South Africa

COTO

Committee of Transport Officials

TMH 3

Specifications for the Provision of Traffic and Weigh-in-Motion Monitoring Services

Version 1.3

Nov 2015

Committee of Transport Officials

TECHNICAL METHODS
FOR HIGHWAYS

TMH 3

Specifications for the Provision of Traffic and Weigh-in-Motion Monitoring Services

Version 1.3
Nov 2015

Committee of Transport Officials

Compiled under the auspices of the:

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Technical Methods for Highways:

The Technical Methods for Highways consists of a series of publications in which methods are prescribed for use on various aspects related to highway engineering. The documents are primarily aimed at ensuring the use of uniform methods throughout South Africa.

Users of the documents must ensure that the latest editions or versions of the document are used. When a document is referred to in other documents, the reference should be to the latest edition or version of the document.

Any comments on the document will be welcomed and should be forwarded to the publisher of the document. When appropriate, such comments may be incorporated in future editions of the document.

Synopsis:

Traffic and Weigh-in-Motion (WIM) monitoring systems are used for the measurement and collection of various traffic and vehicle characteristics, such as traffic counts, operating speeds and axle loads. These characteristics are mainly intended for use in the management, planning and design of road networks.

Provision is also made for the screening of heavy vehicles at weighbridges but not for law enforcement. The specifications are not suitable for law enforcement purposes and such purposes have specifically been excluded from the scope of the specifications.

This document describes a functional specification for Traffic and WIM monitoring systems. The specifications are aimed at ensuring that such systems are of an acceptable quality and standard, and that collected data comply with certain requirements.

Withdrawal of previous publication:

This publication replaces the previous Draft TMH3 “Traffic axle load surveys for pavement design” which was published in 1988. This previous publication is effectively withdrawn with the publication of this document.

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Definitions

Unless inconsistent with the context, in these specifications, the following terms, words or expressions shall have the meanings hereby assigned to them.

General

Employer: The person, organisation or authority who appoints the *Service Provider* for the provision of traffic and WIM monitoring services. Normally, but not necessarily, the road authority responsible for the road on which the service is required.

Road Authority: The organisation or government department that is responsible for the road on which the monitoring service is provided.

Service Provider: The person or organisation that is appointed by the *Employer* to provide the monitoring service. Monitoring services provided in terms of these specifications may only be provided by *Service Providers* to whom valid *Traffic and WIM Monitoring Service Provider Certificates* were issued.

System Supplier: The person or organisation that supplies the traffic and WIM monitoring systems to *Service Providers* for use in the provision of monitoring services. The *System Supplier* is not necessarily the manufacturer of equipment and may source equipment from one or more manufacturers. The *System Supplier* may also provide the same services as *Service Providers,* in which case, the requirements applicable to *Service Providers* will also be applicable to the *System Supplier*.

Certification Organisation: The organisation that is responsible for and undertakes the certification of *Service Providers* and monitoring systems.

Traffic and WIM Monitoring Service Provider Certificate: A certificate issued by the *Certification Organisation* to a *Service Provider* that certifies that the *Service Provider* complies with the requirements of these specifications for the provision of automatic monitoring services and that the *Service Provider* may provide such services in terms of these specifications.

Manual Traffic Monitoring Service Provider Certificate: A certificate issued by the *Certification Organisation* to a *Service Provider* that certifies that the *Service Provider* complies with the requirements of these specifications for the provision of manual traffic monitoring services and that the *Service Provider* may provide such services in terms of these specifications.

Traffic and WIM Monitoring System Certificate: A certificate issued by the *Certification Organisation* to a *System Supplier* that certifies that a monitoring system complies with the requirements of these specifications and that such a monitoring system may be used for the provision of automatic monitoring services in terms of these specifications.

South African Standard Traffic Data Collection Format: The latest version of the COTO TMH14 South African Standard Traffic Data Collection Format document.

Statistical terms

Mean (arithmetic), average: First moment of a probability distribution (for the population or a sample).

Standard deviation: Positive square root of the variance.

Variance: Second central moment of a probability distribution (for the population or a sample).

Accuracy: Closeness or degree of agreement between a measured value and a reference value accepted as the true or correct value.

Deviation: Difference between a measured value and a reference value accepted as the true and correct value. Expressed as a percentage of the reference value.

Reference value: The value which is accepted as the true and correct value for a particular characteristic.

Resolution: The smallest value of the measured parameter that a device is able to discriminate within the measuring range. The resolution does not indicate the accuracy with which a measurement is undertaken and a high resolution does not imply that the system is accurate.

Tolerance limit: The maximum limit which may not be exceeded by a characteristic when a very large number of observations, representative of the population, is made.

Tolerance interval: One half of a zero-centred interval in which at least a certain proportion of the observations must fall when a very large number of observations representative of the population is made.

Percent-within-Limits (PWL): The estimated or measured proportion of observations which fall within the tolerance interval.

Calibration factor: A numerical factor which is used to adjust measurements to compensate for systematic bias or error.

Calibration: Adjustment to a reference level of values obtained from a measuring device.

Monitoring site definitions

Monitoring site: A monitoring site is defined as a single location where all lanes of traffic are monitored as specified by the *Employer* (subject to a maximum of 32 lanes). Unless specified otherwise by the *Employer*, the following roadways and lanes are included in a single monitoring site:

1) Double carriageway roads. Both carriageways are included in the site even if the carriageways are located some distance apart.
2) Intersections and interchanges. All roadways passing through, or at the intersections or interchanges are included in the site.

The *Service Provider* may utilise more than one monitoring system to monitor a site with a large number of lanes, or where the lanes are located some distance apart.

Monitoring day definitions

Normal traffic days: These are days during which the same (or similar) hourly traffic patterns occur on a daily basis during most weeks in a year. These days exclude the other classes of days defined below.

Abnormal days: These are days on which the traffic pattern is influenced by public and school holidays (as well as other days influenced by such holidays). These days are defined based upon known dates of holidays as specified in Appendix B to these specifications.

Devices

Weigh-In-Motion (WIM): Process of measuring the loads of a moving vehicle.

High-speed WIM (HS WIM): The process of measuring loads of vehicles that are travelling at normal speeds on a road. The loads include dynamic forces resulting from the vehicle motion.

Low-speed WIM (LS WIM): The process of measuring static loads of vehicles that are travelling at low speed (typically lower than 15 km/h), usually outside the normal traffic flow. The speeds are so low that the dynamic forces are considered to be negligible.

Sensor: A device that is used for sensing some object.

Axle sensor: A device that measures the presence of a wheel and/or axle.

Single/dual tyre sensor: A device that determines whether a wheel is fitted with a single tyre or with dual tyres.

Wheel load sensor: A device which measures the wheel load of a vehicle.

Axle load sensor: A device which simultaneously measures the combined wheel load for all wheels and tyres on an axle.

Weighbridge: A weighing device which measures the weight or static load of stationary vehicles with a very high level of accuracy suitable for legal purposes.

Monitoring systems

Monitoring system: A generic term for any type of traffic or weigh-in-motion (WIM) monitoring system consisting of all the sensors and equipment required to monitor traffic or axle loads.

Traffic monitoring system: A monitoring system that is used for the monitoring of traffic flow characteristics such as traffic counts and speeds (but not axle loads).

Traffic and HS WIM monitoring system: A system that is used for the monitoring of traffic flow characteristics, as well as axle loads by means of a high-speed (HS) weigh-in-motion device.

HS WIM monitoring system: A system that is used for the monitoring of axle loads by means of a high-speed (HS) weigh-in-motion device (such as a screening station).

LS WIM monitoring system: A system that is used for the monitoring of wheel loads by means of a low-speed (LS) weigh-in-motion device.

Monitoring services

Monitoring service: A generic term for any type of traffic or weigh-in-motion (WIM) monitoring service.

Automatic traffic and WIM monitoring services. Services in which traffic and WIM monitoring are mainly undertaken by means of mechanical and electronic equipment, although some manual assistance may be involved.

Manual traffic monitoring services. Services in which traffic monitoring is undertaken manually by humans, although use may be made of mechanical and electronic devices during the monitoring.

Traffic monitoring service: A service for the monitoring of traffic flow characteristics, such as traffic counts and speeds by means of a Traffic Monitoring system.

Toll traffic monitoring service: A service for the monitoring of classified traffic counts at a toll plaza by means of two or more independent Traffic monitoring subsystems.

Traffic and HS WIM monitoring service: A service for the combined monitoring of traffic flow characteristics and axle loads by means of a Traffic and high-speed (HS) weigh-in-motion Monitoring system.

HS WIM monitoring service: A service for the monitoring of axle loads by means of a high-speed (HS) weigh-in-motion monitoring system (such as for screening purposes at a weighbridge).

LS WIM monitoring service: A service for the monitoring of wheel loads by means of a low-speed (LS) weigh-in-motion monitoring system.

Monitoring duration: The nominal duration over which a site must be monitored as specified in these specifications.

Monitoring data

Good data: Data that have passed the verification tests of these specifications.

Suspect data: Data that have failed the verification tests of these specifications and which require further investigation.

Bad data: Data that have failed the verification tests due to a failed monitoring system.

Uncertain data: Data that have failed the verification tests due to the geometry of the road or the pavement surface.

Missing data: Includes bad data as well as data that have not been submitted to the *Employer* or which were submitted late.

Complete data set: A data set for a specific monitoring period which does not contain any missing or bad data (the data set contains only good or uncertain data).

Mass and load

According to the International System of Units (SI), forces and weights should be expressed in N or kN while masses must be expressed in kg and Mg (ton). In terms of these specifications, however, all loads and forces must be converted and expressed in terms of

equivalent mass units (kg). The conversion must be undertaken with the standard value for gravitational acceleration.

The definitions provided below are not related to those used for purposes of law enforcement nor can the definitions be used for such purposes.

Gravitational acceleration: The acceleration caused by gravity. For the purposes of these specifications, the standard value of 9.80665 m/s^2 must be used.

Mass: Mass is a measure of the amount of material in an object measured in units of kg (kilogram). Can be estimated by dividing the weight or static load (in units of N) of the object by the gravitational acceleration (in units of m/s^2).

Load: The load exercised by a moving or stationary vehicle. Consists of static and dynamic load components. Converted to equivalent mass units of kg by dividing the load measured in units of N by the gravitational acceleration (in units of m/s^2).

Weight: The gravitational force acting on a body mass. Equivalent to the static load exercised by a stationary vehicle.

Static load: Load exercised by a stationary vehicle. Equivalent to the weight of a vehicle.

Static load component: The static load component of the total load exercised by a moving vehicle.

Dynamic load component: The non-static component of the total load exercised by a moving vehicle.

Wheels

Wheel: An assembly of tyres on one side of an axle. An axle consists of one or more wheels, while the wheels may consist of one or more tyres.

Wheel load: The load of one wheel of a moving vehicle. Consists of static and dynamic load components.

Static wheel load: The load or weight of a wheel of a stationary vehicle.

Static wheel load component: The static or weight component of the load exercised by a wheel of a moving vehicle.

Dynamic wheel load component: The dynamic load component of a load exercised by a wheel of a moving vehicle.

Axles

Axle: A single assembly consisting of one or more wheels on the same axle, each wheel consisting of one or more tyres.

Axle load: Sum of all the wheel loads of an axle of a moving vehicle. Consists of static and dynamic load components.

Static axle load: The load or weight of an axle of a stationary vehicle.

Static axle load component: The static or weight component of the load exercised by an axle of a moving vehicle.

Dynamic axle load component: The dynamic load component of a load exercised by an axle of a moving vehicle.

Axle groups

Axle group: A set of axles that are spaced (centre to centre) closer than a distance of 2.2 m between the centres of axles. An axle group is not necessarily related to an axle unit on a vehicle.

Axle group axles: The axles included in an axle group.

Axle group load: The sum of all axle loads included in a group of axles of a moving vehicle. Consists of static and dynamic load components.

Static axle group load: The sum of all axle loads included in a group of axles of a stationary vehicle.

Gross vehicles

Gross vehicle load: The sum of all axle loads of a moving vehicle.

Gross vehicle mass (Static gross vehicle load): The sum of all axle loads of a stationary vehicle.

PREFACE

Traffic and Weigh-in-Motion (WIM) monitoring is undertaken with the purpose of measuring and collecting various traffic and vehicle characteristics, such as traffic counts, operating speeds and axle loads. These characteristics are mainly intended for use in the management, planning and design of road networks and infrastructure.

This document contains a functional specification for the provision of traffic and WIM monitoring services by a *Service Provider* to an *Employer*. Provision is made for both automatic and manual monitoring of traffic. Automatic monitoring is mainly undertaken by means of mechanical or electronic equipment while manual monitoring is mainly undertaken by humans.

Provision is a made in the specifications for the screening of heavy vehicles at weighbridges but not for law enforcement applications. The specifications are not suitable for and may not be used for such applications.

Automatic monitoring services provided in terms of these specifications may only be provided by *Service Providers* (or *System Suppliers*) to whom valid *Traffic and WIM Monitoring Service Provider Certificates* have been issued. These monitoring services may only be provided using monitoring systems that carry valid *Traffic and WIM Monitoring System Certificates*.

Manual monitoring services provided in terms of these specifications may only be provided by *Service Providers* to whom valid *Manual Traffic Monitoring Service Provider Certificates* have been issued. No certification of equipment or devices used for the provision of such services is required.

The issuing of the above certificates will be the responsibility of and undertaken by a *Certification Organisation* specified by the *Employer*.

A number of functional specifications for traffic monitoring and WIM systems are available internationally, but local experience with these specifications has shown that they are not always suitable for use in South Africa. The international specifications also do not cover all the monitoring services that are required. The available specifications were, however used as a basis for the development of the specifications provided in this document, but adjusted for local application. The specifications include the following:

- ASTM, 2002, Standard specification for Highway Weigh-In-Motion (WIM) Systems with User Requirements and Test Methods, Specification number E 1381-02, United States.
- COST Technical Committee on Transport, 1999, COST 323 Weigh-in-Motion of Road Vehicles, Final Report, European WIM Specification, Version 3.0, August 1999.

