

**MCE0107**  
**Issue B**  
**July 2006**

**NMCS2**  
**Advanced Motorway**  
**Indicator (AMI)**  
**Equipment**  
**Requirements**

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First published 2006

Printed and published by the Highways Agency

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## **1 RECOGNITION OF EQUIVALENT STANDARDS, MATERIALS OR ARTICLES**

Any requirements of this specification for goods or materials must be made in accordance with the Manual of Contract Documents for Highway Works, Volume 1 – Specification for Highway Works, Series 100 – Preliminaries, Clause 104.

## **2 INTRODUCTION**

### **2.1 Purpose of document**

This document is the Requirement Specification for the Advanced Motorway Indicator (AMI) and associated outstation equipment. It supersedes earlier specifications for the initial development of the AMI conducted under Highways Agency Contract 1/113. The AMI is a Motorway Signal capable of displaying Mandatory Speed Limit aspects, by illuminating a Red Ring around the central matrix portion of the display.

The AMI is intended to be used on Mandatory Variable Speed Limit schemes, such as the Controlled Motorway scheme (e.g. M25) and Active Traffic Management (e.g. M42). In addition to satisfying Highways Agency Type Approval requirements, the AMI shall form part of a Speed Enforcement System and will therefore require approval by the Home Office. Further information on this process is given in Chapter 12.

### **2.2 Requirements Notation**

Requirements statements are expressed as either:

- mandatory requirements, denoted by M:xxx
- desirable requirements, denoted by D:xxx
- information statements, denoted by I:xxx

where xxx is the unique statement identifier.

Mandatory requirements are those requirements that shall be met in full. They represent the minimum necessary subset of the requirement that, if not fulfilled, would make it impossible to meet the system's objectives. Desirable requirements are those which are less crucial, and need not be met on a specific procurement. Information statements provide additional information for clarification purposes or to support the requirements, they do not constitute a requirement. Text that introduces a section has not explicitly been identified as an Information statement.

A requirement will sometimes comprise of a number of closely related detailed requirements such that it is sensible to express them as part of the same requirement statement. In these cases, the detailed requirement statements are given sub-references of the form a:xxxx.y, where:

- a is M or D
- xxxx is the specific requirement number
- y is the sub-reference number.

These will appear within brackets appended to the sub-requirement statements.

## 2.3 Scope of Document

This specification defines the requirements for the Advanced Motorway Indicator (AMI) and associated outstation equipment. The AMI is a lane-based motorway signal capable of displaying standard aspects within a central matrix. The AMI incorporates a Red Ring for the display of variable mandatory speed limits and dual-colour lanterns. A variant of the AMI shall additionally be capable of providing an output to Speed Enforcement Equipment.

The **AMI** comprises a Central Matrix, Red Ring, Lanterns, Display Driver, interface to AMI Roadside Controller and, where applicable, Interfaces to Speed Enforcement Equipment.

The term **AMI System** is used to refer to a group of AMIs (gantry or post mounted) and their associated AMI Roadside Controller and interconnections. For Portal Gantry-mounted AMIs this includes a Cable Marshalling Unit. (CMU). Therefore this specification defines requirements for

- AMI
- CMU
- AMI Roadside Controller
- AMI to CMU cabling
- AMI Roadside Controller to CMU cabling

The AMI System shall be compatible with NMCS2 architectures, but shall also be capable of interfacing to an IP network.

The AMI shall be capable of operating over an Actively Managed Hard Shoulder, including the associated requirements for Speed Enforcement.

The AMI is capable of receiving Luminance Broadcast information from an Ambient Light Monitor (ALM). The requirements for the ALM are contained in MCE 0110 "Requirements for Ambient Light Monitor (ALM) Equipment"

An overview of the NMCS2 System is presented in MCH 1618, "NMCS2 Technical Overview".

M:1 The design of the AMI shall be suitable for the following applications:

- (a) Portal Gantry installations without operational Speed Enforcement Equipment (M: 1.1)
- (b) Portal Gantry installations with operational Speed Enforcement Equipment (M:1.2)

- (c) Post Mounted installations for Entry Slip and Carriageway sites, without operational Speed Enforcement Equipment (M:1.3)

M:4 AMI systems shall be designed to allow external control from either RS 485 or Ethernet interfaces. This shall be achieved by the implementation of an AMI Roadside Controller, which in combination with the AMI signal, fulfils all the requirements of this Specification. Interfaces referred to as external should be regarded as being those external to the system, defined as AMI, AMI Roadside Controller and where applicable, a Cable Marshalling Unit.

The AMI Roadside Controller shall be designed to provide RS 485 (NMCS2) and Ethernet (IP) interfaces to the control network. Both interfaces shall be tested for interoperability. (M:4.1)

The interface between the AMI Roadside Controller and the AMI shall be designed and tested to provide an RS 485 interface: (M:4.2)

I:5 The principle behind the Speed Enforcement System design is that the Speed Enforcement Equipment must only be activated when the AMIs connected to it are, beyond reasonable doubt, displaying appropriate Aspects and are fault free.

## 2.4 Related Documents

Document	Title
MCE0110	Requirements for Ambient Light Monitor (ALM) Equipment



## 2.5 Glossary of Terms

The terms and abbreviations used in this document are as follows:

<b>ACPO</b>	Association of Chief Police Officers
<b>Actively Managed Hard Shoulder</b>	A section of Hard Shoulder which is capable of being brought into use as a temporary additional running lane in response to operational requirements. (e.g. in Active Traffic Management area). When not in use as a running lane the Hard Shoulder may still be used for stopping in an emergency.
<b>ALM</b>	Ambient Light Monitor
<b>AMI</b>	Advanced Motorway Indicator. A variable speed limit signal used to display Mandatory and other Motorway Signal Aspects. The AMI display incorporates separate Central Matrix, Red Ring, and Lanterns.
<b>AMI-EE</b>	Advanced Motorway Indicator variant with additional functionality to interface with (Speed) Enforcement Equipment.
<b>Aspect</b>	A defined recognisable optical output displayed by the AMI, triggered by a defined command message.
<b>Cable Marshalling Unit</b>	Junction box facilitating the inter-connection of the control and addressing circuits for a group of up to eight gantry-mounted AMIs. Additionally, at gantry sites equipped for speed enforcement, the Cable Marshalling Unit facilitates the interlinking of Speed Enforcement Interface circuits for an Enforcement AMI Group.
<b>CMI</b>	Controlled Motorway Indicator: Previous generation of Mandatory Variable Speed Limit Signal. Forerunner to the AMI.
<b>CMU</b>	Cable Marshalling Unit
<b>AMI System</b>	The AMI System comprises a number of AMIs (gantry or post mounted) controlled by an AMI Roadside Controller. Gantry-mounted variants are connected via a Cable Marshalling Unit.
<b>Central Matrix</b>	The central optical output portion of the AMI front face.
<b>Contractor</b>	Organisation awarded contract by the Highways Agency for supply of the equipment in this specification.
<b>Control Data</b>	Communications data. Generated by the Transponder and used for control of the AMI System.
<b>Control Field</b>	The second byte of a five-byte message used in the communications protocol to define message type and function.

<b>DfT</b>	Department for Transport
<b>Display Driver</b>	An electronic module controlling an optical output device.
<b>Drive Code</b>	An 8 Bit code used in the communications protocol and corresponding to a particular Aspect
<b>EE</b>	(Speed) Enforcement Equipment.
<b>Enforcement Equipment</b>	Equipment required to obtain prosecution of motorists not obeying mandatory speed limits, comprising speed measurement device, camera unit, control unit and AMI interface.
<b>Enforcement AMI Group</b>	One or more AMI-EE units connected to a common CMU and therefore capable of being connected to Speed Enforcement Equipment.
<b>Equipment</b>	Depending on the context, any or all of the equipment to be designed and supplied under the contract.
<b>Ethernet</b>	A Local Area Network (LAN) conforming to the IEEE 802.3 standard.
<b>IP-based Control System</b>	Anticipated Control System and associated communications architecture with the capability to control motorway signalling outstation equipment
<b>Fallback</b>	An alternative bitmap for the central matrix portion of an aspect, which can be displayed by the AMI in the event of pixels in the main bitmap being faulty.
<b>HOSDB</b>	Home Office Scientific Development Branch. Government department working in partnership with specialist representatives from ACPO, to ensure Speed measuring systems are fit for purpose.
<b>Infill Panels</b>	Also referred to as “side closure plates”. Panels fabricated to fill the side and floor apertures between the AMI and Gantry to prevent the hazard of items falling on to the motorway.
<b>Lane Closed Aspect</b>	The “Broken Cross” style of RED X aspect compliant with TSRGD diagram 5003.1 which is used to signify that an Actively Managed Hard Shoulder is not available as a running lane. When displayed in combination with a valid set of mandatory speed limits over the main carriageway renders the main carriageway lanes enforceable at the displayed speed limit. The LANE CLOSED aspect shall use a different Drive Code to the STOP X aspect.
<b>Lantern</b>	A flashing light source incorporated into a Variable Message Sign or Motorway Signal display which is designed to draw attention to the Sign or Signal. (“Conspicuity Device”). Required to accompany certain defined Aspects.

<b>Luminance Control</b>	The process by which the illuminance of a Variable Message Sign or Motorway Signal display can be varied automatically to account for varying ambient lighting conditions
<b>Mandatory Speed Limit Aspect</b>	A speed limit aspect displayed by an AMI with its Red Ring illuminated. Signifies that the prevailing maximum speed is enforceable below the National Speed Limit.
<b>Module</b>	An enclosed sub-assembly of the AMI housing PCB(s), individual components etc. and designed to provide protection to such circuits and components etc. and to allow faulty modules to be easily removed and replaced for maintenance purposes.
<b>Message</b>	A combination of RS 485 - 5 Byte (Each 8 Bits) Hexadecimal Numbers designed to convey Control and Reply Data over the Department's communications system.
<b>Optical Output Device</b>	General term for any part of the AMI display i.e. Main Matrix, Red Ring or Lanterns
<b>Portal Gantry</b>	A portal structure designed to support Motorway Signals, a Variable Message Sign and/or Fixed Destination Signs.
<b>Post</b>	Means of mounting AMI or other Signals at a Motorway or Slip Road verge site.
<b>Red Ring</b>	The part of the AMI display which when emitting light renders the accompanying speed limit mandatory.
<b>Red X</b>	Generic term covering STOP X and LANE CLOSED aspects. These aspects share a common circuit within the Speed Enforcement Interface.
<b>Reply Data</b>	Communications data. Generated by the AMI and forming the replies to Control Data.
<b>AMI Roadside Controller</b>	A microprocessor-controlled unit located within a roadside cabinet that interfaces with the Highways Agency communication system and supervises a number of AMIs on a gantry.
<b>Speed Enforcement Interface</b>	The interface by which an AMI indicates its status to the speed Enforcement Equipment. Internal sensing of voltage, current and optical output from the display must all agree and the AMI must be fault-free for a positive confirmation to be provided over the interface. Furthermore, a valid combination of aspects must be displayed by all AMIs in the Enforcement AMI Group for enforcement to be enabled.
<b>Speed Enforcement</b>	Equipment designed to detect and record evidence of vehicles exceeding the speed limit. The combination of Speed Enforcement Equipment with an

<b>Equipment</b>	Enforcement Group of AMI-EE units can be used to operate a Mandatory Variable Speed Limit Scheme.
<b>Stop Aspect</b>	Generic term representing either (i) the STOP X aspect displayed on a Gantry-mount AMI; or (ii) the TT aspect displayed on a post-mount AMI.
<b>Stop X</b>	Motorway Red X aspect compliant with TSRGD diagram 6031.1.
<b>Supplier</b>	See Contractor
<b>TSRGD</b>	Traffic Signs Regulations and General Directions
<b>TT</b>	'Wicket' aspect signifying both lanes of a two-lane on-slip are closed, compliant with TSRGD diagram 6032.1.

## 2.6 Drawing References

MCX1031 accompanies this specification. Drawings bearing this number originated from Mouchel Parkman under Highways Agency Contract 1/113. The following table shows the mapping between the two numbering schemes:

MCX1031 sheet number	Equivalent MP drawing reference (CGH/42553/)
1	2204D
2	2209C
3	2210C
4	2207I
5	2211C
6	2118C
7	2117E
8	2212A
9	2213A

### 3 AMI SYSTEM FUNCTIONAL REQUIREMENTS

This Chapter describes what the AMI System is required to do in terms of inputs, outputs, major operational functions, error / failure detection reporting, and retained data.

Except where stated, the requirements of Chapter 3, including all subsections that follow, apply to **all** types of AMI defined in Section 2.3.

Where reference is made to NMCS2 Specifications for Signal Site Equipment and the requirements relate to “Signal Drivers” and “Indicators” etc. the requirements shall apply to AMI.

Figures 3.1 and 3.2 below outline the architecture of NMCS2 and IP-based systems respectively:

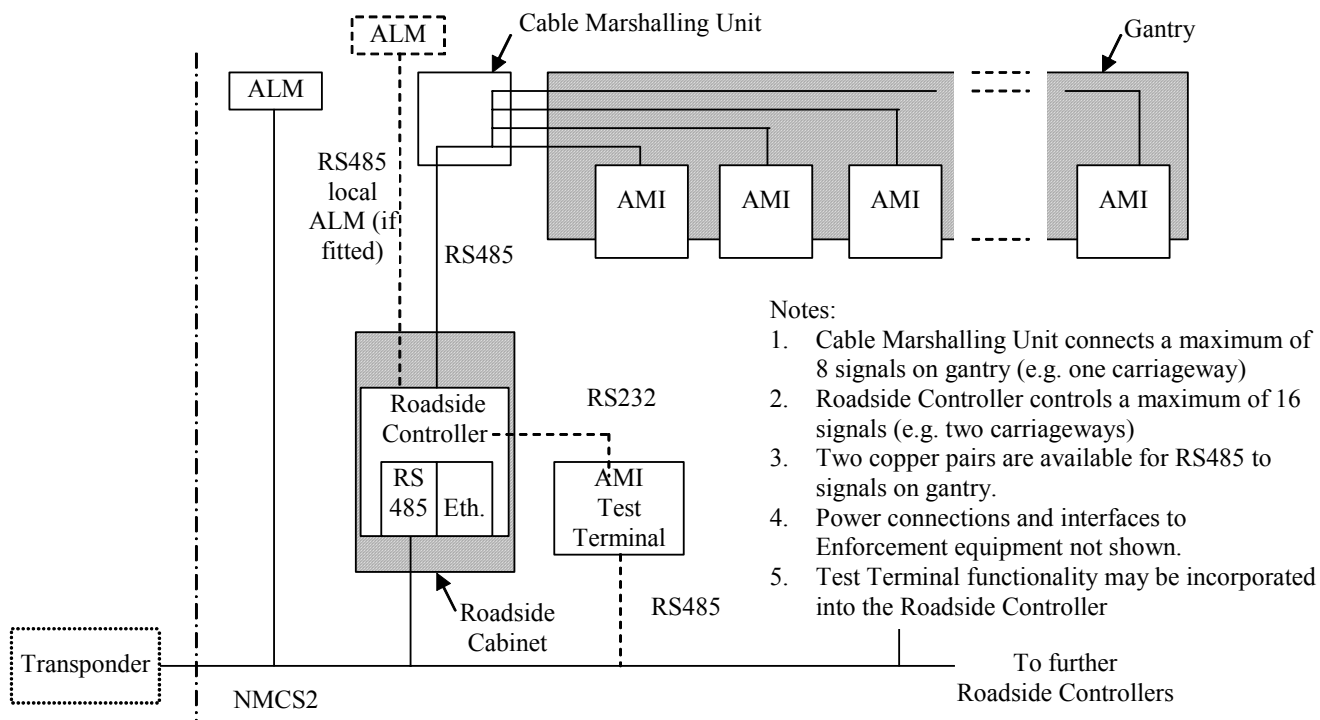


Figure 3.1 – NMCS2 Control System Architecture

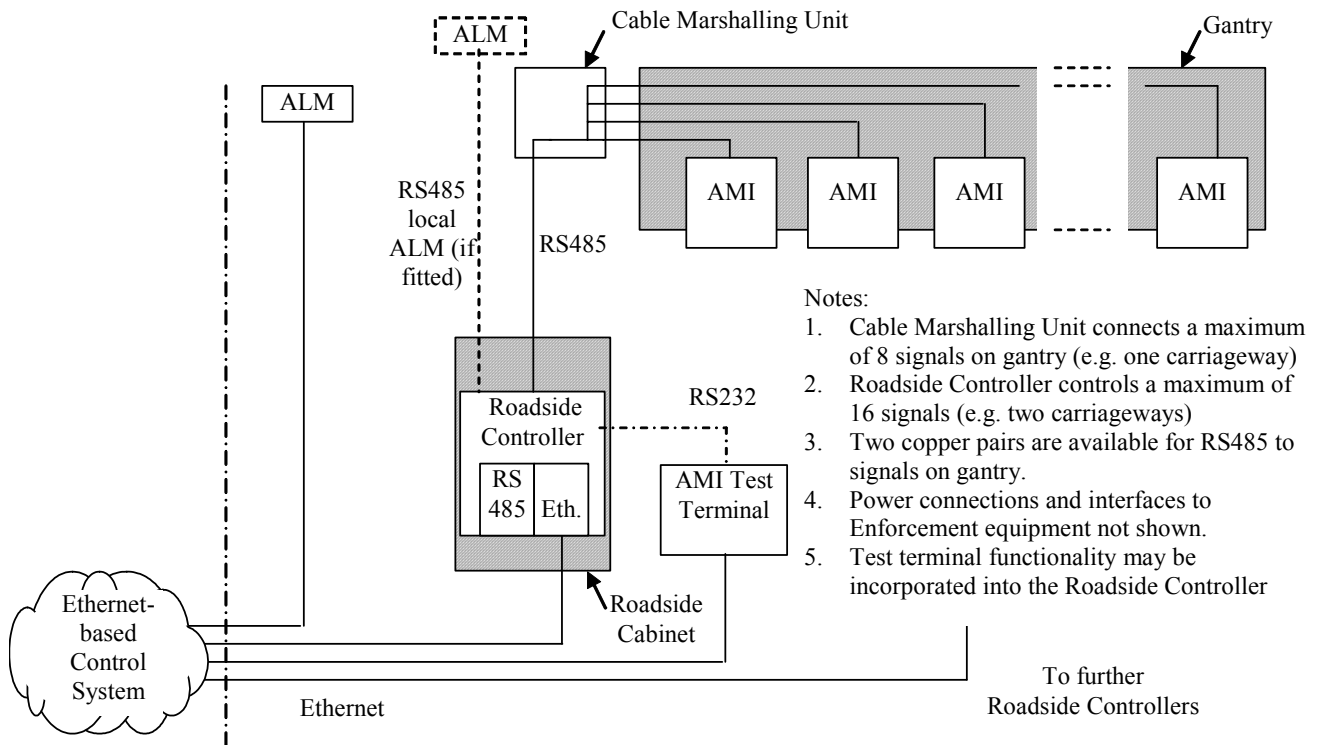


Figure 3.2 – Ethernet Control System Architecture

A typical deployment of the NMCS2 Control System Architecture on a four-lane Portal Gantry, including Actively Managed Hard Shoulder is shown in MCX1031 sheet 7.

