هيئـــة الأشـغـــال العامـــة
Public Works Authority

Qatar Roads Maintenance Manual

قطـــر تستحـــق الأفضـــل
Qatar Deserves The Best

Roads Maintenance Department
Assets Affairs

Document Control

This document has been designed to be issued as a loose leaved volume that allows it to be partially updated at any time when new guidance for any particular section or paragraph is updated. Each update will have a unique amendment number and issue date is located at the bottom of each page. These revisions will also be recorded in the amendments summary table shown below.

Amendment Summary

Amendment No.	Issue Date	Chapter No.	Paragraph No.	Details of Update

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Foreword

Qatar today is going through a period of rapid evolution, which will deliver the Qatar National Vision 2030. "Qatar Deserves the Best" and the Public Works Authority 'Ashghal' strategy requires that we undertake a major change to how we go about doing our business. The Roads Maintenance Department will transform to become a world leading road operator and maintainer of highway assets, a role which supports the strategic objectives of optimised assets, improving safety and putting the customer first.

I am very pleased to introduce the first edition of the "Qatar Roads Maintenance Manual" (QRMM) this document sets out the standards for inspection, maintenance and improving our assets. It is intended to ensure consistency of maintenance standards and value for money across Qatar's highway network. It puts customer safety first and will be incorporated into all relevant contracts. As the QRMM evolves it will move from a structured prescriptive approach to carry out inspections and repairs to a more risk based outcome based approach.

It is important that everyone within Roads Maintenance is familiar with the QRMM, as it sets the standards that we demand of our own staff and contractors, and we urge you to embrace its requirements with enthusiasm. The achievement of the standards contained in the QRMM will be measured and reported. It is important that working together we put maximum effort to strive to achieve 100% performance to ensure that Qatar gets the best, safest and most reliable highway network.

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1.0 Introduction

1.1 Definitions

Asset Management Plan

The Asset Management Plan (AMP) is a tactical plan for managing Ashghal's highway assets to deliver an agreed standard of service.

Bronze Level

An operational level of management deployment and responsibility responding to small scale/minor incidents.

Contingency Plan

A document that outlines how Incidents are to be managed and an escalation process requiring senior management involvement and decision making.

Cross Sectional Position

Allows the exact location of a feature, asset or defect to be identified across the cross section of a carriageway.

Defect

An asset that:

- Experiences deterioration from its normal condition
- Prevents an item from acting in its intended manner
- Is damaged
- Is likely to increase the rate of deterioration of another item
- Causes an unintended hazard or nuisance

Duty Engineer

A suitably qualified and experienced member of staff to be on standby and contactable 24 hours a day, 7 days a week. They shall be committed to, when called upon, attend site, assess and have the authority to support, direct and advise appropriate incident support resources. They will monitor weather forecasts at all times and ensure that appropriate arrangements are made to mitigate any hazards arising from occurrences of severe weather.

Emergency Defect

A defect that requires an immediate response because it represents a danger.

Emergency Services

Public organisations that respond to and deal with emergencies including representatives from the Police, Ambulance or Civil Defence.

Gold Level

A strategic level of management responsibility, established when requested by the Silver level manager to provide strategic support to deal with Major Incidents.

Hazard Mitigation

To make safe, either on a temporary or permanent basis, a defect.

Highway

A public way for purposes of vehicular travel, including the entire area within the right-of-way.

Incident

Any non-recurring event that causes a reduction of roadway capacity or an abnormal increase in demand.

Incident Management Objectives

As described in Chapter 10 of this manual.

ISU (Incident Support Unit)

Incident Support Units aim to minimise disruption to road users, by providing assistance to the Police and by providing a safe and timely response to incidents and clearance of the carriageway to restore normal service.

ITS Maintainer

The maintainer of the technology assets.

Network

Ashghal's defined road network.

Network Referencing System

A method of spatial referencing, where the locations of features, assets and defects are described in terms of measurements along a linear element, from a defined starting point.

Non-Urgent (Category 2) Defects

Defects that do not represent an immediate or imminent hazard or a risk of short-term structural deterioration.

Non-Specialist Inspection

Inspections undertaken by staff that do not have specialist knowledge of the particular asset being inspected.

Operations and Maintenance Manuals

Manuals provided by supplier, manufacturer or installer for any specific specialist equipment or asset.

Overseeing Organisation

The Public Works Authority (Ashghal).

Permanent Repair

To repair a defect so it performs fully to its intended and designed function.

Rainy Season

The time of year where there is an increased risk of rain, which in turn has the potential to cause flooding on the network. The highest probability occurs between the months of November and March.

Rectification Period

The time period within which the hazard created by a defect should be mitigated and the time period within which a temporary or permanent repair to a defect should be carried out.

Right of Way

A reserved corridor of land within which a highway is constructed.

Road Network Management Centre

Roads Assets Affairs control room for undertaking various functions to minimise congestion and ensure reliable journeys for road users.

Road Traffic Collision

Where a vehicle collides with another vehicle, pedestrian, animal, road debris, or other stationary obstruction, such as a tree or a piece of street furniture.

Rural Roads

Lie adjacent to areas which are predominantly natural, with little or minor adjacent built land use development.

Roadway

The portion of a highway, including shoulders, for vehicular use. A divided highway has two or more road ways.

Severe Weather Plan

A document that outlines the processes and procedures for how extreme weather related events such as flooding, fog and high winds are managed, so as to minimise the impact on the highway network and road users.

Silver Level

A tactical level of management responsibility established when the Incident Management Objectives cannot be met or when requested by the Bronze Level manager. Manages larger incidents by allocating or obtaining appropriate resources to ensure satisfactory resolution to normality.

Specialist Inspection

Programmed inspections carried out by competent and appropriately trained or qualified contractors or staff that have specialist knowledge of the particular asset type being inspected.

Standard Incident Response Model

The model used to ensure incidents on the network are dealt with in an appropriate manner and details the escalation process in Incident Management.

Traffic Management Centre (TMC)

An operational facility for monitoring, controlling and managing the roadway traffic through the use of computer based networks connected to roadside equipment. More than one TMC may be operational at any one time.

Temporary Repair

An interim short term repair to a defect that prevents the asset from deteriorating further and allows an asset to perform to its intended function until a more permanent repair can be undertaken.

Urban Roads

Lie adjacent to areas which contain, or are zoned for land use development.

Unified Contact Centre

Ashghal Contact Centre for management of all customer communication streams centrally.

Urgent (Category 1) Defects

Defects that require prompt attention because they represent an imminent risk.

Well Lit Highways

The UK Lighting Boards Code of Practice for Highway Lighting Management.

Works Order System

A system where the lifecycle of defects are recorded, monitored and closed out.

1.2 Abbreviations

AID	Automatic Incident Detection Systems
AMP	Asset Management Plan
AQMS	Air Quality Monitoring Systems
Capex	Capital Budget Expenditure
CCASG	Cooperation Council for the Arab States of the Gulf
CCTV	Closed Circuit Television
CRASH	Capacity Reduction and Significant Hold-ups
DCD	Data Capture Device
DMS	Dynamic Message Sign
EAMS	Enterprise Asset Management System
FWD	Falling Weight Deflectometer
GI	General Inspection
GIS	Geographic Information System
GPR	Ground Penetrating Radar
HRM	High Speed Road Monitor
ILD	Inductive Loop Detection
ILP	Institution of Lighting Professionals
IRI	International Roughness Index
ISU	Incident Support Unit
ITS	Intelligent Transportation System
LCS	Lane Control Sign
LED	Light Emitting Diodes
LPR	Licence Plate Reader
MDS	Magnetometer Detection Systems
MMUP	Ministry of Municipality and Urban Planning
MVDS	Microwave Vehicle Detection Systems
NRS	Network Referencing System
O&M	Operations and Maintenance
O&MM	Operations and Maintenance Manual (Tunnels)

Opex	Operational Budget Expenditure
PDMS	Portable Dynamic Message Sign
PI	Principle Inspection
PIMS	Pavement Inventory Management System
PLG	Professional Lighting Guide
PTZ	Pan, Tilt and Zoom
QCS	Qatar Construction Specification
QGEWC	Qatar General Electricity and Water Corporation (Kahramaa)
QHDM	Qatar Highway Design Manual
QSTM	Qatar Strategic Traffic Model
OHSAS	Occupational Health and Safety Advisory Services
OVDS	Overheight Vehicle Detection Systems
QTCM	Qatar Traffic Control Manual
RAIMS	Right of Way Asset Inventory Management System
RMS	Ramp Metering Systems
RNMC	Road Network Management Centre
RWIS	Roadway Weather Information Systems
SI	Special Inspections
TDMS	Traffic Detection and Monitoring Systems
TMA	Truck or Trailer Mounted Attenuator
TMC	Traffic Management Centre
TSCR	Traffic Signal Control Room
UCC	Unified Contact Centre
VCB	Vertical Concrete Barrier
VIVDS	Video Imaging Vehicle Detection Systems
VRS	Vehicle Restraint System
WIM	Weigh in Motion
WIS	Weigh Inspection Stations
WZTMG	Work Zone Traffic Management Guide
XSP	Cross Sectional Position

1.3 Health and Safety, Environmental and Quality Management

In all aspects of quality management, attention should be paid to the requirements of particular contracts as well as current and relevant legislation, including the Qatar Construction Specifications (QCS) with regard to the environment, health and safety and risk assessment. In every case, procedures should ensure that the appropriate health and safety regulations have been identified and fully adhered to at all times, with the aim of adopting an integrated approach between quality, environment and health and safety.

Risk analysis and management is an integral part of the management of the network and the provision of the routine services. Risk analysis for all activities should be regularly carried out, recorded and should include due regard for the environment, the safety of employees, the public and those nearby. The risk analysis process will involve the identification of hazards, an assessment of the likelihood of occurrence, estimation of the consequences and, ultimately, the management of the actions taken. This involves identifying, evaluating and reviewing the options for controlling the risks. These risk assessments should be reviewed when new or altered hazards are identified.

1.4 Legislation Relating to Roads Maintenance

The list is not exhaustive but is current at the time of writing:

- Qatar Labour Law No. 14 of 2004
- Qatar Human Resources Law No.8 of 2009
- The Qatar Construction Specifications (QCS) and any subsequent revision
- Qatar Environmental Protection Law No. 30 of 2002
- Qatar Traffic Law No. 19 of the Year 2007
- State of Qatar Law No. 6 of 1987 and all subsequent amendments concerning Materials and Equipment from Qatar or other CCASG countries.

1.5 Standards and Guidance

- The Qatar Highway Design Manual (QHDM) and any subsequent revision
- The Qatar Traffic Control Manual (QTCM) and any subsequent revision
- Work Zone Traffic Management Guide (WTZMG) dated July 2014 and any subsequent revisions

- Code of Practice and Specification for Road Openings in the Highway dated January 1992 and any subsequent amendments
- Any current and relevant regulation, notice or circular
- The Guide for Civil Users of Explosives in Qatar prepared by the Ministry of Public Works
- The Qatar Survey Manual, prepared by the Survey Section of the Ministry of Industry & Public Works
- Worker Rights Booklet 2009 (National Human Rights Committee)
- BS ISO 9001: 2008 – Quality Management Systems and any subsequent revision
- BS ISO 14001: 2004 – Environment Management Systems and any subsequent revision
- OHSAS 18001: 2007 – Occupational Health and Safety Management and any subsequent revision
- OHSAS 18002: 2008 – Guidelines for Implementation of OHSAS 18001: 2007 and any subsequent revision
- BS ISO 55000: 2014 – Asset Management Standard: Introduction
- BS ISO 55001: 2014 – Asset Management: Management Systems - Requirements and any subsequent revision
- BS ISO 55002: 2014 - Asset Management: Management Systems – Guidelines for the application of ISO 55001
- The Method of Measurement for Road and Bridgeworks published by the Ministry of Industry and Public Works, Civil Engineering Department, 1987
- Safety Rules issued by the Department of Electricity Networks
- Jointing Manual prepared by Electricity Networks Department
- Qatar Sewage and Drainage Design Manuals
- The Highways Agency's Design Manual for Roads and Bridges
- Ashghal's Safety Inspection Manual – not yet published
- Ashghal's Detailed Inspection Manual – not yet published

- Well Lit Highways – Code of Practice for Highway Lighting Management
- Institution of Lighting Professionals GPO3 – COP for Electrical Safety in Highway Electrical Operations
- Institution of Lighting Professionals PLG07 High Masts for Lighting and CCTV
- Intelligent Transport System (ITS) Specifications and any subsequent revisions
- Qatar Highway Strucutres Design Manual (QHSDM) – not yet published

Note: The local documents listed above (e.g. QHDM, QTCM) are primary documents and should be taken as the lead document. Other documents referred to in the text such as any standards from the Highways Agency Design Manual for Roads and Bridges shall be taken as guidance documents and international best practice, unless otherwise stated within the text.

2.0 Network Hierarchy

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2.1 Introduction

A network hierarchy is the foundation of a coherent, consistent and auditable maintenance strategy. It is also crucial to asset management in establishing levels of service.

It is important that the hierarchy adopted reflects the needs, priorities and actual use of each road in the network. These may be determined by importance – a route leading to a major hospital, for example. They may be determined by environment – rural, urban, busy shopping street, residential street etc. They may be determined by non-vehicular traffic factors such as pedestrian usage. At present, and for the purposes of this document, a footway hierarchy has not been determined; however the footway classification shall be determined to be the same as the adjacent carriageway. As such it shall be subject to the same inspection and maintenance frequencies as the adjacent carriageway. Collectively, these issues may be referred to as the 'functionality' of the section of highway in question.

Ideally, the functionality of any part of the network should be the single basis of policy priorities. It should be the framework to which standards are to be attached together with associated targets and performance objectives. In the context of this manual, hierarchy is the link between maintenance policy and implementation but it can also be a consideration when defining standards for design and new construction.

It is also important that hierarchies are dynamic and regularly reviewed to reflect changes in network characteristics and functionality, so that maintenance policies, practices and standards reflect the current situation rather than the use expected when the hierarchy was originally defined. Where major maintenance, construction or other development involves significant traffic diversion, or when congestion in one part of the network results in traffic shift to another part of the network it is important that these changes are reflected in the hierarchy and subsequently in the maintenance and network management regimes.

2.2 Carriageway Hierarchy

Historically, the roads in Qatar have been classified as Expressway, Primary (includes Expressways), Secondary, Tertiary and Local. During 2013, as part of the Qatar Highway Design Manual project, the Ministry of Municipality and Urban Planning (MMUP) undertook a review of the current functional road network hierarchy and have developed a revised hierarchy based on the future needs of Qatar.

Table 1 details the hierarchy name and road type descriptions that relates to the road network classification encountered in Qatar. It also includes a column showing the maintenance hierarchy description.
This revised road hierarchy has been predominantly developed using the functional category i.e. classifying roads according to the type of service they provide and the degree of access to be provided to adjacent properties. This provides designers and road planning engineers with guidance during the design and planning process.

2.2.1 Road Types

On any road network there are two environments through which a road will pass – Urban and Rural. They have different characteristics in terms of the density of roads, the extent of their adjacent development and the nature of their travel patterns.

Urban and Rural road types can be defined as follows:

Urban roads – lie adjacent to areas which contain, or are zoned for built land use development

Rural roads – lie adjacent to areas which are predominantly natural, with little or minor adjacent built land use development

MMUP have allocated a classification to each of the road types (urban and rural). The Urban Road network is classified as follows:

- Expressways
- Arterials
- Boulevards
- Collectors
- Collector Distributors
- Major
- Minor
- Local
- Service Roads
- Local Roads

The Rural Road network is classified as follows:

- Rural Freeway
- Rural Arterials
- Rural Collectors
- Local Roads

However, for road maintenance purposes and in the context of this document the hierarchies will remain as:

- Expressways
- Primary
- Secondary
- Tertiary
- Local

These terms are well established and understood in Ashghal; they are simple, uncomplicated and easy to apply the inspection and defect repair regime that is further described in this document.
The Network has been classified using the Primary, Secondary, Tertiary and Local Road classification and the inspection and maintenance regimes described in this document are based on that classification.

Table 1: Road Network Hierarchy

Maintenance Hierarchy Description	Design Hierarchy Description	Type of Road General Description	Description	AADT Traffic Flow
Expressway	Expressway Rural Freeway	A high vehicle priority 3+3 or 4+4 street (three to four lanes in each direction) with limited access points	Routes for fast moving traffic with no frontage or pedestrian access. Speed limits are usually in excess of 100kph with few junctions. Pedestrian crossings are segregated and parking is prohibited.	>50,000
Primary	Expressway Major Arterial Rural Freeway	A high vehicle priority 3+3 or 4+4 street (Three to four lanes in each direction) with limited access points	Routes for fast moving long distance traffic with no frontage or pedestrian access. Speed limits are usually in excess of 100 Kph with few junctions. Pedestrian crossings are either segregated or controlled and parking is prohibited	>50,000
Secondary	Minor Arterial Boulevard Rural Arterial	A high vehicle priority 3+3 or 4+4 street (3 to 4 lanes in each direction)	Routes carrying medium to high volumes of traffic connecting urban districts. Traffic mobility is the primary function and limited land use access is permitted. Traffic at intersections is controlled by Roundabouts and Traffic Signals	20,000 - 60,000
Tertiary	Collector – Distributor Major Collector Minor Collector Rural Collector	A medium vehicle priority 2+2 street (Two lanes in each direction)	Carries medium to low volumes of traffic between urban and rural land uses containing specific land uses. Traffic mobility is the major function and some land use access is permitted.	10,000 - 50,000
Local	Local Roads Rural Local Roads	Low vehicle priority 1+1 street (1 lane each direction). Local traffic with frontage access and frequent junctions	Low traffic volumes. Provides access to adjacent rural or urban property or land. Subject to traffic calming measures	Less than 10,000

3.0 Network Referencing System

3.0 Network Referencing System

3.1 Introduction

Most aspects of Ashghal's business require accurate and consistent referencing to the highway network. Currently there is no highway referencing system in the State of Qatar and as such a project has been initiated to devise, design and implement a Network Referencing System (NRS).

Network Referencing will be used to assign a unique address to each location on Qatar's road network including the Primary, Secondary, Tertiary and all Local roads, whether they are maintained by Ashghal or not. The NRS divides the network into Sections that, for asset management purposes, splits the network into practical lengths allowing for:

- easy inventory data collection
- scheduling and programming of carriageway inspections, whether they be visual or machine based surveys
- the ability to locate defects identified from inspections
- monitoring of deterioration
- effective asset management decision making.

Care must be taken to select practical Section lengths as accuracy is essential to all aspects of network referencing. Consequently, the maximum Section length will be five (5) kms. Roads will be divided up at convenient locations such as interchanges and roundabouts, and where a natural point exists, at a maximum of 5 kms.

As a general rule Sections will be terminated at the following locations:

- major road junctions, including roundabouts and interchanges
- ends of slip roads and link roads
- where there are obvious changes in cross section
- changes in the number of lanes
- changes of street name
- laybys separated from the main carriageway including weighbridge areas
- boundaries between maintaining contractors
- sections must not exceed a maximum length of 5 kms

Each asset and defect, whether it is a single point asset, such as a lighting column or a linear type asset such as a safety barrier, will be given a unique reference using the referencing system described in this document. It will be expressed as a distance (chainage) from the preceding start reference location (the start reference node is located at chainage 0 of the reference section) and an offset and cross sectional position.

The Network has been divided into Sections and each Section has been allocated a unique NRS number. The Sections are measured from the centreline of the road. This NRS number is made up of a number of elements that aid in identifying the Section location, the location of assets and the location of defects.

Each Section is defined by its length, start position, end position, direction and is assigned a unique reference – its NRS number. The NRS number is individual to that specific section of road, irrespective of the surrounding Sections. This number will be marked on site at the start of each individual Section with a reference plate. Signs must be visible to allow inspectors to identify which Section is being inspected. Signs must be positioned so they do not obscure visibility or cause a hazard to other road users, including pedestrians. The offset dimensions from the edge of the carriageway should be in accordance with the requirements in Section 0; Paragraph 1.9.14 of the QTCM.

It is essential that the Section start sign is located accurately at chainage 0, as this is the point from which all asset inventory data, inspection surveys and subsequent defects will be based.

3.1.1 Cross Sectional Position

The Cross Section Position (XSP) is an identification mechanism to allow the exact location of a defect to be identified across the cross section of a carriageway on a specific chainage on the highway relating to that Network Referencing position. The XSP will always be perpendicular to the carriageway and is specified by the cross section position codes, examples of which are shown in the drawings.

3.1.2 Cross Section Position Codes

The format for the cross section position codes is as follows:

Asset Code (as below) Number (indicating the number of times the asset occurs across the cross section or the carriageway lane in the direction of survey) Direction Indicator (either I for Increasing Direction or D for Decreasing Direction). For example, a separator between a main carriageway and a left turning lane on the increasing carriageway, where a separator existing between the main carriageway and a service road would be labelled as SPT2(I).

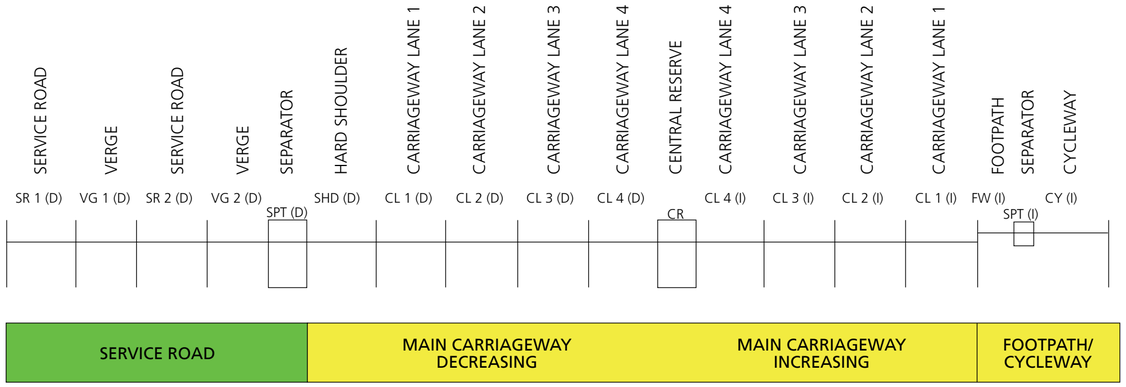
Asset Codes

CL Carriageway Lane
CR Central Reserve
CY Cycleway
FW Footway
LK Link Road
PB Parking Bay
RA Roundabout
SHD Hardshoulder
SP Slip Road
SPT Separator
SR Service Road
VG Verge

The following paragraphs provide detail as to what elements make up a typical NRS Section number.

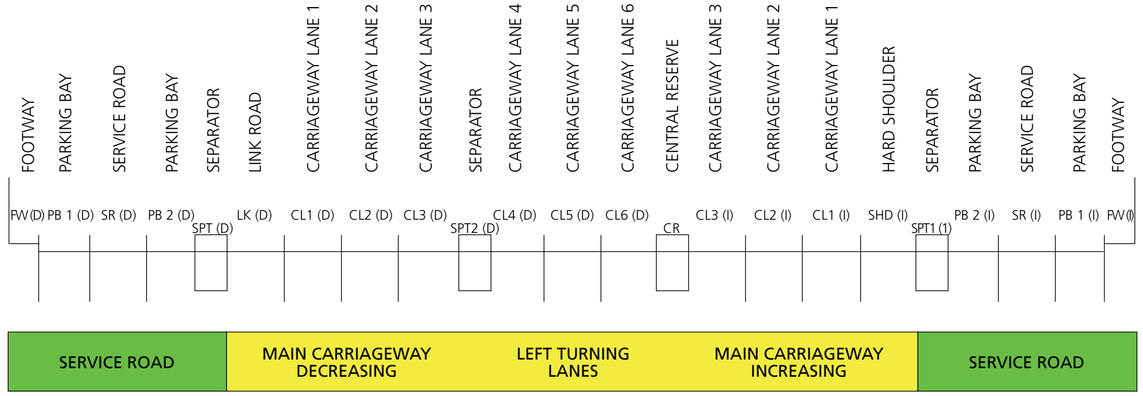
Dual Carriageway Rural Roads

Figure 1: Typical Cross Section Position References - Dual Carriageway Rural Roads



Dual Carriageway Rural Roads

Figure 2: Typical Cross Section Position References - Dual Carriageway Urban Roads



3.1.3 Road Number

Every road on Qatar's road network has been allocated an individual Network Referencing System road number. The road has then been divided up into individual unique Sections, based on the rules described previously.

In order to build in future new road requirements the numbering system chosen for the State of Qatar will be a five figure numbering system which will be allocated to each named road. The numbers will be allocated by type of road as follows:

- Primary Roads – 10000 to 19999
- Secondary Roads – 20000 to 29999
- Tertiary Roads – 30000 to 39999
- Local Roads – 40000+

This number will be marked on site on specific unique signs located in the appropriate location, at the start or end of each Section depending on direction. The NRS has been created in Ashghal's GIS to allow correlation between survey output with the location of defects, features and Sections on site.

3.1.4 Section Numbering

Roads will be divided into Section(s). These Sections will start and end at major reference points for example roundabouts, intersections and T junctions. They are numbered sequentially with a 2 digit reference number starting at 01. Sections will have a maximum length of 5km if no major reference point exists (generally on rural road Sections).

3.1.5 Direction Identifier

Each individual Section on a carriageway has been given a Direction Identifier. This allows differentiation between the two carriageways when carrying out inspections and identifying defects.

Increasing direction refers to the direction of positive displacement from the start point of the Section at chainage 0 and is represented by the letter I on the signs. Section start signs on the Increasing carriageway will always bear the chainage 0

Decreasing direction refers to the direction of negative displacement from the end point of the Section and is the direction along a highway when travelling towards chainage 0 and is represented by the letter D. Signs placed on the decreasing side of the carriageway at the end of the Section will bear the end chainage of the Section to which it refers (see Figure 3).

3.1.6 Section Type Identifier

In order to differentiate Sections of road that have a specific function and are not mainline Sections (main carriageway sections will not be individually identified on the sign plates) and to ensure uniqueness, a Section Type Identifier will be allocated to Sections.

The network will be divided up into 5 different road types known as the Section Type Identifier, each having a different function and each having their own unique identifier to which assets will be tagged:

- Main Carriageway – Carriageway on which the NRS is based and to which the NRS number is allocated. The NRS runs down the centre of the road
- Roundabouts (marked as RA on the signs) – all roundabouts will be allocated a separate NRS number not related to the main carriageway that it sits on; consequently they will not be allocated a Section Number
- Link Road (marked as LK on the signs) – a road that joins the mainline of one carriageway to the mainline of another, generally located at roundabouts and grade separated free flowing interchanges, allocated the same road number as the road that it egresses. The start of the Section and consequently the sign location will be at the point where the link road reaches its full width
- Slip Road (marked as SP on the signs) – located at grade separated junctions and allows traffic to access or egress from a main carriageway, allocated the same road number as the road that it accesses or egresses. The start of the Section and consequently the sign location will be at the point where the slip road reaches its full width
- Service Road (marked as SR on the signs) – single one-way road running adjacent to a main carriageway allowing traffic to access and egress from and to lower grade roads from the main carriageway, allocated the same road number as the road that it services.

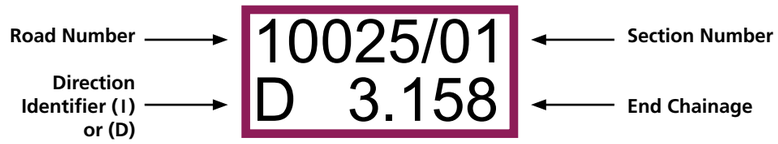
On Sections where there are multiple occurrences of Links, Slip Roads or Service Roads within a Section a number will be added to the Section Type Identifier in order to retain uniqueness e.g. LK 1 (Figure 4). This rule will not apply to Roundabouts as they are allocated their own Road Number (Figure 5).

3.2 Sign Design

Signs are manufactured using 315mm x 150mm x 2mm aluminium plate. Numbers should be black in colour, 50mm X height on a non-reflective white background. The border is 7mm wide in the national colour of Qatar (Pantone number 222c).

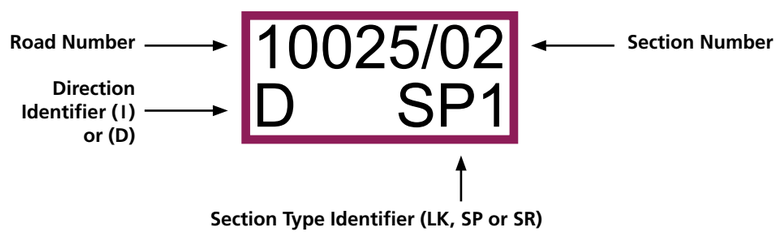
3.2.1 Main Carriageway Signs

Figure 3: Main Carriageway Signage



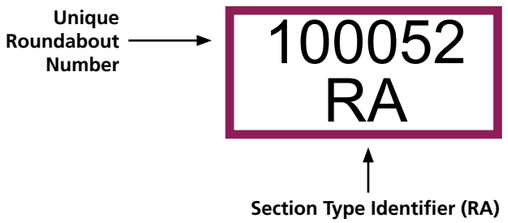
3.2.2 Link, Slip or Service Road Signs

Figure 4: Link, Slip or Service Road Signs



3.2.3 Roundabout Signs

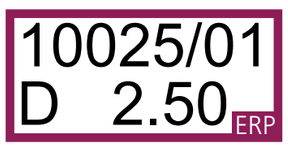
Figure 5: Roundabout Signs



3.2.4 Established Reference Point (ERP) Signs

ERP's are always placed at 2.5km intervals on a Section greater than 3km in length. They indicate the Section in which they fall, the Direction Identifier and have an ERP identifier in the bottom right hand corner; they provide an accurately positioned reference point that can be used as a convenient start/stop point for inspections and surveys. ERP signs are accurately placed to a tolerance of + or – 100mm.

Figure 6: Established Reference Point (ERP) Signs

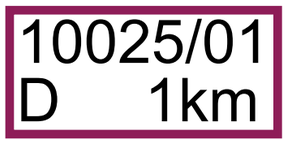


3.2.5 Kilometre Marker (KP) Signs

These marker posts are placed at approximately 1 kilometre intervals along a Section. Where possible they should always be placed so they are easily visible from a travelling works vehicle. They should not be used for accurate measurements as their positional tolerance is not sufficiently accurate (+ or – 10m). They provide inspection and works operatives with an estimated distance measurement along a Section.

An example of a post mounted NRS plate for a Kilometre Marker is as shown in Figure 7:

Figure 7: Kilometre Marker Signs



3.3 Placing of Signs

Depending on their function different types of NRS signs will have different degrees of positional accuracy.

- Accurately Positioned Signs – Signs that are accurately positioned by recording GPS co-ordinates after the sign has been installed. These signs provide the datum for all data recording on that particular Section. Sign types requiring this accuracy will be Section Signs located at the start of Sections and at all 2.5km ERP locations. Where possible, replacement signs will need to be repositioned in the exact same location, otherwise a re-measuring of the Section will be required
- Inaccurately Positioned Signs – These signs (Kilometer Marker's) are not used for accurate measuring, but can be used as a reference for works teams to locate defects.

Once the signs for a Section have been placed the length, in metres, will be measured and recorded in the GIS and used as the base datum information for that particular Section.

In order to reduce NRS sign clutter on Sections, one sign will be placed at the point where a Section ends and where the next Section starts.

For the Increasing side of a Section, signs will be placed at the start of the Section and will display chainage zero. There will not be a sign placed at the end of the Section. The sign at that point will be the start sign for the next Section and will display chainage zero. Kilometre signs and Established Reference Point signs will be placed at their relevant locations if needed.

For the Decreasing side of a Section, signs will be placed at the end of the Section and will display the end chainage of that Section. There will not be a sign placed at the start (end of the inspection direction) of the Section. The sign at that point will be the end sign for the next Section and will display the end chainage. Kilometre signs and Established Reference Point signs will be placed in the relevant locations if needed.

3.4 Typical NRS Sign Layouts

The following figures show examples of the position of NRS signs at a selection of junction locations such as roundabouts, signalised and un-signalised junctions and slip roads.