In addition to the above international specifications, the specifications are also based on the *Standard Specifications for Traffic Data Collection Services* of the South African National Roads Agency Limited.

1 SCOPE OF SPECIFICATIONS

1.1 Background

Traffic and Weigh-in-Motion (WIM) monitoring is undertaken with the purpose of measuring and collecting various traffic and vehicle characteristics, such as traffic counts, operating speeds and axle loads. These characteristics are mainly intended for use in the management, planning and design of road networks and associated infrastructure, but may also be used for other purpose such as toll traffic monitoring.

The scope of these specifications covers the provision of Traffic and WIM Monitoring Services by a *Service Provider* to an *Employer*. The specifications cover all aspects of such services, including but not limited to aspects such as traffic monitoring systems, computer software, monitoring sites, monitoring site assessments, monitoring service specifications and payment requirements. It also covers the certification of *Service Providers* and monitoring systems and the issuing of certificates.

The deliverables of the monitoring services are the provision of traffic and WIM data and related reports to the *Employer* in accordance with the requirements of these specifications. The deliverables do not include the monitoring equipment, computers, software systems or the construction of any other facilities required for such services, and such equipment and facilities shall remain the property of the *Service Provider* and be removed at the termination of a project (unless otherwise specified by the *Employer*). The *Employer* may, however, make facilities available and require that the *Service Provider* use the facilities provided by the *Employer*.

Provision is made in the specifications for the use of monitoring systems for the screening of heavy vehicles at weighbridges but not for law enforcement. The specifications are not suitable for law enforcement and the specifications may not be used for such purposes.

Differentiation is made in the specification between a) automatic traffic and WIM monitoring services and b) manual traffic monitoring services. Automatic traffic and WIM monitoring services mainly involve the use of mechanical or electronic equipment for the monitoring while manual traffic monitoring services are those that are undertaken manually by humans.

1.2 Automatic traffic and WIM monitoring services

Automatic traffic and WIM monitoring services are those in which traffic and WIM monitoring are mainly undertaken by means of mechanical and electronic equipment, although some manual assistance may be involved. The scope of the specifications are limited to the following automatic traffic and WIM monitoring services:

a) *Traffic monitoring services*. These services include the monitoring of traffic flow characteristics, such as traffic volumes (counts) and speeds.

b) *Toll traffic monitoring services*. These services include traffic monitoring at or near to a toll plaza by means of two or more Traffic monitoring systems as described in a) above.

c) *Traffic and High-speed Weigh-In-Motion (HS WIM) monitoring services*. These services include the Traffic monitoring services as in a) above, as well as the monitoring of axle loads of vehicles travelling under normal traffic conditions on a road.

d) *High-speed Weigh-In-Motion (HS WIM) monitoring services.* These services are limited to the monitoring of axle loads, and exclude the Traffic monitoring services as described in a) above.

e) *Low-speed Weigh-In-Motion (LS WIM) monitoring services.* These services include the monitoring of left and right wheel loads of vehicles travelling at low speeds (lower than 10 km/h) to allow direct observations of static loads. These services do not include the Traffic monitoring services in a) above.

1.3 Manual traffic monitoring services

Manual traffic monitoring services are those in which traffic monitoring is undertaken manually by humans, although use may be made of mechanical and electronic devices during the monitoring.

The scope of the specifications for the provision of manual traffic monitoring services is limited to the observation of traffic volumes only. The manual traffic surveys of other traffic characteristics such as speeds are not covered by the specifications.

1.4 SI System of units

The International System of Units (SI) applies to all measurements specified in, and required by, these specifications, except where otherwise indicated in the specifications.

1.5 Overview of specifications

The specifications cover the following aspects of the traffic monitoring and WIM services:

Part 1: Certification and quality assurance requirements:

a) Certification requirements applicable to *Service Providers* and monitoring systems are provided in Chapter 2 (Service provider and monitoring system certification).

b) Quality assurance requirements applicable to *System Supplier*s of automatic monitoring systems are provided in Chapter 3 (Traffic and WIM Monitoring System Supplier quality assurance).

c) Quality assurance requirements applicable to *Traffic and WIM Monitoring Service Providers* are provided in Chapter 4 (Traffic and WIM Monitoring Service Provider quality assurance).

d) Quality assurance requirements applicable to *Manual Traffic Monitoring Service Providers* are provided in Chapter 5 (Manual Traffic Monitoring Service Provider quality assurance).

Part 2: Automatic monitoring system requirements:

a) General requirements applicable to all automatic traffic and WIM monitoring systems covered by these specifications are provided in Chapter 6 (General automatic monitoring system requirements).
b) Requirements applicable to automatic monitoring systems are provided in Chapter 7 (Automatic traffic monitoring system requirements).
c) Requirements applicable to High-speed WIM systems are provided in Chapter 8 (HS WIM monitoring system requirements).
d) Requirements applicable to Low-speed WIM systems are provided in Chapter 9 (LS WIM Monitoring system requirements).
e) Requirements for the assessment of automatic monitoring systems are provided in Chapter 10 (Automatic monitoring system assessment).

Part 3: Automatic monitoring site and system Installation requirements:

a) Requirements for automatic monitoring sites are provided in Chapter 11 (Automatic monitoring site requirements).
b) Requirements for installed automatic monitoring systems are provided in Chapter 12 (Installed automatic monitoring system requirements).
c) Requirements for the assessment of automatic monitoring sites and installed monitoring systems are provided in Chapter 13 (Installed automatic monitoring system assessments).
d) Requirements for work undertaken at sites are provided in Chapter 14 (Site works requirements).

Part 4 Manual traffic monitoring requirements

a) Requirements for different manual monitoring methods are provided in Chapter 15 (Manual traffic monitoring types).
b) Requirements for monitoring sites at which manual traffic monitoring is undertaken are provided in Chapter 16 (Manual traffic monitoring site requirements).
c) Requirements related to manual monitoring fieldworkers are provided in Chapter 17 (Traffic monitoring fieldworker requirements).

Part 5: Monitoring service and data requirements:

d) Requirements related to the provision of monitoring (automatic and manual) services are provided in Chapter 18 (Monitoring service requirements).
e) Requirements for monitoring data (automatic and manual) are provided in Chapter 19 (Monitoring data requirements).

Part 6: Service specification and payment requirements:

a) Requirements for the specification of monitoring services are provided in Chapter 20 (Monitoring service specification).
b) Requirements for the payment of services are provided in Chapter 21 (Payment requirements).

Part 7 Appendices to the specifications:

a) Methodologies for determining tolerance limits and intervals are provided in Appendix A.
b) Definitions of Normal and Abnormal days are provided in Appendix B.
c) A method that must be followed in the assessment of automatic monitoring system accuracies is described in Appendix C.
d) Data verification tests required for the verification of collected traffic and WIM data are described in Appendix D.
e) A list of references is provided in Appendix E.

Part 1
Certification and Quality Assurance Requirements

Part 1: Certification and Quality Assurance Requirements

Part 1 contains the requirements that are applicable to the certification of *Service Providers* and monitoring systems, as well as quality assurance measures that must be implemented by *System Supplier*s and *Service Providers*. These requirements are applicable to the provision of automatic traffic and WIM monitoring services as well as manual traffic monitoring services. The requirements are provided in the following chapters:

Chapter 2 Service provider and monitoring system certification.

Chapter 3 Traffic and WIM Monitoring System Supplier quality assurance.

Chapter 4 Traffic and WIM Monitoring Service Provider quality assurance.

Chapter 5 Manual Traffic Monitoring Service Provider quality assurance

2 SERVICE PROVIDER AND MONITORING SYSTEM CERTIFICATION

2.1 Certification requirements

It is a requirement of these specifications that all monitoring services provided in terms of these specifications may only be provided by certified *Service Providers* using certified traffic monitoring systems. The certification requirements differentiate between automatic and manual services, as follows:

a) **Automatic traffic and WIM monitoring services**. All automatic traffic and WIM monitoring services may only be provided by *Service Providers* to whom valid *Traffic and WIM Monitoring Service Provider Certificates* were issued. Such services may only be undertaken using monitoring systems which carry valid *Traffic and WIM Monitoring System Certificates*.

b) **Manual traffic monitoring services.** All manual traffic monitoring services may only be provided by Service Providers to whom valid *Manual Traffic Monitoring Service Provider Certificates* were issued. No certification is required of equipment used for the provision of such services.

It is a further requirement of these specifications that only *Service Providers* to whom the above service provider certificates were issued may offer their relevant services in a tender to the Employer. For the provision of automatic monitoring services, the offer may only include monitoring systems which carry valid *Traffic and WIM Monitoring System Certificates* and which will not be subject to a review for a period of at least one year after the commencement of the monitoring project.

System Suppliers may also act as *Service Providers* in which case all the requirements applicable to *Service Providers* will then be applicable to the *System Suppliers*, including the certification requirements.

2.2 System Suppliers and Service Providers

A *System Supplier* is the person or organisation that supplies traffic and WIM monitoring systems to *Service Providers* for the provision of monitoring services. The *System Supplier* is not necessarily the manufacturer of the equipment, and may source equipment from one or more manufacturers. The *System Supplier* may also provide the same services as *Service Providers,* in which case the requirements applicable to *Service Providers* will also be applicable to the *System Supplier*.

The *Service Provider* is the person or organisation that is appointed by the *Employer* to provide the monitoring service. Such services must be provided using certified monitoring systems provided by a *System Supplier*. The *Service Provider* may also certify and provide the monitoring systems, in which case the requirements applicable to *System Suppliers* will also be applicable to the *Service Provider*.

2.3 Certification organisation

The *Employer* will specify the *Certification Organisation* that may be used for the certification of *Service Providers* and monitoring systems. In the absence of such a specification, Agrément South Africa must be used for the certification.

The *Certification Organisation* will be responsible for and undertake the certification of *Service Provider* and monitoring systems. The organisation will issue certificates that certify that a *Service Provider* or a monitoring system complies with all the specified requirements of these specifications, including those related to quality control.

2.4 Traffic and WIM Monitoring System Certificates

Traffic and WIM Monitoring System Certificates required for the provision of automatic monitoring services will be issued by the *Certification Organisation* to *System Supplier*s. It is the responsibility of *System Suppliers* to submit an application for certification to the *Certification Organisation*.

Certificates will be issued for specific makes and models of monitoring systems, and a separate certificate is required for each make or model. In situations where a monitoring system consists of a combination of different components, the combination of components will be considered to be a complete monitoring system. The components include both hard- and software components, including system software as well as software that is used for the post-processing of collected data. The certificate will list the combination of components that form part of the system, including the system and post-processing software.

A monitoring system may contain optional components that may not be required for the provision of a particular monitoring service. The certificate must list these components and indicate the components that must be installed to provide a monitoring service.

The certificate will only be applicable to a particular make and model of a monitoring system and set of software. Should any changes be implemented to the monitoring system (including the software), the *Certification Organisation* will decide whether the change can be accommodated by an existing certificate or whether a new certificate will be required. This decision will be based on the extent of the changes that were made to the monitoring system or software.

A *Traffic and WIM Monitoring System Certificate* will only be issued when the requirements of the following chapters of these specifications have been fully complied with:

- Chapter 2 (Service provider and monitoring system certification).
- Chapter 3 (Traffic and WIM Monitoring System Supplier quality assurance).
- Chapter 6 (General automatic monitoring system requirements).
- Chapter 7 (Automatic traffic monitoring system requirements).
- Chapter 8 (HS WIM monitoring system requirements).
- Chapter 9 (LS WIM Monitoring system requirements).
- Chapter 10 (Automatic monitoring system assessment).

The requirements for the assessment of monitoring systems are specified in Chapter 10 (Automatic monitoring system assessment). The requirements provide for certification as well as review of monitoring systems.

The continued validity of a certificate is subject to a review by the *Certification Organisation* every five years. In addition to this review, the *Certification Organisation* may require one additional review at any time during this five-year period. The certificate will only be renewed during such a review when the requirements of the above chapters have been fully complied with.

A *Traffic and WIM Monitoring System Certificate* will be cancelled by the *Certification Organisation* when it is found that a monitoring system no longer complies with the requirements of these specifications. When a certificate is cancelled, no monitoring service may be provided using the monitoring system, even if the certificate issued to a *Service Provider* has not been cancelled.

2.5 Traffic and WIM Monitoring Service Provider Certification

Traffic and WIM Monitoring Service Provider Certificates for the provision of automatic monitoring services will be issued to *Service Providers* as well as *System Suppliers* that also provide monitoring services. The certificate will only be issued for the use of specific certified monitoring systems (one or more) that are provided by *System Suppliers* for the provision of monitoring services. Where a *Service Provider* uses monitoring services that are provided by different *System Suppliers*, a certificate will be required for each individual *System Supplier*. It is the responsibility of *Service Providers* to obtain such certificates from the *Certification Organisation*.

There must be a valid contractual agreement between the *Service Provider* and the *System Supplier* covering the supply and use of monitoring systems. The validity of the *Traffic and WIM Monitoring Service Provider Certificate* is subject to such an agreement being continually in place. The certificate will immediately be cancelled by the *Certification Organisation* when the agreement is cancelled by the *System Supplier*.

A *Traffic and WIM Monitoring Service Provider Certificate* will only be issued when the following requirements are complied with:

a) There is a valid contractual agreement between the *Service Provider* and the *System Supplier* covering the supply and use of monitoring systems that are supplied by the *System Supplier*.

b) The requirements of the following chapters of these specifications:
   - Chapter 2 (Service provider and monitoring system certification).
   - Chapter 4 (Traffic and WIM Monitoring Service Provider quality assurance).

c) The *Service Provider* has technical personnel or sub-contractors that have received training and passed all the assessments required by the *System Supplier* as specified in Chapter 4 (Traffic and WIM Monitoring Service Provider quality assurance).

Requirements for the procedure that must be followed for the assessment of *Service Providers* are provided in this chapter. Requirements are provided for the certification, as well as the review of *Service Providers*.

