version | Date | Details of amendments |
|---|---|---|
| 0 | Jan 2020 | TA 121 replaces IAN 103/08 and IAN 121/09. This full document has been re-written to make it compliant with the new Highways England drafting rules. |

# Foreword

## Publishing information

This document is published by Highways England.

This document supersedes IAN 103/08 and IAN 121/09, which are withdrawn.

This document contains relevant information from MCH 2470 and MCH 2471.

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

Ramp metering is a traffic management technique which manages the number of vehicles joining a main carriageway at peak periods. The purpose of ramp metering is to prevent or delay the onset of flow breakdown on the main carriageway and assist with its recovery.

Ramp metering systems use part-time traffic signals on the slip road which come into operation when traffic sensors on the main carriageway indicate heavy traffic. The detectors on the main carriageway along with queue detectors on the slip road enable the system to determine the required flows from the slip to keep the main carriageway flowing close to critical occupancy.

A successful design of a ramp metering site relies on knowledge and understanding of motorway communication devices and design, traffic flows, motorway traffic behaviours and ramp metering control algorithms.

Ramp metering systems aim to control the flow of vehicles joining the motorway and all-purpose trunk road network and are recognised as being fundamentally different to traditional traffic signalling systems which manage vehicle conflicts and provide safety functionality.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 1.N] apply to this document.

# Abbreviations

**Abbreviations**

| Abbreviation | Definition |
|---|---|
| CLF | Cableless Linking Facility |
| ITM | Integrated Traffic Management |
| MIDAS | Motorway Incident Detection and Automatic Signalling |
| MOVA | Microprocessor Optimised Vehicle Actuation |
| SCOOT | Split Cycle Offset Optimised Technique |
| veh/lane/hr | Vehicles per lane per hour |

# Terms and definitions

**Terms**

| Term | Definition |
|---|---|
| Critical occupancy | The downstream main carriageway occupancy at which the maximum downstream traffic flow rate is achieved. |
| Downstream | That part of the carriageway(s) where the traffic is flowing away from the section in question. |
| Integrated traffic management | An interface between the ramp metering system and one or more third party systems which provides additional system functionality and control. |
| Local scheme | Improvement project undertaken in the vicinity of a ramp metering site with potential to affect traffic characteristics. |
| Main carriageway | The section of road network which vehicles will join or leave via junction merges and diverges. |
| Physical characteristics | The alignment and topology of a ramp metering site.<br><br>NOTE: This includes the number of traffic lanes and gradients on slip roads and the main carriageway, the location of infrastructure etc. |
| Queue detector | Traffic detector (multiple) used to indicate the length of a queue. The queue detectors are located between the presence detector and queue override detector. |
| Ramp metering | A traffic management technique which manages the number of vehicles joining a main carriageway in peak hour periods in response to current traffic conditions. |
| Ramp metering site | The slip road, main carriageway and equipment necessary to operate a ramp metering system. |
| Stop line | The solid white line which is located adjacent to the ramp metering signals and crosses the entry slip road. |
| Traffic characteristics | The speeds, flows, occupancy, congestion seed points and general behaviours of traffic in the vicinity of a ramp metering site. |
| Upstream | That part of the carriageway(s) where traffic is flowing towards the section in question. |

# 1. Scope

## Aspects covered

1.1 This document shall be used for identifying suitable locations that are likely to benefit from the implementation of ramp metering.

1.2 This document outlines the ramp metering appraisal requirements that shall be implemented on all new or modified ramp metering sites.

1.3 The potential for the implementation of integrated traffic management (ITM) shall be assessed using the information in Appendix A as guidance.

*NOTE* *Overseeing Organisation specific requirements related to the treatment of existing ramp metering sites can be found in the National Application Annexes.*

## Implementation

1.4 This document shall be implemented forthwith on all schemes involving ramp metering on the Overseeing Organisations' motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 1.N].

## Use of GG 101

1.5 The requirements contained in GG 101 [Ref 1.N] shall be followed in respect of activities covered by this document.

# 2. Ramp metering appraisal

## General

2.1 For recurrent congestion problems caused either by the merge or the main carriageway traffic characteristics, the site shall be assessed to determine whether it is suitable for ramp metering using the following approach:

1) assess the traffic characteristics at the site;
2) assess the suitability of the entry slip road geometry.