Figure 8: Typical NRS Sign Layout at a Roundabout

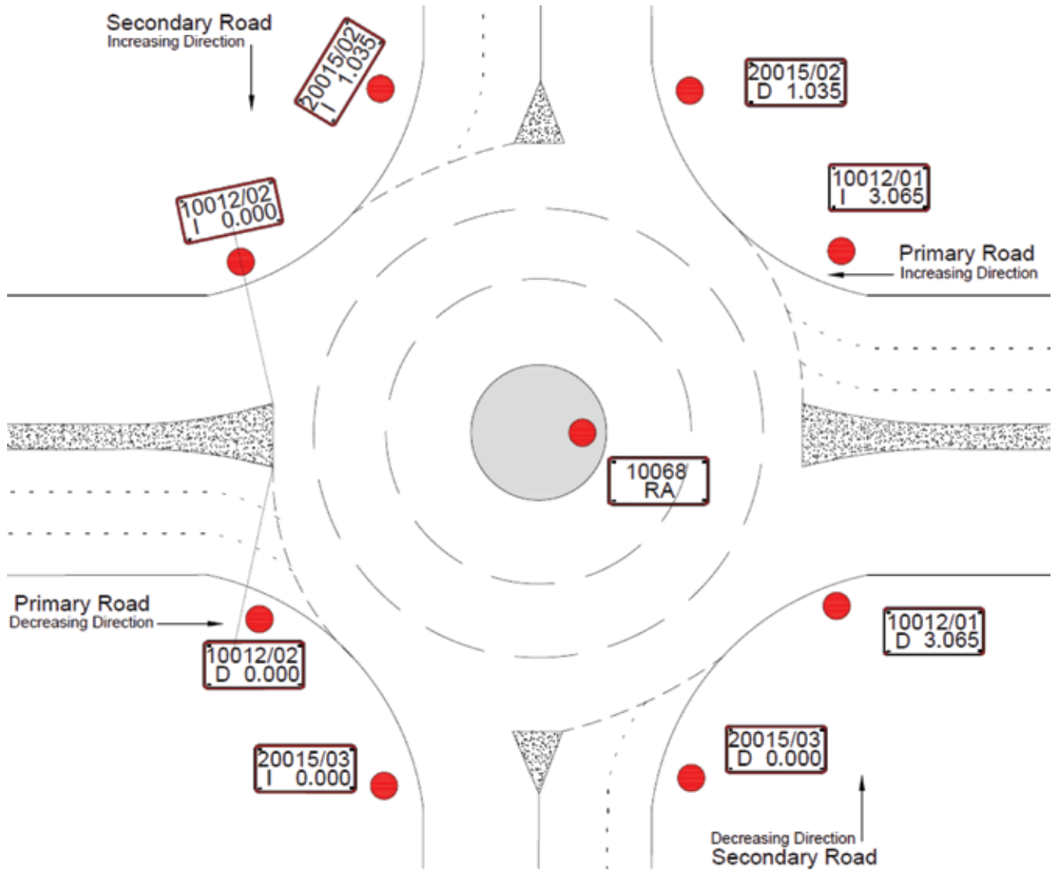


Figure 9: Typical NRS Sign Layout at an Un-signalised Intersection

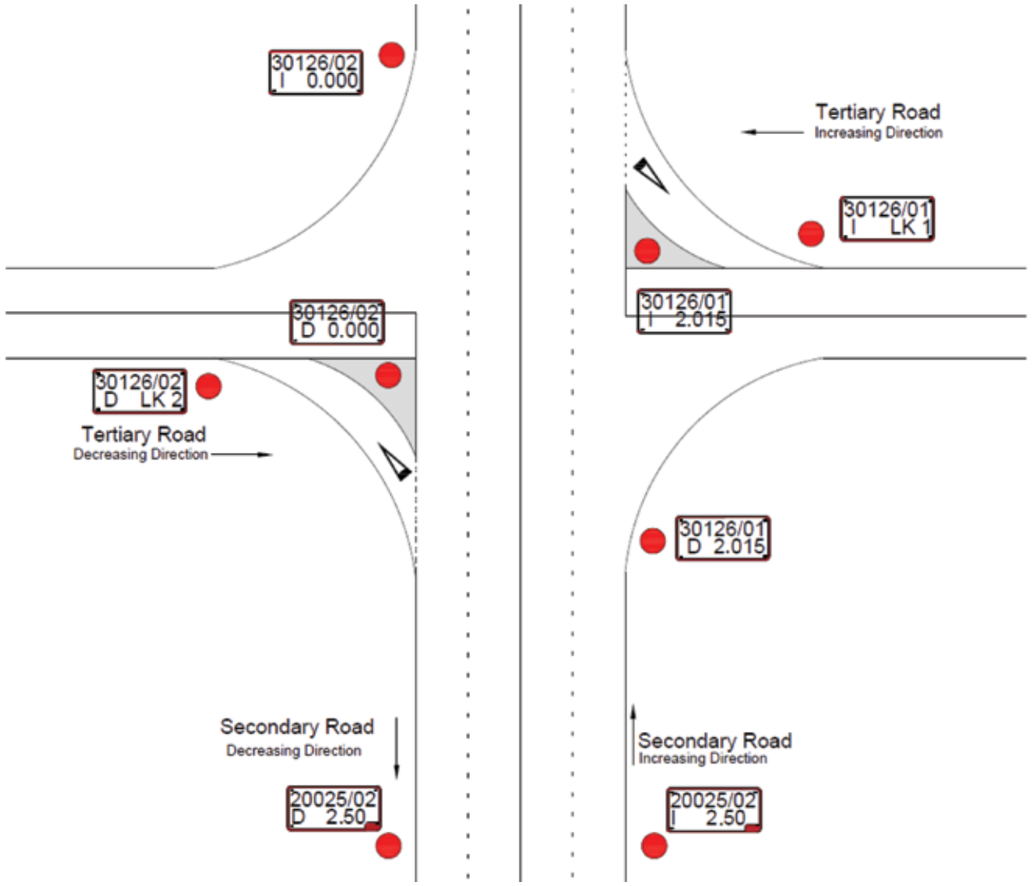


Figure 10: Typical NRS Sign Layout at a Signalised Intersection

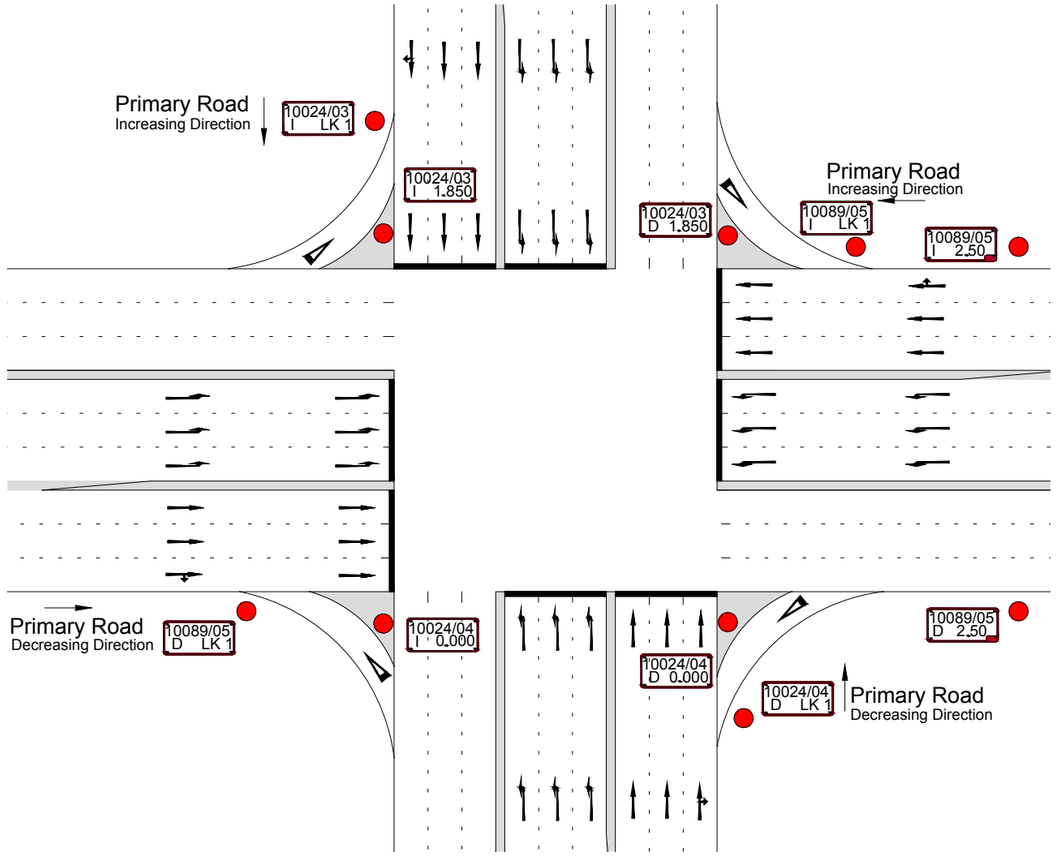
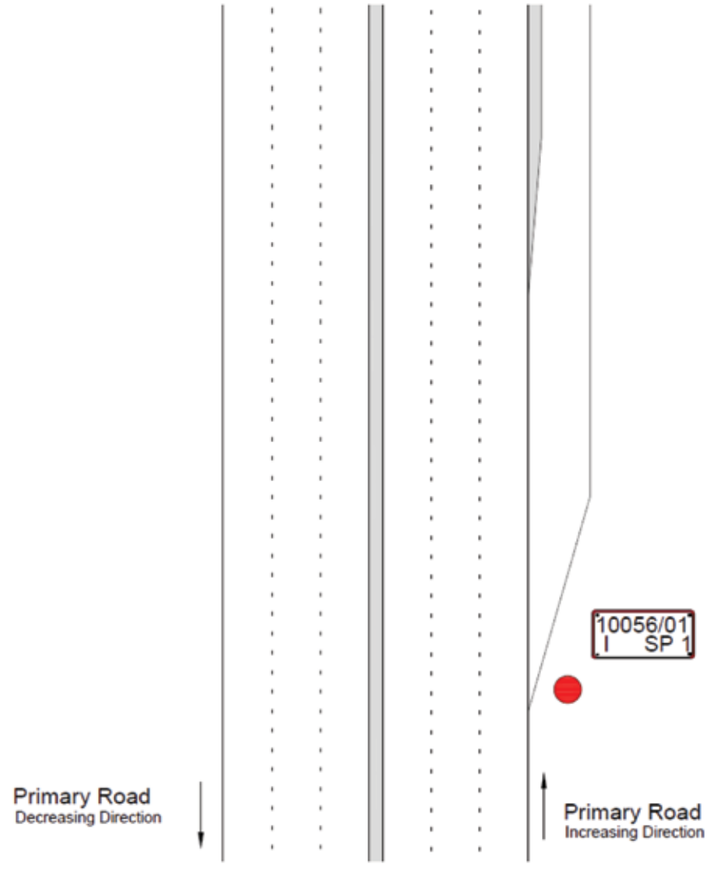


Figure 11: Typical NRS Sign Layout at a Slip Road



4.0 Enterprise Asset Management System (EAMS)

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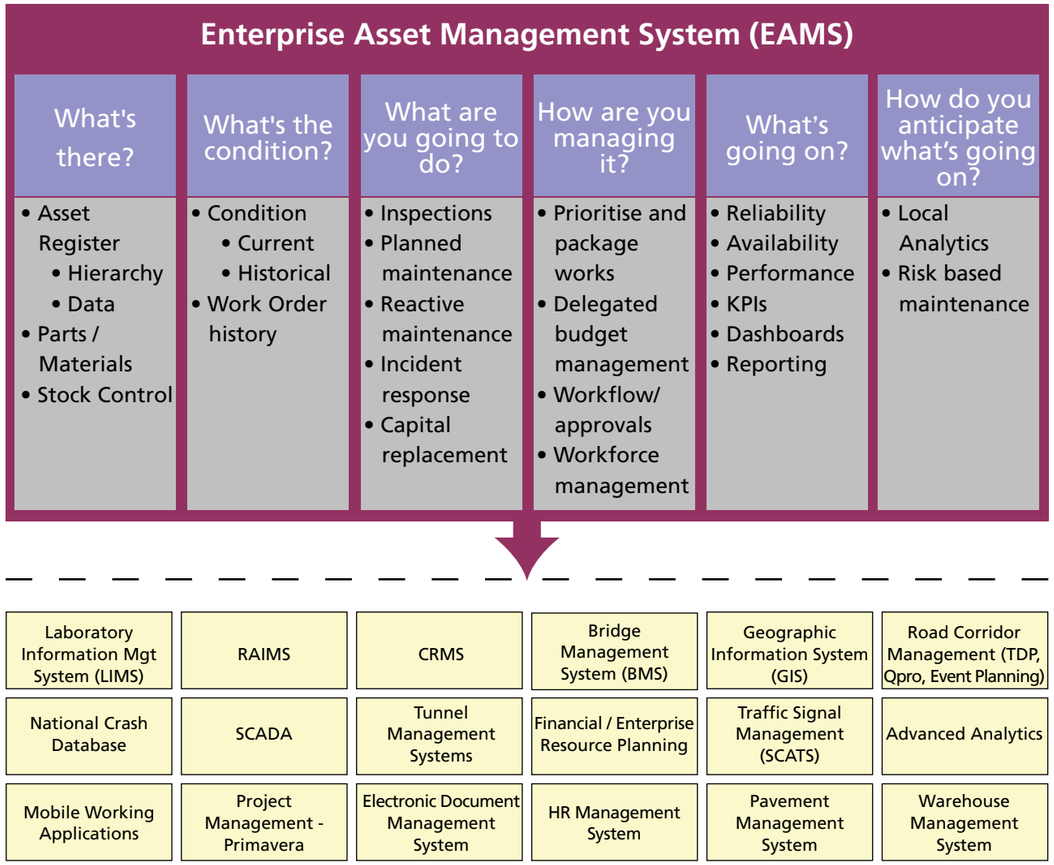
An Enterprise Asset Management System (EAMS) is a requisite in enabling an organisation to effectively and sustainably carry out world class asset management.

Best practice asset management is defined by BS ISO 55001 Managing Assets: Management System - Requirements. It defines systematic and coordinated activities and practices through which an organisation optimally and sustainably manages its assets and asset systems, their associated performance, risks and expenditures over their life cycles for the purpose of achieving its organisational plan. An EAMS enables an organisation to most effectively and efficiently manage its assets based on reliable, up-to-date and consolidated knowledge of its asset base. It involves having a comprehensive asset inventory, knowing the condition of those assets, and managing their lifecycle. Equipped with reliable data, engineers are able to predict the annual level of investment required to deliver a predetermined level of service, in the most cost effective manner, at the agreed level of risk.

The outputs will be a crucial foundation for the management of asset information. It effectively coordinates activities such as inspection routines, reporting, and maintenance and planned interventions. Once asset data is available in EAMS and being maintained consistently, the Asset Management team, using the data provided by the inspection standards described in this manual, will be able to predict the life cycle of the asset, future failures, rates of deterioration and accurately manage maintenance practices and the financial costs involved with asset ownership.

The diagram overleaf shows what the system will be capable of and the links to what external systems that will provide information and data.

Figure 12: EAMS Core Functions and External Systems



5.0 Network Inspections

5.0 Network Inspections

5.1 Network Inspections

The establishment of an effective inspection regime incorporating inspection frequencies, items to be recorded and nature of response is an integral component of an effective highway maintenance strategy. An approved robust inspection regime, incorporating network safety and serviceability, also forms part of Ashghal's defense against third party liability claims.

An inspection, testing and monitoring regime should minimise risks to public safety, provide sufficient data for management and make effective use of resources. The mix of techniques used in the regime, and frequencies at which they are applied, should be determined by considering appropriate criteria in an objective manner, e.g. through a formal risk assessment. The criteria should include, but not be restricted to, public safety, the characteristics of the assets, the consequence of failure, the environment the assets operate in, the services provided, typical rates of deterioration and susceptibility to damage.

The inspection, testing and monitoring techniques should be sufficient to:

- identify condition, defects and signs of deterioration that are significant to safety and management
- identify any significant changes in condition, loading or environment that have occurred since the last observation
- assess or provide information for the assessment of stability and serviceability
- determine or assist the determination of the cause, extent and rate of deterioration
- provide information that can be used to support highway management, i.e. the identification of needs and associated maintenance works.

The inspection regime should provide the basic information for addressing the key objectives of highway maintenance strategy, these are:

- Network safety
- Network serviceability
- Network sustainability.

It will also provide the basic condition data for the development of programmes for maintenance as part of the Asset Management Plan (AMP). All elements of the inspection and assessment regime should be applied systematically and consistently, in accordance with the principles of Quality Assurance.

The inspection regime described shall be the standard to which all roads owned and maintained by Ashghal are maintained. It is also recommended that other third party road owners and maintainers e.g. Qatar Petroleum should use this standard as industry best practice by which they maintain their roads.

Inspections should be carried out by trained, qualified or experienced personnel. To promote inspection consistency and quality, authorities are recommended to carry out regular in-house inspection meetings to assess the competence of inspectors including those provided by external contractors.

5.2 The Watchman Role

The Watchman Role is central to a network management approach and will encompass wide-ranging and varied functions. It dictates the way an organisation responds to the changing needs of itself, stakeholders and customers, encouraging value and innovation and a constantly improving level of service.

An important element of the Watchman Role is the requirement to improve quality, efficiency and effectiveness of operations, thus improving outcomes for customers and overall asset value and involves:

- monitoring customers' perceptions and addressing their complaints
- monitoring the operation, and influences on the network
- monitoring network trends
- identifying needs and risks
- maintaining and improving asset value
- aligning with the corporate strategies and objectives
- proposing solutions or enhancements to operations or network asset.

Network Stewardship is a major element of the Watchman Role. Stewardship is the fostering of ownership of the network, providing a thorough understanding and awareness of the state of the network. This involves working with all Ashghal departments, stakeholders, contractors and the supply chain towards common goals and objectives for the delivery of integrated services for the operation of a safe, reliable and efficient road network that delivers corporate objectives, whilst focusing on the needs and views of the customer.

Through Stewardship, staff will foster network ownership, providing a thorough understanding and awareness of its state. Regular and extensive liaison with stakeholders on or adjacent to the network will enable us to anticipate the impact of any external influences.

The tasks to be performed under the network stewardship element of the Watchman Role are as follows:

- monitoring and identifying network issues
- completing a Watchman Form
- recording and tracking reports on Watchman Register
- reviewing and progression of Watchman issues
- consultation with others who may influence the network
- performance monitoring.

The Watchman Role involves everyone within the business. It promotes a culture of network stewardship throughout every member of staff within Ashghal by encouraging everyone to become the "eyes and ears" of the network.

5.3 Categories of Inspection

5.3.1 Safety Patrols

Safety Patrols are designed to supplement the Safety Inspections described in paragraph 5.2.2 by providing a more frequent surveillance of the road network to identify obvious hazards, those that would be recorded as Emergency or Urgent (Category 1) defects as described in paragraphs 5.3.1 and 5.3.2.

Safety Patrols shall normally be carried out by an inspection team comprising of an inspector and a driver travelling in a vehicle as slowly as prevailing traffic speeds allow without disruption of traffic flow. The inspector will record the start and end time of the inspection for each section of road (based on the NRS), he shall record the location (based on the NRS) of all defects observed and, if reasonably practical, correct, make safe or otherwise protect immediately and report to the base office for action, in the same manner as defects discovered by a Safety Inspection.

A record, either manually or electronically, must be made of all Safety Patrols undertaken and should include the time, the date, the name of the inspector, the method by which the section of the road was patrolled (driven or walked), a list of defects discovered and the NRS section on which they were found. These records shall be retained in an appropriate format for a minimum of 6 years.

Safety Patrols shall be undertaken on a daily basis (including weekends and holidays) on the agreed Strategic Network in between the weekly Safety Inspections. The Strategic Network has been chosen using the following criteria:

- expressways
- roads joining population centres
- roads with political and security sensitivity
- roads with economic importance
- roads of national importance
- roads having daily traffic figures of greater than 30,000 vehicles per day (based on the Qatar Strategic Traffic Model (QSTM) 2011).

These criteria and the resultant network receiving safety patrols will be reviewed on a monthly basis taking account of increase in inspection resources, changes to any processes and procedures, significant changes to the network, ongoing projects that may alter traffic flows, any increase in political sensitiveness and instructions received from senior management.

At major grade separated junctions it may be unnecessary to patrol the main carriageway and all the associated slip roads, and link roads every day. A schedule of which slip roads and link roads will be patrolled and when will be agreed with Ashghal.

5.3.2 Safety Inspections

Safety Inspections are regular visual inspections designed to identify those defects which are likely to create a danger to the public and therefore require immediate or urgent attention and should also cover defects on highway structures and tunnels. They shall normally be driven inspections, with the risk of danger assessed at the time of the inspection, and the defects identified either as Emergency, Urgent (Category 1) or Non-Urgent (Category 2) as described in paragraphs 5.3.1, 5.3.2 and 5.3.3 with an appropriate priority response assigned to the defect.

In particular circumstances, in town centres or shopping areas, there may be the occasional need to complete the inspection on foot. It may be appropriate to undertake Safety Inspections during off-peak periods or at night in order to minimise traffic disruption and maximise safety of both the inspectors and the public.

Safety Inspections shall be carried out from a slow moving vehicle, with an inspector and separate inspector/driver; the vehicle shall be fitted with an automatic distance recorder, although there may be some circumstances where further investigation on foot is necessary. For instance when inspecting in busy urban areas. Data is recorded on a Data Capture Device (DCD). Additional Safety Inspections may be required in response to reports or complaints from the police, other organisations, or the public; as a result of major incidents; or as a result of extreme weather conditions. This is to check whether the network is clear of sand and to assess the functionality of the highway drainage system.

It is also important to record all road sections lengths that have been inspected where no defects have been found, i.e. nil returns, so that a full record of survey history is maintained. Additional inspections may be necessary in response to user or client concern, as a result of incidents or extreme weather conditions, or in the light of monitoring information. These may be identified through the risk management process.

Safety Inspections are categorised into four groups, the frequency on Ashghal's Network and the Asset types to be inspected is shown in the table.

Table 2: Carriageway Safety Inspection Frequencies

Carriageway Safety Inspection Frequencies		
Hierarchy Description	**Frequency**	**Asset to be Inspected**
Expressways	7 days	Carriageway/Footway/Kerb/ Gully/Manhole Covers/ Communication Cabinets/ Retaining Walls/Traffic Signals/Vehicle Restraint Systems/Pedestrian Guardrail/ Road Studs & Markings/ Signs/Road Lighting Points/ Debris
Primary	14 days	
Secondary	28 days	
Tertiary	56 days	
Local	6 months*	

*** Note:** Safety Inspections of local roads will determine the frequency of the subsequent detailed inspections. The frequency of the detailed inspection will depend on the number of defects recorded during the safety inspection.

The parameters which need to be specified for a safety inspection regime are:

- frequency of inspection
- items for inspection
- degree of deficiency
- nature of response.

Frequencies for safety inspections of individual network sections should be based upon consideration of:

- category within the network hierarchy
- traffic use, characteristics and trends
- incident and inspection history
- characteristics of adjoining network elements
- wider policy or operational considerations.

Although the category within the hierarchy, in combination with traffic use, will be the main determinant of inspection frequency, other factors should be taken into account in deciding whether consideration should be given to increasing or reducing the frequency. An on-site risk assessment should be undertaken where there is any uncertainty about the category to be applied. For example:

- road use might be at the margin of the category but have higher than normal levels of traffic growth
- extensive development may be taking place or is planned
- road section length might have a higher than normal level of accidents or related incidents which would suggest unusually high levels of risk
- VIP routes
- in some areas, it may be desirable to combine footway and carriageway inspections to mitigate against problems associated with heavy traffic and parked cars.

Where carriageway and footways intersect, for example at pedestrian crossings, bollards, or other defined crossing points at junctions, the footway should always take precedence in determining of inspection frequencies, defect definition and responses. However, there are particular circumstances when, because of their very nature and importance, frequencies can be varied. These circumstances relate to special usage or vulnerable users, such as access to schools, hospitals, medical centres etc.

5.3.3 Detailed Inspections

Detailed Inspections are generally walked surveys undertaken using a standard measuring wheel, using the Network Referencing System as the framework on which defects are identified and referenced. Data shall be recorded on a DCD using an appropriate inspection program which can be configured for either specialist or non-specialist surveys.

Detailed inspections identify deficiencies in the highway fabric which, if left untreated, are likely to adversely affect its long term performance and serviceability and are useful in determining maintenance and rehabilitation programmes, especially when used in conjunction with other condition assessment surveys.

Although these surveys cannot always establish deterioration mechanisms themselves, visual surveys will identify the symptoms of the deterioration mechanisms which will allow further investigations to be targeted accordingly.

The data gathered from each report shall be input into the Asset Inventory and then into the Works Order System where it will then be reviewed, analysed and prioritised to form a works programme and budget.

Detailed Inspections shall seek to minimise disruption to traffic whilst ensuring adequate access for proper inspection and maintaining a safe working environment for the inspection personnel. On high speed roads for inspector's safety, where possible, Detailed Inspections should be carried out with the protection of a truck or trailer mounted attenuator (TMA) in accordance with the requirements described in the WZTMG.

On roads of 3 lanes or wider expressways, it is usual to survey from the hard shoulder or verge/footway, again protection should be provided by provision of an appropriate TMA. Every 2 or so years (if roadspace allows) detailed inspections should be carried out from the central reserve (median), this enables defects that may not be visible from the hard shoulder to be identified.

Areas of the network, including for example flyovers, underpasses, and high-speed roads without hardshoulders which are deemed to be inaccessible for a walked inspection shall be assessed by a mobile unit or by providing a full closure or by the provision of a lane closure. Each location should be identified and shall be subjected to a risk assessment.

Specific requirements for Detailed Inspection of each activity are set out in the paragraphs in Chapter 7 for each asset. The frequencies are carried out at less frequent intervals than Safety Inspections and are governed by the routine cyclical maintenance programme. Tables 3 and 4 summarise the required frequencies of Detailed Inspections for each activity.

The frequencies shown in Table 3 and 4 should be regularly reviewed. Initially, this review should be undertaken following completion of 2 full cycles of the inspection program i.e. after 2 years' worth of Safety Patrols, Safety Inspections and Detailed Inspections have been completed. This will provide sufficient data to enable Engineers to determine the state of particular sections of the network and if necessary allow an adjustment in the inspection regime according to the number and type of defects being identified. For example inspections on carriageways recently constructed or repaired could be relaxed and conversely inspections could be increased on carriageways that are starting to deteriorate.

Any defects encountered should be assessed as being either Emergency, Urgent (Category 1) or Non-Urgent (Category 2) and dealt with in accordance with the requirements of the safety inspection regime described above.

Many highway elements will require both safety and detailed inspections (whether they are Specialist or Non-Specialist). Where this is the case, these inspections may be combined taking due consideration for the difference in investigatory levels.

Information collected during previous Safety Inspections may provide contributory information for a Detailed Inspection, e.g. a monitoring regime for a temporary repair that is awaiting a permanent repair or when an inspector does not consider a defect to have been severe enough to warrant an urgent repair.

Detailed Inspections should allow for the inspection of the following assets:

- minor carriageway repairs
- footways and cycle tracks
- covers, ratings, frames and boxes (ironwork)
- kerbs, edgings and pre-formed channels
- piped drainage systems
- gullies, catchpits, soakaways and interceptors
- ditches and dwales
- culverts
- balancing ponds and emergency flood areas
- ancillary Items
- geotechnical assets
- soft estate
- sweeping, cleaning and animal carcasses
- vehicle restraint systems and barriers
- fences, walls, screens and environmental barriers
- road studs
- road markings
- road traffic signs
- road traffic signals
- road lighting
- structures
- technology systems.

The maintenance requirements for defects identified as a result of inspections or from complaints received are shown in Chapter 7. Also, where appropriate a Detailed Inspection frequency is given for the asset type or for a particular component of the asset, e.g. the Vehicle Restraint Systems and Barriers section includes the following inspection requirements:

- all vehicle restraint systems, including concrete barriers, shall be carried out at intervals of 2 years in respect of mounting height, surface protective treatment and structural condition
- pedestrian guard rails at intervals of 2 years in respect of surface protective treatment and structural condition.

5.3.3.1 Cyclic Maintenance

For those activities where the cyclic works will completely rectify any defects found e.g. cutting grassed areas or sweeping and cleaning, no formal Detailed Inspection regime is needed, although it is recognised that if an inspector finds defective items under these Asset types, he may recommend bringing forward the date of the next schedule inspection to rectify them.

5.3.3.2 Work Scheduling

Detailed Inspections are separated into Specialist and Non-Specialist types:

- Specialist Inspections – programmed inspections carried out by contractors or staff having specialist knowledge of the particular asset. This is achieved through appropriate technical training of staff that are deemed competent in their field of expertise e.g. Geotechnical specialists inspect cuttings and embankments
- Non-Specialist Inspections – all other asset inspections undertaken by staff not necessarily having any particular specialism, apart from being deemed competent in the inspection process itself
- Special Inspections – out of sequence inspection of an asset resulting from a perceived change to its normal condition. Its purpose is to assess the integrity of the asset and to determine whether there is a danger to the travelling public using, or adjacent to, the network or the asset itself needs further more detailed inspection. For example a special inspection, carried out by a specialist, of a bridge structure may be requested following a bridge strike.

The Enterprise Asset Management System (EAMS) will calculate the appropriate inspection and cyclic maintenance frequencies for each asset type on every road section length on the network i.e. gully emptying and inspection schedules are produced only if gullies exist within the section. These frequencies may be changed by the user based on data and local knowledge of the network. When details of inspections and defects are loaded into EAMS from the DCD, the date of next inspection will be calculated automatically. Similarly, when cyclic work is carried out the date is fed into the system and the next maintenance occurrence will be scheduled.

5.3.3.3 Detailed Inspection Interval/Frequencies

Table 3: Non Specialist Inspection Frequencies

Asset Type	Detailed Inspection Interval/Frequency											
Non Specialist Inspections	Year 1		Year 2		Year 3		Year 4		Year 5		Year 6	
Carriageways - Expressways - Urban	x	x	x	x	x	x	x	x	x	x	x	x
Carriageways - Expressways - Rural		x		x		x		x		x		x
Carriageways - Primary Roads - Urban	x	x	x	x	x	x	x	x	x	x	x	x
Carriageways - Primary Roads - Rural		x		x		x		x		x		x
Carriageways - Secondary Roads		x		x		x		x		x		x
Carriageways - Tertiary Roads		x		x		x		x		x		x
Footways and Cycle Tracks – Urban	x	x	x	x	x	x	x	x	x	x	x	x
Footways and Cycle Tracks – Rural		x		x		x		x		x		x
Covers and Gratings	x		x		x		x		x		x	
Kerb/Channel – Expressways – Urban	x	x	x	x	x	x	x	x	x	x	x	x
Kerb/Channel – Expressways – Rural		x		x		x		x		x		x
Kerb/Channel – Primary – Urban	x	x	x	x	x	x	x	x	x	x	x	x
Kerb/Channel – Primary – Rural		x		x		x		x		x		x
Kerb/Channel – Secondary		x		x		x		x		x		x

Asset Type	Detailed Inspection Interval/Frequency											
Non Specialist Inspections	**Year 1**		**Year 2**		**Year 3**		**Year 4**		**Year 5**		**Year 6**	
Kerb/Channel – Tertiary		x		x		x		x		x		x
Kerb/Channel (Non Carriageway)		x		x		x		x		x		x
Gully/Catchpit/Interceptor/Soakaway/ Catch Basin		x		x		x		x		x		x
Ditches/Swales and their associated Headwalls			x				x				x	
Culverts and their associated Head-walls	x		x		x		x		x		x	
Stock Proof Fencing	x	x	x	x	x	x	x	x	x	x	x	x
Safety Fences - Metal/Concrete				x				x				x
Boundary Fences - Metal/Concrete				x				x				x
Boundary Fences – Timber				x				x				x
Safety Fence - Loose Bolts				x				x				x
Vegetation and Trees (General)		x		x		x		x		x		x
Road Studs - Expressways – Urban	x	x	x	x	x	x	x	x	x	x	x	x
Road Studs – Primary Roads – Urban	x	x	x	x	x	x	x	x	x	x	x	x
Road Studs – Rural Expressways and Primary Roads, all Secondary and Tertiary Roads		x		x		x		x		x		x
Road Markings – Paint		x		x		x		x		x		x
Road Markings – Thermoplastic				x				x				x
Road Sign Face/Post Structural Integrity/Fixings/Clearances/Visual Performance		x		x		x		x		x		x
Traffic Signals Hardware	x	x	x	x	x	x	x	x	x	x	x	x

Asset Type	Detailed Inspection Interval/Frequency											
Non Specialist Inspections	**Year 1**		**Year 2**		**Year 3**		**Year 4**		**Year 5**		**Year 6**	
Lighting Columns		x		x		x		x		x		x
Communications Cabinets: Alignment/ Clean/Serviceability	x	x	x	x	x	x	x	x	x	x	x	x
Transmission Stations		x		x		x		x		x		x
Communications Cabinets: Hardware				x				x				x
Embankments and Cuttings		x		x		x		x		x		x
Litter Picking	As Required											
Sweeping and Cleaning	As Required											

Table 4: Specialist Inspection Frequencies

Activity	Detailed Inspection Interval/Frequency											
Specialist Inspections	**Year 1**		**Year 2**		**Year 3**		**Year 4**		**Year 5**		**Year 6**	
Tension of Safety Fences				x				x				x
Ashghal Vegetation/Trees - Soundness									x			
Non-Ashghal Vegetation/Trees -Soundness									x			
Road Studs Conspicuity (Warning and Advisory)		x		x		x		x		x		x
Road Markings – Skid Resistance	As Required											
Road Markings – Retro Reflectivity	x		x		x		x		x		x	
Lit Signs/Bollards – Electrical Testing				x				x				x
Signs – Night-time Visual Performance and Retro Reflectivity	5 years after installation and then every 2 years thereafter											
Traffic Signals – Electro-mechanical Parts	x	x	x	x	x	x	x	x	x	x	x	x

Asset Type	Detailed Inspection Interval/Frequency											
Non Specialist Inspections	Year 1		Year 2		Year 3		Year 4		Year 5		Year 6	
Traffic Signals – Electrical									x			
Lighting Columns – Electrical									x			
Feeder Pillars – Electrical									x			
Comms Cabinets – Cable Ducts		x		x		x		x		x		x
Comms Cabinets – Electrical		x		x		x		x		x		x
Embankment/Cutting Condition									x			
Structures – General Inspection (GI)				x				x				x
Structures – Principle Inspection (PI)												x

Note: The frequencies described above should be regularly reviewed. They can be relaxed or increased based on the data obtained through previous inspections and knowledge of the network.