The continued validity of a *Traffic and WIM Monitoring Service Provider Certificate* is subject to a review by the *Certification Organisation* every three years. In addition to this

review, the *Certification Organisation* may require one additional review at any time during the three-year period.

The certificate will only be renewed during such a review when the above requirements, as well as the requirements of the following chapters are fully complied with:

- Chapter 11 (Automatic monitoring site requirements).
- Chapter 12 (Installed automatic monitoring system requirements).
- Chapter 13 (Installed automatic monitoring system assessments).

The above assessments will only be required when the *Service Provider* has installed a new monitoring system since the date on which the certificate was issued or previously reviewed. The assessments will be undertaken by the *Certification Organisation* at one or more monitoring system installations, selected either specifically or randomly by the *Certification Organisation.* The requirements for the assessment of the installed monitoring systems are specified in Chapter 13 (Installed automatic monitoring system assessments).

The *Traffic and WIM Monitoring Service Provider Certificate* will be cancelled by the *Certification Organisation* if it is found that the *Service Provider* no longer complies with the requirements of these specifications, or when the approval of a *Service Provider* is withdrawn by the *System Supplier*.

2.6 Traffic and WIM Monitoring Service Provider Assessment

The requirements for the assessment of *Traffic and WIM Monitoring Service Providers* for certification purposes are provided in this section. The issuing of a *Traffic and WIM Monitoring Service Provider Certificate* to a *Service Provider* by the *Certification Organisation* is subject to the condition that the *Service Provider* be assessed and found to comply with the requirements of this chapter.

The *Service Provider* must submit evidentiary documentation to the *Certification Organisation* that shows that the *Service Provider* complies with the requirements of the following chapters of these specifications:

- Chapter 2 (Service provider and monitoring system certification).
- Chapter 4 (Traffic and WIM Monitoring Service Provider quality assurance).

The evidentiary documentation must include the following:

a) The contractual agreement between the *Service Provider* and the *System Supplier* for the supply and use of the monitoring systems.
b) Records of the quality assurance measures that are being implemented by the personnel or sub-contractors of the *Service Provider* (as specified in Chapter 4 (Traffic and WIM Monitoring Service Provider quality assurance)).
c) Records showing the training received and assessments passed by the personnel or sub-contractors of the *Service Provider*. Records must be provided for all the technical personnel and sub-contractors of the *Service Provider*.

The *Certification Organisation* may additionally require interviews with selected (or all) personnel or sub-contractors of the *Service Provider* as part of the assessment.

During the review of a *Service Provider*, the *Certification Organisation* will, in addition to the above assessments, also undertake assessments of one or more installed monitoring

systems in accordance with the requirements of Chapter 13 (Installed automatic monitoring system assessments).

2.7 System Supplier and Service Provider Contractual Agreement

It is a requirement of these specifications that there must be a valid contractual agreement between the *Traffic and WIM Monitoring Service Provider* and the *System Supplier* covering the supply and use of monitoring systems. The validity of the *Traffic and WIM Monitoring Service Provider Certificate* is subject to such an agreement being continually in place.

The agreement must show that the *Service Provider* is approved by the *System Supplier*. The specific monitoring systems for which such approval is given must be specified in the agreement. The agreement must also specify the conditions under which the approval and the agreement may be cancelled by the *System Supplier*.

The agreement must also cover all the obligations of the *Service Provider* and the *System Supplier* in terms of the requirements of these specifications.

2.8 Manual Traffic Monitoring Service Provider Certification

Manual Traffic Monitoring Service Provider Certificates will be issued to *Service Providers* who comply with the requirements of Chapter 5 (Manual Traffic Monitoring Service Provider quality assurance) of these specifications.

In its application to the *Certification Organisation* for certification, the *Service Provider* must submit evidentiary documentation showing that the *Service Provider* complies with the requirements of Chapter 5 (Manual Traffic Monitoring Service Provider quality assurance) of these specifications. The evidentiary documentation must include the following:

a) Manuals used by the *Service Provider* setting out the quality assurance measures implemented by the *Service Provider*.
b) Records of the quality assurance measures that are being implemented by the personnel or sub-contractors of the *Service Provider*.
c) Records showing the training received and assessments passed by the personnel or sub-contractors of the *Service Provider*. Records must be provided for all the technical personnel and sub-contractors of the *Service Provider*.

The Certification Organisation may additionally require interviews with selected (or all) personnel or sub-contractors of the Service Provider as part of the assessment.

The continued validity of a *Manual Traffic Monitoring Service Provider Certificate* is subject to a review of the *Service Provider* by the *Certification Organisation* every three years. In addition to this review, the *Certification Organisation* may require one additional review at any time during the three-year period.

The certificate will be cancelled by the Certification Organisation when it is found that the *Service Provider* no longer complies with the requirements of these specifications. When a certificate is cancelled, no further manual traffic monitoring services may be provided by the *Service Provider*.

3 TRAFFIC AND WIM MONITORING SYSTEM SUPPLIER QUALITY ASSURANCE

3.1 Quality assurance requirements

The requirements for quality control measures that must be implemented by *System Suppliers* are provided in this chapter. These measures must be in place before an application can be made for the certification of the monitoring systems. The requirements of this chapter apply to monitoring systems used in the provision of automatic traffic monitoring services and not to equipment used for manual traffic monitoring.

It is the responsibility of the *System Supplier* to implement quality assurance measures aimed at ensuring the following:

a) That every monitoring system supplied by the *System Supplier* will comply with the requirements of these specifications.
b) That monitoring systems are used, maintained and operated by the *Service Provider* in accordance with the requirements of the *System Supplier,* as well as the requirements of these specifications.

The *System Supplier* must develop manuals that describe and specify the required quality assurance measures to be implemented by the *System Supplier* as well as the *Service Provider*. Copies of these manuals must be submitted to the *Certification Organisation* for approval when an application is made for certification. Copies of the manuals must also be made available to the *Employer*.

In all instances, the *System Supplier* must apply the codes of practice for quality systems as outlined in SABS ISO 9000 to SABS ISO 9004.

3.2 System supplier quality assurance measures

The *System Supplier* is responsible for implementing quality assurance measures that are aimed at ensuring that every monitoring system supplied by the *System Supplier* complies with the requirements of these specifications.

The *System Supplier* must have a manual that sets out the quality assurance measures, and this manual must be used by all the personnel in the organisation. A copy of this manual must be submitted to the *Certification Organisation* for approval when an application is made for a monitoring system certificate. The *System Supplier* must also maintain records as evidence that the manual is being implemented.

The following monitoring system quality assurance measures are required:

a) *Management systems*. The purpose of the management systems is to ensure that quality assurance is enforced at all levels of the organisation, including any external organisations involved in the supply chain. Instructions must be issued with regard to the following:

i) The responsibilities of management personnel responsible for ensuring that the quality assurance system is effectively implemented in the organisation.
ii) The responsibilities of all the personnel in the organisation with regard to quality assurance.

b) *Monitoring system quality assurance*. Procedures must be instituted that will ensure that every monitoring system supplied by the *System Supplier* complies with the requirements of these specifications. Instructions and procedures must be issued with regard to the following:

i) Inspections and tests of monitoring systems that are undertaken, including the testing equipment used for the tests.
ii) Procedures for ensuring that the testing equipment is controlled and calibrated on a regular basis. Certificates or other proof of calibration must be kept on record and made available for inspection.
iii) Procedures that must be followed when it is found that a monitoring system does not comply with the requirements. Steps must be described that must be followed to prevent the unintended use or delivery of such systems. Records must be kept of equipment that fails the tests.
iv) Records of all testing and inspections must be signed by a designated responsible person in the organisation, filed and made available for inspection.

c) *Monitoring system identification*. Each supplied monitoring system must be identified by means of a unique serial number (or numbers) to ensure that the system can be traced. Detailed records must be kept of these numbers, including the particulars of the *Service Provider* to whom the systems were issued or provided.

d) *Internal quality audits*. The *System Supplier* must conduct regular internal audits to ensure that the quality control measures are implemented. The procedures that must be followed during such audits must be specified, as well as any records that must be completed.

e) *Records*. All records must ensure and show that the quality assurance system is operating effectively and that the supplied monitoring systems comply with the requirements of these specifications. Instructions and procedures must also be provided on the filing and control of the records. The record system must meet the following requirements:

i) Records must be traceable to a particular monitoring system.
ii) The records must remain legible for the duration that a monitoring system is in use.
iii) Records must be filed and indexed for ease of retrieval.

3.3 Service provider quality assurance measures

The *System Supplier* is responsible for the implementation of quality assurance measures that are aimed at ensuring that *Service Providers* and their personnel and sub-contractors are competent and continue to be competent to use the monitoring systems in accordance with the requirements of these specifications. These measures must also be implemented when the *System Supplier* also provides monitoring services.

The specific responsibilities of the *System Supplier* in this regard are as follows (more details of these responsibilities are provided in the following sections of this chapter):

a) *Service provider monitoring system manuals*. The development of manuals and specifications for use by the *Service Provider* for the installation, maintenance and operation of a monitoring system.

b) *Service provider quality assurance manuals*. The development of manuals for use by the *Service Provider* for the implementation of quality assurance measures.

c) *Service provider training and assessment*. The training and assessment of the technical personnel and sub-contractors of the *Service Provider* to ensure that they are competent to install, maintain and operate the monitoring systems. The *System Supplier* must prepare a manual that will be used for such training and assessment. The *System Supplier* must also keep records of all persons that have received training and supply details of whether such persons were assessed to be fully competent in the use of the monitoring system.

d) *Monitoring system inspection and assessment*. The regular inspection and assessment of monitoring systems installed by the *Service Provider*. The *System Supplier* must prepare a manual that will be used for such inspection and assessment. The *System Supplier* must also keep records of the inspections and assessments, together with the findings of such inspections and assessments.

Copies of all manuals must be submitted to the *Certification Organisation* for approval when an application is made for a monitoring system certificate. Copies of the manuals must also be made available to the *Employer*.

Copies of the service provider training and assessments, as well as the monitoring system inspection and assessment records must be made available and submitted to the *Certification Organisation*.

3.4 Service provider monitoring system manuals

The *System Supplier* must develop the manuals listed below and make these manuals available to the *Service Provider*:

a) *Installation manual*. This manual must provide full details and specifications for the installation of a monitoring system, together with all the quality assurance measures that must be implemented during the installation. The manual must cover aspects such as the following:

   i) Any drawings that may be required for the installation of the system.
   ii) Specifications for the installation of the system, together with relevant dimensions and tolerances.
   iii) Procedures and steps to be followed during the installation of the system.

iv) Equipment, tools and materials that must be used for the installation of the system and, where appropriate, the use of such equipment, tools or materials.
v) Tests that must be undertaken at various stages to test the installed components.
vi) Quality assurance measures that must be instituted by the *Service Provider* and that must be followed during the installation of the system.
vii) Records that must be kept of the installation of the system.

b) *Maintenance manual*. This manual must provide full details for the maintenance of a monitoring system, together with all the quality assurance measures that must be implemented. The manual must cover aspects such as the following:

i) Methods for the checking of the system and the identification of possible faults or errors.
ii) Procedures and steps to be followed to address any of the identified faults.
iii) Equipment and tools that must be used for the identification of the faults and maintenance of the system.
iv) Tests that must be undertaken to ensure that the maintenance actions were successful.
v) Quality assurance measures that must be instituted and followed by the *Service Provider* during the maintenance of the system.
vi) Records that must be kept of the maintenance of the system.

c) *Operations manual*. This manual must provide full details for the operation of a monitoring system, together with all quality assurance measures that must be implemented while the system is in operation. The manual must cover aspects such as the following:

i) Any calibration that may be required and which must be undertaken.
ii) Setting up the monitoring system to undertake the monitoring service.
iii) Quality assurance measures that must be instituted by the *Service Provider* and that must be followed during the operation of the system.
iv) Records that must be kept of the operation of the system.

3.5 Service provider quality assurance manuals

The *System Supplier* must develop the quality assurance manuals listed below and make these manuals available to the *Service Provider*:

a) *Management systems.* The purpose of the management systems is to ensure that quality assurance is enforced at all levels of the *Service Provider* organisation, including any external organisations or sub-contractors that may be used by the *Service Provider* for the provision of the monitoring services.

b) *Monitoring service quality assurance*. Procedures must be instituted that will ensure that all the monitoring services provided by the *Service Provider* comply with the requirements of these specifications. Instructions and procedures must be issued with regard to the following:

i) Inspections and tests that must be undertaken during the installation, maintenance and operation of monitoring systems, including any testing equipment used for the tests.
ii) Procedures to ensure that testing equipment is controlled and calibrated on a regular basis. Certificates or other proof of calibration must be kept on record and made available for inspection.
iii) Procedures that must be followed when it is found that a monitoring installation does not comply with the requirements or specifications.
iv) Records of all testing and inspections that must be maintained by the *Service Provider*.

c) *Internal quality audits*. The *Service Provider* must conduct regular internal audits to ensure that the quality control measures are implemented. The procedures that must be followed during such audits must be specified, as well as any records that must be completed.

d) *Records*. All records must ensure and show that the quality assurance system is operating effectively and that monitoring services comply with the requirements of these specifications. Instructions and procedures must also be provided regarding the filing and control of the records. The record system must ensure the following:

i) Records must be traceable to particular tasks that have been performed.
ii) The records must remain legible for the duration that a monitoring service is provided.
iii) Records must be filed and indexed for ease of retrieval.

3.6 Service provider training and assessment

The *System Supplier* is responsible for the training and assessment of the technical personnel and sub-contractors of a *Service Provider* to ensure that they are competent to install, maintain and operate the supplied monitoring systems. Training and assessment must be undertaken regarding the following aspects related to the use of monitoring systems:

a) Installation of monitoring systems.
b) Maintenance of monitoring systems.
c) Operation of monitoring systems.
d) Quality assurance of monitoring systems.