### 3.1 AMI Inputs

This subsection details the functional inputs of the AMI System.

#### Connections at AMI Roadside Controller

- NMCS2 Standard Transponder
- Local Ambient Light Monitor (if fitted)
- Ethernet LAN
- AMI Test Terminal – Diagnostics Interface

#### Connections at AMI

- Adjacent AMI – Speed Enforcement Interfaces (AMI-EE Types only)

#### 3.1.1 From the NMCS2 Standard Transponder

M:100 The AMI System shall be provided with an RS 485 communications interface to receive messages from the Standard Transponder. The messages relate to the Central Matrix, Red Ring and Lanterns under the control of the AMI. The target AMI will be identified by the address within the message.

M:101 Messages transmitted to the AMI shall be as defined in TR 2043 Section 3.1.1 and also:

- LUMINANCE BROADCAST message, CF=(2AH)

### **3.1.2 From the Local Ambient Light Monitor**

M:110 The AMI System shall be provided with a second RS 485 communications interface to receive Luminance Broadcast messages from the Local Ambient Light Monitor. The messages relate to the ambient light level measured at the gantry site.

M:111 Messages transmitted to the AMI are:

- LUMINANCE BROADCAST message, CF=(2AH)

### **3.1.3 From the Ethernet LAN**

M:130 The AMI System shall be provided with an Ethernet communications interface capable of receiving messages from an IP-based Control System.

I:131 Messages transmitted to the AMI System from the IP-based Control System shall be based on those defined in TR 2043 Section 3.1.1, for messages transmitted on the RS 485 circuit from the NMCS2 Standard Transponder to the AMI, and also:

- LUMINANCE BROADCAST message, CF=(2AH)

I:132 Messages transmitted to the AMI from the AMI Test Terminal shall provide the AMI Test Terminal facilities required by Chapter 6.

I:133 Details of the message set for communications via the Ethernet LAN are given in Section 11.

### **3.1.4 From Adjacent AMI – Speed Enforcement Interface**

M:140 The AMI-EE variant shall be provided with inputs for the interconnection of the Speed Enforcement Interface confirmation circuits across all AMIs in an Enforcement AMI Group. Requirements for the Speed Enforcement Interface is defined in Chapter 4.

### **3.1.5 From the AMI Test Terminal – Diagnostics Interface**

M:150 The AMI System shall be provided with an input from the AMI Test Terminal PC to provide the diagnostics facilities defined in Section 6.5.

M:151 As an alternative to M:150, the AMI Test Terminal functionality may be integral to the AMI Roadside Controller.

## **3.2 AMI Outputs**

This subsection details the functional outputs of the AMI System.

Each AMI has the following output destinations:

### **Connections at AMI Roadside Controller**

NMCS2 Standard Transponder

Ethernet LAN

AMI Test Terminal – Diagnostics Interface

### **Connections at AMI**

Adjacent AMI – Speed Enforcement Interface (AMI-EE Types only)

### **Connections at Cable Marshalling Unit**

Speed Enforcement Equipment - Speed Enforcement Interface (AMI-EE Types only)

### **3.2.1 To the NMCS2 Standard Transponder**

M:180 The AMI System shall be provided with an RS 485 communications interface to send messages to the Standard Transponder. Messages shall only be transmitted in response to valid messages received from the Transponder. The messages relate to the Central Matrix, Red Ring and Lanterns under the control of the AMI. The source AMI will be identified by the address within the message.

M:181 Messages transmitted by the AMI System shall be as defined in TR 2043 Section 3.2.1.

### **3.2.2 To the Ethernet LAN**

M:190 The AMI System shall be provided with an Ethernet communications interface to send messages to the IP-based Control System.

I:191 Messages transmitted by the AMI to the IP-based Control System shall be based on those defined in TR 2043 Section 3.2.1, for messages transmitted on the RS 485 circuit from the AMI to the NMCS2 Standard Transponder.

I:192 Messages transmitted from the AMI to the AMI Test Terminal shall provide the AMI Test Terminal facilities required by Chapter 6.



I:193 Details of the message set for communications via the Ethernet LAN are given in Section 11.

### **3.2.3 To Adjacent AMI - Speed Enforcement Interface**

M:200 The AMI-EE shall be provided with outputs for the interconnection of the Speed Enforcement Interface confirmation circuits across all AMIs in an Enforcement AMI Group. Requirements for the Speed Enforcement Interface are defined in Chapter 4.

### **3.2.4 To the Enforcement Equipment - Speed Enforcement Interface**

M:210 The Cable Marshalling Unit shall provide an output for the Speed Enforcement Interface connection to the Speed Enforcement Equipment. Requirements for the Speed Enforcement Interface are defined in Chapter 4.

### **3.2.5 To the AMI Test Terminal – Diagnostics Interface**

M:230 The AMI shall be provided with an output from the AMI Test Terminal to provide the diagnostics facilities defined in Section 6.5.

## **3.3 Operation**

This subsection describes the normal functional requirements of the AMI System including the processing of messages and the monitoring, testing and setting of devices.

### **3.3.1 General**

I:251 The AMI Roadside Controller is required so that the AMI control electronics can be implemented in a manner that allows:

- Reduction of duplicated circuitry mounted on the gantry
- Provision of a test terminal connection point at the roadside
- Improved System Reliability

M:252 The AMI Roadside Controller shall provide the capability to utilise either NMCS2 RS 485 or Ethernet as the means to interface to the Highways Agency communications system. A single AMI Roadside Controller shall be capable of controlling up to 16 AMIs in this way. See figures 3.1 and 3.2.

- M:253 Two 2-wire circuits shall be available for the interface between the AMI Roadside Controller and the AMIs. One pair of wires shall be multi-drop RS 485. The function of the other pair of wires shall be designated by the contractor, in a manner that does not interfere with normal operation of the system. The interface shall incorporate a means of remotely resetting the AMIs in the event that communication on the RS 485 is lost.
- M:258 Post-mounted AMIs shall be controlled from an AMI Roadside Controller, but not be connected via a Cable Marshalling Unit.
- D:259 Control and Addressing lines can be connected to all AMI variants in a common manner. For post-mount AMIs, a quad cable will be routed to the base of the post, where address settings will be hard wired and combined in a composite cable up to the sign itself. A means of identifying addresses utilised by post-mount AMIs (and therefore not available for use by gantry-mount) would be beneficial for maintenance purposes.

### 3.3.2 Operation of the AMI - Setting

- M:260 On power up and reset the AMI shall:
- a) De-energise all optical output devices.
  - b) Test all optical output devices and store results
  - c) Set Lantern Synchronisation status to Loss of Synchronisation messages
  - d) Set Luminance status to Loss of Luminance Broadcast messages
  - e) Determine Aspect status from the AMI Display monitoring circuits
  - f) Make ready to respond to messages from the Transponder
- M:261 The AMI shall operate in accordance with the following clauses in TR 2043, Section 3.3.1 as follows:
- M:51 M:52 M:54 M:58 M:59 M:60
- M:262 The Red Ring shall remain on when the AMI display changes from one Mandatory Speed Limit Aspect to another Mandatory Speed Limit Aspect.
- M:263 If an Aspect fails to set correctly the AMI shall attempt to set the 'fallback' display, if available (see M:543). (M:263.1)
- If no 'fallback' display is defined or the 'fallback' display fails to set correctly the AMI shall turn off the Aspect and, where necessary the Red Ring or Lanterns. Aspect and Lantern status shall be reported as OFF. (M:263.2)

If the STOP aspect (STOP X or TT) and the relevant ‘fallback’ aspect both fail to set correctly the AMI shall turn off the Aspect but the Red Lanterns shall continue to flash. Aspect status shall be reported as OFF with Red Lanterns ON. (M:263.3)

### 3.3.3 Aspect Display Capability

M:270 All AMI variants shall be capable of displaying any Aspect defined by SDIN tables 450, 451, 452, 455, 456 and 457, contained in MCH 1689.

M:272 All variants of AMI shall be capable of utilising the following Drive Codes, over and above existing SDIN table definitions. Note: The Standard Aspect Code (SAC) is not received by the AMI or the AMI Roadside Controller (as it is translated into the Drive Code by the Standard Transponder), but is included for completeness:

SAC Byte 1	Mnemonic	Drive Code (contained in SAC Byte 2)	Comments	Notes
10	70	8	Advisory ‘70’ aspect	See note 1
15	X	22	‘Broken Cross’ style of Red X	See note 2
27	1(C)	13	Downward Green Arrow	See note 3
42	70R	21	Mandatory ‘70’ aspect	See note 1

Note 1: The capability to display 70 and 70R aspects is required on all AMI variants. However, for the current implementation, SET requests for these aspects shall be blocked in the AMI Roadside Controller.

Note 2: Utilised on Actively Managed Hard Shoulder AMI installations.

Note 3: For possible future use.

I:273 The suffix ‘R’ is used to denote a speed limit aspect that requires the Red Ring to be displayed (e.g. 60R), as distinct from the equivalent advisory speed limit aspect (e.g. 60).

M:274 The AMI shall comply with the bitmap formats for ‘main’ and ‘fallback’ aspects defined by Drawing MCX1031 sheet 1.

### 3.3.4 Aspect Monitoring

I:280 The following clauses, M:281, M:282, M:283 and M:284 are to establish that the AMI is correctly displaying the correct Aspect.

M:281 When a SET message, CF=(20H) is received, the AMI shall check and validate the data content of the message, before displaying the appropriate Aspect. Pixels required to illuminate to form the aspect shall be confirmed to be ON. All other pixels shall be confirmed to be OFF. The AMI shall Monitor and record the status (ON or OFF) of the Aspect .

When a SET message requests Lanterns, the AMI shall illuminate the appropriate colour Lanterns and monitor their status in accordance with TR 2043, M:76 and M:86. (M:281.1)

The Aspect and Lantern status shall be used to prepare a STATUS REPLY message, CF=(23H) which shall reflect true Aspect and Lantern status as determined under M:281 and M281.1. (M:281.2)

M:281, M:281.1 and M:281.2 shall be completed within 300ms of receiving the last bit of a valid SET message. (M:281.3)

M:282 To confirm that the Aspect, Lantern and Red Ring status remains as set in M:281, the AMI shall routinely monitor their status at least every 5 seconds and retain the most recent result for use in preparing the subsequent STATUS REPLY.

M:283 The monitoring described in M:281 and M:282 shall employ both voltage **and** current measurement techniques for Aspect, Lanterns and Red Ring.

M:284 The AMI shall compare the status of the Aspect and Lanterns displayed with that required by the most recent SET message and if a difference is detected the AMI shall do the following (in the context of M:281 and M:282):

Where the SET message relates to an aspect other than STOP, the AMI shall turn OFF the Aspect (and where necessary the Amber Lanterns) and prepare a status reply as Aspect and Lanterns OFF. (M:284.1)

Where the SET message relates to the STOP aspect (STOP X or TT), the AMI shall turn off the Aspect but the Red Lanterns shall continue to flash. The status reply shall be prepared as Aspect OFF with Red Lanterns ON. (M:284.2)

M:285 The AMI shall incorporate the following checking, implemented either in hardware or software:

The Red Ring shall **ONLY** be capable of being energised for the following Aspects: 20R, 30R, 40R, 50R, 60R, 70R. (M:285.1)

The Amber Lanterns shall **NOT** be capable of being energised in conjunction with the following aspects: NR, STOP X, LANE CLOSED, TT. (M:285.2)

The Red Lanterns shall **ONLY** be capable of being energised in conjunction with the following aspects: OFF, STOP X, LANE CLOSED, TT. (M:285.3)

The Amber Lanterns shall not be set ON with any Mandatory Speed Limit Aspect (20R, 30R, 40R, 50R, 60R, 70R), unless configured to do so by M:312. (M:285.4)

### 3.3.5 Aspect Testing

M:300 The AMI shall routinely energise and test / monitor all optical output devices at least every 15 minutes during all periods when the AMI is set to Aspect OFF.

The test shall cause the appropriate optical output devices to be energised and monitored over a test period which shall not cause the test to be obtrusive during day / night, when observed from any point on the carriageway. (M:300.1)

M:301 When an Aspect other than OFF is set and correctly displayed, the routine testing of all other Aspects shall be suspended. The AMI shall reply with the Test Results stored during the previous routine test of the Aspect.

M:302 The AMI shall respond to the TEST message, CF=(24H) and REQUEST TEST RESULT message, CF=(25H), in accordance with TR 2043, M:100.1 and M:100.2.

The contents of the TEST RESULT message, CF=(26H) shall be determined by the result of the last routine test of the Aspect tested. (M:302.1)

M:303 If a critical failure is detected in the Red Ring (as defined in Table 3.3.8), then all Mandatory Speed Limit Aspects shall be deemed faulty.

### 3.3.6 Flashing Lantern Operation

M:310 The functional requirements for the Lanterns shall comply with all requirements of TR 2043 Section 3.3.4 as follows:

M:125 M:126 M:127 M:128 M:130 M:131 I:132 M:133  
M:134 M:135 M:200 M:1000 M:1001 D:1002 D:1003 M:1004  
I:1005.

M:311 The tolerance on the delay between receiving the last Bit of a FLASHER SYNCHRONISATION message, CF=(27H), and reset of Lanterns to the start of the sequence shall be such that all AMI Lanterns on the same RS 485 link are always synchronised.

M:312 The facility shall be provided to allow the amber flashing lanterns to operate for a period of one minute following receipt of a SET request for a Mandatory Speed Limit Aspect, when the previous display was a different Mandatory Speed Limit Aspect. This shall be configurable at the AMI Roadside Controller.

### 3.3.7 Luminance Control

M:320 Luminance control shall be based on use of the LUMINANCE BROADCAST message, CF=(2AH), which will be broadcast to the AMI from either:

- a) A Transponder via the NMCS2 RS 485 interface - NMCS2 Mode of luminance control. (M:320.1)
- b) An Ambient Light Monitor (ALM) via the Local RS 485 interface - Local Mode of luminance control (M:320.2)

I:321 The ambient light level on the motorway will be determined by an Ambient Light Monitor (ALM). The ALM is designed to operate either:

- a) As a "Slave" device to the Transponder which will poll the ALM and then transmit the LUMINANCE BROADCAST message to all AMIs on the RS 485 link. The AMI operates in NMCS2 Mode for luminance control.
- b) As a "Master" Device installed on every gantry which will broadcast the LUMINANCE BROADCAST message to every AMI on that particular gantry. The AMI operates in Local Mode for luminance control.

M:322 The AMI shall not reply to the LUMINANCE BROADCAST message.

M:323 The Luminance (or Luminous Intensity) of the AMI Aspect and the Lanterns shall be controlled by the AMI based on the data within DATA1 and DATA2 of the LUMINANCE BROADCAST message.

M:324 The data contents of DATA1 and DATA2 of the LUMINANCE BROADCAST message are defined in the ALM specification (MCE0110 – Ambient Light Monitor Equipment.).

The AMI shall adjust the Aspect / Lantern Luminance to the level necessary to comply with the Luminance Ratio requirements of BS EN 12966, for all of the ambient light level values defined by DATA2. (M:324.1)

M:325 The AMI shall use the value of DATA1 to determine the Luminance Mode as follows:

- a) NMCS2 Mode - The value of DATA1 is in accordance with TR 2070, M:1652 and the DATA1 Dim / Bright value shall be used for default luminance control. (M:325.1)
- b) Local Mode - The value of DATA1 is (FFH) and the SET message Dim / Bright value shall be used for default luminance control (M:325.2)

M:326 When DATA2 is a value in the range (01H) to (OFH), the AMI Aspect and Lantern Luminance shall be adjusted using data within the LUMINANCE BROADCAST message as follows:

When DATA1 (NMCS2 Mode) or the last SET message (Local Mode) is ‘Dim’, and DATA2 is any value in the range (01H) to (OFH) the Luminance shall be set to the level corresponding to the value of DATA2 - No Luminance Conflict. (M:326.1)

When DATA1 (NMCS2 Mode) or the last SET message (Local Mode) is ‘Bright’, and DATA2 is any value in the range (01H) to (03H) the Luminance shall be set to the level corresponding to DATA2=(06H) - Luminance Conflict. (M:326.2)

When DATA1 (NMCS2 Mode) or the last SET message (Local Mode) is ‘Bright’, and DATA2 is any value in the range (04H) to (OFH) the Luminance shall be set to the level corresponding to the value of DATA2 - No Luminance Conflict. (M:326.3)

M:327 When DATA2 is (FFH) or (OOH), or a valid LUMINANCE BROADCAST message has not been received in the last 180 seconds, the AMI shall default to Dim / Bright Luminance Control as follows:

When DATA1 (NMCS2 Mode) or the last SET message (Local Mode) is ‘Bright’, the Luminance shall be set to the level corresponding to DATA2=(OFH). (M:327.1)

When DATA1 (NMCS2 Mode) or the last SET message (Local Mode) is 'Dim', the Luminance shall be set to the level corresponding to DATA2=(02H). (M:327.2)

When a valid LUMINANCE BROADCAST message has not been received in the last 180 seconds and no Dim / Bright setting has been confirmed by the NMCS2 Instation, the Luminance shall be set to the level corresponding to DATA2=(02H) (i.e. 'Dim'). (M:327.3)

M:328 All AMIs on the same NMCS2 RS 485 link, or Local RS 485 Link, shall display the same Luminance at any particular time.

The delay between receiving the last Bit of a LUMINANCE BROADCAST message and the actual change in Luminance shall be less than 1 second. (M:328.1)

The tolerance on the delay between receiving the last Bit of a LUMINANCE BROADCAST message and the actual change in Luminance shall be such that all AMIs on the same RS 485 link change their Luminance at the same time +/- 100ms. (M:328.2)

### 3.3.8 Fault Reporting

M:340 The AMI shall comply with the following clauses in TR 2043, Section 3.3.2:

M:75 M:78 M:80 M:82 M:83

."Lamp" shall be taken to mean any optical output device.