5.3.4 Hazard Mitigation

Once a defect has been identified the minimum requirement is to display warning notices and/or make safe any defect which poses an immediate hazard to road users or pedestrians. The hazard should then be reported to the appropriate asset owner e.g. utility companies at the earliest practical opportunity depending on the nature of the defect. This includes the removal of debris from live traffic lanes and the removal of loose road studs and may, at times, require the assistance of the police to help manage the traffic whilst the defect/debris is dealt with.

5.4 Defect Definitions

Defects can occur in the condition of all aspects of the Network. The general definition of a defect to an asset is that it:

- represents a deterioration from the normal condition
- prevents an item from acting in the intended manner
- is damaged
- is likely to increase the rate of deterioration of another item
- causes an unintended hazard or nuisance.

As well as direct measurements of the performance, the presence of defects indicates that the performance has yet to be achieved or indicates why the required performance may not be achieved in the future. Performance will be achieved if defects are identified, categorised and repaired within the Hazard Mitigation and Permanent Repair periods given in the Table 3 and 4. Deciding the category of a defect is based on a series of guidelines and the experience and judgment of the inspector.

Defects, isssues or incidents which are identified as a result of safety, special or detailed Inspections, or following other reports (Police/Emergency Services) and complaints will fall into three categories.

5.4.1 Emergency

An emergency is defined as an incident or defect that requires an immediate response because it represents a danger that may cause injury, loss of life or damage to property and that requires immediate attention and remedial action.

Examples of incidents/defects or scenarios that could be deemed an emergency would be where there is a significant risk of:

- injury to any party using or repairing the network
- major disruption to the normal flow of traffic through the network
- structural deterioration of part of the network
- damage to third party property or equipment
- damage to the environment.

A good rule of thumb can be applied when ascertaining whether an incident or defect is an emergency, and that is - CRASH:

C – Capacity
R – Reduction
A – And
S – Significant
H – Hold-up

Where Capacity means a reduction in the capacity of the carriageway (i.e. a lane is closed) and there is a high risk that there is likely to be traffic hold-ups as a result of the incident or defect then it should become an emergency and dealt with accordingly and an immediate response should be instigated in accordance with Chapter 10 – Incident Management.

The following table is a list of examples of defects deemed to be an Emergency where immediate action is required to mitigate any resultant hazard. This list is not exhaustive.

Table 5: Examples of Emergency Defects

Emergency Defect	Hazard Mitigation	Permanent Repair
Large sinkholes, depressions or potholes that will cause damage to vehicles in carriageway	Make safe by installing appropriate traffic management	Undertake full repair of affected area
Large pieces of debris in live lanes	Install appropriate traffic management to enable safe recovery of debris, including requesting police assistance	Not applicable
Road Traffic Collision where damaged vehicles are blocking live lanes	Install appropriate traffic management to allow emergency services and recovery crews to work	Remove traffic management
Significant damage to infrastructure assets resulting from a Road Traffic Collision	Make safe by removing damaged asset and installing appropriate traffic management	Undertake full repair of damaged asset
Live lanes blocked by significant sand build up	Install appropriate traffic management to isolate blocked lanes and arrange to remove sand from carriageway	Scheme to ensure no future re-occurence
Significant flooding where lanes are impassable	Install appropriate traffic management to isolate blocked lanes or close roads and arrange appropriate plant to remove water from carriageway	Investigate reason for cause of flood and repair, clean or install positive drainage system
Sinkholes, depressions or missing paving blocks in footway	Make safe by coning off	Undertake repair of damaged asset
Unprotected excavations in or adjacent to footways	Make safe by coning off	Undertake full repair of affected area

Emergency Defect	Hazard Mitigation	Permanent Repair
Footways blocked by illegal obstructions causing pedestrians to walk in a live carriageway e.g. construction site fences	Erect warning signs to warn vehicular and pedestrian traffic	Install appropriate pedestrian traffic arrangements or remove obstructions
Missing manhole covers or gully gratings in live lanes	Install lane closure and cone off hazard	Replace cover or grating
Exposed wiring	Isolate electricity supply and make safe	Undertake repair of asset
Structural integrity of lighting column or sign compromised	Remove lighting column or sign	Replace lighting column or sign or erect temporary unit
Loose or hanging parts of a damaged/defective overhead sign	Remove overhanging sign parts	Replace sign or damaged parts
Bridge strikes where damage has occurred to the structure	Call out Structural Engineer to assess damage and if necessary install appropriate traffic management to mitigate hazard	Undertake repairs to damage
Loss of power at Traffic Signal Intersections	Inform police and erect appropriate Traffic Signals not in use signs	Undertake repair

5.4.2 Urgent (Category 1)

Defects that require prompt attention because they represent an imminent risk of either one or more of the following:

- failure to effectively enforce the legality of an asset that has a mandatory or prohibitory function e.g. speed limit, stop or no entry sign
- failure of an asset to fulfil its intended function where such an asset protects the road user and/or facilitates the safe use of the network
- graffiti that is too obscene, blasphemous or otherwise offensive to road users.

Urgent defects should be corrected or made safe at the time of the inspection, if reasonably practicable. Making safe may constitute displaying warning notices, coning off or fencing off to protect the public from the hazard. If it is not possible to correct or make safe at the time of inspection, which will generally be the case, repairs of a permanent or temporary nature should be carried out as soon as possible and in any case within the defined periods shown in Table 6. Permanent repair should be carried out within the prescribed periods shown in Table 6.

Examples of Condition: The following defects are examples of the type that may constitute an Urgent (Category 1) defect. The list should not be regarded as exhaustive and examples are shown in the Highway Inspections Manual:

- potholes, sinkholes and other local defects in the carriageway, footway or cycle track, including missing, rocking or raised ironware, missing footway paving blocks or slabs
- excessive standing water and water discharging on to and/or flowing across the road.

Table 6: Urgent (Category 1) – Defect Rectification Periods

Route Classification	Hazard Mitigation Periods	Permanent Repair
Expressway	<24 hours	28 days
Primary	<24 hours	28 days
Secondary	<24 hours	56 days
Tertiary	<24 hours	56 days
Local	<24 hours	56 days

- damage to vehicle restraint systems and other barriers where the integrity of the system is not functioning
- debris and spillages in traffic lanes and hardshoulders, including sand carried onto carriageway from desert access points
- damaged lighting columns and other street furniture in a dangerous condition
- damaged, defective, displaced or missing regulatory, mandatory or prohibitory traffic signs (Red edged signs) e.g. speed limit signs, no entry signs, stop and give way signs etc.
- damaged, defective, displaced or missing traffic signals
- obscured traffic signs and signals
- trees, shrubs and vegetation which by virtue of their position or condition constitute a hazard to road users
- displaced roadstuds lying in the carriageway, hardshoulder or laybys
- faults in road structures e.g. impact damage to superstructures, supports or parapets, flood damage, insecure expansion joints
- rocking gratings or covers in urban areas causing intrusive noise
- road and sign lighting not operational
- overhead wires in a dangerous condition
- blocked gully gratings and obstructed channels, grips and slot drains
- earth slips where debris has encroached or is likely to encroach on to the road
- rocks or rock faces constituting a hazard to road users.

5.4.2.1 Actions

Once a defect has been identified the inspector will categorize that defect based on the guidelines shown in Table 7. Having decided upon the Category of the defect a decision as to the appropriate action is required. The options are:

- Immediate/Urgent Action – if safe to do so, inspector to make safe at time of inspection or to call out an emergency response resource, appropriately equipped, to make safe. Making safe may constitute displaying warning notices, coning off or fencing off the defect to protect the public
- Temporary Repair – designed to provide an interim short term fix to a defect and to prevent the integrity of the asset deteriorating further. If it is not possible to correct or make safe at the time of inspection, repairs of a temporary nature shall be carried out as soon as possible and in any case within a period of 24 hours. Temporary repairs shall be inspected regularly as part of a Safety Inspection so that they can be monitored for any further deterioration
- Permanent Repair – to be carried out within the timescales defined in Table 6 and is the action taken to provide a long-term repair to a defect such that the integrity of the asset is returned, as far as reasonably practicable, to its pre-defect condition.

It is vital that defects are accurately recorded so that they can be correctly captured into GIS, this will be done via the Data Capture Devices (DCD) pre-loaded with an application that takes a photograph of the defect and records the GPS location of where that photograph was taken. This allows follow up inspections and repair teams to find the defect. It is important to record:

- sufficient information for the defect to be easily found including its GPS position and cross sectional position
- the exact nature of the defect being recorded
- the asset on which the defect has been recorded.

Table 7: Urgent (Category 1) Defect Guidelines

Asset	Defect	Temporary Repair	Permanent Repair
Carriageway	Sinkholes in excess of 300mm dia. and greater than 50mm deep	Make safe by coning off affected area	Full course depth repair required
	Potholes in excess of 300mm dia. and greater than 50mm deep	Fill in with instant road repair or similar product or repair with a proprietary road repairing machine (Jetpatcher)	Full course depth repair required or repair with a proprietary road repairing machine (Jetpatcher)
	Depressions or ridges in excess of 50mm over 1000mm in length	Fill in with instant road repair or similar product or repair with a proprietary road repairing machine (Jetpatcher)	Full course depth repair required or repair with a proprietary road repairing machine (Jetpatcher)
	Obstructions, which reduce the carriageway width, including deposits of sand blown onto the carriageway	Install appropriate Traffic Management and remove obstruction	Remove obstruction

Asset	Defect	Temporary Repair	Permanent Repair
Carriageway	Alligator cracking exceeding 50mm in depth	Fill in potholes that form with instant road repair or similar product or repair with a proprietary road repairing machine (Jetpatcher)	Remove defective carriageway and replace with full course depth repair required or repair with a proprietary road repairing machine (Jetpatche
	Severe shoving exceeding 50mm high	Remove defective carriageway and replace with full course depth repair required or repair with a proprietary road repairing machine (Jetpatcher)	Remove defective carriageway and replace with full course depth repair required or repair with a proprietary road repairing machine (Jetpatcher)
	Severe rutting exceeding 50mm in depth	Fill in with instant road repair or similar product or repair with a proprietary road repairing machine (Jetpatcher)	Full course depth repair required or repair with a proprietary road repairing machine (Jetpatcher)
	Pavement edge surface loss exceeding 300mm	Fill in with instant road repair or similar product or repair with a proprietary road repairing machine (Jetpatcher)	Cut out and square off defective area and undertake a full depth haunch repair
	Edge of carriageway drop off exceeding 100mm	Place temporary traffic management to prevent drivers from encroaching into drop-off	Backfill area with compacted fill

Asset	Defect	Temporary Repair	Permanent Repair
Footway	Missing block paving blocks or potholes in excess of 25mm deep	Relay paving blocks or fill in with instant road repair or appropriate product for footpaths	A full repair required, relay paver blocks or resurface footpath with a full depth repair
	Unprotected excavations in footways	Erect barriers, cone off excavation or place temporary cover	Expedite completion of works
	Cracks, gaps or differences in level in excess of 25mm wide	Fill in with instant road repair or appropriate product for footpaths	A full repair required, relay paver blocks or resurface footpath with a full depth repair
	Loose or rocking paving slabs in excess of +/-25mm.	Cone off affected area	Relay paving slabs
	Illegal obstruction reducing the footway width to <1000mm	Remove obstruction	Remove obstruction
	Standing water in excess of 25mm depth restricting footway width to <1000mm	Cone off affected area	Remove water. Undertake repair to source of flood
	Raised ironwork constituting a trip hazard of >25mm	Cone off affected cover	Reset cover to correct level
Covers, gratings and frames	Worn covers that could cause skidding	Cover top surface with instant road repair	Replace cover

Asset	Defect	Temporary Repair	Permanent Repair
Covers, gratings and frames	Missing covers and gratings	Install lane closure and cone off	Replace cover
	Difference in level in excess of +/-25mm in footway, +/- 50mm in carriageway	Fill with instant road repair	Replace cover and frame
	Loose or rocking items with movement in excess of 25mm causing excessive noise intrusion	Install lane closure and cone off	Replace cover
	Broken or damaged covers, gratings and frames	Install lane closure and cone off	Replace cover
Kerbs, edgings andcChannels	Vertical projections in excess of 25mm	Cone off affected kerb, fill with instant road repair	Reinstate or replace with new
	Horizontal projections in excess of 25mm	Use sandbags to cover the leading edge part of kerb	Reinstate kerb or replace with a new kerb
	Missing kerbs, edgings & channels	Use sandbags or instant road repair to fill gap from missing kerb	Replace kerb, edging or channel
	Loose or rocking items in excess of +/-25mm in the footway and +/-40mm in the carriageway	Use sandbags or instant road repair to fill gap	Reinstate or replace with new

Asset	Defect	Temporary Repair	Permanent Repair
Drainage	Defective highway gullies, chambers, culverts or pipes which result in standing water over 50mm deep that restricts the width of lane to less than half of its width.	Erect flood boards and clear drainage system	Reinstatement of gullies, chambers, culverts and pipes
	Debris within culverts that prevents the free flow of water	Remove debris	Remove debris
Fences and barriers	System does not provide the level of containment to which it is designed	Install suitable temporary fencing	Replace missing/ defective posts, rails and barriers
	Energy Absorbing Systems are damaged such that the integrity and effectiveness is compromised	Erect temporary warning	Repair or replace the system
Vegetation	Obstructed visibility or overhanging trees that could pose a danger to the highway user, including pedestrians using a footway	Erect warning or close footway	Cut back the encroaching vegetation (if on private land then prior permission to be sought from land owner)
Road studs	Displaced road studs in live lanes	Remove from network	Replace Missing/ defective studs with new ones

Asset	Defect	Temporary Repair	Permanent Repair
Road markings	Road markings in safety critical areas with line dimensions reduced by more than 50%	Erect warning signs	Re-paint worn road markings
	Missing road markings, particularly Traffic Signal Stop lines and at junctions with an associated Stop Sign	Erect warning signs	Re-paint road marking
Highway signs	Missing or defective posts, signs and fixings that could pose a danger to the highway user	For warning or regulatory signs, install a temporary sign on an A frame. Other types of signs should be made safe by removal of damaged items	Replace post, signs and fixings
	Headroom less than 2100 & 5200mm over pedestrian and vehicular areas respectively unless on a designated high load route	Remove	Re-install signs at the correct height
Traffic signals	All out	Erect traffic signal out-of-order signs	Repair
	2 red lights out on the same approach	Erect traffic signal out-of-order signs	Replace either bulbs that have blown inside signal or replace the whole signal

Asset	Defect	Temporary Repair	Permanent Repair
Traffic signals	Stuck on red	Turn traffic signal off and erect traffic signal out-of-order signs	Replace wiring or find out where fault is and rectify this in the components part
	Conflicting signals (i.e. signal head facing the wrong way)	Turn sign signal head to face the right way	Turn sign signal head to face the right way
	Road traffic collision damage	Remove damaged components and make any exposed electrical cables safe	Replace traffic signal and re connect electrics
	Signals in dangerous state, i.e. risk of injury or electrical shock	Make safe and turn off power supply	Replace wiring and replace traffic signal
	Door off or missing	Re-attach or replace door	Re-attach or replace door
Road lighting and lit signs	Consecutive columns out (three or more in a row – cable fault)	Investigate outage and repair	Investigate outage and repair
	Exposed wiring	Make any exposed electrical cables safe	Place wiring into correct position
	Road Traffic Collision damage	If necessary remove damaged components and make any exposed electrical cables safe	Replace damaged columns
	Lantern, bowl or bracket broken	Isolate, take down and make safe.	Replace damaged part and turn on power supply

Asset	Defect	Temporary Repair	Permanent Repair
Road lighting and lit signs	Feeder pillar damaged or door open	Make safe by securing door	If necessary replace feeder pillar or replace/repair damaged door
	Column door off or missing	Re-attach or replace door	Re-attach or replace door

5.4.3 Non-Urgent (Category 2)

All other defects, generally identified through walked Detailed Inspections as described. Non-Urgent (Category 2) defects are those which are deemed not to represent an immediate or imminent hazard or risk of short-term structural deterioration. Such defects may have safety implications, although of a far lesser significance than Urgent (Category 1) defects, but are more likely to have serviceability or sustainability implications. These defects are not required to be urgently rectified, and those for which repairs are required shall be undertaken within a planned programme of works, with the priority discussed as part of the annual programme for Capex/Opex works, see Table 8 for defect rectification periods. These priorities together with access requirements, other works on the road network, traffic levels, and the need to minimise traffic management, should be considered.

The programmes of work for rectification should be part of the Asset Management Plan (AMP).

Non-Urgent (Category 2) defects will be categorised according to priority – High (H), Medium (M) and Low (L):

- **High –** defects that are not superficial and do not represent an immediate hazard but has the potential, over time, to deteriorate into a defect that may become more serious. They should be included as part of a future programmed renewal or improvement scheme and delaying the repair will not lead to long term damage of the asset. Monitoring of the defect should be undertaken as part of the planned inspection regime to ensure that further deterioration has not taken place. For example, a small pothole in a carriageway that does not meet the Urgent (Category 1) criteria, but is subjected to regular trafficking.
- Medium – defects that are superficial and are not likely to deteriorate and do not need intervention unless they are to be repaired as part of a programmed renewal of improvement scheme. For example, a pothole that is not subject to trafficking or minor damage to a warning or regulatory sign that does not detract from its meaning or legality
- Low – superficial defects that are not likely to deteriorate if left and will not affect the serviceability of the asset. For example, a kerb defect in an area where there is no pedestrian traffic.

Table 8: Non-Urgent (Category 2) – Defect Rectification Periods

Route Classification	High (H)	Medium (M) & Low (L)
Expressway	6 months	Capex/Opex Schemes
Primary	6 months	Capex/Opex Schemes
Secondary	12 months	Capex/Opex Schemes
Tertiary	12 months	Capex/Opex Schemes
Local	12 months	Capex/Opex Schemes

6.0 Pavement Condition Surveys

6.0 Pavement Condition Surveys

6.1 Introduction

Asset condition is an essential element of an asset management strategy. Condition surveys identify the current condition of the network and provide essential data for both long-term and short-term maintenance funding decisions. Repeatable and reproducible condition surveys at regular intervals allow trend analysis to be used to support asset modelling and confirm the maintenance and rehabilitation decisions. Condition surveys will be carried out at intervals as shown in Table 9, with the data stored in the Pavement Inventory Management System (PIMS).

- **Repeatability** the variability of the measurements obtained by one person (or survey equipment) while measuring the same item repeatedly (i.e. a measure of the accuracy of the testing device)
- **Reproducibility** the variability of the measurement system caused by differences in operator behaviour (i.e. a measure of the influence of equipment operator).

Network surveys should be programmed to minimise disruption to road users.

The pavement condition survey methods to be used are:

- Falling Weight Deflectometer (FWD) - measuring carriageway deflection/ structural capacity

Figure 13: Condition surveys need to be planned around traffic flows and road users

- International Roughness Index (IRI) - measures pavement roughness and ride quality
- Grip Tester - measuring skid resistance
- Ground Penetrating Radar (GPR) - measuring pavement layer thickness and condition
- Coring - used to analyse and confirm pavement layer thickness measured with GPR.

All tests apart from the FWD survey and coring are undertaken at traffic speed which will minimise disruption to road users. Traffic speed surveys are also preferred since they minimise operator's exposure to live traffic.

Table 9: Pavement Condition Survey Frequencies

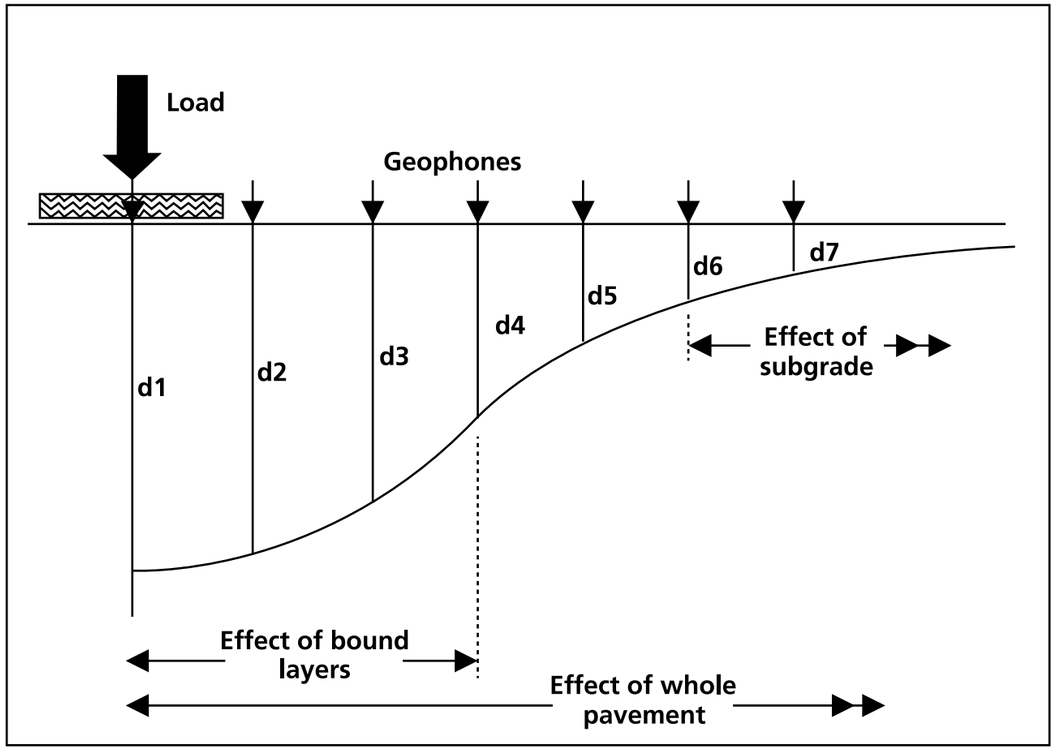
Survey Frequency					
Specialist Inspections	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Road Condition Survey (Rutting/Cracking etc.)	x	x	x	x	x
Carriageway Deflection/Structural Capacity (FWD)			x		
Pavement Roughness (IRI)	x	x	x	x	x
Skid Resistance (Grip Tester)	x	x	x	x	x
Pavement Distress (Laser Survey)	x	x	x	x	x
Pavement layer thickness and condition (GPR)			x		
Pavement layer thickness and condition (Coring)			x		

Pavement surveys and the results provided by them all contribute to the Ashghal Corporate Strategy of Optimized Assets and will be used to determine the maintenance needs of pavement assets contributing to renewal and improvement programmes by contributing to a multi-year programme of road asset maintenance and improvement schemes. Development of this programme in conjunction with the Value Management process will provide a basis for scheme funding of the road asset based on actual needs of the network.

6.2 Carriageway Deflection/ Structural Capacity Surveys

A simple and convenient method to assess the structural integrity of pavements is to apply a load to the surface and measure the resulting deflection. The Falling Weight Deflectometer (FWD) applies an impulse loading which is a close replication of the load of a moving lorry tyre. Using a series of geophones spaced at various distances from the load it is possible to accurately measure the maximum deflection under the load together with the shape of the deflection bowl (i.e. surface deflection measured at distances of up to 2m from the centre of the load).

Figure 14: FWD Deflection Bowl



FWD's are built onto a trailer and the test is carried out with the apparatus in a stationary position.

Figure 15: Falling Weight Deflectometer (FWD)

The technical benefits of undertaking FWD testing include:

1. They produce a force, amplitude and duration approximating the effect of a heavy moving wheel load which allows for the measurement of non-linear visco-elastic stress strain response caused by dynamic traffic loading.
2. They have very accurate deflection measurements, (± 2 microns) especially at large distances (i.e. larger than the thickness of the pavement, from the centre of the load). This is absolutely essential in order to get an accurate determination of layer stiffness using a process known as back-calculation.

The accurate load and deflection measurements are ideally suited to analytical evaluation methods. A major advantage of analytically-based structural design methods over more empirical methods is that the former may be used with any type of material and structure and under all climatic conditions. Consequently the FWD testing and deflection analysis can be adapted to the climatic conditions and pavement construction in Qatar.

The asset condition data predicted from FWD deflection analysis includes the following:

- Normalised deflections - Used as a simple indication of pavement condition and to sub-divide the pavement into homogenous sections with similar performance
- Back-calculated layer stiffness - Used to evaluate the integrity of pavement layers and evaluate the overall foundation support conditions
- Critical stress/strain values - Used to calculate residual life (and predict failure modes) from which any pavement strengthening option (overlays) can be determined.

6.3 Pavement Roughness

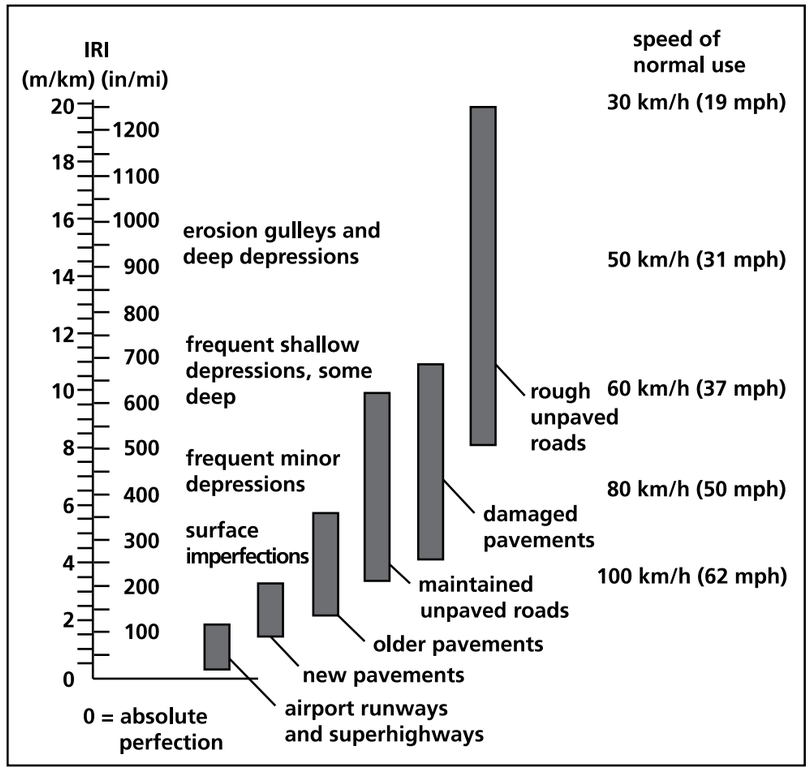
Roughness is an important indicator of pavement riding comfort and safety. From a driver's point of view, rough roads mean discomfort, decreased speed, potential vehicle damage, damage to goods in transit and increased operating cost. Roughness measurements can be used at both the network and project level. At network level, roughness may be used for dividing the network into uniform sections, establishing value limits for acceptable pavement condition, and setting maintenance and rehabilitation priorities. At project level, roughness measurements are used to locate areas of critical roughness and to maintain construction quality control. All pavements have irregularities and surface roughness is influenced by:

- Traffic loading
- Environmental effects
- Construction materials
- Construction quality

The roughness of a pavement usually increases with increased traffic loading and environmental exposure.

For Ashghal's network, roughness is measured using the International Roughness Index (IRI) which is a scale for roughness based on the response of a generic motor vehicle to roughness of the road surface (see Figure 16).

Figure 16: Range of Typical IRI Values



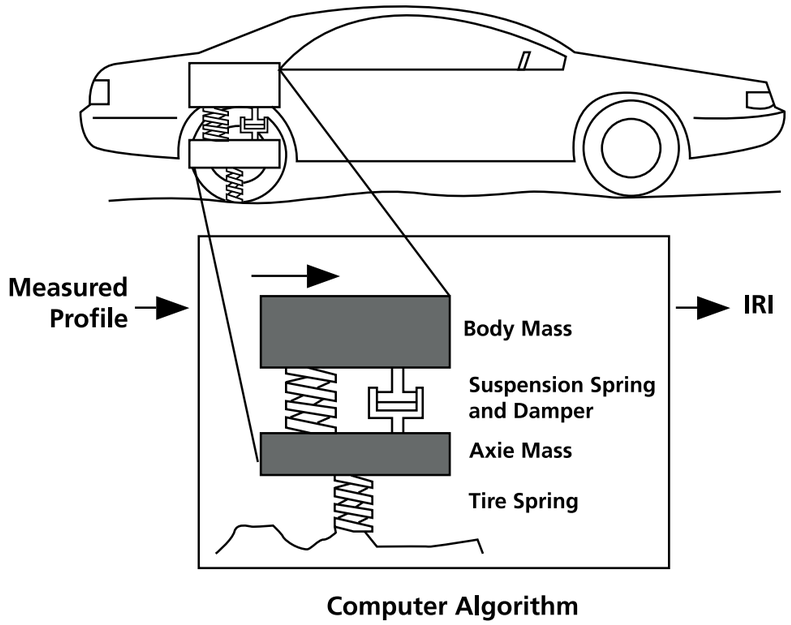
For the Ashghal network IRI will be measured using a Profilometer.

Table 10: Proposed IRI Acceptance Values for Primary and Secondary Roads

Stress/Type	Low	Poor	Very Poor
Expressways/Primary Roads IRI/ Reliability (m/km)	1.5 to <2.0	2.0 to 3.0	>3.0
Secondary Roads IRI/ Reliability (m/km)	2.5 to <3.5	3.5 to 4.5	>4.5

Table 10 details typical IRI acceptance values for Primary and Secondary roads. Values for Tertiary Roads have yet to be determined.

Figure 17: Typical IRI Vehicle Configuration



6.4 Skid Resistance Surveys

Skid resistance is the force developed when a tyre that is prevented from rotating slides along the pavement surface. Skid resistance is an important pavement evaluation parameter because it is inextricably linked to skid related accidents. Skid resistance depends on a pavement surface's microtexture and macrotexture, which are defined as follows:

- Microtexture refers to the small-scale texture of the pavement aggregate component (which controls contact between the tyre rubber and the pavement surface)
- Macrotexture refers to the large-scale texture of the pavement as a whole due to the aggregate particle arrangement (which controls the escape of water from under the tyre and hence the loss of skid resistance with increased speed).

