Public Works Authority

State of Qatar

Intelligent Transportation System (ITS) Specifications

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1   INTRODUCTION

1.1   Purpose of Document

1.   This document defines the technical specifications for the Intelligent Transportation System (ITS) equipment for the State of Qatar.

2.   This document should be read in conjunction with the ITS Deployment Manual, Civil and Structural Standards for the Intelligent Transportation System (ITS) and related documents.

1.2   Use of this document

1.   The users of this document are envisaged to be Consultants, Contractors, ITS equipment supplier/vendors and Stakeholders (directly or indirectly involved in the project) who are providing ITS equipment and services for Ashghal (the Public Works Authority) and other government bodies which require detailed information about the technical requirements for ITS in the State of Qatar.

1.3   Scope of Document

1.   This document details the technical specifications for the design, supply, installation, commissioning and maintenance requirements for ITS equipment. Guidance concerning the installation of ITS equipment is available from the ITS Deployment Manual and in the scheme's detailed project design drawings and/or specification.

2.   The following ITS technologies are specified within this document:

    (a)   Traffic Detection and Monitoring
    (b)   Closed Circuit Television (CCTV) Cameras
    (c)   Roadway Weather Information Systems (RWIS)
    (d)   Overheight Vehicle Detection Systems (OVDS)
    (e)   Weigh In Motion Detection Systems (WIM)
    (f)   Dynamic Message Signs (DMS)
    (g)   Portable Dynamic Message Signs (PDMS)
    (h)   Lane Control Signs (LCS)
    (i)   Ramp Metering Systems (RMS)
    (j)   Tolling and Payment Collection
    (k)   Connected Vehicle Technology
    (l)   Telecommunications Networks
    (m)   Tunnel Systems.

1.4   Documents Layout and Contents

1.   This document describes each type of ITS equipment under the following headings:

(a)   Related Documents

(b)   Equipment Overview

(c)   Non Functional Requirements

(d)   Functional Requirements

(e)   Power and Telecommunications

(f)   Hardware Design Requirements

(g)   Testing.

2.   The first section of the document details the general provisions for ITS equipment, with the following sections providing details for each type of equipment listed in section 1.3. Where details specified within the specific equipment sections overlap with those of the General Provision for ITS; the specific equipment section shall take precedence.

3.   This document references telecommunication with the Traffic Management Centre (TMC), this reference includes the current Traffic Signal Control Room (TSCR), the future Interim TMC (also known as the Road Network Management Centre (RNMC)) and National TMC (NTMC) and any other future TMC facilities.

4.   If there is a case of uncertainty with regards to the specification for ITS equipment the Client shall be consulted immediately before progressing any further.

1.5   Definitions

Client   The body or agency responsible for procuring the ITS equipment and services.

Client's representative   The company or body identified by the Client as having been delegated the necessary responsibilities to represent the Client's undertakings.

Departure from Standard   A Departure from Standard (DfS) is a process whereby the ITS equipment provider can submit an alternative product or solution that either meets or exceeds the requirements of the specification. Where the proposed product or solution neither meets or exceeds the requirements of the specification, the ITS equipment provider shall justify the proposed solution in terms of safety, operational benefits and cost.

Equipment   That which is to be supplied under the Contract and includes all electrical and mechanical hardware, optical, electronic and telecommunication equipment and systems, structures, mountings and enclosures, computer software and all documentation as defined in the Contract.

ITS equipment provider   The company, joint venture or partnership responsible for the design, supply, installation and commissioning of the ITS equipment.

Mean Time Between Failure (MTBF)	Mean Time Between Failure (MTBF) is the mean of a distribution of product life calculated by dividing the total operating time accumulated by a "defined product group" of devices within a given time period, by the total number of failures in that time period.
Qatar Construction Specifications	The Qatar Construction Specifications (QCS) are the recognised specifications in the State of Qatar used in connection with the execution of construction projects. The specifications include the requirements for quality of materials, quality of workmanship and guidance regarding health and safety, documentation standards and testing.
Roadside Controller	The Roadside Controller is the item of equipment that act as the controlling interface between the ITS equipment and the Telecommunications Network. Roadside Controllers will have differing aspects of functionality depending on the equipment being controlled. They are primarily located in ground mounted enclosures adjacent to the ITS equipment they are controlling. They provide diagnostic and control functions and are the point of local connection for technicians for fault finding and maintenance.
Service life	The service life of ITS equipment is its expected lifetime, or the accepted period of its use in service. It is the time that the equipment is expected to be 'serviceable' or supported by its manufacturer or supplier. The service life includes repairs, routine maintenance and upgrades.
Traffic Management Centre	The Traffic Management Centre (TMC) is an operational facility for the monitoring, controlling and management of roadway traffic through the use of computer based networks connected to roadside equipment. More than one TMC may be in operation at any one time.
Traffic Signal Control Room	The Traffic Signal Control Room (TSCR) is an operational facility for the monitoring, controlling and management of the existing Traffic Signal and roadway Closed Circuit Television (CCTV) cameras in the State of Qatar.

1.6   Issue History

Issue 1   First issue

2 GENERAL PROVISIONS FOR ITS

2.1 Related Documents

Reference	Title
Ashghal	Intelligent Transportation System (ITS) Deployment Manual
Ashghal	Civil and Structural Standards for Intelligent Transportation System (ITS)
ASTM E2561-07a	Standard Practice for the Installation of Inductive Loop Detectors
BS EN 1993-1-1	Eurocode 3. Design of steel structures. General rules and rules for buildings
BS 7671	Requirements for electrical installations
BS EN 7430	Code of practice for protective earthing of electrical installations
BS EN 12899	Fixed, vertical road traffic signs
BS EN 50293	Electromagnetic compatibility. Road traffic signal systems
BS EN 60529	Degrees of protection provided by enclosures (IP code)
BS EN 62040	Uninterruptible power systems (UPS). Method of specifying the performance and test requirements
BS EN 62305	Protection against lightning
DIN 41494	Equipment practices for electronic equipment and mechanical structures
DIN/ISO EN 50022	Specification for low voltage switchgear and control-gear for industrial use. Mounting rails
ETSI EN 300 019-1-4	Environmental conditions and environmental tests for telecommunications equipment
IEC 60297	Mechanical structures for electronic equipment, Dimensions of mechanical structures
ISO 9001	Quality management systems — Requirements
ISO 9000-3	Quality management and quality assurance standards -- Part 3: Guidelines for the application of ISO 9001:1994 to the development, supply, installation and maintenance of computer software.
ISO 14001	Environmental Management Systems
ISO/IEC 17011	Conformity assessment. General requirements for accreditation bodies accrediting conformity assessment bodies
ISO/IEC 17021	Conformity assessment. Requirements for bodies providing audit and certification of management systems
ISO/IEC 17025	General requirements for the competence of testing and calibration laboratories
NTCIP	National Transportation Communications for ITS Protocol
QCS	Qatar Construction Specifications
QGEWC (E)	Regulations for Electrical Installations
QGEWC (E)	Regulations for Protective Multiple Earthing
QTCM	Qatar Traffic Control Manual

2.2   Overview

2.2.1   Purpose

1.   This Section describes the general requirements for the design, supply, installation, commissioning and maintenance of ITS equipment in accordance with the detailed project design drawings and/or specifications.

2.3   Non-Functional Requirements

2.3.1   Performance

1.   Each equipment specification contained in this document details the specific performance requirements pertaining to that specification.

2.   All ITS equipment will work 24 hours a day for 365/6 days of the year.

2.3.2   Reliability

1.   Each type of ITS equipment shall be designed to operate continuously for a period of time as specified in the relevant section of this document, when used in the Qatar environment.

2.   Generally, each item of ITS equipment shall have a Mean Time Between Failure (MTBF) of greater than 55,000 hours, unless specifically detailed within the corresponding section of this document. Equipment failure and MTBF metrics will be monitored and recorded through the Client's ITS Asset Management system.

2.3.3   Maintenance

1.   Routine and preventative maintenance procedures shall be provided for all ITS equipment to ensure that the equipment continues to work within the manufacturer's published performance metrics for the State of Qatar.

2.   Where ground-mounted enclosures are installed they shall have a raised concrete plinth, not less than 300mm high, to facilitate maintenance activities. The maintenance plinth shall be constructed in accordance with the detailed project design drawings.

2.3.4   Environmental

1.   All ITS equipment must maintain full functionality and continue to operate within the limits of this specification when subjected to the working environment of the State of Qatar.

2.   All equipment shall function and perform as per the specification, or better, in ambient temperatures ranging from 0°C to 55°C and in 100% relative humidity in accordance with QCS.

2.3.5   Electromagnetic Compatibility

1.   All ITS equipment when operating correctly shall function within the limits of the Electromagnetic Compatibility (EMC) standard Road traffic signal systems, BS EN 50293.

2.   All power and telecommunications cabling shall be installed in accordance with BS 7671 to minimise the effects of interference.

2.3.6   Health and Safety

1.   The ITS equipment provider is reminded of their obligations regarding Health and Safety. Local regulations and guidelines regarding health and safety are defined in QCS.

2.3.7   Documentation

1.   All ITS Equipment shall be supplied with technical documentation comprising such manuals and handbooks accompanied by maps, plans, drawings, diagrams, specifications, computer programs, flow diagrams, coding lists, library programs, and all such information as may be necessary to enable the Client or other end-user to install, commission, operate, maintain, dismantle, reassemble, adjust, modify, extend and dispose of all parts of the system.

2.   The documentation should be arranged under the following general headings and indicative contents (which are not necessarily exhaustive) as may be appropriate to the equipment being supplied:

(a) Hardware details:
- basic technical data, type nos., ratings, product codes, etc.
- details of energy usage at defined load states
- technical description
- warnings and restrictions
- drawing lists, parts lists
- module identification codes
- mass and overall size of each type-numbered item
- packaging material details.

(b) Software manuals:
- data, descriptions and details.

(c) Drawings - mechanical and structural:
- general arrangements
- principle detail drawings.

(d) Drawings - electrical and electronic:
- system schematics, circuit and wiring diagrams.

(e) Installation instructions:
- comprehensive instructions (including drawings for site assembly) for correct installation and connection of all parts of the Equipment, to be retained for reference purposes
- instructions relating to each item of equipment likely to be installed separately.

(f) Commissioning instructions:
- set-up details of addresses, operating parameters, control ranges and limits, etc.
- commissioning procedures and tests.

(g) Operating instructions:
- procedures for normal operation.

(h) Maintenance instructions:
- details of routine maintenance
- cleaning instructions
- trouble-shooting and fault-finding charts.
- maintenance information cards or booklets.

(i) Product 'End of Life' Plan:
- instructions for dismantling the equipment without causing damage
- details of re-usable/recyclable components and materials and the coding system used to identify them,
- details of any precious metals
- details of any hazardous substances, heavy metals or other pollutants with instructions on their safe handling and disposal.

3. The ITS equipment provider shall also make available high quality digital images of the equipment and all components that are field replaceable for the equipment, in JPEG file format. The images shall be provided at the earliest opportunity after the design is finalised and before any equipment is delivered. The Client or Client's representative will incorporate the images into an online electronic register which provides details of items available to system maintainers.

4. Documentation shall be produced in accordance with BS EN 61082 or other Standard as required by the Client or Client's representative and shall be approved by the Client or Client's representative before the system is accepted.

5. Documentation shall use SI units in accordance with ISO 80000-1.

6. Detailed design drawings and structural calculations for each type of pole, gantry or structure used to mount ITS equipment shall be submitted to the Client and/or the Client's nominated representative for approval. The design calculations shall be carried out in accordance with the following standards:

- BS EN 1993-1-1, or
- BS EN 12899.

7. The drawings shall show materials specification and finishes for each item of equipment proposed for use. All weld types and sizes shall be identified on the design and construction drawings.

8. The proposed design for the foundations for each type of pole, gantry or structure shall be submitted, including design calculations and drawings, to the Client and/or the Client's nominated representative for approval.

9.   Power schematic diagrams for all ITS installations shall be submitted to the Client and/or the Client's nominated representative for approval.

10.   Telecommunications schematic diagram shall be submitted to the Client and/or the Client's nominated representative for approval. The telecommunications diagram shall include all systems, subsystems and components, including connections to modems, devices and the telecommunications access and backbone network.

11.   As-built record drawings shall include longitude and latitude data accurate to within two (2) metres for each of the ITS equipment and infrastructure installed.

12.   Documentation should be organised so that unnecessary repetition is avoided. Topics likely to be frequently referenced by the end user (e.g. installation, commissioning, operating and maintenance instructions) should be given prominence. As it is recognised that the volume of the documentation and drawings to be provided will vary considerably with the complexity of the equipment being supplied (ranging from one ring binder to several volumes), the Client or Client's representative should be consulted for its agreement on the presentation and layout of the documents to be provided.

13.   Documents and drawings should normally be provided on CD-ROM in Adobe Acrobat (.pdf) file text recognition format (i.e. converted to pdf from the source programme rather than scanned) using the version current at the time of supply. A minimum of two sets shall be provided. The disks shall be virus checked and fully marked up / labelled prior to despatch to the Client.

14.   The Client or Client's representative may additionally require two sets of final documents and drawings in full size paper form for record purposes. The Client or Client's representative will confirm whether these are required.

15.   When paper copies of text documentation are to be provided, they shall be in A4 format bound into durable binders. The manner in which drawings in paper form are bound may vary with their size and should be agreed with the Client or Client's representative prior to delivery.

16.   Installation instructions to be included in the package of any item of equipment likely to be installed separately or in conjunction with the ITS equipment, shall be in the form of a leaflet or similar, which may be disposed of when installation is complete. It shall have sufficient information (with diagrams) for the item concerned to be correctly installed in position and connected, and describe any necessary set-up procedure.

17.   Maintenance information cards or booklets, one set of which is to be secured within each equipment enclosure or cabinet shall be encapsulated in a durable weatherproof format. They shall show the general layout of equipment and component modules and references in schematic form, and set-up addresses for on-site replacement of component modules.

18.   The file names for drawing and text files will be advised by the Client or Client's representative when the draft versions are presented and agreed during Production Acceptance Testing.

19.   The format and extent of electronic media and/or hardcopy presentation of technical shall be agreed with the Overseeing Organisation before final versions are produced.

2.3.8   Submittals

1.   All ITS equipment shall, as a minimum, meet all the requirements listed in these specifications. Future technological advances may allow for ITS equipment to be provided that exceed the minimum requirements in these Specifications.

2.   Systems and subsystems that minimize the possibility that failure of any single component or module will cause total system failure shall be provided. Failure of one component or module shall not cause the failure of any other component or module.

3.   Product data, design and construction drawings for all of the components shall be submitted to the Client and/or the Client's nominated representative for approval.

4.   The ITS equipment provider shall submit all material in accordance with the submittals procedures described in QCS.

5.   Heat-load calculation sheets, accompanied by related manufacturer's data sheets to support justification of proposed cooling systems shall be submitted to the Client and/or the Client's nominated representative for approval.   Power consumption calculations to support proposed power distribution type and size shall also be submitted.

2.3.9   Quality Assurance

1.   The ITS equipment provider shall have in place a quality system complying with ISO 9001, certified as appropriate for the activities of design, development and production of the ITS equipment to be supplied unless otherwise agreed by the Client or Client's nominated representative. The quality system shall cover each and every location where such activities are undertaken.

2.   The quality system shall have been certified by a certification body accredited to ISO/IEC 17021 unless otherwise agreed by the Client or Client's nominated representative.

3.   In exceptional circumstances, the Client or Client's nominated representative may consider the acceptance of a quality system which, although satisfying the requirements of BS EN ISO 9001, has not been certified as such. Should this be proposed, the Client or Client's nominated representative shall audit the potential supplier's quality system and test facilities before approving use of the proposed supplier.

4.   In addition to the requirements described in QCS, the following requirements:

   (a)   The design and installation of Electrical Installations shall comply with the requirements of the Qatar General Electric and Water Corporation (QGEWC).

   (b)   All ITS equipment shall be supplied in accordance with the Client's ITS Specifications and fully compatible with TMC master software.

(c)   The supplier shall be required to provide, at their own expense, samples of the proposed equipment and all associated approvals, test reports and schedules to verify that the equipment meets all of the Client's requirements.

(d)   When mounting ITS equipment on existing structures, an analysis of the structure to ensure the structure will not fail with the additional equipment shall be provided. The analysis must be performed by a fully qualified professional whose credentials shall be provided to the Client and/or the Client's nominated representative for approval.

2.4   Functional Requirements

2.4.1   Power

1.   Except where detailed in specific sections below, all ITS equipment shall be powered from either
   - A single phase 240Vac 50Hz supply
   - A three phase 415Vac 50Hz supply.

2.   ITS enclosures shall include a power distribution subsystem for each power supply to all components within the enclosure and the related ITS equipment. The circuit breakers shall be properly sized according to the expected loads of the ITS equipment and to meet electrical code requirements.

3.   All electrical equipment and cabling shall be provided in accordance with BS 7671 and the QGEWC regulations,

4.   The power distribution panel shall be directly fed by the main circuit breaker at the electrical point of service. The power distribution assembly shall include an interface and connection to the UPS (where provided). The power assembly shall be connected to the earthing system (refer to QCS for details).

5.   The enclosure shall be earthed in accordance with QGEWC regulations and BS 7671.

6.   The enclosure shall include a 240Vac 13 Amps 3-pin dual socket power outlet to BS 1363. The power sockets shall be installed in accordance with BS 7671 and the QGEWC regulations.

7.   A Transient Voltage Surge Suppressor (TVSS) shall be provided for each external cable connection which is terminated at any item of exposed external equipment, or routed through an outdoor area. The TVSS shall be rated in accordance with:

   - IEEE C62.41 CLASS A or,
   - BS EN 62305.

8.   The TVSS shall be capable of handling minimum 30KA fault current. Provision shall be made for protection of earthing and the shield/armour of coaxial cables and TVSS for each signal conductor.

9.   ITS equipment shall automatically regain full operational functionality when related electrical power supply is restored, without the need for manual intervention.

2.4.2   Dual Power Supply/Uninterruptible Power Supply (UPS) Subsystems

1.   Two independent power supplies (i.e. from separate electrical sub-stations) shall be provided for each ground mounted enclosure location where ITS equipment is proposed. These supplies will be provided by Kahramaa on behalf of the Client.

2.   The worst-case power-load data shall be used to design the electrical conductor sizes. These shall be submitted to the Client and/or the Client's representative for approval.

3.   A UPS shall be provided where required in the detailed design project documentation. The UPS shall meet the requirements of QCS.

4.   Unless otherwise stated in the detailed project design drawings and/or specifications, UPS with a minimum of four (4) hour backup shall be provided for all ITS equipment and telecommunications device locations.

5.   An Automatic Power Transfer Switch (APTS) shall be provided inside the ITS ground mounted enclosure which transfers power from one of the external sources to the electrical distribution system. The APTS shall monitor the status of the primary power source and transfer the power connection to the secondary power source when primary power source fails or suffers degradation. The APTS shall be provided with means to operate in manual mode.

6.   The APTS must be able to transfer the connection with the internal power system, from the primary power source, to the secondary power source, within 1 mains power cycle (less than 20ms).

7.   Additional equipment necessary to eliminate the delay in the transfer of power sources which may cause the ITS equipment to reboot shall be provided.

8.   Each external power supply line shall be terminated at the APTS.

2.4.3   Earthing Rod

1.   All earthing of ITS equipment shall comply with QGEWC regulations and QCS.

2.4.4   Telecommunications

1.   Refer to section 15 within this document for details of telecommunications and networks.

2.5   Hardware Design Requirements

2.5.1   Mechanical and Housing Requirements

1.   ITS equipment not contained in a ground mounted equipment enclosure will have specific housing requirements depending on location, weather conditions and vibration from road

vehicles. Further details are included in the "Mechanical and Housing Requirements" section relevant to each type of ITS equipment.

2.5.2 Mounting Arrangements

1.   All mounting arrangements for ITS equipment shall comply with the requirements of that equipment as detailed in this specification and the detailed design drawings.

2.5.3 Ground Mounted Equipment Enclosures

1.   The ground mounted enclosure shall house telecommunications equipment, power and other related equipment necessary for the operation of ITS equipment, as indicated in the detailed project design drawings.

2.   The ground mounted enclosure shall accommodate the equipment in an environment in accordance with Class 4.2H of ETSI EN 300 019-1-4. The equipment must continue to work within its normal operating parameters in this environment, regardless of location.

3.   The ground mounted enclosure shall be weather resistant and conform to ETSI EN 300 019 and BS EN 60529 with an ingress rating of IP65, as a minimum. Where the ground mounted enclosure needs to be penetrated, such as to facilitate installation of cables, provisions must be made to the penetration(s) in order to maintain the enclosure rating.

4.   The enclosure shall include a multi-point locking mechanism and a minimum of two (2) locks.

5.   Each enclosure door shall be equipped with an adjustable doorstop to hold the door open.

6.   Warning labels shall be provided for all electrical panels in accordance with BS 7671 and QCS. Asset identification information shall be provided on the outside of the enclosure and shall be weather resistant. Asset identification information shall be provided by the Client at the time of commissioning.

7.   All internal connectors, components and wire terminations installed in the enclosure shall be labelled in accordance with the design drawings.

8.   Racks and shelves shall be provided in the enclosure to mount equipment as needed, including telecommunications devices and power assemblies. The rack shall comply with:

  - IEC 60297 or,
  - DIN 41494 (or approved equivalent international standard).

9.   The rack shelves shall be capable of sustaining a constant 10 kg load. For all enclosures utilising telecommunications services from a telecommunications network provider, a nominal mounting space of 200mm x 300mm x 75mm shall be provided for interface modules used by the service provider. The enclosure shall provide an additional fused or breaker protected, UPS-powered receptacle for related power requirement.

10.   The ground mounted enclosure shall include a fluorescent lighting fixture, minimum rating 16 watts, complete with lens or shield and high-efficiency fluorescent lamp starter with rapid start.

11.   Ground mounted enclosures shall be mounted on a concrete foundation of the concrete class and dimensions shown in the detailed project design drawings. Include a cabinet riser when the cabinet is located below grade to protect against water incursion.

2.5.4   Heating, Ventilation and Air Conditioning (HVAC) Subsystem

1.   Where required, the ground mounted enclosure shall include an air conditioning system. The air conditioning system can be either passive or active. The design shall be submitted to the Client or Client's representative for approval.

2.   Where a cooling system involving air conditioner or other heat-exchanger is used, the cooling system shall be mounted next to or on the exterior of the ITS enclosure. Where the enclosure needs to be penetrated, such as to facilitate installation of pipes for coolant supply and return lines, provisions shall be made to the penetration(s) in order to maintain the enclosure rating.

2.5.5   Installation

1.   The ground mounted enclosure shall be installed as shown in the detailed design project drawings. All internal components and UPS (if required) shall be securely mounted.

2.   For ground mounted enclosure installation, apply UV-resistant caulking material along the joints with the enclosure. For mounting under a camera lowering system, position the enclosure away from the space directly below related camera.

3.   Provisions shall be made for all ducts (i.e. power, telecommunications, etc.), in accordance with the detailed project design drawings and/or specifications, that will facilitate the connection between the enclosure and the ITS equipment.

4.   Where cables enter the ground mounted enclosure, they shall be fixed and secured against movement and to relieve stress on the cable termination.   All penetrations to the enclosure shall be sealed with silicone sealant to impede entry of gas, dust and water.

5.   All wires/cables within the enclosure shall be secured and labeled. Earth wires from all electrical devices, including surge suppressors, shall be terminated directly to the dedicated earth terminal in the enclosure. Earth conductors shall not be daisy-chained from device to device.

6.   All conductors carrying electricity at 60Vac or higher shall be segregated from all telecommunications, signal conductors and conductor carrying electricity lower than 60Vac. A minimum of 75mm shall be provided between these two conductor groups. Where conductors belonging to these two groups need to cross each other at distances closer than 75mm, the installer must ensure the conductors are at a 90 degree angle (perpendicular) to each other.

7.   Each wire shall be identified on both ends of the wire with heat shrink, thermal transfer tube type wire markers in English. Adhesive labels are not acceptable. The wire markers shall be white with black lettering. Hand marking of the label is not acceptable.

2.6   Testing and Training

2.6.1   General Testing

1.   Any test facility commissioned to carry out environmental, electromagnetic compatibility or optical performance tests or safety testing of telecommunications equipment shall have been certified to ISO/IEC 17025 by a certification body accredited with IEC 17011

2.   Quality systems relating to the design, development, testing, supply and maintenance of software shall implement the guidance of ISO 9000-3.

3.   The Contractor shall operate an Environmental Management System complying with the requirements of ISO 14001.

4.   Any certification or accreditation necessary to comply with this specification shall have validity current at the time the Contract is placed and be maintained valid throughout the period of the Contract. Evidence of this certification or accreditation shall be provided.

5.   The ITS equipment provider shall be responsible for any testing and/or certification of equipment needed to meet or demonstrate compliance with statutory or regulatory instruments and requirements.

6.   The ITS equipment shall provide reasonable access and facilities for the Client or the Client's nominated representative to audit the operation of its quality systems and test facilities as deemed necessary by the Client or the Client's nominated representative.

7.   The ITS equipment provider shall accept all responsibility for the satisfactory quality, design and workmanship of the ITS equipment being supplied and every part of the system and equipment whether manufactured by or supplied to the ITS equipment provider by supply chain partners and whether specified or approved by name or not.

8.   Documentation detailing the proposed schedule of tests to be undertaken at each stage of the test process for all ITS equipment shall be provided. As a minimum, the tests shall include Production Acceptance Tests (PAT), Site Acceptance Tests (SAT), System Integration Tests (SIT) and a 400-Day Operational Support Period (as a minimum).

9.   All test equipment shall have a valid calibration certification.

10.   The acceptance of each stage of testing does not imply that testing is complete at that stage. If problems are found at a later date or stage of testing, it may be necessary to return to an earlier stage of testing after repairs have been made to the system. If at a later stage of testing, an item of equipment is replaced, repaired, or significantly modified, the equipment shall be retested to the level necessary to isolate any problem and establish a course of action to remedy the situation.

11.   Test procedures, checklists, test forms and data summary sheets shall be provided for each item.   The proposed test procedures shall include a description of the test topics, applicable pass/fail metrics, planned test method and planned test instruments and tools. The Client and/or the Client's nominated representative shall be notified of the date, time and place of each test, as a minimum at least 28 calendar days prior to the date the test is planned to be conducted.   The tests shall be conducted in the presence of the Client and/or the Client's nominated representative.

12.   The Client and/or the Client's nominated representative shall sign the trial test documents as proof of a successful trial test for each item of ITS equipment and ancillary components. If the test trial is unsuccessful, the Client and/or the Client's nominated representative shall be given seven (7) full business days' prior notification before rescheduling another test trial.

13.   ITS Equipment that fails to conform to the requirements of any test will be considered defective and the equipment will be rejected by the Client and/or the Client's nominated representative.   In the event a defect is determined, it shall be determined whether it is limited to a specific unit or could be potential problems in all such units. Equipment rejected because of problems limited to the specific unit may be offered again for retest provided all issues of non-compliance have been corrected and re-tested and evidence thereof submitted to the Client and/or the Client's nominated representative.   The evidence thereof shall include as a minimum a technical report detailing the investigation that has been undertaken to determine the cause of the failure. The report shall detail, as a minimum, the symptoms, cause and what action was required to remedy the failure. This report, further detailed in point 8 below, shall be submitted and approved by the Client and/or the Client's nominated representative prior to a new test date being scheduled.

14.   In the event that the ITS equipment malfunctions during the test period, the Client and/or the Client's nominated representative may declare a defect and require replacement of all equipment at no additional cost.   When a defect is declared, the test and test period shall be restarted from the beginning for that specific ITS equipment.

15.   If ITS equipment has been modified or replaced as a result of a defect, a report shall be prepared and delivered to the Client and/or the Client's nominated representative for acceptance.   The report shall describe the nature of the failure and the corrective action(s) taken.   If a failure pattern, as defined by the Client and/or the Client's nominated representative, develops, the Client and/or the Client's nominated representative may direct that design and construction modifications be made to all similar units without additional cost to the Client.   In the case of problems common to many units, all units shall be modified at no additional cost to the Client.

16.   See relevant subsections below for a detailed description of each type of testing and what it involves.

2.6.2 Production Acceptance Tests (PAT)

1. A Production Acceptance Test (PAT) shall be undertaken at the ITS equipment providers facility prior to shipping the equipment to verify that each ITS equipment meets the requirements described in the detailed project design drawings and/or specifications. If required by the Client, the ITS equipment provider shall provide personnel to observe the PAT in person prior to shipping the equipment.

2. Production acceptance testing shall be undertaken using test schedules agreed by the Client and/or the Client's nominated representative at least four weeks before testing commences.

3. PAT tests shall confirm compliance with this technical specification as well as demonstrate correct communication and fault handling with other external systems.

4. The results of all test results performed by any manufacturer, whether witnessed or not witnessed by the Client and/or the Client's nominated representative, shall be provided within 5 working days of the test date for review and approval.

5. The equipment shall not be shipped without the reports on the related PAT being approved by the Client and/or the Client's nominated representative.

2.6.3 Factory Acceptance Test (FAT)

1. The Factory Acceptance Test (FAT) shall be undertaken to ensure the ITS equipment has been completed to the required functionality, safety and quality and meets all the contractual specifications.

2. The FAT shall be undertaken before shipping to site to ensure the equipment has been completed (constructed, programmed and pre-commissioned) to the required quality and is fully operational. This will include equipment assembled to its final deliverable state either inside or outside the State of Qatar.

3. The FAT shall be undertaken on the equipment due to be shipped to the Client to fulfill their operational requirement and not an alternative product.

4. The factory acceptance test is used to:

   - Provide proof of functionality, quality and integrity with a comprehensive checking process against the product specifications

   - Verify all-important documents (manuals, instructions, plans, drawings) to ensure they accurately reflect the requirements and the equipment operation

   - Ensure that the equipment performs as expected under the testable range of foreseeable conditions, including misuse and errors.

5. The FAT shall be witnessed by the Client or the Client's nominated representative.

6.   Each FAT shall be specific to the product being tested but shall include the following as a minimum;

- Pre-inspection testing and inspection
- Pre-configuration of settings and software
- Preparation of a test register
- Review of drawings and documentation
- Interface testing
- Full communications testing
- Full cycle of powering up, logging on, logging off and powering down.

7.   In the event of a test failing for any reason, the equipment provider must undertake an analysis of the fault. If the fault is considered to be irresolvable, then an exception shall be logged in the test register. At the end of the FAT, the completed tests should be evaluated with the test team including any test failures that occurred. An evaluation meeting shall agree on the nature of any faults encountered and discussing if the FAT should be continued.

8.   One of the following actions shall be taken dependent on the extent of the fault:

- The FAT can be completed if the faults are minor, and the system shall be considered acceptable, subject to the fault being fixed during warranty. A FAT shall also be repeated on a new version of the system incorporating a fix for the fault.
- Testing faults resulting from test procedure error or operator error shall be repeated. The test may be repeated immediately if the error is detected at the time of the FAT.
- Major faults during the FAT shall lead to abandoning the FAT and rescheduling it for a later date pending the fault being resolved appropriately by the equipment provider.
- The FAT tests specified shall be repeated for the SAT.

2.6.4   Site Acceptance Tests (SAT)

1.   A Site Acceptance Test (SAT) shall be undertaken at each ITS equipment location to verify that it meets the requirements described in the detailed project design specifications.

2.   Following the installation of equipment, but prior to the connection with other ITS systems and subsystems, a SAT shall be conducted on each piece of equipment and witnessed by the Client and/or the Client's nominated representative.

3.   The test shall exercise all standalone (non-network) functional operations of the ITS equipment and ancillary components installed and shall demonstrate conformance with the requirements described in the detailed project design specifications, QCS and manufacturer specifications.

4.   The ITS equipment provider shall ensure that the required testing equipment, including a portable computer and test software is provided for the SAT.

5.   If any ITS equipment or ancillary component fails to pass its SAT more than twice, it shall be replaced with new ITS equipment or ancillary component of same make and model and the entire SAT shall be repeated until proven successful.

6.   The SAT shall be conducted for each and every piece of ITS equipment and ancillary components.

7.   Time extensions shall not be granted to perform the SAT due to any failures. Failures during the SAT shall be resolved at no additional cost to the Client.

2.6.5   System Integration Tests (SIT)

1.   The SIT shall also incorporate the network-manageable portions of the ITS system. The SIT shall begin after earlier stages of testing have been successfully completed (i.e. PAT and SAT) and accepted by the Client and/or the Client's nominated representative. When possible, the SIT shall be conducted during the harshest environment period deemed for that particular equipment. The duration of the SIT will be agreed with the Client or the Clients nominated representative prior to starting.

2.   In the event of a system, subsystem, ITS equipment, or ancillary component failure, with the exception of consumable items such as fuses, the Project shall be shut down for purposes of testing and correcting identified deficiencies (System Shutdown). System Shutdown is defined as any condition which, due to work performed by the Contractor, results in the Project, or any system, subsystem, ITS equipment, or ancillary component thereof to cease operation.

3.   The SIT shall be re-started after the identified deficiency has been corrected.

4.   If the total number of System Shutdowns exceeds three (3) due to the same system or subsystem, ITS equipment, or ancillary component;

- the system, subsystem, ITS equipment, or ancillary component shall be removed and replaced with a new and unused unit.

- All applicable PAT and SAT, as deemed necessary by the Client and/or the Client's nominated representative shall be performed and the SIT shall be restarted upon written approval from the Client and/or the Client's nominated representative.

5.   Time extensions shall not be granted to perform the SIT due to any failures. Failures during the SIT shall be rectified at no additional cost to the Client.

6.   Upon the successful completion of the SIT and all the required submittals, testing, training, and documentation have been successfully submitted to and approved by the Client

and/or the Client's nominated representative, the Client and/or the Client's nominated representative shall provide written notice of Final Acceptance.

2.6.6   Operational Support Period (OSP)

1.   All ITS systems and subsystems integrated with the TMC master software and operable from the TMC, operating continuously for a period of 400 consecutive calendar days without failure of any system, subsystem, ITS equipment, or ancillary component.

2.   Upon the written notice of satisfactory completion of the SIT issued by the Client and/or the Client's nominated representative, a 400 consecutive calendar-day Operational Support Period test shall commence for all subsystems, ITS equipment and ancillary components designed, procured, installed, integrated, made operational and tested as part of the ITS Project.

3.   The Client will operate and own the systems, subsystems and ITS equipment and ancillary components during the operational support period.

4.   During the 400-day operational support period, the Contractor shall be responsible for all preventative and remedial maintenance of the ITS systems and subsystems included in the Project.

5.   The Contractor shall submit a detailed operational support plan covering preventive and remedial maintenance of all equipment supplied and installed under the Project. The plan shall include qualifications of the personnel assigned by the Contractor for each activity included.   The plan must be approved by the Client and/or the Client's nominated representative.