M:341 The AMI shall comply with Table 3.3.8 in response to the detection of error conditions.

General faults affecting the AMI shall include, but not be limited to those defined in Table 3.3.8. Other faults specific to the AMI design shall be defined by the supplier and actioned according to the same criteria. (M:341.1)

The STATUS REPLY shall include the current DIM / BRIGHT setting except where indicated, or modified by Section 3.3.7 (Luminance Control). (M:341.2)

In the context of Table 3.3.8, a lantern "pair" is defined as any two lantern modules that are expected to be on at the same time. (M:341.3).

M:343 Table 3.3.8 covers AMI fault reporting for NMCS2 operation. The AMI fault reporting shall be based on Table 3.3.8 and enhanced by the Contractor to include additional diagnostics to facilitate maintenance.



The Contractor shall submit details of the AMI fault reporting, incorporating these enhancements, for the approval of the Overseeing Organisation. (M:343.1)

Single Lamp Failure shall only be reported to COBS via a Status Reply message if the threshold for allowable pixel failures is exceeded. The threshold shall be configurable on a per-Roadside Controller basis. The default setting for this threshold parameter shall be four. In this case a fourth pixel failure of the same colour within the Central Maxtrix shall trigger Single Lamp Failure to be reported. (M:343.2).

Single Lamp Failure shall also be reported in the event of failure of Red Ring pixels. The threshold number of Red Ring pixel failures that give rise to Single Lamp Failure shall be configurable on a per-Roadside Controller basis, independently from the Central Matrix pixel thresholds. (M:343.3).

M:344 The AMI-EE shall indicate the presence of any fault to the Speed Enforcement Equipment via the Speed Enforcement Interface. Refer to chapter 4 for details of this mechanism for disabling enforcement.

M:345 In the event of loss of communications, the AMI system shall endeavour to set the affected AMI display(s) as follows:

(a) if a loss of communication is detected between the AMI Roadside Controller and the NMCS2 transponder (e.g. due to failure of the transponder) then the AMI shall continue to display the current aspect. If the AMI is configured for enforcement then it shall retain the current enforcement relay settings. (M:345.1)

(b) if a loss of communication is detected between the AMI Roadside Controller and the AMI (e.g. due to failure of the AMI Roadside Controller) then the AMI shall default to a blank display. If the AMI is configured as an AMI-EE it shall open all Speed Enforcement Interface relays (A2, A3, A4, A5, A6, A7, AX, AC). (M:345.2)

### **3.3.9 Reset Facility**

M:350 The AMI Roadside Controller shall provide a reset switch for manually re-initialising the AMI during maintenance operations.

### **3.3.10 Watchdog Facility**

M:360 The AMI System shall include a hardware based 'Watchdog' facility which in the event of a 'fatal fault' shall automatically re-initialise the software. The 'Watchdog' facility shall be provided for all processors within the AMI System.

A 'fatal fault' is defined as a software fault which prevents the AMI either setting an Aspect (or flashing Lantern) or determining whether an Aspect (or flashing Lantern) is reliably displayed. (M:360.1)

### **3.4 Retained Data**

M:370 Retained Data requirements are defined in TR 2043, Section 3.6.

**Table 3.3.8 – NMCS2 Fault Reporting**

	<b>AMI Fault</b>	<b>AMI Action</b>	<b>Status Reply</b>	<b>Test Reply</b>
1	Loss of 3 successive NMCS2 Lantern Synchronisation Broadcast messages	Continue to display Aspect / Lanterns as set	Loss of Synchronisation (As TR 2070)	No Change
2	Luminance Conflict (when Aspect/Lanterns not OFF) – M:326 refers	Display Aspect/Lanterns as set at luminance level 06 <sub>H</sub> .	If persists for more than 2 hours invert Dim/Bright bit	No change
3	Luminance Default Control (when Aspect/Lanterns not OFF) – M:327 refers a) Loss of 3 successive NMCS2 Luminance Broadcast messages b) Data Byte 2 set to FF <sub>H</sub> or 00 <sub>H</sub> c) Condition a) AND no NMCS2 Dim/Bright setting confirmed	a) Use Dim/Bright from last SET message b) Use Dim/Bright from last Luminance Broadcast message c) Set Aspect Display to Dim	a) Dim/Bright bit inverted b) Return Dim/Bright bit unchanged from last message received* c) Dim/Bright bit inverted	a) No change b) No change c) No change
4	Heater Fail (when Aspect is OFF and Bright)	Not applicable	No change	No change
5	Aspect failure to turn ON (not with Red Lanterns)	Switch OFF Aspect Display and Lanterns	Aspect and Lanterns OFF and DIM	Aspect FAULTY. All other Aspects and Lanterns as tested
6	Aspect failure to turn OFF	Switch OFF power to Aspect	Aspect and Lanterns OFF and DIM	Stuck ON Aspect PASS. All other Aspects and Lanterns as tested
7	Aspect Failure to turn ON (with Red Lanterns)	Continue to drive Lanterns	Aspect OFF. Lanterns set as requested	Aspect FAULTY. All other Aspects and Lanterns as tested.
8	Aspect Display pixel failure – (non-critical) a) One pixel failure b) Two to four pixel failures	a) Continue to display Aspect/Lanterns as set b) Display 'fallback' Aspect only if it contains fewer pixel failures than main Aspect	a) Single Lamp Failure b) Single Lamp Failure**	a) No change b) No change
9	Aspect Display pixel failure – (critical) a) Five or more pixel failures in main Aspect b) Five or more pixel failures in <b>both</b> main and 'fallback' Aspects without Red Lanterns c) Five or more pixel failures in <b>both</b> main and 'fallback' Aspects with Red Lanterns	a) Display 'fallback' Aspect only if it contains less than five pixel failures b) Switch OFF Aspect Display and Lanterns c) Switch OFF Aspect Display. Continue to drive Red Lanterns	a) Single Lamp Failure b) Single Lamp Failure. Aspect and Lanterns OFF c) Single Lamp Failure. Aspect OFF. Red Lanterns ON.	a) No change b) Aspect FAULTY. All other Aspects and Lanterns as tested c) Aspect FAULTY. All other Aspects and Lanterns as tested
10	Lantern failure to turn ON	Continue to try and drive Lanterns	Lanterns OFF	Requested Lanterns FAULTY. All other Aspects and Lanterns as tested.
11	Lantern failure to turn OFF	Switch OFF power to Lanterns	Lanterns OFF	All Lanterns FAULTY. All other Aspects and Lanterns as tested.
12	Both pairs of a requested Lantern ON at once	Continue to try to drive Lanterns	Lanterns OFF	All Lanterns FAULTY or stuck on Lanterns FAULTY. All other Aspects and Lanterns as tested.
13	Amber Lantern Fail a) Single Lantern failure b) Lantern pair failure	a) Continue to display Aspect and Lanterns as SET b) Continue to display Aspect and Lanterns as SET	a) Single Lamp Failure. Amber Lanterns ON b) Single Lamp Failure. Amber Lanterns OFF	a) No change b) Amber Lanterns FAULTY (as TR2070)

**Table 3.3.8 Continued**

14	Red Lantern Fail a) Single Lantern failure b) Lantern pair failure	a) Continue to display Aspect and Lanterns as SET b) Continue to display Aspect and Lanterns as SET	a) Single Lamp Failure Red Lanterns ON b) Single Lamp Failure Red Lanterns OFF	a) No change b) Red Lanterns FAULTY (as TR2070)
15	Red Ring pixel failure – non-critical fail (less than 6%±0.5% pixels failed)	Continue to display Aspect as SET	Single Lamp Failure***	No change
16	Red Ring pixel failure – critical fail (6%±0.5% or more pixels failed)	Switch OFF power to Red Ring. Set aspect OFF	Single Lamp Failure Aspect as set (OFF)	All Red Ring Aspects FAULTY
17	More than One Aspect displayed simultaneously. Aspect failure to turn OFF.	Remove power to Aspect Display and Lanterns	Aspect and Lanterns OFF	All Aspects FAILED except OFF
18	Watchdog Reset	Carry out initialisation sequence	Aspect OFF until SET	All Aspects as tested.
19	Loss of Communications with AMI Roadside Controller	Set Aspect OFF	No reply	No reply

\*Note: Either the last 'SET' or luminance broadcast received

\*\* Refer to M:343.2

\*\*\* Refer to M:343.3 .

## 4 SPEED ENFORCEMENT INTERFACE FUNCTIONAL REQUIREMENTS

### 4.1 General

M:400 The Speed Enforcement Interface from the AMI System to the Speed Enforcement Equipment shall consist of an electrical interface. Speed Enforcement Interface functionality is not required in non-enforcement AMI variants..

M:402 The design of AMI-EE variants shall utilise plug-in modules to implement the Speed Enforcement Interface functionality. This will allow these modules to be omitted during the assembly of non-enforcement variants of AMI. This includes (but is not limited to) the Primary Monitoring Unit (PMU) and Secondary Monitoring Unit (SMU).

M:403 The PMU and SMU shall use independent methods to prove that the SET Aspect is displayed correctly, including the Red Ring for Mandatory Speed Limit Aspects. (M:403.1)

The PMU shall consolidate the results of its checking method with those of the SMU and shall only provide positive confirmation to the external interface if the logical 'AND' of both methods confirm the SET Aspect is displayed correctly. (M:403.2).

M:404 The Speed Enforcement Interface shall be capable of uniquely identifying the following Enforcement AMI Group display scenarios to the Speed Enforcement Equipment: 20mph, 30mph, 40mph, 50mph, 60mph, National Speed Limit.

The corresponding relay circuits shall be denoted A2, A3, A4, A5, A6, A7 respectively. (M:404.1)

Additionally, the Speed Enforcement Interface shall include the capability to identify that a RED X aspect (either STOP X or LANE CLOSED) is displayed, using the AX relay circuit. (M:404.2).

Furthermore, the AMI shall be capable of closing multiple relays in a defined manner when an aspect is displayed that has no direct bearing on a reduced mandatory speed limit scenario. (M:404.3).

I:405 Current, voltage and optical sensing may be located adjacent to the relevant optical output devices. (I:405.1).

The PMU and SMU may be purely logical modules which receive the status of the current, voltage and optical sensing circuits. (I:405.2).

Optical sensing for enforcement purposes is not required for the Lanterns. (I:405.3)

M:406 The Speed Enforcement Equipment and AMI connected to it shall act together to form an Enforcement System. Irrespective of whether the installation incorporates an Actively Managed Hard Shoulder or not, the AMI System shall provide the Speed Enforcement Equipment with the following information via the Speed Enforcement Interface:

- a) An Aspect is correctly displayed on the AMI. (M:406.1)
- b) No conflicting speed limits are displayed on any AMI in the Enforcement AMI Group. (M:406.2)
- c) All AMIs in the Enforcement AMI Group have no faults. (M:406.3)

I:407 The Speed Enforcement Interface requires the inclusion of test circuitry within the AMI to confirm intended operation of the interface relays. This specification identifies two permissible means of implementing this functionality. Either Test Relays shall be incorporated (as described in section 4.2.2), or as an alternative, a current monitoring technique shall be adopted (refer to 4.2.3). Drawing MCX1031 sheet 2 depicts both options. Contractor's compliance documentation shall clearly identify which test method they have adopted.

I:408 The Speed Enforcement Equipment commences enforcement a minimum time of 1 minute after the Speed Enforcement Interface is set.

M:411 Local Addresses 0 and 8 shall be reserved for use in conjunction with AMIs installed over an Actively Managed Hard Shoulder. Whilst relay setting behaviour is now no different in Hard Shoulder locations, the internal relay testing regime is likely to differ between main carriageway and Hard Shoulder locations (as the Red X circuits are discontinuous in the CMU for main carriageway AMIs). Main Carriageway AMIs shall continue to use local addresses 1 to 7 and 9 to 15.

## 4.2 Speed Enforcement Interface

### 4.2.1 General Requirements

M:420 The Speed Enforcement Interface shall be implemented as shown in Drawing MCX1031 sheet 2 . (M:420.1).

The Cable Marshalling unit performs the following functions in respect of the Speed Enforcement Interface: (M:420.2):

- Implements the interconnections between AMIs in adjacent lanes for Speed Limit aspects. (i.e. Not Red X aspects).
- Provides a single location at which the circuits through each AMI (both individually and collectively) can be accessed for testing purposes.
- Provides a single location at which the Enforcement Equipment may be connected.

The RED X circuits for the Main Carriageway AMIs shall not be connected to the external wiring within the CMU as they do not form part of the Speed Enforcement System. The RED X circuit for the Hard Shoulder AMI shall be connected to the external wiring within the CMU in such a way that it connects to the Speed Enforcement Interface without passing through the Main Carriageway AMI relays. The CMU schematic is shown in Drawing MCX1031 sheet 3. (M:420.3).

The Red Ring does not require its own external relay connection and may be considered an internal function within the AMI. (M:420.4).

The CMU external connections to the AMIs shall be identified as follows and shall use the local addressing indicated:

Applications with Actively Managed Hard Shoulder:

Lane	CMU Internal Circuit	CMU Local Address for 'A' Carriageway	CMU Local Address for 'B' Carriageway	CMU External Socket Labelling
Hard Shoulder	1	0	8	AMI 1
1	2	1	9	AMI 2
2	3	2	10	AMI 3
3	4	3	11	AMI 4
4	5	4	12	AMI 5
5	6	5	13	AMI 6
6	7	6	14	AMI 7
7	8	7	15	AMI 8

Applications without Actively Managed Hard Shoulder:

Lane	CMU Internal Circuit	CMU Local Address for 'A' Carriageway	CMU Local Address for 'B' Carriageway	CMU External Socket Labelling
1	1	1	9	AMI 1
2	3	2	10	AMI 2
3	3	3	11	AMI 3
4	4	4	12	AMI 4
5	5	5	13	AMI 5
6	6	6	14	AMI 6
7	7	7	15	AMI 7
8	n/a	n/a	n/a	n/a

An Enforcement AMI Group shall comprise up to 7 lanes, interconnected by one CMU. However, an 8<sup>th</sup> lane can be supported if an Actively Managed Hard Shoulder is required. When viewed from the direction of approaching traffic, the left-most AMI shall be connected to CMU socket 1, in all scenarios. Therefore, if an Actively Managed Hard Shoulder has been designated then this shall utilise CMU socket 1. Otherwise Lane 1 shall utilise CMU socket 1. (M:420.5)

A single design of CMU shall be adopted for all applications, although the CMU internal wiring implementation may differ between site installations according to whether an Actively Managed Hard Shoulder is present or not. (M:420.6).

M:421 Two independent methods of monitoring shall be incorporated to confirm that any Aspect is displayed correctly.





20	3	-	-	-	-	-	-	-	4
30	4	-	-	-	-	-	-	-	4
40	5	-	-	-	-	-	-	-	4
50	6	-	-	-	-	-	-	-	4
60	7	-	-	-	-	-	-	-	4
70	8	-	-	-	-	-	-	-	4
70R	21	-	-	-	-	-	-	-	4

Note 1                    ‘Enforcement-enabling’ aspects. Closing a single relay enables enforcement if all AMIs in the Enforcement AMI Group are displaying the same ‘Enforcement-enabling’ aspect and no ‘Enforcement-disabling’ aspects are displayed within the Enforcement AMI Group.

Note 2                    ‘Enforcement-neutral’ aspects. Closing all speed relays allows enforcement, providing at least one other AMI in the Enforcement AMI Group is displaying an ‘Enforcement-enabling’ aspect and no ‘Enforcement-disabling’ aspects are displayed within the Enforcement AMI Group.

Note 3                    ‘Enforcement-neutral-X’ aspects. These have the same function as ‘Enforcement-neutral’ aspects, with AX relay also closed to signify that a Red X is being displayed. Required for Actively Managed Hard Shoulder operation.

Note 4                    ‘Enforcement-disabling’ aspects. Leaving all relays open circuit disables enforcement if any one of these aspects is displayed on any AMI in the Enforcement AMI Group, irrespective of what aspect is displayed by the other AMIs in the Enforcement AMI group.

Not used. (M:423.2)

The PMU shall also control the AC Relay (Continuity Circuit) to provide confirmation that any Aspect (including the 'OFF' aspect) is correctly displayed and there are **NO** electrical or communications faults within the AMI. (M:423.3)

Relay outputs (A2, A3, A4, A5, A6, A7, AX) shall only be closed if all appropriate elements of the appropriate aspect are correctly displayed. (M:423.4).

Relay output AC shall only be closed when the AMI has no faults. As a minimum, the fault conditions defined in Table 3.3.8 rows 1 to 18 inclusive shall give rise to the PMU opening the AC relay. (M:423.5)

The PMU relays shall be operated to provide 'Positive Confirmation' such that the default state or any fault condition gives rise to an open circuit. (M:423.6)

The PMU shall include hardware interlocks which prevent the operation of Relays (A2, A3, A4, A5, A6, A7, AX) for all invalid combinations of appropriate energised parts of the display. (M:423.7).

Operation of relays (A2, A3, A4, A5, A6, A7, AX) shall only take place when both electrical and optical monitoring methods confirm that the appropriate elements of the Aspect are correctly displayed, for all aspects. (M:423.8).

The PMU shall use hardware methods for all monitoring, confirmation and interlocking circuits. (M:423.9)

M:424 For all Aspects, the SMU shall compare the Aspect displayed with the SET Aspect requested by the Transponder.

The SMU shall continuously monitor the status of the optical sensing circuits to confirm the correct status of all parts of the Aspect. For Mandatory Speed Limit Aspects this shall include the Red Ring portion of the display. (M:424.1).

M:425 The Speed Enforcement Interface interconnections for an Enforcement AMI Group ensure the Speed Enforcement Equipment functionality is only enabled if a valid combination of aspects is set. The interconnections between the AMIs within the Enforcement AMI Group are achieved by the CMU. Each AMI is only responsible for ensuring that it sets the appropriate relays for the aspect it is displaying.  
The A Relays shall be arranged and interconnected such that:

- a) ANY fault condition within any AMI in the Enforcement AMI Group shall disable enforcement by ensuring the AC circuit is open (M:425.1); however, enforcement will be enabled when AC is closed (due to no fault being present) AND

**EITHER:**

- b) Confirmation is made that a combination of aspects is being displayed within the Enforcement AMI Group that can result in enforcement of the National Speed Limit. (M:425.2)

**OR:**

- c) Confirmation is made that no conflicting Mandatory Speed Limit Aspects are displayed within the Enforcement AMI Group. (M:425.3)

M:430 The AMI shall provide present and historical information on the status of the PMU/SMU relays, capable of being read at the AMI Roadside Controller. In this way it shall be possible to determine when individual relays changed state and determine the event that prompted that change of state.