Each personnel member (including those of sub-contractors) that has received training must be assessed to determine if the member is fully competent to independently undertake any work involved with one or more of the abovementioned aspects. Only members that are considered by the *System Supplier* to be fully competent to undertake the work may pass the assessment. Partial competency may not be accepted.

A record must be kept of all persons that received the training and that have passed the assessment. The records of such persons must be made available and submitted (on request) to the *Certification Organisation*.

A manual must be prepared by the *System Supplier* that will be used in the training and assessment of personnel and sub-contractors of the *Service Provider*. This manual must cover the following aspects:

a) Programmes, contents and training material that will be used in the training of the different aspects related to the use of the monitoring systems.
b) Assessment methods and tests, together with criteria for testing the competency of personnel members.

3.7 Installed monitoring system inspection and assessment

The *System Supplier* must institute a programme for the regular inspection and assessment of the monitoring systems that have been installed and are being operated by the *Service Provider*. The purpose of the inspections and assessments is to determine whether the monitoring systems have been installed and are being maintained, operated and managed in accordance with the requirements of these specifications, including those related to quality assurance.

The *System Supplier* must inspect and assess a minimum of one (1) monitoring system installation per annum for the *Service Provider*. The systems must be selected randomly from a list of installations that have been installed by the *Service Provider* since the previous review. No inspection or assessment is required when the *Service Provider* has not installed a system during the previous year.

A record must be kept of all the inspections and assessments irrespective of whether an installation has failed or passed the assessments. The records of such inspections and assessments, together with the findings of the inspections and assessments must be made available and submitted to the *Certification Organisation* when requested.

A manual must be prepared by the *System Supplier* for use by personnel of the *System Supplier* during the inspection and assessment of installations. The manual must cover all the aspects related to such inspections and assessments, including all the tests that must be undertaken during such inspections and assessments.

4 TRAFFIC AND WIM MONITORING SERVICE PROVIDER QUALITY ASSURANCE

4.1 Quality assurance requirements

This chapter provides the requirements for the quality control measures that must be implemented by a *Traffic and WIM Monitoring Service Provider*. These are in addition to any additional quality control measures that may be required by the *System Supplier*. The requirements of this chapter do not apply to Manual Traffic Monitoring Service Providers.

All quality control measures specified in this chapter must be in place before an application can be made for the certification of a *Traffic and WIM Monitoring Service Provider*. This includes the requirement that the *Service Provider* must have personnel or sub-contractors that have received all the training and passed all the assessments that are required by the *System Supplier*.

In all instances, the *Service Provider* must apply the codes of practice for quality systems as outlined in SABS ISO 9000 to SABS ISO 9004.

4.2 Quality assurance measures

The *Traffic and WIM Monitoring System Supplier* is responsible for making the following manuals (as specified in Chapter 3 (Traffic and WIM Monitoring System Supplier quality assurance)) available to the *Service Provider* who will be responsible for implementing the requirements as set out in the manuals:

a) Service provider monitoring system manuals for the installation, maintenance and operation of a monitoring system.
b) Service provider quality assurance manuals for the implementation of quality assurance measures.

The *Service Provider* must have a system in place for the implementation of all the required quality assurance measures. This system must be in place before an application can be made for the certification of *a Service Provider*.

The quality assurance system must provide for the maintenance of records that must be kept as evidence that the quality assurance measures are being implemented by the personnel or sub-contractors of the *Service Provider*. These records include the following:

a) *Management systems.* Record must be kept of instructions that have been issued to personnel with regard to:
    i) The responsibilities of management personnel tasked with ensuring that the quality assurance system is effectively implemented in the organisation.
    ii) The responsibilities of all personnel in the organisation (including sub-contractors) with regard to quality assurance.

b) *Monitoring service quality assurance*. Records of all testing and inspections undertaken during the installation, maintenance and operation of monitoring systems. Such records must be signed by a designated responsible person, filed and made available for inspection by the *Certification Organisation*.

c) *Internal quality audits*. Records of regular internal audits to ensure that the quality control measures are implemented by all personnel and sub-contractors of the *Service Provider*.

4.3 Personnel training and assessment

It is a requirement of these specifications that monitoring services may only be provided by a *Traffic and WIM Monitoring Service Provider* whose technical personnel and sub-contractors have received all the training and have passed all the assessments required by the *System Supplier*. It is a further requirement that only personnel and sub-contractors that have received such training and have passed such assessments may be used for the provision of the monitoring services.

The *Service Provider* must keep records of all persons that received the training and that have passed the assessment. These records are in addition to the records kept by the *System Supplier*. The records of such persons must be made available and submitted to the *Certification Organisation* when an application is made for certification. The *Traffic and WIM Monitoring Service Provider Certificate* will only be issued to a *Service Provider* whose personnel and sub-contractors have received the training and passed the assessments required by the *System Supplier*.

5 MANUAL TRAFFIC MONITORING SERVICE PROVIDER QUALITY ASSURANCE

5.1 Quality assurance requirements

Requirements for the quality control measures that must be implemented by the *Manual Traffic Monitoring Service Provider* in the provision of manual traffic monitoring services are provided in this chapter. These quality control measures must be in place before an application is made for the certification of a *Manual Traffic Monitoring Service Provider*. This includes the requirement that the *Service Provider* must have personnel or sub-contractors that have received the training and passed the assessments specified in this chapter.

The *Service Provider* must develop manuals that describe and specify the quality assurance measures implemented by the *Service Provider*. Copies of these manuals must be submitted to the *Certification Organisation* for assessment when an application is made for certification. Copies of the manuals must also be made available to the *Employer*.

In all instances, the *Service Provider* must apply the codes of practice for quality systems as outlined in SABS ISO 9000 to SABS ISO 9004.

5.2 Quality assurance measures

The *Service Provider* is responsible for the implementation of a quality assurance system that is aimed at ensuring that manual traffic monitoring is undertaken in accordance to the requirements of these specifications.

The specific responsibilities of the *Service Provider* in this regard are as follows (more details of these responsibilities are provided in the following sections of this chapter):

a) *Quality assurance manuals*. The development of quality assurance manuals and the implementation of the manuals.
b) *Training and assessment*. The training and assessment of technical personnel and sub-contractors aimed at ensuring that they are competent to undertake manual traffic monitoring. A manual must be prepared and used for such training and assessment. The *Service Provider* must also keep records of all persons that have received training and supply details of whether such persons were assessed to be fully competent in the use of the monitoring system.

Copies of all manuals as well as training and assessment records must be submitted to the *Certification Organisation* for approval when an application is made for a monitoring system certificate. Copies of the manuals and records must also be made available to the *Employer*.

5.3 Quality assurance manuals

The *Service Provider* must develop the following quality assurance manuals and ensure that these manuals are implemented by the personnel of the *Service Provider*:

a) *Management systems.* The purpose of the management systems is to ensure that quality assurance is enforced at all levels of the *Service Provider* organisation, including any external organisations or sub-contractors that may be used by the *Service Provider* for the provision of the traffic monitoring services. Specific instructions and procedures must be issued with regard to the following:
   i) The responsibilities of management personnel responsible for ensuring that the quality assurance system is effectively implemented in the organisation.
   ii) The responsibilities of all the personnel in the organisation with regard to quality assurance.

b) *Monitoring service quality assurance*. Quality assurance measures must be instituted that will ensure that all traffic monitoring services provided by the *Service Provider* comply with all of the requirements of these specifications. These measures must include inter alia the following:
   i) Checks aimed at ensuring that the monitoring team has all the data forms and equipment that is required for the monitoring. These checks must be made prior to departure to the monitoring site.
   ii) Tests that must be undertaken on all equipment (including writing utensils) to ensure that equipment is in good working order. These tests must be undertaken prior to departure to the monitoring site.
   iii) Measures aimed at ensuring that a sufficient number of trained fieldworkers and equipment are available for the provision of a traffic monitoring service.
   iv) Measures aimed at ensuring that the monitoring is undertaken at the correct location.
   v) Measures aimed at ensuring that the monitoring is undertaken correctly and in accordance to the requirements of these specifications.
   vi) Measures for ensuring that traffic and other data are captured correctly and submitted to the *Employer* in accordance to the requirements of these specifications.

c) *Internal quality audits*. The *Service Provider* must conduct regular internal audits to ensure that the quality control measures are implemented in the organisation. The procedures that must be followed during such audits must be specified, as well as any records that must be completed. Procedures and instructions must be issued with regard to the following:
   i) Management level quality assurance measures.
   ii) Monitoring service quality assurance measures.
   iii) Records of implemented quality assurance measures.

d) *Records*. Records must ensure and show that the quality assurance system is operating effectively and that the monitoring services comply with the requirements of these specifications. The following records must be maintained by the *Service Provider:*

i) Records that shows that management level quality assurance measures are implemented by the organisation.
ii) Records that shows the quality assurance measures that were implemented for each traffic monitoring service undertaken by the *Service Provider*.
iii) Records of internal audits

Instructions and procedures must also be provided regarding the filing and control of the records. The record system must ensure the following:

i) Records must be traceable to particular quality assurance measures that have been performed.
ii) Records must be filed and indexed for ease of retrieval.

5.4 Training and assessment

It is a requirement of these specifications that only personnel or sub-contractors that have received the required training and have passed the required assessments may be used for the provision of the monitoring services. The *Service provider* is responsible for the training and assessment of the personnel and sub-contractors.

A training manual must be prepared by the *Service provider* that will be used in the training and assessment of personnel and sub-contractors of the *Service Provider*. This manual must cover the following aspects:

a) Programmes, contents and training material that will be used in the training in all aspects related to traffic monitoring. Provision must be made for theoretical as well as practical training of personnel.
b) Assessment methods and tests, together with criteria for testing the competency of personnel members.

The training must cover the following aspects:

a) Monitoring service quality assurance procedures.
b) The different manual traffic monitoring types and requirements pertaining to each monitoring type as specified in Chapter 15 (Manual traffic monitoring types).
c) The requirements pertaining to traffic monitoring sites specified in Chapter 16 (Manual traffic monitoring site requirements).
d) Requirements applicable to manual traffic monitoring fieldworkers as specified in Chapter 17 (Traffic monitoring fieldworker requirements).
e) Requirements for the provision of manual monitoring services as specified in Chapter 18 (Monitoring service requirements).
f) Requirements for collection and submission of manual monitoring data as specified in Chapter 19 (Monitoring data requirements).

Each personnel member (including those of sub-contractors) that has received training must be assessed to determine if the person is fully competent to independently undertake any work involved with one or more of the abovementioned aspects. Only persons that are considered by the *Service Provider* to be fully competent to undertake the work may pass the assessment. Partial competency may not be accepted.

The *Service Provider* must keep records of all persons that received the training and that have passed the assessment. The records of such persons must be submitted to the *Certification Organisation* when an application is made for certification. The *Manual Traffic Monitoring Service Provider Certificate* will only be issued to a *Service Provider* whose personnel and sub-contractors have received training and passed the required assessments.

Part 2
Automatic Monitoring System Requirements

Part 2: Automatic Monitoring System Requirements

Part 2 contains the requirements that are applicable to the monitoring systems that may be used for the provision of traffic monitoring and WIM services. These requirements are applicable to the provision of automatic traffic and WIM monitoring services and not to manual traffic monitoring services. These requirements are provided in the following chapters:

Chapter 6 General automatic monitoring system requirements.

Chapter 7 Automatic traffic monitoring system requirements.

Chapter 8 HS WIM monitoring system requirements.

Chapter 9 LS WIM Monitoring system requirements.

Chapter 10 Automatic monitoring system assessment.

6 GENERAL AUTOMATIC MONITORING SYSTEM REQUIREMENTS

6.1 General requirements

This chapter provides a number of general requirements applicable to the monitoring systems used in the provision of automatic monitoring services. The requirements are aimed at ensuring that the systems are capable of undertaking the required monitoring and that data will be of an acceptable quality.

The requirements are applicable to all types of monitoring systems that are described in these specifications (traffic and WIM). Additional requirements are provided in subsequent chapters of these specifications.

6.2 Environmental conditions

The traffic and WIM monitoring system must be able to operate under the following environmental conditions:

a) It must be possible to install pavement sensors in or on all types of concrete and asphalt pavements found in South Africa. When monitoring is required on a gravel road, it must also be possible to install the sensors in or on the gravel pavement.

b) The system must be able to operate without degradation under ambient temperatures in the range between -10°C to +60°C, a relative humidity in the range of 0 to 90% (not condensing) and during adverse weather conditions.

c) Any sensors that are installed on the road pavement must be able to operate without degradation or loss of sensitivity under road-surface temperatures in the range between -10°C to +80°C and a relative humidity in the range of 0 to 100%. These include sensors that are supported by the pavement and which may be affected by the pavement modulus of elasticity that could vary with temperature.

d) The monitoring system and sensors must be protected against, or must be insensitive to adverse effects that may be caused by vermin, moisture, water, ice, fuel, oil, salt, dust, electrical power spikes, as well as any external electrical or magnetic fields.

6.3 Environmental requirements

The monitoring system may not have the following environmental impacts:

a) The system and sensors may not cause undesirable environmental effects, such as the leaking or spillage of hazardous, toxic or undesirable materials, fluids or gases into the environment.

b) The system and sensors may not be aesthetically or visually obtrusive. All parts of the system must, as far as practically possible, be hidden from view or blended with the background. There may not be any visible loose wiring or parts protruding from the road pavement, ground surface or equipment housing.

6.4 Operational requirements

The monitoring system must comply with the following operational requirements:

a) The system and sensors must be protected against acts of vandalism, criminal or malicious mischief and theft.

b) Where sensors are installed in or on the road pavement, such sensors must remain fixed under all traffic flow and environmental conditions until their removal. The sensors must be able to withstand crossing by tracked vehicles or deflated tyres that are legally allowed on public roads.

c) The system and sensors may not create a road and traffic hazard, nor endanger the safety of people, animals, vehicles and property. Traffic safety requirements for the location of equipment housing are provided in Chapter 12 (Installed automatic monitoring system requirements).