*NOTE 1 Specific examples of traffic characteristics where ramp metering has been found to be particularly effective are:*

*1) merging traffic from entry slip road disrupting main carriageway traffic flow;*
*2) weaving traffic as a result of closely located merge and diverge of adjacent junctions;*
*3) entry slip roads fed by signalised junctions on the adjoining network causing large platoons of motorway bound traffic;*
*4) entry slip road flows overloading merge capacity;*
*5) entry slip road affected by flow breakdown downstream of the junction;*
*6) where queuing traffic is already present on the entry slip road during peak periods;*
*7) short or sub-standard merge areas;*
*8) where a bottleneck exists downstream on the main carriageway as a result of a bend or a gradient;*
*9) two lane entry slip roads which have been artificially reduced to one lane in an attempt to restrict joining traffic.*

*NOTE 2 There are no individual physical characteristics that rule out a site for selection completely. The main consideration is the practicality of locating the stop line and signals safely as these affect both the acceleration distance for vehicles merging safely and the storage capacity for queuing vehicles. Forward visibility to the stop line and signals are required to account for the high approach speeds.*

2.1.1 The assessment of the site to determine its suitability for ramp metering should include the forecast impact on traffic characteristics and road geometry from other schemes.

*NOTE 1 Ramp metering schemes for imminent implementation need not account for any adjustment in traffic growth.*

*NOTE 2 Future traffic growth can be evaluated where, for example, a future development is expected in the vicinity of the junction.*

*NOTE 3 Other schemes likely to have an impact on the traffic characteristics can include:*

*1) changes to traffic flows;*
*2) changes to geometry including road markings;*
*3) changes to the number of lanes / operating regime on the motorway;*
*4) changes to speed restrictions in the area;*
*5) impact of downstream improvement schemes.*

2.2 Traffic characteristics shall be determined using available traffic data from representative time periods (e.g., peak hours over multiple weeks).

*NOTE A MIDAS detection system, for example, is an acceptable source to obtain traffic data that can be collected and analysed.*

2.2.1 The traffic data collection period should allow assessment over a number of days (excluding school holidays, special events and adverse weather conditions).

*NOTE At least a two week period for traffic data collection is typically suitable. However, a more in-depth traffic data assessment provides a more useful understanding.*

## Criteria for provision of ramp metering

2.3 Ramp metering shall be proposed when traffic characteristics and road geometry allow the management of slip road flows and reduce main carriageway congestion.

2.3.1 Ramp metering should be provided when each of the following traffic characteristics are valid:

1) annualised hours of main carriageway delay is greater than 10,000 vehicle hours delay, or average main carriageway speeds are less than 30mph for greater than 100 hours over an annual period;
2) the downstream main carriageway flows per lane are at least 1250 vehicles per hour during congested periods;
3) the average entry slip road flow per lane is not less than 400 vehicles per hour or greater than 1250 vehicles per hour during congested periods;
4) the entry slip road flow is between 10% and 45% of downstream traffic flow on the main carriageway during congested periods.

*NOTE Previous site assessment has demonstrated the average main carriageway delay reduction to be 13%.*

2.3.2 Where entry slip road flows exceed the maximum flow, excessive slip road queuing may be prevented by:

1) provision of integrated traffic management to better manage slip road demand in collaboration with adjoining road authorities (see Appendix A);
2) re-modelling the entry slip road to increase the number of lanes or storage capacity and reduce the entry slip road flow per lane;
3) use of local knowledge, observations and specialist expertise to assist in justifying the suitability of the site.

*NOTE Where the maximum entry slip road flows per lane are exceeded, the installation of a standard ramp metering system can lead to excessive queuing on the entry slip.*

2.3.3 Ramp metering may still be provided when the road geometry includes:

1) one or two lane entry slip roads;
2) curved entry slip road;
3) ghost island;
4) lane gain from entry slip road.

*NOTE Ramp metering can struggle to perform effectively when there is:*

*1) a bottleneck causing a large congestion problem, where capacity of the main carriageway is greatly exceeded;*
*2) a reduction of main carriageway capacity due to lane loss;*
*3) traffic backing up from an off-slip and blocking a lane of the main carriageway;*
*4) diverging tailbacks from downstream motorway intersections;*
*5) roadwork traffic management / accident causing lane loss on the main carriageway.*

## Existing ramp metering sites and new main carriageway interventions

2.4 An assessment shall be conducted where a main carriageway intervention is proposed in the vicinity of an existing ramp metering site, and only subsequently modified or removed with the approval of the Overseeing Organisation.