M:435 The AMI shall incorporate a means for testing the Speed Enforcement Interface relays. This shall either be in accordance with Section 4.2.2 below, or Section 4.2.3 below.

#### **4.2.2 Electrical Interface Testing**

M:440 The Speed Enforcement Interface shall be tested and monitored to check for any faulty relay contacts. Additional changeover Test Relays shall be provided for this function.

M:441 When any Aspect has been set on the AMI, it shall carry out a test of appropriate relays. The precise sequence to be followed depends on how many relays the specified aspect is designed to close (in accordance with the table in M:423).

If an aspect requires closure of more than one relay in addition to AC, then following sequence shall be followed:

- a) Set all Speed Enforcement Interface relays (A2, A3, A4, A5, A6, A7, AX, AC) to open circuit (M:441.1)

- b) Set all Test Relays to the default 'Test' position. (M:441.2)

- c) Open all Speed Enforcement Interface relays (A2, A3, A4, A5, A6, A7, AX, AC) and cause the combination of relays applicable to the aspect to operate – check that the correct states are achieved (M:441.3)

M:442 If an aspect requires closure of only one relay in addition to AC, then the following sequence shall be followed:

- a) Set all Speed Enforcement Interface relays (A2, A3, A4, A5, A6, A7, AX, AC) to open circuit (M:442.1)
- b) Set all Test Relays to the default 'Test' position. (M:442.2)
- c) Open relay AC and cause it to operate - check the correct states are achieved. (M:442.3)
- d) Open the individual interface relay which corresponds to the SET Aspect and cause it to operate – check that the correct states are achieved. (M:442.4)
- e) Confirm that all other interface relays which do not correspond to the SET Aspect have remained open circuit. (M:442.5)

M:443 If an aspect requires closure of only the AC relay, then the following sequence shall be followed:

- a) Set all Speed Enforcement Interface relays (A2, A3, A4, A5, A6, A7, AX, AC) to open circuit (M:443.1)
- b) Set all Test Relays to the default 'Test' position. (M:443.2)
- c) Open relay AC and cause it to operate - check the correct states are achieved. (M:443.3)
- d) Confirm that all other interface relays (A2, A3, A4, A5, A6, A7, AX) have remained open circuit. (M:443.4)

M:444 If ANY ERROR CONDITION is detected during the tests M:441, M:442 or M:443, then the AMI shall abort the test and remove power and drives to all Relays such that they default to an open circuit condition.

Subject to these tests being successful, the Test Relays shall be operated to reconnect all Speed Enforcement Interface relays into circuit so that they are capable of connection to the Enforcement Equipment. (M:444.1)

M:445 On completion of the appropriate test sequence (M:441, M:442 or M:443 above), providing no faults have been detected, then the AMI shall close the relays applicable to the SET Aspect (as defined in M:423). This shall occur between 8 and 15 seconds after the Aspect has been SET.

If the AMI receives another Aspect SET request during the test cycle, the AMI shall abort the test and shall restart the sequence applicable to the latest SET request received. (M:445.1)

If a fault has been detected causing the interface relays to remain open circuit, then the PMU/SMU shall return to a known state and a record of the failure shall be logged for diagnostic purposes. Subsequent Aspect SET requests shall then be given the opportunity to initiate the relay test and closure sequence from the beginning (M:445.2).

I:446 The minimum time in M:445 is designed to prevent the interface from connecting to the Enforcement Equipment during NMCS2 Speed Countdown Sequences.

M:449 The results of the relay test sequences shall be made available for inspection at the AMI Roadside Controller, enabling individual relays in each AMI to be identified.

#### **4.2.3 Alternative Electrical Interface Testing (Current Sensing)**

M:450 The interface shall consist of a number of relay contacts each in series with a current detector. The resistance of the complete circuit through eight signs including all cabling shall be 100 ohms or less. This means that the resistance offered by one relay contact (when ON) and the current detector shall be less than 12 ohms. The current monitoring circuit shall detect currents greater than 3 mA in either sense. Electrical isolation should be greater than 350VDC between the circuit in which the current is being sensed and the output of the current detector.

M:451 The Speed Enforcement Interface shall be tested and monitored to check for any faulty relay contacts. Monitoring of relay operation shall be by the detection of current flow through the relay contacts by the AMI in which the relay resides.

M:452 In order that a given AMI may test its relays using current monitoring, all other AMIs within the Enforcement AMI Group shall be capable of closing their corresponding relays on command so that current may pass through the circuit being tested. The Contractor shall provide details of how the co-ordination of the test sequence is to be achieved, for approval by the Overseeing Organisation.

M:453 When the AMI receives any aspect SET request, it shall open circuit all Speed Enforcement Interface relays (A2, A3, A4, A5, A6, A7, AX, AC) in readiness to test them. After a delay of 15 seconds, a co-ordinated test sequence shall be commenced for each AMI that received a SET message or has yet to complete a test sequence. The test sequence applicable to all aspects is described in M:454.

M:454 When any Aspect is set, the test shall confirm that all relays are fully operative and that there are no faulty contacts as follows:

- a) Close all Speed Enforcement Interface relays (A2, A3, A4, A5, A6, A7, AX, AC) in all interconnected AMIs within the Enforcement AMI Group (M:454.1).
- b) Open all relays in the first AMI in the Enforcement AMI Group and confirm that all relays in this AMI have no current flowing. (M:454.2).
- c) Close all relays in the first AMI in the Enforcement AMI Group and confirm that all relays in this AMI have current flowing. (M:454.3)
- d) Open all relays in the second AMI in the Enforcement AMI Group and confirm that all relays in this AMI have no current flowing. (M:454.4)
- e) Close all relays in the second AMI in the Enforcement AMI Group and confirm that all relays in this AMI have current flowing. (M:454.5)
- f) Repeat the pattern of opening and closing relays and testing for current flow as appropriate for each AMI in the Enforcement AMI Group. (M:454.6)

This procedure shall be completed within 10 seconds. (M:454.7)

M:456 When a new aspect is requested, all Speed Enforcement Interface relays shall be de-energised and the checking operation shall be started again as described in M:453 and M:454.

M:457 If ANY ERROR CONDITION is detected by an AMI during the co-ordinated tests defined in M:454, the AMI shall NOT abort the test sequence. In the event of multiple error conditions being present, allowing the sequence to run to completion enables them all to be detected.

At the completion of the tests, the decision to enable the Speed Enforcement Interface shall be made independently by each AMI as a result of tests within the AMI, without the involvement of the AMI Roadside Controller. (M:457.1)

For an AMI installed over an Actively Managed Hard Shoulder (Local address 0 or 8), at the completion of the test sequence, if ANY ERROR CONDITION has been detected the AMI shall remove power and drives to all relays such that they default to an open circuit condition. (M:457.2).

Not Used. (M:457.3)

For an AMI installed anywhere other than over an Actively Managed Hard Shoulder, at the completion of the test sequence, if any error condition has been detected (EXCEPT

failure of the AX circuit to pass current, which can be ignored, as this circuit is discontinuous in the CMU) has been detected, the AMI shall remove power and drives to all relays such that they default to an open circuit condition. (M:457.4)

Results of the co-ordinated test shall be made available by each AMI to the AMI Roadside Controller for diagnostic purposes. (M:457.5)

If a fault has been detected causing the interface relays to remain open circuit, then the PMU/SMU shall return to a known state and a record of the failure shall be logged for diagnostic purposes. Subsequent Aspect SET requests shall then be given the opportunity to initiate the relay test and closure sequence from the beginning (M:457.6).

I:458 The 15 second delay in M:453 is intended to prevent abortive testing by allowing other signs on the gantry to receive aspect SET commands at slightly different times.

M:459 The results of the relay test sequences shall be made available for inspection at the AMI Roadside Controller, enabling individual relays in each AMI to be identified.



## 5 OPTICAL REQUIREMENTS

### 5.1 General

M:500 The AMI display shall be designed to conform to the Optical Criteria specified by BS EN 12966 – Road vertical signs – Variable Message Traffic Signs

I:501 Ambient light level data will be available to enable the AMI luminance to be set appropriately for the prevailing local conditions.

### 5.2 Technology

M:510 The display technology chosen shall be compatible with the reliability and maintenance requirements of Chapter 7.

### 5.3 Optical Geometry

M:520 The central matrix portion of the AMI display shall be 675mm Wide (less a tolerance of 35mm) by 630 mm high (plus a tolerance of 10mm) .

M:521 The layout of the front face of the AMI shall comply with MCX0920 sheet 1, except that four combined (Red/Amber) lantern modules shall be incorporated.

M:523 The maximum permitted horizontal and vertical pitch of display pixels shall be:

25mm for White pixels (M:523.1)

45mm for Red pixels (M:523.2)

45mm for Green Pixels (M:523.3)

M:524 The arrangements of the Aspect Displays, fonts and Red Ring shall be determined by the Type Approval requirements of DfT.

The Contractor shall finalise the design by demonstration of the Aspects at an off-road location, including testing both in daylight and at night-time. (M:524.1)

The Contractor shall provide details of the test to the Overseeing Organisation, including:

- the duration of the display and
- a graph of luminance during the test period.

The Overseeing Organisation shall determine whether the test results are acceptable. (M:524.2)

M:526 Compliance with this specification will satisfy Highways Agency, DfT, ACPO and HOSDB requirements in respect of AMI display aspect formats.

M:527 The Contractor shall obtain authorisation from DfT of any font which does not conform to TSRGD. This authorisation process shall include (but not be limited to) the submission of drawings of Aspects and fonts to DfT.

## **5.4 Optical Design**

### **5.4.1 General**

I:540 This section relates to the Central Matrix and Red Ring parts of the AMI display. Refer to section 5.5 for details of Lantern requirements .

M:541 All materials used, including the optical components, shall be of high quality and manufactured and protected so that they will not degrade over the design life of the equipment.

M:542 The optical design of the AMI shall include the facility for factory re-configuration, to allow for any future changes and / or additions to the range of Aspects displayed.

M:543 The purpose of the “fallback” aspects is to enable the AMI to continue to operate despite the presence of a small number of failed pixels. In the event of a pixel failure, the AMI shall evaluate whether to display the “main” or “fallback” version of the aspect, in accordance with Table 3.3.8.

### **5.4.2 Performance**

M:550 With reference to BS EN 12966, the required performance classes for Red, White and Green emitters are:

Colour - class C2 (M:550.1)

Luminance (La) - class L3 (M:550.2)

Luminance Ratio (Lr) - class R3 (M:550.3)

Beam Width - class B1 (M:550.4)

M:551 Uniformity shall comply with BS EN 12966-1 section 7.6.

M:552 Visible flicker shall comply with BS EN 12966-1 section 7.7.

M:553 Relative output levels for different colours shall be balanced to match the perception of the human eye (e.g. White:Red ratio approximately 4:1)

## 5.5 Lanterns

M:560 All AMI variants shall incorporate four dual colour Lantern modules, each capable of outputting Red and Amber light.

M:561 The Lantern design shall prevent Red and Amber light being emitted at the same time.

M:562 Each Lantern module shall be round with a diameter of 120mm presented to the front face of the AMI.

M:563 Lantern optical performance for Red light emission shall be equal to or better than the following:

Minimum Luminance (for an area of 100x100 mm) on the 0° Horizontal and 0° Vertical axis of 38,000 cd/m<sup>2</sup> (M:563.1).

Other luminance levels are shown in the table below and are expressed as percentages of the actual value on the 0° Horizontal and 0° Vertical axis (M:563.2).

RED DISTRIBUTION LEVELS						
Horiz→ ↓Vert	0°	±5°	±10°	±15°	±20°	±30°
0°	100	75	40	10	1	-
-3°	75	60	*	*	*	-
-5°	50	*	20	*	*	-
-10°	12.5	*	*	*	6	-
-20°	1.5	*	*	*	*	1
* No specific value required but the luminance at each point shall meet at least the level achieved by the next consecutive measurement						
- No specific value required						

M:564 Lantern optical performance for Amber light emission shall be equal to or better than the following:

Minimum Luminance (for an area of 100x100 mm) on the 0° Horizontal and 0° Vertical axis of 35,000cd/m<sup>2</sup> (M:564.1).

Other luminance levels are shown in the table below and are expressed as percentages of the actual value on the 0° Horizontal and 0° Vertical axis (M:564.2).

<b>AMBER DISTRIBUTION LEVELS</b>			
Horiz→ ↓Vert	0°	±5°	±10°
+5°	50	20	*
+2.5°	75	60	*
0°	100	75	40
-5°	12.5	*	6

\* No specific value required, but the luminance at each test point shall meet at least the level achieved by the next consecutive measurement. For vertical values + refers to angles above the horizontal and – refers to values below the horizontal.

M:565 Lanterns of either colour shall have a luminance uniformity of 5:1 or better.

M:566 When measured on axis under simulated solar illumination of 40,000 Lux at an angle of 10° to the axis, the contrast ratio of the lantern shall be greater than 8:1 for either colour using the same measurement area as above.

M:567 The required chromaticity regions for the colour boundaries of the lantern light and combined colours from real lantern and phantom light shall be within the requirements of the following table.

<b>LANTERN COLOUR BOUNDARIES</b>								
Colour	1		2		3		4	
	x	y	x	y	x	y	x	y
Red	0.660	0.320	0.680	0.320	0.710	0.290	0.690	0.290
Amber	0.536	0.444	0.547	0.452	0.613	0.387	0.593	0.387

## 5.6 Additional AMI Aspects

M:570 All variants of AMI shall have the capability to define additional aspects, which may be required in the future.

M:575 For evaluation purposes in a test environment only, the prototype AMI shall be capable of utilising tailored aspect bitmaps, if required.

M:576 Production AMIs shall not permit the modification or addition of aspect bitmaps, except by authorised means.



## 6 AMI TEST TERMINAL FUNCTIONAL REQUIREMENTS

### 6.1 General

M:600 The AMI System shall support the Monitoring, Testing and Diagnostic facilities described in this Chapter, which shall run as an application software package on an AMI Test Terminal PC, or shall be integral to the AMI Roadside Controller.

M:601 The AMI Test Terminal application shall provide a user friendly, menu-driven interface to the following facilities:

- Monitoring (M:601.1)
- Testing (M:601.2)
- Diagnostics (M:601.3).

M:602 The application software shall provide a ‘friendly’ visual interface with text / bit decoding for easy on-screen interpretation of status and test data - i.e. it shall not be necessary to examine the content of data messages to determine the operational status of the equipment or test results.

M:603 While in use in Monitoring and Testing modes, the application shall produce logs recording:

- each change of equipment status (including change of Aspect displayed) (M:603.1)
- all messages between the AMI System and the Instation (M:603.2)
- all messages between the AMI Test Terminal PC and the AMI System (M:603.3).

The facility shall be provided to print each of these logs. (M:603.4)

M:604 If implemented as a software application on a Test Terminal PC, facilities shall be available though each of the RS 232, RS 485 and Ethernet interfaces as shown in Table 6.1 below.

	<b>RS 232</b>	<b>RS 485</b>	<b>Ethernet</b>
Monitoring (see Section 6.3)	No	Yes	Yes
Test (see Section 6.4)	No	Yes	Yes
Diagnostics (see Section 6.5)	Yes	No	Yes

Table 6.1 - AMI Test Terminal Interface Functions

M:605 The RS 232 diagnostics interface shall either be implemented as a dumb terminal with the AMI Roadside Controller incorporating the software to provide the required functionality, or as an intelligent terminal.

M:606 The AMI Test Terminal shall be able to access the AMI System through the Ethernet interface, for Monitoring, Testing and Diagnostics purposes, via the IP-based Control System. Where several AMIs are mounted on a gantry, it shall be possible to access each of them independently in this way. Refer to Figure 3.2.

## 6.2 AMI Test Terminal Hardware

M:620 The Contractor shall propose suitable computer hardware, operating system and software for the approval of the Overseeing Organisation.

M:621 If the AMI Test Terminal functionality is not integral to the AMI Roadside Controller, then the AMI Test Terminal PC shall be IBM-compatible and shall incorporate the following features:

- VDU
- Keyboard and mouse
- 3 ½ inch floppy drive
- Hard disc drive
- CD-ROM drive
- EIA RS 232 interface
- EIA RS 485 interface
- Ethernet interface.

## 6.3 Monitoring Facilities

M:630 In Monitoring Mode, the AMI Test Terminal shall 'listen in' on communications between the Instation and the AMI. In this mode, the AMI will be controlled by the Instation in the normal manner.

M:631 The Monitoring Facilities shall be provided via RS 485 and Ethernet interfaces.

M:633 Use of the application in monitoring mode shall be invisible to the Instation and all control messages received by the AMI System shall be acted upon as normal.

## 6.4 Test Facilities

- M:640 In 'Test' mode the AMI Test Terminal shall directly control the Aspects displayed on the AMI.
- M:641 The Test Facilities shall be provided via RS 485 and Ethernet interfaces.
- M:643 As a minimum, the application shall support:
- A full test of the AMI Aspect operation based on 'Set' messages, covering each Aspect that the AMI is capable of displaying (M:643.1)
  - A full test of the AMI Lantern operation (M:643.2)
  - A full test of the AMI Red Ring operation, covering each Mandatory Speed Limit Aspect (M:643.3)
  - Additional detailed tests to a modular level covering each processor controlled or monitored item in the equipment (M:643.4)
  - Interrogation using the 'Status Request' message (M:643.5)
  - Interrogation using the 'Request Test Result' message (M:643.6)
  - Interrogation using the 'Device Modification Request' message (M:643.7)
  - On-line monitoring and logging of all control (and reply) data messages, presented in an easy to read, decoded format (M:643.8).