6.   The Contractor shall provide technical personnel familiar with the ITS Project that shall be available on-site within 24 hours of notification of the need for their service. The technical personnel shall be available to reset or restore affected services and to allow the ITS services to resume their normal operation.

7.   In the event that a subsystem, ITS equipment, or ancillary component fails to function properly due to defective materials and/or workmanship within the 400-day operational support period, the Contractor shall repair or replace this subsystem, ITS equipment, or ancillary component. In the event of a subsystem, ITS equipment, or ancillary component failure, with the exception of consumable items such as fuses, the ITS Project shall be shut down for purposes of testing and correcting identified deficiencies (System Shutdown). System Shutdown is defined as any condition which, due to work performed by the Contractor, results in the ITS system, or any subsystem, ITS equipment or ancillary component thereof to cease operation.

8.   The system start shall be re-started for a new 400-calendar day operational support period of consecutive operation of all subsystems, ITS equipment, or ancillary components after the identified deficiency has been corrected.

9.   If the overall system availability during the 400-calendar day operational support period is less than 99.5% or if the total number of System Shutdowns exceeds three (3) due to the same subsystem, ITS equipment, or ancillary component, the Contractor shall:

   (a)   Remove and replace the subsystem, ITS equipment, or ancillary component with a new and unused unit.

   (b)   Perform all applicable SAT and SIT, as deemed necessary by the Client and/or the Client's nominated representative

   (c)   Upon written approval from the Client and/or the Client's nominated representative, restart the SIT for a new 400 consecutive calendar-day operational support period.

2.6.7   Integration

1.   Integration activities of the ITS project shall be coordinated and undertaken such that all systems, subsystems, ITS equipment and ancillary components are integrated with the TMC hardware and in accordance with the detailed project design specifications.

2.   All integration activates shall be coordinated with the Client and/or the Client's nominated representative prior to commencement of any integration activities and shall be agreed in accordance with the project program.

3.   Integration activities shall include the telecommunication nodes (i.e. Managed Ethernet Switches) with the existing and/or proposed fibre optic Ethernet telecommunications network for the design and connectivity of the ITS Project.

4.   All ITS equipment shall be managed and operated by the TMC. The Client may decide to assign the management and operation of some of the equipments to third parties based in Qatar when necessary. The ITS equipment shall be integrated as identified in the detailed design project drawings and/or specifications, into the TMC.

2.6.8   Training

1.   Training shall be provided for the operation and maintenance of all the ITS equipment and ancillary components.

2.   Training shall be designed to familiarise the Client and/or its designers with the design, installation, operation and maintenance of the ITS equipment and the overall system. The training shall also cover functionality, theory of operation, calibration, testing, performance and operating parameters.

3.   The single organised training shall be conducted by the ITS equipment provider. A complete course outline and summary of the experience and qualifications of the instructors shall be submitted to the Client and/or the Client's nominated representative for approval prior to commencement of training. Training sessions may be combined and/or shortened with the agreement of the Client. The training will be conducted at a location agreed with the Client.

4.   The training materials shall be provided in both English & Arabic. The training materials shall include as a minimum:

- Course outline

- A Microsoft Office PowerPoint presentation showing detailed subject material

- Operation and maintenance manuals in both electronic and paper format

- Test equipment and tools

- Any other required information.

5.   If, at any time during a training course, the Client and/or the Client's nominated representative determine that the course is not being presented in an effective manner, the training session shall be suspended. The ITS equipment provider shall make the necessary changes to the course, resubmit the required training materials for approval and reschedule the training course.

2.7   Computer Software Requirements

1.   Where software is written or modified for the Client's use the requirements of this section shall apply to enable the software to be modified by a third party.

2.   The software developed shall be written in a block structured high level language agreed with the Client or the Client's nominated representative. Low level languages shall only be used, by agreement with the Client or the Client's nominated representative, where there are major, demonstrable timing or space constraints on the system or where compatibility with any existing software would provide maintenance or future development advantages. Software coding standards will also have been defined in each case. The languages used shall be sufficiently widespread so as to permit third party maintenance support to be readily obtained.

3.   The medium used for storage and loading of programs shall be agreed with the Client or the Client's nominated representative. This shall be suitable for the way they are likely to be handled and stored and shall not require closely controlled environmental conditions.

4.   The software development methodology used should ensure the development of modular software.

5.   The ITS equipment provider shall ensure that the development environment is adequately maintained for the life of the product and release the necessary software tools and platforms to the Client or the Client's nominated representative at no additional cost.

6.   All documentation, diagrams (including software schematics or automated tool output) and specifications, shall be produced to recognised Standards and, apart from where other standards are agreed, shall use conventions, symbols and terminology defined in the appropriate European or International standards.

7.   There shall be at least two sets of all source programs held on the agreed medium. For reasons of security one set shall be kept remote from the other(s) and regularly updated as

changes are made. By agreement the Client or the Client's nominated representative may hold one set.

8.   The ITS equipment provider shall provide at least two sets of all operational programs including, where appropriate, site-specific data and programs held in PROMS / EPROMS.

9.   All programs supplied shall be clearly identified and include the appropriate issue details and date.

10.   The documentation supplied shall be fully annotated with issue number, date and section reference and shall include the following:

   (a)   A concise description of the overall function of the software.
   (b)   Details of the computer hardware of the system, upon which the software in installed and any proprietary software products used, including databases, operating systems and their version/issue status.
   (c)   A complete list of all modules in the software together with the occupancy of the various forms of store for each module and amount of store available for expansion.
   (d)   A detailed description of the construction of the software system.
   (e)   Clear operating instructions.

11.   In addition, for each module at 10.c) above, there shall be documentation including the following:

   (a)   A description of its operation in sufficient detail to enable its flowcharts and listings to be used by a third party programmer to modify the module.
   (b)   Detailed flow charts or other equivalent descriptions and listings with sufficient comments to promote ease of understanding.
   (c)   Details of interaction with other modules in the software system
   (d)   Each data area or identifier used by the module (this information may be included in the listings).
   (e)   Some form of designation indicating its modification state or issue number.

12.   The documentation shall include details of all the software development tools used for software design, development testing, acceptance, configuration management and application. This shall also indicate their version status (for compatibility purposes).

2.8   Information Security

1.   Providers of ITS equipment are required to ensure that the ITS equipment being provided operates in a secure manner with respect to the Client's Information Security Policy to manage the information risk from ITS equipment being connected to the Client's telecommunications and TMC networks. The Client's Information Security Policy provides a structure to meet the obligations to protect their operational technology and minimise the reputational risk to their business operations.

2.   The Equipment Integration Standard (EIS) is intended to achieve this by providing a mechanism for the ITS Equipment provider organization's to assess, document, treat and

manage the information security risks presented by their equipment when connecting to the ITS telecommunications network or TMC systems. In this way the required levels of trust between Clients and providers can be developed allowing more effective use of the integrated systems.

3. The ITS equipment provider is responsible for designing the equipment / solution to meet the Clients requirements regarding information security. Before permission will be given to connect to the telecommunications network the ITS equipment provider will need to conduct a risk assessment that will demonstrate that the ITS equipment does not pose a risk to the network integrity.

4. ITS equipment providers are expected to have familiarly with ISO 27001 or procure the necessary expertise in developing and delivering solutions in line with information system security best practice.

3 TRAFFIC DETECTION AND MONITORING SYSTEMS

3.1 Related Documents

Reference	Title
Ashghal	Intelligent Transportation System (ITS)Deployment Manual
Ashghal	Civil and Structural Standards for Intelligent Transportation System (ITS)
ASTM E2561-07a	Standard Practice for the Installation of Inductive Loop Detectors
BS EN 1993-1-1	Eurocode 3. Design of steel structures. General rules and rules for buildings
BS EN 7671	Requirements for electrical installations
BS EN 7430	Code of practice for protective earthing of electrical installations
BS EN 12899	Fixed, vertical road traffic signs
BS EN 50293	Electromagnetic compatibility. Road traffic signal systems
BS EN 60529	Degrees of protection provided by enclosures (IP code)
BS EN 62040	Uninterruptible power systems (UPS). Method of specifying the performance and test requirements
BS EN 62305	Protection against lightning
DIN 41494	Equipment practices for electronic equipment and mechanical structures
DIN/ISO EN 50022	Specification for low voltage switchgear and control-gear for industrial use. Mounting rails
ETSI EN 300 019-1-4	Environmental conditions and environmental tests for telecommunications equipment
IEC 60297	Mechanical structures for electronic equipment, Dimensions of mechanical structures
NTCIP	National Transportation Communications for ITS Protocol
QCS	Qatar Construction Standards
QGEWC (E)	Regulations for Electrical Installations
QGEWC (E)	Regulations for Protective Multiple Earthing
QTCM	Qatar Traffic Control Manual

3.2 Equipment Overview

3.2.1 Purpose

1.   This Section describes the requirements for the design, supply, installation, and commissioning of traffic detection and monitoring systems across the entire roadway network with the following key functions, in accordance with the detailed project design drawings and/or specifications.

2.   Traffic Detection and Monitoring Systems are stand-alone detectors that detect the presence of cyclists, pedestrian, vehicles and their characteristics. The detectors are

interfaced with roadside controllers and management systems to provide valuable real-time and historical data, including speed, volumes, vehicle presence, occupancy, gaps, and incident occurrence. This data can then be utilized to complete a variety of functions, including:

- Real-time traffic and incident management
- Traveller information
- Historical analysis
- Origin-destination information
- Roadway capacity analysis
- Performance measures
- Planning and design purposes

3.2.2 Configuration

3. This section details the requirements for:

- Microwave Vehicle Detection Systems (MVDS)
- Inductive Loop Detection (ILD)
- Magnetometer Detection Systems (MDS)
- Bluetooth® Device Matching Systems
- Video Imaging Vehicle Detection Systems (VIVDS)
- Automatic Incident Detection (AID) Systems.

4. The type of system used will be project specific and identified in the detailed design project drawings. Additional information on each system can be found in the Client's ITS Deployment Manual.

3.3 Non-Functional Requirements

3.3.1 Reliability

1. The traffic detection and monitoring systems shall be designed for continuous operation and a service life of 15 years.

2. Individual items of traffic detector equipment shall have a Mean Time Between Failure (MTBF) of greater than 55,000 hours. This requirement will be monitored and recorded through the Client's ITS Asset Management system.

3.3.2 Maintenance

1. The equipment shall be designed and installed such that the minimum routine preventive maintenance (i.e. clearing of dust and sand) interval will be every 6 months from the start of the maintenance period.

2. All equipment shall be easily accessible to the maintenance organisation and require no proprietary tools.

3.4   Functional Requirements

3.4.1   General

1.   The following general requirements apply to each of the detector equipment described in this specification. Any requirements specific to a particular detector equipment are shown in the relevant sections below.

2.   Within this document the term 'detector' shall mean the detector components installed within or above the road surface, the detector's control equipment.

3.   The detectors shall either be fixed point devices e.g. microwave radar, inductive loops, magnetometers and video imaging or shall be probe detectors such as in-vehicle units, Radio Frequency Identification (RFID) and Bluetooth® Readers.

4.   The detectors shall either connect to the telecommunications network (using a suitable wired link) or use cellular (e.g. LTE/4G/3G) or Bluetooth® telecommunication technologies suitable for use on the State of Qatar roadway network. Refer to section 15 for details about the telecommunications network and requirements for interfacing with it.

5.   The detectors shall include a setup program that allows the operator to define detection zones within the detector's field of view. The detector shall be able to automatically configure zones, requiring minimal external tuning.

6.   Each detector system shall be IP addressable (with the exception of inductive loops), shall support a programmable IP address and shall operate over a TCP/IP network connection.

7.   The detector system shall support Point-to-Point Protocol (PPP), Point to Multi-Point Protocol (PMPP) (i.e. polled protocols) and Ethernet protocols. The detector system shall respond to polling requests from the TMC.

8.   The detector system shall be capable of auto-calibration and auto-configuration and allowing manual calibration via supplied vendor tools (software and hardware).

9.   The detector system shall store the configuration and traffic data within the internal non-volatile memory. The detector system shall allow retrieving traffic data locally or from the TMC as identified in the detailed design project documentation.

10.   The detector system shall return to previous configuration when the system resumes proper operation after recovering from a power failure.

3.4.2   General Software Requirements

1.   The traffic detector system shall:

- Use standard data communication protocols and be compatible with the TMC master software

- Allow authorised users to modify previously defined detection system configurations to permit adjustments to the detection zone's size, placement, and sensitivity, and to reprogram the detector's parameters

3.4.3   Microwave Vehicle Detection Systems (MVDS)

1.   The MVDS shall be capable of collecting, storing and providing traffic related data (i.e. vehicle counts, vehicle speeds, vehicle classification counts, etc.) per detection zone in user-defined time intervals from 0 seconds to 24 hours.

2.   The MVDS shall consist of assemblies that include as a minimum: (i) Microwave Vehicle Detectors (MVD); (ii) mounting assembly and structures; (iii) Controller hardware; (iv) suitable cable for the transmission and receipt of data and Telecommunications between the microwave vehicle detector and the controller hardware located in a ground mounted enclosure; and (v) all required power cables as detailed in the detailed design project drawings.

3.   The specific requirements for the MVDS sub assemblies are as follows:

(a)   The MVD shall have a detection range from 2.0 m to 75.0 m

(b)   The MVD shall be capable of collecting the following data per lane: volume, speed, occupancy, counts, average headway, average gap and direction counts

(c)   The MVD performance shall not be adversely affected by weather conditions, such as rain, fog, heat, dust, sand or wind

(d)   The MVD shall operate at a frequency approved by ictQATAR. The MVD's frequency shall not interfere with any known equipment located in the vicinity

(e)   The MVD shall be mountable on new or existing structures (including poles) for a side-fire or over-head configuration, as directed by the detailed project design drawings and/or specifications

(f)   The MVD shall detect speed range from 4 to 280 km/h

4.   General requirements for the mounting assembly are detailed in section 3.5.1

3.4.4   Inductive Loop Detection system

1.   The inductive loop detection system shall consist of assemblies that include as a minimum: (i) inductive loops and detector equipment; (ii) loop assemblies; and (iii) all related equipment as shown in the detailed project design drawings.

The specific requirement for the inductive loop detection system is as follows;

(a)   The inductive loop detection system shall be capable of collecting the following data per lane: volume, average speed, occupancy, classification, counts, 85th percentile speed, average headway, average gap and direction counts

(b)   The inductive loop detection system shall be capable of providing the following minimum accuracy levels: 95% for volume, 90% for occupancy, 90% for speed and +/-1 meter for length for all lanes

(c)   The inductive loop detection system performance shall not be adversely affected by weather conditions, such as rain, fog, heat, dust, sand or wind

(d)   The inductive loop detection system shall detect stationary vehicles located within a detection zone

(e)   The inductive loop detection system shall detect speed range from 4 to 280 km/h

2.   The Loop Wire shall be:

(a)   of size 2.1 mm^2 or 3.3 mm^2, stranded copper with a minimum of seven (7) strands
(b)   fabricated from Cross-linked High Heat Water resistant insulated wire (XHHW)
(c)   insulated using Cross-linked Polyethylene (XLPE), rated for 600V
(d)   labelled on its surface with the manufacturer, maximum rated voltage and wire size

3.   Inductive loop detector equipment shall be installed in a ground mounted enclosure. A detector feeder cable shall connect the inductive loops to the detector equipment via cable terminations in the ground mounted enclosure.

4.   The Detector Feeder Cable shall:

(a)   comprised of shielded twisted pair conductors. Each conductor shall be insulated and have a size between 0.80mm^2 and 3.3mm^2
(b)   be rated for 600V
(c)   be shielded with an aluminum-polyester shield. A drain wire shall be provided with the shield The drain wire shall be insulated with polyethylene

(d) The outer jacket shall have a minimum thickness of 0.75 mm and shall indicate on its surface the manufacturer, maximum rated voltage and wire size.

5. Splicing material, sealant and tape shall have the following properties.

(a) All splicing loop wires and detector feeder wires shall use butt-end connectors or an insulated compression connector

(b) The sealing tape shall be electrical grade, plastic, and self-adhesive

(c) The sealant shall be electrical grade, fast-drying, moisture resistant, and compatible with plastic electrical tape.

6. The Encapsulant shall:

(a) allow being applied on concrete or asphalt, fresh or aged surfaces

(b) not become brittle with age or temperature changes. The encapsulant shall perform as specified in the road surface temperatures range of between 0°C and 85°C and relative humidity between 0% - 100%

(c) not degrade when installed in environments with high temperatures.

3.4.5 Installation

1. Inductive loop feeder cable shall be installed in accordance with requirements of the detailed design.

2. Inductive loops shall be installed in accordance with the Civil and Structural Standards for Intelligent Transportation System (ITS).

3.4.6 Magnetometer Detection Systems (MDS)

1. The MDS shall consist of assemblies that include as a minimum: (i) magnetometer sensors; (ii) access point(s); (iii) repeater unit(s), if needed; (iv) epoxy; (v) software; (vi) cable for the transmission and receipt of data and Telecommunications between the access point and the access box, access box and IP device located in an ITS enclosure; and (vii) all required ducts, power and data cables, as shown in the detailed design drawings.

2. The specific requirement for the MDS is as follows;

(a) The MDS shall be capable of collecting the following data per lane: volume, average speed, occupancy, counts, average headway, average gap and direction counts

(b) The MDS shall be capable of providing the following minimum accuracy levels: 95% for volume, 90% for occupancy, 90% for speed and +/-1 meter for length for all lanes

(c)   The MDS performance shall not be adversely affected by weather conditions, such as rain, fog, heat, dust, sand or wind

(d)   The MDS shall detect stationary vehicles located within a detection zone

(e)   The MDS shall detect speed range from 4 to 280 km/h

3.   The Magnetometer Sensors (MS) shall:

(a)   consist of a magnetometer unit, a microprocessor, and a battery housed in an enclosure.

(b)   have an average battery life of 10 years from the time of installation

(c)   be configurable to emulate as a minimum, the detection zone of a 1.7m x 1.7m inductive loop. In addition, the MS shall be capable of replicating detection zones of different sizes, according to the detailed project design drawings and/or specifications and manufacturer's recommendations

(d)   detect a vehicle by measuring changes in the earth's magnetic field near the MS as caused by a stationary or passing vehicle. The MS shall utilise three-axis magnetic field sensing. The MS shall sample the earth's magnetic field at a rate of 128Hz. The MS shall communicate time-stamped ON and OFF vehicle detection events, and shall automatically recalibrate in the event of a detector lock

(e)   operate in road surface temperatures ranging between 0°C and 85°C.

(f)   communicate by radio to an Access Point (AP) or Repeater Unit (RU), according to the detailed project design drawings and/or specifications. The MS shall transmit detection data within 150ms of a detected event, and automatically re-transmit a detected event in the event the AP or RU does not acknowledge receiving the data. Each MS shall be capable of stopping the re-transmission of data after eight (8) attempts

(g)   transmit a unique identifying code to the AP or RU. When the AP or RU are not powered, or are not provided in the vicinity of the MS, then the MS shall not detect vehicles

(h)   the radio links between each MS and the AP or RU, and between the RU and an AP shall meet the following requirements:

     (i)   The physical layer of the radio links shall comply with protocol IEEE 802.15.4

     (ii)   The frequency band shall range between 2,400 and 2,483.5MHz (ISM unlicensed band)

     (iii)   There shall be a minimum of 16 frequency channels, which shall be user-configurable. Each channel shall have a bandwidth of 2MHz

(iv)   The transmit/receive bit rate shall be as a minimum 250kbps

(v)   The receive sensitivity shall be -95dBm at a 1% packet error rate.

(vi)   be capable of accepting software and firmware updates either remotely over the telecommunications network, or locally on site from a laptop using a secure wireless link.

4.   The Access Point (AP) shall:

(a)   collect the data transmitted by either a MS or a RU. In addition, the AP shall establish time synchronization, transmit configuration commands, transmit message acknowledgements and process the data from the MS

(b)   AP shall be able to support up to 16 MS

(c)   AP shall have a minimum coverage area 40m

(d)   be capable of relaying the data collected by a MS or RU to an MDS controller in a ground mounted enclosure, and/or a local/remote traffic management network by using either wired or wireless connections, or both

(e)   have the capability of accepting two types of input voltage:

(f)   be 48Vdc nominal (35-58Vdc): Typically supplied through Power over Ethernet (PoE)

(g)   be 12Vdc nominal (10-20Vdc): Typically supplied by solar power arrays.

(h)   be connected to the ITS enclosure by utilising a standard Ethernet compatible, outdoor rated, 4-pair CAT5 or better cable. The maximum cable length shall be 100m

(i)   support the following connection models for IP telecommunication:

(i)   Connection via a wired network path
(ii)   Connection via a wireless network path (e.g. using GSM cellular networks or CDMA cellular networks).

(j)   be capable of accepting software and firmware updates either remotely over the telecommunications network, or locally on site from a laptop using a secure wireless link. In addition, the AP shall be capable of delivering firmware upgrades to other devices that constitute the MDS

(k)   be capable of providing the following interfaces to/from other components and/or devices:

(i)   to/from MS via 802.15.4 PHY radio
(ii)   to/from RU via 802.15.4 PHY radio

        (iii)   to/from laptop via TCP/IP over 10Base-T-Ethernet

        (iv)   to/from TMC via TCP/IP over 10Base-T-Ethernet or cellular data modem.

5.   The Repeater Unit (RU) shall:

(a)   be battery operated and have an average battery life of 10 years from the time of installation

(b)   communicate directly to an AP, the RU shall be capable of supporting a maximum of 10 MS. If the RU supports another RU (i.e. tandem repeater), the maximum number of supported MS shall be six (6)

(c)   maximum distance to AP 250m

(d)   be capable of accepting software and firmware updates either remotely over the telecommunications network, or locally on site from a laptop using a secure wireless link

(e)   be capable of providing the following interfaces to/from other components and/or devices:

        (i)   to/from MS via 802.15.4 PHY radio

        (ii)   to/from RU via 802.15.4 PHY radio

        (iii)   to/from AP via 802.15.4 PHY radio.

6.   The Epoxy shall:

(a)   be used for the installation of the MS in the pavement shall be a mixable two-part epoxy resulting in a 100% solid silicone polyurea-based joint sealant, mixed to the manufacturers recommendations.

(b)   have a cure time of less than 30 minutes and excellent adhesion to the pavement. The sealant shall be capable of being applied at an ambient air temperatures ranging from 0°C to 55°C and a road surface temperature in the range 0°C to 85°C

7.   The Magnetometer software shall:

(a)   support in excess of 100,000 MS, APs and RUs

(b)   allow an operator to program, operate, and read current status of all system features and functions using a laptop computer or remote TMC workstation

(c)   allow authorised users to modify previously defined detection configurations to permit adjustments to the detection zone's size, placement, and sensitivity, and to reprogram the detector's parameters either onsite or remotely from the TMC

(d)   have the capability of preparing reports. These shall include as a minimum:

(i)   Lane occupancy over a specified time interval; averages data from all MS in lane

(ii)   Number of vehicles observed over a specified time interval

(iii)   Calculated median and average speed over a specified time interval; intelligently corrected for 'no vehicle detected' situations

(iv)   Calculated average vehicle length

(v)   Calculated average separation between two successive vehicles

(vi)   Historic fault event log.

(e)   as a minimum allow the following functions:

(i)   Operate over a TCP/IP connection

(ii)   Give the operator the ability to save/back-up the AP configuration to a file or load/restore the configuration from a file

(iii)   Contact APs by IP address and issue configuration/management commands to individual MS, APs, and or RUs. Similarly, the software shall be capable of configuring and managing groups of the detection system components

(iv)   The software shall have the capability of creating congestion areas and depict them on a map that is real-time

(v)   Diagnostic of detection equipment

(vi)   Real-time display of wireless signal strength and link quality of all devices

(vii)   Battery level of both repeaters and MS

(viii) Automatic alarm notifications such as downtime

(ix)   The software shall be capable of contacting APs by IP address and issue configuration/management commands to individual MS, APs, and or RUs, or a group of these.

3.4.7 Bluetooth® Device Matching Systems

1.   The Bluetooth® Device Matching System shall be capable of obtaining the Media Access Control (MAC) of Bluetooth® devices passing near the Bluetooth® Readers. The data shall be processed to determine travel time, speed, and origin-destination information on a roadway. The Bluetooth® equipment shall be provided with the most current version of Bluetooth® software / firmware.

2.   The Bluetooth® Device Matching System shall consist of assemblies that include as a minimum: (i) Bluetooth® Reader(s); (ii) server; (iii) software; (iv) if applicable, a cable for the transmission and receipt of data between the Bluetooth® Reader(s) and a ground mounted enclosure; and (v) all required ducts, power and data cables, as shown in the detailed project design drawings.

3.   Bluetooth® Reader shall:

(a)   consist of as a minimum: (i) cellular modem and Ethernet telecommunication; (ii) a Class 1 Bluetooth® antenna; (iv) a Secure Digital (SD) type flash memory card; (v) a power source input; (vi) Telecommunications port(s); and (vii) an ITS enclosure to house the aforementioned components with a minimum IP-rating of IP65.

(b)   include cellular modem when Ethernet telecommunication is not available. If Ethernet telecommunication is available, the Bluetooth® Reader shall provide a port for communications to/from a laptop or IP device via TCP/IP over 10BASE-T/100BASE-T Ethernet

(c)   be capable of obtaining, encrypting and storing the MAC address of Bluetooth® devices passing within the coverage area of the Bluetooth® Reader

(d)   have an operating range of up to 100m between target device/vehicle and Bluetooth® Reader

(e)   have a remotely configurable coverage area e.g. narrow detection zone for monitoring a single lane of traffic or wide span detection zone covering the entire width of the roadway

(f)   be capable of detecting vehicles travelling at speeds up to of 280km/h

(g)   be capable of storing data for a minimum of 100,000 records on storage media (SD card)

(h)   be capable of transmitting and receiving signals in the range 2.400 to 2.480GHz frequency and having a signal sensitivity of at least -90dBm

(i)   be capable of accepting software and firmware updates either remotely over the telecommunications network, or locally on site from a laptop using a secure wireless link.

4.   Bluetooth® Software shall:

(a)   allow an operator to program, operate, and read current status of all system features and functions using a laptop computer or remote TMC workstation

(b)   have the capability of preparing reports according to the user's needs. These shall include as a minimum:

(i)   Average Speed
(ii)   Travel time
(iii)   MAC matching data
(iv)   Origin-destination data
(v)   Historic fault event log.

5.   The software shall allow the following functions as a minimum:

(a)   Operate over a web-based secure interface and utilise Dynamic IP addresses for data communications

(b)   Give an authorized user tools to access and query archived data

(c)   Graphically depict average speed, travel time, and/or origin-destination data on a map that is real-time

(d)   Provide diagnostics and status of the system's equipment

(e)   Prompt automatic alarm notifications such as downtime.

3.4.8   Video Imaging Vehicle Detection Systems (VIVDS)

1.   For details of the VIVDS camera please refer to CCTV section 4.

3.4.9   Automatic Incident Detection (AID) Systems

1.   The AID System shall consist of assemblies that include as a minimum: (i) video detection camera(s) with mounting kits; (ii) AID video analyzers; (iii) an AID server; (iv) AID software; (v) cabling for the video detection camera(s) to the ITS enclosure; (vi) interface to telecommunications network.

2.   An AID system shall be supplied and installed to provide real-time incident detection as shown in the detailed design project drawings. The AID shall perform its functions for different lighting and weather conditions.

3.   The AID system shall interface with a range of CCTV cameras, including PTZ, to obtain live streaming images.

4.   The AID shall alert the TMC operator within 20 seconds of an incident.

5.   The AID shall detect at least 90% of all incidents within its configured detection zone.

6.   The AID shall provide the facility to record the video streams in MPEG 4 format for later use.

7.   The AID system shall cover a minimum of 4 lanes.

8.   The AID system shall interface with the IP-based telecommunications network to send alerts and alarms to the TMC operators.

9.   The AID system shall have the capability of detecting and alerting to the TMC operators the following types of incidents (as a minimum):

Traffic events
- Stopped Vehicles
- Wrong way traffic
- Speed Drops
- Over speed
- Traffic Congestion

Non traffic events
- Smoke and fire detection
- Pedestrians and animals
- Debris and lost cargo

Traffic data
- Flow speed
- Zone occupancy
- Traffic volume counting
- Gap time
- Density per lane
- Vehicle classification

Technical alarms
- Loss of video
- Poor quality video/lens obstruction
- Loss of power to any of the on-street AID equipment
- Movement/tampering with any of the on-street AID equipment

10. The AID system shall be capable of detecting and monitoring a minimum of 1000 simultaneous incidents.

11. When requested by the TMC operator, the AID system shall be capable of streaming video to the TMC.

3.5 Power and Telecommunications

3.5.1 Power

1. Bluetooth® Reader Power Requirements

(a) The Bluetooth® Reader shall be powered with solar power.

(b) The solar power system shall include the solar panels, batteries, mounting hardware, and solar power controller.

(c) The solar panels shall automatically charge batteries provided within the Bluetooth® Reader.

(d) The Bluetooth® Reader shall be capable of stopping the charging of solar batteries when they are fully charged to prevent damage to the batteries.

(e) The Bluetooth® Reader enclosure shall include active or passive cooling to prevent overheating of the on-board controller and batteries.

(f) The Bluetooth® Reader enclosure shall be lockable and shall be rated IP65.

(g) The Bluetooth® Reader shall include a voltage regulator to prevent overcharging or overdrawing of the battery system

3.5.2 Telecommunications

1. In addition to the Telecommunications Interface requirements in Section 15, the following NTCIP requirements shall also apply for the traffic detector equipment.

2. All detectors and roadside detection equipment shall fully comply with NTCIP 1206 standard for Object Definitions for Data Collection and Monitoring.

3.   Optional objects and requirements shall confirm to NTCIP 1201 for Global Object
Definitions.

4.   To claim conformance to NTCIP 1209, each NTCIP component shall support all the
mandatory requirements as defined in the standard.

3.6   Hardware Design Requirements

3.6.1   Mounting Arrangements

1.   Above ground traffic detection equipment shall:

(a)   be mounted on new or existing structures. The mounting arrangement shall be
designed to withstand a design wind speed of 120 km/h with gusts up to 160 km/h

(b)   be designed in accordance with:

(i)   BS EN 1993-1-1 or approved equivalent international standard
(ii)   The Client's Civil and Structural Standards for Intelligent Transportation
System (ITS) and appropriate Client's design criteria
(iii)   the QHDM.

(c)   be mounted in accordance with the detailed project design drawings

(d)   all detection zones shall be verified as being contained within the specified elevation
angle according to the manufacturer's recommendations and that the detectors are
capable of fully detecting all vehicles within its detection range.

be connected via a suitable cable to the roadside controller located in a ground
mounted enclosure.

2.   For Inductive Loops the installer shall:

(a)   Install the loop cable in a clockwise manner. The number of loop turns runs shall be
based on the inductance required by the manufacturer to achieve proper operation.
The first run of the loop cable shall be placed in the bottom of the saw cut, with each
subsequent turn placed on top of the preceding turn

(b)   Push the loop cable to the bottom of the saw cut with a non-metallic object to avoid
damages to the insulation. No fewer than three (3) turns shall be installed in the
loops in the saw cut slot.

(c)   Insert the two tails from the loop, twisted together a minimum of 10 turns per meter, in the duct leading to the chamber

(d)   Test leakage resistance, series resistance, and inductance before sealing the saw cut slot. Leakage resistance greater than 10MΩ is necessary when tested at 375V DC minimum. Series resistance is not to exceed 2.6ohms per 300m. Inductance is to be between 50µH and 700µH

(e)   Seal the saw cut slots with the encapsulant approved by the Client and/or the Client's nominated representative

(f)   Seal the duct at the curb after placing the loop tails inside

(g)   Joint the loop cable to the detector feeder cable in accordance with the detailed design drawings. The joint shall be encased with sealant to prevent water from penetrating it. The length of the loop cable/detector feeder cable shall not exceed the necessary length identified in The Client's Civil and Structural Standards for Intelligent Transportation System (ITS) and detailed design project drawings in order to avoid cross-talk between loops

(h)   Extend the detector feeder cable to the terminal strip in the ITS enclosure without joints. The inductance of loop and detector feeder cable shall be between 50 µH and 700 µH

(i)   Connect the detector feeder cables to the loop detector amplifier. The amplifier shall be adjusted to obtain the necessary sensitivity.

3.   Magnetometer Sensor (MS) Installation

(a)   The MS shall be installed in accordance with the detailed project design drawings

(b)   The MS shall be installed in a core drilled hole of a size to suit the MS with 5mm clearance around the edge of the MS

(c)   The MS shall be placed in the hole such that the top of the MS is 10mm below the carriageway surface level and installed correctly relative to the direction of traffic flow.

(d)   The hole shall be sealed with epoxy resin sealant.

(e)   The MS shall be installed within the required operating range of the AP or RP.

(f)   A suitable cable shall be installed between the AP and the MDS Controller in the ground mounted enclosure.

4.   Bluetooth® Reader Installation:

(a)   The Bluetooth® Reader(s) shall be installed in accordance with the detailed project design drawings

(b)   The Bluetooth® reader shall be mounted on a carriageway side of a structure (pole or gantry leg) at the side of the road. It shall be mounted at a minimum 3.0m above the carriageway surface and shall be angled such that the antenna is perpendicular to the direction of traffic.

(c)   provide cellular or IP configured Telecommunications in accordance with the detailed project design drawings and/or specifications

(d)   verify that each Bluetooth® Reader provides accurate collection of MAC address data.

5.   Automatic Incident Detection (AID) System Installation

(a)   AID cameras shall be installed as indicated on the detailed design project drawings in order to provide full viewing coverage of the roadway.

(b)   The AID cameras performance and functions for different lighting and weather conditions shall be verified

(c)   The AID video analyser shall process the video stream from the AID cameras and run the algorithm to automatically detect an incident. The AID video analyzers shall be installed at the TMC

4 CLOSED CIRCUIT TELEVISION CAMERAS

4.1 Related Documents

Reference	Title
Ashghal	Intelligent Transportation System (ITS)Deployment Manual
Ashghal	Civil and Structural Standards for Intelligent Transportation System (ITS)
ISO 12233	Photography. Electronic still picture cameras. Resolution measurements
BS EN 50132-7	Alarm systems. CCTV surveillance systems for use in security applications. Application guidelines
Consultative Committee for International Radio (CCIR)	Television standard of PAL
OIML R 141 Edition 2008	Procedure for calibration and verification of the main characteristics of thermographic instruments
NTCIP 1201	Global Object (GO) Definitions
NTCIP 1205	Objects for CCTV Camera Control
NTCIP 1206	Object Definitions for Data Collection
NTCIP 1209	Object Definitions for Transportation Sensor Systems (TSS)
QCS	Qatar Construction Specifications

4.2 Equipment Overview

4.2.1 Purpose

1. This Section describes the general requirements for the supply, installation, and commissioning of Closed Circuit Television (CCTV) surveillance and security cameras and camera detectors (Pan, Tilt, Zoom (PTZ) and fixed) in accordance with the detailed project design drawings and/or specifications with the following purposes:

- Visual surveillance and security to enable TMC operators to have an enhanced situational awareness of the transport network

- Support enforcement through the use of Image Processing and LPR systems that use images to identify individual vehicles

- The operation of cameras as an additional means to automatically detect specific events/issues when used with Image Processing (e.g. integrated with Automatic Incident Detection (AID)).