6.5 Power provision requirements

The following power related provision requirements apply to the monitoring system:

a) In terms of these specifications, it is the responsibility of the *Service Provider* to obtain or procure the power required to operate a monitoring system.

b) Any power source may be used, but the power supply must be sufficient to allow continuous operation of the monitoring system over the duration of a monitoring service.

6.6 Data recording capabilities

The monitoring system must have the following data recording capabilities:

a) The system must be capable of recording *individual vehicle* data as specified in the *South African Standard Traffic Data Collection Format*, including all the data required to produce the header and other required records.

b) Traffic monitoring and HS WIM systems must have sufficient capacity to record data for all vehicles passing a site for the periods between data extractions.

c) Recorded data may not be lost when power supply to the system is interrupted or when the system is switched off.

6.7 Data extraction requirements

The monitoring system must have the following data extraction capabilities:

a) The system must allow data extraction while in operation without affecting the data collection and processing capabilities of the system, irrespective of the method according to which data are extracted.

b) Any method may be used for the extraction and supply of data, subject to the following requirements:

   i) No data may be lost as a result of the extraction method.
   ii) The data must be supplied within the time period as specified in Chapter 19 (Monitoring data requirements).

6.8 Post-processing software requirements

Traffic data may be processed by means of software provided as part of the monitoring equipment or by means of post-processing software on completion of the monitoring. Both types of software are considered to form part of a monitoring system and must be certificated as part of the monitoring system as specified in Chapter 2 (Service provider and monitoring system certification), The post-processing software includes all software that are used to process traffic data up to the submission of data to the *Employer*.

7 AUTOMATIC TRAFFIC MONITORING SYSTEM REQUIREMENTS

7.1 System requirements

This chapter provides the requirements for automatic monitoring systems that may be used for the provision of Traffic monitoring, Toll traffic monitoring, as well as Traffic and HS WIM Monitoring services. These requirements are in addition to the general requirements provided in Chapter 6 (General automatic monitoring system requirements).

Traffic monitoring systems are used to measure traffic flow characteristics, such as traffic volumes (counts) and the operating speeds of vehicles travelling under normal conditions on a roadway without interrupting the flow of traffic.

For Toll traffic monitoring services, two or more Traffic monitoring systems operating independently must be used to monitor the traffic. The specifications in this chapter are applicable to each of the individual monitoring systems.

7.2 Traffic monitoring system types

Differentiation is made in these specifications between different automatic traffic monitoring types and accuracy classes. The *Employer* will specify the monitoring type and accuracy class when requiring an automatic traffic monitoring service.

Provision is made for the following automatic monitoring system types (A to E) listed below. For each type, provision is made for two accuracy levels (1 and 2). The system types and accuracy levels are as follows:

a) *Type A traffic monitoring systems* with vehicle, speed, axle and single/dual tyre detection. These systems provide for the monitoring of characteristics such as vehicle lengths, speeds, number of axles, axle spacing and tyre configuration (single or dual). Differentiation is made between the following two sub-types:

   i) *Type A1 systems* with the highest levels of detection and vehicle classification accuracy. Recommended for traffic monitoring where the highest levels of accuracy are required.

   ii) *Type A2 systems* with relatively high levels of detection and vehicle classification (categorization) accuracy. Recommended for long-term traffic monitoring where relatively high levels of accuracy are required. Also recommended for HS WIM installations.

b) *Type B traffic monitoring systems* with vehicle, speed and axle detection but without single/dual tyre detection. These systems provide for the monitoring of characteristics such as vehicle lengths, speeds, number of axles and axle spacing, but not tyre configuration. Differentiation is made between the following two sub-types:

i) *Type B1 systems* with the highest level of detection and a relatively high level of vehicle classification (categorization) accuracy. Recommended for toll traffic monitoring where the highest level of vehicle detection accuracy is required but not the highest level of vehicle classification accuracy.

ii) *Type B2 systems* with a relatively high level of detection and a medium to high level of vehicle classification (categorization) accuracy. Recommended for long-term traffic monitoring where a relatively high detection level is required, but medium to high levels of vehicle classification accuracy are acceptable. Also recommended for HS WIM installations (but only for the lanes in which HS WIM monitoring is undertaken).

c) *Type C traffic monitoring systems* with vehicle and speed detection but without axle and single/dual tyre detection. These systems provide for the monitoring of characteristics such as vehicle lengths and speeds but not of number of axles, axle spacing and tyre configuration. Differentiation is made between the following two sub-types:

i) *Type C1 systems* with a relatively high level of detection and a medium to low level of vehicle classification (categorization) accuracy and where axle data are not required. Recommended for long-term traffic monitoring, as well as short-term traffic monitoring on roads where relatively high detection levels are required but medium to low vehicle classification accuracy are acceptable.

ii) *Type C2 systems* with a medium level of detection and a relatively low level of vehicle classification (categorization) accuracy and where axle data are not required. Recommended for short-term traffic monitoring on roads where a medium level of detection and relatively low vehicle classification accuracy is acceptable.

d) *Type D traffic monitoring systems* without vehicle length, speed, axle and single/dual tyre detection. These are basic systems which only provide for traffic counts and not for the monitoring of characteristics such as vehicle lengths, speeds, number of axles, axle spacing and tyre configurations. Vehicle classification may be based on an assumed average speed for the site but the accuracy of such classification will be relatively poor. Differentiation is made between the following two sub-types:

i) *Type D1 systems* with a medium level of detection accuracy and either no vehicle classification (categorization) or a low level of vehicle classification (categorization) accuracy. Recommended for short-term traffic monitoring on roads where a medium level of detection accuracy is acceptable, but where vehicle classification is either not required, or a low level of accuracy is acceptable.

ii) *Type D2 systems* with a relative low level of detection accuracy and either no vehicle classification (categorization) or a low level of vehicle classification accuracy. Recommended for short-term traffic monitoring on roads where relatively low levels of detection accuracy are acceptable. Vehicle classification is either not required or a low level of accuracy is acceptable.

e) *Type E traffic monitoring systems* without vehicle and single/dual tyre detection but with speed and axle detection. These systems provide for the monitoring of characteristics such as number of axles and axle spacing, but not tyre configuration. Vehicle units and lengths cannot be directly detected or measured but can be indirectly identified or estimating from axle spacing data. Differentiation is made between the following two sub-types:

i) *Type E1 systems* with a relatively high level of detection and a medium to low level of vehicle classification accuracy. Recommended for long-term traffic monitoring, as well as short-term traffic monitoring on roads where relatively high detection levels are required but medium to low vehicle classification accuracy are acceptable.

ii) *Type E2 systems* with relatively low levels of detection and vehicle classification accuracy. Recommended for short-term traffic monitoring on roads where a medium level of detection and relatively low vehicle classification accuracy is acceptable.

The detection requirements for the different monitoring system types are summarised in the following table:

System Type	Veh length	Speed	Axle	Tyre Conf
A1/A2	✓	✓	✓	✓
B1/B2	✓	✓	✓	
C1/C2	✓	✓		
D1/D2	(*1)	(*2)	(*3)	
E1/E2	(*4)	✓	✓	

(*1) May be estimated using an assumed average speed for the site

(*2) An average speed may be assumed for the site

(*3) Vehicle units may be identified from axle detectors

(*4) Vehicle units and lengths may be identified/estimated from axle data

In the absence of a traffic monitoring system type and accuracy level specification by the Employer, the following monitoring systems and accuracy levels must be used:

- Type B1 monitoring systems for toll traffic monitoring.
- Type B2 monitoring systems when integrated with HS WIM monitoring (but only for lanes in which HS WIM monitoring is undertaken).
- Type C1 monitoring systems for long- and short-term traffic monitoring.

When a traffic monitoring system type and accuracy level is specified by the Employer (or when required in the previous paragraph), the Service Provider will be allowed to use one of the alternative monitoring types listed in Table 1, but subject to the condition that the alternative system is certified and complies with all requirements of these specification. In the alternative, only those components may be used that are required to provide the equivalent detection levels required for the specified monitoring system (subject to the requirement that only components may be excluded that have been defined as optional in the Traffic and WIM Monitoring System Certificate). The use of the alternative system is furthermore subject to the condition that no additional payment will be made for the

monitoring service and that payment for the service will be made at the tariff tendered for the specified monitoring system type.

Table 1 Alternative automatic traffic monitoring system types

Required type	Automatic monitoring types that may be used by Service Provider									
	A1	A2	B1	B2	C1	C2	D1	D2	E1	E2
A1	✓									
A2	✓	✓								
B1	✓		✓							
B2	✓	✓	✓	✓						
C1	✓	✓	✓	✓	✓					
C2	✓	✓	✓	✓	✓	✓				
D1	✓	✓	✓	✓	✓	✓	✓			
D2	✓	✓	✓	✓	✓	✓	✓	✓		
E1	✓	✓	✓	✓					✓	
E2	✓	✓	✓	✓					✓	✓
✓ May be used by Service Provider subject to conditions										

7.3 Traffic monitoring system size specification

In addition to the type specification provided in the previous section, the *Employer* must also specify the size of the required system. The size is specified in terms of the number of traffic lanes that must be monitored. For toll traffic monitoring systems, the number of independent Traffic monitoring systems (two or more) must also be specified.

Except where otherwise specified by the *Employer*, the traffic monitoring system must be installed over the full width of a roadway. In the case of a double carriageway road, the monitoring system must be installed on both carriageways, even if the carriageways are some distance apart (either as a single system or as a combination site utilising more than one monitoring system as specified in Chapter 11 (Automatic monitoring site requirements)).

On a road with paved shoulders, the system must be extended to include the paved shoulders. When the shoulders are narrow, to such an extent that vehicles travelling on the shoulder effectively form part of the traffic on the adjacent lane, the vehicles will be included as part of the traffic in the lane. When the shoulders are wide, to the extent that it effectively operates as a separate lane, it must be defined as a separate lane of the roadway. The decision to define a shoulder as a lane must be agreed to by the *Service Provider* and the *Employer*.

7.4 Detection capabilities

All traffic monitoring systems must have the following detection capabilities (Types A to E monitoring systems):

a) *Vehicle detection*. The system must be able to detect all vehicles, other than animal-drawn vehicles and bicycles, which are travelling on the roadway or on the paved shoulders of the roadway and crossing the monitoring site.

b) *Vehicle differentiation*. The system must be able to differentiate between closely following vehicles, but must be able to detect vehicle-trailer combinations.

c) *Vehicle straddling*. The system must be able to detect vehicles straddling over two lanes of traffic and assign such a vehicle to one of the two lanes.

d) *Vehicle categories (classes or types)*. The system must be able to detect categories (classes or types) of vehicles as specified in these specifications. For systems in which speeds are not recorded, an average speed for the monitoring site may be used for the categorization (classification) of vehicles. Where the system is capable of identifying animal-drawn vehicles and bicycles, such vehicles must either be recorded as a separate vehicle category or discarded by the system.

Where required, the system must also have the following additional detection capabilities:

a) *Speed detection* (Types A, B, C and E monitoring systems). The system must be capable of measuring the speed of each vehicle travelling over the monitoring site. The system must also be capable of detecting whether a vehicle has stopped on the monitoring site.

b) *Axle detection* (Types A, B and E monitoring systems). The system must have the capability of detecting all axles with wheels touching the road surface. Where wheel or axle load sensors are used for the detection of axles, the sensors must be capable of measuring a force on the road surface equivalent to 100 kg or higher per wheel (or 200 kg or higher per axle).

c) *Single/Dual tyre detection* (Type A monitoring systems). The system must be capable of determining whether a wheel is fitted with a single tyre or with dual tyres.

7.5 Data requirements

The traffic monitoring system must be capable of recording *individual vehicle* data as specified in the *South African Standard Traffic Data Collection Format*, including all the data required to produce the header records defined by the format.

All monitoring systems (Types A to E) must be capable of measuring and recording the following data for each *individual* vehicle passing the monitoring site:

a) *Departure date and time*. The departure date and time on and at which the back of the vehicle crosses a specific point on the site (front of the vehicle when a vehicle reverses over the site).

Dates and times must be recorded in South African Standard Time, which is the Universal time (Greenwich Mean Time) plus 2 hours. The recording may not change should Daylight Saving Time be introduced in the country.

The recorded dates and times may not deviate more than 30 seconds from the Standard Time at any time.

Where multiple monitoring systems are used at a Combination site or at a Toll monitoring site, the time synchronisation between the different systems may not differ by more than 5 seconds at any time.

b) *Physical lane number*. The physical lane number on which a vehicle was physically detected, irrespective of the direction in which the vehicle was travelling.

The system must be capable of recording data for up to 32 physical lanes, either as a Single system or combined at a Combination site (as specified in Chapter 11 (Automatic monitoring site requirements)).

Types A, B, C and E monitoring systems (with speed detection) must be capable of measuring and recording the following data for each vehicle passing the monitoring site:

a) *Direction of travel* (forward/reverse). The direction of travel over the site. Vehicles normally travel in the forward direction, but vehicles may be travelling in the reverse direction. This can occur when a vehicle reverses over the site, a vehicle is travelling in the wrong direction or when a vehicle is overtaking another.

b) *Assigned lane number* (physical or virtual). The lane number to which a vehicle travelling in the reverse direction is assigned. Provision must be made for the following *Employer*-selectable options:

i) Assignment to another physical lane. This option is the default in situations where overtaking occurs (typically on two-lane roads).
ii) Assignment to a virtual lane. A virtual lane is a lane that does not exist but which is used to record vehicles in a reverse direction. This option is the default for all situations other than where overtaking occurs.
iii) No assignment to any lane (vehicle is ignored).

The system must be capable of recording data for up to 32 virtual lanes in a Single system or as a total for a Combination site (in addition to physical lanes).

c) *Vehicle speed*. The speed of the vehicle as recorded at a fixed position of the vehicle (normally the front bumper or axle) and a fixed point on the site. The speed of stopped vehicles must be recorded as zero.