## 6.5 Diagnostics Facilities

- M:650 The Diagnostics Facilities shall be provided via RS 485 and Ethernet interfaces.
- M:651 The AMI Test Terminal shall provide the following Diagnostics facilities:
- AMI configuration details, including as a minimum: AMI Variant, Address, Software Versions, Settings of any Configuration switches (M:651.1)
  - Detailed fault information specific to the supplier (M:651.2)
  - Current condition and fault status of optical output devices (M:651.3)
  - Luminance level and Luminance control source (M:651.4)
  - Status of the RS 485 links - NMCS2 and Local Communications (M:651.5)
  - Time since installed (M:651.6)
  - On time of optical output devices (M:651.7)
  - On time of other mechanical elements (e.g. fans) (M:651.8)
  - Maximum internal temperature reached (M:651.9)
  - Minimum internal temperature reached (M:651.10)
  - Present and historical information to allow enforcement status to be determined for each AMI in an Enforcement AMI Group. As a minimum it shall be possible for a maintenance engineer to determine when individual enforcement relays changed state and what event prompted the change of state. (M:651.11).



## 7 NON-FUNCTIONAL REQUIREMENTS

This section describes the Non-Functional Requirements of the equipment in terms of performance, reliability, maintainability and operating environment. Effectively these requirements describe how well the equipment functions shall be performed.

### 7.1 Performance

M:700 All Equipment comprising the AMI System shall be submitted for the approval of the Overseeing Organisation and tests carried out to demonstrate compliance with the Specification.

M:701 All Equipment comprising the AMI System shall comply with the performance requirements of TR 1100.

M:702 The performance of the AMI Central Matrix, Red Ring and Lanterns shall comply with the requirements of TR 2043, Section 4.1.

M:703 All Equipment comprising the AMI System shall conform to the following Physical Performance characteristics of BS EN 12966 – Road vertical signs – Variable message traffic Signs:

Temperature Class T1 (M:703.1)

Pollution Class D2 (M:703.2)

Protection Class P3 (M: 703.3)

### 7.2 Reliability

M:710 All Equipment comprising the AMI System shall comply with the reliability requirements of TR 1100.

M:711 All components shall be chosen for the optimum reliability to minimise visits to a gantry site to replace or repair the AMI.

M:712 The predicted Mean Time Between Failure (MTBF) for all variants of AMI, calculated using a recognised model, shall exceed 20,000 hours

### 7.3 Maintenance

- M:720 All Equipment comprising the AMI System shall comply with the maintenance requirements of TR 1100.
- M:721 The design and construction shall incorporate the requirements of Specification MCH1349 “Maintenance and Operational Requirements, to be provided with New Systems and Equipment”.
- M:722 The design and construction of all Equipment shall ensure that the minimum recommended interval between routine maintenance inspections shall be not less than twelve-months.

### 7.4 Physical Testing

- M:730 All Equipment comprising the AMI System shall be subject to Environmental Testing in accordance with BS EN 12966 – “Road vertical signs – Variable message traffic Signs”, TR 2130 “Environmental Tests for Motorway Communications Equipment and Portable and permanent Traffic Control Equipment” and BS EN 50293 “Electromagnetic Compatibility – Road Traffic Signal Systems – Product Standard” as described below.
- M:731 AMI-EE variants shall be subject to additional Environmental and EMC Testing in accordance with HOSDB Publication “The Speedmeter Handbook”.

#### 7.4.1 Environmental

- M:740 Environmental Testing shall be undertaken on a full size AMI Test Unit. The AMI Roadside Controller shall be properly installed within a Cabinet Type 600. Interconnecting cables shall be provided to fully represent an operational installation. The Test Unit shall be powered-up and operational, to exercise the equipment. The test configuration shall be approved by the Overseeing Organisation. The following specific tests shall be performed:

**Impact (M:740.1)**

The test shall follow the procedure given in Table 13 of BS-EN 12966-1.

**Vibration (M:740.2)**

The test shall follow the procedure given in Table 14 of BS-EN 12966-1.

**Drop and Topple (M:740.3)**

The test shall follow the procedure given in TR 2130. Drop test on bottom edge of an AMI on transport frameworks, as supplied (equivalent to packaged). AMI Roadside Controller to be tested in transport packaging.

**Bump (M:740.4)**

The test shall follow the procedure given in TR 2130. AMI Roadside Controller to be tested in transport packaging.

**Corrosion (M:740.5)**

The test shall follow the procedure given in Table 15 of BS-EN 12966-1. Not required for AMI Roadside Controller.

**Water Penetration (M:740.6)**

The test shall follow the procedure given in Table 16 of BS-EN 12966-1. Not required for AMI Roadside Controller.

**Dust penetration (M:740.7)**

The test shall follow the procedure given in Table 17 of BS-EN 12966-1. Not required for AMI Roadside Controller.

**Temperature (M:740.8)**

The test shall follow the procedure given in Table 18 of BS-EN 12966-1.

**7.4.2 EMC**

M:750 All Equipment comprising the AMI System shall meet the requirements of BS EN 50293 for:  
Emissions (M:750.1)  
Immunity (M:750.2)

M:751 The AMI Roadside Controller shall be properly installed within a Cabinet Type 600. Interconnecting cables shall be provided to fully represent an operational installation. The AMI Test Unit and Roadside Controller shall be powered and operational, to exercise the Equipment. The configuration shall be approved by the Overseeing Organisation.

**7.5 Safety**

M:760 All Equipment comprising the AMI System shall comply with the safety requirements of TR 1100.

## **7.6 General**

M:770 All other requirements of TR 1100 shall be met unless specifically stated otherwise in this document.

## **8 EXTERNAL INTERFACES**

This Chapter describes the electrical, protocol, and message requirements of the equipment external interfaces. Note that the interface between the AMI Roadside Controller and AMI is regarded as being internal to the system

### **8.1 Electrical**

This subsection describes the electrical and physical connection characteristics of the external interfaces. The AMI System shall provide external interfaces for RS 485 and Ethernet data communications and control signals to the Speed Enforcement Equipment.

#### **8.1.1 RS 485 - NMCS2 and Local Interfaces**

- M:800 The AMI Roadside Controller shall provide two separate and isolated electrical interfaces to RS 485 lines complying with the requirements of TR 2043 Section 5.1.1 excluding M:254. One of these interfaces may be used for connection of an ALM in 'local' mode.
- M:801 Each RS 485 interface shall include a separate 'Anti-Streaming' circuit for hardware and software faults designed to prevent the RS 485 'TX Enable' signal from causing continuous transmission and hence affecting the operation of other NMCS Devices connected to the same communication link.
- M:802 Although regarded as an internal interface within the AMI System, the interface between the AMI Roadside Controller and the AMI shall be protected against lightning damage in accordance with section of 12.7.5 of TR 1100.
- I:803 The interface between the AMI Roadside Controller and the AMI is regarded as internal to the AMI system and therefore not described in this section. Refer to section 2.

#### **8.1.2 Ethernet LAN Interface**

- M:810 The AMI Roadside Controller shall be provided with an interface to an Ethernet LAN conforming to the IEEE 802.3 standard.
- M:812 The Ethernet line interface of the AMI System shall capable of being protected against lightning damage in accordance with Section 12.7.5 of TR 1100, either at the time of installation or by the later addition of an appropriate module at such time the Ethernet interface is required to be activated.

When fitted, the lightning protection module shall be located as close as possible to the point of entry of the Ethernet cable into the AMI System. (M:812.1)

Not Used (M:812.2)

Not Used (M:812.3)

The protection module shall be provided with its own low impedance earth. (M:812.4)

M:813 Circuits are required to operate in the presence of common mode voltages up to 50 volts AC rms without the protection circuit operating.

M:814 The lightning protection module shall comply with the let-through voltage characteristics of ITU-T Recommendation K17.

M:815 The lightning protection module shall permit 10-BaseT to operate normally.

### **8.1.3 AMI Test Terminal - Diagnostics Interface**

M:820 The AMI Test Terminal shall be provided with an interface complying with the EIA RS 232 standard.

M:821 The AMI Test Terminal shall also use the Ethernet LAN interface described in Section 8.1.2 above, for monitoring, testing and diagnostic purposes.

## **8.2 Enforcement Equipment Electrical Interfaces**

### **8.2.1 Speed Enforcement Interface – Adjacent AMIs**

M:830 The Speed Enforcement Interface to adjacent AMIs shall comply with the requirements defined in Chapter 4.

M:831 The Cable Marshalling Unit shall be provided with Termination Connectors for each lane where an AMI is not installed. Each Termination Connector shall contain appropriate loopbacks to enable the Speed Enforcement Interface to operate correctly.

### **8.2.2 Speed Enforcement Interface**

M:835 The interface to the Enforcement Equipment shall comply with requirements defined in Chapter 4.

M:836 The DC resistance of any of the Speed Enforcement Interface circuits, or the Continuity circuits, when measured on a gantry fitted with eight AMIs, a Cable Marshalling Unit and associated cabling (as shown in Drawing MCX1031 sheet 2) shall not exceed 100 Ohms

total, when relay contacts are closed. This shall apply whichever relay testing method is adopted.

### **8.3 Protocol**

This subsection describes the protocol requirements for communications with the NMCS2 Standard Transponder and the IP-based Control System

#### **8.3.1 RS 485 - NMCS2 and Local Interfaces**

I:840 The AMI System will be controlled by a NMCS2 Transponder. The AMI Roadside Controllers shall act as 'slaves' in a Multi-Drop configuration over the RS 485 link from the transponder. Similarly the AMIs shall act as 'slaves' in a Multi-Drop configuration over the RS 485 communications link from the AMI Roadside Controller (Refer to Figure 3.1).

M:842 The NMCS2 and Local RS 485 interfaces shall comply with communications protocol defined in TR 2067.

#### **8.3.2 Ethernet LAN Interface**

I:851 Refer to Section 11.

### **8.4 Messages**

This subsection describes the message (format and content) requirements for the operation of the external RS 485 and Ethernet interfaces.

#### **8.4.1 RS 485 - NMCS2 and Local Interfaces**

M:860 The NMCS2 RS 485 interface shall ignore all control messages other than those listed in Section 3.1.1.

M:861 The Local RS 485 interface shall ignore all control messages other than those listed in Section 3.1.2.

M:862 Where any control message received includes a Parity Error, the message shall be ignored.

M:863 Where any control message received contains a Control Field (CF) other than one defined in Section 3.1.1 and 3.1.2, the message shall be ignored.

M:864 The format and data content of all reply messages transmitted by the AMI System on the NMCS2 RS 485 circuit shall conform to the format and data content defined in TR 2070, Chapter 9.

Where any control message received has a format and data content other than that defined in TR 2070, Chapter 9 the message shall be ignored. (M:864.1)

M:865 The Local RS 485 interface shall not transmit any reply messages.

#### **8.4.2 Ethernet LAN Interface**

I:871 Refer to Section 11.



## 9 POWER SUPPLY

This Chapter describes the requirements of the AMI System power supplies. The AMI and AMI Roadside Controller shall be powered independently.

### 9.1 Normal Operation

M:900 The AMI shall operate from a 230V (Nominal), 50Hz (Nominal) mains supply as provided by a UK Electricity Supply Company.

M:901 The AMI Power Supply shall comply with TR 2043, Chapter 6 as follows:

M:352 M:375 M:376

M:902 The Power Supply Unit shall meet the requirements specified in TR 1100. The relevant sections are:

- Section 12.1.1
- Section 12.1.2
- Section 12.1.4
- Section 12.1.6
- Section 12.1.7.

M:903 The AMI power consumption shall be within the following limits:

The worst case power consumption of any AMI variant shall not exceed 350VA when displaying the 60R aspect at the highest possible Luminance level..(M:903.1)

M:904 The AMI shall employ soft start switched mode power supply designs to eliminate surge current. All components used in the design shall be selected whilst considering the elimination of surge current.

M:905 The AMI shall operate without degradation in performance over the supply limits given in the following specifications:

TR 1100 Technical and Quality Requirements (M:905.1)

BS EN 50293 Electromagnetic compatibility. Road traffic signal systems. Product standard. (M:905.2)

HOSDB Speedmeter Handbook (M:905.3)

## 9.2 Outside Limits

M:910 The AMI shall operate as follows:

When the mains supply is outside the limits necessary to ensure correct operation, the AMI shall 'shut down' in an orderly manner without any unexpected or detrimental effects to the AMI System. (M:910.1)

When the mains supply returns to within the limits needed to ensure correct operation, the AMI shall perform an Initialisation (Reset) sequence, under the control of the AMI Roadside Controller, without requiring manual intervention. (M:910.2)

M:920 The AMI Roadside Controller shall operate as follows:

When the mains supply is outside the limits necessary to ensure correct operation, the AMI Roadside Controller shall 'shut down' in an orderly manner without any unexpected or detrimental effects to the AMI System. (M:920.1)

When the mains supply returns to within the limits needed to ensure correct operation, the AMI Roadside Controller shall perform an Initialisation (Reset) sequence and shall re-initialise the AMIs under its control, without requiring manual intervention (M:920.2)

D:921 In the event of the AMI Roadside Controller shutting down, the AMI Roadside Controller should as a 'last gasp' attempt to blank the displays of the AMIs it controls.

M:930 In the event of both the AMI Roadside Controller and the AMI shutting down, the AMI System shall recover to normal operation as required in M:910 and M:920 irrespective of the sequence in which the system components recover.

## 10 HARDWARE DESIGN CONSTRAINTS

This Chapter describes the physical and mechanical constraints due to the operational environment, system addressing requirements and physical interfaces.

### 10.1 Mechanical and Physical Constraints

**General**

I:1000 The AMI System comprises a number of AMIs (Gantry or Post mounted) controlled by an AMI Roadside Controller and when installed on a Gantry, interconnected via a Cable Marshalling Unit (CMU)

**AMI Roadside Controller**

M:1002 The AMI Roadside Controller shall be implemented using 19inch equipment practice for mounting within a roadside Cabinet Type 600.

The AMI Roadside Controller shall be capable of being mounted in other 19inch racks or cabinets and shall not be solely constrained to Cabinet Type 600.

M:1003 The height of the AMI Roadside Controller unit shall not exceed 6U.

**CMU**

M:1004 The CMU shall be designed to attach to the gantry structure and shall incorporate a hinged door to allow maintenance access. Connectors and Glands shall be on the underside of the CMU enclosure.

M:1005 The dimensions of the CMU shall not exceed 500mm (W) x 500mm (H) x 300mm (D).

## **10.2 Structural Arrangements**

### **10.2.1 General**

M:1010 The AMI design shall incorporate a safe and quick method of installation with appropriate lane closures. Removal of an AMI from a gantry and installation of a replacement AMI in its place should be possible within 30 minutes of making ready the requisite lifting equipment at the gantry site. The total duration of lane closure will depend upon the geography of the carriageway and so cannot be mandated.

M:1011 The design shall demonstrate a low risk of parts falling on to the motorway during any erection, removal and maintenance operation.

M:1012 The Contractor's design shall minimise the number of components / mounting brackets on the gantry structure.

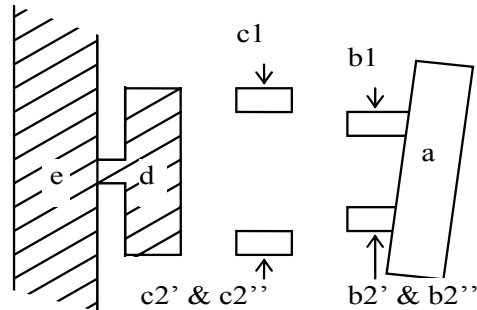
M:1013 The Contractor shall submit, with the design, Method Statements for erection, removal and any maintenance operation, for approval by the Overseeing Organisation and Technical Approval Authority (TAA).

M:1014 Removal / replacement of an AMI, when following the Method Statement provided by the Contractor, shall not damage the gantry paintwork.

- M:1015 If dissimilar materials are used all connections shall be protected against “bi-metallic corrosion”.
- M:1016 For the purpose of the structural design a design life of 20 years shall be assumed.
- I:1017 The AMI shall not be required to incorporate a mechanism for adjusting its alignment. Any mechanisms required to adjust the alignment of the AMI are to be provided outside the scope of these requirements. This applies to all AMI variants and all types of gantry. For example, an intermediate mounting frame (“Interface Frame”), designed as part of the infrastructure, could be used to provide the interface between the AMI and the supporting structure.
- M:1018 The structural elements of the AMI enclosure shall be fabricated from structural aluminium.
- M:1019 The AMI shall be capable of subsequent removal and re-erection anywhere on the Highways Agency network, where wind gust speed (as defined in BD 51/94) does not exceed 51 m/s.

### **10.2.2 AMI Mounting Arrangement Requirements**

- M:1020 The AMI shall be capable of being installed on gantries with or without permanent maintenance access, or posts for entry-slip use. A common design of AMI enclosure shall be used for all installations.
- M:1021 The contractor shall design two alternative forms of bracketry, one applicable to: “Standard” AMI installations (e.g. M42) , the other applicable to installations where a CMI has previously been installed (e.g. M25).
- M:1022 The structural elements of the AMI mounting arrangements shall be fabricated from structural steel.
- M:1030 All AMI erection, maintenance and removal operations shall be viable under currently accepted safe systems of Traffic Management.
- M:1033 Interfaces for mounting connections shall be suitable for structures constructed of aluminium, steel or other structural materials.
- M:1040 The mounting principle and outline installation sequence for the AMI is shown in figures 10.2, 10.3, 10.4, 10.5 and 10.6 below. Drawing MCX1031 sheets 5, 8 & 9 the geometry of the brackets to be supplied with the AMI.