4.2.2   Configuration

1.   This specification supports the following configurations:

- PTZ CCTV for general surveillance and security of the roadway

- Fixed camera for surveillance and security of specific locations

- Fixed camera for image processing in Licence Plate Reader (LPR) and AID systems (where AID will utilise Video Imaging Vehicle Detections System (VIVDS))

- Fisheye lens to provide full 360° local area surveillance and security

- Infrared thermography for the detection of overheating road vehicles and/or fires

- Infrared thermography to support CCTV surveillance

- Fixed infrared thermography for the detection of faulty vehicle brakes.

2.   The configuration of any camera and associated equipment (as detailed in this section) shall support optimum performance based on the specific requirement of that installation and wider requirements of the network.

3.   This section, where possible, has been written to support new equipment development and innovation (e.g. it aims to define the performance and not the equipment, whether this is for types of photosensitive elements or the use of dome or PTZ cameras).

4.3   Non Functional Requirements

4.3.1   Reliability

1.   The CCTV system shall be designed for continuous operation for a service life of 15 years regardless of location and in accordance with the manufacture recommendations.

2.   The camera, lens and (where applicable) PTZ mechanisms shall have a MTBF greater than 55,000 hours and shall be demonstrated through theoretical calculation using accepted mechanical and electrical standards.

4.3.2   Maintenance

1.   Information regarding Camera Lowering Device (CLD) is included in the Civil and Structural Standards for Intelligent Transportation System (ITS)

2.   It shall be possible to safely lower, maintain and raise all pole mounted cameras and related equipment from a location at ground level in such a way as to allow easy of access to conduct maintenance on the camera, lens, PTZ mechanism and other equipment located at the camera head.

3.   The lowering and rising of a pole mounted camera shall not cause damage or degradation of the camera functions and operations.

4.   Cameras and other remote CCTV equipment shall maintain accuracy and not require a site operative to conduct local recalibration in less than a one year period.

5.   All installations shall be easily accessible to enable the maintenance and replacement of equipment.

4.3.3   General Environmental

1.   All equipment shall function and perform as per the specification in ambient temperatures ranging from 0°C to 55°C and in the range of 0% - 100% relative humidity.

2.   The CCTV Camera housing shall be rated to minimum IP55 in accordance with BS EN 60529.

4.3.4   Thermography Environmental

1.   The thermography detection system shall be able to operating in relative humidity of the range 0% - 100%.

4.4   Functional Requirements

4.4.1   General CCTV

1.   Any installed camera shall provide a clear view to the TMC operator. This can include the use of electronic image stabilising technology integrated within the camera as long as it does not reduce the resolution as detailed within this specification.

2.   Where not stated otherwise within this section all (1) Camera/s, (2) Lens/es, (3) Software (drivers and Image Processing)), (4) Video encoding/decoding, (5) Mounting structure and (6) Housing requirements shall conform to those of General CCTV Requirements detailed in section 2.

3.   Recording of CCTV images shall be in MPEG4 format

4.4.2   General Camera Requirements

1.   The camera output shall confirm to International Telecommunication Union (ITU-R) Television standard of PAL 625lines/ 50Hz, 2:1 interlaced colour.

2.   The CCTV camera shall provide a minimum of 540 Television Lines (TVL) resolution when measured with at least 5% depth of modulation or more, observing a ISO 12233 horizontal resolution test chart at 7.5lx illumination in day conditions and 0.1 lx illuminations at night conditions.

3.   Any electronic methods used to enhance the resolution of the image shall not reduce the resolution below 540 TVL.

4.   The camera shall support a minimum shutter speed of 1/50th seconds in day conditions and 1/25th seconds at night conditions.

5.   The camera shall allow remote adjustment of shutter speed.

6.   With automatic gain control turned off, the camera shall support a minimum sensitivity to enable it to produce 350mV of video signal from an 11 step gamma grey scale chart, when using 400lx and then a 10lx 3200°K colour temperature source. The camera shall demonstrate a full 700mV dynamics range of black to white and full colour signal output during the test.

7.   The camera shall have a Signal-to-Noise (SNR) greater than 46dB at day conditions and 39dB at night conditions when collecting light from one frame.

8.   The camera image sensor function shall not create any vertical smears.

9.   The camera shall support through-the-lens white balancing, fixed white balancing, and automatic gain control.

4.4.3   Lenses General

1.   The type, size and performance of the lens installed shall be appropriate to the camera image sensor it is to operate with and the intended application.

2.   The camera housing or any other CCTV component shall not create observable internal reflection or flaring caused by strong light sources outside the angle of view when at the widest angle of view or caused by point light sources within the field of view.

3.   The lens for surveillance and security cameras shall not create observable spherical aberration when the image is in focus both at the centre and corners of the field of view.

4.   The lens for surveillance and security cameras shall not create observable:

- Pincushion or barrel distortion across its full range of focus
- Chromatic aberrations due to incorrect focusing of light at a single focal point
- Vignetting at any iris or zoom setting.

4.4.4   Fixed Camera

1.   Fixed cameras shall support fixed focal length lens with an auto-iris, with a manual integral mean of focus and mechanically lock the lens focus ring once adjusted.

2.   Fixed cameras used for Hard shoulder monitoring shall have a Field of View (FoV) in the range 3° to 10°.

4.4.5   PTZ Camera

1.   TMC operator, using standard control room equipment, shall be able

- to differentiate moving traffic in both day and night conditions
- to differentiate a BS EN 50132-7 chart (or similar, in scale and detail) located 500m from the camera in both day and night conditions
- To easy recognises a human face from an individual standing at the base of the camera pole in both day and night conditions.

2.   The PTZ functionality of the camera shall include:

- Manual/auto focus
- Manual/auto iris with ND spot filter.

3.   A focused image at maximum zoom shall remain in focus as the zoom angle is increased to maximum wide angle.

4.   PTZ cameras shall have a 10:1 zoom with a FoV in the range of 4° to 50°

5.   The PTZ camera shall be capable of

- pan speed in the range of 30° to 60° per second
- tilt speed in the range of 12° to 30° per second
- a minimum PTZ and Focus positional performance accurate and repeatable to within 0.5 degrees for pan and tilt and 2% of full range for focus and zoom

6.   Pan and tilt movement shall meet the specific requirement of a location, however a normal roadway camera installation is expect to have:

- Minimum pan movement of 0° to 360° pan
- Minimum tilt movement of +10° above the horizontal and -80° below the horizontal.

7.   In conjunction with the control software, the PTZ camera shall be capable of returning to a preset "home" position when a preset touring sequence is not active, or when the PTZ

control of the camera has been left idle for more than a set duration, unless the camera is switched to a manual override mode.

8.   In conjunction with the control software, the PTZ camera shall be capable of multiple pre-set positions (minimum of 6), with a positioning accuracy of plus or minus 1/2 degree. Auto focus, auto iris, pan, tilt, and zoom functions shall be included in each pre-set position.   The PTZ subsystem shall have the capability to scan between any two electronically-set limits, and to implement a scan through a predetermined sequence of pre-set locations.

4.4.6   Portable CCTV

1.   Portable CCTV that is installed at the roadside shall use an IP configured connection capable of utilising the cellular (3G/4G) phone network.   Note image quality shall automatically match the available communication bandwidth with a minimum frame rate of 6 Frames per Second (FPS). TMC Operators shall be able to remotely alter image quality.

2.   Portable CCTV shall have a minimum of 36 hours recording capacity at full bandwidth and 30fps

3.   Portable CCTV systems that are to operate unattended shall detect and send alerts to TMC operators in the event of unexpected location change or cabinets access.

4.   Portable CCTV surveillance and security systems that are to operate unattended shall support VIVDS functionality (see section 4).

5.   Where the portable CCTV system is trailer based, it shall meet all State of Qatar and client trailer standards (further trailer requirements are defined in section 9 - Portable DMS).

4.4.7   Video Imaging Vehicle Detection System

1.   The VIVDS camera, lens and location configuration shall be optimized to ensure detection performance against operational requirement.

2.   The VIVDS camera shall transmit images directly to the Image Processing unit for vehicle detection and/or counting.

3.   The VIVDS camera system shall support, as a minimum, the following:

- Has a signal-to-noise ratio at 2.5-lx sensor illumination of no less than 50 dB un-weighted.

- Shutter speed and processing shall be sufficient to detect all vehicles travelling at speeds up to 280Km/h through the detection zone. Performance shall be validated

via detailed calculations (i.e. including: vehicle speed, shutter speed, buffering and processing speed, detection area) and demonstrations.

- Generates a clear, high-contrast colour image under site illumination of 0.8 lx or higher, and black-white image under site illumination of 0.1 lx or higher, without reliance on infrared lighting. The camera shall automatically switch between colour and monochrome (grey scale) mode under regular and low light conditions respectively.

- It is desirable for the camera to support multiple lens configurations thus be flexible with its physical location in relation to the detection area without reducing detection performance.

4. The VIVDS cameras shall be able to electronically minimise the effect of vibration on their performance.

4.4.8   License Plate Reader (LPR) Cameras

1. The LPR camera system shall be capable of capturing images of license plates of all vehicles on roadways include those traveling at speeds up to 280 Km/h through its detection zone. The performance shall be validated through detailed calculations (i.e. including: vehicle speed, shutter speed, buffering and processing speed, detection area) and demonstrations.

2. The LPR camera shall be equipped with lens or lens assembly sized for optimal viewing of license plate at each individual deployed position (distance, height, and angle off the lane axis). An inventory of lens shall be provided against each specific site location and camera.

3. The minimum mounting height shall be 6.0m above the carriageway.

4. LPR cameras shall function on both the forward and rear facing mode

5. The LPR camera, lens and location configuration shall be optimized to ensure detection performance against operational requirement.

6. The LPR cameras shall provide clear still images of license plates during day and night conditions. The still image format shall be in JPEG format and shall be encrypted prior to storage or transmission to the TMC. The encryption standard shall use encrypted key security based on Advanced Encryption Standard (AES).

7. The LPR camera shall be equipped with an Infra-red illuminator for low visibility conditions.

8. The camera unit shall, as a minimum have the capacity to store locally 100,000 images in the event of a communication failure.

9.   The LPR cameras shall be able to electronically minimize the effect of vibration on their performance.

10.   The LPR cameras system shall accept electronic or electrical trigger signal from one or more external sources for activation of the image-capture function.

11.   It is desirable for the LPR camera to be able to perform all the functions of a VIVDS camera.

12.   Unless otherwise specified to a higher standard within this section (i.e. on CCTV) all data and communication specification shall fully comply with NTCIP 1201, NTCIP 2106 and 1209 standard.

4.4.9   Thermography Camera

1.   The thermography cameras shall be used for the detection of over or under heated brakes on vehicles and for the detection of fires and unexpected heat sources.

2.   The thermography camera shall have as a minimum resolution of 1280x960 pixels.

3.   The thermography camera shall have a minimum temperature measurement accuracy of +/-3% or difference of 20°C, whichever provides the greatest accuracy.

4.   The thermography camera shall have a minimum temperature detection range of 0 to 500°C and shall not be expected to detect below 0°C.

5.   The number of defective photosensitive elements with which the thermography sensor detects heat shall not exceed 0.3% of the total number of sensitive element specified for the product.

6.   Where different thermography cameras are used to view opposite wheels/brakes, they shall be calibrated together to provide an accurate comparison of heat temperatures.

7.   The thermography camera shall be supported by LPR cameras to capture the vehicle license plate

8.   When the thermography camera detects a faulty vehicle, it shall send an alert to the TMC. The thermography camera controller shall also send an alert to a DMS placed downstream of the camera and provide an audible alarm as well to divert the suspect vehicle off the roadway.

9.   Where thermography cameras are used to detect faulty brakes or fire, the system as a whole shall be capable of detecting a failure of the camera and send an alert to the TMC.

10.   It shall be possible to calibrate and verify all thermography equipment in controlled conditions and do so following internationally recognized and relevant standards (e.g. OIML R 141 Edition 2008) for calibration.

4.4.10   Fisheye Camera

1.   The fisheye camera shall support, as a minimum, the following:

- Capable of 360˚ FoV on the horizontal axis and a minimum of 180˚ FoV on the vertical axis.

- An image sensor with a minimum resolution of 5 megapixels.

- Generates a clear, high-contrast colour image under site illumination of 0.8 lx or higher, and black-white image under site illumination of 0.1 lx or higher, without reliance on infrared lighting. The camera shall automatically switch between colour and monochrome (grey scale) mode under regular and low light conditions respectively.

- Has a signal-to-noise ratio at 2.5-lx sensor illumination of no less than 50dB un-weighted.

4.4.11   Video Encoding

1.   Any CCTV encoding shall support as a minimum standard H.264/MPEG4.

2.   Encoder and decoder combined latency shall be no more than 100ms.

3.   Video encoding and decoding for surveillance and security cameras shall support a transmit minimum of two simultaneous video streams generated in different compression formats from the same analogue video signal. Where the first video stream has a minimum of 4CIF (704 horizontal pixels, 480 vertical pixels) frame size and at a frame rate of up to 30fps and the second has a minimum of 1CIF (352 horizontal pixels, 240 vertical pixels) frame size and at a frame rate of up to 3fps.

4.4.12   Software General

1.   All CCTV and camera systems as a whole (i.e. including any Image processing software) shall be able to be fully integrated with the ITS Master Software at the TMC as well as offer a backup monitoring and control software option.

2.   The camera communication shall support and comply with the following network protocol and standards: Internet IP with fixed IP address, TCP, UDP, ICMP, ARP, RTP, RTSP, DHCP, HTTP, and SNMPv2.

3.   Unless otherwise specified to a higher standard within this section (i.e. on CCTV) all data and communication specification shall fully comply with NTCIP 1205 standard. Suppliers shall use Table 4-2: Conformance Statement Table in NTCIP 1205 to indicate what conformance group each NTCIP component supports.

4.   CCTV surveillance and security camera shall include a video overlay capabilities so that the TMC operator can control the video overlay.

4.4.13   VIVDS Software

1.   The Image Processing system shall analyse the CCTV camera video output for processing, storing, and reporting the collected vehicle detection data.

2.   The VIVDS shall emulate below ground detection by producing volume, average speed, occupancy, classification, counts, average headway, average gap, direction counts and wrong direction alerts.

3.   Within the same field of view the VIVDS shall be capable of detecting:

- Approaching traffic
- Stopped traffic and incidents
- Wrong way traffic
- Pedestrians and animals
- Debris
- Fire or smoke.

4.   The VIVDS shall be capable of displaying real-time video to a site operative on site or remotely to operators within the TMC.

5.   Once setup, the VIVDS shall not require adjustments unless the geometry of the roadway is modified.

6.   The VIVDS software shall allow configuration, setup, data logging, and retrieval via a local laptop or remote TMC computer. The software shall allow the operators and site operative to:
- Adjust all features and functions of the video detection camera
- Perform any calibration
- Adjust detection sensitivity
- Adjust communication addresses and operational modes
- Retrieve data.

7.   Operation log shall include hardware run-time operation logs of detected faults and events (e.g. measured traffic data and alarms).

8.   Unless otherwise specified to a higher standard within this section (i.e. on CCTV) all data and communication specification shall fully comply with NTCIP 1201, NTCIP 2106 and 1209 standard.

4.4.14   LPR Software

1.   The LPR software shall use compatible decryption software to that provided for the LPR camera

2.   The LPR camera software shall create an accurate timestamp for each license plate image captured. The timestamp shall accurately represent the moment the picture was taken.

3.   For the purpose of time stamping images the LPR camera software shall synchronise its time with that of the TMC.

4.4.15   Thermography Software

1.   The thermography detection system as a whole shall be able to update the ITS Master Software as well as any backup monitoring and control software/s with images and alerts with a latency that allows a vehicle to be stopped safely before it enters specific localized areas (e.g. tunnel).

2.   The thermography camera software shall create an accurate timestamp for each license plate image captured. The timestamp shall accurately represent the moment the picture was taken.

3.   For the purpose of time stamping images the thermography camera software shall synchronise its time with that of the TMC.

4.4.16   Fisheye Camera Software

1.   The camera software shall provide, as a minimum, the following functionality:

•   Virtual Pan-Tilt-Zoom (ePTZ) functionality and panoramic view creation to show specific points-of-interest within the camera's FoV.

•   Ability to stream ePTZ and panoramic streams of the entire FoV simultaneously and at varying bitrates, image resolutions and frame rates.

•   Video motion tracking to allow multiple de-warped camera views to track multiple objects within the cameras FoV.

- Support for a minimum of 10 user-defined zones per camera for video motion detection, vehicle tracking and object classification. Objects that shall be classified within the camera's FoV include (but not limited to) cars, trucks, pedestrians and cyclists.

2.   The camera images shall be digitally flattened (de-warped), either within the camera itself or using the supplied software, in near real-time to provide operators with a clear, distortion-free view of the roadway. The latency of the hardware or software in generating a flattened image from the incoming video stream should not exceed 1sec. Note: the latency described above does not include delay due to transmission equipment or telecommunications infrastructure between the camera and the traffic management centre.

4.5   Power and Telecommunications

4.5.1   Power

1.   Equipment shall be supplied and installed using suitable adapters and conform to requirements stated in section 2.

4.5.2   Telecommunications

1.   Video and control related data shall follow the specification as described in section 13.

2.   All video shall be encoded before transmission and then decoded at the TMC.

3.   The camera shall support both RJ45 and BNC connections.

4.6   Hardware Design Requirements

4.6.1   General Mechanical and Housing Requirements

1.   Camera housing or shrouding shall not appear within the field of view.

2.   Non dome PTZ cameras shall be installed with a self-cleaning facility located outside of the field of view.

3.   The mounting hardware shall also be capable of withstanding vibration of up to 0.75 mm total excursion from 5 to 30 Hz, and peak random vibrations of 5G's from 30 to 1,000 Hz.

4.   The CCTV related equipment shall be of sound construction and free from hazards

4.6.2   PTZ Camera Mechanical and Housing Requirements Mounting Arrangements

1.   The complete PTZ camera unit shall weigh be no greater than 15Kg.

4.6.3   Fixed Camera Mechanical and Housing Requirements Mounting Arrangements

1.   The complete fixed camera unit shall weigh be no greater than 7Kg.

4.6.4   Dome Camera Mechanical and Housing Requirements Mounting Arrangements

1.   Where CCTV dome camera utilising a cable based Camera Lowering Device (CLD) shall also utilise a case a Suspension Contact Unit (SCU) and the complete system confirm to the following specifications:

    (a)   The SCU shall be installed between the pole or structure and the camera's connections to power and data cables

    (b)   The SCU shall utilise dual latching arms to connect the CCTV camera to the camera lowering device

    (c)   The SCU shall have a load capacity of the dual latching arm device of at least 275Kg with a safety factor of 4 to 1, and a locking mechanism between the fixed and moveable components of the lowering device

    (d)   The locking mechanism shall operate by alternately raising and lowering the assembly using the crank and lowering cable such that when latched, all weight is removed from the CLD cable

    (e)   The fixed unit shall include a heavy duty cast tracking guide and means to allow latching in the same position each time

    (f)   Self-aligning contact units and receiver brackets shall be provided to automatically align the centreline of the camera apparatus with the centreline of the camera pole or structure upon raising and locking into position

    (g)   All electrical, video, coaxial, and other connections between the fixed and moveable portions of the contact block shall be protected from weather

    (h)   The electrical contacts shall be made of corrosion resistant stainless-steel to prevent degradation of the connections

    (i)   The disconnect unit housing shall include a replaceable neoprene gasket provided to seal the interior from dust and moisture without the use of pressurization

    (j)   The connector block shall consist of a self-aligning and self-adjusting female and male socket contact halves.

2.   CCTV dome camera utilising a cable based CLD shall provide portable, detachable lowering tools:

    (a)   Consisting of a lightweight metal frame and a crank assembly with a quick release cable connector, an adjustable safety clutch, and a variable speed reversible electric motor

(b)   That is compatible with accessing the support cable through the hand hole of the pole, and shall attach to the pole with one single bolt

(c)   When attached to the hand hole, the tool shall support itself and the load, assuring lowering operations and providing a means to prevent freewheeling

(d)   Shall be equipped with a positive breaking mechanism to secure the cable reel during raising and lowering operations and to prevent freewheeling

(e)   Shall include a disconnect unit for electrically connecting the equipment installed on the lowering device's equipment connection box to the power, data, and video cables (as applicable)

(f)   With a reduction gear to reduce the manual effort required to operate the lifting handle to raise and lower a capacity load

(g)   The lowering tool shall include an adapter for operating the lowering device by a portable drill with a clutch mechanism

(h)   The CLD's pulleys and portable lowering tool shall be provided with sealed, self-lubricated bearings, oil tight bronze bearings, or sintered bronze brushings

(i)   Weights and/or counterweights shall be provided as necessary to assure that the alignment of pins and connectors are proper for the camera support to be raised into position without binding

(j)   The lowering unit shall have sufficient weight to disengage the camera and its control components in order that it can be lowered properly.

3.   CCTV dome camera utilising a cable based CLD shall operate a cable to the following capabilities:

(a)   The lowering cable shall have a minimum breaking strength of 800kg

(b)   A lift unit support subsystem with prefabricated components shall be included to preclude the lifting cable from contacting the power or video cabling

(c)   The CLD's lowering cable shall move within the pole or externally-mounted duct during lowering and raising operations. All other cables must remain stable and secure during lowering and raising operations

(d)   The lowering cable shall not touch or interfere with other electrical and mechanical cabling within the pole. The CLD cables shall be completely separated from electrical, Telecommunications, and other cables.

4.   The camera housing, PTZ mechanism and any other equipment located at the top of a camera pole shall allow maximum play of +/- 5 degrees when locked in the raised position

under sustained wind speeds of 120 km/h with gusts up to 160 km/h, with camera housing presenting an effective wind loading surface of maximum 0.1 m2.

4.6.5 Camera Poles

1.   The CCTV camera pole shall be of the height described in the detailed project design drawing and/or specifications and comply with section 2. The standard minimum installed height shall be 15m and the maximum installed height shall be 25m.

2.   The design of the pole and foundations shall meet the requirements of QCS

5 ROADWAY WEATHER INFORMATION SYSTEM

5.1 Related Documents

Reference	Title
NTCIP 1201	Global Object (GO) Definitions
NTCIP 1204	Standard for Environmental Sensor Station Interface Protocol
QCS	Qatar Construction Specifications

5.2 Equipment Overview

5.2.1 Purpose

1. This Section describes the general requirements for the design, supply, installation, commissioning and maintenance of Roadway Weather Information Systems (RWIS) and Air Quality Monitoring (AQM) systems in accordance with the detailed project design drawings and/or specifications.

2. This equipment is to be used to inform TMC operators with accurate environmental information and so enable:

    *   Appropriate early warning to road users (target of within 5 minutes of detection) for hazardous conditions
    *   The planning and implementation of operational procedures to adapt the roadway network operations during changing weather conditions.

5.2.2 Configuration

1. This specification supports the following configurations:

    *   RWIS and AQM installed throughout the State of Qatar

2. As a minimum the RWIS shall consist of the following:

    *   Passive Sensor
    *   Air Temperature/Relative Humidity Sensor
    *   Precipitation and Visibility Sensor
    *   Wind speed and Direction Sensor
    *   Barometric Pressure Sensor
    *   Roadside controller
    *   Software and/or Equipment Room Server
    *   Housing and Mounting Structure.

3.   As a minimum the AQM shall consists of the following:

- Particle Sensor
- Gas Sensor
- Remote Processing System
- Software and/or Equipment Room Server
- Housing and Mounting Structure.

4.   The configuration of any RWIS, AQM and associated equipment shall support optimum performance based on the specific requirement of that installation and wider requirements of the network.

5.   This specification, where possible, has been written to support new equipment development and innovation (e.g. it aims to define the performance and not the equipment).

5.3   Non Functional Requirements

5.3.1   Reliability

1.   The RWIS and AQM system shall be designed for continuous operation for a service life of 15 years and in accordance with manufacture recommendations.

2.   The RWIS and AQM system shall have a MTBF greater than 55,000 hours. This shall be demonstrated through theoretical calculation using accepted mechanical and electrical standards.

5.3.2   Maintenance

1.   It shall be possible, through technology and process, to safely maintain all RWIS and AQM equipment from a location at ground level. This should be done in such a way as to allow easy access to conduct maintenance on equipment.

2.   The equipment shall be designed and installed such that the minimum routine preventive maintenance interval will be every 6 months from the start of the maintenance period.

3.   All equipment shall be easily accessible to the maintenance organisation and require no proprietary tools.

4.   Any lowering and rising of pole mounted equipment shall not cause damage or degradation of the equipment functions and operations.

5.   All installations shall be easily accessible to enable the replacement and maintenance of equipment. Where detectors are installed in the road surface the ability to access and maintain the equipment must not require time consuming and complex procedures.

6.   Sensors and other remote RWIS and AQM technologies shall maintain accuracy and not require a site operative to conduct local recalibration in less than any one (1) year period.

7.   A site operative shall be able to connect (i.e. for calibration, configuration and fault testing) locally to the RWIS and AQM systems via spare ports without removing it from its operating location. It is desirable that such a connection is an easily accessible RJ45 port. As a minimum EIA-232 or RS-422/485, half or full duplex shall be supported.

5.3.3   General Environmental

1.   All ITS equipment must maintain full functionality and continue to operate within the limits of this specification when subjected to the working environment of the State of Qatar.

2.   All equipment shall function and perform as per the specification in ambient temperatures ranging from 0°C to 55°C and in the range of 0% to 100% relative humidity in accordance with QCS.

5.3.4   RWIS Environmental

1.   The Passive Pavement Sensor shall operate in surface temperatures ranging between 5°C and 85°C.

2.   The supplier shall demonstrate that the Air Temperature/ relative Humidity sensor has been protected from water, dust and dirt suitable for yearly weather conditions for the State of Qatar.

3.   The air temperature/relative humidity sensors shall be housed in a Stevenson screen to protect the sensor from scattered and direct solar radiation and precipitation.

4.   The visibility sensors shall be housed in an enclosure made from, UV-resistant material rated to IP65.

5.   The visibility sensors' optical components and the lenses shall be protected to minimize the impact of precipitation, haze, and sand. Protective measures shall not interfere with the accuracy of the visibility sensor.

6.   The barometric pressure sensor shall be housed in an enclosure rated IP32.

5.4   Functional Requirements

5.4.1   General

1.   Any installed RWIS and AQM systems shall provide accurate and reliable measurements, to the TMC, from their installed location.

2.   The Roadside controller shall be capable of:

- Performing multiple tasks simultaneously to optimise data acquisition from the different environmental sensors.

- Collecting data from all sensors (note a Roadside controller could support both RWIS and AQM sensors)

- Process, store, and transmit the data to the TMC software upon a polled request.

3. The Roadside controller shall be expandable to accommodate additional ITS technologies (i.e. environmental sensors, CCTVs, etc.) and wireless device control of DMS or flashing beacons.

5.4.2 RWIS

1. Where pavement sensors are installed in the ground they shall have a minimum operating and detection temperature range of 5°C to 85°C while maintaining a temperature accuracy of 0.5°C.

2. The Humidity sensor head shall be capable of reducing the potential for condensation on the sensor.

3. The Humidity sensor shall have a relative humidity range of 0 to 100% and, as a minimum accuracy of ±2.5% in the temperature range 0°C to +70°C

4. The Air Temperature sensor shall, as a minimum, be accurate to ±0.5°C in the temperature range 0°C to +70°C

5. The Visibility sensors shall measure atmospheric visibility based on particles (smoke, sand, haze, fog, and rain) in the air. It is desirable for the visibility sensors to have the capability to identity fog, mist, smoke, and sand/dust.

6. The Visibility sensor shall have a visibility Meteorological Optical Range (MOR) range of between 10m and 2000m (minimum).

7. The Visibility sensor shall be installed to the direction for correct operation. The line of site of the visibility sensor shall not be obscured by passing traffic or other obstructions.

8. The Visibility sensors shall confirm to International Civil Aviation Organisation (ICAO) and World Meteorological Organisation (WMO) specifications.

9. The Visibility sensor shall have self-test and monitoring feature.

10. The Visibility sensor shall be calibrated to operate in weather condition in the State of Qatar

11. The Visibility sensor shall be operate in the ambient air temperature range of 0°C to 55°C

12. The Precipitation sensor shall utilise a capacitive device to determine different types of precipitation (e.g. rain or drizzle).

13. The Precipitation sensors shall have a minimum precipitation detection sensitivity of 0.05mm/h within 10 minutes.

14.   The Wind Speed and Direction sensor shall be accurate to

- ±0.5m/s or 5% of the wind speed reading at wind speeds of up to 75 m/s

- A response time of 250ms ±2%, for 360° of wind direction

15.   The barometric pressure sensor shall provide accurate barometric measurements regardless of location.

16.   The barometric pressure sensor shall operate, as a minimum, with a pressure range of 750hPa to 1,100hPa with an accuracy of ±10.0hPa in the temperature range of 0°C to +70°C.

5.4.3   AQM

1.   The particle monitor shall measure particles 10 microns and/or 2.5 microns aerodynamic diameter (PM_{10}, $PM_{2.5}$).

2.   The AQM shall have the capability of taking and analysing air samples. The gas types to be monitored shall include

- Carbon Monoxide (CO)
- Ozone (Ground level) (O_3)
- Nitrogen Dioxide (NO_2)
- Sulphur Dioxide (SO_2)

3.   The AQM shall have an integrated zero calibration system which can be manually or remotely activated.

5.4.4   General Software

1.   Unless otherwise specified to a higher standard within this section (i.e. RWIS and AQM) all data and communication specification shall fully comply with NTCIP 1204 standard for Environmental Sensor Station Interface Protocol. Note the maximum response time for any object shall be 200ms.

2.   Optional objects and requirements shall confirm to NTCIP 1201 for Global Object definitions.

3.   The following optional NTCIP 1204 user need shall be treated as mandatory along with any optional requirement associated with these user need:

(a)   User Need ID 2.5.2.1, Monitor Weather Conditions.

(b)   User Need ID 2.5.2.1.1, Monitor Pressure

(c)   User Need ID 2.5.2.1.2, Monitor Winds

(d)   User Need ID 2.5.2.1.3, Monitor Temperature

(e)   User Need ID 2.5.2.1.4, Monitor Humidity

    (f)   User Need ID 2.5.2.1.5, Monitor Precipitation

    (g)   User Need ID 2.5.2.1.7, Monitor Visibility

    (h)   User Need ID 2.5.2.2, Monitor Pavement

    (i)   User Need ID 2.5.2.2.1, Monitor Pavement Surface Condition

    (j)   User Need ID 2.5.2.6, Monitor Air Quality

    (k)   User Need ID F.1.1.2, Provide Compressed Data

    (l)   User Need ID F.1.1.3, Provide Off-line Log Data

4.   A completed Protocol Requirements List (PRL) as contained in NTCIP 1204, Section 3.3.7 Protocol Requirements List, shall be completed to indicate which options of this NTCIP standard are implemented. This completed PRL shall indicate what mandatory and optional requirements the NTCIP component actually supports, and the value ranges.

5.4.5   RWIS Software

1.   The roadside controller shall undertake diagnostic monitoring of its own operation and sensors. It shall reset itself if the roadside controller software enters an indeterminate state. If a fault is detected or reset occurs then a fault alert should be sent to the TMC operative.

2.   The roadside controller shall have the capability to be remotely reset by an authorised user.

3.   The RWIS TMC interface shall be scalable to support existing and proposed RWIS sites and sensors.

4.   The RWIS TMC interface shall be able to poll each RWIS on a scheduled basis.

5.   The RWIS TMC interface shall provide administrative capabilities to allow the addition of authorised users, editing RWIS site maps, and RWIS site configurations, among others.

6.   The RWIS TMC interface shall have the capability of notifying an operator or authorized user of alarms and/or alert notifications for pre-determined weather parameters.

7.   The RWIS TMC interface shall be capable of creating and maintaining a historic fault event log.

8.   All RWIS and AQM systems, as a minimum, shall support 60 second updates to the TMC

5.5   Power and Telecommunications

5.5.1   Power

1   The RWIS and AQM systems shall support both mains power and localised power generation options (e.g. solar and wind power).

5.5.2   Telecommunications

1.   All RWIS and AQM systems shall support Ethernet protocol and be IP addressable for remote Telecommunications with the TMC through an RJ45 connection.

2.   It is desirable for the RWIS and AQM system to support cellular (3G/4G) communication with the TMC along with wired Telecommunications (IP over a fibre optic network).

5.6   Hardware Design Requirements

5.6.1   General Mechanical and Housing Requirements

1.   RWIS and AQM structure design shall sustain wind speeds of 120km/h with gusts up to 160km/h.

2.   The mounting hardware shall prevent the movement of the environmental sensors at any direction by the force of the wind.

3.   The mounting hardware shall have the capability of rotating the environmental sensors to ensure proper installation.

4.   The cabling shall be suitable for the environment of the equipment to provide a proper functioning system.

6   OVERHEIGHT VEHICLE DETECTION SYSTEMS

6.1   Related Documents

Reference	Title
NTCIP 1201	Global Object (GO) Definitions
NTCIP 1206	Object Definitions for Data Collection
QCS	Qatar Construction Specifications

6.2   Equipment Overview

6.2.1   Purpose

1.   This Section describes the requirements for the supply, installation, and commissioning of Overheight Vehicle Detection System (OVDS) that shall monitor the height of vehicles on the road and raise an automated alert with roadside infrastructure and/or TMC operators when a vehicle over the prescribed height.

6.2.2   Configuration

1.   This specification supports the following components for OVDS configuration:

- Overheight vehicle sensors

- Audible alarm

- Roadside controller

- Housing and Mounting Structure

- LPR (section 4)

- DMS (section 8) downstream of the sensor

- Software

- OVDS shall also include vehicle detection equipment (section 3) to support vehicle directional identification.

2.   This specification defines LED infrared sensor OVDS. Other options are available (e.g. CCTV using Image Processing). Where non LED infrared detectors are proposed they shall require client approval.

6.3   Non Functional Requirements

6.3.1   Performance

1.   OVDS shall conform to the performance specification detailed within this document and any further test as detailed by the client. All designs shall be submitted to the client or the client's nominated representative for approval.