The system must be capable of measuring speeds between 0 and 250 km/h.

d) *Vehicle length*. The length of a vehicle as measured from front to rear bumper. For Types A to C systems, the vehicle lengths must be measured directly and for Type E systems, the lengths may be estimated from axle spacing measurements (subject to the accuracy requirements of this chapter).

The system must be capable of recording vehicle lengths up to 50 m.

e) *Vehicle following property*. The system must be able to classify a vehicle as either following or free flowing as defined in the *South African Standard Traffic Data Collection Format*. The *Employer* will specify the parameters (gap time and speed differential) required for this classification.

Types A, B and E monitoring systems (with axle detection) must be capable of measuring and recording the following data for each vehicle passing the monitoring site:

a) *Number of axles*. This is the number of axles on the vehicle. The system must be able to record up to 15 axles per vehicle.

b) *Axle spacing* for all axles (except first axle). The spacing between subsequent axles. The system must be able to record axle spacing of up to 20 m.

Types A and B monitoring systems must be capable of measuring and recording the following data for each vehicle passing the monitoring site:

a) *Number of trailers*. The total number of trailers towed by the vehicle. The system must be able to record up to 15 trailers per vehicle. This measurement is not required for Type E monitoring systems.

b) *Bumper-to-1st axle spacing*. The distance measured from the front bumper to the centre of the first axle. The system must be capable of recording a spacing of up to 10 m. In situations where the first axle is detected before the front bumper, a negative spacing must be recorded. This measurement is not required for Type E monitoring systems.

Type A monitoring systems (with single/dual tyre detection) must be capable of measuring and recording whether the wheels of a vehicle have single or dual tyres.

All monitoring systems (Types A to E) must be capable of classifying and recording vehicle categories as specified in the *South African Standard Traffic Data Collection Format*. The required vehicle categories for the different monitoring system types are as follows:

a) *Types A and B monitoring systems*. Vehicles must be categorised as one of the following categories:

iii) Light vehicles (not subdivided further into the light vehicle subcategories).
iv) Heavy vehicles, subdivided into all the heavy vehicle subcategories allowed for by the *South African Standard Traffic Data Collection Format.*

b) *Types C to E monitoring systems*. Vehicles must be classified as one of the following two classes*:*

i) Light vehicles (not subdivided further into the light vehicle subcategories).
ii) Heavy vehicles (not subdivided further into the heavy vehicle subcategories).

In situations where the system was not able to measure a particular data item, the system must have the capability of marking or tagging such data items in such a way that allows differentiation between missing and measured data items. Missing data items may not be recorded as zero values (except where otherwise allowed by the *South African Standard Traffic Data Collection Format*).

7.6 Resolution requirements

The traffic monitoring system must be capable of achieving the measurement resolutions provided in Table 2. The resolutions must be smaller than or equal to those specified in the table.

Table 2 Measurement resolutions

Characteristic	Required resolution
Departure time	0.1 second
Vehicle speed	1 km/h
Vehicle length	0.1 m
Bumper-to-1st axle spacing	0.1 m
Axle spacing	0.01 m

7.7 Detection accuracy

The vehicle, axle and single/dual tyre detection accuracy of the system is specified in terms of *tolerance limits*. A tolerance limit is the maximum limit for the count of erroneous detections, expressed as a percentage of a reference count when a very large count representative of the population is made. The reference count is the actual count of vehicles, axles, wheels and tyres passing the monitoring site.

Erroneous detections include the following:

a) *Vehicle detection*. Vehicles that were missed (not detected) or created (invented) by the system under the following conditions:
   i) Normal travel in which no straddling, lane changing, wrong direction movements, reversing or stopping occur on the monitoring system.
   ii) Vehicles straddle the system (vehicles that straddle two lanes or when lane changing occurs).
   iii) Vehicles travelling in the wrong direction or reversing over the site. This condition will only be assessed when required by the Certification Organisation as specified in Chapter 10 (Automatic monitoring system assessment).

b) *Trailer detection*. Trailers that were missed (not detected) or created (invented) by the system (requirements are only provided for normal travel).

c) *Axle detection*. Axles that were missed (not detected) or created (invented) by the system (requirements are only provided for normal travel).

d) *Wheel detection*. Wheels that were missed (not detected) or created (invented) by the system for determining whether single or dual tyres have been fitted (requirements are only provided for normal travel).

e) *Single/dual tyre classification*. Incorrect classification of whether single or dual tyres have been fitted to a wheel (requirements are only provided for normal travel).

The proportion (percentage) of erroneous detections is determined by means of the following formula:

$$P = 100 \cdot \frac{E}{R}$$

In which:

P = Proportion (percentage) of erroneous observations
E = Count of erroneous observations
R = Actual (reference) count

Tolerance limits are provided in Table 3 for the different types of erroneous detections. Differentiation is made between systems that will be used for traffic and toll monitoring

purposes. The tolerance limits are applicable to the mixture of all vehicle categories in the traffic stream (including motorcycles).

The tolerance limits provided in the table are applicable when a very large count representative of the population of vehicles passing the monitoring site is made. In practice, this is not possible and an assessment must be made by means of a random sample of vehicles. The methodology provided for tolerance limit tests for proportions in Appendix A must be used for such an assessment.

Table 3 Tolerance limits for invalid detection

Characteristics	Travel	Tolerance limits for various traffic monitoring types									
		A1	A2	B1	B2	C1	C2	D1	D2	E1	E2
Vehicle detection	Normal travel	0.5%	1%	0.5%	1%	1%	5%	5%	10%	1%	5%
	Straddling vehicles	5.0%	10%	5.0%	10%	10%	20%	20%	35%	10%	20%
	Wrong dir/reversing	0.5%	1%	0.5%	1%	1%	5%	5%	10%	1%	5%
Trailer detection	Normal travel	1.0%	2%	1.0%	2%	-	-	-	-	-	-
Axle detection	Normal travel	0.5%	1%	0.5%	1%	-	-	-	-	0.5%	1%
Wheel detection	Normal travel	2.5%	5%	-	-	-	-	-	-	-	-
Single/dual tyre	Normal travel	0.5%	1%	-	-	-	-	-	-	-	-

7.8 Vehicle categorization (classification) accuracy

Vehicle categorization (or classification) accuracy is specified in terms of *tolerance limits*. A tolerance limit is the maximum limit for the count of erroneously categorized vehicles, expressed as a percentage of a reference count when a very large count representative of the population is made. The reference count is the actual count of vehicles of a particular type.

An erroneous categorization is one in which a vehicle of a particular category was either not categorized or wrongly categorized by the system. The proportion (percentage) of erroneous categories is determined by means of the following formula:

$$P = 100 \cdot \frac{E}{R}$$

In which:

P = Proportion (percentage) of erroneously categorized vehicles
E = Count of erroneously categorized vehicles
R = Reference count

Tolerance limits are provided in Table 4 for the different vehicle categories. The Vehicle categories in the table are defined in accordance with the *South African Standard Traffic Data Collection Format*. The table differentiates between different detection systems, as well as systems that will be used for traffic and toll monitoring purposes.

The assessment must exclude vehicles that:

a) Were missed or created (invented) by the system (refer to the previous section).

b) Straddle two lanes when passing over the monitoring site.
c) Change lanes when passing over the site.
d) Travel in a direction opposite to the normal direction of travel.
e) Reverse over the site.
f) Accelerate or decelerate while passing the site.
g) Stop on the site.

The tolerance limits provided in the table are applicable when a very large count representative of the population of vehicles passing the monitoring site is made. In practice, this is not possible and an assessment must be made by means of a random sample of the vehicles. The methodology provided for tolerance limit tests for proportions in Appendix A must be used for such an assessment.

Table 4 Tolerance limits for vehicle categorization

Vehicle category (class)	**Tolerance limits for various traffic monitoring types**									
	A1	A2	B1	B2	C1	C2	D1	D2	E1	E2
Vehicles not categorised, or which were wrongly categorised by the monitoring system	2.0%	3.5%	3.5%	7.0%	10%	15%	-	-	10%	15%
Vehicles that should have been categorised as light but which were not categorized or categorized as heavy	1.0%	2.0%	2.0%	4.0%	6.0%	10%	-	-	6.0%	10%
Vehicles that should have been categorized as heavy but which were not categorized or categorized as light	3.0%	6.0%	6.0%	12%	20%	30%	-	-	20%	30%
Heavy vehicles wrongly categorized into one of the heavy vehicle subclasses (excluding buses)	4.0%	8.0%	8.0%	15%	-	-	-	-	-	-

7.9 Speed, length and axle spacing accuracy

This accuracy of the observation of vehicle speeds, lengths and axle spacing is specified in terms of *tolerance intervals*. A tolerance interval is defined as *one half* of a *zero-centred interval* in which at least a certain *proportion* of the *population* of *deviations between observed and reference values* for a specific characteristic must fall. This proportion is termed the percent-within-limits or PWL. The reference values are the values measured by means of devices that are deemed accurate.

The deviations between observed and reference values are determined as percentages by means of the following formula:

$$D_i = 100 \cdot \frac{O_i - A_i}{A_i}$$

In which:

i = Observation number.
D_i = Deviation in measuring a given characteristic.
O_i = Observed value of the characteristic.

A_i = Actual value of the characteristic.

The assessment must exclude those for vehicles that:

a) Straddle two lanes when passing over the monitoring site.
b) Change lanes when passing over the site.
c) Travel in a direction opposite to the normal direction of travel.
d) Reverse over the site.
e) Accelerate or decelerate while passing the site.
f) Stop on the site.

The tolerance interval is a prescribed interval (half width) in which a minimum percentage of deviations (PWL) must fall when applied to a very large number of observations representative of the population of all possible observations. In these specifications, a minimum percent-within-limits (PWL) of 95% is prescribed. The required tolerance intervals are provided in Table 5.

The speed, length and axle spacing assessments must differentiate between light and heavy vehicles and separate assessments are required for the two vehicle categories. Motorcycles may be excluded from the assessments (in addition to animal-drawn vehicles and bicycles).

The range of reference values provided in the Table 5 define a lower bound of observations that must be included in the accuracy assessment. Any observations lower than the minimum values must be excluded from the assessments.

The tolerance intervals provided in the table are applicable when a very large number of observations that are representative of the population of vehicles passing the monitoring site are made. In practice, this is not possible and an assessment must be made by means of a random sample of vehicles. The method provided for tolerance interval tests in Appendix A must be used for this purpose.

Table 5 Tolerance intervals for vehicle speed, length and axle spacing

Characteristics	Range of reference values	Vehicle types (*)	Tolerance limits for various monitoring types			
			A1,A2,B1,B2,C1	C2	D1/D2	E1/E2
Vehicle speed	> 30 km/h	Light & Heavy	±5%	±10%	-	- ±5%
Vehicle length	3.0 to 5.0 m	Light only	±15%	±30%	-	±30%
	> 5.0 m	Light & Heavy	±10%	±20%	-	±20%
Axle spacing	1.0 m to 3.0 m	Light & Heavy	±10%	-	-	±10%
	> 3.0 m	Light & Heavy	±5%	-	-	±5%
(*) Excluding motorcycles, bicycles and animal drawn vehicles						

8 HS WIM MONITORING SYSTEM REQUIREMENTS

8.1 HS WIM requirements

This chapter provides the requirements for High-Speed WIM Monitoring Systems. Such systems may be provided as a stand-alone system or must be integrated with a Traffic Monitoring System to provide an integrated Traffic and HS WIM Monitoring service.

The requirements of this chapter are in addition to the requirements provided in Chapter 6 (General automatic monitoring system requirements) and Chapter 7 (Automatic traffic monitoring system requirements).

8.2 Static and dynamic loads

Loads measured by means of HS WIM systems consist of two components, namely the static and dynamic load components. Engineering applications of axle loads, however, only require estimates of the static load component rather than the actual impact forces as measured by WIM sensors. The reasons for this requirement are as follows:

a) The technical analysis (or design) procedures that are used for the engineering design of pavements are based on static axle loads. The dynamic load component depends on the condition of the road pavement, and can thus be expected to change in future as the road deteriorates or when the road is rehabilitated. The design procedures must therefore make an estimation of the dynamic loads as a function of the condition of the road and add this component back to the static load.
b) The screening of vehicles at weighbridges should be based on static axle loads since vehicles are stationary when weighed at a weighbridge.

Many of the requirements of these specifications are aimed at minimising the effect of the dynamic load component with the purpose of improving the accuracy with which static axle loads can be estimated. However, it is not possible to fully eliminate dynamic loads and statistical methods are thus used to remove the effect from the observations.

8.3 HS WIM Monitoring system types

When specifying a HS WIM monitoring system, the *Employer* must specify the following:

a) Whether a stand-alone system is required or whether it must be integrated with a traffic monitoring system. Where the system will be used for screening purposes, the required screening facilities must be specified.
b) Where required, the type of traffic monitoring system that must be integrated with the HS WIM system (types as defined in Chapter 7 (Automatic traffic monitoring system requirements)). Types A2 and B2 traffic monitoring systems are generally recommended for this purpose (but only for the lanes in which the HS WIM monitoring is undertaken).

In the absence of a traffic monitoring type specification by the Employer, Type B2 traffic monitoring systems must be used in lanes in which HS WIM monitoring are undertaken.

8.4 HS WIM Monitoring system sizes

When specifying a HS WIM monitoring system, the *Employer* must specify the lanes on which HS WIM monitoring must be undertaken. In the absence of such a specification, HS WIM monitoring must only be undertaken on the left-most lanes in each direction of travel at the site. Where the HS WIM in integrated with a traffic monitoring system, the traffic monitoring must be undertaken over all lanes of the road.

8.5 Accuracy levels

The Employer must also specify the required HS WIM accuracy level. Differentiation must be made between the following accuracy levels:

a) *Class I - Relatively high level of accuracy*. This level of accuracy is recommended for use on very smooth road surfaces where dynamic effects will be low. This class should be used when it critical to achieve a relatively high level of accuracy.
b) *Class II - Higher level of accuracy*. This level of accuracy is recommended for roads that carry medium to high volumes of heavy vehicle traffic and where a higher level of accuracy is required.
c) *Class III - Lower level of accuracy*. This level of accuracy is recommended for roads that carry low volumes of heavy vehicle traffic and where a lower level of accuracy is acceptable.