Key



**Items required under AMI supply contract:**

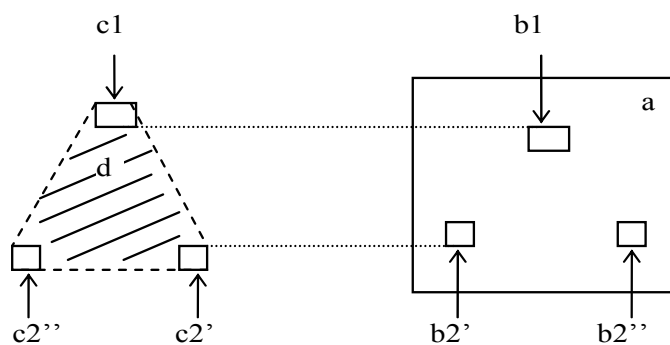
- a = AMI enclosure
- b1 = Upper bracket fixed to enclosure during manufacture
- b2 = Pair of lower brackets fixed to enclosure during AMI manufacture
- c1 = Upper bracket for attachment to interface frame
- c2 = Pair of lower brackets for attachment to interface frame



**Items external to AMI supply contract:**

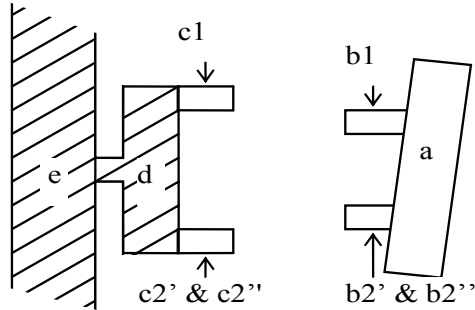
- d = Interface Frame
- e = Part of gantry beam

*Figure 10.2 – AMI mounting arrangement schematic, viewed from side of AMI:  
 Component parts prior to installation*



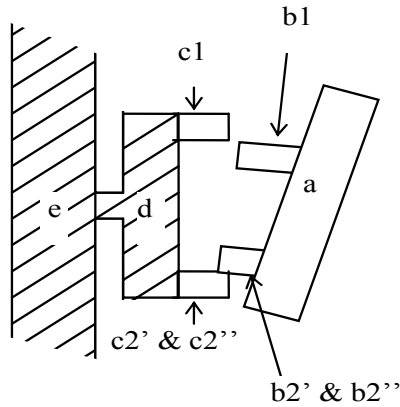
For Key refer to figure 10.2

*Figure 10.3 – Schematic showing rear view of AMI and front view of  
 interface frame: Relative positions of mounting brackets.*



For Key refer to figure 10.2

*Figure 10.4 – AMI mounting arrangement schematic: Stage 1 of installation – Interface Frame Brackets (c) fixed to Interface Frame (d).*



For Key refer to figure 10.2

*Figure 10.5 – AMI mounting arrangement schematic: Stage 2 of installation – AMI enclosure pivoting on lower Interface Frame Brackets (c2' and c2'').*



### ***Infill Panels***

M:1050 On gantries that have walkway access, side and floor apertures between the AMI and the gantry shall be sealed by “infill panels” to prevent the hazard of items falling onto the motorway. No gap of greater than 3mm shall be permitted.

### ***Trial Erection of AMI Brackets***

M:1070 The Contractor shall construct in the shop a sample length of the gantry web associated with the Works that receives AMI brackets. The area that receives brackets may be constructed out of any suitable material such as wood. The contractor shall fabricate sample brackets for approval by the Overseeing Organisation and undertake a trial erection of the brackets onto the sample gantry web in the shop. This shall be done prior to mass production of the fabrication of the remaining number of brackets. The Overseeing Organisation shall be present during the trial erection of the brackets to the sample. The sample part of the gantry shall be drilled and tapped to receive brackets using the same methodology and equipment proposed for the gantries in situ. This trial shall be used for approval and development of the erection method statements.

### ***Alignment***

I:1082 Whilst the Interface Frame may itself allow for adjustment, the fixed position of the Interface Frame ensures that the alignment is preserved following removal and replacement of the AMI.

## **10.2.3 Approval in Principle**

M:1090 The design of the AMI mounting arrangements requires structural approval. An Approval in Principle document shall be completed by the Contractor in accordance with BD 2/89 and TRH 1679 and submitted to the Overseeing Organisation for subsequent approval by the Highways Agency.

## **10.2.4 Design Certification**

M:1100 On completion of the designs, Design Certificates in accordance with BD 2/89 shall be submitted to the Overseeing Organisation for subsequent acceptance by the Technical Approval Authority (TAA). Design Certificate B shall be used.

## **10.2.5 Specification for Highway Works**

M:1110 The general specification for the mounting arrangements shall be the Specification for Highway Works, March 1998, published by The Stationery Office as Volume 1 of the



Manual of Contract Documents for Highway Works, as modified and extended by the following:

***Working and Fabrication Drawings***

M:1120 Working and Fabrication Drawings of the structural work shall be submitted to and approved by the Overseeing Organisation in compliance with Sub-Clause 104.15 of the Specification for Highway Works. Working and Fabrication Drawings shall be fully dimensioned and show all specification details of materials (including the type and grade of all steels to be utilised), weld details (with cross references to welding procedures defined in accordance with BS EN 288:Part 3), tolerances and all other information necessary to fabricate the structures.

***Materials and Workmanship***

M:1130 All materials and workmanship shall be the best of their respective kinds and all work shall be performed in the best and most workmanlike manner. Materials shall be in accordance with the current British Standard Institution Specification and workmanship shall be in accordance with the current British Standard Code of Practice.

M:1131 If materials other than aluminium or steel are proposed for the AMI enclosure, then an Alternative Tender shall be submitted giving design calculations and other relevant supporting information. This Alternative Tender shall be accompanied by a fully compliant Tender utilising aluminium or steel as the structural materials. Alternative materials (e.g. plastic or composite materials) may be considered if this gives a clear benefit to the Purchaser (e.g. a significant saving in weight) and the safety, design, structural and reliability requirements of the Specification are met.

M:1140 Finish colour shall be Matt Black non reflective to BS 4800 (or suitable equivalent).

***Structural Steelwork***

M:1150 Structural steelwork and fixings shall be in accordance with the Specification for Highway Works, Series 1800. Hollow sections shall be sealed to prevent ingress of water.

M:1151 Structural Steel shall comply with EN10210-1 grades S275J2H and S355J2H or BS EN10025 grades S275, S275J2 for plate and rolled sections.

M:1152 Structural steelwork and fixings shall be painted to comply with Highways Agency Specification for Standard Gantries, Inland B Difficult Access, Type 10 in Vol. 2 of Specification for Highway Works or supplied Hot Dip Galvanised. Galvanising shall be an approved hot-dip process at the rate of 610g/sq.m and in accordance with BS 729.

M:1153 All welds shall be self cleaning and shed water. No site welding shall be permitted. Welders engaged on the fabrication of steel structures shall have been tested in accordance with BS EN 287:Part 1 and hold a Welder Approval Certificate valid for the type of work on which they are employed. The Overseeing Organisation will require evidence that the welders are properly certified and that the manufacturer's quality system permits only those so certified to produce welds within their range of competence.

***Aluminium or Aluminium Alloy Structural Work***

M:1160 Structural aluminium and aluminium alloys shall comply with Clause 2.1 of BS 8118:Part 2. With reference to Clause 2.2. of BS 8118 : Part 2, the use of castings is not permitted. Bolts, nuts, washers and rivets shall comply with Clause 2.3 of BS 8118 : Part 2. Welding consumables shall comply with Clauses 2.4 of BS 8118 : Part 2.

- M:1161 Welding procedure specifications in accordance with BS EN 288:Part 2 shall be submitted to the Overseeing Organisation for approval. Welders engaged on the fabrication of aluminium or aluminium alloy structures shall have been tested in accordance with BS EN 287:Part 2 and hold a Welder Approval Test Certificate valid for the type of work on which they are employed. The Contractor shall provide evidence to the Overseeing Organisation that the welders are properly certified and that the manufacturer's quality system permits only those so certified to produce welds within their range of competence.
- M:1162 To prevent retro-reflection, the surface of aluminium or aluminium alloy sheets, extrusions and sections forming permanently exposed structures shall be dulled using a method agreed by the Overseeing Organisation or coated with paint.

### ***Handbook for Structures***

- M:1170 The Handbook for Structures shall be produced in hard copy in A4 (A3 where necessary) loose-leaf form and contained in ring type binders, with trigger operated mechanisms of a minimum of 4 rings, and suitable for updating of pages. An index page shall also be incorporated to show the current issue date of each individual page.
- M:1171 The Handbook for Structures shall be produced to meet the requirements of the system design documentation and the Maintaining Authority.
- M:1172 The Handbook for Structures shall include the following detail:
- a) As built General and Structural Arrangements and Fabrication drawings.
  - b) Detailed technical descriptions of materials used.
  - c) Parts lists including details of paint systems.
  - d) Method Statement for erection and instructions for dismantling and re-erecting.

## **10.3 Construction**

### **10.3.1 General**

- M:1200 The AMI System shall be designed to have a design life of not less than 15 years when used in the UK Motorway Environment and maintained in accordance with the manufacturers' recommendations.
- M:1201 Material combinations which, when in contact, give rise to galvanic corrosion shall not be used without the provision of protection adequate for the design life of the equipment.

M:1202 All metalwork shall be protected and finished during manufacture either for corrosion protection or aesthetic appearance. The protection shall be maintenance free and effective for the design life of the equipment.

The standard of construction, finish, sealing and materials shall be in accordance with comparable NMCS items. (M:1202.1)

Unfinished metal surfaces will not be permitted. All external and internal surfaces of the Enclosure and all Modules shall be finished using appropriate methods, painting or coloured anodising, to provide a high quality aesthetic appearance. (M:1202.2)

M:1203 All connectors, cable glands, fasteners, locks, hinges, fittings, screws, nuts, bolts etc. which form part of any closure system or any removable panel or any fixing shall be manufactured from non-corrodible material.

M:1204 All external connectors shall be fitted to underside or rear facing surfaces only. Such items shall not be fitted to any upward facing surface.

M:1205 All external connectors shall be Environmental "Weatherproof" type and shall incorporate suitable inserts, seals and accessories for environmental proofing. This includes all MIL-C-5015 connectors referred to in this specification.

M:1206 The orientation of all external connectors shall be consistent throughout the Equipment.

M:1207 All stranded cable cores shall be terminated via crimped ferrule terminals prior to insertion in 'Screw Clamp' terminals.

M:1208 Cables and Optical Fibres (if used) shall be neatly formed and installed using an effective cable / fibre management system and fitted with strain relief and cable / fibre protection where necessary.

M:1209 Flying leads with inline connections within the AMI shall not be permitted, except in the case where a flying lead may facilitate the removal of a hot component

M:1210 All Printed circuit boards shall be designed in a modular fashion.

The size and weight of removable Modules shall be kept to a minimum suitable for easy and safe handling by one person. (M:1210.1)

The removable Modules shall be designed to be easily removed using a single standard tool such as a socket driver. (M:1210.2)

All connections to Modules shall be achieved using polarised plug / socket arrangements that can be easily disconnected. (M:1210.3)

It is preferable that the Modules are totally enclosed assemblies using heavy duty, ruggedised connectors. This would allow maintenance to be carried out on a module removal basis without exposing the contents of a module to the elements. (M:1210.4)

Securing springs for holding in Modules shall not be used. (M:1210.5)

Studs for fixing Modules or assemblies shall be of the through panel captive type or welded to the panel. Screws retained by locking nuts shall not be used for this purpose. (M:1210.6)

- M:1211 All printed circuit boards shall be coated with protective lacquer material finish to prevent damage by moisture.
- M:1212 All covers, doors, protective screens, plates, external connectors etc., necessary for environmental protection, shall be provided with seals which are maintenance free and shall remain effective for the design life of the equipment.
- M:1213 Any joints in the Enclosures shall be sealed prior to assembly.
- M:1214 Protective covers, as approved by the Overseeing Organisation, shall be fitted to all external connectors.
- M:1215 The name of the manufacturer, any logo or any other marking shall not be shown on any external surface other than to identify the equipment in accordance with TR 1100.
- M:1216 External connectors shall be mounted as indicated on MCX0920, whilst being spaced sufficiently far apart to allow easy removal of each connector individually.

### 10.3.2 Equipment Layout

- M:1230 The internal hardware layout within the AMI shall be designed to allow easy removal and replacement of modules from the rear of the enclosure.
- M:1234 The installation shall be designed to make the equipment as easy as possible to comprehend, use and maintain.
- M:1235 Proposals for the layout of equipment showing the positioning of all equipment, cabinets, interconnecting cables and the layout of equipment within cabinets etc. shall be submitted in any tender and be subject to the approval of the Overseeing Organisation in any contract.
- M:1236 All switches shall be covered, shrouded or recessed, or have a rotary action to prevent accidental movement.
- M:1237 Where settings are not common to all sites, configuration switches shall be on the outside of a module or accessible through an aperture from the outside of the module.

### 10.3.3 Identification Labels

- M:1250 English text and terminology shall be used for all labels.
- M:1251 All labels shall be of high quality, suitable for the application and professionally printed on a plastic or metal based material. Hand written or paper labels are not permitted.
- M:1252 All removable covers and panels which expose any point with a voltage greater than 50 Volts, AC or DC shall be clearly labelled both internally and externally with appropriate warning labels in accordance with BS 5378.
- M:1253 All switch positions, settings, test points, connectors fuses, MCBs, and visual status indicators shall be clearly labelled to identify their circuit designation and function.
- M:1254 All Modules shall be clearly labelled to identify their function.
- M:1255 All wires and cables shall be individually labelled using coloured and numbered plastic collets to provide a unique identity corresponding to the terminology used for the wiring diagram(s).
- M:1256 Information cards shall be fitted to the AMI to provide on-site maintenance information in the form of Schematic and Block diagrams etc.

#### **10.3.4 Earthing**

- M:1260 The Equipment earthing method and standard shall comply with BS 7671 – “Requirements for Electrical Installation” and BS 7430 – “Code of Practice for Earthing”.
- M:1261 The AMI shall be provided with clearly identified Earth Connection Point on the internal and external (Forming a Through Connection) rear faces of the Enclosure(s) which shall be individually electrically bonded, internally to all Equipment and externally to the Gantry / Post earth connection point.
- M:1262 All Earth Connection Points shall be clearly labelled with labels – “SAFETY ELECTRICAL EARTH - DO NOT REMOVE”.
- M:1263 All metalwork not normally expected to carry current shall be bonded to the Earth Connection Point using earth cables, crimped lugs, studs and fasteners. Such metalwork shall include equipment panels, structural members, access doors, screens, glands, conduits, sheaths etc.
- M:1264 All earth cables shall be green / yellow and suitable for the equipment loading and for protection purposes.

#### **10.3.5 Electrical Connections**

- I:1270 Refer to drawing MCX1031 sheet 7 .
- M:1271 All external connections shall meet the Environmental and EMC requirements defined in Chapter 7.
- M:1272 All replaceable internal Modules shall be fitted with sockets and plugs as appropriate to allow easy disconnection and removal of equipment.
- M:1273 Lightning Protection Module(s) shall be installed, as close as possible to the connection panel on the rear of the enclosure, on all connections to the NMCS power distribution and data communications system.
- M:1274 All cable cores and wires shall be individually identified and numbered using coloured and numbered collets.

## **10.4 Enclosure**

### **10.4.1 General**

- M:1280 The AMI enclosure shall be designed to allow dispersal of heat generated during operation.
- M:1281 The AMI enclosure shall incorporate one or more lifting eyes that remain attached to the enclosure.

### **10.4.2 Front Face**

- M:1290 The function of the front face is to allow the optical characteristics of the AMI to meet the required optical performance standards, whilst preventing the ingress of dirt and moisture. The design shall take the following into account:

The front face shall provide a smooth, flat, scratch resistant, wipe-clean surface which is predominantly non reflective. (M:1290.1)

The visible area of transparent material (e.g. Polycarbonate) shall be kept to a minimum. (M:1290.2)

Any coating material shall be suitable for the design life of the AMI and the environment for which it is intended. (M:1290.3)

- M:1295 The proposed Front Face shall be fitted during all optical and physical testing.

### **10.4.3 Internal Environment Monitoring**

- I:1300 The AMI is not required to incorporate heaters, as the risk of condensation is deemed to be low and the design of the front face precludes the use of a continuous polycarbonate sheet.

- M:1301 The AMI shall incorporate a internal environment sensors as follows, which shall report their readings periodically to the AMI Roadside Controller:

Temperature sensor (M:1301.1)

Humidity sensor (M:1301.2)

- M:1302 In order to ensure there is no possibility of damage to internal components due to excessive heat build up, the AMI shall include a high temperature thermal cut out. Mechanism.



#### **10.4.4 Maintenance Access into rear of AMI enclosure**

- M:1310 The rear face of the AMI enclosure shall incorporate one or more access doors for the purpose of allowing replacement of internal modules, within the constraints of the mounting geometry specified by Drawing MCX1031 sheet 5..
- M:1311 The AMI enclosure access door(s) shall be designed in such a way that when open, they do not hinder access and egress along gantries with walkways (e.g. DOT and SNMD standards gantries).
- M:1312 AMI enclosure access door(s) shall be fitted with suitable locks.
- I: 1315 Rear maintenance access is required to cater for installations where maintenance access is permitted and for ease of maintenance in the factory.

### **10.5 Status Indicators**

#### **10.5.1 General**

- M:1320 The AMI shall include Visual Status Indicators for the following functions and conditions:
- a) Power On
  - b) RS 485 Receive Data
  - c) RS 485 Transmit Data
  - d) Fault Indicators

#### **10.5.2 Speed Enforcement Interface**

- M:1325 The PMU shall include Visual Status Indicators to show the status of the Electrical Interface relays as output to the Enforcement Equipment.

Visual Status Indicators shall be provided to show the status of each of the Relays (A2, A3, A4, A5, A6, A7, AX, AC) in the PMU. (M:1325.1)

### **10.6 Addressing**

#### **10.6.1 Addressing - AMI**

- M:1332 Electronic identification of internal modules that are not site dependant shall use hard-wired links rather than switches, to prevent settings being changed accidentally.

- M:1335 The addressing AMI Systems shall enable each AMI to be uniquely identifiable by the relevant control system and by maintenance personnel, without the need for specialised external equipment.
- M:1336 In the event of AMI removal and replacement, the cabling and control infrastructure shall enable the new unit to adopt the same address the old unit, without external intervention.
- M:1337 It is envisaged that the AMI Roadside Controller will implement a mapping between NMCS2 addresses and site addresses for each AMI. This may either be configurable in software via the Test Terminal or be configured in hardware. If address plugs or equivalent physical devices are used then for ease of maintenance these shall be located in the roadside cabinet.
- M:1338 The proposed design of the addressing function shall require approval by the Overseeing Organisation.

## 10.7 External Interfaces

- M:1340 This sub-section details the interfaces external to the AMI System. (This excludes the interface between the AMI Roadside Controller and the AMI as this is regarded as internal to the system).

### **Interfacing to AMI:**

- a) Power Supply - AC Mains
- b) AMI / Speed Enforcement Equipment Electrical Interface - Adjacent AMIs (AMI –EE variants only)

### **Interfacing to AMI Roadside Controller**

- c) Power Supply – AC Mains
- d) RS 485 - NMCS2
- e) RS 485 – Local
- f) Ethernet LAN Interface
- g) AMI Test Terminal- Maintenance and Diagnostics Interface (refer to M:1390)

### **Interfacing to Cable Marshalling Unit**

- h) AMI / Speed Enforcement Equipment Electrical Interface - Enforcement Equipment (AMI–EE variants only)

- M:1341 Other internal or external interfaces may be included by the supplier. All Interfaces specifications shall be subject to the approval of the Overseeing Organisation.