2.   The configuration of any OVDS and associated equipment shall support optimum performance at all times.

6.3.2   Reliability

1.   The OVDS system shall be designed for continuous operation for a service life of 12 years.

3.   LED infrared shall have a manufacture minimum stated service life of 55,000 hours.

6.3.3   Maintenance

1.   It shall be possible, through technology and process, to safely maintain all OVDS equipment.

2.   A site operative shall be able to connect (i.e. for calibration, configuration and fault testing) locally to the OVDS systems via spare ports without removing equipment from its operating location (e.g. accessible an available RJ45 / RS232 port).

3.   Audible alarm and OVDS sensors shall have adjustable mounting brackets to support efficient and flexible, maintenance/configuration.

4.   The OVDS system shall detect failed sensors and failed alarms and transmit alerts to the TMC.

6.3.4   Environmental

1.   All ITS equipment must maintain full functionality and continue to operate within the limits of this specification when subjected to the working environment of the State of Qatar.

2.   All equipment shall function and perform as per the specification in ambient temperatures ranging from 0°C to 55°C and in the range of 0% - 100% relative humidity in accordance with QCS.

4.   LED Infrared equipment shall be installed in such a way that it is not affected by sun light or other light sources.

6.4   Functional Requirements

6.4.1   General

1.   The OVD shall consist of dual-eye LED infrared emitter and spectrally matching detector mounted on opposite sides of the roadway.

2.   The OVDS system shall have direction-of-travel detection capability.

3.   The OVDS shall eliminate the effect of ambient light and provide an internal environmental control that reduces operational failure from dust, sand, fog, condensation and insects.

4.   The OVDS system shall, as a minimum, detect a 65 mm diameter object located approximately 25 mm above the detection height travelling between 1 km/h and 120 km/h.

5.   The OVDS shall support direct wiring with an audible alarm and DMS.

6.   The latency from detection to transition of an alert of an Overheight vehicle to the TMC operator, audible alarm, LPR and DMS shall be no greater than 200ms.

7.   On detection of an over height vehicle the OVDS as a minimum:

        (a)   Activate an audible alarm

        (b)   Activate LPR towards the vehicle concerned

        (c)   Transmit a notification to operators at the TMC

        (d)   Display a configured message on the downstream DMS. This message shall be include the vehicle number plate detected by the LPR sub system.

6.4.2   OVDS Audible Alarm

1.   The audible alarm shall be a direction-oriented alarm.

2.   The audible alarm shall be capable of a klaxon sound when detecting Overheight vehicles.

3.   The audible alarm volume and duration shall be configurable. The alarm noise shall not exceed 140dB at 1.0 metre.

4.   The audible alarm shall be directed toward the location of the detected vehicle as shown in the detailed design.

5.   The DMS shall be located as shown in the detailed design.

6.   The audible alarm shall be capable of at least 110db at a distance of 3m.

7.   Where audible alarm installations are in the proximity of residential areas and/or offices the Client of the Client's designated representative shall be consulted regarding configuration and shielding if no such provision has been supplied by the designer.

6.4.3   OVDS Software

1.   The OVDS TMC interface shall ensure that only authorized users will be permitted to update its configuration. (numbering)

2.   The OVDS TMC interface shall create an accurate timestamp for each Overheight vehicle. The timestamp shall accurately record the moment the vehicle passes through the sensors.

3.   Unless otherwise specified to a higher standard within this section (i.e. on OVDS) all data and telecommunication specification shall fully comply with NTCIP 1206 standard for Object Definitions for Data Collection and Monitoring.

4.   Optional objects and requirements shall confirm to NTCIP 1201 for Global Object Definitions.

5.   The OVDS Roadside controller shall be capable of allowing local programming via a laptop.

6.   A site operative shall be able to remotely check system status and change the settings and update firmware.

7.   The OVDS TMC interface shall be capable of creating and maintaining a fault and detections event logs.

6.5   Power and Telecommunications

6.5.1   Power

1.   Equipment shall be supplied and installed with suitable adapters and conform to requirements stated in section 2.

6.1.1   Telecommunications

2.   All OVDS systems shall support Ethernet protocol and be IP addressable for remote Telecommunications with the TMC over the telecommunication network (section 13).

6.6   Hardware Design Requirements

6.1.2   Mechanical and Housing Requirements

1.   The OVDS mounting hardware shall utilise a design wind speed of 120 km/h with gusts up to 160 km/h for their design.

2.   The mounting hardware shall prevent the movement of the OVD or audible alarm in any direction by the force of the wind.

3.   The mounting hardware of the OVDs shall have the capability of adjusting the angular orientation of the axis in both the horizontal and vertical.

7   WEIGH IN MOTION DETECTION SYSTEMS

7.1   Related Documents

Reference	Title
NTCIP 1201	Global Object (GO) Definitions
NTCIP 1206	Object Definitions for Data Collection
QCS	Qatar Construction Specifications
COST 323 Class B(10)	European Commission's Transport Directorate, DG VII Recommendation

7.2   Equipment Overview

7.2.1   Purpose

1.   This Section describes the requirements for the design, supply, installation, commissioning and maintenance of a high-speed Weigh-In-Motion (WIM) system that shall monitor, for the purpose of enforcement, the weight of moving vehicles on the road and raise an automated alert with roadside equipment and TMC operators when an over-weight vehicle is detected, in accordance with the detailed project design drawings and/or specifications.

7.2.2   Configuration

2.   This specification supports the following components for WIM configuration:

   (a)   Weighing sensors (e.g. quartz piezo sensor)
   (b)   Vehicle detection equipment (e.g. vehicle loop detectors (Section 3))
   (c)   Roadside controller
   (d)   Housing and Mounting Structures
   (e)   LPR (Section 4)
   (f)   DMS (Section 8)
   (g)   Software.

3.   The configuration of any WIM and associated equipment shall support optimum performance at all times.

7.3   Non Functional Requirements

7.3.1   Reliability

1.   The WIM system shall be designed for continuous operation for a service life of 15 years.

7.3.2   Maintenance

1.   It shall be possible to safely maintain all WIM equipment with minimal disruption of traffic. This should be done in such a way as to allow easy access to conduct maintenance on equipment.

2.   All installations shall be easily accessible to enable the replacement of equipment.

3.   The WIM roadside controller shall detect failed equipment and transmit alerts to the TMC.

7.3.3   WIM Sensor Environmental

1.   The WIM sensor must maintain full functionality and continue to operate within the limits of this specification when subjected to the working environment of the State of Qatar.

7.4   Functional Requirements

7.4.1   WIM General

1.   WIM systems shall provide accurate and reliable detection of 95% of vehicles weighted, within ± 10 % of gross vehicle mass based on the recommendations of COST 323 Class B(10) working group.

2.   The WIM system shall be able to be calibrated in order to ensure consistent measurements over the service life of the product.

3.   The WIM sensor shall be installed to meet manufacture geographic and client operation requirements.

4.   The WIM system shall provide accurate vehicle weight measurements, without requiring vehicles to alter their normal in-lane behaviour. Where WIM equipment has specific advantages but requires lane management measures it should be proposed to the client for approval.

5.   The WIM system shall raise an alert when a vehicle weighting greater than the user defined values travels over the sensor. This alert shall be transmitted to the operators at the TMC.

6.   The WIM system shall support four or more user defined vehicle weight alert trigger thresholds.

7.   The WIM system shall be able to determine a minimum of six user defined vehicle classifications.

8.   The WIM system shall be able to use the following ITS components to support recording, monitoring, control and enforcement of vehicles travelling from the WIM sensors: CCTV, LPR, DMS.

9.   WIM sensors shall be installed perpendicular to the direction of traffic, and shall be of sufficient width to monitor both vehicular wheel paths within a lane.

10.   WIM sensor sets shall have a maximum load bearing capacity no less than 4.6N per square mm.

11.   Each WIM sensor shall be installed to a depth no greater than 10mm. The sensor slot shall be sealed with an epoxy resin sealant

12.   The WIM system shall provide as a minimum of two detection units i.e. magnetometers. One vehicle detection unit shall be located upstream of the WIM sensors and the other shall be located downstream of the WIM sensors.

13.   The latency from detection to transition of an alert of overweight vehicle shall be no greater than 200ms.

14.   The WIM system shall be able to capture vehicles with speeds in the range 15km/h to 120km/h.

7.4.2   WIM Software

1.   The WIM system shall include software to support complete WIM operations both at the road side and within the TMC.

2.   The WIM system shall record and monitor, as a minimum: axle weights, gross weight, axle spacing, lane, vehicle speed, date and time.

3.   The WIM system software shall be capable of allowing local programming and downloading via a laptop, or from the WIM TMC interface.

4.   The WIM TMC interface shall ensure that only authorized users shall be permitted to update its configuration or download data.

5.   The WIM TMC interface shall create an accurate timestamp for each vehicle evaluated. The timestamp shall accurately record the moment the vehicle passes over the WIM sensors.

6.   For the purpose of time stamping images the WIM system shall synchronise its time with that of the TMC.

7.   Unless otherwise specified to a higher standard within this section (i.e. on WIM) all data and telecommunication specification shall fully comply with NTCIP 1206 standard for Object Definitions for Data Collection and Monitoring.

8.   Optional objects and requirements shall confirm to NTCIP 1201 for Global Object Definitions.

9.   The WIM system software shall allow remotely monitor the system status, change settings and update firmware.

10.   The WIM system software shall be capable of creating and maintaining a historic faults and detection event logs.

11.   The WIM system software shall be capable of locally recording at least 100,000 records.

7.5   Power and Telecommunications

7.5.1   Telecommunications

1.   All WIM systems shall support Ethernet protocol and be IP addressable for remote telecommunications with the TMC over the telecommunication network (Section 15).

7.5.2   Power

1.   Refer to general provisions in section 2.

7.6   Hardware Design Requirements

7.6.1   General Mechanical & Housing Requirements

1.   Refer to general provisions in section 2.

8 DYNAMIC MESSAGE SIGNS

8.1 Related Documents

Reference	Title
BS EN 12966-1	Vertical Road Signs – Part 1: Variable Message Signs
BS 7671	Requirements for Electrical Installations
NTCIP 1201	Global Object (GO) Definitions
NTCIP 1203	Object Definitions for Dynamic Message Signs (DMS)
BS EN 12464-1	Lighting of Indoor Work Places
BS EN 60529	Degrees of Protection Provided by Enclosures (IP Code)
ETSI EN 300 019-1-4	Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-4: Classification of environmental conditions; Stationary use at non-weather protected locations.
IEC 60297	Mechanical structures for electronic equipment – Dimensions of mechanical structures of the 482,6 mm (19 in) series
BS EN 12675	Traffic signal controllers. Functional safety requirements

8.2 Equipment Overview

8.2.1 Purpose

1. The DMS is an overhead sign capable of displaying standard pre-programmed aspects within a matrix of Light Emitting Diodes (LED). The DMS shall incorporate dual-colour lanterns using LED matrices. DMS are used to provide drivers with information about congestion, incidents, events and road safety messaging in order that drivers can make informed decisions about their journey or receive information on important national campaigns.

2. Parking information DMS are deployed on routes to car-parks and provide information regarding car-park space availability.

3. This Section details the supply, installation, and commissioning of DMS on a roadway in accordance with the detailed project design drawings and/or specifications.

8.2.2 Configuration

1. The DMS comprises a Display Matrix, Lantern matrices, Display Driver, interface to DMS Roadside Controller.

2. DMS shall be either "Walk-in" type DMS or rear access type DMS. Both types of DMS shall utilise the same optical components.

3. Walk in DMS shall be capable of spanning the entire roadway and shall be capable of displaying information related to the lane configuration of the roadway.

4.   Rear access DMS shall not span over any part of the roadway. It shall be installed such that it only spans the verge and hard shoulder.

5.   This specification defines the requirements for the DMS and associated roadside controller.

6.   The term DMS System is used to refer to a DMS and its associated roadside controller and interconnections. Therefore this specification defines requirements for:

   • DMS
   • DMS roadside controller
   • DMS to DMS roadside controller cabling.

7.   The DMS assembly shall consist of as a minimum:
   • Full colour DMS
   • DMS roadside controller
   • DMS roadside controller ground mounted enclosure
   • DMS software
   • An assembly for mounting the DMS on a structure.

8.   Car park DMS shall comprise a sign face in which, in accordance with the detailed design, are installed a series of character modules to represent the number of parking spaces available at certain car-parks.

8.3   Non Functional Requirements

8.3.1   Performance

1.   The optical performance of the DMS shall comply with the requirements section 7 of BS EN 12966.

2.   The Class designation(s) for the photometric parameters of the DMS shall be declared by the equipment provider.

3.   The physical performance of the DMS shall meet the requirements of section 8 of BS EN 12966. The DMS shall comply with the following classes;

   • Temperature   T1

   • Protection Class   P3

4.   The structural performance of the DMS shall conform to section 8.3 of BS EN 12966

5.   The electrical performance of the DMS shall conform to section 8.4 of BS EN 12966

8.3.2   Reliability

1.   The DMS shall be designed to have a service life in excess of 15 years when installed in the roadside environment in the State of Qatar.

8.3.3   Maintenance

1.   The equipment shall be designed such that the minimum recommended routine maintenance interval is not less than 6 months.

2.   All DMS shall have safety anchor points installed to allow operative to secure a safety / fall arrest harness.

8.3.4   Environmental

1.   The DMS inclusive of all of its cables and components shall maintain full functionality and continue to operate within the limits of this specification when subjected to the working environment in the State of Qatar.

2.   The design shall take account of the environmental impact of the DMS through all of its stages of the DMS Life cycle.

8.4   Functional Requirements

8.4.1   General "Walk-In" Dynamic Message Signs

1.   This Section details the design, supply, installation, and commissioning of a walk-in type Dynamic Message Sign (DMS) on a roadway in accordance with the detailed project design drawings and/or specifications.

8.4.2   DMS LED Display Modules

1.   The DMS display shall be a full colour matrix display area as defined in section 7.2 of BS EN 12699.

2.   The Beam width shall conform to classification B7 of BS EN 12966

3.   The LED display modules shall be fully interchangeable. A LED display module may consist of one or two circuit boards. If two (2) boards are used, they shall be mounted physically to each other using durable non-corrosive hardware. The removal of a display module or LED board shall not require the use of proprietary tools.

4.   The DMS display modules shall contain solid-state electronics to control pixel data and read pixel status.

5.   Each LED display module shall be mounted to the rear of the display's front face panels using durable non-corrosive hardware. No tools shall be required for module removal and replacement. The modules shall be mounted such that the LEDs emit light through the face panel's pixel holes and such that the face panel does not block any part of the viewing cone of any of the LEDs in any pixels.

6.   The LEDs shall be individually mounted directly on a printed circuit board (PCB).

7.   Each pixel shall consist of a minimum of one (1) independent string of discrete LEDs for each colour. All pixels shall contain an equal quantity of LED strings. The failure of an LED string or pixel shall not cause the failure of any other LED string or pixel in the DMS.

8.   Each pixel shall contain the quantity of discrete LEDs needed to output white coloured light as a minimum luminous intensity of 12,400 candelas per square meter when measured using a photometric meter through the DMS front face panel assembly.

9.   The LED packages shall be fabricated from UV light resistant epoxy. The LEDs shall also be protected from external environmental conditions, including moisture, wind, dust, sand, and dirt.

10.   The colours emitted by the LEDs shall conform to section 7.2 of BS 12966. The class designation C1 or C2 for the colour photometric parameter by the equipment provider.

11.   The LED colours shall be tested in accordance with section 9.3.5 of BS EN 12966.

12.   The uniformity measurement shall be in accordance with section 9.3.4 of BS EN 12966.

13.   The LEDs shall be rated by the LED manufacturer to have a minimum lifetime of 100,000 hours of continuous operation while maintaining a minimum of 70% of the original brightness.

14.   Each LED driver board shall communicate with the DMS roadside controller using an addressable network protocol.

15.   The DMS roadside controller shall continuously measure and monitor all LED module power supply voltages and provide the voltage readings to the TMC DMS interface or a local laptop computer on command.

16.   Removal or failure of any LED module shall not affect the operation of any other LED module or sign component. Removal of one or more LED module shall not affect the structural integrity of any part of the sign.

8.4.3   Characters, Fonts and Colour Requirements

1.   The display area of the DMS shall be capable of displaying a minimum of three (3) lines of characters using a 450 mm font that meets the height to width ratio and character spacing as detailed in the QTCM. The width of the sign, and thus number of character per line, shall cover the entire span of the lanes of the roadway at the location to be installed.

2.   The DMS shall be capable of displaying American Standard Code for Information Interchange (ASCII) characters 32 through 126, including all uppercase and lowercase letters and digits 0 through 9, at any location in the message line.

3.   The DMS shall be capable of displaying English and Arabic characters.

4.   The DMS shall be capable of displaying pictograms and graphic symbols.

5.   The DMS shall be factory loaded with the fonts described in the QTCM.

6.   The DMS fonts shall have character dimensions that meet the requirements of the QTCM.

7.   The full colour matrix DMS shall have the capability of displaying the colours described in the QTCM

8.4.4   DMS Roadside controller

1.   The DMS roadside controller shall be a stand-alone microprocessor-based system which does not require continuous communication with DMS control software at the TMC in order to perform most DMS control functions.

2.   The DMS shall be IP addressable by using a local laptop/PC or from the TMC.

3.   The DMS roadside controller shall meet the following minimum operational requirements:

*   Communicate using embedded NTCIP protocol over an IP configured network.

*   Contain memory for storing changeable and permanent messages, schedules, and other necessary files for operation of the roadside controller.

*   Include a front panel user interface with graphical LCD a laptop interface, as a minimum, for direct operation and diagnostics as described herein.

*   Contain a minimum of three (3) RS232 communication ports.

*   Contain a minimum of one (1) RS422 communication port with RJ45 connector.

*   Have the ability to display volatile messages in free form text from the TMC.

*   Contain a minimum of one (1) Ethernet port with RJ45 connector.

*   Contain firmware (embedded software) that shall monitor all external and internal sensors and communication inputs and control the display modules as directed by external control software and the front panel interface.

4.   The DMS roadside controller and associated communication equipment shall be installed in a ground mounted enclosure.

5.   The DMS roadside controller shall have the capability of modifying the brightness of the LED display matrix manually or automatically based on ambient lighting conditions.

6.   The DMS roadside controller shall be capable of monitoring and displaying the currently active message (if any) including graphical messages on the roadside controller front panel LCD display. This display shall mimic the main DMS Display.

7.   The DMS roadside controller shall direct all of the LED modules to perform diagnostic tests of all their pixels. The roadside controller shall then collect and report the results of the pixel testing. The test shall be initiated either locally or from the remote control software.

8.   The DMS roadside controller shall also be capable of automatically detecting in real-time the status of each of the display's pixels and reporting their on/off status.

9.   The DMS roadside controller shall monitor and report the functional status of regulated power supplies located in the DMS by monitoring diagnostic outputs located on the supplies. The roadside controller shall monitor the output voltage of each power supply and the status of each output fuse.

10.   The DMS roadside controller shall monitor and report the operational status of the fans.

11.   The DMS roadside controller shall monitor the readings of all light, temperature, and humidity sensors installed in the DMS housing.

12.   The DMS roadside controller shall be capable of automatically informing a site operative (via the local LCD panel) and the TMC software of the occurrence of important events and equipment failures.

13.   The DMS roadside controller shall continuously monitor the DMS housing's temperature sensors and shall automatically shutdown the DMS if the internal enclosure temperature exceeds a safety threshold. This threshold shall have a default value of +60ºC and shall be configurable at the roadside controller. The DMS will send notification to the central system (e.g. located at the TMC) in the event of a DMS automatic shutdown.

14.   If the temperature approaches the threshold, the roadside controller shall reduce the brightness of the sign face. If the temperature continues to increase and exceeds that threshold, the roadside controller shall trigger a warning notification event and blank the face of the sign. The sign face will remain blank until the temperature begins to drop. As the temperature drops, the roadside controller will gradually increase the brightness of the display face, eventually returning to full brightness.

15.   When the DMS roadside controller detects that it has been restarted due to a manual reset or error condition, it shall send a notification to the central system.

16.   When the DMS roadside controller detects a power failure, the roadside controller shall automatically indicate it on the front panel LCD and send notification to the central system.

17.   Upon loss of Telecommunications the DMS shall automatically blank the face of the sign.

8.4.5   DMS Software

1.   The DMS TMC interface software shall allow communication between multiple users and multiple signs across the same Telecommunications network.

2.   The DMS TMC interface software shall be provided by the DMS manufacturer. The software shall operate on desktop, server and laptop computers used within the TMC.

3.   The DMS TMC interface software shall provide a user-friendly Graphical User Interface (GUI), and support at least 700 DMSs. The software shall be scalable to increase the number of DMSs without limitation.

4.   The DMS TMC interface software shall support DMS Telecommunications via any combination of dedicated hardwired serial network, fiber-optic network, dial-up cellular modem, Cellular IP modem, spread spectrum radio, Ethernet, or other.

5.   The DMS TMC interface software shall support DMS control, monitoring, and diagnostic functions described in this specifications.

6.   The DMS TMC interface software shall have the capability of controlling a DMS remotely from the TMC and locally at the DMS site by using a laptop/PC.

7.   The DMS TMC interface software shall support different level of rights and authorisation's to control DMS, the ability to create and modify messages within software, and the ability to modify DMS settings or running content on DMS.

8.   The DMS TMC interface software shall include an event logging system.

9.   The DMS TMC interface software shall allow system administrators and other authorised users to configure system parameters and functions.

10.   The DMS TMC interface software shall monitor the frequency of communication packets from the DMS roadside controller. If the software detects that communication has not occurred between the DMS roadside controller and TMC for longer than a configurable timeout, then the software will automatically activate a communication loss message.

8.4.6   Installation Requirements

1.   The walk-in DMS shall be installed as shown in the detailed project design drawings and/or specifications.

2.   The DMS shall not be installed without ensuring adequate electrical service has been run to the site.

3.   The ventilation system shall be operational within 72 hours after the DMS installation.

4.   The message libraries shall be pre-loaded in to the DMS roadside controller prior to deployment.

8.4.7   Rear Access DMS General

1.   This Section details the supply, installation, and commissioning of a rear access type DMS on a roadway in accordance with the detailed project design drawings and/or specifications.

8.4.8   DMS LED Display Modules

1.   These shall meet the requirements of section 8.3.2 above

8.4.9   Characters, Fonts and Colour Requirements

1.   The display area of the DMS shall be in accordance with the detailed design project plans and shall meet the height to width ratio and character spacing as detailed in the QTCM

2.   The DMS shall be capable of displaying ASCII characters 32 through 126, including all uppercase and lowercase letters and digits 0 through 9, at any location in the message line or as specified in BS EN 12966.

3.   The DMS shall be capable of displaying English and Arabic characters.

4.   The DMS shall be capable of displaying pictograms and graphic symbols.

5.   The DMS shall be factory loaded with the fonts described in the QTCM.

6.   The DMS fonts shall have character dimensions that meet the requirements of the QTCM.

7.   The colour full matrix DMS shall have the capability of displaying the colours described in the QTCM.

8.4.10   DMS Roadside enclosure

1.   These shall meet the requirements of section 8.3.4 above

8.4.11   DMS Software

1.   These shall meet the requirements of section 8.3.5 above

8.4.12   Installation Requirements

1.   The rear access DMS shall be installed as shown in the detailed project design drawings.

2.   The DMS shall not be installed prior to the availability of electric power.

3.   The ventilation system shall be operational within 72 hours after the DMS installation.

4.   The required message libraries and shall be pre-loaded in to the roadside controller prior to deployment.

8.4.13   Parking DMS

1.   Car park DMS shall have the same functional, power and telecommunications requirements of rear-access DMS.

8.5   Power and Telecommunications for all DMS

8.5.1   Power Supply

1.   The DMS shall have two (2) duct termination points to install power cables and telecommunications cables.

2.   The DMS shall include an electrical panel and circuit breakers that meet the requirements of BS 7671.

3.   The wiring for LED display modules, environmental control circuits, and other DMS components shall be installed in the DMS housing in a neat and professional manner. The cable sizes shall be properly sized in accordance with the requirements of BS 7671.

8.5.2   UPS

1.   Where required in the project design, a UPS shall be provided by the DMS equipment provider and shall be installed within the DMS housing or ground mounted enclosure, as shown in the detailed project design drawings and/or specifications. The UPS system shall be capable of operating the DMS while displaying the current message on the sign for a minimum of four (4) hours.

8.5.3   Telecommunications Interface

1.   In addition to the Telecommunications Interface requirements in Section 2, the following NTCIP requirements shall also apply for the DMS roadside controller.

2.   The Telecommunications interface between the DMS roadside controller and the TMC or laptop computer (NTCIP components) shall comply with the NTCIP requirements below.

8.5.4   Conformance

3.   The DMS system shall conform to the applicable standards listed in this specification. To claim conformance with the above referenced standards, the implementation of NTCIP for the DMS System shall fulfill the mandatory requirements and objects as identified in the referenced standards.

4.   Optional objects and requirements in the referenced standard(s) needed to satisfy a functional requirement in the detailed project design specifications shall be conformant with the appropriate standard and any standards it references (e.g. NTCIP 1201 and 1203).

8.5.5   NTCIP 1201 and 1203

1.   The Telecommunications interfaces between the various components of the DMS system shall use and conform to NTCIP 1201 and 1203. Each NTCIP component shall provide Full, Standardised Object Range (FSOR) support of all objects required by these procurement specifications unless otherwise indicated below. The maximum Response Time for any object or group of objects shall be 200ms.

2.   To claim conformance to NTCIP 1201 and NTCIP 1203, each NTCIP component shall support all the mandatory requirements as defined in those standards. In addition, each NTCIP component shall support and conform to the following optional requirements (predicates) in the NTCIP 1203, as listed in Section 3.3.3:

    (a)   User Need ID 2.3.2.1.3, DMS, and all mandatory requirements for the predicate <DMS>.

    (b)   User Need ID 2.3.2.2.2, LED, and all mandatory requirements for the predicate <LED>.

    (c)   User Need ID 2.3.2.3.2, Matrix, and all mandatory requirements for the predicate <Matrix>.

(d)   User Need ID 2.3.2.3.2.1, Full Matrix.

(e)   User Need ID 2.4.2.2, Logged Data Exchange.

(f)   User Need ID 2.5.1.2, Determine Sign Display Capabilities.

(g)   User Need ID 2.5.1.3, Manage Fonts, and all mandatory requirements for the predicate <Fonts>.

(h)   User Need ID 2.5.1.5, Manage Automatic Brightness, and all mandatory requirements for the predicate <AutoBright>.

(i)   User Need ID 2.5.2.2, Remotely Reset the Sign roadside controller.

(j)   User Need ID 2.5.2.3.6, Change Message Display Based on an Internal Event, with the exceptions of Requirement 3.5.2.3.5.1.3, Configure Message for Power Loss Event, and 3.5.3.3.4, Monitor Power Loss Message.

(k)   User Need ID 2.5.3.1.3, Monitor Subsystem Failure Details – Low-Level Diagnostics.

(l)   User Need ID 2.5.3.1.5, Monitor Sign Environment.

(m)   User Need ID 2.5.3.1.8, Monitor Door Status.

(n)   User Need ID 2.5.3.1.9, Monitor roadside controller Software Operations.

(o)   User Need ID 2.5.3.1.10, Monitor Automatic Blanking of Sign.

(p)   User Need ID 2.5.3.1.12, Monitor Power Voltage.

3.   The implementation shall be provided with a completed Protocol Requirements List (PRL) as contained in NTCIP 1203, Section 3.3 PRL, to indicate which options of this NTCIP standard were implemented.

8.6   Hardware Design Requirements

8.6.1   Mechanical and Housing requirements - DMS Housing ("walk-in" Type)

1.   The materials and finish used for the construction of the DMS shall be effective for a maintenance free and effective design for the life of the DMS.

2.   The DMS housing shall include small weep holes to drain any water (e.g. accumulate due to condensation) or dust. The weep holes shall be screened to prevent the entrance of animals and insects into the housing.

3.   The structural performance of the DMS shall be in accordance with section 8.3 of BS EN 12966.

4.   The DMS housing shall include multiple galvanised steel eyebolts on the top of the housing to allow lifting the sign during shipping, handling, and installation without any damage to the housing.

5.   The DMS structural assembly hardware (i.e. nuts, bolts, screws, and locking washers) shall be stainless steel or galvanised A325 high-strength steel.

6.   The access to the DMS housing shall be provided through an access door on the side of the housing. The access door shall not compromise the IP rating of the DMS. The access door shall include a keyed lock and a door handle with a hasp for a padlock. The access door shall not extend more than 1 m from the housing when opened at a 90-degree angle.

7.   The DMS housing shall provide a minimum of three (3) dual un-switched 13 amp sockets for testing purposes. These sockets shall be installed in accordance with BS 7671. A dual socket shall be provided at each end of the housing and the third dual socket shall be provided near the center of the housing.

8.   The housing shall include emergency lighting that automatically illuminates the interior in the event of a power outage. The emergency lighting must be capable of operation without power for a minimum of 90 minutes.

9.   The DMS housing shall contain a minimum of one (1) compact fluorescent light (CFL) fixture for every 2.4 m of housing width. The lamps shall be evenly spaced across the housing ceiling and provide uniform light distribution for maintenance purposes. The light provided by the lamps shall meet the requirements of BS EN 12464.

10.   Lights inside the housing shall be controlled by switches in the DMS enclosure. The switches shall be located near each housing access door. Each light shall be automatically extinguished upon locking of the enclosure door.

11.   The internal structure of the DMS shall not have any sharp edges or edges sticking out. A secure enclosed walkway shall be provided at the rear of the housing. The walkway's surface shall be non-slip.

12.   The DMS display area shall meet the requirements of BE EN 12966. The display area shall be constructed with multiple rigid panels, each of which supports and protects a full-height section of the Light Emitting Diode (LED) display matrix.

13.   The DMS display area borders (top, bottom, left side, and right side) which surround the front face panels and LED display matrix shall be painted black to maximize display contrast and legibility. The borders shall be a minimum of 300 mm.

14.   The DMS shall have a positive pressure active cooling inside the main enclosure that will maintain the temperature inside the ITS enclosure at 21°C +/-2°C with a relative humidity between 20% and 100%, non-condensing.

15.   At the DMS housing, a manual override timer switch shall be located just inside the access door to manually activate the ventilation system. The switch shall be adjustable from zero (0) to four (4) hours.

16.   The DMS shall automatically shut down the LED modules to prevent damaging the LEDs if the measured internal enclosure air temperature exceeds a maximum threshold temperature. The threshold temperature shall be configurable and shall have a default factory setting of +60°C.

17.   The DMS shall contain an automatically controlled defog system that warms the DMS front face when the internal DMS relative humidity is near condensation levels. This system shall keep the front face polycarbonate panel free of fog and condensation. The heat generated by the defog system shall not damage any part of the DMS.

18.   The DMS housing shall include an ambient light sensor that provides accurate ambient light condition information to the DMS roadside controller for automatic light intensity adjustment. The DMS roadside controller shall continuously monitor the light sensors and adjust the LED display matrix intensity to a level that creates a legible message on the DMS face.

19.   The DMS shall include external and internal temperature sensors. A minimum of one (1) external temperature sensor shall be mounted to the rear wall of the DMS housing. The sensor shall be placed such that it is never in direct contact with sunlight. The DMS shall contain a minimum of one (1) internal temperature sensor, which shall measure the internal temperature of the air (0°C to +60°C). The DMS roadside controller shall continuously measure and monitor the temperature sensors in the housing. The temperatures from the DMS roadside controller shall be read by remote and local computers.

20.   The DMS housing shall include a minimum of one (1) humidity sensor. The humidity sensors shall detect and operate under conditions from 0 to 100% relative humidity in 1% or smaller increments. The DMS roadside controller shall continuously measure and monitor the humidity sensor(s) in the housing. The temperatures from the DMS roadside controller shall be read by remote and local computers.

8.6.2   Mechanical and Housing requirements - DMS Housing (Rear Access Type)

1.   The materials and finish used for the construction of the DMS shall be effective for a maintenance free and effective design for the life of the DMS.

2.   The DMS housing shall include small weep holes to drain any water (e.g. accumulate due to condensation) or dust. The weep holes shall be screened to prevent the entrance of animals and insects into the housing. The structural performance of the DMS shall be in accordance with section 8.3 of BS EN 12966.

3.   The DMS housing shall include multiple galvanised steel eyebolts on the top of the housing to allow lifting the sign during shipping, handling, and installation without any damage to the housing.

4.   The DMS structural assembly hardware (i.e. nuts, bolts, screws, and locking washers) shall be stainless steel or galvanised A325 high-strength steel.

5.   The doors shall have a retaining latch mechanism to hold the door open at a 90-degree angle to prevent open doors from blowing in the wind.

6.   Each access door shall contain a minimum of two (2) captive-type latches to lock them in the closed position. These latches shall be captive to prevent them from falling off. They

shall pull the door tight and compress a gasket located around the perimeter of each door. The gasket shall prevent water from entering the enclosure around the doors.

7.   The DMS housing shall include a single dual un-switched 13 amp outlet for testing. The outlet shall be installed in accordance with BS 7671

8.   The display area panels shall provide a high-contrast background for the DMS display matrix. The mask of each panel shall be painted black and shall contain an opening for each pixel. Openings shall be large enough to not block any portion of the viewing cones of the LEDs.

9.   LED display modules shall mount to the inside of the DMS front face door panels. No proprietary tools shall be needed for removal and replacement of LED display modules.

10.   The DMS shall have positive pressure active cooling inside the main enclosure that will maintain the temperature inside the ITS enclosure at 21°C +/-2°C with a relative humidity between 20% and 100%, non-condensing.

11.   The ventilation system shall consist of two or more air intake ports, which shall be located near the bottom of the DMS rear wall. Each intake port shall be covered with a filter that does not compromise the IP rating of the enclosure. Fans shall be mounted at each intake port of sufficient capacity to maintain an airflow that will maintain the thermal management of the enclosure.

12.   An exhaust port shall be provided for each air intake port at the DMS housing. The exhaust port shall be placed near the top of the rear wall. All exhaust port openings shall be screened to prevent the entrance of insects and small animals.

13.   The DMS shall automatically shut down the LED modules to prevent damaging the LEDs if the measured internal enclosure air temperature exceeds a maximum threshold temperature. The threshold temperature shall be configurable and shall have a default factory setting of +60°C.

14.   The DMS housing shall include an ambient light sensor that provides accurate ambient light condition information to the DMS roadside controller for automatic light intensity adjustment. The DMS roadside controller shall continuously monitor the light sensors and adjust the LED display matrix intensity to a level that creates a legible message on the DMS face.