With respect to the measurement of asset condition it is important to acknowledge that skid resistance changes over time. In addition to possible gains in the first two years following construction (as the roadway is worn away by traffic and rough aggregate surfaces become exposed) it will decrease with age and also varies with climatic conditions. Seasonal variation is quite significant and some international testing standards make allowance for the

time of year that the survey is undertaken. In Qatar, skid resistance surveys will mainly be undertaken using Findlay Irvine's GripTester which measures skid resistance of the road surface at the time of the survey.

Figure 18: GripTester

The GripTester is a 3 wheeled trailer developed in the mid 1980's by Findlay Irvine. The pavement is tested wet using a water supply carried by the towing vehicle. The test wheel is fitted with a smooth tyre compliant with an American Society of Testing and Materials (ASTM) specification. It is mounted in the same direction as the other wheels but is geared so that it travels more slowly. It is therefore forced to slip continuously across the surface. The slip speed is a fixed 14.5% of the vehicle speed, i.e. a slip speed of 7 km/h if the test speed is 50 km/h. The testing system is reliable, cost effective, accurate and versatile. Data is collected continuously by the equipment and presented every 10 meters.

6.5 Pavement Distress

Pavement distress is a useful measure of the condition of a pavement for network asset management and can provide invaluable information for determining the correct maintenance treatment. Detailed inspections provide very detailed information but they are not appropriate as a network survey since they are time consuming and expose survey teams to considerable traffic risks. Traffic speed visual distress surveys are an ideal alternative since they are not only safer but they can cover the entire network in a relatively short time period. There will be some inevitable but acceptable loss of definition when compared to walked surveys although the recorded data arguably has better repeatability and reproducibility which will be beneficial for measuring future deterioration trends.

At network level, crack measurement will be undertaken using laser technology with other defects being identified and classified visually using high resolution video. The full list of principal defects that need collection as part of the survey is listed. To comply with the network and detailed site inspection requirements, the condition of each defect identified in bold will be assessed based on three condition categories, namely, (Low (L), Medium (M) or High (H)).

- **Total cracking**
- **Transverse cracking**
- **Fatigue (alligator)**
- **Block cracking**
- **Edge cracking**
- **Longitudinal cracking**
- **Patching**
- **Pot-holes**
- **Bleeding**
- **Polished aggregate**
- **Raveling**
- **Rutting**
- **Depressions.**

The surface defects measuring equipment used to assess network condition will be subjected to a vigorous site inspection trial to ensure that the recorded data is repeatable and reproducible.

6.6 Ground Penetrating Radar

Radar techniques are well known and were originally developed for the detection of objects in the sky, on land or on sea. These methods have been adapted for the investigation of non-conductive materials e.g. soils, rocks, concrete etc. in a technique commonly known as Ground Penetrating (Probing) Radar (GPR). Figure 19 has been taken from Section 3 of the Highways Agency's Design Manual for Roads and Bridges, Volume 7; HD29, Data for Pavement Assessment to illustrate the concept as applied to pavements.

Figure 19: Reflection of radar signal at pavement interfaces and signal waveforms

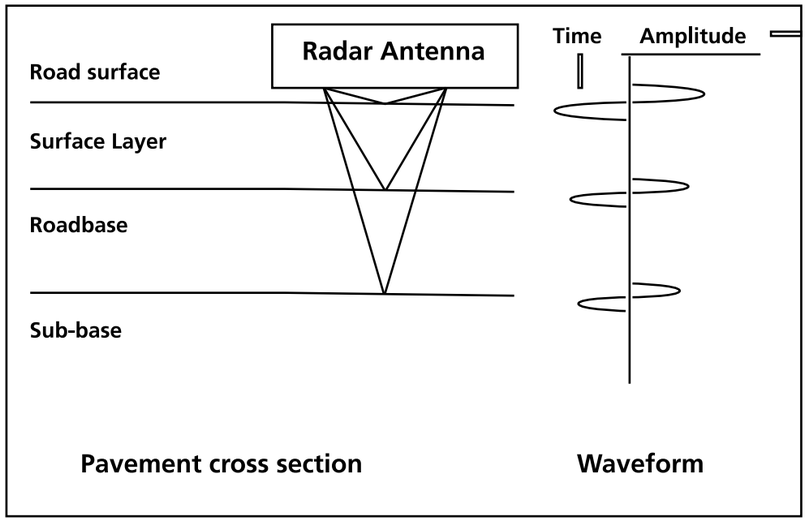
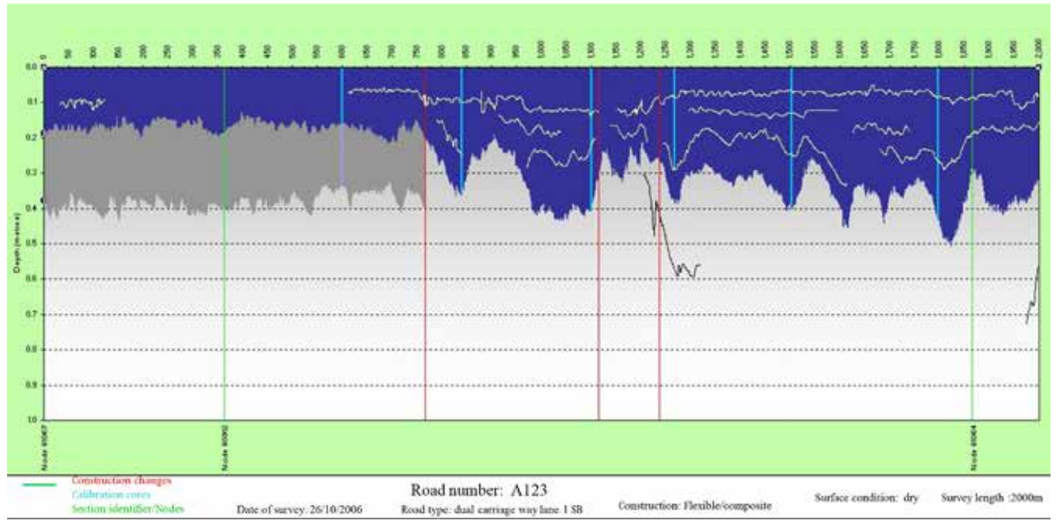


Figure 20: Example of ground radar slice of major road pavement



Based on knowledge of the dielectric constant - the speed with which the waves travel through various materials it is possible to estimate the depth of these various interfaces below the surface. When this is done the thickness and variation in the layer structure can be estimated.

It is important to take a number of cores to ensure there is a clear relationship between the cores and the GPR plot (i.e. calibrate the GPR analysis).

The depth of penetration differs with the radar frequency of the aerial used and it is usual for an experienced contractor to run several aerials together to ensure best results.

One of the major advantages of GPR is its ability to predict layer thickness and demonstrate where there are significant changes in construction. Under certain circumstances traffic speed radar can be used with caution to consider variations in sub-base (lower layers) moisture content.

7.0 Routine Maintenance of Highways

7.0 Routine Maintenance of Highways

7.1 Pavements

The requirements relate to minor repairs to the carriageway in order to ensure that all pavements provide a safe, even and comfortable surface for all users, including pedestrians, and cyclists. It is assumed that repairs relate to the following paved area assets:

- trafficked areas
- hard shoulders
- paved medians
- paved traffic islands
- median cross-overs.

The types of material making up these assets vary and will include bituminous materials, concrete and pre-cast concrete paving blocks. Repair techniques for each type of material used will vary.

Minor carriageway repairs are routine and do not relate to larger scale work needed to strengthen the carriageway. They will be undertaken to ensure that vehicles and pedestrians can traverse the paved area safely, to maintain its integrity and to prevent further deterioration. Defects requiring minor repairs comprise rutting, potholes, fine crazing, permeable surfaces, fretting, loss of chippings, dislodged, broken or missing paving blocks.

7.1.1 Modes of Deterioration

Roads deteriorate over time and how this deterioration develops is largely dependent on the construction of the road and the type and volume of traffic using it.

The principal reasons for deterioration of roads are environmental effects, wear and tear or a combination of both. When a combination of both occurs, the rate of deterioration of the road increases quickly.

7.1.2 Environmental Factors

- rain – when rain penetrates cracks in the carriageway surface and traffic loads create hydraulic pressure the surface material can break up.
- air – causes oxidization of bitumen in flexible road surfacing, causing the material to become brittle and prone to cracking.
- sunlight – UV radiation breaks down the bitumen used in flexible road construction.
- heat – the thermal expansion and contraction of material due to temperature variations will crack the road surface.

7.1.3 Wear and Tear

This occurs either due to the volume and weight of traffic passing over the road or the activities of utility companies. The weight of vehicles is generally associated with high numbers of HGVs passing over the road. By contrast, light vehicles, such as cars, impose very little or no weight on the road and therefore have very little impact.

Works undertaken by utility companies also negatively affects the structure of the road because they create a break in the road structure and surface materials, and could weaken the road. If these works are poorly repaired then this effect builds up in time and the life expectancy of the road is greatly reduced.

7.1.4 Types of Repair

There are a number of tools that are available to the maintenance engineer when undertaking minor carriageway repairs. In the main, repairs will comprise of permanent repairs to potholes (previously identified via the inspection process) and are usually in the form of traditional patching methods or by use of propriety asphalt repair techniques.

Repairs to pre-cast concrete block paving will generally mean removal of the damaged block(s) and replacement with same.

However, in high risk areas, consideration to filling in areas where blocks are missing with a temporary bituminous type material should be considered, with a permanent repair at the timescales shown in Table 6. There will also be times when repairs need to be carried out prior to maintenance works e.g. surface dressing or other preventative maintenance techniques such as asphalt sealcoating. This often requires repairs to potholes, open joints and cracking prior to application of the surface treatment.

7.1.5 Inspection Requirements

Detailed Inspections shall be carried out at intervals of 6 months on Urban Expressways and Urban Primary Roads, at intervals of 1 year on Rural Expressways, Rural Primary and all Secondary and Tertiary Roads. They shall be coordinated as fully as possible with the detailed inspection of other items in the highway as a whole.

7.2 Footways and Cycle Tracks

7.2.1 General

The requirements relate to minor repairs to footways and cycle tracks. The requirements do not relate to larger scale work which would normally be classed as, or linked to, structural maintenance jobs.

A footway is a paved facility for pedestrians, usually within the highway boundary and usually consists of hand laid pre-cast concrete paving blocks. Footways include the walking surfaces of subways, under bridges, over bridges and pedestrian rights of way. They may occasionally fall outside the highway boundary.

Repairs to pre-cast concrete paving blocks in footways generally mean removal of the damaged block(s) and replacement with same. However, in high risk areas on footways, where pedestrian traffic is high consideration to filling in areas where blocks are missing with a temporary bituminous type material should be considered.

A cycle track is a paved facility available for persons with pedal cycles, with or without a right of way on foot, usually within the highway boundary.

Damage to footways is usually caused by vehicle over-riding, particularly in urban areas and at road junctions where the footway may be immediately adjacent to the carriageway edge. Consideration should then be given to the provision of high strength in-situ concrete margins up to 1 m wide behind the kerb or locally at road junction radii. Alternatively, consideration should be given to carrying out an improvement scheme to alleviate vehicle overrunning, in which case a report and proposal for action should be made to Ashghal.

7.2.2 Inspection Requirements

Detailed Inspections shall be carried out at intervals of 6 months in urban areas and at intervals of 1 year in rural areas, Rural Primary and all Secondary and Tertiary Roads. They shall be coordinated as fully as possible with the detailed inspection of other items in the highway as a whole.

7.3 Covers, Gratings, Frames and Boxes (Ironwork)

7.3.1 General

The requirements relate to repairs to, and the occasional replacement of, all types of metal (and occasionally plastic) gratings, covers, frames and boxes that are the direct responsibility of Ashghal. Although the requirements do not relate to repairs to items that are the responsibility of other parties (e.g. Kahramaa, Ooredoo), it may be necessary on occasions, if there is a hazard to road users, to make such defects safe and to recover the costs incurred from the responsible parties.

The majority of covers are situated in carriageways and footways but those in verges, particularly those verges that are likely to be traversed by pedestrians, should not be ignored.

It may often be difficult to decide whether a cracked or broken item is in real danger of collapse. If in doubt, it should be replaced, irrespective of its position.

Defects in covers and gratings may pose particular danger to pedal and motor cycle users. It should be remembered that their occupancy on a carriageway will not always be limited to the nearside lane. Rocking gratings or covers with only small movement under load may nevertheless be a nuisance in urban areas because of the intrusive noise they make. If complaints are received, they should be corrected.

Many covers in carriageways, footways and cycle tracks are the responsibility of third party utilities and possibly other parties. The 2013 amendment to the Qatar Code of Practice for Undertakers Apparatus and Reinstatements requires the owner of the apparatus to maintain his apparatus in the street to the reasonable satisfaction of Ashghal. If an inspection indicates a hazardous defect, it should be made safe and at the same time the owner should be given notice to carry out permanent repairs depending on the severity of the defect and the effectiveness of action undertaken to make the defect safe. All costs incurred by Ashghal including, making safe, shall be recovered from the apparatus owner via the Green Claims process.

7.3.2 Inspection Requirements

Detailed Inspections shall be carried out at the detailed inspection intervals required for the pavement within which they are situated, as described in paragraph 7.1.5, or alternatively, with the cleaning out of highway gullies, catchpits, soakaways and interceptors.

When inspecting the gratings of gullies and other similar surface water catchment items, the opportunity should be taken to check that the asset appears to be functioning satisfactorily and is not partially or wholly blocked. If the item is not functioning correctly then action should be taken to clear the blockage, within the appropriate timescales defined in Tables 7 or 8, through liaison with the Drainage Maintenance Department.

7.4 Kerbs, Edgings and Pre-formed Channels

7.4.1 General

The requirements relate to minor repairs to kerbs, edgings and pre-formed channels of all types. The requirements do not relate to larger scale works that would be classed as or linked to structural maintenance jobs.

Although these items tend to be stable by their nature and construction specification, hazardous conditions can develop quickly when either individual kerbs, or short lengths, are damaged or put out of alignment by vehicle overrun, or when local subsidence occurs. Frequent damage by vehicles may suggest the need for local re-alignment or a more robust specification.

7.4.2 Inspection Requirements

Detailed Inspections shall be carried out at the same frequency as that laid down for the abutting carriageway, footway or cycle track as described in paragraph 7.1.5. Where a carriageway kerb also abuts a footway or cycle track, the higher frequency of inspection shall apply.

Detailed Inspections are designed to note only those types of defects likely to require routine maintenance rather than to establish general structural condition. They may point to the need to bring forward other surveys.

7.5 Highway Drainage

The requirements for drainage relate to all elements of the drainage system from the point at which water drains from the paved or other areas, structures and subsoil, to the outfall or soakaway. The requirements for drainage also relate to the prevention and mitigation of the effects of flooding.

The purpose of drainage is to remove water from hardened surfaces, where it may represent a hazard and disrupt the free flow of traffic, cycles and pedestrians and from sub-layers of the pavement and adjoining earthworks, where its presence may damage the pavement or other structures. In removing the water, the drainage system must be maintained to its design performance or similar to prevent pollution of ground and surface water, and flooding of adjoining property or services. This requirement includes drainage systems that interface with parts of the public drainage system. It is noted that in Qatar subsurface drainage is generally not a problem and is rarely used.

There is also a responsibility to ensure that polluted effluent from clearing of highway drainage is not directed indiscriminately into watercourses.

To mitigate the effects of flooding from all sources, documented contingency plans for dealing with the flooding of any part of the Network should be prepared in advance and implemented as soon as flooding occurs or is forecast.

7.6 Piped Drainage Systems

7.6.1 General

The requirements relate to minor repairs and treatment of defects within all types of piped drainage systems, including slot drains.

A record of piped drainage systems shall be maintained. The record shall be kept in the Geographic Information System (GIS) as a separate layer and will supplement information held in the inventory by providing details of pipe runs. Ownership of the drainage systems should be established and indicated on the record.

If properly designed and constructed, piped drainage systems should be self-cleansing and maintenance should only become necessary when a blockage or other fault occurs. Those parts of a system that habitually give trouble should be known and will need to be inspected more frequently than normal.

Symptoms of blockage or faults that should normally prompt further investigation include: backing up and flooding at the entry points to the piped drainage system; wet areas on verges; and the presence of vegetation.

7.6.2 Inspection Requirements

Detailed Inspections of piped drainage systems shall normally be carried out once every 10 years unless the need for a greater frequency has been agreed, or there is evidence of blockage or some other fault noted on safety inspections, or reports and complaints received from other sources.

Inspections shall be carried out using techniques appropriate to the nature of the drainage system. Methods of inspection which may be suitable include:

- pulling a mandrel through the pipe line: This may indicate if a pipe is broken, distorted, silted up or contains roots, but it will not distinguish between these defects
- flushing: Flushing pipelines is less informative than using a mandrel but will provide the best method of inspection in areas of subsidence and where the use of a mandrel is not appropriate
- inspection at catchpits, soakaways and interceptors during or immediately following a period of prolonged rainfall: Measurement of the depth of water within the entries of pipes, in successive catchpits, soakaways or interceptors along a drain-run will give an indication of whether there is any blockage or fault

- video inspection: This technique may be appropriate, although its use should generally be restricted to parts of the network having particular drainage problems.

Maximum use shall also be made of gully, catchpit, soakaway and interceptor emptying and cleansing operations, and of their inspection procedures, to check that piped drainage systems are operating satisfactorily.

7.7 Gullies, Catchpits, Soakaways, Interceptors and Catch Basins

7.7.1 General

The requirements relate to the removal of silt and other detritus from all types of highway gullies, catchpits, soakaways, interceptors and catch basins and, so far as possible, to an inspection of the condition of the items and their operation. They do not relate specifically to the inspection of frames and gratings or to the cleansing of gratings, although these operations shall be carried out whenever emptying takes place. Cleansing should also include testing the outfall pipe from the gully into the main surface water carrier drain or the outfall into the soakaway, ensuring that the integrity of the pipe is sound and fully functioning. This should be carried out by charging the gully with water and monitoring if it empties normally.

Catch Basins includes any underground structure that holds and transports water from the highway to Emergency Flood Areas or Balancing Ponds. They should be fully functioning and be free from sand.

A record of all gullies, catchpits, soakaways and interceptors should be held in the Right of Way Asset Inventory Management System (RAIMS), together with required emptying frequencies.

7.7.2 Inspection Requirements

Detailed Inspections of gullies, catchpits, soakaways and interceptors shall be carried out at intervals of 1 year on all roads. They shall be coordinated as far as possible with emptying and cleansing operations and, where applicable, with the detailed inspection of other items in the highway.

7.7.3 Maintenance Requirements

Gullies, catchpits, soakaways and interceptors shall be emptied and cleaned once per year, prior the start of the rainy season in late summer, although a need for a greater (or lesser) frequency may be established and agreed as a local variation. A decision about a variation should be made with local knowledge in mind, with known flooding hotspot areas taken into consideration. The frequency of cleansing of oil interceptors will depend upon their design and location, and should be given particular consideration.

Silt and other solids arising from emptying and cleansing operations pose a potential threat of pollution and shall be disposed of in accordance with local environmental regulations.

7.8 Ditches and Swales

7.8.1 General

The requirements relate to clearing and minor damage repairs to ditches and swales.

Ditches can be unlined or lined with concrete. Ditches and swales can become blocked with silt, sand, debris, rubbish, bank erosion or overgrown with vegetation to the extent that the free flow of water is impeded. Blockage by sand is common particularly in areas prone to sand drifting and they should be free from sand build up. Water in a ditch is not itself harmful unless stagnation occurs (resulting in a health hazard), flooding is caused, or a resulting higher water table adversely affects the road or other structural foundations.

A record of all ditches shall be held in RAIMS, together with required clearing frequencies.

7.8.2 Inspection Requirements

Detailed Inspections of ditches, swales and headwalls shall be carried out at intervals of 2 years or at the same frequency as the adjacent carriageway if visible from the carriageway. The need for a greater inspection frequency may be necessary in locations which are particularly vulnerable to sand build up, or there are reports and complaints received outside the normal inspection procedures. Ad-hoc inspections at vulnerable locations should be undertaken following sand storm events.

7.8.3 Maintenance Requirements

Ditches, wherever practicable, shall be cleaned out by machine at no greater interval than once every 2 years or as required following inspections, complaints or reports of blockages.

7.9 Culverts

7.9.1 General

The requirements relate to culverts having a span less than 1.8m and corrugated metal culverts less than 0.9m span. This section relates only to examination for scour and the maintenance of free flow of water through culverts. Routine maintenance is therefore largely a matter of inspection and clearance when the need arises.

Larger culverts shall be inspected and maintained as highway structures, and are outside the scope of this section and should be maintained in accordance with Chapter 8 - Routine Maintenance of Structures.

It should be noted that many culverts can tolerate some silting and vegetation growth before efficiency is impaired to the point where the culvert should be cleared. Grilles fitted across the ends of some culverts are however particularly prone to blockage, restricting free flow of water through the culvert and may need to be inspected more frequently.

7.9.2 Inspection Requirements

Detailed Inspections of culverts shall be carried out at intervals of 1 year on all roads and should be timed to happen before the rainy season.

7.9.3 Maintenance Requirements

All debris that prevents the free flow of water should be cleared immediately. Clearance work should also be programmed to be undertaken before the onset of the rainy season.

7.10 Balancing Ponds and Emergency Flood Areas

7.10.1 General

The requirements relate to repairs to balancing ponds and emergency flood areas. They do not relate to any associated feeder pipes or ditches.

Balancing ponds, emergency flood areas and associated feeder pipes, or ditches, are generally provided for flood control purposes where the storm run-off from highway surfaces is too rapid to be safely dealt with by the receiving water courses and piped drainage system. This important provision and the need for maintenance can easily be overlooked, since the ponds are sometimes some distance from the highway.

The effectiveness of balancing ponds and emergency flood areas can be easily and seriously impaired, so particular attention should be paid to the following possible faults:

- blockage of the feeder pipe or ditch
- silting in the pond causing a loss of storage capacity
- damage or erosion to the pond banks, walls or bunds
- damage or obstruction to the pond outlet, which will affect the controlled rate of discharge.

A record of all balancing ponds and emergency flood areas should be held in RAIMS. Specific details of each pond or area, including capacity and means of access should be included in this record.

7.10.2 Inspection Requirements

Detailed Inspections of balancing ponds and emergency flood areas with an outflow regulating device shall be carried out at 6 month intervals, unless it is agreed that a greater frequency is necessary as a local variation.

7.11 Ancillary Items

7.11.1 General

The requirements relate to maintenance and repairs to ancillary drainage items including headwalls, aprons, sluices, tidal flaps, penstocks, valves and pumps.

A schedule of the more important ancillary items for highways drainage, including all sluices, tidal flaps and pumps, shall be prepared and maintained and stored within EAMS.

A complete drainage system may include many ancillary items and these should be inspected for erosion damage and operational efficiency. It is particularly important that sluices, tidal flaps and pumps operate as intended because a fault can result in extensive damage and flooding.

7.11.2 Inspection Requirements

Detailed Inspection of headwalls, aprons and the like where associated with culverts or ditches, shall be carried out at the same time and at the same frequency as the associated asset e.g. for culverts at intervals of 1 year and for ditches at intervals of 2 years. Those associated with piped drainage systems shall be carried out at the same time as piped drainage systems.

Detailed Inspection of sluices and the like shall be carried out at intervals of 6 months.

Detailed Inspection and maintenance of pumps and other specialised equipment shall be carried out in accordance with the manufacturers' recommendations.

7.12 Flooding

7.12.1 General

The requirements relate to flooding of the highway caused by the inadequate provision or operation of highway drainage facilities or by inadequacies in the non-highway drainage system.

The advantages of an accurate, location referenced inventory system for gullies and other drainage items is highlighted by the problems which are often experienced when dealing with flooding. Such drainage items are often submerged and may be the cause of flooding. Their easy location will help to speed relief and reduce the extent of the hazard and any related interference with traffic flow, claims and complaints. All locations prone to flooding should be identified as flooding hotspots and listed within the Severe Weather Appendix of the Contingency Plan.

7.12.2 Inspection Requirements

Additional Safety Patrols should be undertaken during or immediately after periods of very heavy/prolonged precipitation to identify areas which have become flooded. Particular attention should be made to areas known to be prone to flooding.

7.12.3 Maintenance Requirements

Where flooding occurs, causing hazardous conditions, the appropriate warning signs (W429 plus a P313.9 supplementary plate) in accordance with Qatar Traffic Control Manual (not yet published) shall be placed in position as quickly as possible.

The cause of the flooding shall be ascertained and given prompt attention, in order to restore the highway to a reasonable condition. Where it is determined that the flooding is attributable to inadequate infrastructure, given the nature of the weather conditions under which it occurred, the necessary action to permanently relieve the problem shall be the subject of a prompt report, and proposal for action. If the cause is attributable to the actions of a third party, the matter should be taken up with them at the earliest opportunity.

- any damage resulting from negligence would be dealt with through the red/ green claims processes.

7.13 Geotechnical Assets

7.13.1 General

The requirements relate to inspection regimes and repair timescales for the routine maintenance of earthworks.

The requirements for geotechnical assets relate to pavement sub-grades, embankments and cuttings, and generally any subsoil conditions that may affect the Network. The requirements relate to identifying potential problems and carrying out routine maintenance only. Any large scale maintenance work is outside the requirment of this manual.

Failures of geotechnical assets may create hazards to users, cause damage to paved areas, structures, services or other property, and disrupt the free flow of traffic and other road users. Identifying failures in their early stages of development is advantageous as they can often be stabilised before more serious consequences occur.

Guidance on failure modes and their identification and procedures for repairs are set out in the Highways Agency's Design Manual for Roads and Bridges, Volume 4; Section 1; Part 4; HA 41 Maintenance of Highway Geotechnical Assets.

Slopes at an early stage of instability can often be recognised by bulging of the slope profile (at the bottom of the potential slip), by development of tension cracks (at the top of the potential slip) or by evidence of water seepage.

7.13.2 Inspection Requirements

Detailed Inspections of all embankments and cuttings shall be carried out at intervals of 1 year, to check for any indication of slippages or rock slides. If evidence is found that the embankment, or the cutting, may be unstable in any way, a further inspection by a geotechnical specialist shall be requested to confirm the initial findings.

A Detailed Inspection of all embankments and cuttings shall be made by a competent person at intervals of 5 years to check slope stability, in accordance with the guidance given in HA 41.

7.13.3 Maintenance Requirements

It is recognised that in cases where geotechnical investigations have to be undertaken and remedial works designed, it may not be possible to carry out effective permanent repairs within 28 days. Details of any design and analysis carried out in accordance with HA 41 will need to be retained for a period to be specified.

7.14 Soft Estate

7.14.1 General

The soft estate is defined as: the vegetated part of the highway estate together with hard landscaping areas (as opposed to engineering/operational part of the highway including structures, carriageway, hard shoulder and central reserve that may be constructed with concrete, bituminous materials, steel, etc.).

The vegetated element of the Soft Estate is generally managed by the local Municipalities (Baladiya), with the hard landscaping (retaining walls, raised beds, reinforced earth walls and paved areas within landscape areas etc.) elements being managed by Ashghal.

However, there is a safety responsibility that will need to be maintained. Vegetation must not restrict visibility at junctions, access points and bends. Sight lines and minimum stopping distances must be kept clear and signs, lights and marker posts must not be obstructed. Overhanging vegetation must not obstruct users of the highway (vehicular or pedestrian) or highway personnel carrying out inspections or surveys. Also, Ashghal have a responsibility for trees within falling distance of the highway and to hard surfaced areas that are to be kept free from vegetation.

7.14.2 Inspection Requirements

There are no particular inspection requirements for the soft estate elements that remain the responsibility of Ashghal. However, the safety responsibility remains and any safety defects should be picked up during the regime of normal programmed inspections (safety patrols, safety inspections and detailed inspections). Defects raised should be recorded in the normal manner with DCD's and passed to appropriate teams to action with follow up inspections carried out to ensure that actions are carried out. It is also important to ensure that the responsible Baladiya are made aware of any actions undertaken.

7.14.2.1 Grassed Areas and Scrub

Safety of the highway user is of prime concern but amenity, nature conservation and nuisance to others must also be considered. The design intention of landscape schemes, i.e. the landscape and ecological functions, must be taken into account.
Expert advice from landscape managers should be sought to achieve the correct balance between safety, amenity, nature conservation and value for money. They will confirm when additional specialist advice is required. Where environmental databases

exist they should be consulted before any work is carried out.

Standards of maintenance should reflect the surrounding landscape. A higher standard of maintenance for amenity may be appropriate in built-up areas where housing and businesses front the highway and in areas of particular importance such as Al Corniche and junction interchanges.

7.14.2.2 Irrigation Systems

The irrigation system and its infrastructure are maintained by the Baladiya.

7.14.2.3 Trees and Planted Areas

Trees are important for amenity and nature conservation reasons and should be preserved but they can be a serious hazard to highway users and adjoining land users if they are allowed to become unstable.

Inspections by highway maintenance personnel during the normal course of inspections can reveal evidence of damage to trees or signs of ill health. Once identified expert arboriculture advice should then be sought. Close liaison with the responsible Baladiya should take place to determine where the responsibility for action lies. All highway trees require an arboriculture inspection every 5 years but this period may be reduced on the advice of an arboriculturist.

It is important that arboriculture advice is obtained to advise on the appropriate frequency of inspections and works required for each individual street or mature tree.

Planted areas may comprise native trees and shrub species on the inter-urban network, or non-native species in urban areas.

Appropriate regular management techniques including thinning, coppicing and pruning will be required to achieve the design intention.

7.15 Sweeping, Cleaning and Animal Carcasses

7.15.1 General

Generally, sweeping and cleaning responsibility lies with the local Municipality; however, Ashghal should hold regular liaison meetings to ensure that the division of responsibility has been agreed and that standards of cleanliness are maintained. The requirements detailed relate to Ashghal's responsibility for the sweeping and cleaning of all channels and hardshoulders, clearing and removal of debris from traffic lanes, hardshoulders, verges and medians, removal of litter, and footway and cycle track sweeping.

7.15.2 Inspection Requirements

No Detailed Inspections are necessary and reliance shall be placed on the regular Safety Inspections and Safety Patrols detailed above to decide when any special action needs to be taken.

7.15.3 Maintenance Requirements

Hardshoulders, verges, channels, medians and slopes shall be swept and the litter picked as the need arises in order to achieve the standards of cleanliness required. To achieve these standards responsible organisations should respond to the accumulation of litter in a pro-active rather than a re-active way. This can be achieved best by a combination of programmed scavenges, as need dictates, to establish the overall cleanliness standard, and "hot spot" scavenges in locations where the highway has become heavily littered as a result of other factors such as debris from vehicles or wind-blown litter. Other locations where litter accumulates tends to be at the tops of slip roads, around traffic signal junctions, around food outlets and service areas. If a particular source of wind-blown litter can be identified then the owners should be requested to control their site more effectively.

Footways and cycle tracks shall be swept as the need arises but not more frequently than once per year unless it is agreed that a greater frequency is necessary as a local variation, if sand accumulation becomes a particular issue.

Debris encountered by inspectors and other maintenance personnel in traffic lanes and on hardshoulders, and which constitutes an immediate hazard, shall be removed immediately, if reasonably practical and inspector's safety can be maintained. If urgent and safe retrieval is not possible then a request to the Traffic Police for help should be made.

Otherwise road users shall be protected as far as possible. As a minimum, the aim should be to display notices warning of the hazardous conditions, before reporting

at the earliest opportunity with a request for immediate action. Such action shall be completed within the shortest possible time and in all cases within 24 hours.

Large animal carcasses, such as camels, which could be a hazard or distraction to road users should be treated as an Emergency or Urgent (Category 1) defect and removed from the network as soon as possible.

7.16 Vehicle Restraint Systems and Barriers

7.16.1 General

The requirements relate to maintenance and repairs to all types of vehicle restraint systems (steel, wire rope and Vertical Concrete Barrier - VCB), parapets and associated installations such as end terminals, crash cushions, pedestrian guard rails and pedestrian fences (including those designed to prevent pedestrians crossing highways).

Maintenance is generally confined to the repair of damaged sections and ensuring correct assembly and operation. Maintenance of crash cushion installations should assess whether, in a collision, the installation can act as it is designed to do and it is fit for purpose. The repair of damaged sections will usually be instigated by Inspections, whether they are regular safety type inspections, by detailed inspections or by reports from other sources. Generally, barrier damage will have compromised the integrity of the system and will require prompt attention in view of the likelihood of danger to road users. Maintenance requirements are therefore more onerous than for the majority of other items within this manual.