2.5 The traffic characteristics and road geometry of the current and proposed arrangement shall be assessed as follows:

1) main carriageway characteristics (changes to speed limits, quantity of lanes, merge type and length);

2) ramp metering characteristics (changes to gradient, alignment, traffic signals and proximity of diverge);

3) traffic characteristics (changes to the quantity and ratio of downstream main carriageway flows and slip road flows).

*NOTE* *The treatment of existing ramp metering sites and new main carriageway interventions can be assessed using the assessment tool available from the Overseeing Organisation as described in the National Application Annexes. The assessment tool can help to determine any expected changes in annualised hours of operation based on the traffic characteristics and the road geometry proposals.*

2.6 The existing ramp metering system shall be:

1) retained in its current state if the annualised hours of operation are expected to be at least 40;

2) modified as necessary to be compatible with the main carriageway intervention if the annualised hours of operation are expected to be at least 60.

# 3. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |

# Appendix A. Integrated traffic management

## A1 Introduction

Integrated traffic management (ITM) is the practice of connecting to and sharing information between local authority and national authority control systems to reduce congestion in the locality of a motorway junction and improve efficiency through the coordinated operation of both systems. This typically involves providing an interface between ramp metering systems and traditional traffic signalling systems.

ITM requires the commitment and cooperation of both the national and local authorities and both organisations should be involved at all stages in the process of developing an ITM solution.

## A2 Benefits of ITM

The fundamental purpose of ITM is to improve the flow of traffic at the boundary of the motorway and local road network. The technical approach integrates the operation of ramp metering with the operation of the adjacent traffic signal systems to better manage the combined network. Information / data from one system is dynamically used by the other system to better manage and control the traffic intending to join the motorway from the local road network.

When functioning correctly ITM can deliver the following benefits:

Primary benefits:

1) overall improvement of junction performance during peak demand;
2) net reduction in journey times for vehicles crossing the junction on the local network and vehicles entering the motorway network from the local network;
3) reduction in journey times for vehicles travelling along the motorway through the junction;
4) improvement in the utilisation of the circulatory junction for local traffic;
5) reduction in the likelihood of queue blocking at the roundabout from vehicles trying to enter the motorway;
6) improvement of ramp metering operation through minimising the effects of queue override and optimising queue management.

Secondary benefits:

1) improved working relationships between national and local authorities;
2) improved maintenance agreements;
3) opportunity to implement other improvements at the junction.

## A3 Criteria for the selection of ITM

### A3.1 Basic criteria

The criteria for assessing the suitability of a site for the application of ITM relates to the control mode of the traffic signal systems at the junction and the resultant local traffic conditions.

A potentially suitable ITM site requires the operation of ramp metering and the partial or full signalisation of the interchange which typically uses one of the following traffic signal control modes. The most suitable ITM strategy will be dependent on the control mode for the junction.

1) cableless linking facility (CLF);
2) microprocessor optimised vehicle actuation (MOVA); or
3) split cycle offset optimised technique (SCOOT).

If the junction is partially signalised, the performance of ITM will be improved if the partial signalisation occurs on the arm of the junction which provides the highest flows to the motorway in either the a.m. or p.m. peak demand period. In addition, the junction should be sufficiently congested such that it will benefit from ITM.

ITM should provide benefits when the flow of traffic onto the slip road is higher than the ramp metering system or motorway merge can cope with efficiently. When assessing the suitability of a site, this situation is most easily recognised through analysis of the queue profiles within the ramp metering system (frequent high-flow requests from the queue management or queue override algorithm).

If slip road flows exceed 1250 veh/lane/hr for short periods of time, then ITM should also be assessed for potential use as it is likely that these very high flows could be smoothed out by ITM.

An understanding of the following elements should support the decision as to whether a junction with ramp metering is suitable for ITM:

1) flow rates on the slip road and on the main carriageway;
2) proportion of time the ramp metering system spends in queue management mode as opposed to the main carriageway control mode;
3) the number of times that queue override events occur in a typical peak period;
4) the profile of the queue on the slip road. A queue which regularly fluctuates from small to large may be supportive for ITM;
5) the profile of the release rate from the stop line. Erratic release rates may indicate that ITM could be adopted;
6) typical sizes of platoons entering the slip road from the signalised gyratory;
7) control strategy and settings of the traffic signal system feeding traffic on to the motorway;
8) any evidence of traffic queuing from the motorway merge onto the local road network.