In the absence of an accuracy level specification by the Employer, a HS WIM system with a Class II accuracy level must be provided.

8.6 Detection capabilities

The HS WIM system must have the following detection and measurement capabilities:

a) *Axle load measurement*. The system must be capable of measuring and recording axle loads of individual axles of a vehicle. Such measurement may be undertaken by either wheel or axle sensors and at least one such sensor must be installed on each lane that is monitored. Where wheel load sensors are used, the axle load must be recorded as double (twice) the wheel load.
b) *Axle spacing measurement*. The load sensors must also be capable of measuring and recording axle spacing.
c) *Off-scale detection*. The system must be capable of detecting wheels that did not fully pass over but only clipped the wheel or axle load sensors. Sufficient sensors must be provided to ensure that all wheels clipping the load sensors are detected.

8.7 Screening requirements

Where screening facilities are specified for a HS WIM monitoring system at a weighbridge, an electronic communication facility must be provided which is capable of passing all the information collected for individual vehicles to another computer or control system. The requirements for the communication facility will be specified by the *Employer*.

8.8 Data requirements

The HS WIM system must be capable of recording *individual vehicle* data as specified in the *South African Standard Traffic Data Collection Format*, including all the header records required for the recording of such data. In addition to the data specified in Chapter 7 (Automatic traffic monitoring system requirements), the system must measure, collect and record the following data for each vehicle passing the monitoring site:

a) *Number of axles*. This is the number of axles for which axle loads were recorded. The system must be able to record axle spacing and wheel or axle loads for up to 15 axles per vehicle.

b) *Load measurement resolution*. The load resolution with which the axle loads on the vehicle were measured. This resolution may change from vehicle to vehicle, but not from axle to axle on the same vehicle.

c) *Axle spacing*. The spacing between subsequent axles as measured by the wheel or axle load sensors. The system must be able to record an axle spacing of up to 20 m.

d) *Axle loads*. The loads for each axle as measured by a wheel or axle load sensor. Where wheel load sensors are used, the axle load must be recorded as double (twice) the wheel load. Where separate axle sensors are used, wheel load sensors must be capable of measuring wheel loads between 250 and 10 000 kg and axle load sensors must be capable of measuring axle loads between 500 and 20 000 kg. Where separate axle sensors are not used, wheel load sensors must be capable of measuring wheel loads between 100 and 10 000 kg and axle load sensors must be capable of measuring axle loads between 200 and 20 000 kg. The system must be capable of measuring the loads for vehicles travelling at speeds higher than 15 km/h up to a speed of 140 km/h.

e) *Load sensor clipping*. The system must indicate whether the load sensor was clipped by any of the wheels of the vehicle. Such clipping must be detected by means of off-scale sensors.

In a situation where the system is not able to measure a data item, the system must use marks or tags to allow identification of invalid data items. Invalid data items may not be tagged or marked by means of zero values.

Vehicle, axle or wheel loads may NOT be used as a criterion in the vehicle classification systems described in Chapter 7 (Automatic traffic monitoring system requirements) of these specifications.

8.9 HS WIM Sensor step requirements

Where a HS WIM sensor is mounted on the surface of the road pavement, the height of the step between the top of the HS WIM sensor and the adjacent road surface may not exceed 2 mm at any location along the up- and downstream edges of the sensor.

The height of the step must be measured by means of a 2 mm thick 150 mm diameter circular plate and a straight edge.

8.10 Resolution requirements

The HS WIM system must be capable of achieving the measurement resolutions provided in Table 6. The resolutions must be smaller or equal to those specified in the table.

Table 6 HS-WIM Load and spacing resolutions

Characteristic	Required resolution
Load measurements	10 kg
Axle-spacing measurement	0.01 m

8.11 Axle detection and axle spacing accuracy

The axle detection and axle spacing measurements by means of the load sensors must comply with the requirements of Chapter 7 (Automatic traffic monitoring system requirements).

8.12 Load accuracy

The accuracy of load measurements made by HS WIM systems is specified in terms of *tolerance intervals*. A tolerance interval is defined as *one half* of a *zero-centred interval* in which at least a certain *proportion* of the *population* of *deviations between observed and reference loads* must fall. This proportion is termed the percent-within-limits or PWL.

For the purposes of these specifications, three reference loads must be used, namely a) gross vehicle loads (mass), b) axle group loads for axle groups with more than one axle and c) axle loads for axle groups with one axle.

The test vehicles used for the accuracy assessment must be selected randomly from the traffic stream. The reference loads for the test vehicles must be obtained from a static weighbridge but if a weighbridge is not available, the reference loads may be obtained from a certified LS WIM system.

In order to reduce the effect of dynamic loads on the evaluation, a test site should be selected that complies with the roadway and desirable pavement requirements of Chapter 11 (Automatic monitoring site requirements). Loads measured at wind speeds of greater than 30 km/h may also be excluded from the assessment (optional).

The deviations between the observed loads and the reference loads are determined in percentages by means of the following formula:

$$D_i = 100 \cdot \frac{O_i - R_i}{R_i}$$

In which:

i = Observation number.
D_i = Deviation in load measurement.
O_i = Observed load (WIM measurement).
R_i = Reference load.

The observed loads are those measured by the HS WIM system. The observed loads shall NOT be used for calibrating the system.

In HS WIM systems where wheel load sensors are used and where reference loads are available for the different wheels on the axle (from either the weighbridge or the LS WIM), the observed axle load shall be estimated by means of the following formula:

$$\text{Observed axle load} = \frac{\text{Reference axle load}}{\text{Reference wheel load}} \cdot \text{Observed wheel load}$$

Where reference wheel loads are not available, the observed axle load shall be estimated as double the observed wheel load.

The tolerance interval is a prescribed interval within which a minimum percentage of deviations must fall when applied to a very large number of observations representative of the population of all possible observations. In these specifications, a minimum percent-within-limits (PWL) of 95% is required. The required tolerance intervals are given in Table 7 for the three reference loads.

The minimum values provided in the table define a lower limit for observations that must be included in the accuracy assessment. Any observations lower than the minimum values must be excluded from the assessment.

The assessment must also exclude vehicles that:

a) Straddle two lanes when passing over the monitoring site.
b) Change lanes when passing over the site.
c) Travel in a direction opposite to the normal direction of travel.
d) Reverse over the site.
e) Accelerate or decelerate while passing the site.
f) Stop on the site.
g) Crosses the site when the wind speed exceeds 30 km/h (optional).

Table 7 differentiates between the different accuracy classes I to III.

The tolerance intervals provided in the table are applicable when a very large number of observations that are representative of the population of vehicles passing the monitoring site are made (including repeated passes of the test truck over the site). In practice, this is not possible and an assessment must be made by means of a random sample of vehicles. The method provided for tolerance interval tests in Appendix A must be used for this purpose.

Table 7 HS WIM Tolerance intervals for load measurements

Load	Minimum Value Tested	Tolerance intervals for different accuracy classes		
		Class I	Class II	Class III
Gross vehicle mass	3 500 kg per axle	±8%	±10%	±15%
Axle group load (*1)		±12%	±15%	±20%
Single axle load (*2)		±12%	±15%	±25%
*1 Excluding groups with one axle *2 Single axles in single axle groups				

8.13 Calibration of HS WIM systems

No procedure is prescribed in these specifications for the calibration of a HS WIM system and the calibration procedure prescribed by the *System Supplier* must be implemented.

Although no calibration procedure is prescribed in these specifications, a calibration process is described in Chapter 19 (Monitoring data requirements) based on load measurements by a HS WIM system. This process includes a requirement that the calibration factor produced by the process must fall in the range 0.90 to 1.10. Should the factor fall outside this range, the HS WIM system must be recalibrated to comply with this requirement.

9 LS WIM MONITORING SYSTEM REQUIREMENTS

9.1 LS WIM requirements

This chapter provides requirements for monitoring systems that must be used for the provision of Low-Speed (LS) WIM Monitoring services. These requirements are in addition to the general requirements provided in Chapter 6 (General automatic monitoring system requirements) but not the requirements for traffic monitoring systems provided in Chapter 7 (Automatic traffic monitoring system requirements).

LS WIM monitoring systems are used to measure left and right wheel loads of vehicles travelling at low speeds (lower than 10 km/h) to allow direct observations of static loads. The systems are used for purposes such as axle load observations as well as the calibration and validation of HS WIM systems.

9.2 System size specification

When specifying a LS WIM monitoring system, the *Employer* must also specify the required size of the system. The size is specified in terms of the number of systems that must be operated at one site. Where the LS WIM is installed on the roadway, a separate system will be required for each lane to be monitored.

9.3 Operational requirements

The LS WIM system must comply with the following requirements:

a) The system must be able to operate under manual control.
b) The system must be portable and the system must be easily moved between monitoring sites.
c) The system must be equipped with both left and right wheel load sensors.

When loads are being measured, the vehicle drivers must be requested to fully release all brakes on the vehicle.

9.4 Data requirements

The LS WIM system must be able to measure, collect and record the following data for each vehicle:

a) *Number of axles*. This is the number of axles for which loads were recorded. The system must be able to record axle loads for up to 15 axles per vehicle.

b) *Left and right wheel loads for all axles*. The wheel loads for each axle as measured by a wheel load sensor. The system must be capable of measuring wheel loads between 250 and 10 000 kg for vehicles travelling at speeds lower than 10 km/h.

9.5 Resolution requirements

The LS WIM system must be capable of achieving the measurement resolution provided in Table 8. The resolution must be smaller or equal to that specified in the table.

Table 8 LS WIM Axle load measurement resolution

Characteristic	Required resolution
Load measurements	10 kg

9.6 Load accuracy

The accuracy of load measurements made by a LS WIM system is specified in terms of *tolerance intervals*. A tolerance interval is defined as *one half* of a *zero-centred interval* in which at least a certain *proportion* of the *population* of *deviations between observed and reference loads* must fall. This proportion is termed the percent-within-limits or PWL.

For the purposes of these specifications, the observed load at a LS WIM is taken as the sum of the left and right wheel loads while the reference load is taken as the static axle load measured at a static weighbridge. Gross vehicle mass and axle group loads are not used in the assessment.

The deviations between observed and reference axle loads are determined as percentages by means of the following formula:

$$D_i = 100 \cdot \frac{O_i - R_i}{R_i}$$

In which:

i = Observation number.
D_i = Deviation in load measurement.
O_i = Observe sum of wheel loads (LS WIM measurement).
R_i = Reference axle load.

The tolerance interval is a prescribed interval in which a minimum percentage of deviations must fall when applied to a very large number of observations, representative of the population of all possible observations. In these specifications, a minimum percent-within-limits (PWL) of 95% is required. The required tolerance intervals for the deviations are given in Table 9.

The minimum values provided in the table define a lower limit for observations that must be included in the accuracy assessment. Any observations lower than the minimum values must be excluded from the assessment.

The tolerance intervals provided in the table are applicable when a very large number of observations, representative of the population of vehicles passing the monitoring site are

made (including repeated passes of the test truck over the site). In practice, this is not possible and an assessment must be made by means of a random sample of vehicles or passes of the test truck. The method provided for tolerance interval tests in Appendix A must be used for this purpose.

Table 9 LS WIM Tolerance limits for load measurements

Load	Minimum value	Tolerance interval
Axle load	1 250 kg	±5%

10 AUTOMATIC MONITORING SYSTEM ASSESSMENT

10.1 System assessments

The issuing of a *Traffic and WIM Monitoring System Certificate* by the *Certification Organisation* to a *System Supplier* for a monitoring system is subject to the condition that one installation of the monitoring system is assessed and found to comply with the requirements of this chapter in addition to the requirements of the following chapters of these specifications:

- Chapter 3 (Traffic and WIM Monitoring System Supplier quality assurance).
- Chapter 6 (General automatic monitoring system requirements).
- Chapter 7 (Automatic traffic monitoring system requirements).
- Chapter 8 (HS WIM monitoring system requirements).
- Chapter 9 (LS WIM Monitoring system requirements).

10.2 Monitoring system assessment reviews

A full monitoring system assessment, as specified in this chapter, will be undertaken when an application is made for a new *Traffic and WIM Monitoring System Certificate*. For the review of the monitoring systems as required in Chapter 3 (Traffic and WIM Monitoring System Supplier quality assurance), however, the *Certification Organisation* may only require a partial assessment of the system.

The review must, at a minimum, include assessments of the following requirements as specified in this chapter:

a) Evidentiary documentation.
b) Visual inspection assessments.

The requirements below will be assessed when an application is made for a new certificate. During the review of the monitoring system, the *Certification Organisation* will decide on whether these assessments must be undertaken.

a) Operational assessments.
b) Accuracy assessments.
c) Data assessments.

10.3 Monitoring system assessment

The *Systems Supplier* will be responsible for undertaking the assessments required by these specifications, but such assessments must be undertaken under control and supervision of the *Certification Organisation*. The *System Supplier* will inter alia be responsible for the following:

a) Selection and preparation of the site and the installation of a monitoring system at which the assessment will be undertaken.
b) Provision of all testing equipment and facilities that are required for the assessment.
c) Undertaking all required tests and the collection and analysis of test data.
d) Submission of the information and collected data, as well as the results of the assessment to the *Certification Organisation*.

The *Certification Organisation* will verify that the assessments have been undertaken in accordance with the specifications, and that the assessments have not been falsified or fabricated. For this purpose, it will not be necessary to verify all the data collected during the assessments and a sample of data may be randomly or specifically selected for this purpose. The *Certification Organisation* will also verify that collected data were analysed correctly and that the system complies with the accuracy and other requirements of these specifications.

10.4 Monitoring system components

The monitoring system installation for the assessment must include all the components, including those that are considered as optional. Where a monitoring system consists of optional components, assessments must also be undertaken to determine whether the operation and accuracy of the system will not be affected by excluding the optional components.