15.   The DMS shall include external and internal temperature sensors. A minimum of one (1) external temperature sensor shall be mounted to the rear wall of the DMS housing. The sensor shall be placed such that it is never in direct contact with sunlight. The DMS shall contain a minimum of one (1) internal temperature sensor, which shall measure the internal temperature of the air (0°C to 70°C). The DMS roadside controller shall continuously measure and monitor the temperature sensors in the housing. The temperatures from the DMS roadside controller shall be read by remote and local computers.

16. The DMS housing shall include one humidity sensor. The humidity sensor shall detect and operate under conditions from 0 to 100% relative humidity in 1% or smaller increments. The DMS roadside controller shall continuously measure and monitor the humidity sensor in the housing. The humidity readings from the DMS roadside controller shall be read by remote and local computers.

8.6.3   Mounting Structure Requirements

1. The DMS shall be mounted on a cantilever, mid-span, or full span structure as shown in the project design drawings.

2. The DMS structure shall utilise a design wind speed of 120 km/h with gusts up to 160 km/h for their design, and shall meet with the requirements of BS EN 12966.

8.6.4   DMS roadside controller Ground mounted enclosures

1. The DMS roadside controller enclosure shall protect all internal components from rain, sand, dust, and corrosion in accordance with minimum IP 56 standards in accordance with BS 60529.

2. The DMS roadside controller enclosure shall include the following assemblies: power indicator, surge suppression on both sides of all electronics, communication interface devices, connection for a laptop computer for local control and programming.

3. The roadside controller enclosure shall provide safe and convenient access to all modular assemblies, components, wiring and other materials located within the enclosure. All internal components shall be capable of being removed and replaced by a technician.

4. The ground mounted enclosure shall accommodate the equipment in an environment in accordance with Class 4.2H of ETSI EN 300 019-1-4. The equipment must continue to work within its normal operating parameters in this environment, regardless of location

5. The DMS roadside controller shall be mounted in a standard EIA 480 mm (or IEC 60297) equipment rack with a maximum 4U space requirement or as specified in BS EN 12675.

6. The enclosure shall contain a power panel board and circuit breakers.

7. The enclosure shall contain a utility outlet circuit consisting of a minimum of two (2) 13A 240 Vac, 50 Hz double non-switched sockets, installed in accordance with the requirements of BS 7671

8. The enclosure shall include one (1) earthing lug that is electrically bonded to the enclosure.

9 PORTABLE DYNAMIC MESSAGE SIGNS

9.1 Related Documents

Reference	Title
BS EN 12966-1	Vertical Road Signs – Part 1: Variable Message Signs
BS 7671	Requirements for Electrical Installations
NTCIP 1201	Global Object (GO) Definitions
NTCIP 1203	Object Definitions for Dynamic Message Signs (DMS)
NTCIP 1204	Object Definitions for Environmental Sensor Stations
BS EN 60529	Degrees of Protection Provided by Enclosures (IP Code)
ETSI EN 300 019-1-4	Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-4: Classification of environmental conditions; Stationary use at non-weather protected locations.
BS EN 12675	Traffic signal controllers. Functional safety requirements

9.2 Equipment Overview

9.2.1 Purpose

1   This Section is to include the supply, installation and commissioning of a Portable Dynamic Message Sign (PDMS) for use along roadways. The PDMSs may be utilised for work zone, emergency, special events, and any other applications that the Client considers.

9.2.2 Configuration

The PDMS assembly shall consist of as a minimum: (1) an amber PDMS display; (2) local PDMS controller; (3) power equipment; and (4) trailer for transporting the PDMS.

9.3 PDMS Non-Functional Requirements

9.3.1 Performance

1.   The optical performance of the PDMS shall comply with the requirements section 7 of BS EN 12966.

2.   The Class designation(s) for the photometric parameters of the PDMS shall be declared by the equipment provider.

3.   The physical performance of the PDMS shall meet the requirements of section 8 of BS EN 12966. The PDMS shall comply with the following classes;

- Temperature   T1

- Protection Class   P3

4.   The structural performance of the PDMS shall conform to section 8.3 of BS EN 12966

5.   The electrical performance of the PDMS shall conform to section 8.4 of BS EN 12966

9.3.2   Reliability

1.   The PDMS shall be designed to have a service life in excess of 15 years when installed in the roadside environment in the State of Qatar.

2.   Routine and preventive maintenance procedures to maintain the equipment and identify any equipment shall be proposed. Parts or components considered necessary in order that the PDMS achieves it expected service life shall be identified in the proposal.

9.3.3   Maintenance

1.   The equipment shall be designed such that the minimum recommended routine maintenance interval is not less than 6 months.

9.3.4   Environmental

1.   The PDMS inclusive of all of its cables and components shall maintain full functionality and continue to operate within the limits of this specification when subjected to the working environment in the State of Qatar.

2.   The design shall take account of the environmental impact of the PDMS through all of its stages of the PDMS Life cycle, including disposal.

3.   All equipment shall function and perform as per the specification in ambient temperatures ranging from 0°C to 55°C in the range of 0% to 100% relative humidity.

9.4   Functional Requirements

9.4.1   PDMS Display

1.   The display for PDMS shall have a transportation mode and an operation mode. The transportation mode shall be utilised for storing and transporting the PDMS. The operation mode shall be utilised when the PDMS displays a message. The PDMS display shall be securely fixed to the trailer on both modes.

2.   The PDMS display shall be capable of rotating 360 degrees about the PDMS vertical axis to allow the correct alignment of the display to motorists.

3.   The PDMS display shall include both a hydraulic lift and a heavy duty hand winch to easily raise and lower the PDMS display.

4.   The PDMS display shall include a silicone coating to protect it from moisture and atmospheric contaminants..

5.   The PDMS display shall be capable of displaying up to four (4) lines of text per message. Each line shall consist of a minimum of eight (8) characters. The characters shall be 450 mm high and 280 mm wide. The message displayed on the sign shall be visible up to 800 m for both daytime and night time operation.

6.   The Beam width shall conform to classification B7 of BS EN 12966

7.   The LED display modules shall be fully interchangeable. A LED display module may consist of one or two circuit boards. If two (2) boards are used, they shall be mounted physically to each other using durable non-corrosive hardware. The removal of a display module or LED board shall not require the use of special tools.

8.   The PDMS display modules shall contain solid-state electronics to control pixel data and read pixel status.

9.   Each LED display module shall be mounted to the rear of the display's front face panels using durable non-corrosive hardware. No tools shall be required for module removal and replacement. The modules shall be mounted such that the LEDs emit light through the face panel's pixel holes and such that the face panel does not block any part of the viewing cone of any of the LEDs in any pixels.

10.   The LEDs shall be individually mounted directly on a printed circuit board (PCB).

11.   Each pixel shall consist of a minimum of one (1) independent string of discrete LEDs for each color. All pixels shall contain an equal quantity of LED strings. The failure of an LED string or pixel shall not cause the failure of any other LED string or pixel in the PDMS.

12.   Each pixel shall contain the quantity of discrete LEDs needed to output white colored light as a minimum luminous intensity of 12,400 candelas per square meter when measured using a photometric meter through the PDMS front face panel assembly.

13.   The LED packages shall be fabricated from UV light resistant epoxy. The LEDs shall also be protected from external environmental conditions, including moisture, wind, dust, sand, and dirt.

14.   The colours emitted by the LEDs shall conform to section 7.2 of BS 12966. The class designation C1 or C2 for the colour photometric parameter must be declared by the equipment provider.

15.   The LED colours shall be tested in accordance with section 9.3.5 of BS EN 12966.

16.   The uniformity measurement shall be in accordance with section 9.3.4 of BS EN 12966.

17.   The LEDs shall be rated by the LED manufacturer to have a minimum lifetime of 55,000 hours of continuous operation while maintaining a minimum of 70% of the original brightness.

18.   The PDMS shall be capable of displaying English and Arabic characters.

19.   The PDMS shall be capable of displaying pictograms and graphic symbols.

20.   Each line of the PDMS display shall be capable of displaying characters in various alpha, numeric, and alphanumeric combinations.

21.   The PDMS display shall also be capable of displaying directional arrow message. The arrow messages shall meet the requirements described in the QTCM.

22.   The PDMS display shall be capable of displaying at least three (3) messages sequentially. Each message shall be displayed in one or two phases to convey the message.

23.   The PDMS display shall come with factory-loaded messages and shall be capable of storing 255 user-programmable messages, 94 pre-programmed messages, and a 94 message sequence display.

24.   The PDMS shall be capable of operating in ambient temperatures ranging from 0ºC to 55ºC and with relative humidity in the range 0% - 100%. The PDMS shall operate in all weather conditions.

25.   The PDMS display board shall have both automatic and manual dimming capabilities to adjust the level of luminosity of the display for both daylight and night time conditions.

26.   The PDMS display shall include an internal clock to facilitate scheduled programming.

27.   The PDMS shall detect and send alerts to TMC in the event of unexpected location change, angle of operation or cabinet access.

9.4.2   Trailer

1.   The PDMS display shall be mounted on a trailer.

2.   The trailer shall meet all State of Qatar trailer standards (including colouring and markings), it shall be suitably robust for the intended operation.

3.   The trailer and the components of the PDMS shall be designed in such a way as to allow one person to perform all transporting and operating functions without assistance.

4.   The trailer shall be designed for unlimited on-roadway travel at 110 km/h.

5.   The trailer and all mounted equipment shall be designed to withstand a wind speed of 120 km/h with wind gusts of 160 km/h when stationary and in use.

6.   Trailer shall be supplied with a hand brake. The hand brake shall allow the trailer to be safely dismounted on a gradient of at least 10%.

7.   The trailer shall include:

(a)   Stabilising legs and levelling indicator
(b)   A minimum of 4 lashing down points to ensure safe installation and operation during high winds
(c)   At least one lifting eye to support safe, stable and level lifting at maximum weight
(d)   Earthing rods
(e)   Spare wheel
(f)   Lockable IP44 rated storage enclosures to house all non-electrical equipment required to operate the trailer.

8.   It shall be possible to lock the trailer stabilising legs and hydraulic mast to ensure unauthorised persons cannot alter the settings.

9.   Where batteries are provided they shall be sealed and maintenance free, easily replaceable, include control circuit to prevent deep-discharge of any batteries, support a minimum service life of 2 years.

9.4.3   PDMS Roadside controller

1.   The PDMS shall include a roadside controller that shall monitor the PDMS display, power source, and ancillary equipment. The roadside controller shall also allow authorised users to modify the PDMS display settings.

2.   The roadside controller shall be housed in a secure enclosure, which shall be mounted upon the equipment trailer. The enclosure shall have a minimum rating of IP 65. The enclosure shall include a light fixture to facilitate working during night-time conditions.

3.   The local controller shall include a LCD display that will mimic the display of the PDMS display.

4.   The local controller shall incorporate different levels of password protection to prevent unauthorised users from modifying messages or settings.

5.   The local controller shall have a memory system that stores the settings to prevent loss from a power failure. The local controller shall restart without user intervention after power resumption.

6.   The roadside controller shall be capable of automatically adjusting the brightness of the display.

7.   Transient voltage Surge Suppression (TVSS) shall be included in all the PDMS.

8.   The roadside controller shall provide and log the status of power supplies and stored charge, as well as the occurrence of operational/fault logs.

9.   The roadside controller shall include an easily accessible reset switch inside the controller enclosure.

10.   The roadside controller enclosure shall accommodate the equipment in an environment in accordance with Class 4.2H of ETSI EN 300 019-1-4. The equipment must continue to work within its normal operating parameters in this environment, regardless of location

9.5   Power and Telecommunications

9.5.1   General

1.   The PDMS shall be powered with solar power. In addition, the PDMS shall have the capability of being hard-wired to a single phase 240Vac 50Hz power service point.

2.   The PDMS shall be capable of operating for twenty-four (24) hours a day for 30 consecutive days without interruption of service and without the need for auxiliary power sources.

9.5.2   Solar Power

1.   The solar power system shall include the solar panels, batteries, mounting hardware, and solar power controller.

2.   The solar panels shall automatically charge batteries. The PDMS shall have a solar array dimensioned to a size suitable to operate the PDMS display and recharge the batteries.

3.   The PDMS shall be capable of stopping the charging of solar batteries when they are fully charged.

4.   The PDMS enclosure where solar batteries are provided shall include a fan to protect the on-board controller and the battery charger from overheating.

5.   The PDMS battery box shall be lockable and shall be rated IP 65.

6.   The battery box shall include a thermal management system capable of maintaining the batteries with the temperature range specified by the battery manufacturer.

7.   The solar-powered battery array shall include a voltage regulator to prevent overcharging or overdrawing of the battery system.

8.   A switch shall be provided to disconnect the solar power supply for maintenance purposes.

9.5.3   Electrical Power

1.   The PDMS shall have a connection point to allow the PDMS to operate with an external electrical service point. The connection point shall be rated IP 65.

2.   The electrical wiring and switchgear shall conform to the requirements of BS 7671.

3.   This external power supply shall operate the PDMS and its ancillary components. The PDMS shall be capable of recharging the batteries when utilising the external electrical power. The batteries shall not be overcharged.

4.   The PDMS shall include an isolated earthing circuit. The main system of supply shall be TN-S. All conductive and exposed parts shall be connected to the earthing terminal. The PDMS trailer shall not be part of the earthing system but shall be earthed.

5.   The PDMS shall include a main electrical isolation switch.

9.5.4   Telecommunications

1.   The local controller shall have both a serial (RS-232) port and an Ethernet port.

2.   The local controller shall communicate with the TMC through cellular (3G/4G) telecommunications.

9.5.5   Telecommunications Interface

1.   The following NTCIP requirements shall apply for the PDMS controller.

2.   The Telecommunications interface between the PDMS controller and the TMC or laptop computer (NTCIP components) shall comply with the following NTCIP requirements.

3.   This specification references several standards through their NTCIP designated names. Each NTCIP Standard referenced in this standard specification shall implement the latest version of the Standards.

9.5.6   Conformance

1.   The PDMS system shall conform to the applicable standards listed in this specification. To claim conformance with the above referenced standards, the implementation of NTCIP for the PDMS System shall fulfill the mandatory requirements and objects as identified in the referenced standards.

2.   Optional objects and requirements in the referenced standard(s) needed to satisfy a functional requirement in the detailed project design specifications shall be conformant with the appropriate standard and any standards it references (e.g. NTCIP 1201 and 1203).

9.5.7   NTCIP 1203

1.   The Telecommunications interfaces between the various components of the PDMS system shall use and conform to NTCIP 1203. Each NTCIP component shall provide Full, Standardised Object Range (FSOR) support of all objects required by these procurement specifications unless otherwise indicated below. The maximum Response Time for any object or group of objects shall be 200ms.

2.   To claim conformance to NTCIP 1201 and NTCIP 1203, each NTCIP component shall support all the mandatory requirements as defined in those standards. In addition, each NTCIP component shall support and conform to the following optional requirements (predicates) in the NTCIP 1203, as listed in Section 3.3.3.

   (a)   The implementation shall support all mandatory requirements for User Need ID 2.3.2.1.3, PDMS, and all mandatory requirements for the predicate <DMS>.

   (b)   The implementation shall support all mandatory requirements for User Need ID 2.3.2.2.2, LED, and all mandatory requirements for the predicate <LED>.

   (c)   The implementation shall support all mandatory requirements for User Need ID 2.3.2.3.2, Matrix, and all mandatory requirements for the predicate <Matrix>.

   (d)   The implementation shall support User Need ID 2.3.2.3.2.1, Full Matrix.

   (e)   The implementation shall support all mandatory requirements for User Need ID 2.4.2.2, Logged Data Exchange.

   (f)   The implementation shall support all mandatory requirements for User Need ID 2.5.1.2, Determine Sign Display Capabilities.

   (g)   The implementation shall support all mandatory requirements for User Need ID 2.5.1.3, Manage Fonts, and all mandatory requirements for the predicate <Fonts>.

(h)   The implementation shall support all mandatory requirements for User Need ID 2.5.1.5, Manage Automatic Brightness, and all mandatory requirements for the predicate <AutoBright>.

(i)   The implementation shall support all mandatory requirements for User Need ID 2.5.2.2, Remotely Reset the Sign Controller.

(j)   The implementation shall support all mandatory and optional requirements for User Need ID 2.5.2.3.6, Change Message Display Based on an Internal Event, with the exceptions of Requirement 3.5.2.3.5.1.3, Configure Message for Power Loss Event, and 3.5.3.3.4, Monitor Power Loss Message.

(k)   The implementation shall support all mandatory requirements for User Need ID 2.5.3.1.3, Monitor Subsystem Failure Details – Low-Level Diagnostics.

(l)   The implementation shall support all mandatory and optional requirements for User Need ID 2.5.3.1.5, Monitor Sign Environment.

(m)   The implementation shall support all mandatory requirements for User Need ID 2.5.3.1.8, Monitor Door Status.

(n)   The implementation shall support all mandatory requirements for User Need ID 2.5.3.1.9, Monitor Controller Software Operations.

(o)   The implementation shall support all mandatory requirements for User Need ID 2.5.3.1.10, Monitor Automatic Blanking of Sign.

(p)   The implementation shall support all mandatory requirements for User Need ID 2.5.3.1.12, Monitor Power Voltage.

(q)   The implementation shall be provided with a completed PRL as contained in NTCIP 1203, Section 3.3 Protocol Requirements List, to indicate which options of this NTCIP standard were implemented.

3.   If the PDMS is supplied with a GPS reader and/or electronic compass, then the PDMS controller shall implement the specified Environmental Sensor Stations in accordance with NTCIP 1204. The following objects shall be supported;

- Longitude
- Latitude
- Direction of travel

10   LANE CONTROL SIGNS

10.1   Related Documents

Reference	Title
BS EN 12966-1	Vertical Road Signs – Part 1: Variable Message Signs
BS 7671	Requirements for Electrical Installations
NTCIP 1201	Global Object (GO) Definitions
NTCIP 1203	Object Definitions for Dynamic Message Signs (DMS)
BS EN 12464-1	Lighting of Indoor Work Places
BS EN 60529	Degrees of Protection Provided by Enclosures (IP Code)
ETSI EN 300 019-1-4	Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-4: Classification of environmental conditions; Stationary use at non-weather protected locations.
IEC 60297	Mechanical structures for electronic equipment – Dimensions of mechanical structures of the 482,6 mm (19 in) series
BS EN 12675	Traffic signal controllers. Functional safety requirements
QCS	
QGEWC (E)	Regulations for Protective Multiple Earthing
QGEWC (E)	Regulations for Electrical Installations

10.2   Equipment Overview

10.2.1   Purpose

1.   This Section details the supply, installation, and commissioning of Lane Control Sign(s) (LCS) on a roadway in accordance with the detailed project design drawings and/or specifications. LCS are positioned above the centre of each running lane to provide information about speed limits, lane closures and lane changes. Where the design requires, LCS shall also be installed over the hardshoulder.

2.   This specification defines the requirements for the LCS and associated local controller equipment. The LCS is a lane-based sign capable of displaying standard pre-programmed aspects within a central matrix of Light Emitting Diodes (LED). The LCS incorporates dual-colour lanterns and a Red Ring for the display of Variable Mandatory Speed Limits.

3.   The LCS comprises a Central Matrix, Red Ring, Lanterns, Display Driver, an interface to the LCS Roadside Controller and, where applicable, Interfaces to Speed Enforcement Equipment.

4.   The term LCS System is used to refer to a group of LCS and their associated Roadside Controller and interconnections. Therefore this specification defines requirements for

- LCS
- LCS Roadside Controller
- LCS to LCS Roadside Controller cabling.

10.2.2   Configuration

1.   The LCS assembly shall consist of as a minimum:

- Full colour LCS
- LCS controller
- LCS controller ground mounted enclosure
- LCS software
- An assembly for mounting the LCS on a structure.

10.3   Non-Functional Requirements

10.3.1   Performance

1.   The optical performance of the LCS shall comply with the requirements section 7 of BS EN 12966.

2.   The Class designation(s) for the photometric parameters of the LCS shall be declared by the equipment provider.

3.   The physical performance of the LCS shall meet the requirements of section 8 of BS EN 12966. The DMS shall comply with the following classes;

- Temperature   T1
- Protection Class   P3

4.   The structural performance of the LCS shall conform to section 8.3 of BS EN 12966

5.   The electrical performance of the LCS shall conform to section 8.4 of BS EN 12966

10.3.2   Reliability

1.   The LCS shall be designed to have a service life in excess of 15 years when installed in the roadside environment in State of Qatar.

2.   Routine and preventive maintenance procedures shall be proposed to maintain the equipment and identify any equipment, parts or components considered necessary in order that the LCS achieves it expected service life.

10.3.3 Maintenance

1.   The equipment shall be designed such that the minimum recommended routine maintenance interval is not less than 6 months.

2.   Detailed documentation detailing the maintenance procedures shall be provided.

10.3.4 Environmental

1.   The LCS inclusive of all of its cables and components must maintain full functionality and continue to operate within the limits of this specification when subjected to the working environment in the State of Qatar.

2.   The design shall take account of the environmental impact of the LCS through all of its stages of the LCS Life cycle.

10.4   Functional Requirements

10.4.1   LCS LED Display Modules

1.   The LCS display shall be a full colour matrix display area as defined in section 7.2 of BS EN 12966.

2.   The Beam width shall conform to classification B7 of BS EN 12966

3.   The LED display modules shall be fully interchangeable. The removal of a display module or LED board shall not require the use of proprietary tools.

4.   Each LED display module shall be mounted to the rear of the display's front face panels using durable non-corrosive hardware. No tools shall be required for module removal and replacement. The modules shall be mounted such that the LEDs emit light through the face panel's pixel holes and such that the face panel does not block any part of the viewing cone of any of the LEDs in any pixels.

5.   The LEDs shall be individually mounted directly on a printed circuit board (PCB). The pitch of the LEDs shall be less than 30 mm.

6.   The failure of an LED string or pixel shall not cause the failure of any other LED string or pixel in the LCS.

7.   Each pixel shall contain the quantity of discrete LEDs needed to output white coloured light as a minimum luminous intensity of 12400 candelas per square meter when measured using a photometric meter through the LCS front face panel assembly.

8.   The colours emitted by the LEDs shall conform to section 7.2 of BS 12966. The class designation C1 or C2 for the colour photometric parameter must be declared by the equipment provider.

9.   The LED colours shall be tested in accordance with section 9.3.5 of BS EN 12966.

10.   The uniformity measurement shall be in accordance with section 9.3.4 of BS EN 12966.

11.   The LEDs shall be rated by the LED manufacturer to have a minimum lifetime of 100,000 hours of continuous operation while maintaining a minimum of 70% of the original brightness.

12.   Each LED driver board shall be microprocessor-controlled and shall communicate with the LCS controller using an addressable network protocol. The microprocessor shall process commands from the LCS roadside controller to display data, perform diagnostic tests, and report pixel and diagnostic status.

13.   The LCS controller shall continuously measure and monitor all LED module power supply voltages and provide the voltage readings to the TMC or a laptop computer on command.

10.4.2   Characters, Fonts, and Colour Requirements

1.   The display area of the LCS shall have a minimum active area of 1.2 m by 1.2 m.

2.   The LCS shall display characters with a minimum height of 150 mm.

3.   The LCS shall be capable of supporting the following features:

(a)   Display alpha numeric characters, including letters, numbers, and punctuation.
(b)   Display graphical symbols.
(c)   Display English and Arabic characters.
(d)   Selection of particular character fonts style.
(e)   Horizontal alignment of text on the display, including left, center, and right justification.
(f)   Vertical alignment of text on the display, including top, middle, and bottom justification.
(g)   Adjusting the spacing horizontally between characters or vertically between lines of text.
(h)   Display of graphic bitmaps of various sizes ranging to very small to the size of the entire LCS matrix.

4.   The LCS shall be factory loaded with the fonts described in the QTCM.

5.   The full colour matrix LCS shall include a library of common symbols included in the QTCM for easy insertion of graphic images.

6.   The full colour matrix LCS shall have the capability of displaying the colours described in the latest edition of the QTCM.

10.4.3   LCS Roadside Controller

1.   The LCS roadside controller shall be a stand-alone microprocessor-based system, which does not require continuous communication with LCS control software in order to perform most LCS control functions.

2.   The LCS roadside controller shall be IP addressable by using a local laptop/PC or from the TMC.

3.   The LCS roadside controller shall meet the following minimum operational requirements:

(a)   Communicate using embedded NTCIP protocol.
(b)   Contain memory for storing changeable and permanent messages, schedules, and other necessary files for controller operation.
(c)   Include a front panel user interface with graphical LCD and keypad for direct operation and diagnostics as described herein.
(d)   Contain a minimum of three (3) RS232 communication ports.
(e)   Contain a minimum of one (1) RS422 communication port with RJ45 connector.
(f)   Contain a minimum of one (1) Ethernet port with RJ45 connector.
(g)   Contain firmware (embedded software) that shall monitor all external and internal sensors and communication inputs and control the display modules as directed by external control software and the front panel interface.
(h)   The roadside controller shall be capable of controlling up to 16 LCS units including main carriageways, hard shoulders and off-ramps

4.   The LCS roadside controller and associated communication equipment shall be installed in ground mounted enclosure.

5.   The LCS roadside controller shall be mounted in a standard EIA 480 mm (19 inch) (or IEC 60297) equipment rack with a maximum 4U space requirement or as specified in BS EN 12675.

6.   The LCS roadside controller shall have the capability of modifying the brightness of the LED display matrix manually or automatically.

7.   The LCS roadside controller shall be capable of monitoring and displaying the currently active message (if any) including graphical messages on the controller's front panel LCD display. This display shall mimic the LCS display and can switch through the individual LCS displays.

8.   The LCS roadside controller shall direct all of the LED modules to perform diagnostic tests of all their pixels. The controller shall then collect and report the results of the pixel testing. The test shall be initiated either locally or from the remote control software.

9.   The LCS roadside controller shall also be capable of automatically detecting in real-time the status of each of the display's pixels and reporting their on/off status.

10.   The LCS roadside controller shall monitor and report the functional status of regulated power supplies located in the LCS by monitoring diagnostic outputs located on the supplies. The controller shall monitor the output voltage of each power supply and the status of each output fuse.

11.   The LCS roadside controller shall monitor and report the status of the fans in the LCS unit and the LCS Controller.

12.   The LCS roadside controller shall monitor the readings of all light and temperature sensors installed in the LCS housing.

13.   The LCS roadside controller shall be capable of automatically informing a maintenance operator (via the local LCD panel) and a central control system of the occurrence of important events and subsystem failures.

14.   The LCS roadside controller shall continuously monitor the LCS housing's temperature sensors and shall automatically shut down the LCS if the internal housing temperature exceeds a safety threshold. This threshold shall have a default value of +60ºC and shall be configurable at the controller.

15.   If the temperature approaches the threshold, the controller shall reduce the brightness of the sign face. If the temperature continues to increase and exceeds that threshold, the controller shall trigger a warning notification event and blank the face of the sign. The sign face will remain blank until the temperature begins to drop. As the temperature drops, the controller will gradually increase the brightness of the display face, eventually returning to full brightness.

16.   When the LCS roadside controller detects that it has been restarted due to a manual reset or error condition, it shall send a notification to the TMC.

17.   When the LCS roadside controller detects a power failure, the controller shall automatically blank the front panel LCD.

10.4.4   LCS Software

1.   The LCS TMC interface software shall allow communication between multiple users and multiple signs across the same Telecommunications network.

2.   The LCS TMC interface software shall be provided by the LCS equipment provider. The software shall operate on desktop and laptop computers.

3.   The LCS TMC interface software shall provide a user-friendly graphical user interface, and support at least 12000 LCSs. The software shall be scalable to increase the number of LCSs without limitation.

4.   The LCS TMC interface software shall support LCS control, monitoring, and diagnostic functions described in this specifications.

5.   The LCS TMC interface software shall have the capability of controlling a LCS remotely from the TMC and locally at the LCS site by using a laptop.

6.   The LCS TMC interface software shall support different level of rights and authorizations to control an LCS, the ability to create and modify messages within software, and the ability to modify LCS settings or run content on LCS.

7.   The LCS TMC interface software shall include an event logging system.

8.   The LCS TMC interface software shall allow system administrators and other authorized users to configure system parameters and functions.

9.   The LCS TMC interface software shall monitor the frequency of communication packets from the TMC to the LCS. If the software detects that communication has not occurred between the roadside controller and TMC for longer than a configurable timeout, then the software shall automatically activate a communication loss message.

10.5   Power and Telecommunications

10.5.1   Power

1.   The LCS controller enclosure shall include an electrical panel board and circuit breakers that meet the requirements of BS 7671.

2.   The wiring for LED display modules, environmental control circuits, and other LCS components shall be installed in the LCS housing in a neat and professional manner. The cable sizes shall be properly sized in accordance with BS 7671.

10.5.2   UPS

1.   Where required in the project design, the UPS shall be provided by the LCS equipment provider and shall be installed within the LCS ground mounted enclosure housing or controller enclosure, as shown in the detailed project design drawings and/or specifications. The UPS system shall be capable of operating the LCS while displaying the current message on the sign for a minimum of four (4) hours.

10.5.3   Telecommunications

1.   The LCS roadside Controller shall be IP addressable and shall be integrated with the LCS TMC interface software over the IP Telecommunications network.

2.   The LCS system shall conform to the NTCIP 1203. To claim conformance with the above referenced standards, the implementation of NTCIP for the LCS system shall fulfil the mandatory requirements and objects as identified in the referenced standards.

3.   Optional objects and requirements in the referenced standard(s) needed to satisfy a functional requirement in the detailed project design specifications shall be conformant with the appropriate standard and any standards it references (e.g. NTCIP 1201 and 1203).

10.5.4   NTCIP 1203

1.   The Telecommunications interfaces between the various components of the LCS system shall use and conform to NTCIP 1203. Each NTCIP component shall provide Full, Standardised Object Range (FSOR) support of all objects required by these procurement specifications unless otherwise indicated below. The maximum Response Time for any object or group of objects shall be 200ms.

2.   To claim conformance to NTCIP 1201 and NTCIP 1203, each NTCIP component shall support all the mandatory requirements as defined in those standards. In addition, each NTCIP component shall support and conform to the following optional requirements (predicates) in the NTCIP 1203, as listed in Section 3.3.3.

    (a)   The implementation shall support all mandatory requirements for User Need ID 2.3.2.1.3, VMS, and all mandatory requirements for the predicate <VMS>.

    (b)   The implementation shall support all mandatory requirements for User Need ID 2.3.2.2.2, LED, and all mandatory requirements for the predicate <LED>.

    (c)   The implementation shall support all mandatory requirements for User Need ID 2.3.2.3.2, Matrix, and all mandatory requirements for the predicate <Matrix>.

    (d)   The implementation shall support User Need ID 2.3.2.3.2.1, Full Matrix.

(e) The implementation shall support all mandatory requirements for User Need ID 2.4.2.2, Logged Data Exchange.

(f) The implementation shall support all mandatory requirements for User Need ID 2.5.1.2, Determine Sign Display Capabilities.

(g) The implementation shall support all mandatory requirements for User Need ID 2.5.1.3, Manage Fonts, and all mandatory requirements for the predicate <Fonts>.

(h) The implementation shall support all mandatory requirements for User Need ID 2.5.1.5, Manage Automatic Brightness, and all mandatory requirements for the predicate <AutoBright>.

(i) The implementation shall support all mandatory requirements for User Need ID 2.5.2.2, Remotely Reset the Sign Controller.

(j) The implementation shall support all mandatory and optional requirements for User Need ID 2.5.2.3.6, Change Message Display Based on an Internal Event, with the exceptions of Requirement 3.5.2.3.5.1.3, Configure Message for Power Loss Event, and 3.5.3.3.4, Monitor Power Loss Message.

(k) The implementation shall support all mandatory requirements for User Need ID 2.5.3.1.3, Monitor Subsystem Failure Details - Low-Level Diagnostics.

(l) The implementation shall support all mandatory and optional requirements for User Need ID 2.5.3.1.5, Monitor Sign Environment.

(m) The implementation shall support all mandatory requirements for User Need ID 2.5.3.1.9, Monitor Controller Software Operations.

(n) The implementation shall support all mandatory requirements for User Need ID 2.5.3.1.12, Monitor Power Voltage.

3. The implementation shall be provided with a completed PRL as contained in NTCIP 1203, Section 3.3 Protocol Requirements List, to indicate which options of this NTCIP standard were implemented.

10.6   Hardware Design Requirements

10.6.1   Mechanical and Housing Requirements

1.   The LCS shall comprise a structure mounting module and a roadside controller mounted in a ground level enclosure.

10.6.2   LCS Housing

1.   The LCS shall be designed to have a design life of not less than 15 years when used in State of Qatar.

2.   The materials and finish used for the construction of the LCS shall be effective for a maintenance free and effective design for the life of the LCS.

3.   LCS structural hardware for assembly shall be galvanized A325 high-strength steel and shall be appropriately sized for the application.

4.   The LCS housing shall include multiple mounting brackets bolted to the exterior rear wall to facilitate handling and installation.

5.   The structural performance of the LCS shall be in accordance with section 8.3 of BS EN 12966.

6.   The LCS housing shall provide safe and convenient access to all modular assemblies, components, wiring, and subsystems located within the LCS housing. All of those internal components shall be removable and replaceable by a site operative.

7.   One (1) access door shall be provided for each sign. These doors shall be vertically hinged and shall contain a section of the sign's front face. The doors shall swing out from the face to provide access to the interior. Each door shall extend the full height of the display matrix.

8.   The doors shall have a retaining latch mechanism to hold the door open at a 90-degree angle to prevent open doors from blowing in the wind.

9.   Each door shall form the face panel for a section of the sign. The LED modules shall be mounted to the door and be removable from the door when in the open position. Other sign components, such as power supplies, wiring, etc. shall be located inside the sign and be accessible through the door opening. Each door shall contain a minimum of two (2) captive-type latches to lock them in the closed position. The latches shall pull the door tight and compress a gasket located around the perimeter of each door.

10.   The front face panels shall provide a high-contrast background for the LCS display matrix. The aluminium mask of each panel shall be painted black and shall contain an opening for

each pixel. Openings shall be large enough to not block any portion of the viewing cones of the LEDs.

11.   Each door panel shall have a single polycarbonate sheet attached securely to the inside of the aluminium panel. The polycarbonate sheet shall cover all of the pixel openings. The polycarbonate shall be sealed to prevent water and other elements from entering the LCS. The polycarbonate shall contain UV inhibitors that protect the LED display matrix from the effects of ultraviolet light exposure and prevent premature aging of the polycarbonate itself.

12.   LED display modules shall mount to the inside of the LCS front face door panels. No tools shall be needed for removal and replacement of LED display modules.

13.   The LCS front face borders (top, bottom, left side, and right side), which surround the front face panels and LED display matrix, shall be painted black to maximize display contrast and legibility.