### A3.2 Irregular causes of congestion

ITM should be assessed for potential use where local traffic conditions cause irregular congestion. For example, junctions near major venues which generate localised problems causing the gyratory to 'lock' may be suitable for ITM.

The relatively low costs of an ITM solution mean that it should be assessed for potential use to address even the most irregular causes of congestion.

### A3.3 Liaison between authorities

ITM works optimally when it provides a mutual benefit to traffic on the national and local road networks or provides a benefit to one of the networks without having a detrimental effect on the other. As such, ITM requires the commitment and involvement of both national and local authorities in the process of developing an ITM solution.

## A4 The ITM interface

There are two possible mechanisms for providing the interface between the ramp metering and traffic signal systems as follows:

### A4.1 Local link connection

A local link requires infrastructure to be installed on-street to allow communication between the two systems. The connection may be either a wireless or cabled link. For a cabled solution, the durability of the link, cost of construction materials and post-installation maintenance should be assessed. For a wireless link, a radio path analysis under varying conditions should be conducted.

### A4.2 Centralised instation connection

A centralised instation connection can be implemented if both the ramp metering and the traffic signal systems operate using a centralised control (e.g., urban traffic control system) which can facilitate a greater range of information-sharing and control functionality. These solutions would not typically require the implementation of any specialised on-street cabling or equipment.

Irrespective of the interfacing option, it is necessary to ensure that information security of either system is not comprised in any way.

It is recommended that the national and local authority stakeholders are consulted with regard to acceptable standards for cabling or equipment installation within their jurisdiction. The termination and testing of the cables, equipment and control logic should be carried out by engineers competent in the disciplines of ramp metering and traffic signal systems.

If installing infrastructure on-street, a mini-pillar or chamber at the network boundary fence line may simplify demarcation points for maintenance purposes but also adds complexity to the design and introduces an additional failure point.

## A5 ITM control strategy

ITM control strategy can be used to vary signal timings on the signalised junction to ensure the most efficient flow of traffic onto the motorway and local network. In its most basic form, ITM can limit the number of vehicles trying to enter the motorway system by reducing green time on the approach road with the highest supply of motorway-bound traffic.

The control strategy is facilitated by sharing real time network metrics (speeds, occupancies, flows, events etc.) between the two systems. Both systems will need to be configured to send / receive the appropriate data and eventual control mechanisms. The configuration activities should be undertaken by a person(s) competent in the discipline of ramp metering and traditional traffic signals systems. The chosen control mechanism may differ depending on traffic behaviours observed on-street or the control mode of the traffic signal systems.

The key to an efficient ITM solution is ensuring that the systems optimise the flow of traffic across both networks. Achieving the optimal set-up is a skilled task for a team having competencies in both ramp metering calibration and traffic signal control.

Control & Communications Technology
Appraisal

# TA 121
# England National Application Annex to TA 121 Ramp metering

(formerly IAN 103/08, IAN 121/09)

Revision 0

**Summary**
This National Application Annex contains the Highways England specific appraisal requirements for ramp metering.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

**This is a controlled document.**

# Contents

# Release notes

| Version | Date | Details of amendments |
|---|---|---|
| 0 | Jan 2020 | Highways England National Application Annex to TA 121. |

# Foreword

## Publishing information

This document is published by Highways England.

This document supersedes IAN 103/08 and IAN 121/09, which are withdrawn.

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This National Application Annex gives the Highways England-specific appraisal requirements for ramp metering.

Ramp metering is a traffic management technique which manages the number of vehicles joining a main carriageway at peak periods. The purpose of ramp metering is to prevent or delay the onset of flow breakdown on the main carriageway and assist with its recovery.

Ramp metering systems use part-time traffic signals on the slip road which come into operation when traffic sensors on the main carriageway indicate heavy traffic. The detectors on the mainline along with queue detectors on the slip road enable the system to determine the required flows from the slip to keep the mainline flowing close to critical occupancy.

A successful design of a ramp metering site relies on knowledge and understanding of motorway communication devices and design, traffic flows, motorway traffic behaviours and ramp metering control algorithms.

Ramp metering systems control the flow of vehicles joining the motorway and all-purpose trunk road network and are recognised as being fundamentally different to traditional traffic signal systems which manage vehicle conflicts and provide critical safety functionality.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 1.N] apply to this document.

# Terms and definitions

**Terms**

| Term | Definition |
|---|---|
| Ramp metering | A traffic management technique which manages the number of vehicles joining a main carriageway in peak hour periods in response to current traffic conditions. |

# E/1. Existing ramp metering sites and new mainline interventions

E/1.1 A ramp metering site shall only be removed with the approval of Highways England.