Examples of defects related to this section can be found in the Safety Inspection Manual. Reference should also be made to BS 7669-3 1994: Guide to the Installation, Inspection and Repair of Safety Fences, BS EN 1317 and Highways Agency's Design Manual for Roads and Bridges, Volume 2; Section 2; Part 8; TD19 Requirement for Road Restraint Systems

7.16.2 Inspection Requirements

Detailed Inspections of all vehicle restraint systems and associated installations shall be carried out at intervals of 2 years in respect of mounting height, surface protective treatment and structural condition.

Detailed Inspections of pedestrian guard rail and pedestrian fences shall be carried out at intervals of 2 years in respect of surface protective treatment and structural condition.

Detailed Inspections of VCB shall be carried out at intervals of 2 years in respect of height and structural condition.

7.16.3 Maintenance Requirements

Tensioning bolts of steel tensioned safety fences shall be checked, lubricated and reset to the correct torque every 2 years, preferably in conjunction with the Detailed Inspection, in accordance with the instructions given in BS 7669-3, due to the high ambient temperatures experienced in Qatar the tensioning bolts should be torqued up to finger tight.

Damaged sections of vehicle restraint systems, end terminals and crash cushions where the integrity of the system is compromised shall be treated as Urgent (Category 1) defects unless damage is clearly superficial with no loss of integrity of the system. Permanent repairs shall be carried out as soon as possible and in any case within 14 days.

Mounting heights of all types of vehicle restraint systems should be in accordance with BS 7669-3 or with the manufacturer's recommendations. The mounting height for tensioned corrugated beams, untensioned corrugated beams, open box beams and rectangular hollow sections should be 610mm ± 30mm for the erection of new safety fences and 610mm ± 75mm for in-service fences unless manufacturers recommendations state otherwise.

The mounting height for wire rope should be 585mm ± 10mm (centre of the upper pair). Where the set-back is 1.5 m or less, the height (to the centre of the beam or centre of the upper pair of ropes) should be related to the edge of the paved surface. Elsewhere the height should be measured from the general ground level beneath the face of the beam.

Fences found to be outside the tolerances specified should be treated as Non-Urgent (Category 2) defects and repaired as a scheme within in timescales described in Table 8.

7.17 Fences, Walls, Screens and Environmental Barriers

7.17.1 General

The requirements relate to repairs to all types of fences (excluding vehicle restraint systems) which are the responsibility of the Ashghal, including:

- animal (camel) fencing
- sand fencing
- boundary fencing
- pedestrian fences
- walls and retaining walls <1.5m
- anti-glare screen fences
- environmental barriers

They do not relate to vehicle parapets and pedestrian parapets on bridges and other structures, including the structural elements of environmental barriers. They do not relate to retaining walls of retained height greater than 1.5 m, which are covered in Chapter 8 - Routine Maintenance of Structures.

The replacement of steel, concrete, and timber elements made necessary as a result of long term deterioration is not covered by this manual, but the requirements for Detailed Inspections are included to provide a means of identifying the need for a replacement scheme.

Aspects of condition that may affect the achievement of the performance requirements for fences, walls, screens and environmental barriers are:

- rotten wooden elements that affect function or promote deterioration
- corroded metal that affects function or promotes deterioration
- concrete cracking, spalling or reinforcement corrosion that affects function or promotes deterioration
- brickwork cracking, spalling or loss or mortar that affects function
- missing, broken, deformed or cracked components that affect function or promote deterioration
- loose nuts, bolts and other components that may represent a hazard or promote deterioration
- lack of tension in a strained wire fence
- too low fence or barrier (caused by subsidence or otherwise)
- loss of paint, galvanising or other protective system
- effects of spray and pollutants degrading colour or transparency
- excess accumulation of sand against any type of fence. In particular where the accumulation of sand exceeds 75% of the full height of the fence for fencing that is designed to prevent sand encroaching onto the carriageway

The appearance of fences, walls, screens and environmental barriers is important and any repairs or replacement sections must maintain the uniformity of their appearance, unless the existing is obsolete.

7.17.2 Inspection Requirements

Detailed Inspections shall be carried out in respect of integrity, and their intended purpose, at intervals of 6 months and as far as possible during inspections of other highway items.

Detailed Inspections shall be carried out at intervals of 2 years in respect of structural condition.

7.17.3 Maintenance Requirements

Where sand build-up around a fence has been identified through inspection or complaint then this should be removed to ensure that the fence performs as it is intended. In vulnerable locations it should be considered that removal of sand should become a cyclical task and carried out before the onset of the sand and dust storm season and in any case must be removed before the accumulation reaches 75% of the full height of the fence.

7.18 Road Studs

7.18.1 General

The requirements relate to reflective and non-reflective road studs of all material types and colours.

The inspection and maintenance requirements for road studs are set out in the Highways Agency's Design Manual for Roads and Bridges, Volume 8; Part 2; Section 2; TD26 Inspection and Maintenance of Road Markings and Road Studs on Motorways and Trunk Roads.

To be effective, all types of road studs must be firmly fixed and remain at the correct level. Reflecting types must retain their reflectivity in accordance with the requirements in the Qatar Traffic Control Manual Section 8, Part 3.

All studs depend on a degree of trafficking to keep lenses clean but the lenses can become dirty, or obscured by deposits of detritus, and can become less effective by becoming more deeply embedded in the road surface.

Road studs which become loose or displaced are further defects which need maintenance attention. Road studs can lose adhesion and break up under severe stress from vehicle wheels.

Inspection of all road studs for looseness is virtually impossible in terms of both scale and practicability, particularly in those traffic conditions where displacement is more likely to occur. The requirements are that Detailed Inspections for this purpose should, wherever possible, be carried out when lane closures for other activities are in operation. Where displacement is beginning to occur in significant groupings, indicative of a general fault condition, specific closures for road stud inspection should be arranged.

7.18.2 Inspection Requirements

Detailed Inspections for defective or missing road studs shall be carried out at intervals of 6 months or 1 year in conjunction with the detailed inspection of other carriageway items depending on the class of road being inspected. Defects to be recorded shall be as follows:

- Wear, corrosion, damage
- Loose or missing studs or inserts
- Loss of or damage to retro-reflective lenses
- Sinkage i.e. where surface mounted studs are pushed down into the road surface
- Settlement i.e. where studs have settled below their specified level
- Detritus on lenses
- Integrity and security of casings of "embedded" studs (housings)
- Loss of adhesion or breaking up of surface mounted road studs under traffic loading
- Misalignment with existing road markings.

Detailed Inspections for reflective conspicuity shall be carried out at intervals of 1 year during the hours of darkness and where possible at the same time as other similar inspections for road and sign lighting, and reflective road markings and signs. Three methods are most commonly used:

- Visual night time inspection
- Traffic speed survey using specialised equipment such the High Speed Road Monitor (HRM)
- By using specialised handheld equipment.

Defects relating to the general condition of road studs are likely to be detected in the first instance by Safety Inspections.

For any other defect where more than 1 stud in any 10 suffers from any of the defects described in paragraph 7.18.2, they shall be treated as Non-Urgent (Category 2) defects and replacement shall be completed within 3 months of the defect threshold being exceeded.

Replacement of all road studs shall comply with the requirements of the Qatar Traffic Control Manual Section 8, Part 3.

7.18.3 Maintenance Requirements

Displaced road studs lying on the carriageway, hardshoulders or lay-bys and loose road studs, if judged to be a hazard, shall be treated as an Urgent (Category 1) defect and removed in accordance with the timescales shown in Table 6 or immediately if it can be done safely.

7.19 Road Markings

7.19.1 General

The requirements relate to inspection regimes for the inspection and routine maintenance of machine and hand laid road markings in the following materials on Qatar's road network:

- sprayed and screeded thermoplastic
- water-bourne traffic paint
- solvent based kerb paint
- cold plastic
- coloured pavement markings e.g. red coloured surfacing at school Gateways.

The inspection and maintenance requirements for road markings, which are summarised below, are set out in the Highways Agency's Design Manual for Roads and Bridges, Volume 8; Section 2; Part 2; TD26 Inspection and Maintenance of Road Markings and Road Studs on Motorways and Trunk Roads.

In Qatar there are examples of rows of raised ceramic studs (also known as Botts' Dots) in lieu of a lane marking line system. This system provides the driver with tactile feedback when moving from lane to lane. It is the intention of the recently drafted QTCM to discontinue this type of lane marking system and installations should be identified and recorded as Non-Urgent (Category 2) defects and gradually replaced.

To be effective, road markings must not be obscured by erosion; they should not have spread appreciably from the original size; they must retain colour; they must have adequate skidding resistance; and, where appropriate, retro-reflectivity. Where defects occur these will not always be apparent as a result of visual inspection and, if circumstances warrant, it may be necessary to carry out specialist inspections and tests as laid down in TD26 to ascertain the condition of the markings.

7.19.2 Inspection Requirements

Detailed Inspections in respect of wear, luminance factor, skid resistance and retro-reflectivity shall be undertaken at intervals of 1 year for painted markings and 2 years for thermoplastic markings.

Inspections shall initially be visual and condition shall be assessed against the criteria set out in TD26. Any suspect areas identified by the visual inspections shall be noted and further testing as described in TD26 shall be instigated

7.19.3 Maintenance Requirements

7.19.3.1 Retro-reflectivity

Inspections for adequacy of reflective conspicuity shall be carried out during the hours of darkness and where possible be combined with other similar inspections for

road studs, road and sign lighting, where practical.

For longitudinal road markings, ideally, surveys for retro-reflectivity should be carried out using equipment capable of travelling at traffic speed (e.g. HRM such as ECODYN) with the results averaged out over 100m intervals.

For areas of the network that cannot be surveyed by equipment described above (e.g. Stop Lines, Give Way lines etc.) the assessment of retro reflectivity should be undertaken using handheld retro-reflectometers. The procedure for in-situ testing shall be that as described in TD26 Annex G.

7.19.3.2 Wear

A visual assessment for line marking wear shall be carried out on 50% of the road markings at each location or every 20m for continuous road markings area for continuous road markings. The threshold level for wear is where there is less than 50% of the marking remaining. Once the threshold is met then action should be taken. Where this level is exceeded at critical safety areas (e.g. Stop Line at a junction) then immediate action should be taken and it treated as an Urgent (Category 1) defect and dealt with in accordance with the requirements shown in Table 7.
In all other areas they should be treated as Non-Urgent (Category 2) defects and repaired in the timescales described in Table 8. These defects may be left and repaired as part of a planned programme of works.

7.19.3.3 Luminance Factor

A visual assessment for luminance factor shall be carried out on 50% of the road markings at each location or every 20m for continuous road markings area for continuous road markings. The threshold levels for luminance factor are as follows:

- less than 0.30 for white lines
- less than 0.20 for yellow lines.

Where these levels are breeched at critical safety areas (e.g. Stop Line at a junction) then immediate action should be taken and it treated as an Urgent (Category 1) defect.

In all other areas they should be treated as Non-Urgent (Category 2) defects and repaired in the timescales described in Table 8. These defects may be left and repaired as part of a planned programme of works.

7.19.3.4 Skid Resistance

Skid Resistance measurements shall be carried out annually on a quarter of the critical areas of the network that pose a risk to the road user through skidding or potential accidents such as Give Way lines and/or Stop lines, large areas of paint (exit arrows to slip roads) and transverse yellow bar markings. Measurements should be taken on the most trafficked areas of the marking at each location and an average calculated. The method of assessment should be by the Pendulum Skid Tester or by the Findlay Irvine microGripTester. Threshold levels for Skidding Resistance are as follows:

- less than 45 for normal areas
- less than 55 for large surface areas e.g. letters, numbers and arrows
- less than 55 for transverse yellow bar markings.

Where these levels are breeched then immediate action should be taken and it treated as an Urgent (Category 1) defect.

7.20 Road Traffic Signs

7.20.1 General

The requirements relate to routine inspection and cyclic maintenance of permanent road traffic sign installations including Prohibitory, Warning Signs, Direction Signs, Street Name Plates, Delineators and Overhead Gantry Signs. It includes all associated sign posts, brackets, fixings and electrical elements. The requirements do not relate to Dynamic Message Signs (DMS) which are covered under Chapter 9 – Intelligent Transportation Systems.

The inspection and maintenance requirements for road traffic signs, which are summarised below, are set out in the Highways Agency's Design Manual for Roads and Bridges, Volume 8; Section 2; Part 2; TD25 Inspection and Maintenance of Traffic Signs and will be the standard to which road traffic signs are to be maintained in the state of Qatar.

TD25 sets out the inspection requirements for regulatory, warning, informatory and directional traffic signs. It also sets out the frequency of the inspections, by instrumental or visual means, to determine the condition of the signs, as well as categorisation of defects. Response and repair times are detailed as per the timescales shown in Tables 6 and 8. This will ensure that they are maintained to a consistent and satisfactory level and assist in planned maintenance.
A schedule of permanent traffic signs and their associated attributes requiring inspection should be held in the Right of Way Inventory Management System (RAIMS).

The purpose of inspections is to detect sign defects, including lighting failures, associated with the performance of the sign as quickly as is reasonably possible after occurrence.
Signs need to be inspected:

- because deterioration of the structure supporting the sign may have occurred
- to ensure that the signs can be seen, and are not dirty or obscured by vegetation
- becasue after a period of years the visual performance of a sign begins to degrade.

Signs shall be inspected for the following:

- visual performance
- electrical safety and operation
- structural integrity

Satisfactory performance of a traffic sign can usually be achieved for a considerable period after erection. Routine maintenance procedures promote the continued effectiveness of the sign and monitor any deterioration in performance.

For lit signs on gantry's and lit bollards, night-time patrols to identify outages shall be carried out at the same time as those for lighting columns described in Section 7.21.

7.20.2 Advertising Signs

Advertising signs placed on the highway by third party organisations (including Qmedia signs) must be authorised by Ashghal to ensure that they comply with the appropriate lateral clearance and vertical mounting height standards as defined in QHDM and QTCM. They must be placed in locations that do not compromise the safety of pedestrians, drivers and workers on the highway. Signs affecting road safety should be identified and recorded during routine Safety Inspections and should be treated as Urgent (Category 1) defects and if possible removed immediately. For more substantial signs and those not compromising an immediate safety hazard, such as those provided by Qmedia, contact should be made with the owner and a request made to remove the sign and move it to an agreed safe location.

7.20.3 Inspection Requirements

All signs should be subjected to a detailed inspection at 12 month intervals for the following aspects:

- Location:
  - lateral and vertical clearances to edges of signs are in accordance with Section 0; Paragraph 1.9.14 of the QTCM
- Visual performance:
  - obscuration, for example by, dirt, graffiti, foliage or other signs or structures
  - loss of sign face material
  - correct orientation relative to driver
- Electrical safety and operation:
  - general condition and safety
  - operation of luminaires
  - alignment of luminaires
- Operational effectiveness/structural integrity:
  - condition of the sign plate
  - condition and presence of clips, rails and other fixings
  - condition of sign post including the pole/post galvanising, foundation and alignment of the post
  - condition of any moving parts including hinges for fold down signs

Inspections shall initially be visual and condition shall be assessed against the criteria set out in TD25. Further inspection methods, as described in TD25, may also be appropriate and shall be initiated where suspect areas are identified.

After a period of time the visual performance of a sign begins to degrade due to fading, ingrained dirt, reduction of the retro reflective properties of sign face material, peeling, damage and vandalism. Therefore in addition to the detailed inspection detailed above in Table 3, all signs should be inspected 5 years after installation and thereafter at intervals of 1 year.

A check should be made on the coefficient of retro reflectivity of the white sheeting elements of the sign and the degradation of the coloured elements.

7.20.4 Maintenance Requirements

7.20.4.1 Sign Cleaning

Inspections of sign faces shall be made after the signs have been cleaned, therefore cleaning should be undertaken at intervals of 2 years, unless, due to local conditions this frequency is increased. Sign faces can be damaged by inappropriate cleaning with abrasive materials (including Treated Sewage Effluent (TSE)). Permanent damage can also result if cleaning is not carried out at sufficiently frequent intervals. Advice should be sought from the sign plate and sheeting manufacturer about the appropriate cleaning regime and materials to be used.

Low level signs will accumulate dirt and grime faster and therefore additional cleaning may be required on an "as required" basis depending on weather and other local conditions. This information should be recorded in EAMS. Gantry mounted sign faces shall be cleaned as required and where possible as part of a lane closure for other works. Any variation to the cleaning frequency to take account of local conditions must be approved in advance.

7.20.4.2 Bulk Lamp Changes

Where appropriate bulk lamp changes of sign lighting associated with overhead sign gantries shall be carried out at the same time as other work in order to reduce the traffic management requirements. Care shall be taken to fit the correct lamp for the unit. Lamps shall be indelibly marked with the date of installation to enable any warranties to be claimed in the event of premature failure. This information should be recorded in RAIMS.

7.20.4.3 Signs Obscured by Vegetation

Signs must remain clearly visible in accordance with the visibility distances described in the tables in TD25, which are the current standards until the release of the Qatar Highway Design Manual in the near future, which will take precedent. The clear visibility distance is to be maintained to all parts of the sign face, when viewed from the centre of the near side lane. The check for visibility shall form part of Detailed Inspections. Where signs are obscured by trees, pruning shall be carried out following liaison with the Baladiya. Where trees or shrubs persistently obscure a sign, consideration should be given to re-locating the sign or, subject to the approval of the Baladiya, removal of the tree or shrub.

7.20.4.4 Sign Post - Structural/Mechanical integrity

The sign post shall be inspected for any structural or mechanical defects, in accordance with the Institution of Lighting Engineers Technical Report Number 22, Managing a Vital Asset: Lighting Supports: Planned Inspection Regime and TD 23 Section 5.27, Annex D, Table 9.

7.20.4.5 Numbering of Signs

All signs, bollards and beacons shall be numbered to assist night-time patrols and inventory systems. Numbers should preferably be on adhesive labels consisting of black numerals on a white reflective background, fixed to the sign post or bollard in a position that can be readily seen from a moving vehicle. Under no circumstances must reference numbers be applied to any part of the sign face. On high speed roads numerals up to 75mm high would be appropriate otherwise a character height of 50mm should be adequate.

7.20.4.6 Testing for Electrical Safety

All lighting units and private cabling systems associated with signage shall be tested for electrical safety as required by BS 7671 within a maximum of 6 years after installation and every 2 years thereafter.

7.21 Road Lighting

7.21.1 General

The requirements relate to the routine maintenance of road lighting installations.

Requirements and guidance for the inspection and maintenance of road lighting are set out in the Highways Agency's Design Manual for Roads and Bridges, Volume 8; Section 3; TD23 Inspection and Maintenance of Road Lighting. Consideration should also be given to advice given in Well Lit Highways the UK Lighting Boards Code of Practice for Highway Lighting Management.

High masts, masts, structural wires, hoists, winches, cables and supporting attachments of catenary lighting systems are not covered in this section. These elements are to be considered as structures and as such the maintenance regimes are covered in Chapter 8 - Routine Maintenance of Structures. Close liaison should take place between the two separate asset departments when undertaking any maintenance to ensure that effort and resource is not wasted. Consideration should also be given to the Institution of Lighting Professionals (ILP) Technical Report Professional Lighting Guide (PLG) 07 High Masts for Lighting and CCTV (2013 edition)

7.21.2 Inspection requirements

The condition of road lighting, including electrical, mechanical and structural elements, shall be inspected for the performance and integrity of the system. The safe and effective maintenance of road lighting is dependent on trained, competent, and well equipped personnel. TD23 recommends two types of inspection - Safety and Detailed.

7.21.2.1 Safety Inspections

- day-time safety inspections – carried out as part of the programmed safety inspections undertaken by the Highways Safety Inspection Team, as prescribed in Table 2. Designed to identify and record obvious defects such as column damage, hanging lanterns and missing doors etc. This inspection should also record day-burning lanterns
- night-time lamp outage inspections - programmed safety inspections carried out in darkness, shall identify and record all road lighting failures as prescribed in Table 11. However, if other defects are observed, they shall be also recorded and reported.

Table 11: Street Lighting Safety Inspection Frequency

Hierarchy Description	Frequency	Inspection Area
Expressways	28 days	Performance of the lighting system
Primary	28 days	Lamp failures
Secondary	28 days	Lamp cycling (switching on and off)
Tertiary	28 days	Luminaire bowl/glass obscured/dirty
Local	28 days	Any visible damage

These inspections will be carried out from a moving vehicle with a driver and an observer with all defects recorded manually or on appropriate Data Capture Devices (DCD). Inspection frequencies are shown in Table 11. Additional un-programmed safety inspections should be carried out in the event of reports of adverse weather conditions or a major road traffic accidents.

7.21.2.2 Detailed Inspections

Detailed inspections should be carried out in accordance with TD 23 and involve comprehensive visual scrutiny and specified testing of the structural, electrical and mechanical elements of the road lighting system. The inspections shall include:

- detailed visual inspection of the structural integrity of lamp columns
- detailed electrical testing of column wiring
- detailed inspection of lighting feeder pillars
- electrical testing of underground cable networks
- visual inspection of the operating environment for safety and maintenance
- structural testing of lighting columns to ILP report PLG 07.

Table 12: Detailed Inspection and Testing Criteria

Equipment	Type of Inspection	Frequency
Columns/Brackets	Visual Inspection of column structural and Electrical integrity to TD23	At Bulk Lamp change
Columns	Structural Testing to TD23 & ILP PLG 07	Manufacturers recommended end of life of column and then every six years depending on the results of the end of life inspection
Luminaires	Detailed inspection of all electrical components to TD23 and condition survey	At Bulk Lamp change
Feeder Pillar	Detailed electrical inspection to TD23 and visual structural inspection including paintwork	At Bulk Lamp change
Underground Cable Network	Full electrical testing to BS 7671	Every 6 years
Column Wiring	Electrical testing of column wiring to BS 7671 and TD23	Every 6 years

7.21.3 Pedestrian Subway Lighting

Pedestrian subway lighting and associated equipment should be inspected on foot in daylight. The integrity and operation of self-contained emergency luminaires should be confirmed during routine daytime highway Safety Patrols.

Self-contained emergency luminaires should be tested in accordance with the general principles of BS 5266. To provide sufficient illumination to ensure safe egress of the subway, 50% of the total emergency lighting system should be tested for full duration at each bulk lamp change. The full duration testing of any specified emergency luminaire is therefore completed every 2 years.

The frequency of inspection of pedestrian subways is specified at every 28 days. Reference should also be made to TD23, Annex B, Table 7, Pedestrian Subway Routine Maintenance and Inspection Intervals.

Additional guidance is provided in the Institution of Lighting Professionals Technical Report Number 13, Lighting of Pedestrian Subways.

7.21.4 LED Technology

LED luminaires are being considered as an alternative and replacement to currently utilized light sources i.e. High Pressure Sodium (HPS). All aspects of street lighting maintenance requirements within this document shall be inclusive of LED luminaires.

Further research may provide evidence of additional improved characteristics over currently employed light sources (HPS), which would result in improved maintenance methodology. These will be identified, validated and current maintenance practices amended accordingly.

HPS street lighting is readily identified as not working as the single light source would fail and the immediate area would be in darkness. An LED luminaire consists of multiple light sources and only a catastrophic failure of the luminaire would result in the area being in darkness. A light source failure in an LED luminaire would result in the fitting remaining in light but would result in a reduced amount of light being provided. Therefore, an LED luminaire shall be considered as light failed or out, when more than 30% of the individual LED's are not working. This is reflected in the L70 requirements of the approved LED luminaires.

7.21.5 Defect Categories

The condition of the road and pedestrian subway lighting systems shall be monitored through routine and non-routine inspections. Defects identified through inspections or through random reports from the Customer Service Centre shall be categorised as specified in Table 13, according to the potential hazard they may present.

Table 13: Defect Categories

Category of Defect	Description
Urgent (Category 1)	A defect which may result in an unacceptable structural or electrical hazard to the public
Non-Urgent (Category 2) (High and Medium Priority)	A defect which results in an unacceptable quality of lighting or presents a safety hazard to maintenance personnel
Non-Urgent (Category 2) (Low Priority)	All other electrical defects, lighting failures and structural faults which are considered to be less critical

7.21.6 Response Times

All defects shall be repaired, according to the category of failure within the response time specified in Table 14. The times quoted are maximum response times between notification to Ashghal and the repair being completed.

Table 14: Response Times

Category of Defect	Maximum Response Time	Response
Urgent (Category 1)	24 hours	Maintenance operatives shall work within Ashghal Health and Safety Regulations and the WZTMG
Non-Urgent (Category 2) (High and Medium Priority)	5 working days	Where road restrictions apply repairs are to be carried out under planned maintenance closures, Kahramaa shall be notified of any failures within 24 hours
Non-Urgent (Category 2) (Low Priority)	6 months or at planned works	Works should be incorporated into planned maintenance programmes wherever practicable

7.21.7 Bulk Lamp Change Frequencies

Table 15: Bulk Lamp Change Frequencies

Lamp Type	Abbreviations	Bulk Lamp Change Interval
High Pressure Sodium	SON	36 Months
Fluorescent	MCFE, SL, PL	24 Months

8.0 Routine Inspection and Maintenance of Structures

8.0 Routine Inspection and Maintenance of Structures

8.1 Introduction

The establishment of an effective structures inspection regime incorporating inspection frequencies, items to be recorded and nature of response, is one of the most crucial components of an effective highway maintenance strategy. An approved robust inspection, testing and monitoring regime incorporating network safety and serviceability, also helps to form defense against third party liability claims.

It will also provide the basic condition data for the development of programmes for maintenance as part of the Asset Management Plan. All elements of the inspection and assessment regime should be applied systematically and consistently, in accordance with the principles of Quality Assurance.

The methodology for undertaking inspections is based on the UK standards including those set out in the Highways Agency's Design Manual for Roads and Bridges (DMRB), Volume 3; Section 1; Part 4; BD 63 Inspection of Highway Structures.

For the purpose of this document, highway structures to be considered for the programmed structural inspections described in Section 8.3 are defined as any bridge or other structure that impinges in any way within the footprint of the highway or that materially affects the support of the highway or land immediately adjacent to it, that are owned by the Qatar Public Works Authority (Ashghal) and meets the dimensional criteria defined in Table 16.

Table 16: Structures Within Scope

Structure Type	Definition	Scope (see Note 1)
Bridge, footbridge, buried structure, subway underpass, culvert and any other similar structure	A structure supporting the highway as it crosses an obstacle (e.g. watercourse, valley or flood plain) or a service (e.g. local road or railway) OR a structure supporting the passage of a service (e.g. local road or railway) over the highway	All structures with a clear span or, internal diameter greater than 1.5m and 0.9m for corrugated metal culverts
Earth retaining structure	A structure associated with the highway where the dominant function is to retain earth	All structures with an effective retained height, i.e. the level of fill at the back of the structure above the finished ground level at the front of the structure, of 1.35m or greater
Reinforced / strengthened soil / fill structure with hard facings	A structure associated with the highway where the dominant function is to stabilise the slope and/or retain earth	All structures with an effective retained height of 1.5m or greater
Sign and/or signal gantry/ cantilever (see Notes 2 and 3)	Portal and cantilever structures spanning the highway, that support signs and/or signals	Structural aspects of all sign/signal gantries
Mast (see note 3)	Cantilever mast for traffic signals	Structural aspects of all cantilever masts
	High mast for lighting	Structural aspects of all lighting masts of 20m or greater, i.e. the vertical distance from top of post to bottom of flange. Includes winches, hoists, etc.
	Mast for camera, radio, speed camera and telecommunication transmission equipment	Structural aspects of all masts
	Catenary lighting support system	Structural aspects of all catenary support systems including structural wires
Access gantry (see Note 4)	A moveable structure providing access to a highway asset, typically for bridge inspection and maintenance	All moveable access gantries
Tunnels	An enclosed length of road of 90m or more	Structural aspects of all tunnels (refer to BD 53 for other criteria relevant to tunnels, e.g. M&E requirements)
Other structures	Other structures that are within the footprint of the highway, e.g. service/utility crossings	Structures providing service only crossings either above or below the carriageway
	Other structures not in the above subgroup as agreed with the Overseeing Organisation	To be agreed with Ashghal
Third Party structures	Any of the above categories but owned by others, e.g. private owners or utility companies	To be agreed with Ashghal

8 - Routine Inspection and Maintenance of Structures

Notes for Table 16:

1. Highway structures which are marginally outside these dimensions, especially those which are subject to hydraulic action, may be included within the scope of this Standard by agreement with the Overseeing Organisation.
2. Where sign/signal gantries and masts are also subject to separate Electrical and Mechanical inspections, staff undertaking any inspection should be instructed to be vigilant at all times and report defects of any nature considered to require urgent attention to the relevant authority/ organisation.
3. Signs/signal gantries and masts – structural aspects should include foundations, columns, beams, arms and any structural connections between these. The inspection should also give due consideration to any significant attachments and their connections.
4. All access gantries should be subject to inspections in accordance with The Institution of Structural Engineers publication The Operation and Maintenance of Bridge Access Gantries and Runways.

8.1.1 Purpose

The overall purpose of inspection, testing and monitoring is to check that the highway structures stock is safe for use and fit for purpose and to provide the data required to support the overall asset management programme.

Inspection, testing and monitoring form the basis of good management practice and should be used to:

- Provide data on the current condition, performance and environment of a structure, e.g. severity and extent of defects, material strength and loading. The data enables the Structures Manager to assess if a highway structure is currently safe for use and fit for purpose, and provides sufficient data for actions to be planned where structures do not meet these requirements
- Inform analyses, assessments and processes, e.g. change in condition, cause of deterioration, rate of deterioration, maintenance requirements, effectiveness of maintenance and structural capacity. The outputs inform management planning and enable cost effective plans, which deliver the agreed Levels of Service, to be developed
- Compile, verify and maintain inventory data, e.g. structure type, dimensions and location, for all the highway structures Ashghal is responsible for.

The above points illustrate that the data provided by inspection, testing and monitoring is fundamental to highway structures management and hence to good management practice.

8 - Routine Inspection and Maintenance of Structures

8.2 Health and Safety

Ashghal must ensure that all operations associated with routine maintenance of highway structures are undertaken in accordance with current Health and Safety legislation and in accordance with QCS Section 11 Health and Safety.

It should be noted that many structures, or parts of structures, will be classified as confined spaces. Common examples include culverts, box girders, bearing chambers and areas such as the access space below large expansion joints. For entry into confined spaces it will be necessary to prepare a Permit to Enter in each case and introduce access procedures which have been developed to accommodate Health and Safety requirements.

Health and safety issues requiring attention during normal maintenance work include:

- working on construction sites
- parking vehicles and moving on foot alongside live carriageways
- traffic management to allow access
- working at height to access elements of structures to be inspected, maintained or painted, using scaffold, mobile elevating work platforms, etc.
- working in, on or adjacent to water, railways, etc.
- toxic substances – lead in paint, solvents, resins, adhesives, waterproofing membranes, cement, etc.
- lone working, e.g. by bridge inspectors
- night work
- working in confined spaces
- presence of hypodermic needles.

When undertaking maintenance operations, all operatives must adhere to Ashghal's relevant standard procedures for dealing with typical situations. It is important that personnel are properly trained to recognise unusual situations and to carry out risk assessments to safeguard their own and others' health, safety and wellbeing as necessary.

8.3 Inspection Requirements

An adequate inspection regime should be implemented for all highway structures to check they are safe for use and fit for purpose. The inspection regime should be supplemented by testing and monitoring where appropriate. The inspection regime should include Maintenance Inspections (Safety Inspection, General, Principal, Special and Inspection for Assessment); and Acceptance Inspections as required.

The inspection, testing and monitoring regime should provide data that aligns with and supports the good management practice identified in this manual.

A procedure should be implemented whereby the inspector has a clearly defined duty to inform the Structures Manager, at the earliest possible opportunity, of any defects that may represent an immediate risk to public safety.

8.3.1 Basis and Principles

An inspection, testing and monitoring regime should minimise risks to public safety, provide sufficient data for management and make effective use of resources. The mix of techniques used in the regime, and frequencies at which they are applied, should be determined by considering appropriate criteria in an objective manner, e.g. through a formal risk assessment. The criteria should include, but not be restricted to, public safety, the characteristics of the assets, the consequence of failure, the environment the assets operate in, the services provided, typical rates of deterioration and susceptibility to damage.