14.   The LCS housing shall have an electronically controlled ventilation system and a failsafe thermostat designed to keep the internal LCS air temperature lower than +60°C, when the outdoor ambient temperature is +55°C or less.

15.   The ventilation system shall consist of two or more air intake ports, which shall be located near the bottom of the LCS rear wall. Each intake port shall be covered with a filter that removes airborne particles measuring 500 microns in diameter and larger.

16.   An exhaust port shall be located near the top of the rear LCS wall. One exhaust port shall be provided for each air intake port. All exhaust port openings shall be screened to prevent the entrance of insects and small animals.

17.   The LCS shall automatically shut down the LED modules to prevent damaging the LEDs if the measured internal housing air temperature exceeds a maximum threshold temperature. The threshold temperature shall be configurable and shall have a default factory setting of +60°C.

18.   An aluminium hood attached to the rear wall of the LCS shall cover each air intake and exhaust port. All intakes and exhaust hoods shall be thoroughly sealed to prevent water from entering the LCS.

19.   The LCS housing shall include a photo sensor that provides accurate ambient light condition information to the LCS controller for automatic light intensity adjustment. The LCS controller shall continuously monitor the light sensors and adjust the LED display matrix intensity to a level that creates a legible message on the LCS face.

20.   The LCS shall include an external temperature sensor. The external temperature sensor shall be mounted to the rear wall of the LCS housing. The sensor shall be placed such that it is never in direct sunlight. The temperatures from the LCS controller shall be read by remote and local computers.

10.6.3   LCS Roadside Controller Housing Requirements

1.   The LCS controller housing shall include the following assemblies: power indicator, surge suppression on both sides of all electronics, communication interface devices, connection for a laptop computer for local control and programming.

2.   The LCS controller housing shall provide safe and convenient access to all modular assemblies, components, wiring, and other materials located within the housing. All internal components shall be removable and replaceable by a site operative.

3.   The housing shall contain a power panel board and circuit breakers.

4.   The housing shall contain a utility outlet circuit consisting of a minimum of two (2) 13A 240 Vac dual un-switched outlets, protected in accordance with BS 7671. The outlets shall be mounted inside the housing and located near the panel board or as specified in BS EN 12675.

5.   The housing shall include one (1) main earthing lug that is electrically bonded to the housing.

10.6.4   Mounting Structure Requirements

1.   The LCS shall be mounted on new or existing structures, as shown in the detailed design drawings.

2.   New LCS structures shall utilise a design wind speed of 120 km/h with gusts up to 160 km/h for their design, and shall meet with the requirements of BS EN 12966.

3.   The Gantry mounting shall facilitate a safe a quick method for the installation and removal of the LCS with the minimal number of components.

4.   The LCS shall incorporate facilities for lifting equipment to be fixed for installation and removal.

10.6.5   Installation Requirements

1.   The LCS shall be supplied and installed accordance with the detailed project design drawings.

2.   The LCS shall not be installed prior to the availability of electric power.

3.   The required message libraries and shall provide the message libraries shall be pre-loaded prior to deployment.

11   RAMP METERING SYSTEMS

11.1   Related Documents

Reference	Title
NTCIP 1201 v03	Global Object (GO) Definitions
NTCIP 1207:2001	Object Definitions for Ramp Meter Control (RMC) Units
NTCIP 1209 v02.17	Object Definitions for Transportation Sensor Systems (TSS)
NTCIP 2101:2001	Point to Multi-Point Protocol Using RS – 232 Subnetwork Profile
NTCIP 2103 v02	Point-to-Point Protocol over RS – 232 Subnetwork Profile
NTCIP 2104:2003	Ethernet Subnetwork Profile
NTCIP 2201:2003	Transportation Transport Profile
NTCIP 2202:2001	Internet (TCP/IP and UDP/IP) Transport Profile
NTCIP 2301 v02	Simple Transportation Management Framework (STMF) Application Profile (AP) (AP-STMF)
Ashghal	Civil and Structural Standards for Intelligent Transportation System (ITS)
Ashghal	Intelligent Transportation System (ITS) Deployment Manual
AASHTO	Standard Specification for Supports for Highway, Signs, Luminaires, Traffic Signals
BS 873	Road Traffic Signs
BS 1361	Cartridge fuses for A.C. circuits in domestic and similar premises
BS 381C	Specifications for colours for identifications
BS 5493	Code of practice for protective coatings of iron and steel structures against corrosion.
BS 7430	Code of practice for protective earthing of electrical installations
BS 7671	Requirements for electrical installations
BS EN 60269-1	Low Voltage fuses – General Requirements
BS EN 1011	Process of arc welding carbon and carbon manganese steels
BS EN 12368	Traffic control equipment. Signal heads
BS EN 12899	Fixed, vertical road traffic signs. Fixed signs
BS EN 60529	Specification for degrees of protection provided by enclosures (IP code)
ISO 1461	Hot dip galvanized coatings on iron and steel articles
ISO 12944	Paints and varnishes. Corrosion protection of steel structures by protective paint systems
DIN 40050	Enclosures for electrical equipment
DIN 6163 Part 5	Diffusion lenses for Traffic Signals
QGEWC (E)	Regulations for Electrical Installations
QGEWC (E)	Regulations for Protective Multiple Earthing

11.2   Equipment Overview

11.2.1   Purpose

1. This Section describes the requirements for the supply, installation, and commissioning of ramp meter equipment and related roadway furniture at metered roadway on-ramps in accordance with the detailed project design drawings and/or specifications.

2. When the Ramp metering is operational, it shall release platoons of vehicles from the on-ramp to the main line carriageway to optimize the corridor performance. Algorithms within the ramp metering control software shall ensure that the performance of the ramp metering is complementary to other ITS interventions for corridor management.

11.2.2   Configuration

1. A Ramp Metering System shall consist of as a minimum:

   (a)   signal poles
   (b)   signal heads
   (c)   flashing beacons
   (d)   ramp meter controller
   (e)   signs
   (f)   flexible and armoured cables
   (g)   inductive loops
   (h)   chambers.

11.3   Non-Functional Requirements

11.3.1   Reliability

1. The system shall have a Mean Time Between Failure (MTBF) of 20,000 hours.

2. The Ramp Metering system shall be designed to have a service life in excess of 10 years when installed in the roadside environment in the State of Qatar.

3. Routine and preventive maintenance procedures shall be proposed to maintain the equipment and identify any equipment, parts or components considered necessary in order that the Ramp Metering System achieves it expected service life.

11.3.2   Maintenance

1. The equipment shall be designed such that the minimum recommended routine maintenance interval is not less than 6 months.

2. Detailed documentation detailing the maintenance procedures shall be provided.

11.3.3   Environmental

4.   All ITS equipment must maintain full functionality and continue to operate within the limits of this specification when subjected to the working environment of the State of Qatar.

5.   All equipment shall function and perform as per the specification in ambient temperatures ranging from 0°C to 55°C and in the range 0% to 100% relative humidity in accordance with QCS.

11.4   Functional Requirements

11.4.1   Ramp Meter Signal Poles

1.   Ramp meter signal poles shall be of the tubular steel with a flanged base, having an internal electrical termination point accessible through a lockable inspection window.

2.   The ramp meter signal pole assembly shall include:

•   holding down bolts, nuts, washers and shims required for erection
•   pole
•   electric terminal block
•   lockable cover for inspection window with two sets of keys
•   all grommets
•   Cable glands and cable anchor points.

3.   Ramp meter signal poles shall have dimensions conforming to those given in the detailed design drawings.

4.   The ramp meter signal poles shall be of mild steel construction galvanized and powder-coated to conform to the requirements of

•   ISO 12944
•   ISO 1461.

4.   All welded connections of the ramp meter signal poles shall conform to BS EN 1011.

5.   The electric terminal block shall be located within the ramp meter signal pole. The terminal block shall be fully accessible through a lockable inspection window. The terminal block shall be securely fixed to the pole.

6.   The terminal block shall be electrically isolated from the ramp meter pole and shall have a minimum capacity of 2 x 20 connectors. Each connector shall have a minimum rated capacity of 100 watts at 240 Vac and shall be in compliance with the requirements of the QGEWC.

7.   The ramp meter signal pole shall have the facility to secure incoming cables at a point prior to the connection to the terminal block.

8.   The ramp meter signal pole shall be fitted with an electrical earthing stud such that at least four (4) earth connections can be made to it.

9.   Ramp metering signal poles shall also be used for installing advance flashing beacons.

11.4.2   Signal Heads

1.   Traffic Signal Heads shall be manufactured in accordance with BS EN 12368.

2.   Three-section signal heads shall be used. Drawings of the proposed signal heads shall be submitted for Client or the Client's nominated representative review and approval.

3.   Signal heads shall be constructed out of high quality polycarbonate plastic and any metal fittings shall be protected against corrosion. The signal heads shall include:

    (a)   LED
    (b)   Optical reflectors (if appropriate).
    (c)   Lenses.
    (d)   Transformers.
    (e)   Visors.
    (f)   Anti-phantom devices (if appropriate)
    (g)   Brackets, frames, and all fixtures and fittings required for mounting.
    (h)   Backing board.

3.   The design and construction of signal heads shall allow for all of the following features:

    (a)   Hinged lens panels to allow quick access to the LED lamps.
    (b)   Flexible, detachable visors.
    (c)   Easily adjustable mounting system.

4.   The signal heads shall be LED for each section. The signal heads will be required to operate within the temperatures as detailed within this section.

5.   Signal heads shall be mounted on the ramp meter signal pole as shown in the detailed project design drawings. The mounting system shall not require predrilling or permanent attachment of brackets to the signal pole.

6.   The mounting system shall allow the signal heads to be adjusted through an arc of 30 degrees about its vertical axis.

7. The mounting system shall allow mounting two (2) three-section ramp meter signal heads one above the other on a single pole such that the vertical faces being presented to oncoming traffic of each head remain in the same plane. The mounting system shall allow mounting the signal heads asymmetrical from the centre-line of the pole.

8. If the use of optical reflectors is deemed appropriate, the optical reflectors shall be made of a high grade aluminium and mirror finished.

9. Diffusion lenses shall be constructed with an internal cobweb pattern and shall be coloured red, amber, or green as defined by the colour limits defined in DIN Standard DIN 6163 Part 5 and BS EN 12368.

11.4.3   Flashing Beacons

1. Flashing Beacons shall be manufactured in accordance with BS EN 12368.

2. Flashing beacons along with appropriate signage shall be provided to warn the drivers of ramp meter operation as detailed in the detailed design requirements.

3. The flashing beacons along with appropriate signage shall be installed on signal poles located in advance of the ramp meter and on at least one side of the entrance.

4. The flashing beacons shall meet specifications listed below or specifications as per QTCM or as designated by the Client or the Client's nominated representative:

5. The beacon shall consist of one or more signal sections that operate in a flashing mode.

6. The beacon shall consist of circular amber indications in each signal face.

7. The beacon shall be flashed at a rate of at least 50 times per minute or more.

8. The illuminated period of a flash shall be a minimum of 1/2 and a maximum of 2/3 of the total cycle.

9. The beacon shall provide an automatic dimming feature.

11.4.4   Ramp Meter Controller

1. The ramp meter controller shall be micro-processor based and capable of meeting all the operational requirements described in the detailed project design specifications. The supply of a ramp meter controller shall include:

   • basic control hardware including relays housings and enclosures
   • all additional modules and circuits required to meet the operational specification
   • all internal wiring, all detector modules and control circuits
   • plates, fixings and fastenings

- Cables glands, seals, and clips.

2.   Data Sheets of the proposed ramp meter controllers shall be submitted to the Client or the Client's nominated representative for review and approval.

3.   The ramp meter controller shall meet the following Functional Requirements:

- Operate as Single-lane or dual-lane metering without bypass-lane operation.

- Provide separate user programmable timings for green, amber, and red indications for Start-up, normal, and shutdown metering cycles as specified in the ramp metering guidelines document or NTCIP 1207 specifications for ramp meters.

- Metering rates based on user-programmed durations of green and red indications for normal metering cycle. The controller shall permit entry of values of each of these durations in a 1 to 99 second range in 0.1 second increments. A zero entry for any of these indications shall inhibit metering in the specified lane.

- Users' ability to program the durations of green, amber and red indications for start-up and shutdown cycles. A zero entry for any of these indications shall only inhibit that indication.

- Collect roadway speed, volume, and occupancy data per lane with detector polling at a rate of every 1/10th of a second or higher frequency.

- Collection of volume and occupancy data from other detectors of the ramp meter by using detector polling at a rate of every 1/10th of a second or higher frequency.

- Calculate and report total volume, average speed, and average occupancy over a user-specified interval ranging from 10 seconds to 60 seconds in one-second intervals.

- Traffic responsive operation based on speed, volume, and/or occupancy measurements from roadway lanes based on user-specified threshold values. The metering rates shall be selectable from a pre-programmed table corresponding to a range of these values.

- Queue override functionality using user-specified thresholds for occupancy of queue detector shall be provided.

- Support functions of other detectors utilised in the ramp meter operation.

- Activate a minimum of two (2) flashing beacons during all metered cycles. The controller shall provide for the activation of each flashing beacon a user-specified duration prior to the activation of signal indications in the start-up cycle.

4.   Once a ramp meter begins operation, the controller shall operate a minimum duration specified by the user.

5.   When a ramp meter operation ends, the controller shall ensure that the ramp meter operation will remain shut down for a user-specified duration.

6.   The controller shall be provided with the following operational modes:

   (a)   Computer control.
   (b)   Manual control.
   (c)   Local mode with multi-plan traffic responsive operation.
   (d)   Signal on/off mode.

7.   All equipment supplied shall be compatible with existing ramp meter signal controllers.

8.   Ramp meter controllers shall be programmed in accordance with the parameters recommended by a ramp meter design study and as designated and as agreed with the Client or the Client's nominated representative.

9.   Competent personnel shall be provided to program the controller.

10.   The controller shall be housed in a ground mounted enclosure of sufficient size to accommodate the controller and all other associated equipment and shall provide easy access for maintenance and test purposes.

11.   The enclosure shall meet the requirements of BS EN 12675. Enclosures shall be painted to a colour and specification agreed by the Client.

12.   A suitable foundation shall be constructed for the enclosure, and it shall allow for the entry and exit of all cables. The enclosure shall be secured to the foundation by anchor bolts.

11.4.5   Ramp Meter Cable

1.   Flexible ramp meter cable shall be comprised PVC insulated conductors, galvanized steel wire armour with an overall PVC sheath to

   •   BS 6346
   •   BS EN/IEC 60228
   •   BS EN/IEC 60332-1-2
   •   BS EN/IEC 50363-2.

2.   The cable shall be coloured as per QCS.

3.   Each individual core shall be uniquely identifiably by either having a uniquely coloured PVC sheathing or by its PVC sheathing having a unique, repetitive marking.

4.   The voltage drop along the length of the cable shall be no more that 4% of the supply voltage

5.   Cable shall be supplied in 500 m lengths and wound onto a suitable cable drum.

6.   Cable shall be supplied in four sizes: 4 core, 8 core, 12 core, or 20 core. The individual cores shall be stranded.

7.   Where Inductive Loops are used, they shall confirm to the standards specified in Traffic Detection section of QCS.

8.   The number of inductive loops shown in the detailed project design drawings shall be provided.

11.5   Power & Telecommunications

11.5.1   Power Supply Requirements

1.   Please refer to Section 2, General provisions for ITS

11.5.2   Telecommunications

1.   In addition to the Telecommunications Interface requirements in Section 15, the following NTCIP requirements shall also apply for the Ramp Meter Controller (RMC).

2.   This specification references several standards through their NTCIP designated names. Each NTCIP Standard referenced in this standard specification shall implement the following standards (Also listed in the table at the end of this section).

        a.   NTCIP 1201 v03
        b.   NTCIP 1207
        c.   NTCIP 1209 v02.17
        d.   NTCIP 2101
        e.   NTCIP 2103 v02
        f.   NTCIP 2104
        g.   NTCIP 2201
        h.   NTCIP 2202
        i.   NTCIP 2301 v02

3.   To claim conformance with the above referenced standards, the implementation of NTCIP for the ramp meter system shall fulfil the mandatory requirements and objects as identified in the referenced standards.

4.   Optional objects and requirements in the referenced standard(s) needed to satisfy a functional requirement in the detailed project design specifications shall be conformant with the appropriate standard and any standards it references (e.g. NTCIP 1206, NTCIP 1201).

5.   The ramp meter system shall conform to NTCIP 2301 and fulfil all the General Requirements and SNMP Requirements in NTCIP 2301. An NTCIP component may support additional Application Profiles at the manufacturer's option. Responses shall use the same Application Profile used by the request. Each NTCIP component (e.g. the RMC, laptop computer, management software) shall support the receipt of Application data packets at any time allowed by the subject standards.

6.   The implementation shall be provided with a completed PRL as contained in NTCIP 2301, Annex A to indicate which options of this NTCIP standard were implemented.

7.   The Telecommunications link between the Roadside controller unit and the TMC interface software shall use a routable protocol. As such, the NTCIP components shall conform to NTCIP 2202 and fulfill all its mandatory requirements. In addition, the NTCIP components shall support the Transmission Control Protocol (TCP) options defined by the standard. An NTCIP component may support additional Transport Profiles at the manufacturer's option. Response datagrams shall use the same Transport Profile used in the request. Each NTCIP component shall support the receipt of datagrams conforming to any of the identified Transport Profiles at any time.

8.   The implementation shall be provided with a completed PRL as contained in NTCIP 2202, Annex A to indicate which options of this NTCIP standard were implemented.

9.   NTCIP components may support additional Subnet Profiles; however, only one Subnet Profile shall be active on a given Telecommunications port on the Roadside controller component at any one time. If the NTCIP component has a Telecommunications port that supports multiple Subnet Profiles, the NTCIP component shall be configurable to allow a user to activate the desired Subnet Profile and shall provide a visual indication of the currently selected Subnet Profile.

10.   The implementation shall be provided with a completed PRL as contained in NTCIP 2104, Annex A to indicate which options of this NTCIP standard were implemented.

11.   NTCIP 1207 provides for the exchange of information to support functionality related to the operation of RMC units. Each NTCIP component shall provide Full, Standardised Object Range (FSOR) support of all objects required by these procurement specifications unless otherwise indicated below. The maximum Response Time for any object or group of objects shall be 200ms.

12.   To claim conformance to NTCIP 1207, each NTCIP component shall support all the mandatory objects for all the mandatory conformance groups as defined in the standard. The definition of each conformance group is found in Section 4 of the standard, while Section 5 indicates which conformance groups are mandatory.

13.   For each implementation, each NTCIP component shall support the following conformance groups:

    (a)   Database Management.
    (b)   Time Management.
    (c)   Timebase Event Schedule.
    (d)   Scheduling.
    (e)   Report.

15.   In addition, for each implementation, each NTCIP component shall support and conform to all the mandatory objects for all the optional conformance groups as required in the specifications.

16.   Table 5-1, Conformance Table in NTCIP 1207 shall be completed to indicate what the NTCIP component actually supports.

11.5.3   Software - NTCIP Requirements

1.   The latest version of the ramp metering Maintenance/Diagnostics Laptop software shall be provided, which shall be able to execute all commands and monitor/modify all settings available within Roadside controller using the same NTCIP object definitions required above regardless of whether these are utilised by the Ramp Metering TMC interface software. In addition, any software upgrades shall be provided until the end of the 400-day operational support period.

11.6   Hardware Design Requirements

11.6.1   Mechanical and Housing requirements

1.   Signal posts shall be installed vertically onto their prepared foundations using an appropriate fixing method approved by the Client or the Client's nominated representative.

2.   Where designated, posts shall be painted or powder coated with an approved paint or powder coat before installation of signal heads, flashing beacons, and signs.

3.   Signal heads, signs, and flashing beacons shall be installed as shown on the detailed project design drawings.

4.   Final positioning and fixing shall not be undertaken without the Client's or the Client's nominated representative's approval.

11.6.2   Ramp Meter Controller Housing

1.   The Ramp meter controller ground mounted enclosure shall be installed as detailed project design drawings.

2.   The housing shall be positioned so that when the access doors are opened to their fullest extent they will not cause obstruction or present a hazard to members of the public.

3.   The power supply shall be contained within its own separate duct, up to the point at which it enters the ground mounted enclosure.

4.   Where a separate housing is required, it shall be positioned directly adjacent to the controller housing.

5.   The Ramp metering controller shall be installed and commissioned by competent site operatives using the correct equipment.

6.   The ground mounted enclosure shall accommodate the equipment in an environment in accordance with Class 4.2H of ETSI EN 300 019-1-4. The equipment must continue to work within its normal operating parameters in this environment, regardless of location

11.6.3   Cabling

1.   All cables shall be installed in the ducts indicated in the detailed project design drawings.

2.   All external cables terminating within the controller shall be clearly labelled as to their function, destination, and nominal voltage.

3.   These cables shall, on entering the controller housing, be clamped and supported such that any stress or strain on the cables themselves shall not be transmitted to the controller's internal components.

4.   Spare or redundant cables entering the controller housing shall be terminated in such a fashion that they do not interfere in any way with access to the controller's internal components.

5.   The conductors of these cables shall be electrically isolated and sealed against the ingress of moisture.

6.   A single dedicated cable shall service each individual ramp meter and flashing beacon pole. On entering the signal pole, the cable shall be firmly anchored to the pole.

7.   At least 3.0 m of spare cable shall be allowed for within the signal pole, over and above that length which is required to reach the termination block.

8.   Spare or redundant cores within the cable shall be terminated at the termination block and labelled 'Spare'.

9.   The core acting as earth protection shall be connected directly to the body of the signal pole by means of the pole's earthing stud.

10.   The cable armouring shall not be used as the protective earth conductor.

11.   With the exception of loop cable to loop feeder cable connections, the jointing of cables shall not be permitted.

12.   Where jointing of the cables is permitted, this shall be undertaken using a suitable jointing kit of an approved type which allows the integrity of the protective earth conductors to be maintained.

13.   Loop cable to loop feeder cable joints shall only be located within a chamber.

12 TOLL AND PAYMENT COLLECTION

(This section is intentionally blank. To be updated within future revisions.)

13   CONNECTED VEHICLE TECHNOLOGY

(This section is intentionally blank. To be updated within future revisions.)

14   ENFORCEMENT SYSTEMS

(This section is intentionally blank. To be updated within future revisions.)

15   TELECOMMUNICATIONS NETWORKS

15.1   Related Documents

Reference	Title
BS 2782-3-326A - 326C	Methods Of Testing Plastics. Mechanical Properties. Determination of Tensile Strength And Elongation Of Plastics Films
BS EN 13101	Steps for Underground Man Entry Chambers. Requirements, Marking, Testing and Evaluation of Conformity
BS EN 187105	Single Mode Optical Cable (Duct/Direct Buried Installation)
BS EN 50290-2-21	Communication Cables. Common Design Rules And Construction. PVC Insulation Compounds
BS EN 50346	Information Technology. Cabling Installation. Testing Of Installed Cabling
BS EN 60793-2	Optical Fibres. Product Specifications. General
BS EN 60794-3-11	Optical Fibre Cables. Outdoor Cables. Product Specification for Duct, Directly Buried and Lashed Aerial Single-Mode Optical Fibre Telecommunication Cables
BS EN 61300-2-45	Fibre Optic Interconnecting Devices and Passive Components. Basic Test and Measurement Procedures. Tests. Durability Test by Water Immersion
BS EN 61386-24	Conduit Systems for Cable Management. Particular Requirements. Conduit Systems Buried Underground
BS EN 61753-021-3	Fibre Optic Interconnecting Devices and Passive Components. Performance Standard. Single-Mode Fibre Optic Connectors for Category U. Uncontrolled Environment
BS EN 61754-20-100	Fibre Optic Interconnecting Devices and Passive Components. Fibre Optic Connector Interfaces. Interface Standard for LC Connectors with Protective Housings Related To IEC 61076-3-106
BS EN 62134-1	Fibre Optic Interconnecting Devices and Passive Components. Fibre Optic Closures. Generic Specification
BS EN 61753-052-3	Fibre Optic Interconnecting Devices And Passive Components Performance Standard. Single-Mode Fibre, Pigtailed-Style Fixed Attenuators for Category U. Uncontrolled Environment
EIA/TIA-455-34	Interconnection Device Insertion Loss Test
EIA/TIA-455-59	Measurement Of Fiber Point Discontinuities Using An Otdr
EIA/TIA-455-60	Measurement Of Fiber Of Cable
EIA/TIA-455-61	Measurement Of Fiber Or Cable Attenuation Using An OTDR
EN 124	Gully Tops and Manhole Tops For Vehicular And Pedestrian Areas. Design Requirements, Type Testing, Marking, Quality Control
G.652.D	Characteristics Of A Single-Mode Optical Fibre And Cable
GR-771-CORE	Generic Requirements For Fiber Optic Splice Closures
NFPA 502A	Standard for Road Tunnels, Bridges, And Other Limited Access Highways
Telcordia SR-4731	Optical Time Domain Reflectometer (OTDR) Data Format
EIA/TIA-455-107-A	Fiber Optic Test Procedure: Return Loss
EIA/TIA-598-B	Colour Coding For Electrical Cable

ISO/IEC 11801	Information Technology – Generic Cabling for Customers Premises
IEC 61156-5	Multicore and symmetrical pair/quad cables for digital communications
BS EN 50173	Information Technology – Generic Cabling Systems. General Requirements

15.2   Equipment Overview

15.2.1   Purpose

1.   This section details the requirements and guidance for the design of telecommunication network equipment to meet the requirements for the ITS operation.

2.   The Telecommunications network shall be based upon internationally recognized open standards and shall accommodate technologies and protocols specifically for ITS. This will include National Transportation Communications for ITS Protocol (NTCIP) and Urban Traffic Management & Control (UTMC).

15.2.2   Scope of Document

1   This section will cover the requirements for the telecommunications network for ITS provision in the State of Qatar. The network is configured in such a way as to provide end to end connectivity for ITS in the following scenarios.

- Field to Field Connections
- Centre to Field Connections
- Centre to Centre Connections

2   The network shall comprise the following elements connected together in configurations appropriate to deliver the required service:

- Fibre Optic Cables
- Fixed line Transmission Equipment
- Wireless Transmission Equipment
- Data cables
- End devices

15.3   Non Functional Requirements

15.3.1   Reliability

1.   The telecommunications network equipment shall be designed to operate continuously for a service life of 15 years when used in the Qatar roadway.

2.   Individual items of equipment must have a Mean Time Between Failure (MTBF) of greater than 55,000 hours. This requirement will be monitored and recorded through the Clients ITS Asset Management system.

3.   The overall telecommunications network shall have an MTBF of greater than 500,000 hours.

15.3.2   Environmental

1.   The Telecommunications network inclusive of all of its cables and components both above and below ground must maintain full functionality and continue to operate within the limits of this specification when subjected to the working environment in the State of Qatar.

8.   All ITS equipment must maintain full functionality and continue to operate within the limits of this specification when subjected to the working environment of the State of Qatar.

9.   All equipment shall function and perform as per the specification in ambient temperatures ranging from 0°C to 55°C and in the range 0% -100% relative humidity in accordance with QCS.

15.3.3   Documentation

1.   Documentation certifying that all test equipment has been calibrated within twelve (12) months of the test date shall be provided and a copy of the submitted calibration documents shall be included with the test instrument.

15.4   Functional Requirements

15.4.1   Fibre optic cable requirements

1.   The fibre optic cable shall be all-dielectric, dry-filled, loose-tube, dispersion-unshifted, Single Mode Fibre (SMF) with low water peak, gel free, and suitable for underground outside plant installation.

2.   The fibre optic strands shall be splice-compatible with the existing dispersion-unshifted SMF and require no electronic equipment for dispersion compensation between new and existing fibre.

3.   The fibre optic cable strands shall be in accordance with

- The International Telecommunication Union (ITU-T) G.652.D,
- BS EN 60793-2 and
- BS EN 61300.

4.   Only optical fibres meeting the requirements presented in the below table shall be used.

Geometry	
Cladding Diameter	125µm, ±0.7 µm
Core-to-Cladding Concentricity	≤0.5 µm
Cladding Non-circularity	≤0.7%
Mode Field Diameter	1,550 nm; 10.4 µm, ±0.5 µm
Coating Diameter	245 µm, ±5 µm
Coloured Fibre Nominal Diameter	250 ±15 µm
Cabled Fibre Attenuation	1,310 nm, ≤0.4dB/km; 1,550 nm, ≤0.3dB/km; 1625nm, ≤0.25dB/km
Point Discontinuity	1,310 nm, ≤0.05dB/km; 1,550 nm, ≤0.05dB/km
Cable Cutoff Wavelength	≤1,260 nm. λ_{ccf}
Total Dispersion:	1,625 nm ≤23.0 ps/(nm•km)
Macrobend Attenuation Turns – 100	Outer diameter (OD) of the mandrel – 60 mm, ±2 mm; ≤0.05 dB at 1,550 nm
Cabled Polarization Mode Dispersion	<0.5 $ps/\sqrt{km}$
Cabled Fibre Attenuation	1,310 nm, ≤0.4dB/km; 1,550 nm, ≤0.3dB/km

Table 1 Fibre-Optic Optical Performance Requirements

5.   The fibre optic cable shall include loose buffer tubes that isolate internal optical fibres from outside forces and provide protection from physical damage as well as water ingress and migration. The buffer tubes shall allow for expansion and contraction of the cable without damage to internal optical fibre. Each fibre optic cable buffer tube shall contain 12 strands.

6.   The marking and color-coding of the fibres and buffer tubes shall conform to telecommunication industry requirements as detailed in

   •   TIA/EIA-598-B
   •   BS EN 60793-2

7.   The fibres shall be colored with UV curable inks that remain clearly distinguishable as the intended color.

8.   The fibre optic cable shall contain a dielectric central strength member and dielectric outside strength member to prevent buckling of the cable and provide tensile strength. The fibre optic cable shall withstand a pulling tension of 2,700 N without damage to any components of the fibre optic cable.

9.   The fibre optic cable shall contain a dry water-blocking material to prevent the ingress of water within the outer cable jacket. The water-blocking materials shall be non-nutritive,

dielectric, and homogeneous, and free from dirt and foreign matter. The dry water blocking compound shall be applied longitudinally around the outside of the central buffer tubes. The water-blocking material shall comply with the requirements of BS EN 61300-2-45.

10.   The fibre optic cable shall contain at least one ripcord under the sheath. The ripcord shall allow the removal of the sheath by hand or with pliers.

11.   The fibre optic cable shall include rods to lend symmetry to its cross section when necessary.

12.   The cable's outer jacket shall be marked with the manufacturer's name, fibre type, fibre strand count, date of manufacture, and cable length. The marking shall be legible and shall have a color that contrasts with the outer jacket's color.

13.   Cable for installation in tunnels shall meet the requirements of NFPA 502A.

14.   The fibre optic cable shall be capable of withstanding a minimum unloaded bend radius of 160mm, and a minimum loaded bend radius of 105mm to a pulling tension of 2,700 N. The bending of the fibre optic cable up to the minimum bend radius shall not affect the optical characteristics of the fibre.

15.   The fibre optic cable shall be capable of withstanding the tests for water penetration in accordance with BS EN 61300-2-45.

16.   Each drum of fibre optic cable shall have protective caps installed on the ends of the fibre optic cable. These shall be fitted upon completion of the cable manufacturing tests at the factory and shall not be removed until the cable is ready for splicing or termination.

15.4.2   Ethernet Data Cable requirements

1.   Twisted pair cable for carrying digital data signals. This type of cable is used in structured cabling for Ethernet data networks. The cable standard provides performance of up to 500 MHz for Category 6 (Cat6) and is suitable for Ethernet (10BASE-T), Fast Ethernet (100BASE-TX), and Gigabit Ethernet (1000BASE-T). The cable can also be used to carry other signals such as telephony and video.

2.   The cable shall meet the requirements of;

- ISO/IEC 11801
- IEC 61156-5
- BS EN 50173
- EIA/TIA 568.

3.   The cable shall be unscreened and shall consist of 4 symmetrical twisted pairs of copper conductors having the following characteristics;

- The conductors shall be 0.5mm diameter (24AWG)

- High Density Polyethylene (HDPE) insulation meeting the colour code requirements of EIA/TIA 568.
- A maximum conductor DC resistance of 95 ohms/km
- Impedance (1.0 – 250MHz): 100 ± 15ohms
- Pair to Ground Capacitance Unbalanced of less than 330 pF/100m
- Resistance Unbalanced of less than 5%
- An overall Low Smoke, Zero Halogen (LS0H) sheath of not less than 0.5mm wall thickness

4.   For external use (i.e. in ducts, ground mounted enclosures and ITS equipment), the cable shall have an extruded polyethylene outer sheath of not less than 1.8 mm wall thickness.

5.   Where the cable is to be installed in tunnels or other environments where fire is a recognised hazard, the outer sheath shall be made from a LS0H compound of not less than 2.0mm wall thickness. LS0H cable shall meet the flame resistant requirements of IEC 60332-3-24.

6.   Ethernet data cable shall be terminated at each end on a Registered Jack (RJ) 45 termination system. The cable shall be terminated using Insulation Displacement Connection (IDC) "punch-down" terminations. ITS equipment, Roadside controllers and telecommunication equipment shall all be interconnected using Cat6 patch-leads with RJ45 terminations on each end complying with EIA/TIA 568.

15.4.3   Fibre Optic splice enclosure requirements

1.   Fibre optic splice enclosures shall be installed where two or more cable ends need to be spliced.

2.   The splice enclosure shall provide storage for fibre splices, non-spliced fibre, and buffer tubes.

3.   The splice enclosure shall encase the sheath opening in the cable, and organize and store optical fibre strands.

4.   The splice enclosure shall provide splice trays and shall be expandable for future expansion.

5.   The splice enclosures shall comply with

- Telcordia Technologies' GR-771-CORE
- BS EN 62134-1 standards.

6.   The splice enclosures shall be selected in such a way that the appropriate number of fibre optic strands can be accommodated.

7.   Spliced fibres within a splice enclosure shall not be subjected to a bend radius smaller than 30 mm, and buffer tubes shall not be subjected to a bend radius smaller than 40 mm.

8.   The splice enclosure shall provide fibre optic cable penetration end caps to accommodate a minimum installation of two (2) trunk fibre optic cables and two (2) fibre optic drop cables. The caps shall have the appropriate diameter for the cable being spliced.

9.   The splice enclosure shall enclose all optical fibre splices within it. The splice enclosure shall not degrade the mechanical and environmental integrity of the fibre-optic cables enclosed in it.

15.4.4   Splice Tray requirements

1.   Splice trays shall be securely attached in the enclosure and be accessible at all times.

2.   The splice trays shall provide adequate storage for the fibre optic cable that is spliced and for unused fibres.

3.   The splice trays shall hold the buffer tubes rigidly in place and provide protection for fusion splices.

4.   The splice tray shall accommodate the minimum bend radius of the fibre optic strand.

5.   The splice tray shall include a clear plastic cover to allow visual inspection of the fibres stored within.

15.4.5   Fibre cable termination and connector assembly requirements

1.   The fibre optic cable terminations and connectors shall utilise type LC connectors and shall be designed for single mode 9/125 μm optical fibres.