- M:1342 AMI interconnecting cables and connectors shall be environmentally acceptable and approved by the Highways Agency. TR 2130 provides details of environmental test conditions.
- M:1343 All data connector receptacles on the AMI and Cable Marshalling Unit shall be cylindrical reverse bayonet coupling to specification VG95234 (equivalent to MIL-C-5015). Connectors shall be manufactured from stainless steel in accordance with service class E, F or R, and incorporate neoprene (or equivalent) mono-block insulators and grommets. Connector inserts (pin or socket contacts as indicated by P or S in the code number) shall be of the non-removable bonded-in solder type.
- M:1346 All AMI variants shall incorporate a power connector and a single data connector. The power connector is of the same specification on all AMI variants, whereas the data connector has two different forms. On AMIs configured for gantry-mounting data connector is designated PL3, whereas on AMIs configured for post-mounting, the data connector is designated PL8 to differentiate its pin-out.

All AMI variants shall incorporate an external AC mains connection inlet (type Marechal, Product Code 61 18015), which shall be mounted directly to the equipment enclosure, without the use of a wall box or an inclined sleeve. (M:1346.1) (Refer to 10.7.1).

Note: The corresponding cable mounted socket outlet will require a lid self-opening to 180° (Marechal Product Code 61 14015 18), however provision of this outlet does not form part of this contract.

AMIs configured for Post-mounting shall incorporate a composite 11-way data plug (PL8, type VG95234 20-33P) which facilitates connection to the communications network, incorporating dedicated pins for RS 485 interfaces (refer to 10.7.2). The AMI local addressing shall also utilise pins in PL8 as follows: (M:1346.2)

PIN K	ADDRESS 1
PIN J	ADDRESS 2
PIN F	ADDRESS 4
PIN E	ADDRESS 8
PIN H	ADDRESS COMMON

AMIs configured for Gantry-mounting shall incorporate a composite 37-way data plug (PL3, type VG95234 28-21P) which facilitates connection to the Cable Marshalling Unit, incorporating dedicated pins for the following external interfaces (M:1346.3):

- RS 485 – Refer to 10.7.2
- Speed Enforcement Interface connections to adjacent AMIs – Refer to 10.7.4

The AMI local addressing shall also utilise pins in PL3 as follows:

PIN E	ADDRESS 1
PIN K	ADDRESS 2
PIN a	ADDRESS 4
PIN g	ADDRESS 8
PIN S	ADDRESS COMMON

M:1348 The Cable Marshalling Unit shall incorporate:

Speed Enforcement Interface 14-way socket (SK6, type VG95234 22-19S) (M:1348.1) – Refer to 10.7.5

Eight composite 37-way sockets (SK7, type VG95234 28-21S) which each facilitate connection of an AMI, with pin outs as follows (M:1348.2):

PIN W	Control RS 485 – A
PIN V	Control RS 485 – B
PIN U	Local/RESET – A
PIN T	Local/RESET – B
PIN E	ADDRESS 1
PIN K	ADDRESS 2
PIN a	ADDRESS 4
PIN g	ADDRESS 8
PIN S	ADDRESS COMMON
PIN f	20mph Circuit from AMI to CMU
PIN m	30mph Circuit from AMI to CMU
PIN s	40mph Circuit from AMI to CMU
PIN e	50mph Circuit from AMI to CMU
PIN k	60mph Circuit from AMI to CMU
PIN r	National Speed Limit Circuit from AMI to CMU
PIN d	RED X Circuit from AMI to CMU
PIN j	CONTINUITY Circuit from AMI to CMU
PIN R	20mph Circuit from CMU to AMI

PIN J	30mph Circuit from CMU to AMI
PIN D	40mph Circuit from CMU to AMI
PIN P	50mph Circuit from CMU to AMI
PIN H	60mph Circuit from CMU to AMI
PIN C	National Speed Limit Circuit from CMU to AMI
PIN N	RED X Circuit from CMU to AMI
PIN G	CONTINUITY Circuit from CMU to AMI
PIN Z	EARTH (RS 485 Screen) (Terminated at the CMU)
PIN A	NOT connected within CMU
PIN B	NOT connected within CMU
PIN F	NOT connected within CMU
PIN L	NOT connected within CMU
PIN M	NOT connected within CMU
PIN b	NOT connected within CMU
PIN c	NOT connected within CMU
PIN h	NOT connected within CMU
PIN n	NOT connected within CMU
PIN p	NOT connected within CMU
PIN X	NOT connected within CMU
SHELL	CABLE SCREEN

M:1349 For CMU installations on gantries equipped for Speed Enforcement, but where not all eight AMIs are present, each unused socket requires a dummy link plug to be inserted (PL7, type VG95234 28-21P) with pins inter-connected in accordance with Drawing MCX1031 sheet. This is to ensure continuity of the speed confirmation circuits.

### 10.7.1 Power Supply - AC Mains

M:1350 The external AC mains connection inlet shall be of a 1+N+E wiring configuration, and utilise pins as follows

**PIN ALLOCATION**

- 1 = Live
- N = Neutral
- E = Earth

### 10.7.2 RS 485 - NMCS2 and Local

M:1355 The AMI shall utilise four pins within the composite data connector to provide input connections as follows:

Within post-mount AMI data connector PL8 (M:1355.1):

PIN L	Control RS 485 – A
PIN M	Control RS 485 – B
PIN A	Local/RESET – A
PIN B	Local/RESET – B

Within gantry-mount AMI data connector PL3 (M:1355.2):

PIN W	Control RS 485 – A
PIN V	Control RS 485 – B
PIN U	Local/RESET – A
PIN T	Local/RESET – B

I:1356 The Contractor shall identify suitable connectors for use in association with RS 485 connection to the AMI Roadside Controller.

### 10.7.3 Ethernet LAN Interface

M:1360 The AMI Roadside Controller shall incorporate at least one external RJ-45 connector to allow the future control of the AMI System via IP.

M:1365 The RJ-45 connector shall be of an environmental standard suitable for use in a roadside cabinet.

I:1366 The AMI itself does not require an external RJ-45 connection.

### 10.7.4 Speed Enforcement Interface – To Adjacent AMIs

M:1370 Gantry-mount AMI shall utilise sixteen pins within composite data connector PL3 to provide connections as follows: (Not applicable to post-mount AMI).

PIN f	20mph Circuit from AMI to CMU
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PIN m	30mph Circuit from AMI to CMU
PIN s	40mph Circuit from AMI to CMU
PIN e	50mph Circuit from AMI to CMU
PIN k	60mph Circuit from AMI to CMU
PIN r	National Speed Limit Circuit from AMI to CMU
PIN d	RED X Circuit from AMI to CMU
PIN j	CONTINUITY Circuit from AMI to CMU
PIN R	20mph Circuit from CMU to AMI
PIN J	30mph Circuit from CMU to AMI
PIN D	40mph Circuit from CMU to AMI
PIN P	50mph Circuit from CMU to AMI
PIN H	60mph Circuit from CMU to AMI
PIN C	National Speed Limit Circuit from CMU to AMI
PIN N	RED X Circuit from CMU to AMI
PIN G	CONTINUITY Circuit from CMU to AMI

M:1373 Speed Enforcement Interface Interconnection Cables shall be produced to the requirements of Drawing MCX1031 sheet 4.

#### 10.7.5 Speed Enforcement Interface - To Enforcement Equipment

M:1380 The Cable Marshalling unit shall provide SK6 with pins utilised as follows:

PIN A	COMMON
PIN B	20 MPH
PIN C	30 MPH
PIN D	40 MPH
PIN E	50 MPH
PIN F	60 MPH
PIN G	CONTINUITY
PIN H	EARTH (Terminated at the CMU)
PIN J	NATIONAL SPEED LIMIT
PIN K	RED X
PIN L	NOT connected within CMU
PIN M	NOT connected within CMU
PIN N	NOT connected within CMU

PIN P	NOT connected within CMU
SHELL	CABLE SCREEN (Terminated at BOTH ends)

M:1381 Speed Enforcement Interface Interconnection Cables shall be produced to the requirements of Drawing MCX1031 sheet 4.

#### 10.7.6 Not Used

#### 10.7.7 Test Terminal Interfaces

M:1390 The AMI Roadside Controller shall be provided with a socket to connect to the Test Terminal PC via the RS 232 interface.

The socket design shall be defined by the supplier and offered to the Overseeing Organisation for approval. (M:1390.1)

#### 10.7.8 Interconnecting Cables

M:1400 Interconnecting cables and 'dummy link' connectors shall be manufactured in accordance with Drawing MCX1031 sheet 4 and specification TR 2033. All connectors shall be cylindrical reverse bayonet coupling to specification VG95234 (equivalent to MIL-C-5015). Connectors shall be manufactured in accordance with service class E, F or R. Connector inserts (pin or socket contacts as indicated by P or S in the code number) shall be of the non-removable bonded-in solder type. .

M:1401 Cables shall be moulded to the connectors in accordance with the requirements of TR 2033. Dummy 'end link' connectors shall be sealed by injection moulding process specified (in accordance with TR 2033) for the cable assemblies.

M:1402 In order to meet the EMC requirements and comply with TR 2033 the cable screen shall have a 360<sup>0</sup> termination to the connector shell.

I:1403 Even though not connected within the equipment, pins L, M, b, c and h are through-connected in the AMI-CMU cable and are reserved for future expansion.

I:1406 Drawing MCX1031 sheet 4 takes precedence over MCX0733 in respect of cable specifications for post-mount AMIs.





## 11 SOFTWARE DESIGN CONSTRAINTS

This Chapter describes the design constraints of the software within the system. It covers software production standards, special interface requirements and capacity and expansion constraints.

### 11.1 Standards

M:1500 The AMI software and software documentation shall comply with the requirements of TR 1100 and the maintenance and hand-over requirements

M:1501 The AMI software shall be labelled with a version number and date.

M:1502 A copy of the Source Code shall be supplied to the Highways Agency.

### 11.2 Migration to Internet Protocol

I:1510 It is intended to migrate Transponder to Signal communications from the current RS 485 link to an Internet Protocol (IP) infrastructure. This will apply to all current information exchanges on the existing Transponder to AMI Roadside Controller RS 485 link. Future potential uses of an IP interface and the file transfer that may become possible with the higher transmission speed are:

- A new messaging and file transmission structure over IP
- Downloading new application software to the Controller
- Downloading configuration files to the Controller
- Uploading of operational and fault logs to the Instation

The new capabilities that have to be provided within the AMI Roadside Controller to enable IP migration are detailed below.

#### 11.2.1 General

M:1511 All existing capabilities using the RS 485 Transponder to AMI Roadside Controller link shall be retained.

M:1512 The AMI Roadside Controller shall be configurable to use either the existing RS 485 Transponder to Controller link or the alternative IP interface.

This configuration shall be via the AMI Test Terminal or other front panel link to be agreed with the Overseeing Organisation. (M:1512.1)

M:1513 The AMI Roadside Controller shall store additional configuration information as required to support the operation of the IP interface, as 'IP Configuration Data'.

### 11.2.2 Network Connection and Layer Protocols

M:1520 The Ethernet interface shall comply with ISO 8802-3, using twisted-pair medium attachment unit (MAU) and baseband medium, type 10BASE-T (IEEE 802.3, section 14) as a minimum.

The connection shall support the half-duplex, 10Mbit/s mode. (M:1520.1)

M:1521 The AMI Roadside Controller shall support and use the Medium Access Control (MAC) mechanisms in ISO 8802-3 for the relevant interface type.

M:1522 A unique MAC address shall be assigned to each AMI Roadside Controller.

I:1523 Each AMI Roadside Controller will require a unique MAC address. This can be achieved through either the procurement of third party Ethernet modules, or the allocation of a block of MAC addresses from the IEEE by obtaining an Organisationally Unique Identifier (OUI).

M:1524 The AMI Roadside Controller Ethernet interface shall implement IP Version 4 network layer as defined in RFC 1122 (Requirements for Internet Hosts - Communication Layers).

M:1525 The Frame Length/Type field (IEEE 802.3, section 3.2.6) shall have value 0800H, indicating that the next protocol layer is IP version 4.

M:1526 The AMI Roadside Controller shall implement the Internet Control Message Protocol (ICMP) conforming to RFC 792 (Internet Control Message Protocol).

I:1527 The AMI Roadside Controller Ethernet interface shall implement ICMP to support the PING utility.

M:1528 The AMI Roadside Controller shall implement the User Datagram Protocol (UDP) to support broadcast messages as defined in RFC 768 (User Datagram Protocol) and RFC 1122 (Requirements for Internet Hosts - Communication Layers).

M:1529 The AMI Roadside Controller shall implement Transmission Control Protocol (TCP) as defined in RFC 793 (Transmission Control Protocol) and RFC 1122 (Requirements for Internet Hosts - Communication Layers).

M:1530 The AMI Roadside Controller shall support IP traffic data queuing and prioritisation using the Differentiated Services mechanism as defined in RFC 2474 (Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers) and RFC 2475

(An Architecture for Differentiated Service).

- I:1531 The AMI Roadside Controller shall be capable of providing IP traffic prioritisation to ensure that there is a low risk of IP datagrams containing high priority traffic experiencing excessive latency.

### **11.2.3 Communications Application Interface**

- M:1540 The AMI Roadside Controller Ethernet Link (TCP/IP or UDP/IP) shall be accessed using a socket interface based on release 4.3 of the Berkeley Software Distribution Interprocess Communication (BSD IPC) facilities, or its equivalent for the chosen operating system.

### **11.2.4 Link Operation**

#### ***Link Establishment***

- I:1550 The AMI Roadside Controller shall act as a client on the Signal Transponder-Controller link and a server on the AMI Test Terminal link. The typical link operation is described in the following sections.

#### ***Server Operation***

- M:1551 To initiate a connection, the server shall create an internet stream socket, bind a port address to the socket and then listen for incoming connection requests from clients.
- M:1552 The address family of the socket shall be the internet address family (AF\_INET).
- M:1553 The socket type shall be a stream socket (SOCK\_STREAM).
- M:1554 The underlying protocol to be used shall be TCP.
- M:1555 Internet and port addresses shall be read from IP Configuration Data.
- M:1556 When an incoming connection request is received from a client, the server shall accept the connection and create an accept socket with the same characteristics as the listen socket.
- I:1557 The link between the client and the server is now established and data can be sent and received between the two socket end-points.

#### ***Client Operation***

- M:1558 To initiate a connection, the client shall create an internet stream socket and request a connection to the server's socket.

M:1559 The address family of the socket shall be the internet address family (AF\_INET).

M:1560 The socket type shall be either stream socket or socket datagram, as below:

Where the protocol used is TCP, the socket type shall be a stream socket (SOCK\_STREAM). (M:1560.1)

Where the protocol used is UDP, the socket type shall be a socket datagram (SOCK\_DGRAM). (M:1560.2)

M:1561 The underlying protocol to be used shall be TCP or UDP.

Both TCP and UDP mechanisms shall be supported. (M:1561.1)

M:1562 The server's internet and port addresses shall be read from IP Configuration Data.

I:1563 In the case of TCP, when the connection has been accepted by the server, the connection is established and data can be sent and received between the two socket end-points.

#### ***Link Disconnection and Recovery***

M:1564 Once the link is established, the connection shall remain open until either the client or server is shut down or until an error is detected.

M:1565 If the client or server detects an error while sending or receiving data, the link shall be disconnected and any data buffered at the socket level shall be discarded.

M:1566 If the client or server is shut down, the link shall be disconnected.

M:1567 If the link is disconnected for any reason, the client shall attempt to reconnect as described above.

#### ***Sending and Receiving Data***

I:1568 Application messages sent between internet stream sockets are passed as a byte stream. Messages are written to the socket as a number of bytes and are read from the destination socket as a number of bytes.

M:1569 To send a message on the link, the client or server shall write the message to its local socket.

M:1570 To receive a message on the link, the client or server shall read data from its local socket until a complete message has been received.

### 11.2.5 Message Set Support

I:1580 The AMI Roadside Controller is required to support the existing Transponder to AMI Roadside Controller message set as specified in TR2070 (NMCS2 – Message Control Point to Point) and TR 2142 (NMCS2 – Motorway Message Control Message Sign Equipment) on the Ethernet link. Each existing message will be encapsulated within a TCP/IP message wrapper.

M:1581 The AMI Roadside Controller shall support the existing Transponder to AMI Roadside Controller messages as defined in TR2070 and TR 2142.

M:1582 A message transmitted on the link shall consist of:  
a data length field. (M:1582.1)  
a data field. (M:1582.2)

M:1583 The data length field shall be four octets in length.

M:1584 The value of the data length field shall equal the length of the data field.

M:1585 The data field shall comprise a Transponder to AMI Roadside Controller message as specified in TR2070 or TR 2142.

### 11.2.6 Services

I:1586 The AMI Roadside Controller is required to support a range of IP-based services, e.g. FTP and TELNET. These services will be used in various combinations to communicate with the Instation and also to allow maintenance personnel to perform on-site and remote diagnostic activities. The services outlined in this section are intended to eventually replace the encapsulated HDLC message exchange method where the message contents will be adapted and extended to use new data structures defined for the services.

I:1587 The services listed below are those which have been identified by the Overseeing Organisation as being the most immediately applicable for use with the IP-enabled AMI Roadside Controller. However, as the NMCS system evolves to use IP for Instation to roadside communications, the inclusion of other IP services may be required.

#### ***The PING Command***

M:1590 The AMI Roadside Controller shall support the PING command.

- I:1591 The PING command should be implemented using the ICMP 'Echo' facility.
- I:1592 The PING command is a mechanism to determine if a path exists between two hosts. It is an invaluable diagnostic tool that can be used at either the Instation or Controller.

***File Transfer Protocol (FTP)***

- I:1593 The AMI Roadside Controller may use FTP for the download of new software and configuration data.
- M:1594 The Controller shall support file transfer using FTP as defined in RFC 959 (File Transfer Protocol).

The Controller shall be capable of acting as either an FTP client or server. (M:1594.1)

***Network Time Protocol (NTP)***

- M:1595 The AMI Roadside Controller shall support NTP v3 as defined in RFC 1305 (Network Time Protocol (Version 3) Specification, Implementation and Analysis).

The AMI Roadside Controller shall act as an NTP client. (M:1595.1).

The AMI Roadside Controller shall implement NTP using unicast mode. (M:1595.2)

- M:1596 The AMI Roadside Controller shall set its internal clock to the time obtained from the NTP client application.
- I:1597 The implementation of NTP between the HALOGEN service and RCC COBS uses the unicast mechanism. It is anticipated that the Controller will rely on the same mechanism. Both multicast and manycast are considered undesirable due to their addressing requirements.
- I:1598 The IP address of the NTP server should be stored in IP configuration data.