E/1.1.1 To gain approval from Highways England, the ramp metering task force change request form should be submitted as detailed in Appendix A.

*NOTE* *A tool to assess the treatment of ramp metering sites and mainline interventions can be obtained from Highways England by contacting the ramp metering task force at the following email address: RMTF@highwaysengland.co.uk.*

# E/2. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |

# Appendix E/A. A Ramp metering task force change request form

Table to be completed and submitted to RMTF@highwaysengland.co.uk

**Table E/A.1 Ramp metering task force change request form**

| Status Quick Ref. | | | | |
|---|---|---|---|---|
| Change Number: | | Status: | o Submitted<br>o Deferred<br>o Rejected | o Accepted<br>o Implemented |
| Date: | | | | |

**Table E/A.2 Ramp metering task force change request form**

| | | | |
|---|---|---|---|
| Proposal Details | | | |
| Originator's Name: | | Originator's Ref: | |
| Request Title: | | | |
| Change Type | Site Specific o<br>Core System o | | |
| Location(s) | | | |
| Items Affected: | o Hardware / o Software / o Configuration / o Documentation /o Drawing / o Other: | | |
| Request Detail: | | | |
| Reason: | | | |
| Will the change or its implementation have an effect on the operation of the RM site, or the network? | o Yes<br>o No | | |
| If YES – How? | | | |
| Supporting Docs: | | | |
| Perceived Priority: | o HIGH<br>o MEDIUM<br>o LOW | | |
| Anticipated Cost of Change: | N/A | | |
| Payment Responsibility | RMTF o<br>Scheme o<br>Area Team o<br>Other: | | |

**Table E/A.3 Ramp metering task force change request form**

| Initial Review | | |
|---|---|---|
| Reviewed By: | | |
| Position: | | |
| Company: | | |
| Signed: | | |
| Date: | | |
| Agreed Status: | o Deferred<br>o Rejected<br>o Accepted | |
| Agreed Priority: | o HIGH<br>o MEDIUM<br>o LOW | |
| Highways England Project Sponsor | | |
| Signed: | | |
| Date: | | |
| Explanation: | | |

**Table E/A.4 Ramp metering task force change request form**

| Subsequent Review (only to be completed following Further Analysis) | | |
|---|---|---|
| Reviewed By: | | |
| Position: | | |
| Company: | | |
| Signed: | | |
| Date: | | |
| Agreed Status: | o Deferred<br>o Rejected<br>o Accepted | |
| Agreed Priority: | o HIGH<br>o MEDIUM<br>o LOW | |

**Table E/A.4 Ramp metering task force change request form** (continued)

| | |
|---|---|
| Explanation: | |

**Table E/A.5 Ramp metering task force change request form**

| Change Request History | |
|---|---|
| Date: | Comment: |

Department for Infrastructure
An Roinn Bonneagair

Control & Communications Technology
Appraisal

# TA 121
# Northern Ireland National Application Annex to TA 121 Ramp metering

(formerly IAN 103/08, IAN 121/09)

Revision 0

**Summary**
There are no specific requirements for Department for Infrastructure Northern Ireland supplementary or alternative to those given in TA 121.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated team in the Department for Infrastructure, Northern Ireland. The email address for all enquiries and feedback is: dcu@infrastructure-ni.gov.uk

**This is a controlled document.**

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| 0 | Jan 2020 | Department for Infrastructure Northern Ireland National Application Annex to TA 121. |

Control & Communications Technology
Appraisal

# TA 121
# Scotland National Application Annex to TA 121 Ramp metering

(formerly IAN 103/08, IAN 121/09)

Revision 0

**Summary**
There are no specific requirements for Transport Scotland supplementary or alternative to those given in TA 121.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Transport Scotland team. The email address for all enquiries and feedback is: TSStandardsBranch@transport.gov.scot

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| 0 | Jan 2020 | Transport Scotland National Application Annex to TA 121. |


Control & Communications Technology
Appraisal

# TA 121
# Wales National Application Annex to TA 121 Ramp metering

(formerly IAN 103/08, IAN 121/09)

Revision 0

**Summary**
There are no specific requirements for Welsh Government supplementary or alternative to those given in TA 121.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Welsh Government team. The email address for all enquiries and feedback is: Standards_Feedback_and_Enquiries@gov.wales

**This is a controlled document.**

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