The inspection, testing and monitoring techniques should be sufficient to:

- identify condition, defects and signs of deterioration that are significant to highway structure safety, long term integrity and management
- identify any significant changes in condition, loading or environment that have occurred since the last inspection
- assess or provide information for the assessment of stability and serviceability
- determine or assist the determination of the cause, extent and rate of deterioration
- provide information that can be used to support highway structures management, i.e. the identification of needs and associated maintenance works.

The inspection, testing and monitoring regime should seek to meet the criteria described in the purpose of inspections, testing and monitoring in the most cost effective manner.

8.3.2 Inspection Process

The inspection regime should enable any defects which may cause an unacceptable safety or serviceability risk or a serious maintenance requirement to be detected in good time in order to safeguard the public and the structure and implement remedial actions. The different types of inspection are described below and are followed by guidance on the inspection requirements of other owners, the frequency of inspections, scheduling of inspections and the inspection of Mechanical and Electrical (M&E) equipment.

Inspections should be carried out by appropriately qualified, trained and experienced personnel. To promote inspection consistency and quality it is recommended that regular in-house inspection meetings are carried out to assess the competence of inspectors. External contractors are required to demonstrate that their personnel are adequately trained and competent for the work they undertake.

8.3.3 Preparation for Inspections

Carrying out appropriate preparatory work greatly improves the likelihood of inspections being performed safely, successfully and efficiently and of providing the correct and accurate data. The amount of preparatory work carried out should be appropriate to the type of inspection.

8.3.4 Preliminary Review

Existing records of the structure should be reviewed beforehand to obtain a thorough understanding of what the inspection involves and to identify any specific difficulties that are likely to be encountered. For Principal and Special Inspections, it is suggested that this review includes a desk study and a reconnaissance of the structure.

8.3.5 Method Statement

A method statement that summarises all relevant information should be prepared and agreed before undertaking an inspection. The statement should take into account the preliminary review, access requirements, environmental considerations and Health and Safety checks. The level of detail given should be appropriate to the circumstances and the type of inspection. The following information should normally be included in the method statement:

- details and programme of the work to be undertaken for the inspection
- equipment required
- methods of access to be used
- traffic management details
- a risk assessment including safe procedures for dealing with hazards
- resources and competence of the staff to be employed
- planned working times
- temporary works to be provided
- protection from highway, railway and other traffic
- requirements for action by others
- any co-ordination or notification required
- any required permits, e.g. confined space entry and working
- any environmental impacts of the work.

Copies of the method statement and risk assessment should be retained on the Bridge Management System (BMS) for future reference. In many cases it will be appropriate for these documents to be added to the structure's Health and Safety File. Generic method statements and risk assessments may be appropriate for groups of similar structures.

8.3.6 Undertaking Inspections

A decision should be made as to whether the inspector should, or should not, review the previous inspection report during (or immediately before) the current inspection. Using the previous inspection report may enable the inspector to focus on more critical elements. However, it may also bias the inspection process and cause the inspector to overlook defects on other elements. The experience, training and competence of the inspector should be taken into consideration when deciding on the approach to adopt. The approach agreed should be used by all highway structures inspectors and be applied consistently over time. A different approach may be adopted for each inspection type.

All inspections should result in a report, in a format commensurate with the inspection type, which gives a clear and accurate description of the structure's condition. The reports should be uploaded into the BMS and the identified defects will be automatically added to the Structures Workbank, from which a forward work plan and work scheduling will be developed and maintenance work prioritised in a systematic manner.

An inspection pro-forma should be drawn up before an inspection is undertaken to specify the relevant information to be collected. This pro-forma can be in a paper format that can be filled out manually on site by the inspector or similarly in a digital format on a Data Capture Device (DCD) that again can be completed on site by the inspector. The information in the DCD will then be uploaded directly into Ashghal's BMS. The pro-forma should be able to accommodate data on the form and materials of the structure, the referencing system, the span/panel and elements being inspected, the extent, severity and location of any defects, the recommended action and its priority, and inspector's comments. Some of the aforementioned information may be entered onto the pro-forma before the inspection.

Standardised formats should be used for inspection reports. The format should be clear, follow a logical sequence and incorporate all the necessary information.

The inspection reports support maintenance planning and management and should assist this process by adopting a relatively consistent format from one inspection cycle to the next.

A completed inspection pro-forma may be sufficient as the General Inspection report. Principal and Special Inspections should result in a more detailed and comprehensive report.

The report of a Principal Inspection should comment on the significance of any defects, include a completed inspection pro forma (normally as an appendix) and give a broad statement on the overall condition of the structure. The report should state if a Special Inspection is required, and where attention should be given to particular elements during the following General or Principal Inspection. The report should give due consideration to effective whole life management of the structure and provide associated recommendations on maintenance options, associated cost estimates and programming.

8.3.7 Categories of Inspection

8.3.7.1 Safety Inspections

All structures should be subjected to a regular inspection; these should be undertaken as part of the regular highway Safety Inspections carried out by highway maintenance inspectors and staff. This inspection will only provide a cursory visible check of the structural elements that are visible from the highway and will identify obvious deficiencies or signs of damage that may require urgent attention, such as damage to the superstructure and bridge supports of overbridges, damage to parapets, insecure expansion joint plates, etc.

Safety Inspections should be undertaken at frequencies which ensure the timely identification of safety related defects and reflect the importance of a particular route or asset. Safety inspections may also be as a result of notification of a defect by a third party, e.g. police or public.

The Structures Manager should be satisfied that the frequency of highway Safety Inspections is suitable and, if unsuitable, decide how to deal with the need for additional surveillance.

All highway structure management and maintenance staff should be encouraged to be vigilant at all times when moving around the network and to report anything that might need urgent attention (this is known as the Watchman Role and is further described in paragraph 5.1 of this manual).

The general public should be encouraged to report any highway structure defects/ accidents affecting highway structures resulting in damage that they feel may pose a risk to public safety.

This is normally best achieved by providing appropriate contact details (e-mail and/or telephone) on Ashghal's website and on the structures identification plate fixed to the structure itself.

It is recommended that the Structures Manager makes formal contact with the highway maintenance staff and, if necessary, explains the important features to observe or defects to report on highway structures during Safety Patrols and the information that should be recorded if a defect is observed, e.g. structure location and defect description.

8.3.7.2 General Inspection

It is recommended that all highway structures should be subject to a regular General Inspection not more than 2 years following the previous General or Principal Inspection.

General Inspections comprise a visual inspection of all visible parts of the structure and, where relevant to the behavior or stability of the structure, adjacent earthworks or waterways that can be inspected without the need for special access or traffic management arrangements.

Guidance on General Inspections for highway structures is included in CSS Bridge Condition Indicators Volume 2: Guidance Note on Bridge Inspection Reporting and Addendum to CSS Bridge Condition Indicator Volume 2.

8.3.7.3 Principal Inspection

The purpose of a Principal Inspection is to provide detailed information on the physical condition of all inspectable parts of a highway structure. A Principal Inspection is more comprehensive and provides more thorough information than a General Inspection.

It is recommended that all highway structures should be subject to a regular Principal Inspection not more than 6 years following the previous Principal Inspection unless a risk assessment has been carried out to define an alternative interval. Principal Inspections comprise a close examination, within touching distance, of all accessible parts of a structure, including, where relevant, underwater parts and adjacent earthworks and waterways, utilising suitable access and/ or traffic management works as necessary. Closed circuit television may be used for areas of difficult or dangerous access, e.g. obscured parts of a structure, confined spaces and underwater inspections.

A Principal Inspection may include a modest programme of tests, e.g. hammer tapping

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to detect loose concrete cover or half-cell and chloride measurements to enable risk of reinforcement corrosion to be assessed, when considered necessary.

A Principal Inspection should be of sufficient scope and quality to determine:

- the condition of all parts of the structure:
  - The location, severity, extent and type of all defects on the structure, including, where appropriate, detailed descriptions and / or photographs (or sketches) of the defects that clearly identify their location and illustrate the severity / extent of damage
- the extent of any significant change or deterioration since the last Principal Inspection
- any information relevant to the stability of the structure.

A Principal Inspection should establish:

- the scope and urgency of any remedial or other actions required before the next inspection
- the need for a Special Inspection and/or additional investigations
- the accuracy of the main information on the structure held in the inventory on the BMS.

8.3.7.4 Special Inspection

The purpose of a Special Inspection is to provide detailed information on a particular part, area or defect that is causing concern, or inspection of which is beyond the requirements of the General/Principal Inspection regime.

A Special Inspection may comprise a close visual inspection, testing and/or monitoring and may involve a one-off inspection, a series of inspections or an ongoing programme of inspections. As such, Special Inspections are tailored to specific needs.

There are occasions when a more specific inspection, concentrating on the condition of particular parts of the structure, is required The need for a Special Inspection normally arises due to specific circumstances or following certain events, for example:

- when a particular problem is detected during an earlier inspection of the structure or of similar structures
- on particular structural forms or types, e.g. cast iron structures, post tensioned structures, structures strengthened with bonded plates
- on structures that have loading or other forms of restrictions on use, e.g., restriction of traffic on bridges
- when the necessary frequency or access arrangements for a particular part of the structure are beyond those available for General or Principal Inspections
- on bridges that have to carry an abnormally heavy load – inspections may be done before, during and after the passage of the load
- structures in areas of mineral extraction, when subsidence occurs
- structures if settlement is observed greater than that allowed for in the design. The cause should be identified and steps taken to monitor the rate of settlement and to assess the urgency of remedial measures
- structures involved in a major accident, chemical spillage or fire. The inspection should investigate the damage to the structure
- following a flash flood to check for scour or other damage
- to check specific concerns, possibly based on new information, e.g. concerns over the quality of previously used batches of rebar or concrete
- where a post tensioned bridge has a regime of Special Inspections implemented as a result of an earlier investigation or a Special Inspection is required in accordance with Highways Agency's Design Manual for Roads and Bridges, Volume 3; Section 1 ; Part 3; BA 50 Post-tensioned Concrete Bridges. Planning, Organisation and Methods for Carrying Out Special Inspections.

A policy should be developed clarifying when it is appropriate to carry out a Special Inspection. Further guidance on Special Inspections is provided in BD 63.

8.3.7.5 Inspection for Assessment

Inspections for Assessment are undertaken when necessary to provide the information required to undertake a structural assessment. The Highways Agency's Design Manual for Roads and Bridges, Volume 3; Section 3; Part 3; BD 21 The Assessment of Highway Bridges and Structures provides guidance on undertaking an Inspection for Assessment and recommends that these be done in conjunction with a Principal Inspection.

8.3.7.6 Acceptance Inspection

The need for an Acceptance Inspection should be considered when there is a changeover of responsibility for the operation, maintenance and safety of a structure from one party to another. The purpose of an Acceptance Inspection is to provide the party taking over responsibility for the structure with a formal mechanism for documenting and agreeing the current status of, and outstanding work on, a structure prior to handover. The scope of an Acceptance Inspection depends on the circumstances, e.g. handover of a new structure, transfer of an existing structure, and hand back of a structure after a concession period. Acceptance responsibilities and activities depend upon the form of contract, but the Acceptance Inspection is normally carried out by the party taking over responsibility but who may be

accompanied by the other party to facilitate agreement. The Acceptance Inspection should include:

- the identification of any permanent access provisions and features affecting the safety and security of the structure. These should be discussed in detail and agreement reached before handover
- the identification and handover of all the necessary records, As-built drawings, maintenance and operating manuals and Health and Safety Files which have an impact on the future management of the structure
- agreement of the date on which the authority takes over responsibility for the structure. The agreement should be recorded in the Structure File on the BMS
- It is recommended that Acceptance Inspections on new, existing and concession structures should also include the following as appropriate.

8.3.7.7 Handover of a New Structure

Handover of new highway structures shall be in accordance with Asset Affairs Project Handover Procedural Document.
As a guide, Handover Inspections shall follow the Principal Inspection format, and be carried out before the issue of the contract Completion Certificate. The inspection team should be provided with the Supervising Consultants Defects List (Snag List) prior to the inspection. The inspection should identify and record any defects not included on the Supervising Consultants Snag List, any developing problems and work outstanding under the contract and secure agreement on the works to be completed. This should act as the benchmark for the final inspection carried out before the end of the Maintenance Period and for subsequent inspections. A construction contract normally includes a Maintenance Period during which the contractor is responsible for making good defects. The Maintenance Period starts on the date specified in the Completion Certificate. The length of the Maintenance Period should be specified in the contract (typically 400 days).
A final inspection should be undertaken prior to the end of the Maintenance Period to identify any defects before the expiry of the contractual obligations. The timing of the inspection should be sufficient to allow agreement of the work to be undertaken by the contractor and, if necessary, enforcement of contractual obligations. The inspection may follow General or Principal Inspection format depending upon the type and form of the structure and the length of time since handover or the last inspection.

8.3.7.8 Transfer of an Existing Structure

An Acceptance Inspection should be undertaken prior to an authority taking over responsibility of an existing structure. A Principal Inspection format should be carried out as part of the Acceptance Inspection unless the results of a recent Principal Inspection are deemed to be relevant and sufficient.

8.3.7.9 Hand back after a Concession Period

An Acceptance Inspection should be undertaken before hand back at the end of a concession period. The inspection should compare the current condition and performance of the structure against the measures specified in the contract. This should include a Principal Inspection unless the results of a recent Principal Inspection are deemed to be relevant and sufficient.
This information should be used to identify and agree items of outstanding work to be completed, in order to satisfy the contract measures, before hand back. The timing of the Acceptance Inspection should be sufficient to allow agreement of the outstanding work to be undertaken by the Contractor/Concessionaire and, if necessary, enforcement of contractual obligations.

8.3.8 Inspection Requirements of Other Owners

Where other owners have structures within the footprint of the highway, they are responsible for ensuring the safety, integrity and adequacy of those structures for use by the public. The inspection of other owner structures normally falls into two categories:

- newer structures – an appropriate inspection regime is likely to have been recorded in the licence/maintenance agreement
- older structures – there is unlikely to be a statement of inspection requirements in a formal agreement. The highway authority only has the power to act to ensure safety in default of action by the other owner when the structure becomes dangerous. A highway authority cannot insist retrospectively on a regime of inspection and maintenance to be undertaken by the other owner where there is no clear statement of requirements in a formal agreement.

In certain cases a highway authority can be reasonably confident on the basis of available information that an owner is acting responsibly and has an adequate regime of inspections in place. In some cases, however, this conclusion cannot be justified and the highway authority should carry out General Inspections of such structures in the wider interests of public safety. This in no way negates the primary responsibility of the actual owner toward public safety and structural integrity. Ashghal will be developing a Policy for dealing with inspection of highway structures owned by others in the future.

8.3.9 Frequency of Inspections

This document recommends a General Inspection be undertaken not more than 2 years after the previous General or Principal Inspection and for a Principal Inspection to be carried out not more than 6 years after the previous Principal Inspection. When a General Inspection coincides with a due Principal Inspection only the latter is undertaken.These inspection frequencies are generally interpreted as a 2 and 6 year General and Principal Inspection regime. This regime is suitable for most highway structures but in some circumstances it may be necessary to decrease the intervals while in others it may be acceptable to increase the intervals.

8.3.10 Decreasing the Inspection Interval

When a structure is known or suspected to be subject to a rapid change in condition or circumstances, the default interval between inspections should be reduced accordingly. The reduced interval should be such that any significant change in condition or circumstances can be identified and assessed in time for appropriate action to be implemented. The revised inspection regime and reasons for more frequent inspections should be recorded in the Structure File. The more frequent inspection may be limited to a specific element or feature.

8.3.11 Increasing the Inspection Interval

Highway structures are long life assets and their constituent components deteriorate at different rates due to a wide range of factors, e.g. material type, construction form, usage, environment and exposure and maintenance. The recommended two year General Inspection and six year Principal Inspection regime represent accepted best practice. However, these intervals may not always represent the most cost effective solution for some structures while in some cases it may not be feasible to follow these intervals due to access difficulties. Inspection intervals may therefore be increased for these structures. The suitability of increased inspection intervals should be assessed, justified using a risk assessment, and recorded on the BMS as a 'Departure from Standard' giving full justification behind the decision. A risk assessment in this regard must give due consideration to the following:

- a General Inspection at not more than 2 years after the previous General or Principal Inspection is recommended good practice for all highway structures. Relaxing the General Inspection intervals supported by risk assessment should only be considered as an interim solution as authorities work towards a two year interval
- the interval between General Inspections should not exceed 3 years, i.e. a General Inspection should occur at the latest 3 years after the previous General or Principal Inspection
- type, quality, extent and results of previous inspections, testing, monitoring, structural assessment, etc.
- accessibility of all parts of a structure, for example:
  - if the inspector can get close to all parts of a structure during a General Inspection, there may be little difference between the General and Principal Inspection. A Principal (or Special) Inspection may only be required when the need has been identified by a General Inspection
  - if the inspector cannot get close to all parts of the structure during a General Inspection and there is a likelihood of significant defects not being detected, there is a need for more regular Principal (or Special) Inspections
  - providing suitably current data for calculating the Condition Performance Indicator (Bridge Condition Indicator)
  - the ease of producing practical and workable inspection budgets and schedules, i.e. scheduling may become unduly complicated if different inspection intervals (especially for General Inspections) are used across the highway structures stock.

8.3.12 Risk Assessment

A risk assessment should be specific to a structure or group of similar structures. An assessment method should be developed that seeks to quantify:

- the likelihood of rapid deterioration or other incidents
- the consequence of unchecked deterioration / incidents.

Assessment of the likelihood of rapid deterioration or other incidents should include, but not be limited to, the following criteria where relevant:

- exposure severity, e.g. mild, moderate or severe, and external influences which may cause rapid deterioration or failure, e.g. significant change in use (above, adjacent or beneath), loading that exceeds existing restrictions, stray current/electrical corrosion
- current condition and level of contamination, e.g. chlorides or carbonation, and how these conditions may influence the rate of deterioration. The age of the structure may also be considered
- material type and the typical rate of deterioration for the observed deterioration mechanism. Many defects are known to take many years

to develop to the point where they require maintenance or present a risk to structural integrity or public safety. The maintenance/repair history of the structure should be taken into consideration and structure specific characteristics such as fatigue-prone details and susceptibility to scour damage, should be considered

- severity and extent of damage due to incidents, such as vehicle impact, scour and vandalism, and whether this is likely to lead to further deterioration before it is repaired
- potential mode of failure, e.g. brittle or ductile failure
- extent of failure, e.g. local or global failure.

Assessment of the consequence of unchecked deterioration and other incidents should include, but not be limited to, the following criteria where relevant:

- consequence of failure of the structure or its elements, e.g.
- the likely number of fatalities and casualties based on the size of the structure and traffic volume on the route crossed and obstacle crossed
- traffic delay costs incurred through diversions/congestion based on the route type and availability of diversion routes
- socio-economic impact based on the location of the structure and the community served, e.g. industrial, business or residential
- increased costs due to unchecked deterioration/incidents resulting in more expensive maintenance work at a later date.

The suitability of increased inspection intervals should then be assessed through a risk matrix, e.g. as shown in Table 17.

The risk assessment should be recorded in the Structure File and agreed by the Structures Manager before the frequency of inspections is changed. The validity of the risk assessment should be re-confirmed and recorded by the Structures Manager after each Principal Inspection or when any other significant change in the condition of the structure becomes apparent.

8.3.13 Scheduling Inspections

Inspection scheduling should seek to make the most efficient use of the resources available and minimise disturbance to the public, e.g. plan inspections to take advantage of traffic management planned for other reasons such as lighting, signing and carriageway inspections.

Inspections should ideally be scheduled in accordance with the frequencies described in this document unless an agreed alteration has been accepted with the appropriate risk assessments undertaken and accepted. Inspections should be grouped by area to ensure that traveling between structures is minimised and time spent on gathering defect information is optimised.

Table 17: Risk Assessment Matrix

		Consequence of unchecked deterioration/incident		
		Low	**Medium**	**High**
Likelihood of rapid deterioration or other incidents	Low	**Suitable for increased interval**	**Suitable for increased interval**	**May be suitable for increased interval**
	Medium	**Suitable for increased interval**	**May be suitable for increased interval**	**Use recommended inspection regime**
	High	**May be suitable for increased interval**	**Use recommended inspection regime**	**Use recommended inspection regime**

8.4 Maintenance Requirement

8.4.1 Introduction

This part is introduced in order to formalise the procedures for routine maintenance of highway structures and to ensure that vital maintenance functions are carried out in a timely manner. It sets out those operations, and their frequency, which are to be undertaken as routine maintenance. The maintenance requirements specified will not necessarily be comprehensive but are nevertheless intended to provide sufficient guidance to enable development of the schedules described in Paragraph 8.4.3.

Many of the tasks listed in this part are fairly minor in themselves, but failure to carry them out may lead to deterioration of the structure, and the need for more serious and costly repair operations in the future. Generally, it is considered cost effective in whole life terms, to undertake timely routine maintenance. It forms an important component in developing a coherent ongoing bridge management strategy.

The maintenance requirements are grouped by structure type rather than by activity.

8.4.2 Routine Maintenance

The items of routine maintenance given in the subsequent chapters should be regarded as those which relate to servicing rather than repair and which will usually be undertaken regularly at pre-determined intervals.

Routine maintenance does not cover the repair or renewal of structural elements or components which have become unserviceable because of general wear and tear or have deteriorated for other reasons. Such work should be identified during the regular inspection process, and should be included in a planned structural maintenance programme.

8.4.3 Routine Maintenance Schedules

Items of routine maintenance which are appropriate for each particular structure should be identified; a schedule of operations should be prepared and agreed. Reference should be made to the Structure Maintenance Manual to ensure that any specific requirements are incorporated. This will be particularly necessary for large and complex structures and components. Any identified schedule should be appended to the Maintenance Manual and will remain valid until an element or component is replaced or modified, or a particular need develops.

For newly constructed structures, routine maintenance schedules should be prepared in association with the handover or initial principal inspection. Any special arrangements or requirements for routine maintenance should be supplied by the

bridge designer and included in the Maintenance Manual. Schedules for existing structures can often usefully be prepared in association with programmed inspections.

8.4.4 Routine Maintenance Frequencies

The frequencies with which routine maintenance operations are to be carried out are described in each chapter. The specified intervals shall be treated as recommended guidelines, but be adhered to as closely as possible, although it is appreciated that in order to plan the works efficiently slight variance from target dates may be necessary.

The specified frequencies may not be appropriate in all circumstances and may need to be modified to take account of local conditions and the needs of individual structures, e.g. by reducing maintenance intervals. Such local variations shall be subject to the approval of Ashghal. Approval will only be given where the need for such a variation is clearly justified.

If there is a need to carry out routine maintenance operations more frequently than the recommended intervals (e.g. drains regularly block), consideration should be given to the implementation of capital maintenance works, to reduce the necessity for such frequency. It may also be appropriate to combine routine maintenance operations with other works or bridge inspections, to minimise traffic management costs and delays.

8.4.5 Maintenance Responsibilities

Overbridges, Underbridges, Subways, Retaining Walls, Footways and Special Structures:

The extent of responsibility deemed to be associated with these structures is for the maintenance of all structural elements below, and including, the waterproofing membrane as well as parapets and associated pilasters. Other assets on or in the vicinity with the structure such as the surfacing, road markings, lighting columns, parapets, safety fencing, kerbing and road studs etc. are associated with the highway.

However, it is vital that the Structures Manager must be consulted before any highway maintenance work is carried out in the vicinity of an existing highway structure.

8.5 Retaining Walls and Bridge Substructures

8.5.1 General

The routine maintenance requirements for retaining wall and bridge substructure elements are given below.

8.5.2 Piers, Abutments, Wing-Walls, Retaining Walls, Reinforced Earth Walls and Crib Walls

8.5.2.1 Maintenance Requirements Include:

- remove graffiti
- clean artwork
- remove any vegetation from the structure
- clear sand debris from bearing shelves
- clean drainage channels
- rod outlet pipes to ensure effective operation and check on completion
- clear drainage outlet manhole chambers
- rod weep pipes and remove silt and debris
- check operation of flap valves and grease where required
- repair gap sealant to movement joints
- check pedestrian protection measures.

Note: Access restrictions may prevent the effective rodding of all drainage pipes. This must be recorded in order to assess the longer term maintenance implications of such a problem.

8.5.2.2 Maintenance Interval

- 12 months

8.5.2.3 Time of Maintenance

All drains should be cleared and be working properly before the rainy season starts.

8.5.3 Columns

8.5.3.1 Maintenance Requirements include:

- remove graffiti
- remove sand, debris and bird droppings

8.5.3.2 Maintenance Interval

- 12 months

8.6 Bridge Superstructures

8.6.1 General

The routine maintenance requirements for bridge superstructure elements are given below. The works required are limited in nature because most will be categorised minor or major maintenance. It is therefore particularly important to ensure that routine maintenance work on adjacent structures is coordinated to maximise the use of any access plant and traffic management measures which are required.

8.6.2 Steel Beams, Girders, Trusses, Concrete Beams and Fascia's

8.6.2.1 Maintenance Requirements Include:

- remove graffiti
- remove sand, debris and bird droppings from flanges
- clear drainage holes for box sections.

8.6.2.2 Maintenance Interval

- 12 months

8.6.3 Deck Carriageway, Verge and Parapet Cantilever

8.6.3.1 Maintenance Requirements Include:

- grass and weeds should be removed from verges and channels where their presence is considered to be detrimental to the satisfactory performance of the structure.
- repair gap sealant to movement joints

8.6.3.2 Maintenance Interval

- 12 months

8.7 Components

8.7.1 General

The routine maintenance requirements for common structural elements are given below. Additional requirements for more complex components will be specified in the Structure Maintenance Manual.

8.7.2 Expansion Joints

8.7.2.1 Maintenance Requirements Include:

- clean out debris and vegetation. For large expansion joints with provision for access from below the deck, any silt trays/troughs should be emptied and low pressure water jetting should be used for cleansing purposes
- clear drainage systems
- check and tighten where necessary any loose nuts and bolts. Replace where appropriate
- replace gaskets where this is a specific requirement detailed in the Structure Maintenance Manual.

8.7.2.2 Maintenance Interval

- 12 months

8.7.3 Deck Drainage

8.7.3.1 Maintenance Requirements

- the requirements for the routine maintenance of surface drainage in the carriageway, footway or verge are given in Section 7.5 - Highway Drainage
- sub-surface drainage outlet pipes and below deck systems should be rodded, where accessible, to ensure satisfactory operation.

8.7.3.2 Maintenance Interval

- the complexity and accessibility of sub-surface and below deck systems will vary considerably. An appropriate maintenance interval should be agreed with overseeing organisation. Normally this interval will be between 12 and 24 months.

8.7.4 Metal Parapets

8.7.4.1 Maintenance Requirements Include:

- check and tighten where necessary any loose nuts or bolts. Replace as appropriate
- clear hollow section drainage holes.

8.7.4.2 Maintenance Interval

- 12 months

8.7.5 Masonry and Concrete Parapets

8.7.5.1 Maintenance Requirements Include:

- remove graffiti
- remove any vegetation.

8.7.5.2 Maintenance Interval

- 2 months

8.7.6 Bearings (Elastomeric, Sliding and Roller)

8.7.6.1 Maintenance Requirements Include:

- remove general dirt, sand and debris
- where appropriate, clean sliding and roller surfaces if accessible and regrease to ensure satisfactory performance. (Additional advice relating to the bearing manufacturers' instructions should be included in the Structure Maintenance Manual).

8.7.6.2 Maintenance Interval

- 12 months – remove general sand, dirt and debris
- 10 years – clean and regrease.

8.8 Subways

8.8.1 General

The maintenance requirements for those elements which relate to the structural integrity of subways are given below.

8.8.1.1 Maintenance Requirements Include:

- remove graffiti
- clear drainage channels
- clear any sand build up
- clean drainage outlets. Rodding/jetting where required
- check (and rectify where necessary) seating of drainage gratings or covers, replace any missing or defective items
- repair gap sealant to movement joints
- check and clean security mirrors.

8.8.1.2 Maintenance Interval

- 12 months

8.9 Culverts

8.9.1 General

The routine maintenance of culverts described here relates only to those culverts which are classified as highway structures (see Table 16). Smaller culverts and piped drainage systems are covered by paragraph 7.5 – Highway Drainage.

It should be noted that many culverts will be classified as confined spaces and general reference should be made to the advice given in paragraph 8.2.

The routine maintenance requirements for culverts are given below.

8.9.1.1 Maintenance Requirements Include:

- remove any vegetation sand and debris from within the structure
- remove any silt build-up which is restricting flow through the culvert
- repair gap sealant to movement joints.

8.9.1.2 Maintenance Interval

- 12 months

8.10 Sign Signal Gantries, High Masts and Catenary Lighting

8.10.1 General

The maintenance requirements for the structural aspects of sign signal gantries, high masts and catenary lighting are given below.

8.10.1.1 Maintenance Requirements Include:

- tighten holding down bolts where necessary

8.10.1.2 Maintenance Interval

- 12 months

8.10.2 Non-structural Aspects

The requirements relating to maintenance of lighting are given in paragraph 7.21.

Other non-structural items such as hoists, winches and electrical fixings shall be checked for correct operation, cleaned and lubricated as appropriate, in accordance with the manufacturer's recommendations and at a maximum interval of 12 months. Any electrical work shall be carried out by specialist contractors having full regard to the safety and well-being of operatives and the public.

8.11 Inspection and Routine Maintenance of Tunnels

The requirements for Tunnels relate to highway tunnels and portals, any associated Tunnel Management Centre's and monitoring equipment, service buildings and plant rooms.

The cleaning and maintenance requirements for tunnels and associated equipment, summarised overleaf in Table 18, are set out in the Highways Agency's Design Manual for Roads and Bridges, Volume 2; Section 2; Part 9 BD 78, Chapter 14 – Tunnel Operation and Maintenance. Further concise detail is provided in the Highways Agency's Design Manual for Roads and Bridges, Volume 2; Section 2; Part 3; BA 72, Maintenance of Road Tunnels.

For the purpose of classification for provision of safety facilities, a road tunnel is defined as any subsurface highway structure enclosed for a length of 90m or more. In addition to the requirements that are unique to tunnels, where appropriate, requirements for items contained in other sections (e.g. paved areas) apply within tunnels.

Table 18: Tunnel Equipment Cleaning and Maintenance Frequencies

Item	Equipment	Cleaning Frequencies	Maintenance Frequencies
1	Lighting luminaires	1 - 2 months	8 – 36 months
2	Lighting controls and Photometers	12 months	12 months
3	Jet fan overhaul		48 months
4	Axial flow fans and auxiliary equipment		Minor: 4000 hours Major: 25000 hours
5	Obscuration meters	1 month	Minor: 1 month Major: 12 months
6	CO_2 monitors	3 months	3 - 12 months
7	Anemometers		6 months
8	Ventilation computer	1 month	1 month
9	Remote control system		6 months
10	Variable message signs	6 months	12 months
11	Safety barriers		6 months
12	Movable barriers		6 months
13	Traffic recording/induction loops		3 -12 months
14	Traffic computer	6 months	1 month
15	Peripheral units	6 months	6 months
16	Emergency phones	1 month	3 months
17	Fire Hydrants in tunnel recesses	6 months	6 months
18	Hand fire extinguishers	6 months	12 months
19	Fire hydrant main		6 months
20	Automatic fire alarm system		3 months
21	CCTV cameras and equipment	1 month	1 month
22	Public address loudspeaker systems		6 months
23	Radio system	12 months	6 months
24	Over height vehicle detectors		6 months
25	Escape doors and tunnel walls	To be agreed	6 months
26	Transformers		12 months
27	HV switch gear	12 months	12 months
28	LV switch gear	24 months	12 months
29	Emergency switch gear and UPS systems	12 - 24 months	1 - 3 months
30	Batteries	I week	1 - 12 months
31	Gullies	1 month	
32	Sumps	1 month	
33	Foul sumps	1 - 3 months	
34	Oil and petrol separators	I month	
35	Pumps	I week	I month
36	Pump controls	I week	I month
37	Valve actuators	I week	I month
38	Road surfacing	I week	Minor: 1 month Medium: 12 months Major: 7 - 10 years

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Specific requirements for the operation, emergency response and service activities should be determined for each tunnel and set out in the Operation and Maintenance Manuals (O&MM) for the tunnel. These requirements are subject to continuous review, risk assessment and improvement during the life of the tunnel. In general, efficient operation and a rapid response in the event of equipment failure or other emergency will be required.