2.   Unless where specifically required otherwise, or limited by available connector type at the terminated device, Angled Physical Contact (APC) connectors shall be used for all backbone connections. Physical Contact (PC) and other similar versions of related connector type(s) shall be used on spur connections, and on short-distance (local) connections.

3.   APC connectors shall have an end contact surface angled between 7.5 and 8.5 degrees (nominal 8 degrees). The return loss of mated pairs shall be 65dB or greater.

4.   PC connectors shall have an end contact surface angled between -0.3 and +0.3 degrees (nominal 0 degree). The return loss of mated pair shall be 50dB or greater.

5.   The fibre optic connectors shall meet requirements of

   •   TIA/EIA-568-A,
   •   TIA/EIA-604,
   •   BS EN 61753-021-3

   as applicable, and shall be tested according to the Telcordia/Bellcore GR-326-CORE standard.

6.   Buffer Tube Fan-out Kits shall be installed when fibre optic cables are terminated. A kit that supports 12 fibre strands which is compatible with the fibre optic cable being terminated and that is color-coded to match the optical fibre color scheme shall be used. .

7.   Where "pigtails" (pre-terminated cable assemblies) are utilised, these shall consist of single mode 9/125 µm optical fibres with factory-installed connectors on one end of the cable and an un-terminated optical fibre on the other. The pre-terminated connector assemblies shall be factory installed and 100% tested for insertion and return losses.   The fibre stand shall be protected by a tight buffer sheath to protect the fibre.

8.   Insertion loss of the pigtails shall be 0.2dB or less per connector using EIA/TIA-455-34 test procedure.

9.   Return loss of the product shall be 50dB or more per connector using

   •   TIA/EIA-455-107-A
   •   BS EN 61753-052-3.

10.   Pigtails used for termination of Out Side Plant (OSP) fibre optic cable shall be jacketed bundles each consisting of twelve (12) or six (6) fibre strands packaged in a common jacket.

11.   Pigtails used for direct termination into a device shall be jacketed bundles each consisting of one single (simplex) fibre strand or one pair (duplex) of fibres strands packaged in a common jacket.

12.   Unless where specifically required otherwise, the core jacket of the fibres in pigtail bundles shall conform to telecommunication industry requirements as detailed in

   •   TIA/EIA-598-B
   •   BS EN 61753-052-3.

13.   Fibre optic patch cords shall be single mode 9/125 µm optical fibres terminated to an LC fibre optic connector at both ends.

14.   Patch cords shall be jacketed bundles each consisting of one single (simplex) or one pair (duplex) fibres packaged in a common jacket. Unless where longer length is required to suit installation conditions or specifically required otherwise, patch cords shall be 2.0 m long.

15.4.6   Pre-Terminated Patch Panel requirements

1.   The pre-terminated patch panel shall be compatible with the fibre optic cable being spliced and its connectors. The patch panel shall be suitable for installation in an enclosure with mounting arrangements in accordance with

   •   EIA 310-D (480mm)
   •   IEC 60297

2. The pre-terminated patch panel shall have a minimum of 12 panel connectors. The connectors shall be factory-installed and terminated.

3. If required by the project design, patch panels which include splice trays can be used, to allow for cable termination within the cabinet or enclosure.

15.4.7 Fibre Optic Attenuator requirements

1. Fibre optic attenuators shall be passive (i.e. not requiring electrical power) devices that attenuate the optical signal power by a specified amount of dB and at related optical wavelength.

2. The connectors on fibre optic attenuators shall be factory assembled LC connectors. The connectors shall be of the female version.

3. Unless where specifically required otherwise, the fibre optic cable attached to the fibre optic attenuators shall have a maximum length of 1.0m.

4. Insertion loss of the fibre optic attenuator shall be 0.2dB or less per connector using EIA/TIA-455-34 test procedure.

5. The return loss of the fibre optic attenuator shall be 50dB or more per connector using EIA/TIA-FOTP-107 test procedure.

6. Fibre optic attenuators shall have fixed attenuation level of 1, 2, 5, 10, 15, 20, and 25dB for the used wavelength(s).

15.4.8 Optical Add-Drop Multiplexer and Wavelength Division Multiplexing

1. Optical Add-Drop Multiplexers (OADM) shall provide for shared use of a high-capacity Telecommunications channel(s) by multiple Telecommunications connections of lower speeds. The multiplexers shall support networking of similar units, interconnected via a set or sets of backbone optical fibres, thus establishing a network in which data streams from any of the devices connected to any multiplexer in the network can be routed to any other device connected to any part of the network.

2. OADMs shall include products which employ Wavelength Division Multiplexing (WDM) technologies. WDM OADMs shall be capable of supporting a minimum of multiple carrier wavelengths (colours) through the backbone connection, with data speeds of up to 40 Gbps per carrier wavelength (colour).

3. The OADM must include a chassis system with minimum 30% spare slots for future additions of optional interface modules and provide blank cover for all unused slot spaces.

4. The Chassis shall be suitable for installation in an enclosure with mounting arrangements in accordance with

   - EIA 310-D (480mm)
   - IEC 60297

5.   Management software for the proposed unit must be provided. The software functionalities shall include, but not limited to the following:

    a. management of OAMP (operations, administration, maintenance, and provisioning) functionalities
    b. management and presentation of site alarms and controls
    c. management and authentication of user credentials

6.   capability to save and restore system configuration information.

7.   Where possible with management configuration, inhibit all unnecessary communication paths among the network ports.

8.   OADMs and WDM OADMs shall support routing protocol based on TCP/IP or other protocols as approved specifically by the Client or the Client's nominated representative.

9.   OADMs and WDM OADMs shall be of modular design consisting of system cage or cages, plug-in modules for power supply, processors, management module, optional environmental monitoring modules, and optional interface modules. Optional interface modules shall include interface modules for trunk-line connection and for different types of add-drop connections. Interface modules for trunk-line connection shall support data speed of minimum 10Gbps per channel. Interface modules for add-drop connection shall include interface modules, as separate modules per kind, for serial (RS232, RS422, and or RS485) connections, 10BaseT, 100BaseT, 1GBaseT, and 10GBaseT Ethernet, and 1Gbps, 10Gbps Ethernet connections over fibre. Ports on the interface module shall auto-negotiate for speed.

10.   OADMs and WDM OADMs shall support Ethernet service, either as native platform or encapsulated over other Telecommunications platform. The supported Ethernet speed shall be 10 Mbps, 100 Mbps, 1 Gbps, or 10 Gbps as appropriate for the related interface module.

11.   OADMs and WDM OADMs shall support redundant-ring network topology, with self-healing recovery time of 50ms or less in case of a breach in the ring. Malfunction or power failure of a single OADM shall not cause other OADMs in the same network to fail.

12.   Interface modules for optical add-drop connection shall have transmit level and receive sensitivity level of such magnitude and combination that one module pair of the same model series, while maintaining bit error rate of $10E^{-12}$, will support transmission distance over a fibre optic connection of 10km, 20km, 40km, 80km as appropriate for the applicable signal power budget.

13.   Functional standards for the OADMs shall be

    •   IEEE 802.3 full-duplex operation;
    •   IEEE 802.1p priority queuing,
    •   IEEE 802.1w Rapid Spanning Tree Protocol,
    •   IEEE 802.1QVLAN, 802.3u,
    •   IGMP v3 (RFC#3376) multicast, SNMP.

14.   OADMs and WDM OADMs shall allow hot-swapping (insertion and removal of redundant power supply and interface module without causing disruption to regular functions) of interface modules while in full operation.

15.4.9   Erbium Doped Fibre Amplifier (EDFA)

1.   The EDFA shall amplify the optical signal without converting the incoming optical signal to electrical format as an intermediate step.

2.   Management software for the proposed unit shall be provided. The management software shall be capable of managing the product remotely from the TMC.

3.   The EDFA shall amplify the optical signal in the C-band (1530 to 1565nm) wavelength ranges.

4.   The EDFA shall allow user-adjustable gain of minimum 40dB for an input optical signal of -30dBm, with a top output level of up to +26dBm.

5.   The EDFA shall provide a minimum optical isolation of 30dB.

6.   The EDFA shall be equipped with LC/APC optical connectors.

7.   The EDFA shall be equipped with female 9-pin D shell RS232 connector for local monitoring and configuration.

15.4.10   Network Switches

1.   Network Switches shall be Open Systems Interconnection (OSI) Layer-2 or OSI Layer-3 Managed Ethernet Switch with redundant fibre optic backbone connections. The network switch design shall be fixed hardware configuration, stackable or chassis-modular hardware design. The network switch shall be capable of learning the MAC address of network devices attached to each port and optimizing data stream routing. Network switches used as nodes in a network with redundant paths (redundant-ring, mesh or other Telecommunications topologies) shall be equipped with multiple high-capacity (uplink) ports for connections with the adjacent Telecommunications network nodes.

2.   Management software shall be provided for all proposed network switches.

3.   The network switch shall inhibit all unnecessary communication paths among the network ports of the Ethernet switch with switch management configuration (where possible).

4.   The network switch shall have a minimum of five (5) RJ45 ports.

5.   The network switch shall support Rapid Spanning Tree Protocol (RSTP). The supplier shall demonstrate with simulated looped network paths that broadcast storm is effectively blocked with RSTP settings.

6.   Backbone connections between network switches shall be a minimum of two (2) km via single mode optical fibres.

7.   Local connections shall be RJ45 10BaseT/100BaseTx auto-negotiating ports.

8.   Switch Overhead shall be managed using SNMP protocol.

9.   The network switch forwarding method shall be "Store and Forward" with IEEE 802.3x flow control, and optionally "Cut-Through" method, with selectable intelligent mode for mixed use of both methods for optimum throughput rate.

10.   The network switch shall have a minimum address capacity of 2000 MAC addresses with automatic address learning, migration, and fixed or variable address aging duration.

11.   The network switch shall support a minimum of 255 VLANs.

12.   Buffer shall be minimum 128kbytes SRAM, 4Mbytes DRAM.

13.   The network switch shall have a maximum Redundant-Ring Recovery Time of 300ms.

14.   The network switch shall have a maximum latency of 8 μsec @100mbps.

15.   Functional standards supported by the network switch shall include

- IEEE 802.3 full-duplex operation;
- IEEE 802.1p priority queuing,
- IEEE 802.1w RSTP,
- IEEE 802.1QVLAN,
- IEEE 802.3u,
- IGMP v3 (RFC#3376) multicast.

16.   Where pluggable Local-Area-Network/Wide-Area-Network (LAN/WAN) interface is supported, the network switch shall allow hot-swapping (insertion and removal of module without causing disruption to regular functions) of LAN/WAN interface module while in full operation.

17.   Where more than four (4) devices of similar types of the same manufacturer are required in the same enclosure, the appropriate system rack, power module (modules), and accessories if and available as standard product by the manufacturer.

18.   Rack-mounted version shall be in accordance with

- EIA 310-D (480mm)
- IEC 60297

15.4.11   Network Router

1.   Network Routers shall be OSI Layer-2 or OSI Layer-3 managed routers with redundant fibre optic backbone connections. The network router design shall be fixed hardware configuration, stackable or chassis-modular hardware design. The network router shall interface with Ethernet and non-Ethernet Telecommunications connections, and it shall be

capable of learning the MAC address of network devices attached to each port and optimizing data stream routing. Network routers used as nodes in a network with redundant paths (redundant-ring, mesh or other Telecommunications topologies) shall be equipped with multiple high-capacity (uplink) ports for connections with the adjacent Telecommunications network nodes.

2.   Management software shall be provided for all proposed network routers.

3.   The network router shall be configured to inhibit all unnecessary communication paths among the network ports of the Ethernet switch with switch management configuration (where possible).

4.   The network router shall have as minimum 16 RJ45 ports.

5.   The network router shall support RSTP. Looped network paths shall be simulated to demonstrate that broadcast storm is effectively blocked with RSTP settings.

6.   The network router shall support and be equipped to implement Network Address Translation (NAT) functionalities.

7.   The network router shall support Link Aggregation Control Protocol (LACP) in accordance with:

- IEEE 802.3ad
- IEEE 801.1ax.

8.   Supported number of Link Aggregation Groups (LAGs) shall be minimum 16, and supported number of ports per LAG shall be minimum four (4).

9.   The network router shall be equipped to interface Telecommunications traffic of Ethernet and non-Ethernet protocols via WAN ports. Options for WAN ports shall include but not limited to dial-up telephone, E1, and 3G and 4G cellular services.

10.   The network router shall accept two (2) or more hot-swappable redundant power supply modules.

11.   The network router shall allow hot-swapping (insertion and removal of module without causing disruption to regular functions) of redundant power supply and LAN/WAN interface modules while in full operation.

15.4.12 Optical Small Form factor Plug (SFP) Module

1.   Optical SFP module shall be pluggable module for use with OADMs, network router and switches, amplifiers, network interface cards on computers and other similar devices. Optical SFP modules shall support data speed of 100Mbps, 1Gbps, or 10Gbps as appropriate, or as indicated in the detailed project specifications.

2.   Optical SFP modules shall be product(s) made by or officially approved by the same manufacturer of the device into which it is plugged into.

3.   Optical SFP modules shall be hot-pluggable (allow insertion and removal of module from the related device without causing disruption to regular functions of the device while in full operation).

4.   Optical SFP modules shall be equipped with two (2) female connector for 9/125µm single mode optical fibres per Telecommunications link. The fibre optic connectors shall be LC connectors.

5.   Optical SFP modules shall receive required power supply only through the plug-in port of the related device.

6.   Optical SFP modules shall support transmission distance of 10km, 20km, 40km, and 80km as appropriate for the applicable optical power budget.

7.   Optical SFP modules shall have transmit level and receive sensitivity level of such magnitude and combination that two (2) modules of the same model will support transmission distance of 10km, 20km, 40km, 80km as appropriate for the applicable power budget. The modules shall maintain a bit error rate of less than $10E^{-9}$.

15.4.13   Ethernet (10 Base-T/100Base-T) Media Converters

1.   Ethernet Media Converters shall be converters that interface between a copper-based 10Mbps or 100Mbps Ethernet connection(s) and a fibre-optic based 10Mbps or 100Mbps Ethernet connection(s).

2.   Configuration/management software shall be provided for the proposed media converter(s).

3.   Media converters shall be equipped or provided with suitable mounting hardware for installation on a 35mm steel DIN rail to EN 50022.

4.   Media converters shall support the following standards:

   - IEEE 802.3 10BaseT/100BaseTx
   - IEEE 802.3 10BaseFl/100BaseFx.

5.   Media converters shall be equipped with female RJ45 Telecommunications port and interface with 10Mbps/100Mbps Ethernet signal through this port.

6.   Media converters shall be equipped with two (2) female connector for 9/125µm single-mode optical fibres per Telecommunications link. The fibre optic connectors shall be LC connectors.

7.   Media converters shall interface with fibre-optic based 10Mbps/100Mbps Ethernet signal via the optical ports.

8.   Media converters shall perform with a bit error rate of less than $10E^{-9}$.

15.4.14   Terminal Servers

1.   Terminal servers shall be converters that interface between a copper-based RS232, RS422 or RS485 serial connection(s) and a 10Mbps or 100Mbps Ethernet connection(s). The Ethernet connection(s) may be copper-based or FO-based as appropriate for the application.

2.   Configuration/management software shall be provided for the proposed terminal server(s).

3.   Terminal servers shall be equipped or provided with suitable mounting hardware for installation on a

   *   35mm steel DIN rail to EN 50022.
   *   EIA 310-D (480mm)
   *   IEC 60297 equipment mounting.

4.   Terminal servers shall support the following standards:

   *   IEEE 802.3 10BaseT/100BaseTx,
   *   IP-ARP
   *   UDP
   *   TCP
   *   SNMP
   *   TFTP
   *   RS232
   *   RS422
   *   RS485.

5.   For copper-based Ethernet connection, terminal servers shall be equipped with female RJ45 communications port and interface with 10Mbps/100Mbps Ethernet signal through this port.

6.   For fibre-optic based Ethernet connection, terminal servers shall be equipped with two (2) female connector for 9/125µm single mode optical fibres per Telecommunications link, and interface with an Ethernet signal through this port. The fibre optic connectors shall be LC connectors.

7.   Terminal servers shall be equipped with a female 9-pin D-shell communications port for copper-based EIA RS232, RS422, or RS485 serial signal, as applicable, with control lines. The terminal servers shall interface with the relevant serial signal via this port. Data rate of the serial port shall be user selectable up to a minimum of 19.2Kbps.

8.   Terminal servers shall be equipped with minimum 256 Byte EEPROM for storage of configuration settings, and 128kByte RAM for operation.

9.   Terminal servers shall allow configuration through local programming port.

10.   Terminal servers shall support controls of the RTS, CTS lines.

11.   Terminal servers shall support XON/XOFF flow control through hardware.

12.   Terminal servers shall allow firmware update through the Ethernet or serial port.

13.   Terminal servers shall perform with bit error rate of less than $10E^{-9}$.

15.4.15 Transceivers

1.   Transceivers shall be converters that interface between one or one pair of signal format, at one side of the transceiver, and one other signal format, via a carrier medium suitable for long-distance transport, at the other side of the transceiver.

2.   Transceivers shall usually be used in pairs, with a (long-distance) transmission medium connected between the two. Transceiver type shall include, but not limited to the dial-up modems or RS232 to Unshielded twisted-pair (UTP) voice-grade telephone cable.

3.   Video transceivers shall be specialty converters that interface between two camera signal formats, analog video over 50-Ohm coaxial cable and PTZ serial signal via copper-based serial connection, at one side, and another signal format for long-distance transport, at the other side. Video Transceiver type shall include, but not limited to the following types:

    - Fibre optic video transceiver: serial/coaxial video signals to fibre optic strands.
    - T1 Video transceiver: serial/coaxial video signals to T1 telephone cable.

4.   Configuration/management software shall be provided for the proposed transceiver unit.

5.   The transceiver shall support the following standards:

    - IEEE 802.3 10BaseT/100BaseTx
    - EIA RS232
    - RS422
    - RS485.

6.   For copper-based Ethernet connection, the transceiver shall interface and be equipped with female RJ45 communications port for 10Mbps/100Mbps Ethernet signal.

7.   For fibre-optic based Ethernet connection, the transceiver shall be equipped with two (2) female connectors for 9/125μm single-mode optical fibres per Telecommunications link. The fibre optic connectors shall be LC form.

8.   Transceivers shall interface and be equipped with Telecommunications port for copper-based EIA RS232, RS422, RS485 serial signal, as applicable, with control lines, minimum data speed up to 19.2kbps.

9.   Transceivers shall perform with a bit error rate of less than $10E^{-9}$.

15.4.16 Secure Gateways

1.   The secure gateway shall be network interface equipped with ability to screen inbound and outbound data traffic for cyber threats, and direct data transport accordingly. Screening shall include user configurable features, including VPN, URL/port/MAC filtering, SQL code injection, Spyware Protection, intrusion prevention, Antivirus Scanning, HTTPS Scanning, IM/P2P Control and user reporting.

2.   Management software shall be provided for the proposed unit.

3.   A secure gateway shall be utilised as an edge switch between the ITS network and external networks.

4.   The secure gateway shall support and be equipped to implement Instant Message (IM) and Peer to Peer (P2P) filtering measures, granular bandwidth control (allocating maximum bandwidth per application), spyware protection, antivirus scanning, etc., for protection against threats from within the network.

5.   The secure gateway shall support and be equipped to implement NAT and advanced routing (OSPF, Multicast) functionalities.

6.   The secure gateway shall support and be equipped to implement protocol suites for securing IP Telecommunications, including but not limited to Internet Protocol Security (IPSec), Secure Sockets Layer (SSL), Transport Layer Security (TLS) and Secure Shell (SSH).

7.   The secure gateway shall support and be equipped to implement filtering of packets on combination of IP, port, and MAC addresses. This feature shall include allowance for user entry and edits of the white and black lists of the IP/port/MAC addresses.

8.   The secure gateway shall support and be equipped to implement stateless or stateful filters on internet protocol application layer.

9.   The secure gateway shall support and be equipped to implement adhoc filtering schemes, including scripts against SQL code injection, detection and alarming of attempts of automated (software directed) trials of user login credentials.

10.   The secure gateway shall support and be equipped to implement detection and annunciation of and protection against DoS (Denial of Service) attacks.

11.   The secure gateway shall support and be equipped to implement Point to Point Tunneling Protocol (PPTP), Layer 2 Tunneling Protocol (L2TP) and Generic Route Encapsulation (GRE) Virtual Private Network (VPN), combined with firewall and IPSec.

12.   The secure gateway shall support and be equipped with minimum four (4) 10/100Mbps Ethernet auto-negotiating ports via RJ45 connectors, and minimum one (1) 10/100Mbps WAN ports.

13.   The secure gateway shall support a minimum of 200 VPN tunnels.

14.   The secure gateway shall support a minimum firewall throughput of 100Mbps.

15.   The secure gateway shall be equipped with minimum 256 MB static memory and eight (8) MB flash memory.

16.   The secure gateway shall support overhead management using SNMP protocol.

17.   The functional standards of the security gateway shall be IEEE 802.3 full-duplex operation; 802.1p priority queuing, 802.1w Rapid Spanning Tree Protocol, 802.1QVLAN, 802.3u, IGMP v3 (RFC#3376) multicast.

18.   Product shall be rated for long-term operation under a minimum ambient temperature range of 0°C to 55°C, and relative humidity range of 5% to 100%, non-condensing.

15.4.17   Voice Telephony

1.   Telephone devices used for voice Telecommunications shall be based upon IP protocols. Telephony instruments shall be vandal proof.
2.   The inter-arrival packet delay for IP Telephony should not exceed 150ms.
3.   IP Telephony services will be regarded as Traffic Class 1, with the highest possible priority and Quality of Service (QoS).
4.   Voice telephony equipment deployed in tunnels must meet the requirements of NFPA 502A.

15.4.18   Requirements for services of Public Network Leased Lines

1.   This sub section is for the supply, installation and commissioning of a Telecommunications subsystem for Field to Control Centre communication that makes use of leased fixed line Telecommunications services, in accordance with the detailed project design drawings and/or specifications.

2.   The communication system shall consist of as a minimum (1) communication medium and (2) all necessary components to transmit over the medium.

3.   CSU/DSU for Data Service shall be transceivers used to connect a Data Terminal Equipment (DTE) device, to a digital circuit compatible with the commercial data services offered in the deployment area. The data service shall be an IP digital data service.

4.   The IP data service will utilise a fixed IP address as opposed to a dynamic address.

5.   The CSU/DSU shall support data speed of up to 10Mbps or 100Mbps.

6.   The CSU/DSU shall be equipped with data-line surge protector.

7.   The CSU/DSU shall support and be equipped with minimum one (1) RJ45 10BaseT port for connection to Ethernet hosts.

8.   The CSU/DSU shall support and be equipped with one Telecommunications port for configuration.   The configuration port shall be DB9/RS232, USB type A, RJ45 10BaseT/100BaseTx or as approved by the Client or the Client's nominated representative.

9.   The CSU/DSU shall have typical MTBF of minimum 850000 hours.

10.   The CSU/DSU shall have an enclosure rated IP54 or higher.

11.   It is the responsibility of the leased line service provider to provide test results for the service up to the service delivery point. The service delivery provider must provide Ashghal with the IP address of the service termination point.

12.   Testing of the application over the IP service will be undertaken in conjunction with the service desk at the Traffic Signal Control Room or at the TMC

15.4.19 Wireless Communication requirements

1.   This sub-section is for the supply, installation and commissioning of a Telecommunications subsystem for Field to Centre or Field to field communication that makes use of leased wireless cellular data services, in accordance with the detailed project design drawings and/or specifications.

2.   The communication system shall consist of as a minimum (1) a communication medium, and (2) all necessary components to transmit over the medium.

3.   Cellular data transceivers shall be data radio compatible with the commercial 3G or 4G cellular data services offered in the deployment area.

4.   Management software shall be provided for all proposed equipment.

5.   An antenna appropriate and antenna cable shall be provided. The antenna and cable shall be appropriate for the frequency band used by the cellular data system and shall be mounted in such a way that it cannot be interfered with.

6.   When the antenna is mounted outside an ITS enclosure, the appropriate surge suppressor for the antenna connection shall be provided.

7.   The wireless antenna and receiver shall support HSPA/EDGE/GPRS cellular technologies, or newer 4G/LTE where such service is available in the deployment area.

8.   The wireless antenna and receiver shall support and be equipped to implement NAT, GRE tunneling, URL/MAC filtering.

9.   Product shall support and be equipped with minimum one (1) SIM card.

10.   Product shall support and be equipped with one (1) female 50-Ohm BNC or SMA connector for connection with an external antenna.

11.   Product shall support the frequency band used by the cellular data service available in the deployment area.

12.   Product shall transmit at up to 26dBm minimum (user tunable), and has receiver sensitivity of -108dBm or lower.

13.   Product shall support and be equipped with minimum two (2) RJ45 10BaseT/100BaseTx auto-negotiating ports for connection to Ethernet hosts. Product shall be capable of supporting the maximum data throughput rate afforded by the cellular data service available in the deployment area.

14.   Product shall support and be equipped with one communications port for configuration. Configuration port shall be DB9/RS232, USB type A, RJ45 10BaseT/100BaseTx or as approved by the Client or the Client's nominated representative.

15.   Product shall have typical MTBF of minimum 55,000 hours.

16.   Product shall support MAC and SSL based authentication, AES 128/256 triple DES with CBC-MAC encryption.

17.   Product shall support RTP/IP, UDP/IP, TCP/IP, HTTPS, VRRP, NTP, DNS, DHCP, ARP, WDS protocols.

18.   Functional standards shall be:

    a.   IEEE 802.3 full-duplex operation
    b.   802.1p priority queuing
    c.   802.1w Rapid Spanning Tree Protocol
    d.   802.1QVLAN, 802.3u
    e.   IGMP v3 (RFC#3376) multicast.

19.   Product enclosure rating shall be IP67 or higher.

20.   Antenna for cellular data transceivers shall be omni-directional antenna for mobile ITS deployments, and directional antenna for stationary permanent ITS deployment. The antenna shall be designed specific for the radio frequency band employed by the applicable cellular services.

21.   Omni-directional antenna shall have antenna gain of 3dBi in a 10-degree cone in all horizontal directions. Directional antenna shall have antenna gain of 3dBi in a 10-degree cone in the aimed direction.

22.   Surge suppression equipment shall be provided inside the related equipment cabinet, on the antenna cable for antenna mounted outdoor, outside the cabinet. The surge suppressor shall be earthed to appropriate earthing system via copper conductor of minimum 6mm^2 effective size.

23.   A connector shall be used, designed for 50-Ohm coaxial cable through cabinet wall for all antenna cable route through the cabinet wall(s). The connector shall be equipped with appropriate gasket to prevent ingress of water and solid particles through the penetration.

24.   Installation techniques shall be used such that the transmission and mechanical characteristics of the used products are not degraded and meet the installation standards expected by the respective manufacturers, unless otherwise approved by the Client or the Client's nominated representative.

25.   Antenna cable shall be installed in such a way that neither the minimum bending radius nor the allowable pulling tension are violated during or after installation.

26.   The installation must be inspected and approved by the Client or the Client's nominated representative.

27.   Continuous cable runs between allowable termination points through and in equipment enclosures shall be used; termination or splicing of the cable outside of these explicit termination points are not permitted.

28.   Refer to ITS Specifications, General Provisions for ITS, except where otherwise stated in the articles below. The intent of this testing is to confirm performance compliance of individual components, of interconnected components as single entity (subsystem) at each deployment site, and of interconnected subsystems as a single integrated overall system.

29.   Testing of this subsystem consist of verifying related installation based on applicable standards, approved shop drawings, verifying performance of installed devices involving some or all of the test methods listed in the following sections.

30.   Compliance of performance requirement of individual hardware shall be verified by means of comparing specific performance data as described in manufacturer's data sheet, product certifications, and other relevant shop drawings against detailed project design specifications.

31.   Compliance of visible physical property requirements of individual hardware shall be verified by means of comparing related manufacturer's data sheet, product certifications, relevant shop drawings, and visual verification of the product against detailed project design specifications.

32.   Compliance of performance requirement of integrated subsystems, as single entities, shall be verified by means of observation and measurement of relevant performance parameters.

33.   Perform Received Signal Strength Indication (RSSI) testing as per instruction of the modem manufacturer, adjust orientation and/or elevation of related antenna, or replace the antenna with product having higher antenna gain as applicable. Measured RSSI must be at least 3dBm higher than the receiver sensitivity of the modem to be considered acceptable.

34.   Test forms for individual and group of test items to facilitate documentation of test results shall be proposed to the Client or the Clients representative. The test forms shall include

related test objectives, Pass/Fail Criteria originate from the related columns in the detailed project design specifications.

15.5 Power Requirements

15.5.1 General

1. Where a power adapter is required for dedicated use by a device, the power module shall be designed for continuous long-term operations at the temperature range of the related electronic device. A dedicated power supply termination point shall be provided for each power module, including power-distribution terminal blocks and power receptacles. The termination points shall be labeled with the identity of the correspondent electronic device.

2. One set of applicable spare fuses for each device in the related ITS enclosure shall be provided. The number of spare units shall be equivalent to 10 percent of the used quantity, but not less than two (2) of each type and size.

3. A UPS shall be provided and installed within the ITS enclosure where all device and hub Telecommunications devices are located, as shown in the detailed project design drawings. The UPS system shall be capable of operating all of the telecommunications equipment and ITS equipment for a minimum of four (4) hours.

4. Earthing for all equipment shall be in accordance with

    - BS 7671
    - BS 7430
    - QCS.

15.6 Hardware Design Requirements

15.6.1 Fibre Optic Cable installation

1   Fibre optic cable shall be installed in the duct shown in the detailed design drawings and shall meet

    - BS EN 60794-3-11
    - BS EN 187105.

2.   It shall be verified that the duct and its inner-duct (if used) are free from damage prior to the installation of the cable.

3. Installation techniques shall be employed that ensure that the optical and mechanical characteristics of the cable are not degraded. Unless otherwise approved by the Client or the Client's nominated representative, use only the equipment and procedures specified by the manufacturer of the fibre optic cable.

4.   The cable shall be installed in such a way that neither the minimum bending radius nor the allowable pulling tension is violated during installation.

5.   The Client or the Client's nominated representative shall be provided with four (4) copies of the cable manufacturer's recommended maximum pulling tension for each cable size and type before the installation. These pulling tensions shall be specified for pulling from the cable's outer jacket.

6.   A list of pulling lubricants approved by the cable manufacturer and guidelines for their application shall be provided to the Client or the Client's nominated representative.

7.   The installation system to be used must be inspected and approved by the Client or the Client's nominated representative.

8.   The fibre optic cable(s) shall be labelled with tags approved by the Client or the Client's nominated representative. The tags shall be installed on the cable within the splice chamber indicating the cable type, fibre counts, and shall be permanent tags. The lettering of the tags shall be permanent ink.

9.   The fibre optic cable slack at ITS chambers shall be coiled in a figure eight pattern. A cable slack of 15m shall be provided at ITS chambers, and 60m at ITS splice chambers, where 30m shall be provided at each side of the cable splice point.

15.6.2   Requirements for installation of fibre optic cables in buried ducts

1.   Fibre-optic cables shall be installed in inner duct inside the duct if the total of the cross-section areas of the installed cable(s) is less than 40% of the internal cross-section area of the duct, as agreed with the Client or the Client's nominated representative.

2.   The material of the inner duct shall be made of HDPE. The inner duct shall consist of two or more inner duct cells. Provide nylon pull tape in each unused inner duct cell. The used inner duct product must be specifically designed for use as inner duct.

3.   One tracer wire shall be installed in each duct. The tracer wire conductor shall be made of copper, with a wire size of minimum $2mm^2$.

4.   Only approved lubricant shall be used in the amount recommended by the cable manufacturer to facilitate pulling the cable.

5.   Cable ends shall be sealed at all times during installation, using an approved cable end cap. Tape shall not be used to seal the cable end. The cable ends shall remain sealed until termination takes place.

6.   The allowable pulling tension shall be 70% of the manufacturer's maximum pulling tension for pulling by the outer jacket. The allowable pulling tension shall not be exceeded at any time during cable installation by using one of the following methods, as approved by the Client or the Client's nominated representative.

7.   If the fibre optic cable is pulled by mechanical means, a torque-limiting clutch device shall be used to ensure the allowable pulling tension is not exceeded. Also, a strain gauge shall be attached to the pulling line at the cable exit location, and at a sufficient distance from the take-up device, such that the strain gauge can be read throughout the entire cable pulling operation. The torque-limiting clutch device and the strain gauge must have been calibrated within 12 months at the time of use.

8.   Fused swivels that are designed to break when the applied load exceeds the allowable tension set at 70% of the strength of the fibre optic cables are also acceptable.

9.   Every precaution shall be taken to ensure that the cable is not damaged during storage and installation. Workers shall not step on the cable or run over it with any vehicle or equipment. The fibre optic cable shall not be pulled along the ground, over edges or corners, over or around obstructions, or through unnecessary curves or bends. The Approved cable guides, feeders, shoes and bushings shall be used to prevent damage to the cable during installation. Any fibre optic cables that are damaged shall be replaced or reinstated at no additional cost to the Client.

10.   Cable shall be installed in continuous runs between allowable termination points in equipment enclosures; termination or splicing of the cable outside of these explicit termination points are not permitted.

11.   Fibre optic cable shall not be pulled around any bends smaller than 20 times the cable diameter when under load and 10 times the cable diameter at no load, but in no case smaller than 12 times the cable outside diameter. Entrances in and out of ducts and enclosures shall be made smooth so as not to damage the cable sheath.

12.   Fibre optic cable may be pulled through intermediate chambers to facilitate easier installation.

13.   The necessary length of cable to be installed shall be pulled from one splice enclosure to the immediate next downstream splice enclosure.

15.6.3   Fibre Optic Splicing requirements

1   Cable shall be spliced at the ITS chambers only at the locations shown in the detailed project design drawings. Fusion splicing technique shall be used.

2   The splicing machine shall be capable of splicing fibres with a 250µm coating. The machine shall have the capabilities of measuring the splice loss, have a sleeve heater, a battery charger and a built in power meter.

3   Optical bi-directional average splice loss shall be less than 0.15dB

4   Cables shall be spliced as shown in the detailed project design drawings (i.e. buffer tubes and fibre colors shall match with the splicing plan).

5   Cables entering and exiting the splice enclosure shall be labeled with the cable destination.

6   A splicing plan shall be provided for the approval of the Client or the Client's nominated representative.

7   The splice location shall be documented identifying the source and destination of each fibre in each splice tray. The buffer tubes and fibres used during the installation of the splices shall also be documented.