***Remote Access Mechanisms (TELNET and SSH Commands)***

- M:1599 The AMI Roadside Controller shall be capable of supporting either an SSH or TELNET session to enable local or remote users to access Controller facilities.

Login to either an SSH or TELNET session shall be restricted by a username/ password. (M:1599.1)

D:1600 SSH is the preferred mechanism.

I:1601 The choice of remote access mechanism provided is expected to depend upon the operating system chosen for the Controller, but may be either SSH (Secure Shell) or TELNET/SSL.

### ***Simple Network Management Protocol (SNMP)***

M:1602 The AMI Roadside Controller shall be capable of supporting SNMP v1 and SNMP v3.

The AMI Roadside Controller shall act as an SNMP agent. (M:1602.1)

I:1603 The Simple Network Management Protocol (SNMP) can be used as a mechanism for the management of AMI Roadside Controllers from the instation. The precise nature of this management will be defined by future applications.

I:1604 The SNMP Management Framework presently consists of five major components:

An overall architecture, described in RFC 2571 (An Architecture for Describing SNMP Management Frameworks).

Mechanisms for describing and naming objects and events for the purpose of management. The first version of this Structure of Management Information (SMI) is called SMIv1 and is defined In RFC 1155 (Structure and identification of management information for TCP/IP-based internets), RFC 1212 (Concise MIB Definitions) and RFC 1215 (Convention for defining traps for use with the SNMP). The second version, called SMIv2, is described in RFC 2578 (Structure of Management Information Version 2 (SMIv2)), RFC 2579 (Textual Conventions for SMIv2) and RFC 2580 (Conformance Statements for SMIv2).

Message protocols for transferring management information. The first version of the SNMP message protocol is called SNMPv1 and is described in RFC 1157 (Simple Network Management Protocol). The third version of the message protocol is called SNMPv3 and is described in RFC 1906 (Transport Mappings for Version 2 of the Simple Network Management Protocol (SNMPv2)), RFC 2272 (Message Processing and Dispatching for the Simple Network Management Protocol (SNMP)) and RFC 2574 (User-based Security Model (USM) for version 3 of the Simple Network Management Protocol (SNMPv3)).

Protocol operations for accessing management information. The first set of protocol operations and associated PDU formats is defined in RFC 1157. A second set of protocol operations and associated PDU formats is described in RFC 1905 (Protocol Operations for Version 2 of the Simple Network Management Protocol (SNMPv2)).

A set of fundamental applications is described in RFC 2573 (SNMP Applications).

I:1605 SNMP v3 supersedes and replaces v2 which was originally developed to incorporate enhancements to the protocol without having to wait for the security-related additions in



v3 to be agreed. However, v3 still references a number of the v2 RFCs.

- I:1606 SNMP username and passwords shall be stored in IP Configuration Data. This information may be encrypted for security purposes, the mechanism used will be agreed with the Overseeing Organisation.
- M:1607 The implementation of SNMP shall support MIB-II as specified in RFC 1213 (Management Information Base for network management of TCP/IP-based internets: MIB-II).
- I:1608 Development of the required MIB libraries shall be co-ordinated by the Overseeing Organisation.

#### ***Extensible Markup Language (XML) /Hypertext Transfer Protocol (HTTP)***

- M:1609 The AMI Roadside Controller shall be capable of supporting the Hypertext Transfer Protocol (HTTP) v1.1.  
Security shall be provided using HTTP-S (HTTP with SSL). (M:1609.1)
- M:1610 The AMI Roadside Controller shall be capable of supporting Extensible Markup Language (XML) v1.0.
- I:1611 XML is well suited for the extraction and display of diagnostic/status information retained within the AMI Roadside Controller with good visualisation mechanisms available through the use of web browsers. XML also provides the capability of sourcing the data in a machine-readable form, e.g. to transfer fault information into a database for historical analysis.

#### **11.2.7 Security**

- I:1620 The nature of an IP-based network leaves it potentially vulnerable to malicious attack. There are a number of standard mechanisms for improving the security of the system, these are covered below.
- M:1621 The Controller shall use well-known ports for standard services, e.g. port 80 for HTTP. All unused ports shall be disabled. (M:1621.1)
- I:1622 To prevent unauthorised IP traffic between the Instation and AMI Test Terminal Ethernet ports, the Controller should control the routing of IP packets between the two interfaces.
- M:1623 The ability to route IP traffic between the two Ethernet ports shall be configurable.

I:1624 Secure Sockets Layer (SSL) provides application-level encryption for Web browsers and other applications.

M:1625 The AMI Roadside Controller shall be capable of supporting SSL v2.0 and v3.0.

The AMI Roadside Controller shall be capable of using FTP, HTTP and TELNET with SSL. (M:1625.1)

The AMI Roadside Controller shall be capable of using FTP with both SSH1 and SSH2. (M:1625.2)

M:1626 The AMI Roadside Controller shall support SNMP agents that include provision for SHA, MD5 and DES security features.

I:1627 The Highways Agency network is an intranet that is isolated from the Internet via a range of security measures. Thus, a private Certification Authority (CA) can be created to certify internal servers and users on the network and provide a sufficient level of trust within the limits of the Highways Agency security policy. In contrast, any (web) servers running externally for public access shall be certified by an independent CA in order to provide a sufficient level of trust for general users.

I:1628 To prevent unauthorised access to AMI Roadside Controllers, username/passwords and signed SSL/SSH certificates will be used to provide user and authentication. Additional security measures will also be provided at the Instation to ensure protection of the equipment there; these measures may include the use of signed certificates managed by the Overseeing Organisation or a nominated third party.

M:1629 The Contractor shall be capable of acting as a private CA to create and manage signed SSL/SSH certificates used to prevent unauthorised access to the AMI Roadside Controller.

The generation and management of certificates shall conform to the HighwaysAgency's security policy. (M:1629.1)

M:1630 The Contractor shall use suitable software to create private certificates.

The software shall allow for the creation of certificates with an expiry period. (M:1630.1)

M:1631 The certificates shall be capable of being loaded onto remote access equipment such as the AMI Test Terminal and used by the IP-based services when establishing a secure link to the AMI Roadside Controller.

M:1632 The list of certificates shall be maintained on the AMI Roadside Controller in configuration data.

It shall be possible to modify the list of certificates held on the AMI Roadside Controller.  
(M:1632.1)

It shall be possible to install or remove certificates from the AMI Test Terminal.  
(M:1632.2)

### **11.2.8 IP Configuration Data**

M:1640 The AMI Roadside Controller shall store all the configuration data required to support the operation of the IP Interface.

IP Configuration data shall include as a minimum all data as identified by this specification. (M:1640.1)

IP Configuration data shall include all additional data and information as required to support the correct implementation of a complete IP interface. (M:1640.2)

M:1641 The AMI Roadside Controller shall provide sufficient non-volatile storage capacity to store all IP configuration data, including device address and Instation IP .

M:1642 It shall be possible to program the address details and other IP Configuration Data from the AMI Test Terminal.

### **11.3 Spare Capacity and Performance**

M:1690 New versions of application process object code resident in the AMI shall be capable of being uploaded from the AMI Roadside Controller. This excludes firmware whose purpose is dedicated to Enforcement functionality.

## 12 PROTOTYPES AND ACCEPTANCE

### 12.1 General

- M:1700 Prototypes of all Equipment covered by this Specification shall be offered for approval by the Overseeing Organisation before the production of supply units commences.
- M:1710 Prototype Equipment shall be of the same standard of build quality and finish as production units.
- M:1720 All Equipment shall be assembled in appropriate enclosures and presented, as a fully working prototype AMI System, for approval by the Overseeing Organisation. One sample of each fully working prototype shall be subject to a 'trial' erection on the appropriate mounting structure at a location to be agreed during the Contract Period, and prior to the commencement of full production assembly.

### 12.2 Prototype Manufacture

- M:1730 Prior to the manufacture of any prototype or at a time agreed by the Overseeing Organisation, the Contractor shall submit the following for the agreement of the Overseeing Organisation:
- General Arrangement Drawings, Design Calculations, Block Diagrams, Circuit Diagrams, Schematic Diagrams, Interconnections and Equipment Layout Details, Parts Lists, fusing details and Power Distribution. (M:1730.1)
  - Hardware Design Specification. (M: 1730.2)
  - Functional Design Specification. (M: 1730.3)
  - Software Design Specification. (M: 1730.4)
  - Optical Performance Test Certification. (M: 1730.5)
  - Material/Component test/environmental test certification. (M: 1730.6)
  - Maintenance Documentation as defined in Section 12. (M: 1730.7)
  - Prototype Unit Test and Inspection Schedules (Test Plan) constructed to demonstrate compliance with each Mandatory Requirement in this Specification, including Requirements defined by reference to other documents. (M: 1730.8)
  - Environmental and EMC Test Schedules. (M: 1730.9)
  - Production Test and Inspection Schedule. (M: 1730.10)
- M:1740 Where, for the purposes of Environmental Testing, a Test Module is proposed, their use will only be accepted where the component/module mounting details and layout provided are identical to those of production units. It should therefore be assumed that an individual Test Module shall represent the arrangement for each Equipment/Enclosure type to be supplied. Test Module details shall be suitably documented and submitted for

the approval of the Overseeing Organisation prior to the commencement of their manufacture.

### 12.3 Prototype Compliance Tests

- M:1750 The Contractor shall demonstrate to the Overseeing Organisation, by means of witnessed tests and inspections of the Prototype Unit or Pre-Production Unit as required by the contract, compliance with all functional and non-functional requirements (including Environmental and EMC) of the Specification including requirements brought into the specification by reference to other documents and in accordance with MCG 1069 'NMCS2 Test Strategy'.
- M:1760 The Contractor shall satisfy himself that the equipment will meet the Compliance Test requirements by carrying out his own preliminary tests before the equipment is offered for Compliance Testing in the presence of the Overseeing Organisation.
- M:1770 All instruments, simulators (including line simulators) and specialised test apparatus necessary for testing any equipment which may be supplied as separate modules or sub-assemblies shall be identified in the Test and Inspection Schedule and provided by the Contractor. These shall be arranged in a manner which is representative of the equipment's situation within the NMCS2 communications system.
- M:1780 Reliability tests shall be carried out at ambient temperature with the equipment set up and operating continuously for a minimum of 48 hours. Proposals for tests at elevated temperature over a shorter period may be offered as an alternative subject to the approval of the Overseeing Organisation.
- M:1790 The reliability test shall be carried out after the Contractor's preliminary tests but before the Compliance Test. The Contractor shall provide to the Overseeing Organisation results of the reliability test.
- M:1800 Tests shall be carried out to demonstrate that the Equipment is compatible with TR 2067 'NMCS2 RS 485 Communications: Electrical and Protocol'.
- M:1810 Tests shall be carried out to demonstrate that the Equipment is compatible with TR 2142 'NMCS2 Message Control Message Sign Equipment'
- M:1820 Tests shall be carried out to demonstrate that the Equipment is compatible with TR 2072 'NMCS 2 Signal Subsystem', TR2139 'NMCS2 Message Sign Subsystem' and TR 2070 'NMCS2 Message Control Point to Point'.

- M:1830 The Test and Inspection Schedules shall be updated as appropriate on conclusion of testing and all results recorded. Any modifications required by the Overseeing Organisation to ensure compliance with the requirements of the Specification shall be included in the Production equipment and the Test and Inspection Schedules as appropriate.
- M:1840 On completion of Compliance Testing, and as a condition of acceptance by the Overseeing Organisation, the Contractor shall provide complete certification and all documentation demonstrating compliance with all requirements of the Specification.

## **12.4 Production Acceptance**

- M:1850 All production equipment being supplied under the Contract shall be subject to testing and inspection in the presence of the Overseeing Organisation.
- M:1860 The Contractor shall demonstrate by means of tests, inspections or other means (as agreed with the Overseeing Organisation) compliance with all functional and non-functional requirements of the Specification.
- M:1870 The Contractor shall agree with the Overseeing Organisation a subset of the Compliance Tests to meet Production testing requirements.
- M:1880 Production Tests will permit the testing of a complete Sign and Controller or of separate modules or sub-assemblies in accordance with the procedures developed during Compliance Tests.
- M:1890 Production tests shall also ensure by means of tests and inspections satisfactory operation and integrity of any wiring or circuitry supplied under the Contractor's design but redundant within the requirements of the specification.
- M:1900 The Contractor shall ensure that the equipment meets the Production Test requirements by carrying out his own preliminary tests before the equipment is offered for tests in the presence of the Overseeing Organisation.
- M:1910 All instruments, simulators and specialised test apparatus necessary for testing any equipment which may be supplied as separate modules or sub-assemblies shall be identified in the Test and Inspection schedule and provided by the Contractor.
- These shall be arranged in a manner which is representative of the equipment's situation within the NMCS2 communications system. (M:1910.1)
- M:1920 Reliability tests shall be carried out at ambient temperature with the equipment set up and operating continuously for a minimum of 48 hours. Proposals for tests at elevated

temperatures over a shorter period may be offered as an alternative subject to the Overseeing Organisation.

- M:1930 The reliability test shall be carried out after the Contractor's preliminary tests but before the Production Test. The Contractor shall provide to the Overseeing Organisation results of the reliability test.
- M:1940 On completion of Production Testing, and as a condition of acceptance by the Overseeing Organisation, the Contractor shall provide complete certification of results and all documentation demonstrating compliance with all requirements of the Specification.

## **12.5 Type Approval**

### **12.5.1 Home Office Type Approval**

- M:1950 The AMI shall be submitted as part of a Mandatory Variable Speed Limit Enforcement System to HOSDB for Type Approval.
- M:1960 Home Office Type Approval shall be obtained for the AMI.
- M:1970 The design, implementation and manufacture of the checking methods used to implement the Speed Enforcement Interface shall meet Home Office Type Approval requirements as part of a Mandatory Variable Speed Limit Enforcement System.
- M:1980 Once Home Office Type Approval has been granted the manufacturer or his agent shall not change any component or alter any circuit or software without permission of the Home Office and Highways Agency.

### **12.5.2 Highways Agency Type Approval**

- M:1990 Highways Agency Type Approval procedures shall be followed and achieved as required in TRG 0500 and TR 1100.
- M:2000 Highways Agency Type Approval shall be obtained for the AMI.

## 13 REFERENCES

### 13.1 Highways Agency

BD 2/89	Technical Approval of Highway Structures on Motorway and other Trunk Roads, Part 1, General Procedures
MCH 1618	NMCS2 Technical Overview
MCH 1621	Software Design and Tender Response Requirements
MCH 1689	NMCS2 Data System Message and Site Data Header Code Register
TR 1100	Technical and Quality Control Requirements
TR 1173	Motorway Communications Cables
TR 1238	Motorway Power Cables
TR 2033	Weatherproof Cable Assemblies
TR 2043	NMCS2: Signal Site Equipment
TR 2067	NMCS2: RS 485 Communications
TR 2070	NMCS2: Message Control
TR 2072	NMCS2: Signals Subsystem
TR 2110	NMCS2 Certification and Qualification Package
TR 2130	Environmental Tests for Motorway Communications Equipment
TR 2142	NMCS2: Message Control (RS 485) Message Sign Subsystem
TRG 0500	Statutory Approval of Equipments for the Control of Vehicular and Pedestrian Traffic on Roads
TRH 1679	Controlled Motorway – Technical Approval (Structures)
	Manual of Contract Documents for Highway Works: Volume 1, Specification for Highway Works

### 13.2 British Standards

BS EN 287	Approval testing of welders for fusion welding
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BS EN 288	Specification and approval of welding procedures for metallic materials
BS 729	Specification for hot dip galvanized coatings on iron and steel articles
BS 5378	Safety signs and colours
BS 6121	Mechanical cable glands
BS 7430	Code of practice for earthing
BS 7671	Requirements for electrical installation. IEE Wiring Regulations. Sixteenth edition.
BS 8118	Structural use of aluminium
BS EN 50293	Electromagnetic compatibility. Road traffic signal systems. Product standard.
BS EN 10025	Hot rolled products of non-alloy structural steels. Technical delivery conditions.
BS EN 10210	Hot finished structural hollow sections of non-alloy and fine grain structural steels
BS EN 12966	Road vertical signs – Variable Message Traffic Signs

### **13.3 Home Office**

HOSDB	Speedmeter Handbook
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## 13.4 Others

MIL-C-5015 Connectors electrical circular, threaded AN type

Electrical Industries Association RS 485 Standard

Traffic Signs Regulations and General Directions 1994

The Electricity at Work Regulations 1989 (SI1989No.635)

Health and Safety at Work etc. Act 1974

Internet Engineering Task Force Requests For Comments (RFCs):

RFC 768 (User Datagram Protocol)

RFC 792 (Internet Control Message Protocol).

RFC 793 (Transmission Control Protocol)

RFC 959 (File Transfer Protocol).

RFC 1122 (Requirements for Internet Hosts - Communication Layers).

RFC 1155 (Structure and identification of management information for TCP/IP-based internets)

RFC 1157 (Simple Network Management Protocol

RFC 1212 (Concise MIB Definitions)

RFC 1213 (Management Information Base for network management of TCP/IP-based internets: MIB-II).

RFC 1215 (Convention for defining traps for use with the SNMP).

RFC 1305 (Network Time Protocol (Version 3) Specification, Implementation and Analysis).

RFC 1905 (Protocol Operations for Version 2 of the Simple Network Management Protocol (SNMPv2)).

RFC 1906 (Transport Mappings for Version 2 of the Simple Network Management Protocol (SNMPv2))

RFC 2272 (Message Processing and Dispatching for the Simple Network Management Protocol (SNMP))

RFC 2474 (Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers)

RFC 2475 (An Architecture for Differentiated Service)

RFC 2571 (An Architecture for Describing SNMP Management Frameworks).

RFC 2573 (SNMP Applications).

RFC 2574 (User-based Security Model (USM) for version 3 of the Simple Network Management Protocol (SNMPv3).

RFC 2578 (Structure of Management Information Version 2 (SMIPv2)),

RFC 2579 (Textual Conventions for SMIPv2)

RFC 2580 (Conformance Statements for SMIPv2).

## 14 AMENDMENT HISTORY

<b>Date</b>	<b>Issue</b>	<b>Comments</b>
May 2006	A	Development Contract 1/113
July 2006	B	Tender 1/179