Equipment must operate correctly at all times for the safety and comfort of road users and those who work in the tunnel, and to avoid disruption to road users from unplanned tunnel closures. Equipment must operate efficiently. Escape facilities must function as intended at all times. The tunnel structure and equipment must remain structurally and electrically safe, so as not to present a hazard to the public or workers in the tunnel. As repairs or the replacement of tunnels and equipment are costly, effective maintenance is likely to be the best way of preserving the value of the tunnel and equipment in order to obtain best value for money.

The pollution of ground and surface water from discharges into the tunnel drainage system following tunnel cleaning or an accidental spillage must be prevented.

Emergencies in tunnels can have major effects. Contingency plans for emergencies should be covered in the O&MM for each tunnel. Training and exercises, both desktop and full rehearsal, in association with the emergency services are required.

8.12 Inspection of Mechanical and Electrical Equipment

Mechanical and Electrical (M&E) equipment associated with highway structures includes, but is not limited to, lighting and ventilation in road tunnels, lighting in pedestrian underpasses and hydraulic rams on moveable bridges. The stewardship of this equipment is likely to be the responsibility of the Structures Manager.

An appropriate regime of inspection (and testing) of M&E equipment should be established. The inspection regime should be commensurate with the principles described above and the manufacturer's recommendations.

The manufacturer's recommended spares should be held in stock for M&E equipment to facilitate quick repair when an inspection identifies a defect.

Useful guidance on the inspection and testing of M&E equipment associated with highway structures is provided in DMRB Volume 5, section 7 Series 7000 Mechanical and Electrical Installations in Road Tunnels, Moveable Bridges and Bridge Access Gantries.

9.0 Intelligent Transportation Systems

9.0 Intelligent Transportation Systems

9.1 General

Various investments have been made on stand-alone Intelligent Transportation System (ITS) systems in the State of Qatar in recent times and some of those are listed below. These systems should be preserved and incorporated into the ITS Master Plan, Architecture and Action Plan.

The requirements of this manual cover the technology systems, but are not limited to, safe access and general, non-specialised maintenance of technology systems, electrical installations and their surroundings, which form part of the network technology system. Maintenance of the specialised electrical/electronic plant will be undertaken by a number of methods:

- Specialist technology contractors under separate contracts procured by the employer
- In house specialist resources.

9.1.1 Purpose

These sections set out Ashghal's performance requirements in relation to the carrying out of maintenance services on ITS and its associated infrastructure. The performance requirements detailed within these sections are structured to deliver outcomes for the various categories of work described.

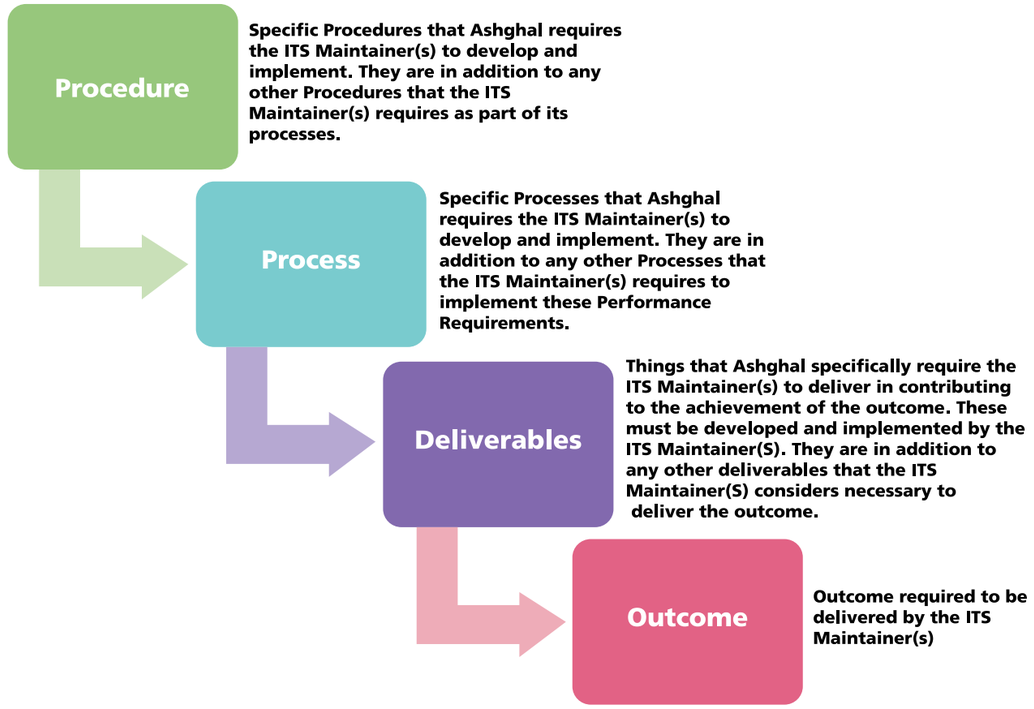
The ITS Maintainer(s) is generally free to choose the method by which these outcomes are to be delivered, but the chosen method must include the Ashghal requirements where stated as a deliverable, process or procedure. The ITS Maintainer(s) is encouraged to be innovative in the manner in which the outcomes are delivered which should not necessarily follow any previous maintenance requirements and operational practices. In addition to any performance metrics that the ITS Maintainer(s) wishes to utilise, the ITS Maintainer(s) must, as a minimum, measure performance using the metrics described in each asset type section.

The scope of maintenance includes, but is not limited to the following ITS assets:

- Closed Circuit Television (CCTV) Cameras
- CCTV Mast Ancillary Equipment
- Roadway Weather Information Systems (RWIS)
- Traffic Detection and Monitoring (TDMS)
- Dynamic Message Signs (DMS)
- Portable Dynamic Message Signs (PDMS)
- Lane Control Signs (LCS)
- Overheight Vehicle Detection Systems (OVDS)
- Weigh In Motion Detection Systems (WIM)
- Ramp Metering Systems (RMS)
- Road Traffic Signal System
- Telecommunications Networks.

The scope for each asset type is contained within individual sub-sections within Section 9.2 – ITS Asset Specific Requirements. These sections detail the maintenance requirements for each asset type and are subsequently described in greater detail in the following format in Figure 21.

Figure 21: Outcome Based Maintenance



The deliverables, processes and procedures (shown in Figure 21) for each ITS Asset Type as detailed within Section 9.2 are not exhaustive. They represent what Ashghal requires the ITS Maintainer(s) to carry out in addition to that which the ITS Maintainer(s) deem is required to deliver the stated outcomes.

9.1.2 Philosophy / Rational

The ITS Maintainer(s) is expected to take a risk based approach to the execution of the asset maintenance. In the context of these requirements a risk based approach means that the ITS Maintainer(s) develops its operational maintenance regime using data and information about the network. This should underpin intelligent decisions about where and when to undertake maintenance work.

The primary risks that the ITS Maintainer(s) must mitigate are:

- Safety - avoid the network becoming hazardous to highway users and reduce the risks to road-worker safety
- Availability - avoid risk to maintaining free flow of traffic.

The ITS Maintainer(s) is required to produce an ITS Asset Maintenance Plan (AMP) for acceptance by the ITS Manager at the start of each annual maintenance year, as detailed within section 9.1.9. This QRMM document will be used to support the development of the AMP, which will detail what maintenance is undertaken and at what frequency. The AMP will also contain sufficient detail to show how the ITS Maintainer(s) will maintain the ITS equipment within the Network.

The ITS Maintainer(s) will clear faults within the response / restore times specified within this document.

The Performance Requirements described here are outcome focused leaving the ITS Maintainer(s) to choose its asset maintenance methodology, subject to incorporating Ashghal's particular specified requirements. As a result it is expected that the ITS Maintainer(s) develops and implements innovative methods for delivering the Services that will reduce cost in order to optimise the ITS Maintainer(s) performance. The use of fixed performance targets has been avoided wherever practicable.

The approach expected is that the ITS Maintainer(s) measures and understands its performance, and more importantly uses measurement data to improve its performance and also reduce cost.

9.1.3 Key Operational Processes for the ITS Maintainer(s)

The following are key operational processes that the ITS Maintainer(s) is required to perform:

- To adopt and develop the key procedures and processes indicated within the asset specific requirements shown in Section 9.2
- These requirements are minimum requirements and the ITS Maintainer(s) must supplement them with any activity required to meet its contractual obligations
- Include detailed procedures in its Quality Plan in relation to the inspection, making safe and repair of the asset.

9.1.4 Traffic Management Centre (TMC)

References to Traffic Management Centre (TMC), within these sections, include reference to the current Traffic Signal Control Room (TSCR), the future Road Network Management Centre (RNMC) and any other future TMC facilities.

9.1.5 General Requirements

The following sections contain aspects of ITS asset maintenance that have general requirements that are common to the ITS contained within this manual.

All the maintenance shall be in accordance where relevant to Ashghal ITS Specifications, Qatar Construction Specifications (QCS), Operations and Maintenance Manuals and other related authorities requirements.

9.1.6 Maintenance Levels

The maintenance levels for ITS are split into 2 types - 'first' and 'second' line maintenance. Each level is described below and has been translated into the associated requirements within each of the asset sections in Section 9.2.

- 'First line' maintenance is mainly on-site repair of a system, by replacing hardware or software and could involve remote reset or repair
- 'Second line' maintenance involves the swapping of hardware and repairing of hardware off-site or returning the hardware to the manufacturer for repair.

Each asset type sub-section in Section 9.2 contains a table similar to Table 19 – Maintenance Levels shown below which will provide details of the maintenance level requirements for the asset.

Table 19: Maintenance Levels

Maintenance Level	Requirement
'First line'	On site repair/reset or remote repair/reset
'Second line'	Swap modules and faulty equipment returned to depot for repair or returned to the manufacturer for repair/replacement.

9.1.7 Fault Categories and Response / Restore Times

Table 20 sets out the fault restoration times that are required by Ashghal in relation to faults occurring with its ITS Systems. The Response / Restore Service times indicated in the table are maximum times which start from the time the ITS Maintainer(s) is requested to make a response to a fault, whether it be the result of an accident, emergency fault, power supply failure, environment or climatic change, or at the request from the O&M Engineers, the TMC, Traffic Police or other authorised party that requires immediate attention.

Within each asset type category in Section 9.2 a similar table to Table 20 – Fault Categories and Response / Restore Times is provided, which identifies faults and the fault category to which the fault is attributed.

Table 20: Fault Categories and Response / Restore Times

Fault Category	Response / Restore Times
UT (Urgent ITS)	Service is to be restored within 4 hours
T1	8 hours
T2	24 hours

9.1.8 Fault Definitions

UT – An Urgent ITS fault is an incident or fault that fulfills the following criteria:

- An unforeseen event which directly or indirectly affects the ITS asset and causes or has the potential to cause disruption to the free flow of traffic or threatens the safety of customers
- Faults or defects involving ITS assets causing an immediate or imminent risk to the safety of the public, the ITS Maintainer(s) workforce or others
- Immediate response requests to 'make safe' ITS assets from the TMC staff, the Traffic Police, other emergency organisations, Works Contractors and authorised organisations.

If, for whatever reason, corrective action or repair is not reasonably practical within the specified period even if third party assistance is required, the ITS Maintainer(s) affects temporary measures to make safe or mitigate the effect of the incident, defect or fault and immediately instigates procedures to affect a full repair in the most effective and efficient manner.

The ITS Maintainer(s) shall ensure that all relevant parties are fully informed and updated before the end of the next working day on the status of any incident, defect or fault repair or other actions taken.

All defects to electrical installations which represent an immediate hazard (UT) shall be protected or, whenever possible, made safe at the time of inspection.

T1 – fault response time must be within 4 hours from notification or when the ITS Maintainer(s) becomes aware of a fault. A fault that has less importance than a UT fault on assets that are not critical to the management of the free flow of traffic or would cause an immediate of imminent risk to the safety of the traveling public e.g. faults associated with weigh inspection systems.

T2 – fault response time must be within 8 hours from notification or when the ITS Maintainer(s) becomes aware of a fault. Faults that are not critical and will not compromise the safe operation of any ITS asset system e.g. loops.

9.1.9 ITS Asset Maintenance Plan (AMP)

The ITS Maintainer(s) shall be responsible for the delivery and implementation of ITS routine maintenance which should be detailed within the ITS AMP. The ITS Maintainer(s) is required to produce an ITS AMP for acceptance by the ITS Manager at the start of each annual maintenance year.

This QRMM document will be used to support the development of the AMP, which will detail what maintenance is undertaken and at what frequency. The AMP will also contain sufficient detail to show how the ITS Maintainer(s) will maintain the ITS equipment within the Network.

The ITS Maintainer(s) shall maintain an AMP that includes time and/or risk based approaches for undertaking condition assessments, assessing and prioritising defects and undertaking maintenance. The AMP will also include the methodology for undertaking maintenance and repairs in accordance with the current maintenance and fault management requirements. It shall provide detailed information (but not limited) of all the assets, asset type, frequency of routine maintenance visits, visit due dates and types of visit.

Table 21 provides an example of the minimum information required in a table format as part of the AMP for each ITS asset being maintained.

Table 21: AMP Table Example

Asset Ident	Asset Type	Asset Category	Location of Asset	Maintenance Activities to be Undertaken	Frequency of Activity	Methodology of Undertaking the Activity	Maintenance Visit Due Date

Asset condition surveys shall be carried out as an integral part of the maintenance programme and should be detailed within the AMP.

All maintenance shall be carried out in accordance with the equipment manufacturer's maintenance manuals and any additional recommendations as detailed in existing Operation and Maintenance Manuals.

All maintenance undertaken shall be recorded within the relevant ITS Maintainer(s) existing electronic or paper based Asset Management System if such a system exists, although in future this will be required to be captured within Ashghal's Enterprise Asset Management System (EAMS).

9.1.10 Maintenance of ITS Assets at or near Tunnels

It is essential that ITS equipment and procedures are in place to manage tunnel operations 24 hours a day and to satisfy European Union Tunnel Safety Directives. The ITS equipment that is in place and shall be put in place in the future to manage the tunnel safety will be varied and will be managed and maintained through a series of operational contracts. This document specifically addresses the Ashghal requirements for those parts of the ITS that are overseen and monitored by the TMC.

Listed below are the ITS assets which shall convey data to the future Master Software located within the TMC:

- Automatic Incident Detection (AID) Systems
- Closed Circuit Television (CCTV) cameras
- Traffic detectors
- Heat detectors
- Roadway Weather Information Systems (RWIS)
- Overheight Vehicle Detection System (OVDS)
- Lane Control Signs (LCS)
- Speed Control Signs (SCS)
- Dynamic Message Signs (DMS)
- Emergency Roadside Telephones (ERT), see section 8.11 Inspection and Routine Maintenance of Tunnels, Table 18.

Faults that occur in any of the above assets which are located within a tunnel have a fault category of UT and consequently the 'time to restore service' is 4 hours.

It should be noted that tunnel equipment maintenance arrangements shall vary depending upon any local agreements which are in place for each tunnel. Those agreements should be read in conjunction with this document. The tunnel agreements will indicate which of the above assets are monitored by the tunnel control room and consequently which assets are outside the scope of this document.

9.1.11 Electrical Maintenance

The ITS Maintainer(s) shall be responsible for the management of the Electrical Maintenance across all ITS related Infrastructure.

ITS Maintainer(s) shall carry out all maintenance in accordance with BS 7671:2008 + Amendment 1:2011 (BS 7671) Requirements for Electrical Installations.

ITS Maintainer(s) shall carry out Periodic Inspection and Testing of the electrical installation as recommended in Regulation 135.1 of BS 7671. The reporting of the periodic inspection shall be recorded on an Electrical Installation Condition Report. Any alterations or additions including minor works to existing electrical installations shall be compliant with BS 7671, inspected and tested and the findings recorded on a Minor Electrical Installation Works Certificate.

All Ashghal ITS assets with highway power supplies require Periodic Inspection and Testing to BS 7671 they shall also be identified and inventoried. All assets contained in the inventory shall be subject to at least one full test over a maximum interval of 6 years unless specified otherwise.
The inventory and programme of 6 yearly Periodic Inspections shall be contained within the future EAMS and currently within any other suitable software package capable of storing a programme of works.

Traffic management will be undertaken by the ITS Maintainer(s) in accordance with the Work Zone Traffic Management Guide and should seek to minimise disruption. There will be restrictions on certain routes, requiring the ITS Maintainer(s) to carry out operations at certain times.

The ITS Maintainer(s) shall liaise with QGEWC (Kahramaa) at regular intervals to ascertain the time and location of any regulated interruption to power supplies.

The following remedial and temporary works shall be carried out during power supply failures:

- **Mains Supply Shut Down** – The ITS Maintainer(s) on receipt of a power supply shut down notice from the QGEWC shall be present on site at the time of shut down to 'Switch off" the ITS asset. They shall also be present at the end of the shutdown period to "Switch on" and check the ITS Asset for the normal operation.
- **Main Cable Damage** – In the event of a power supply cut off due to main cable damage, the ITS Maintainer(s) on receiving the fault report either from Traffic Police or from other sources shall coordinate with the QGEWC and be present on site at the time of restoration of the mains supply to "Switch on" and check the ITS asset for the normal operations.

9.2 ITS Asset Specific Requirements

The pages immediately following contain specific asset type information in terms of the scope and metrics as well as outcomes, deliverables, processes and procedures.

The asset types for which individual sections exist are:

- Closed Circuit Television (CCTV) Cameras
- CCTV Mast Ancillary Equipment
- Roadway Weather Information Systems (RWIS)
- Traffic Detection and Monitoring System (TDMS)
- Dynamic Message Signs (DMS)
- Portable Dynamic Message Signs (PDMS)
- Lane Control Signs (LCS)
- Overheight Vehicle Detection Systems (OVDS)
- Weigh In Motion Detection Systems (WIM)
- Ramp Metering Systems (RMS)
- Road Traffic Signal System
- Telecommunications Networks.

Ramp Metering systems are made up of a combination of the above asset types and intermediate controlling devices at the roadside. The asset types have been considered individually and refer to any specific requirements for Ramp Metering systems.

9.2.1 Closed Circuit Television (CCTV) Requirements

9.2.1.1 Scope

This Section describes the general requirements for maintenance of Closed Circuit Television (CCTV) surveillance and security cameras and camera detectors (Pan, Tilt, Zoom (PTZ) and fixed).

As a minimum CCTV maintenance shall consist of the following:
Pan, Tilt and Zoom (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 License Plate Reader (LPR) and Automatic Incident Detection (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.

9.2.1.2 Outcomes

CCTV equipment is located on the network to capture and transmit real time images of the network. The cameras are intended to give a clear real time view of what is happening on the network to assist operators in deciding on any support that is needed.

They will support:

- 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 AID.

The CCTV system as a whole allows operators to monitor the operation of the network, traffic conditions and manage incidents and will enable faster response and faster clearance of incidents.

The required outcomes are that:
The CCTV equipment continues to fulfil its intended purpose
The CCTV equipment operates efficiently and without premature loss of equipment life
The CCTV equipment does not present a hazard to road users or ITS Maintainer(s).

9.2.1.3 Deliverables

- To ensure that the CCTV equipment is fully operational
- To ensure that the CCTV equipment components are free from physical and electrical defects which present a hazard to road users or ITS Maintainer(s).

9.2.1.4 Process Requirements

- Assess and record the condition of all CCTV equipment and installations
- Ensure that all current legislative requirements are met
- Maintain the performance of all CCTV equipment components and installations and to rectify any defects which will prevent achievement of the required outcomes or increase the rate of deterioration of the CCTV equipment or other equipment
- Any faults which occur in the CCTV equipment shall be rectified within timescales indicated in Table 22.

Table 22: CCTV Fault Rectification Timescales

Fault Description	Fault Category
CCTV Equipment failure	UT
CCTV failure within a tunnel or within 1 km of a tunnel portal (both directions)	T1
All other faults	T2

9.2.1.5 Procedures

The ITS Maintainer(s) undertakes maintenance in accordance with Table 23.

Table 23: CCTV Equipment Maintenance Schedule

Maintenance Level	Requirement
'First line'	On site repair/reset or remote repair/reset
'Second line'	Swap modules and faulty equipment returned to depot for repair or returned to the manufacturer for repair/replacement.

- Ensure that all CCTV equipment has identification markers for future EAMS logging that are correctly located and are clearly visible and legible. The identification details to be included within future EAMS must also contain the correct asset information
- Prepare and maintain an Asset Management Plan that includes time and/or risk based approaches for undertaking condition assessments, assessing and prioritising defects and undertaking maintenance. The AMP will also include the methodology for undertaking repairs in accordance with the current fault management requirements
- Assess the condition of and maintain all components of CCTV equipment in accordance with the approved AMP.
- Record all CCTV equipment maintenance activities within the future Ashghal asset management database EAMS
- Ensure that all CCTV equipment maintenance and repairs comply with the relevant standards and regulations.

9.2.1.6 Metrics

The Key Performance Indicators associated with CCTV equipment will be measured through the use of data contained within the future EAMS.

9.2.2 Closed Circuit Television (CCTV) Pole Ancillary Equipment Requirements

9.2.2.1 Scope

This Section describes the general requirements for maintenance of Pole Ancilliary Equipment (including Camera Lowering Device (CLD) , pan/tilt/zoom mechanisms and mountings associated with CCTV (PTZ and Fixed) (including AID) Cameras.

9.2.2.2 Outcomes

CCTV equipment is located on the network to capture and transmit real time images of the network. The effectiveness of the CCTV equipment to fulfil its designed role is to a large extent reliant upon its location. CCTV Camera poles and mountings give the cameras an optimal position from which to monitor the network and are located at strategic positions in order to secure the effectiveness of the CCTV Cameras. They may also enable CCTV cameras to be lowered and raised for maintenance purposes.

The required outcomes are that:

- The CCTV Pole Ancillary Equipment

continues to fulfil its intended purpose
- The CCTV Pole Ancillary Equipment operates efficiently and without premature loss of equipment life
- The CCTV Pole Ancillary Equipment does not present a hazard to road users or ITS Maintainer(s).

9.2.2.3 Deliverables

- To ensure that the CCTV Pole Ancilliary Equipment are fully operational
- To ensure that the CCTV Pole Ancillary Equipment are free from physical and electrical defects which present a hazard to road users or ITS Maintainer(s).

9.2.2.4 Process Requirements

- Assess and record the condition of all CCTV Pole Ancilliary Equipment
- Ensure that all current legislative requirements are met
- Maintain the performance of all CCTV Pole Ancillary Equipment and to rectify any defects which will prevent achievement of the required outcomes or increase the rate of deterioration of the CCTV Pole Ancillary Equipment or other equipment
- Any faults which occur in the CCTV Pole Ancillary Equipment shall be rectified within timescales indicated in Table 24.

Table 24: CCTV Pole Ancillary Equipment Rectification Timescales

Fault Description	Fault Category
CCTV Mast Ancillary Equipment failure	UT

9.2.2.5 Procedures

The ITS Maintainer(s) undertakes maintenance in accordance with Table 25.

Table 25: CCTV Pole Ancillary Equipment Maintenance Schedule

Maintenance Level	Requirement
'First line'	On site repair/reset or remote repair/reset
'Second line'	Swap modules and faulty equipment returned to depot for repair or returned to the manufacturer for repair/replacement.

- Prepare and maintain an Asset Management Plan that includes time and/or risk based approaches for undertaking condition assessments, assessing and prioritising defects and undertaking maintenance. The AMP will also include the methodology for undertaking repairs in accordance with the current fault management requirements
- Assess the condition of and maintain all components of the CCTV Pole Ancillary Equipment in accordance with the approved Asset Management Plan
- Record all CCTV Pole Ancillary Equipment maintenance activities within Ashghal's future asset management database EAMS
- Ensure that all CCTV Pole Ancillary Equipment maintenance and repairs comply with the relevant standards and regulations.

9.2.2.6 Metrics

There are no Key Performance Indicators associated with CCTV Pole Ancillary Equipment.

9.2.3 Roadway Weather Information Systems (RWIS) Requirements

9.2.3.1 Scope

This Section describes the general requirements for maintenance of Roadway Weather Information Systems (RWIS) and Air Quality Monitoring Systems (AQMS).

As a minimum the RWIS installation 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 Controllers
- Software and/or Equipment Room Server
- Housing and Mounting Structure.

As a minimum the AQMS installation shall consists of the following:

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

9.2.3.2 Outcomes

RWIS and AQMS equipment will be used to provide accurate and timely weather information to Ashghal and its partners. The information gathered by these systems will be used to assist Ashghal in fulfilling its role as a network operator, particularly in times when adverse weather conditions prevail. This equipment is to be used to provide TMC operators with accurate environmental information and so enable:

- Appropriate early warning to road users (target of within 5 minutes of detection) of hazardous conditions
- The planning and implementation of operational procedures in accordance with procedures described in Chapter 11 – Severe Weather, to adapt the roadway network operations during changing weather conditions.

The required outcomes are that:

- RWIS and AQMS equipment continues to fulfil its intended operational purpose
- RWIS and AQMS equipment operates efficiently and without premature loss of equipment life
- RWIS and AQMS equipment does not present a hazard to road users or ITS Maintainer(s).

9.2.3.3 Deliverables

- To ensure that the RWIS and AQMS equipment is fully operational
- To ensure that RWIS and AQMS components are free from physical and electrical defects which present a hazard to road users or ITS Maintainer(s).

9.2.3.4 Process Requirements

- Assess and record the physical, electrical and operational condition of all RWIS and AQMS equipment and installations
- Ensure that all current legislative requirements are met
- Maintain the performance of all RWIS and AQMS equipment components and installations and to rectify any defects which will prevent achievement of the required outcomes or increase the rate of deterioration of the RWIS and AQMS or other equipment
- Any faults which occur in the RWIS and AQMS equipment shall be rectified within the timescales indicated below:

Table 26: RWIS and AQMS Equipment Rectification Timescales

Fault Description	Fault Category
The only forecasting site for the area (corridor) is affected	UT
All Other Faults	T1

9.2.3.5 Procedures

The ITS Maintainer(s) undertakes maintenance in accordance with Table 27.

Table 27: RWIS and AQMS Equipment Maintenance Schedule

Maintenance Level	Requirement
'First line'	On site repair/reset or remote repair/reset
'Second line'	Swap modules and faulty equipment returned to depot for repair or returned to the manufacturer for repair/replacement.

- Ensure that all RWIS and AQMS equipment has identification markers for future EAMS logging, that they are correctly located and are clearly visible and legible. The identification details included within future EAMS must also contain the correct asset information
- Prepare and maintain an Asset Management Plan that includes time and/or risk based approaches for undertaking condition assessments, assessing and prioritising defects and undertaking maintenance. The AMP will also include the methodology for undertaking repairs in accordance with the current fault management requirements
- Assess the condition of and maintain all components of RWIS and AQMS equipment in accordance with the approved AMP
- Record all RWIS and AQMS equipment maintenance activities within EAMS
- Ensure that all RWIS and AQMS equipment maintenance and repairs comply with the relevant standards and regulations.

9.2.3.6 Metrics

The Key Performance Indicators associated with RWIS will be measured through the use of data contained within the future EAMS.

9.2.4 Traffic Detection and Monitoring Systems

9.2.4.1 Scope

This Section describes the general requirements for maintenance of traffic detection and monitoring systems across the entire network.

As a minimum the Traffic Detection and Monitoring Systems (TDMS) shall consist of the following:

- 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.

9.2.4.2 Outcomes

TDMS are stand-alone detectors that detect the presence of cyclists, pedestrian and vehicles. 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 and destination information
- Roadway capacity analysis
- Performance measures
- Planning and design purposes.

The TDMS equipment is safety related and will be used to provide automatic queue protection through automatic signal and message sign settings in dynamic response to traffic conditions such as congestion and incidents. It seeks to prevent incidents due to congestion and secondary incidents by providing advance warning of slow moving / stationary traffic, and to improve traffic flows. It is also used to provide traffic data to support the operation of the TMC. The TDMS will also collect real time traffic data used for performance analysis of the road network and for design purposes.

The required outcomes are that:

- The TDMS equipment continues to fulfil its intended operational purpose
- The TDMS equipment operates efficiently and without premature loss of equipment life
- The TDMS equipment does not present a hazard to road users or ITS Maintainer(s).

9.2.4.3 Deliverables

- To ensure that the TDMS and associated roadside equipment is fully operational and available
- To ensure that TDMS and associated roadside equipment components are free from physical and electrical defects which present a hazard to road users or ITS Maintainer(s).

9.2.4.4 Process Requirements

- Assess and record the condition of all TDMS equipment and installations
- Ensure that all current legislative requirements are met
- Maintain the performance of all TDMS equipment components and installations and to rectify any defects which will prevent achievement of the required outcomes or increase the rate of deterioration of the TDMS or other equipment
- Any faults which occur in the TDMS equipment shall be rectified within timescales indicated in Table 28.

Table 28: TDMS Equipment Rectification Timescales

Fault Description	Fault Category
TDMS equipment failure	UT
All Other faults (except loop/detector failure)	T1
Loop / Detector failure	T2

9.2.4.5 Procedures

The ITS Maintainer(s) undertakes maintenance in accordance with Table 29.

Table 29: TDMS Equipment Maintenance Schedule

Maintenance Level	Requirement
'First line'	On site repair/reset or remote repair/reset
'Second line'	Swap modules and faulty equipment returned to depot for repair or returned to the manufacturer for repair/replacement.

- Ensure that all TDMS and associated roadside equipment has identification markers for future EAMS logging, that they are correctly located and are clearly visible and legible. The identification details included within future EAMS must also contain the correct asset information
- Prepare and maintain an Asset Management Plan (AMP) that includes time and/or risk based approaches for undertaking condition assessments, assessing and prioritising defects and undertaking maintenance. The AMP will also include the methodology for undertaking repairs in accordance with the current fault management requirements
- Assess the condition of and maintain all components of TDMS equipment in accordance with the approved AMP
- Record all TDMS equipment maintenance activities within Ashghal's future asset management database EAMS
- Ensure that all TDMS equipment maintenance and repairs comply with the relevant standards and regulations.

9.2.4.6 Metrics

The Key Performance Indicators associated with TDMS equipment will be measured through the use of data contained within the future EAMS.

9.2.5 Dynamic Message Signs (DMS) Requirements

9.2.5.1 Scope

This Section describes the general requirements for maintenance of Dynamic Message Signs (DMS) across the network. As a minimum the DMS shall consist of the following:

- Display Matrix
- Lantern Matrices
- Display Driver
- Interface to DMS Roadside Controller.

9.2.5.2 Outcomes

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.

The required outcomes are that:

- The DMS equipment continues to fulfil its intended purpose
- The DMS equipment operates efficiently and without premature loss of equipment life
- The DMS equipment does not present a hazard to road users or ITS Maintainer(s).

9.2.5.3 Deliverables

- To ensure that the DMS and associated roadside equipment are fully operational
- To ensure that DMS units and associated roadside equipment are free from physical and electrical defects which present a hazard to road users or ITS Maintainer(s).

9.2.5.4 Process Requirements

- Assess and record the condition of all DMS equipment and installations
- Ensure that all current legislative requirements are met
- Maintain the performance of all DMS equipment components and installations and to rectify any defects which will prevent achievement of the outcomes or increase the rate of deterioration of the DMS equipment or other equipment
- Any faults which occur in the DMS equipment shall be rectified within timescales indicated in Table 30.

Table 30: DMS Equipment Rectification Timescales

Fault Description	Fault Category
Dynamic Message Sign failure Associated roadside equipment failure	UT
All Other Faults	T1

9.2.5.5 Procedures

The ITS Maintainer(s) undertakes maintenance in accordance with Table 31.

Table 31: DMS Equipment Maintenance Schedule

Maintenance Level	Requirement
'First line'	On site repair/reset or remote repair/reset
'Second line'	Swap modules and faulty equipment returned to depot for repair or returned to the manufacturer for repair/replacement.

- Ensure that all DMS and associated roadside equipment has identification markers for future EAMS logging, that they are correctly located and are clearly visible and legible. The identification details included within future EAMS must also contain the correct asset information
- Prepare and maintain an Asset Management Plan (AMP) that includes time and/or risk based approaches for undertaking condition assessments, assessing and prioritising defects and undertaking maintenance. The AMP will also include the methodology for undertaking repairs in accordance with the current fault management requirements
- Assess the condition of and maintain all components of DMS equipment in accordance with the approved AMP
- Record all DMS equipment maintenance activities within Ashghal's future asset management database EAMS
- Ensure that all DMS equipment maintenance and repairs comply with the relevant standards and regulations.