8   The splice enclosures shall be secured to the wall of the ITS splice chamber to avoid laying out the enclosure at the bottom of the chamber.

15.6.4   Fibre Optic Termination requirements

1.   Optical bi-directional average splice loss shall be less than 0.15dB.

2.   The fibre optic cable shall be terminated as indicated in the detailed project design drawings. All terminations shall only be performed in equipment enclosures, or in splice enclosure. Terminate all fibres that are not utilised at a particular enclosure and cap unused fibres that end in an enclosure.

3.   All fibre terminations shall be made by splicing the fibre strand to factory connectorised pigtails using fusion splicing only. The pigtails shall be tight-buffered and strengthened with aramid to reduce the possibility that accidental mishandling will damage the fibre or connection. The pigtails shall be equipped with fibre optic connectors with ceramic ferrules, unless otherwise approved by the Client or the Client's nominated representative. The size and optical characteristics of the glass core of the fibre in the pigtail shall exactly match those of the fibre to which the pigtail is spliced.   All fibre optic connectors, whether on pigtails or equipment, shall be labelled to preclude improper connection. The labeling method(s) must be approved by the Client or the Client's nominated representative prior to use.

15.6.5   Fibre Optic Cable Testing requirements

1.   Refer to ITS Specifications, General Provisions for ITS, except where otherwise stated in the articles below. The intent of this testing is to confirm performance compliance of individual components, of interconnected components as single entity (subsystem) at each deployment site, and of interconnected subsystems as a single integrated overall system.

15.6.6   ITS Draw Chambers and Ducting

1.   Draw chambers that have the dimensions shown in the detailed design project drawings shall be installed. Any changes must be approved by the Client or the Client's nominated representative.

2.   The ITS draw chamber shall be constructed with the materials shown in the detailed design project drawings and be in accordance with QCS.

3.   The length, width, and depth of the draw chamber shall conform to the dimensions shown in the detailed design project drawings. The depth of the chamber may be modified

according to the detailed design project drawings in order to suit the depth of the ducts entering and exiting the draw chamber.

4.   The ITS draw chamber shall have a frame and cover that complies with the requirements of BS EN 124 and be marked according to Client's Civil and Structural Standards for Intelligent Transportation System (ITS).

5.   The maximum distance between draw chambers in a straight run shall be 250m.

6.   ITS draw chambers are required where there is a change of direction of greater than 22.5 degrees.

7.   A pulling ring (pulling Anchor) shall be attached to the reinforcing material, cast and fixed opposite of each duct entrance shall be provided in each draw chamber.

15.6.7   ITS Lateral Chamber Requirements

1.   Lateral chambers that have the dimensions shown in the detailed design project drawings shall be installed. Any changes must be approved by the Client or the Client's nominated representative.

2.   The ITS lateral chamber shall be constructed with the materials shown in the detailed design project drawings and be in accordance with QCS.

3.   The length, width, and depth of the draw chamber shall conform to the dimensions shown in the detailed design project drawings. The depth of the chamber may be modified according to the detailed design project drawings in order to suit the depth of the ducts entering and exiting the draw chamber.

4.   The ITS lateral chamber shall have a cover that meets BS EN 124 and be marked according to The Client's Civil and Structural Standards for Intelligent Transportation System (ITS).

5.   The maximum distance between lateral chambers in a straight run shall be 100 m.

6.   ITS lateral chambers are required where there is a change of direction of greater than 22.5 degrees.

15.6.8   Chambers removal Requirements

1.   Where indicated in the detailed design project drawings, the ITS chambers shall be removed and the ground reinstated to a condition acceptable to the Client or the Client's nominated representative.

2.   Cables in the chamber shall be protected against damage. Utility owners of cable connected for live operations shall be notified that the chamber is being removed. In the event damage occurs, the utility owner shall be notified and repair the damage immediately. The fibre-optic cables shall be tested upon completion of the removal and construction of the chambers to verify that the OTDR measurements indicate that the

fibre-optic cable is acceptable per Ashghal ITS Specifications. The waste material arising from the demolition shall be disposed of in approved designated areas.

15.6.9 Underground Duct

1.   100mm High Density Polyethylene (HDPE) ducts suitable for underground installation for both electric power and Telecommunications shall be provided and installed. Product data sheets shall be submitted for review and approval from the Client or the Client's nominated representative.

2.   The ducts for underground installation shall be resistant to chemical elements such as benzene, and shall be protected against material degradation due to oxidation or corrosion.

3.   A polypropylene pull rope shall be provided and tied off in each duct. The breaking strength for the provided rope shall not be less than 8kN.

4.   The underground duct shall be constructed with the materials shown in the detailed design project drawings and be in accordance with :

- BS EN 61386-24
- BS EN 50290-2-21
- QCS.

15.6.10 Marker Tape for Underground Fibre Optic Cables

1.   Marker tape shall be installed wherever cables are to be directly buried in the ground to warn of the presence of fibre optic cables.

2.   The marker tape shall be of low density polyethylene, of thickness at least 100 micron. Its width shall be 400mm and be orange in colour, with black marking indicating the presence of fibre optic cable in both English and Arabic. Its location in respect of the cable position is identified within the Contract documentation

3.   The material shall be colour fast, and resistant to chemical action in typical ground conditions experienced in Qatar. These may vary from extremely wet to extremely dry, and with very high salinity. The ground temperature may vary from 0 to 40°C

4.   The material shall be mechanically durable. The manufacturer shall demonstrate the samples complying with this specification have been tested for compliance with BS 2782, Part 3, Method 326A to 326C or an equivalent standard.

15.6.11 Aboveground Duct

1.   Rigid Galvanized Steel (RGS) duct shall be supplied and installed for above-ground installations.

2.   RGS duct shall be for long-term use above ground and protected against material degradation. Product data sheets shall be submitted for review and approval from the Client or the Client's nominated representative.

3.   A polypropylene pull rope shall be provided and tied off in each duct. The breaking strength for the provided rope shall not be less than 8kN

4.   The aboveground duct shall be constructed with the materials shown in the detailed design project drawings and be in accordance with QCS.

15.6.12   Underground Duct – Installation Requirements

1.   Underground ducts shall be encased in concrete as indicated in the detailed design project drawings. In those instances where a new duct is added, the new duct run shall be longitudinal to the existing duct run.

2.   Ducts shall be protected against the ingress of concrete by protecting the duct terminations when pouring the concrete.

3.   All ducts shall be tested by the pulling through of a brush and mandrel. The brush shall be circular in diameter and designed for duct cleaning. The diameter of the brush shall be 110% that of duct being tested and cleaned.

4.   The mandrel used for duct testing shall be made from iron or steel and shall 93% the diameter of the duct being tested. The mandrel shall be a minimum of 240mm long

5.   Trenches shall be restored to an acceptable condition as approved by the Client or the Client's nominated representative.

6.   A polypropylene cord shall be installed inside the ducts or inner-duct .

7.   The ingress of debris, sand, or other material into the duct and/or innerduct shall be prevented.

15.6.13   Aboveground Duct – Installation Requirements

1.   Aboveground ducts or conduit shall be securely attached to structures, walls, decks, or any other surface as indicated in the detailed design drawings. Fixings suitable for the product and the mounting surface shall be used to secure the RGS ducts to the surface. Bushings appropriate to the duct or conduit, as recommended by the manufacturer shall be used at the end of the RGS ducts.

2.   A polypropylene cord shall be installed inside the ducts or innerduct to facilitate the pulling of the electrical or Telecommunications cable.

3.   The ingress of debris, sand, or other material into the duct and/or innerduct shall be prevented.

15.6.14 Optical Time Domain Reflectometer (OTDR) testing requirements

1.   OTDR measurements shall be performed after the installation of the fibre optic cable(s), based on

- EIA/TIA-455-59
- EIA/TIA-455-60
- EIA/TIA-455-61
- EIA/TIA-455-34
- BS EN50346.

2.   OTDR tests shall involve tests using OTDR on the fibre-optic circuits, excluding any attenuators, and electronic device(s) based on

- EIA/TIA-455-59
- EIA/TIA-455-60
- EIA/TIA-455-61
- EIA/TIA-455-34
- BS EN50346.

3.   OTDR Tests shall be carried out on all fibres in the cable, in both directions at all wavelengths specified in the design Proposal. As a minimum, all of the fibres will be tested at 1310 nanometers (nm) and 1550nm.

4.   The Client, or the Client's representative shall be informed of when the OTDR testing is to be undertaken so that they can arrange witnessing of the testing.

5.   The following procedure outlines the key steps for performing the OTDR Test. The tests shall be performed with environmental conditions as recommended in TIA/EIA-455-B during testing. Pre-connectorized pigtails shall be terminated on both ends of tested fibre prior to testing.

6.   The OTDR shall be capable of recording and storing the fibre test results in Telcordia SR-4731 OTDR Data Format.

7.   OTDR testing shall be performed from each end of the cable. Single end OTDR testing shall not be accepted for installed cables.

8.   OTDR – Test documentation shall include:

- Cable ID

- Cable Location: begin and end point

- Fibre ID, including tube and fibre colour

- Operator name

- Date and Time

- Setup Parameters, including cable characteristics, optical wavelengths, pulse width, range and scale.

8.   OTDR – Test results shall include:

- Total fibre trace

- Splice loss/gain

- Marking of optical events >0.10dB

- Measured Length (cable marking)

- Total Length (OTDR measured).

9.   An optical fibre is considered acceptable if all of the following requirements are met:

- Individual bi-directional average splice loss is less than 0.15dB per splice

- No single direction loss can be greater than 0.20dB

- Connector loss is less than 0.75dB per mated connector pair. Where the installed fibre-optic connector assembly terminates onto a connector at a fibre-optic device, and the said mating device connector is not separable from the device, then the insertion loss of the single installed fibre-optic connector assembly shall be less than 0.35dB

- Connector return loss (connector reflectance loss) is less than -55dB per mated connector pair

- Optical power loss introduced by unexpected loss events, such as those caused by micro-bending, pinching and sharp bends in fibre, is less than 0.5dB per cause, and the total loss introduced by such causes, combined, is less than 1dB. All power losses not attributable to planned connectors and splices are considered unexpected loss events.

10.   A hard copy and an electronic copy of OTDR traces shall be provided to the Client or the Client's nominated representative.

11.   The OTDR, optical power meter, light source and all instruments used for testing of the fibres shall be calibrated. All test instruments shall be calibrated within twelve (12) months prior to use. Documentation certifying that all test equipment has been shall accompany the test instrument and a copy shall be submitted with the test results.

12.   Personnel conducting OTDR and optical power testing must have been trained and be experienced with the test procedures to be utilised for fibre optic cable testing.

13.   The test instruments shall operate with wavelengths of 1300 and 1550nm. The optical power meter shall have a decibel milliwatt measurement scale with a range of +3 to -45dBm for SMF operation and an accuracy of 0.5dB or better.

15.6.15 Optical Power Meter Testing Requirements

5.   Optical Power meter testing shall be undertaken on all fibres in both directions at the wavelengths specified in the design proposal. As a minimum, all of the fibres will be tested at 1310nm and 1550nm.

6.   The Client or the Client's representative shall be informed of when the optical power meter testing is to be undertaken so that they can arrange witnessing of the testing.

7.   The tests shall be undertaken in accordance with the equipment manufacturer's specifications.

8.   The bidirectional tests shall be recorded and the two way loss shall be used as the pass/fail result. The following details the information required.

- Fibre number
- Fibre Colour
- Buffer Tube
- Length (m)
- Limit (dB)
- Loss (dB)
- Pass/ Fail
- Comments

9.   In the event of fibres failing the OTDR and Power tests by being outside the optical budget, an acceptable resolution must be proposed to the Client or the Client's representative.

10.   Air Leak Test shall be undertaken on all splice enclosures after related splice work is completed. The Air Leak Test is intended to demonstrate that the related splice enclosure is leak proof after the installation is completed. A sample of these tests will be witnessed by the Client or the Client's representative.

16   TUNNELS

16.1   Related Documents

Reference	Title
RFC3261	Open SIP Standards
Recommendation P.37	International Telecommunications Union –Telecommunications (ITU-T)
ETS 300-381	Telephony for hearing impaired people; Inductive coupling of telephone earphones to hearing aids
Standard 502A	National Fire Protection Association (NFPA). Road Tunnels, Bridges and other Limited Access Highways.
BS EN 124	Gully tops and manhole tops for vehicular and pedestrian areas. Design requirements, type testing, marking, quality control
2004/54/EC	Directive 2004/54/EC of the European Parliament and of the Council of 29 April 2004 on minimum safety requirements for tunnels in the Trans-European Road Network
IEC 60331	Tests for electric cables under fire condition
IEC 60332	Tests on electric and optical fibre cables under fire conditions

16.1.1   Purpose

1.   This section is for the design and implementation of ITS equipment in tunnels, where a road tunnel is a subsurface or enclosed highway structure of a length greater than 90m with limited access and egress.

16.1.2   Configuration

1.   The operational equipment requirements for road tunnels will vary with length, locations, traffic volumes and vehicle speeds.

2.   For tunnels where there is airflow and access between carriageways, i.e. a long underpass, this will be regarded as a single zone.

3.   For tunnels with separate bores i.e. with no natural airflow or direct access between carriageways, each bore will be regarded as a separate zone.

2.   The configuration of the ITS equipment for tunnels will be as a result of the operational regime for the tunnel including the following aspects;
- road layout
- tunnel length
- number of bores
- number of lanes
- cross-sectional geometry
- vertical and horizontal alignment

- type of construction
- Contra-flow requirements
- traffic volume per bore (including its time distribution)
- risk of congestion (daily or seasonal)
- access time for the emergency services
- presence, percentage and type of dangerous goods traffic
- characteristics of the access roads
- lane width
- speed considerations
- geographical and meteorological environment.

4.   Operational activities in road tunnels include: ventilation, fire safety, lighting, drainage, tunnel control and traffic control. All of these activities can be automated however their operation requires to be fully coordinated and elements cannot be operate in isolation.

5.   Of overriding concern in road tunnels is the safety of the tunnel users and those responsible for operating and maintaining the tunnel. The prevention of fire is of prime concern and ITS technologies shall be deployed that minimise the risk of a fire starting and identify vehicles that pose a high risk to the tunnel.

6.   The safety or road users in the tunnel is also of concern and ITS measures common to normal roadway applications shall be used however the quantities and configurations will change to reflect the different conditions encountered.

16.1.3   Exclusions

1.   This specification details the requirements for ITS in tunnels. The following items are excluded as they are not ITS specific;
- Fire detection
- Drainage
- Ventilation
- Lighting
- Fire fighting equipment
- Electrical supplies
- Stand-by electrical supplies
- Fixed signs

2.   These systems whilst outside the remit of ITS shall be integrated into the tunnel control and management system along with the ITS.

16.2   Requirements

1.   The document provides information on the general considerations, design and operational requirements of ITS for road tunnels, together with details of the maintenance and operational aspects involved.

2.   Specifications for the equipment to be deployed in tunnels are documented separately but are referred here.

3.   Each tunnel will need to be regarded as unique and as such there is no prescribed level of ITS equipment that shall be installed in the tunnel. ITS deployment will be as a result of the operational requirements of the tunnel, corridor management procedures and its surrounding roadway network.

16.2.1   General Tunnel ITS Requirements

1.   National Fire Protection Association (NFPA) Standard 502A stipulates that tunnels longer than 90m shall have a means of preventing approaching traffic from entering the tunnel in the event of a fire.

2.   NFPA 502 also stipulates that tunnels longer than 240m shall be provided with
   •   a means to stop traffic entering the tunnel in the event of a fire
   •   the means of controlling traffic within the tunnel
   •   the means to clear traffic downstream of the fire site following activation of the fire alarm.

3.   ITS in tunnels will be managed and controlled from the TMC. During tunnel maintenance, local control will be managed from the tunnel control building through liaison with the TMC.

4.   Equipment in tunnels will be controlled by a combination of Supervisory Control and Data Acquisition (SCADA) and ITS. The identification of which system will interface with which equipment will be provided in the Concept of Operations for the Tunnel.

5.   Cable route chambers shall have frames and covers of D400 rating in accordance with BS EN 124.

6.   All ITS equipment within the tunnel and on the tunnel approached shall be connected to two diverse power and two diverse Internet Protocol (IP) telecommunications systems to provide a suitable levels of resilience.

7.   ITS equipment deployed in tunnels shall be capable of operating in ambient temperature s between 5°C and 55°C

8.   Road Tunnels shall have direct means through the use of barriers and signal lights, of stopping approaching traffic entering the tunnel in the event of an incident.

9.   The operation of ITS equipment installed in the tunnel shall be coordinated with the local ITS equipment outside the tunnel such that the system provide road users with complimentary and not contradictory information. This will be particularly important for the implementation of diversions during tunnel closures or incidents.

10.   A range of ITS technologies is available which can be deployed on the approach and within the tunnel. These deployments shall be done in an appropriate combination to provide extremely high levels of detection. These technologies include, but are not limited to:

(a)   Automatic Incident Detection (AID) Systems (see section 3)
(b)   Closed Circuit Television (CCTV) cameras (see section 4)
(c)   Traffic detectors (see section 3)
(d)   Heat detection (see section 4)
(e)   Roadway Weather Information Systems (RWIS) (see section 5)
(f)   Overheight Vehicle Detection System (OVDS) (see section 6)
(g)   Lane Control Signs (LCS) (see section 10)
(h)   Speed control Signs (SCS) (see section 10)
(i)   Emergency Telephones (see this section)
(j)   Dynamic Message Signs (DMS) (see section 8).

16.2.2   Automatic Incident Detection Systems

1.   AID systems shall be used to provide warning of incidents and events that will require action to be taken. The action will range from providing driver information through to complete tunnel closure and evacuation.

2.   AID systems shall be used to detect:

(a)   Stopped traffic
(b)   Pedestrians and animals
(c)   Wrong way traffic
(d)   Debris and lost cargo
(e)   Heat and fire
(f)   Smoke.

3.   AID systems shall be selected to meet the operational requirements of the tunnel and its approaches. The equipment shall be suited to the type and volumes of traffic that the tunnel will accommodate.

4.   The telecommunications equipment used for the AID equipment must be suited to the video signal protocols. AID systems can use either analogue or digital systems.

5.   AID will primarily be based around the use of video systems with other non-video based products as support systems.

16.2.3   CCTV and other cameras

1.   CCTV shall be used to provide 100% constant coverage of the tunnel and its approaches/exits. Both fixed and PTZ type of CCTV shall be used. The cameras shall meet the optical requirements of this specification.

2.   Where emergency exits and tunnel refuge points are provided in the tunnel, these shall have coverage from more than one CCTV camera.
3.   All emergency telephones inside the tunnel and on its approaches shall be covered by more than one CCTV camera. This can include the option whereby a CCTV camera is installed in or at the emergency telephone unit.

4.   The CCTV Cameras to be deployed shall be suited to the environment of the tunnel including use during incidents and shall be rated to at least IP65 in accordance with BS EN 60529.

5.   Both fixed and PTZ cameras shall have the facility for the screen to be cleaned by remote control from the TMC or the tunnel management building. Water storage containers and pipework shall be included as part of the installation.

6.   Digital Video Recorders (DVR) shall be installed at the tunnel control room. Where a tunnel control room is not available, the video signals will be transmitted to the TMC for storage. The DVR shall have sufficient capacity to store 72 hours of video images at full speed and full resolution.

16.2.4   Traffic detectors (e.g. magnetometers, inductive loops)

1.   Traffic detectors are used to detect traffic and can record vehicle speeds, counts, classify vehicle types and detect vehicles driving the wrong way.

2.   Because of the need to enhance detection in tunnels so that systems can react more quickly, it is essential that traffic detectors are more closely spaced inside the tunnel to improve the data granularity. Traffic detectors shall be spaced no more than 100m apart.

16.2.5   Heat (Thermography) Detection

1.   Fire is a big risk in tunnels and measures to detect high temperature heat sources both before a vehicle gets to the tunnel and when it is in the tunnel is important.

2.   Over and under heated brake on vehicles are hazards that increase the risks inside tunnels. Heat detection systems capable of measuring over or under heated brakes shall be installed on the approach to tunnels with the capability to identify and warn the suspect vehicle not to enter the tunnel.

3.   The detectors shall be located at a point prior to the last interchange before the tunnel, such that the suspect vehicle can be warned of the problem and prevented from entering the tunnel. The Driver of the suspect vehicle shall be presented with both a visual and audible warning.

16.2.6   Overheight Vehicle Detection System

1.   Overheight Vehicle Detection System OVDS shall be installed on the approach to tunnels at a point prior to the last interchange before the tunnel.

2.   The OVDS shall be supported by an LPR system to identify the overheight vehicle.

3.   OVDS shall have the capability to identify and warn the detected vehicle so that it can be diverted away from the tunnel entrance.

4.   The detectors shall be located such that the suspect vehicle can be warned of the problem and prevented from entering the tunnel. The Driver of the suspect vehicle shall be presented with both a visual and audible warning.

16.2.7   Lane Control Signs

1.   LCS shall be installed on the approaches to the tunnel to provide driver information about the current tunnel status and operations. LCS can also be used as Speed Control Signs (SCS) to manage vehicle speeds.

2.   Where LCS are used as SCS, the sign shall be enabled for speed enforcement and shall be connected to the speed enforcement cameras.

3.   LCS shall be installed at the entrance to the tunnel and shall be repeated at equal intervals along the tunnel length with a final LCS signs at the exit of the tunnel. LCS shall be placed at intervals no greater than 100m.

4.   LCS must be capable of displaying a red cross, a green directional arrow or an amber directional arrow as described in Directive 2004/54/EC of the European Parliament and of the Council of 29 April 2004 on minimum safety requirements for tunnels in the Trans-European Road Network

5.   LCS shall be located such that they are outside the tunnel vehicle envelope (Maintained Headroom) and so will not be damaged by traffic.

6.   The legends displayed by the LCS shall meet the requirements of the tunnel operations plan.

7.   Where the option to use the tunnel in a contraflow operation is provided, LCS shall be mounted back to back to provide information to traffic travelling in both directions.

8.   LCS used for contraflow operation shall include safety interlocks to prevent signs on opposing lanes providing incorrect and conflicting information.

16.2.8   Emergency Telephones

1.   Emergency Telephones shall be installed on both side walls of the tunnel and shall be spaced no more than 100m. The first and last emergency telephone in the tunnel bore shall be within 15m of the tunnel entrance or exit.

2.   Where cross passage emergency exits or emergency refuges are provided, these shall also have an emergency telephone within.

3.   Emergency Telephones shall use Voice over IP (VoIP) as the transmission protocol based on Open SIP Standards (RFC3261).

4.   The Emergency telephones shall immediately connect through to the TMC upon the handset being lifted.

5. Emergency Telephones shall be compliant with inductive coupling to Hearing Aids having a `T' switch position. The Emergency telephone shall be tested to (European Telecommunications Standard (ETS) 300-381 and in accordance with the International Telecommunications Union – Telecommunications (ITU-T) recommendation P.37.

16.2.9 Radio Rebroadcast System

1. A Radio Rebroadcast System (RRS) shall be installed in tunnels over 240m in length. The RRS shall be used by the emergency services in the event of an incident in the tunnel to allow safe radio communications to be maintained.

2. The base station equipment shall be installed in each of the tunnel control buildings and shall be operated and maintained by the Ministry of the Interior (MoI).

3. The antenna shall be in the form of a leaky feeder cable located along the centreline of the ceiling of the tunnel. The leaky feeder cable shall meet the requirements of IEC 60331 and IEC 60332.

4. The RRS shall be a broadband radio rebroadcast system capable of operating the following services
   - Terrestrial Trunked Radio (TETRA) used by MoI (police), civil defence (fire brigade) and the Supreme Council of Health (ambulance service)
   - Fourth Generation (4G) mobile telephony used by the MoI (police and State Security)

16.2.10 Public Address System

1. A Public Address (PA) system shall be installed in all tunnels over 240m in length, to allow the tunnel operators to communicate with drivers and passengers in the event of an emergency or incident.

2. Where the tunnel comprises more than one zone, the PA system shall be separated in to zones to isolate messages between zones.

3. The PA system shall be designed such that the effects of ambient noise and echo / reverberation are minimised.

4. The acoustic design for the PA system shall allow for the audio output of the speakers to be at least 6dB above the ambient noise levels when the ventilation fans are operating.

16.2.11 Dynamic Message Signs

5. DMS shall be placed on truss gantries on the approach to the tunnel at a point prior to the last exit before the tunnel.

6. DMS shall be placed on truss gantries on the approach to the tunnel at a point midway between the DMS prior to the last exit before the tunnel and the tunnel entrance. The DMS shall be placed on the same gantry as the LCS.

7.   As the DMS are not inside the tunnel, they do not need to conform to the product and material requirements for use in a tunnel environment.

16.2.12 Roadway Weather Information Systems

1.   RWIS shall be placed on the approach to the tunnel portals in order that the tunnel ventilation system can match the prevailing wind conditions, improving ventilation performance.

2.   Tunnels less than 240m will equip one station at one of the portals. Tunnels 240 m length and above shall be equipped with RWIS, one at each of the portals.

3.   Weather stations will measure the following conditions:

(a)   Ambient Temperature
(b)   Ambient Humidity
(c)   Wind speed
(d)   Wind direction
(e)   Solar radiation
(f)   Visibility

16.3 Hardware Design Requirements

16.3.1 General Mechanical and Housing Requirements

1   Due to the composition of the detergents used in tunnel cleaning and the pollution caused by vehicles, all exposed ITS equipment and components, their structures and fixings shall be manufactured from a stainless steel of a composition suited to the tunnel environment. All nuts, bolts, screws and washers shall also be of a stainless steel compatible with other metals.

2   Where stainless steel materials are fixed to mild steel materials, the interfacing surfaces shall be separated by nylon or polytetrafluoroethylene (PTFE) bushes and washers to prevent galvanic corrosion.

3   All cables and cable labelling components used in tunnels for Telecommunications purposes shall have Low Smoke and Zero Halogen (LS0H) insulation shall be;
    •   fire retardant in accordance with IEC 60332
    •   fire resistant in accordance with IEC 60331

4   ITS sign and signal enclosures shall be constructed of stainless steel. Where the equipment has a display, the display face shall be fabricated from clear fire retardant material and shall have stainless steel fixtures and fittings. All ITS Signs and signals shall be left un-painted.

5   All cable entry points, plugs and sockets to all ITS equipment shall all be rated to IP65 in accordance with BS EN 60529. Cable ducts shall be sealed where the cables come above ground. The seal shall provide against the entry of gas and moisture into equipment cubicles.

6   Equipment cabinets or cubicles located in the tunnel shall be recessed and flush with the tunnel wall surface.

7   The exposed sections of the enclosures or cubicles shall be stainless steel.

8   All cable shall be protected in either enclosed steel trunking or underground ducts.

17   ABBREVIATIONS

Glossary of Acronyms	
Term	**Definition**
3G/4G	Third Generation / Fourth Generation Cellular Networks
AASHTO	American Association of State Highway and Transportation Officials
AC	Alternating Current
ADSL	Asymmetric Digital Subscriber Line
AES	Advanced Encryption Standard
AGC	Automated Gain Control
AID	Automatic Incident Detection
ANSI	American National Standard Institute
AP	Access Point
AP	Application Profile
APC	Angled Physical Contact
APTS	Automatic Power Transfer Switch
AQM	Air Quality Monitoring
ARP	Address Resolution Protocol
ASCII	American Standard Code for Information Interchange
ASDS	Average Speed Detection Systems
ASN.1	Abstract Syntax Notation 1
ASTM	American Society for Testing and Materials
AWG	American Wire Gauge
BNC	Bayonet Neill–Concelman
BS	British Standard
BS EN	British Standard European Norm
BS ISO	British Standard International Standards Organisation
CBEMA	Computer Business Equipment Manufacturers Association
CCD	Charge-coupled Device
CCTV	Closed Circuit Television
CDMA	Code Division Multiple Access
CFL	Compact Fluorescent Light
CFR	Code of Federal Regulations
CLD	Camera Lowering Device
CSA	Canadian Standards Association
CSU	Channel Service Unit
CTS	Clear to Send
DC	Direct Current
DD	Draft for Development
DES	Data Encryption Standard

Glossary of Acronyms	
Term	**Definition**
DHCP	Dynamic Host Configuration Protocol
DIN	Deutsches Institut für Normung
DMS	Dynamic Message Signs
DNS	Domain Network Server
DoS	Denial of Service
DRAM	Dynamic Random-Access Memory
DSU	Data Service Unit
DTE	Data Terminal Equipment
DWDM	Dense Wavelength Division Multiplexer
EDFA	Erbium Doped Fibre Amplifier
EDGE	Enhanced Data rates for GSM Evolution
EEPROM	Electrically Erasable Programmable Read-Only Memory
EIA	Electronic Industries Alliance
EC	European Community
EMC	Electromagnetic Compatibility
ESS	Environmental Sensor Station
ETS	European Telecommunication Standards
ETSI	European Telecommunication Standards Institute
FAT	Factory Acceptance Test
FSOR	Full, Standardised Object Range
Gbps	Giga bits per second
GIS	Geographic Information System
GO	Global Object
GPRS	General Packet Radio Service
GUI	Graphical User Interface
HDPE	High Density Polyethylene
HEPA	High-Efficiency Particulate Air
HSPA	High Speed Packet Access
HTTP	Hypertext Transfer Protocol
HVAC	Heating, Ventilation and Air Conditioning
ICMP	Internet Control Message Protocol
ID	Identification
IDC	Insulation Displacement Connection
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IGMP	Internet Group Management Protocol
IM	Instant Messaging
IP	Internet Protocol

Glossary of Acronyms	
Term	**Definition**
IPSec	Internet Protocol Security
ISM	Industrial, Scientific and Medical
ISO	International Organization for Standardization
ITS	Intelligent Transportation System
ITU-T	International Telecommunications Union – Telecommunications
km	Kilometre
kN	Kilo Newton
JPEG	Joint Photographic Experts Group
Kbps	Kilobits per second
LACP	Link Aggregation Control Protocol
LAG	Link Aggregation Group
LAN	Local Area Network
LC	Lucent Connector
LCS	Lane Control Signs
LPR	License Plate Recognition
LS0H	Low Smoke, Zero Halogen
LTE	Long Term Evolution
MAC	Media Access Control
MDS	Magnetometer Detection System
MHz	Mega Hertz
MIB	Management Information Base
MoI	Ministry of Interior
MOR	Meteorological Optical Range
MPEG	Motion Picture Expert Group
MS	Magnetometer Sensor
MTBF	Mean Time Between Failure
MVD	Microwave Vehicle Detector
MVDS	Microwave Vehicle Detection System
MVP	Machine Vision Processor
NAT	Network Address Translation
NFPA	National Fire Protection Association
nm	Nano metre
NTCIP	National Transportation Communications for ITS Protocol
NTP	Notice to Proceed
OADM	Optical Add-Drop Multiplexers
OAMP	Operations, Administration, Maintenance, and Provisioning
OD	Outer Diameter
OLS	Optical Line Loss

Glossary of Acronyms	
Term	**Definition**
OSI	Open Systems Interconnection
OSP	Out Side Plant
OSPF	Open Shortest Path First
OTDR	Optical Time Domain Reflectometer
OVD	Overheight Vehicle Detector
OVDS	Overheight Vehicle Detection System
P2P	Peer to Peer
PA	Public Address
PAL	Phase Alternating Line
PAT	Production Acceptance Test
PC	Physical Contact
PCB	Printed Circuit Board
PDMS	Portable Dynamic Message Signs
pf	Pico farad
PHY	Physical Layer
PICS	Profile Implementation Conformance Statement
PMPP	Point to Multi-Point Protocol
PoE	Power over Ethernet
PPP	Point-to-Point Protocol
PPS	Passive Pavement Sensor
PPTP	Point to Point Tunnelling Protocol
PRL	Protocol Requirements List
ps	Pico second
PTFE	Polytetrafluoroethylene
PTZ	Pan-Tilt-Zoom
PVC	Polyvinyl Chloride
PWA	Public Works Authority
QCS	Qatar Construction Standards
QGEWC	Qatar General Electricity and Water Corporation
QHDM	Qatar Highway Design Manual
QTCM	Qatar Traffic Control Manual
RAM	Random-Access Memory
RFC	Request for Comment
RFID	Radio Frequency Identification
RGS	Rigid Galvanized Steel
RJ	Registered Jack
RMC	Ramp Meter Control
RMS	Root Mean Square

Glossary of Acronyms	
Term	**Definition**
RPU	Remote Processing Unit
RRS	Radio Rebroadcast System
RSSI	Received Signal Strength Indication
RSTP	Rapid Spanning Tree Protocol
RTP	Real-time Transport Protocol
RTS	Request to Send
RTSP	Real Time Streaming Protocol
RU	Repeater Unit
RWIS	Roadway Weather Information System
SAT	Site Acceptance Test
SCADA	Supervisory Control and Data Acquisition
SD	Secure Digital
SFP	Small Form factor Plug
SIM	Subscriber Identity Module
SIT	System Integration Test
SMA	Sub-Miniature version A
SMF	Single Mode Fibre
SNMP	Simple Network Management Protocol
SQL	Structured Query Language
SSH	Secure Shell
SIT	System Integration Test
SSL	Secure Sockets Layer
STMF	Simple Transportation Management Framework
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol / Internet Protocol
TETRA	Terrestrial Trunked Radio
TFTP	Trivial File Transfer Protocol
TIA	Telecommunications Industry Association
TLS	Transport Layer Security
TMC	Traffic Management Center
TNC	Threaded Neill–Concelman
TS	Technical Specification
TSCR	Traffic Signal Control Room
TSP	Total Suspended Particulate
TSS	Transportation Sensor Systems
TVL	Television Lines
TVSS	Transient Voltage Surge Suppression
UDP	User Datagram Protocol

Glossary of Acronyms	
Term	Definition
UPS	Uninterruptable Power System
URL	Uniform Resource Locator
USB	Universal Serial Bus
UTMC	Urban Traffic Management and Control
UTP	Unshielded Twisted-Pair
UV	Ultraviolet
Vac	Voltage in Alternating Current
Vdc	Voltage in Direct Current
VDE	Verband der Elektrotechnik
VIVDS	Video Imaging Vehicle Detection System
VLAN	Virtual Local Area Network
VMS	Variable Message Sign
VoIP	Voice over Internet Protocol
VPN	Virtual Private Network
VRRP	Virtual Router Redundancy Protocol
WAN	Wide Area Network
WDM	Wavelength Division Multiplexing
WDS	Windows Deployment System
WIM	Weigh-In-Motion
XHHW	Cross-Linked High Heat Water Resistant
XLPE	Cross-Linked Polyethylene
µm	Micro metre