9.2.6.6 Metrics

The Key Performance Indicators associated with DMS equipment will be measured through the use of data contained within the future EAMS.

9.2.6 Portable Dynamic Message Signs (PDMS) Requirements

9.2.6.1 Scope

This Section describes the general requirements for maintenance of Portable Dynamic Message Sign (PDMS) for use along roadway across the network.
As a minimum the PDMS shall consist of the following:

- an amber PDMS display
- local PDMS controller
- power equipment
- trailer for transporting the PDMS.

9.2.6.2 Outcomes

The PDMS may be utilised for work zone, emergency, special events, and any other applications that the Client considers.

The required outcomes are that:

- The PDMS equipment continues to fulfil its intended purpose
- The PDMS equipment operates efficiently and without premature loss of equipment life.

- The PDMS equipment does not present a hazard to road users or ITS Maintainer(s).

9.2.6.3 Deliverables

- To ensure that the PDMS and associated roadside equipment are fully operational.
- To ensure that PDMS units and associated roadside equipment are free from physical and electrical defects which present a hazard to road users or ITS Maintainer(s).

9.2.6.4 Process Requirements

- Assess and record the condition of all PDMS equipment and installations
- Ensure that all current legislative requirements are met
- Maintain the performance of all PDMS equipment components and installations and to rectify any defects which will prevent achievement of the outcomes or increase the rate of deterioration of the PDMS equipment or other equipment
- Any faults which occur in the PDMS equipment shall be rectified within timescales indicated in Table 32.

Table 32: PDMS Equipment Rectification Timescales

Fault Description	Fault Category
Dynamic Message Sign failure	UT
Associated roadside equipment failure	UT
All Other Faults	T1

9.2.6.5 Procedures

The ITS Maintainer(s) undertakes maintenance in accordance with Table 33.

Table 33: PDMS Equipment Maintenance Schedule

Maintenance Level	Requirement
'First line'	On site repair/reset or remote repair/reset
'Second line'	Swap modules and faulty equipment returned to depot for repair or returned to the manufacturer for repair/replacement.

- Ensure that all PDMS and associated roadside equipment has identification markers for future EAMS logging, that they are correctly located and are clearly visible and legible. The identification details included within future EAMS must also contain the correct asset information
- Prepare and maintain an Asset Management Plan (AMP) that includes time and/or risk based approaches for undertaking condition assessments, assessing and prioritising defects and undertaking maintenance. The AMP will also include the methodology for undertaking repairs in accordance with the current fault management requirement
- Assess the condition of and maintain all components of PDMS equipment in accordance with the approved AMP
- Record all PDMS equipment maintenance activities within Ashghal's future asset management database EAMS
- Ensure that all PDMS equipment maintenance and repairs comply with the relevant standards and regulations.

9.2.6.6 Metrics

The Key Performance Indicators associated with PDMS equipment will be measured through the use of data contained within future EAMS.

9.2.7 Lane Control Signs (LCS) Requirements

9.2.7.1 Scope

This Section describes the general requirements for maintenance of Lane Control Sign(s) (LCS) on the network.

As a minimum the LCS shall consist of the following:

- Central Matrix
- Red Ring
- Lanterns
- Display Driver
- an interface to the LCS Roadside Controller
- where applicable, interfaces to speed enforcement equipment.

9.2.7.2 Outcomes

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. The LCS are positioned above the centre of each running lane to provide information about speed limits, lane closures and lane changes. The required outcomes are that:

- The LCS equipment continues to fulfil its intended purpose
- The LCS equipment operates efficiently and without premature loss of equipment life
- The LCS equipment does not present a hazard to road users or ITS Maintainer(s).

9.2.7.3 Deliverables

- To ensure that the LCS and associated roadside equipment are fully operational
- To ensure that LCS units and associated roadside equipment are free from physical and electrical defects which present a hazard to road users or ITS Maintainer(s).

9.2.7.4 Process Requirements

- Assess and record the physical, electrical and operational condition of all LCS and associated roadside equipment and installations
- Ensure that all current legislative requirements are met
- Maintain the performance of all LCS equipment components and installations and to rectify any defects which will prevent achievement of the outcomes or increase the rate of deterioration of the LCS equipment or other equipment
- Any faults which occur in the LCS equipment shall be rectified within timescales indicated in Table 34.

Table 34: LCS Equipment Rectification Timescales

Fault Description	Fault Category
Lane Control Sign(s) failure	UT
Associated roadside equipment failure	UT
All Other Faults	T1

9.2.7.5 Procedures

The ITS Maintainer(s) undertakes maintenance in accordance with Table 35.

Table 35: LCS Equipment Maintenance Schedule

Maintenance Level	Requirement
'First line'	On site repair/reset or remote repair/reset
'Second line'	Swap modules and faulty equipment returned to depot for repair or returned to the manufacturer for repair/replacement.

- Ensure that all LCS and associated roadside equipment has identification markers for future EAMS logging, that they are correctly located and are clearly visible and legible. The identification details included within future EAMS must also contain the correct asset information
- Prepare and maintain an Asset Management Plan (AMP) that includes time and/or risk based approaches for undertaking condition assessments, assessing and prioritising defects and undertaking maintenance. The AMP will also include the methodology for undertaking repairs in accordance with the current fault management requirements
- Assess the condition of and maintain all components of LCS equipment in accordance with the approved AMP
- Record all LCS equipment maintenance activities within Ashghal's future asset management database EAMS
- Ensure that all LCS equipment maintenance and repairs comply with the relevant standards and regulations.

9.2.7.6 Metrics

The Key Performance Indicators associated with LCS equipment will be measured through the use of data contained within the future EAMS.

9.2.8 Overheight Vehicle Detection Systems (OVDS) Requirements

9.2.8.1 Scope

This Section describes the general requirements for maintenance of Overheight Vehicle Detection Systems (OVDS) for use along roadway across the network.

As a minimum the OVDS shall consist of the following:

- Overheight vehicle sensors
- Audible alarm
- Roadside controller
- Housing and Mounting Structure.

9.2.8.2 Outcomes

The OVDS 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 passes the detection equipment.

The required outcomes are that:

- The OVDS equipment continues to fulfil its intended purpose
- The OVDS equipment operates efficiently.
- and without premature loss of equipment life
- The OVDS equipment does not present a hazard to road users or ITS Maintainer(s).

9.2.8.3 Deliverables

- To ensure that the OVDS and associated roadside equipment are fully operational.
- To ensure that OVDS units and associated roadside equipment are free from physical and electrical defects which present a hazard to road users or ITS Maintainer(s).

9.2.8.4 Process Requirements

- Assess and record the condition of all OVDS equipment and installations
- Ensure that all current legislative requirements are met
- Maintain the performance of all OVDS equipment components and installations and to rectify any defects which will prevent achievement of the outcomes or increase the rate of deterioration of the OVDS equipment or other equipment
- Any faults which occur in the OVDS equipment shall be rectified within timescales indicated in Table 36.

Table 36: OVDS Equipment Rectification Timescales

Fault Description	Fault Category
All Faults	T1

9.2.8.5 Procedures

The ITS Maintainer(s) undertakes maintenance in accordance with Table 37.

Table 37: OVDS Equipment Maintenance Schedule

Maintenance Level	Requirement
'First line'	On site repair/reset or remote repair/reset
'Second line'	Swap modules and faulty equipment returned to depot for repair or returned to the manufacturer for repair/replacement.

- Ensure that all OVDS and associated roadside equipment has identification markers for future EAMS logging, that they are correctly located and are clearly visible and legible. The identification details included within future EAMS must also contain the correct asset information
- Prepare and maintain an Asset Management Plan (AMP) that includes time and/or risk based approaches for undertaking condition assessments, assessing and prioritising defects and undertaking maintenance. The AMP will also include the methodology for undertaking repairs in accordance with the current fault management requirements
- Assess the condition of and maintain all components of OVDS equipment in accordance with the approved AMP
- Record all OVDS equipment maintenance activities within Ashghal's future asset management database EAMS
- Ensure that all OVDS equipment maintenance and repairs comply with the relevant standards and regulations.

9.2.8.6 Metrics

The Key Performance Indicators associated with OVDS equipment will be measured through the use of data contained within the future EAMS.

9.2.9 Weigh Inspection Stations Requirements

9.2.9.1 Scope

This Section describes the general requirements for the maintenance of Weigh Inspection Station (WIS) at various locations across the network.

As a minimum the WIS shall consist of the following:

- Vehicle detection sensors (e.g. quartz/ piezometer)
- Dynamic Message Signs (DMS)
- Roadside controllers
- Traffic signal equipment
- CCTV camera equipment
- Static weigh scales and associated systems.

9.2.9.2 Outcomes

The WIS shall monitor, for the purpose of enforcement, the weight, height and classification of vehicles using the road adjacent to the site.
The required outcomes are that:

- The WIS equipment continues to fulfil its intended purpose
- The WIS equipment operates efficiently and without premature loss of equipment life
- The WIS equipment does not present a hazard to road users or ITS Maintainer(s).

9.2.9.3 Deliverables

- To ensure that the WIS and associated roadside equipment are fully operational
- To ensure that the WIS and associated roadside equipment are free from physical and electrical defects which present a hazard to road users or ITS Maintainer(s).

9.2.9.4 Process Requirements

- Assess and record the condition of all WIS equipment and installations
- Ensure that all current legislative requirements are met
- Maintain the performance of all WIS equipment components and installations and to rectify any defects which will prevent achievement of the outcomes or increase the rate of deterioration of the WIS equipment or other equipment
- Any faults which occur in the WIS equipment shall be rectified within timescales indicated in Table 38.

Table 38: Weigh Inspection Station Equipment Rectification Timescales

Fault Description	Fault Category
All Faults	T1

9.2.9.5 Procedures

The ITS Maintainer(s) undertakes maintenance in accordance with Table 39.

Table39: Weigh Inspection Station Equipment Maintenance Schedule

Maintenance Level	Requirement
'First line'	On site repair/reset or remote repair/reset
'Second line'	Swap modules and faulty equipment returned to depot for repair or returned to the manufacturer for repair/replacement.

- Ensure that the WIS and associated roadside equipment has identification markers for future EAMS logging, that they are correctly located and are clearly visible and legible. The identification details included within future EAMS must also contain the correct asset information
- Prepare and maintain an Asset Management Plan (AMP) that includes time and/or risk based approaches for undertaking condition assessments, assessing and prioritising defects and undertaking maintenance. The AMP will also include the methodology for undertaking repairs in accordance with the current fault management requirements
- Assess the condition of and maintain all components of WIS equipment in accordance with the approved AMP
- Record all WIS equipment maintenance activities within Ashghal's future asset management database EAMS
- Ensure that all WIS equipment maintenance and repairs comply with the relevant standards and regulations.

9.2.9.6 Metrics

The Key Performance Indicators associated with WIS equipment will be measured through the use of data contained within the future EAMS.

9.2.10 Weigh-In-Motion Detection System (WIM) Requirements

9.2.10.1 Scope

This Section describes the general requirements for the maintenance of high-speed Weigh-In-Motion (WIM) systems for use along roadway across the network.
As a minimum the WIM Systems shall consist of the following:

- Weighing sensors (e.g. quartz piezo sensor)
- Vehicle detection equipment
- Roadside controller
- Housing and Mounting Structures
- License Plate Reader (LPR)
- Dynamic Message Signs (DMS).

9.2.10.2 Outcomes

The high-speed WIM system 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.
The required outcomes are that:

- The WIM Systems equipment continues to fulfil its intended purpose
- The WIM Systems equipment operates efficiently and without premature loss of equipment life
- The WIM System equipment does not present a hazard to road users or ITS Maintainer(s).

9.2.10.3 Deliverables

- To ensure that the WIM Systems and associated roadside equipment are fully operational
- To ensure that the WIM Systems and associated roadside equipment are free from physical and electrical defects which present a hazard to road users or ITS Maintainer(s).

9.2.10.4 Process Requirements

- Assess and record the condition of all WIM System equipment and installations
- Ensure that all current legislative requirements are met
- Maintain the performance of all WIM System equipment components and installations and to rectify any defects which will prevent achievement of the outcomes or increase the rate of deterioration of the WIM System equipment or other equipment
- Any faults which occur in the WIM System equipment shall be rectified within timescales indicated Table 40.

Table 40: WIM System Equipment Rectification Timescales

Fault Description	Fault Category
All Faults	T1

9.2.10.5 Procedures

The ITS Maintainer(s) undertakes maintenance in accordance with Table 41.

Table 41: WIM System Equipment Maintenance Schedule

Maintenance Level	Requirement
'First line'	On site repair/reset or remote repair/reset
'Second line'	Swap modules and faulty equipment returned to depot for repair or returned to the manufacturer for repair/replacement.

- Ensure that all WIM System and associated roadside equipment has identification markers for future EAMS logging, that they are correctly located and are clearly visible and legible. The identification details included within future EAMS must also contain the correct asset information
- Prepare and maintain an Asset Management Plan (AMP) that includes time and/or risk based approaches for undertaking condition assessments, assessing and prioritising defects and undertaking maintenance. The AMP will also include the methodology for undertaking repairs in accordance with the current fault management requirements
- Assess the condition of and maintain all components of WIM System equipment in accordance with the approved AMP
- Record all WIM System equipment maintenance activities within Ashghal's future asset management database EAMS
- Ensure that all WIM System equipment maintenance and repairs comply with the relevant standards and regulations.

9.2.10.6 Metrics

The Key Performance Indicators associated with WIM System equipment will be measured through the use of data contained within the future EAMS.

9.2.11 Ramp Metering Systems (RMS) Requirements

9.2.11.1 Scope

This Section describes the general requirements for maintenance of ramp meter equipment and related roadway furniture at metered roadway on-ramps.

As a minimum the RMS shall consist of the following:

- signal poles
- signal heads
- flashing beacons
- ramp meter controller
- signs
- flexible and armoured cables
- inductive loops.

9.2.11.2 Outcomes

When Ramp Metering is operational, it releases platoons of vehicles from the on-ramp to the main line carriageway to optimise the road 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.

The required outcomes are that:

- The RMS equipment continues to fulfil its intended purpose
- The RMS equipment operates efficiently and without premature loss of equipment life
- The RMS equipment does not present a hazard to road users or ITS Maintainer(s).

9.2.11.3 Deliverables

- To ensure that the RMS and associated roadside equipment are fully operational
- To ensure that RMS units and associated roadside equipment are free from physical and electrical defects which present a hazard to road users or ITS Maintainer(s).

9.2.11.4 Process Requirements

- Assess and record the condition of all RMS equipment and installations
- Ensure that all current legislative requirements are met
- Maintain the performance of all RMS equipment components and installations and to rectify any defects which will prevent achievement of the outcomes or increase the rate of deterioration of the RMS equipment or other equipment
- Any faults which occur in the RMS equipment shall be rectified within timescales indicated Table 42.

Table 42: RMS Equipment Rectification Timescales

Fault Description	Fault Category
Ramp Metering System	UT
All other Faults	T1

9.2.11.5 Procedures

The ITS Maintainer(s) undertakes maintenance in accordance with Table 43.

Table 43: RMS Equipment Maintenance Schedule

Maintenance Level	Requirement
'First line'	On site repair/reset or remote repair/reset
'Second line'	Swap modules and faulty equipment returned to depot for repair or returned to the manufacturer for repair/replacement.

- Ensure that all RMS and associated roadside equipment has identification markers for future EAMS logging, that they are correctly located and are clearly visible and legible. The identification details included within future EAMS must also contain the correct asset information
- Prepare and maintain an Asset Management Plan (AMP) that includes time and/or risk based approaches for undertaking condition assessments, assessing and prioritising defects and undertaking maintenance. The AMP will also include the methodology for undertaking repairs in accordance with the current fault management requirements
- Assess the condition of and maintain all components of RMS equipment in accordance with the approved AMP
- Record all RMS equipment maintenance activities within Ashghal's future asset management database EAMS
- Ensure that all RMS equipment maintenance and repairs comply with the relevant standards and regulations.

9.2.11.6 Metrics

The Key Performance Indicators associated with RMS equipment will be measured through the use of data contained within the future EAMS.

9.2.12 Road Traffic Signal System Requirements

9.2.12.1 Scope

The requirements relate to the routine maintenance of permanent traffic signal installations at intersection, junctions, outside emergency vehicle stations, and at controlled pedestrian crossings on Ashghal's network. The equipment covered includes road traffic signals, traffic signal controllers (and any other equipment located inside the controller case), any other case forming part of the site, detector cases, roadside transmission cabinets, miscellaneous equipment cabinets, optical equipment and detector loop, push button or tactile facilities.

The requirement does not include High Mast columns (excluding doors, brackets and all attachments). Traffic Signal Posts and Traffic Signal instation equipment.

9.2.12.2 Outcomes

Modern signal equipment is expected to operate correctly without regular routine adjustments. The inspection and maintenance procedures specified in this manual are intended to ensure that traffic signals continue to perform in accordance with the equipment specifications, and safety is not compromised. Traffic Signals and associated equipment are employed to prevent exit queuing on the network, entry control, traffic safety, congestion reduction and integration of traffic into the surrounding network.

The required outcomes are that:

- The Traffic Signal equipment continues to fulfil its intended purpose
- The Traffic Signal equipment operates efficiently and without loss of economic life
- The Traffic Signal equipment does not present a hazard to road users or ITS Maintainer(s).

9.2.12.3 Deliverables

- To ensure that the Traffic Signals and associated roadside equipment are fully operational
- To ensure that Traffic Signals units and associated roadside equipment are free from physical and electrical defects which present a hazard to road users or ITS Maintainer(s).

9.2.12.4 Process Requirements

- Assess and record the condition of all Traffic Signals equipment and installations
- Ensure that all current legislative requirements are met
- Maintain the performance of all Traffic Signals equipment components and installations and to rectify any defects which will prevent achievement of the outcomes or increase the rate of deterioration of the Traffic Signals equipment or other equipment
- Any faults which occur in the Traffic Signals equipment shall be rectified within timescales indicated Table 44.

Table 44: Road Traffic Signal Equipment Rectification Timescales

Fault Description	Fault Category
All Traffic Signal Failure (includes any Red light failures)	UT
Traffic Signal Loop Failure	TI

9.2.12.5 Procedures

The ITS Maintainer(s) undertakes maintenance in accordance with Table 45.

Table 45: Road Traffic Signal Equipment Maintenance Schedule

Maintenance Level	Requirement
'First line'	On site repair/reset or remote repair/reset
'Second line'	Swap modules and faulty equipment returned to depot for repair or returned to the manufacturer for repair/replacement.

- Ensure that all Traffic Signals and associated roadside equipment has identification markers for future EAMS logging that are correctly located and are clearly visible and legible. The identification details included within future EAMS must also contain the correct asset information
- Prepare and maintain an Asset Management Plan (AMP) that includes time and/or risk based approaches for undertaking condition assessments, assessing and prioritising defects and undertaking maintenance. The AMP will also include the methodology for undertaking repairs in accordance with the current fault management requirements
- Assess the condition of and maintain all components of Traffic Signals equipment in accordance with the approved AMP
- Record all Traffic Signals equipment maintenance activities within Ashghal's future asset management database EAMS
- Ensure that all Traffic Signals equipment maintenance and repairs comply with the relevant standards and regulations.

9.2.12.6 Metrics

The Key Performance Indicators associated with Traffic Signals equipment will be measured through the use of data contained within the future EAMS.

9.2.13 Telecommunications Network Requirements

9.2.13.1 Scope

This Section describes the general requirements for maintenance of the Telecommunications Network for ITS provision in the State of Qatar.

The network currently and in future shall comprise of 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.

9.2.13.2 Outcomes

The Telecommunications Network will connect the entire roadside ITS to the TMC where the ITS equipment will be managed and controlled.

The required outcomes are that:

- The Telecommunication Network continues to fulfil its intended purpose
- The Telecommunication Network operates efficiently and without loss of economic life
- The Telecommunication Network does not present a hazard to road users or ITS Maintainer(s).

9.2.13.3 Deliverables

- To ensure that the Telecommunication Network and associated roadside equipment is fully operational
- To ensure that Telecommunication Network and associated roadside equipment is free from physical and electrical defects which present a hazard to road users or ITS Maintainer(s).

9.2.13.4 Process Requirements

- Assess and record the condition of all Telecommunication Network and installations
- Ensure that all current legislative requirements are met
- Maintain the performance of all Telecommunication Network components and installations and to rectify any defects which will prevent achievement of the outcomes or increase the rate of deterioration of the Telecommunication Network or other equipment
- Any faults which occur across the Telecommunication Network shall be rectified within timescales indicated in Table 46.

Table 46: Telecommunication Network Rectification Timescales

Fault Description	Fault Category
Telecommunication Network Failure	UT
All other faults	TI

9.2.13.5 Procedures

The ITS Maintainer(s) undertakes maintenance in accordance with Table 47.

Table 47: Telecommunication Network Maintenance Schedule

Maintenance Level	Requirement
'First line'	On site repair/reset or remote repair/reset
'Second line'	Swap modules and faulty equipment returned to depot for repair or returned to the manufacturer for repair/replacement.

- Ensure that all Telecommunication Network and associated roadside equipment has identification markers for future EAMS logging, that they are correctly located and are clearly visible and legible. The identification details included within future EAMS must also contain the correct asset information
- Prepare and maintain an AMP that includes time and/or risk based approaches for undertaking condition assessments, assessing and prioritising defects and undertaking maintenance. The AMP will also include the methodology for undertaking repairs in accordance with the current fault management requirements
- Assess the condition of and maintain all components of Telecommunication Network in accordance with the approved AMP
- Record all Telecommunication Network maintenance activities within Ashghal's future asset management database EAMS
- Ensure that all Telecommunication Network maintenance and repairs comply with the relevant standards and regulations.

9.2.13.6 Metrics

The Key Performance Indicators associated with Telecommunication Network will be measured through the use of data contained within the future EAMS.

10.0 Incident Management

10.0 Incident Management

10.1 General

Ashghal are responsible for dealing with incidents at an operational level, providing support to the Emergency Services and other responders involved in any incident that affects the highway and the safe operation of it. Ashghal will provide tactical incident management such as traffic management when required, and undertaking asset maintenance or repairs required as a result of incidents.

In the event of an incident occurring on the highway it is essential for maintenance personnel to respond as quickly as possible in order to minimise any danger, disruption or delay to the public. It is a fact that incidents on the network are a significant cause of disruption to traffic flow with the associated delay and congestion. Various studies have considered the causes of congestion and it is generally accepted that incidents contribute around 25% to the overall congestion levels.

Incident management covers a wide spectrum of activity ranging from the removal of debris from the carriageway to dealing with extreme weather, through to responding to complex multi-agency national crises. The particular arrangements to be put in place for dealing with incidents will clearly vary depending on the size and scale of the incident.

In order to deal with incidents that occur on the road network Ashghal have prepared a Roads Contingency Plan, this document details the processes and procedures for dealing with any incidents that disrupt normal traffic flow. It introduces the Standard Incident Response Model that is used in the UK and explains how Ashghal, in conjunction with its maintenance crews (internal or Works Contractors), would deal with an incident on or off the network.

The Standard Incident Response Model and Ashghal's Contingency Plan details the incident escalation process from Operational (Bronze) to Tactical (Silver) to Strategic (Gold). These stages of hierarchical command structure can be applied to the resolution of spontaneous and planned operations, such as events. The 3 levels reflect the level of responsibility, experience, capability and empowerment of the person responsible at the time. An incident should be escalated to the next higher level of command when the Incident Management Objectives cannot be met or are threatened. These objectives are described as common objectives identified by Ashghal for all agencies involved in managing incidents and are as follows:

- saving and protecting life
- protecting property
- providing road users with timely information
- containing the emergency
- limiting its spread
- maintaining critical services
- maintaining normal service at an appropriate level

- protecting the health and safety of personnel
- safeguarding the environment
- promoting self-help and recovery
- restoring normality as soon as possible.

It is important to ensure that relationships are established with all emergency responders that have a responsibility for dealing with incidents on the network; this includes the Police, the Fire and Rescue Department, the Ambulance Service, the Ministry of Environment, Ministry of Health, local Municipalities and any other responders that may get called to an Incident.

10.2 Managing Incidents on Ashghal's Network

10.2.1 The Future

Ashghal currently, do not have the capability to fully deal with incidents impacting on the network. There are a number of projects currently being worked on that will set the resources in place to enable this to happen, these projects are "Roads Operation and Maintenance (O&M) Operational Control Room", now known as the Road Network Management Centre and "Incident Management".

The Roads Network Management Centre (RNMC) project will deliver an Operational hub for the Ashghal Roads Network. It will establish a 24/7 resource dedicated to managing any planned or emerging issues affecting the roads network. Working closely with the Ashghal Unified Contact Centre (UCC) and other TMCs within Qatar, the RNMC will manage Roads O&M's response to incidents, emergencies and events that affect or have the potential to affect the road network. Acting as Ashghal's eyes and ears on the network, the RNMC will deploy a range of "state-of-the-art" and best in class ITS systems; systems that will give Ashghal control over incidents impacting its rapidly expanding network. The RNMC will be built and delivered to world standards and will improve Ashghal's resilience in responding to emergency incidents in particular. At the same time the RNMC will enhance safety by reducing accidents, improving accident survival and minimising secondary impacts.

It will facilitate smoother traffic on Qatar's roads by reducing congestion, resulting in more reliable journey times and allowing for more trusted and accurate travels. From an environmental point of view, the RNMC will assist in improving air quality and reduce emissions in areas prone to congestion, hence delivering a sustainable system. Moreover, the RNMC will contribute to delivering improved customer satisfaction and keep the public informed about the roads network, reducing driver frustration and minimising the conditions that lead to incidents.

However where they do occur, the Incident Management response will include the deployment of specialist Incident Support Unit resources which will be established through the Incident Management (Phase 1) project.

10.2.2 Defect Management through the Unified Contact Centre

Currently, customer complaints, including those reported by the police (which may or may not require an immediate response), are managed through the UCC which is manned on a 24 hours a day 7 days a week basis.

Ashghal shall ensure that a suitably qualified member of staff (The Duty Engineer) is on standby 24 hours a day, 7 days a week. Standby is defined as being committed to be available to attend on site without delay, when required. They are required to, when called upon, attend site, make an assessment of the issue reported and where necessary take appropriate action.

Upon receipt of a call the UCC agent will ask a series of scripted questions to determine what action should be taken. If certain criteria is met that determines the issue requires an immediate response, the UCC will contact the Duty Engineer who will visit site, assess the issue and if necessary mobilise other available resources to attend. This may include the deployment of a suitably equipped vehicle and teams able to deploy traffic management.

This vehicle should be equipped with specialist equipment that allows it to be able to perform the following functions:

- making safe any hazardous situations by removal of debris or objects causing obstruction to the road users
- filling potholes or depressions with bagged cold asphalt instant road repair material
- making safe any road safety devices/signs that may need immediate attention as a result of a road accident and prevent any harm to the road users or pedestrians
- provide support to the Emergency Services when dealing with Road Traffic Incidents including providing temporary traffic management including the setting up of traffic diversions, clearing up debris, making safe damage to the asset and taking and recording of sufficient data on site to allow repair of the damaged asset at a later date. This should include details of the culprit.

10.3 Response Times

Currently there are no response times for Incident Management, best endeavours are undertaken to ensure that any emergencies reported on the network are dealt with in future, following the introduction of the Incident Support Unit (ISU) service response times will need to be established.

A Response Time for attendance at an incident is defined as the time taken from receipt of notification of the incident to commencement of appropriate action at the site of the Incident.

The introduction of the ISU service will be carried out in phased approach. Initially, in Phase 1, ISU units will be deployed in Doha City Centre with subsequent phases being deployed into the rural areas later on. Once adequate incident data has been gathered from Phase 1 and subsequent ISU roll-out phases, then appropriate, achievable response times will be determined.

11.0 Severe Weather

11.0 Severe Weather

11.1 General

Severe weather refers to any meteorological phenomenon that has the potential to endanger safe passage or cause disruption to the Network and in Qatar includes heavy rain, high winds, fog, high temperatures and sandstorms. As such year round planning is required to ensure that any events are managed in an appropriate manner. This should include the preparation of a Severe Weather Plan which would form part of the Contingency Plan.

11.2 Operational Preparedness

Throughout the year a suitably qualified Duty Engineer shall be available on a 24/7 basis. The Duty Engineer shall undertake a daily review of weather forecast information available from publically available websites. Ashghal should consider obtaining a daily weather forecast from a dedicated weather forecast provider. This service should include a detailed 24 hour daily forecast that details any significant hazards along with timings. It should, when necessary, include a specific warning forecast for high winds (speed and maximum gust), fog (visibility in metres) and rainfall (intensity and duration). Also, it should provide a 2 to 5 day forecast, which should detail a general synopsis and trends on the hazards described above.

The Duty Engineer shall review the daily and 2 to 5 day forecasts, and will ensure that all necessary precautions and steps are taken to ensure that Ashghal is in a suitable state of readiness to react to conditions as they occur and ultimately to ensure that any hazards are mitigated and the Incident Management Objectives are met.

A daily report should be circulated with the state of readiness indicated as Red/Amber/Green, to the Duty Engineers and an agreed Management circulation list.

The actions required for each state of readiness are described as:

- **GREEN**: No action required
- **AMBER**: Ensure that specialist equipment and contractors are placed on standby and are available to be deployed as and when necessary
- **RED**: As Amber state, including proactive deployment and patrolling of the network at known hot spots.

During a severe weather event if the Incident Management Objectives cannot be met then consideration should be given to implementing the Roads Contingency Plan, with dedicated resources brought in to manage the event and the clear-up.

Once the event has passed then the event will enter the clear-up phase. In order to return the network to normality as quickly as possible as many resources as required should be allocated as soon as reasonable practicable.

11.3 Flooding

Rain and any subsequent flooding, can cause significant effects on the network and cause disruption to the travelling public. Generally, flooding occurs at locations where there is inadequate or ineffective drainage. The Rainy Season in Qatar generally occurs between the months of December and February each year, although rain can occur between October and April. It is extremely rare that it occurs at any other times of the year. Ashghal should be adequately prepared for and be able to react to flooding events on the Qatar road network. Ashghal have prepared a Roads Contingency and Disaster Recovery Manual, which includes a section on Flooding and details the processes and procedures for dealing with flooding events on the Network. The objectives of the arrangements are the same as those stated above.

Following a flood event, inspections will be made, this will aim to establish, where possible, the cause of the flood and also to ensure that all debris is cleared from the carriageway and no damage to the infrastructure has occurred.

11.4 High Winds

High winds and subsequent dust and sand storms that result from it can occur year round in Qatar with the peak occurring between the months of April and August. The effects resulting from high winds are varied with each one having the potential to affect the network in a different manner. Incidents that can occur as a result of high winds are:

- overturned high sided vehicles
- damage to highway assets and trees and any resultant debris encroaching on to or blocking the carriageway
- sand drifts encroaching onto the highway
- poor visibility.

There are a number of proactive actions that should take place following a forecast for high winds. This includes the setting of Variable Message Signs where available, the mobilisation of specialist arboriculture contractors to remove fallen trees from the carriageway and to make safe any dangerous branches overhanging the carriageway. Sand removal from the carriageway should be considered as an urgent defect requiring immediate attention, with appropriate resources allocated.

Priority for clear-up should be given to known hot spots on the Primary network, with the remaining network following. There may be times when a road needs to be closed due to excessive sand build up, this should be undertaken by the Police with Ashghal providing support for traffic management and setting up of diversion routes.

In known vulnerable areas where accumulation of sand is a regular occurrence during high winds, consideration should be given to carrying out additional mitigation measures in the form of specific schemes designed to prevent sand build up. There are a number of measures that should be considered:

- live wind breaks e.g. tree planting
- protection of the loose sand particles through use of crop residues, plastic sheeting or chemical adhesives
- re-vegetation
- installation of sand fencing.

11.5 Fog

The effects of fog will be the same as dust storms and can reduce visibility to low levels causing considerable disruption through reduced traffic speed and in the extreme can cause multiple road traffic collisions. Where possible, Variable Message Signs displaying an appropriate warning message such as “Fog Slow Down” should be deployed to warn motorists.