10.5 Assessment site

The *System Supplier* will be responsible for the selection and preparation of the assessment site. The system may be assessed at a new site or at an existing site that complies with the roadway and desirable pavement requirements specified in Chapter 11 (Automatic monitoring site requirements).

The traffic monitoring system must be installed over all lanes at the site (and shoulders were appropriate). On multilane roads, however, the installation is only required for one of the travel directions, provided that the system is installed over at least two lanes in the direction. WIM monitoring systems must be assessed in combination with a traffic monitoring system but the WIM assessment is only required for one of the lanes at the site.

Where assessments of load accuracies are required, the following additional requirements apply:

a) The site should preferably be near to a static weighbridge that can be used to undertake the reference load measurements.
b) Where a weighbridge is not available, a certified LS WIM may be used to undertake the load measurements. A suitable location must then be available at which a LS WIM system can be installed. Preference should be given to the installation of the LS WIM on the roadway itself or on the paved shoulder, but a constructed lay-by may also be used for this purpose. The LS WIM site must be at least 1 km downstream or at least 5 km upstream of the assessment site to prevent the possible interference of traffic flow at the assessment site.

Approval must be obtained from the *Road Authority* responsible for the road on which the monitoring system assessment will be undertaken. The *System Supplier* will also be responsible for restoring the site to the satisfaction of the *Road Authority* responsible for the road on completion of the assessment.

10.6 Assessment duration

The monitoring system assessment must be undertaken over the following durations:

a) *Assessments required for new certificates*. The duration of the monitoring assessment required for new certificates are as follows:

   i) 28 Days for monitoring systems that will be used for traffic monitoring over periods of longer than 7 days.
   ii) 14 Days for monitoring that will only be used for traffic monitoring over periods of 7 days or shorter.

b) *Reviews of monitoring systems*. During reviews the duration of the assessment must be the minimum required to complete all the assessments required for the review.

During the assessment, a total of 24 hours of grace will be allowed during which the *System Supplier* may undertake adjustments or repair the equipment, provided that the make, type or version of the equipment is not changed. Failure to comply with this requirement will be taken as failure of the system.

Some of the assessments may require interference with the operation of the system, but where possible, the assessments must be undertaken without affecting operations.

Data must continuously be collected over the duration of the assessment. Data must be available for the full assessment period, excluding the grace period and the periods during which the monitoring system assessments have interfered with the operation of the system. Failure in providing the full data set will be taken as failure of the system.

10.7 Evidentiary documentation

The *System Supplier* must submit the evidentiary documentation listed below to the *Certification Organisation* to show that the system complies with the following requirements. The Certification Organisation will assess the documentation to determine whether the system and document complies with the requirements of these specifications.

a) The following manuals as specified in Chapter 3 (Traffic and WIM Monitoring System Supplier quality assurance):

   i) System supplier quality assurance manuals.
   ii) Service provider quality assurance manuals.
   iii) Service provider training manuals.
   iv) Service provider monitoring system manuals.

b) The following general requirements as specified in Chapter 6 (General automatic monitoring system requirements):

i) Environmental conditions.
ii) Environmental requirements.
iii) Operational requirements.
iv) Power provision requirements.
v) Data recording capabilities.
vi) Data extraction requirements.
vii) Real-time monitoring requirements.

c) The following traffic monitoring system requirements as specified in Chapter 7 (Automatic traffic monitoring system requirements):

i) Detection capability requirements.
ii) Data requirements.
iii) Resolution requirements.

The evidentiary documentation must include evidence that shows that the system is capable of detecting and recording the directions of vehicles travelling in the wrong direction or which are reversing over the monitoring site. Where such evidence are not acceptable to the Certification Organisation, the Service Provider will be allowed to undertake an assessment at a site at which the monitoring system is installed in the reverse direction (opposite to the normal direction of travel). In such case, the detection accuracy requirements of Chapter 7 (Automatic traffic monitoring system requirements) will apply.

d) The following high-speed WIM system requirements as specified in Chapter 8 (Traffic and HS WIM monitoring system requirements):

i) Detection capability requirements.
ii) Data requirements.
iii) Resolution requirements.

e) The following low-speed WIM system requirements as specified in Chapter 9 (LS WIM Monitoring system requirements):

i) Data requirements.
ii) Resolution requirements.

10.8 Visual inspection assessment

A visual inspection of the installed monitoring system will be undertaken by the *Certification Organisation*, with the assistance of the *System Supplier*, with the purpose of evaluating the following general requirements as specified in Chapter 6 (General automatic monitoring system requirements):

a) Whether the installed system and sensors have not caused, or will not cause, undesirable environmental effects.
b) Whether the installed system and sensors are not aesthetically or visually obtrusive.
c) Whether the system is reasonably protected against theft and vandalism.
d) Whether the sensors remain fixed for the duration of the assessment and the likelihood that the sensors will remain fixed in future.

e) Whether the system or sensors may create a road or traffic hazard or endanger the safety of people, animals, vehicles or property.

10.9 Operational assessment

Operational assessments of the installed system must be undertaken by the *Certification Organisation*, with the assistance of the *System Supplier*, to determine whether the system complies with the following general requirements as specified in Chapter 6 (General automatic monitoring system requirements):

a) Whether recorded data will be lost when power supply to the system is interrupted or switched off.
b) Whether the system allows data extraction while in operation, and without affecting the data collection and processing capabilities of the system.
c) Whether the system has the specified real-time monitoring capabilities.

10.10 Accuracy assessment

The following accuracy assessments must be undertaken by the *System Supplier* under the control and supervision of the *Certification Organisation*, with the purpose of evaluating whether the system complies with the accuracy requirements of these specifications:

a) Vehicle, trailer, axle, wheel and single/dual tyre detection and vehicle classification accuracy requirements as specified in Chapter 7 (Automatic traffic monitoring system requirements).
b) Speed, vehicle length and axle spacing accuracy requirements as specified in Chapter 7 (Automatic traffic monitoring system requirements).
c) High-speed WIM load accuracy requirements as specified in Chapter 8 (Traffic and HS WIM monitoring system requirements).
d) Low-speed WIM load accuracy requirements as specified in Chapter 9 (LS WIM Monitoring system requirements).

The methodology that must be followed for the assessment of the accuracy of a monitoring system is described in Appendix C. This methodology requires that the *System Supplier* must undertake all the required assessments while the *Certification Organisation* only needs to verify the assessments on a sampling basis. The purpose of such verification is to ensure that the assessments have been correctly undertaken and that the assessments have not been falsified or fabricated.

The minimum sample size requirements for the accuracy assessments by the *System Supplier* are given in Table 10. Differentiation is made in the table between the different accuracy requirements as well as the different monitoring system types and classes. The minimum sample sizes are applicable to vehicles that comply with the different requirements of the accuracy specifications (including any range or minimum value requirements).

The *System Supplier* may increase any of the minimum sample sizes in Table 10 to improve the statistical reliability of the assessment. No vehicles, however, may be excluded from the sample when the sample size is increased.

The sample sizes required by the *Certification Organisation* for the verification of the assessments will be determined by the organisation.

Table 10 Minimum sample size requirements for monitoring system assessments

Traffic monitoring requirements	Traffic monitoring system type									
	A1	A2	B1	B2	C1	C2	D1	D2	E1	E2
Vehicle detection - Normal travel	600	300	600	300	300	60	60	30	300	60
Vehicle detection - Straddling veh	60	30	60	30	30	30	30	30	30	30
Vehicle detection – Wrong direction	600	300	600	300	300	60	60	30	300	60
Trailer detection	300	150	300	150	-	-	-	-	-	-
Axle detection	600	300	600	300	-	-	-	-	600	300
Wheel detection	120	60	-	-	-	-	-	-	-	-
Single/dual tyre	600	300	-	-	-	-	-	-	-	-
Vehicles not/wrongly categorised	300	150	150	75	50	30	-	-	50	30
Light vehicles categorised as heavy	300	150	150	75	50	30	-	-	50	30
Heavy vehicles categorised as light	300	150	150	75	50	30	-	-	50	30
Heavy vehicles wrongly categorised	300	150	150	75	50	30	-	-	50	30
Light vehicle speed > 30 km/h	100	100	100	100	100	100	-		100	100
Heavy vehicle speed > 30 km/h	100	100	100	100	100	100	-		100	100
Light vehicle length 3 to 5 m	100	100	100	100	100	100	-	-	100	100
Light vehicle length > 5 m	100	100	100	100	100	100	-	-	100	100
Heavy vehicle length > 5 m	100	100	100	100	100	100	-	-	100	100
Light vehicle axle spacing 1 to 3 m	100	100	100	100	-	-	-	-	100	100
Light vehicle axle spacing > 3 m	100	100	100	100	-	-	-	-	100	100
Heavy vehicle axle spacing 1 to 3 m	100	100	100	100	-	-	-	-	100	100
Heavy vehicle axle spacing > 3 m	100	100	100	100	-	-	-	-	100	100

HS WIM monitoring requirements	HS WIM monitoring system class		
	Class I	Class II	Class II
Gross vehicle mass	200	200	200
Axle group mass (excl single axles)	200	200	200
Single axle load	200	200	200

10.11 Data assessment

The *System Supplier* will be required to extract data on a daily basis and submit the data to the *Certification Organisation* in accordance with the requirements specified in Chapter 19 (Monitoring data requirements). The data must be converted to the format as specified in the *South African Standard Traffic Data Collection Format* and authenticated by means of authentication software to be provided by the South African National Road Agency Ltd (SANRAL).

The submitted data must be verified and analysed by the *System Supplier* in accordance with the requirements of and using the data management software of the South African National Road Agency Ltd (SANRAL) as specified in Chapter 19 (Monitoring data requirements). The requirements include those applicable to the time periods in which the verification must be completed. The results of the verification and analysis must be made available to the *Certification Organisation*.

If any of the data are found suspect, then the data must be investigated by the *System Supplier* and recommendations made to the *Certification Organisation* on whether the data must be accepted or rejected in terms of the requirements specified in Chapter 19 (Monitoring data requirements). The *Certification Organisation* may accept or reject such recommendations. If rejected, the system will be considered to have failed.

Part 3
Automatic Monitoring Site and System Installation Requirements

Part 3: Automatic Monitoring Site and System Installation Requirements

Part 3 contains the requirements that are applicable to monitoring sites and system installations where traffic monitoring and WIM services are provided. These requirements are applicable to the provision of automatic traffic and WIM monitoring services and not to manual traffic monitoring services. The requirements are provided in the following chapters:

Chapter 11 Automatic monitoring site requirements.

Chapter 12 Installed automatic monitoring system requirements.

Chapter 13 Installed automatic monitoring system assessments.

Chapter 14 Site works requirements.

11 AUTOMATIC MONITORING SITE REQUIREMENTS

11.1 Site requirements

This chapter provides requirements that must be complied with in locating monitoring sites at which monitoring systems will be installed for the provision of monitoring services.

The requirements of this chapter are not only applicable at the commencement of a monitoring service but must be complied with for the full duration of the service.

11.2 Monitoring site definition

A monitoring site is a single location where all the lanes of traffic are monitored as specified by the *Employer*. The site must include all the roadways and lanes on the site (up to a maximum of 32 lanes per site). On double carriageway roads, both carriageways are included, even if such carriageways are located some distance apart. Where monitoring is undertaken at an intersection or interchange, all the roadways at the intersection or interchange must be included as part of the site (unless specified otherwise by the *Employer*).

In situations where a *Service Provider* may require multiple monitoring systems to monitor all the roadways and lanes as a single site, the *Service Provider* may define partial sites and combine these sites in a Combination site as specified in the *South African Standard Traffic Data Collection Format*. For the purpose of these specifications, such a combination site is treated as a single site. The *Employer* may, however, specify that the collected data must be submitted for each individual partial site or for the combination site as a whole.

Where toll monitoring is undertaken, each individual toll monitoring system must be defined as a separate monitoring site and not as a combination site. Each individual monitoring system must operate fully independently of each other.

11.3 Monitoring site stratification

Short-term (shorter than one year) traffic characteristics must be expanded to equivalent annual characteristics using expansion factors derived by means of a stratification system. The stratification systems (one or more) that must be used for this purpose is defined in TMH 8 (COTO, 2015).

The system requires that both short-term and long-term monitoring sites must be grouped into stratification strata and clusters consisting of one or more monitoring sites with similar characteristics. Each stratum must contain at least one long-term monitoring site. For each stratum or cluster, a set of expansion factors and typical traffic characteristics must be derived from the long-term sites that can be used for deriving equivalent annual characteristics at the short-term sites.

The *Service Provider* in co-operation with the *Employer* will be responsible for implementing the stratification system, including the grouping of monitoring sites in strata and clusters (unless otherwise specified by the *Employer*). The Employer will specify the software that must be used by the Service Provider for this purpose. In the absence of such specification, the software specified by the South African National Road Agency Ltd (SANRAL) shall be used for this purpose.

11.4 Monitoring site location

The *Employer* will specify a road section on which traffic and/or WIM monitoring must be undertaken, but the *Service Provider* is responsible for selecting the exact location of the monitoring site. The *Service Provider* is responsible for ensuring that the roadway at the site complies with the requirements specified in this chapter.

The *Employer* or *Road Authority* may make information available that can be used by the *Service Provider* for the selection of the location of the monitoring site. The *Service Provider* will, however, be responsible for ensuring that the provided data is correct and that the selected location fully complies with the requirements specified in this chapter.

In the selection of the site, consideration must be given to the probability that the roadway may deteriorate to such an extent that it may not comply with the requirements specified in this chapter during the required period of observations. Should a monitoring site be discontinued during monitoring, the requirements specified in Chapter 21 (Payment requirements) of these specifications will apply.

11.5 Existing monitoring sites

Where an existing monitoring site is available on a road section, preference must be given to the re-use of such a site. The *Service Provider* must therefore investigate the suitability of such a site in terms of the following requirements:

- It must be possible to install the monitoring system at the site (the site must be compatible with the requirements of the monitoring system).
- The site must fully comply with the requirements specified in this chapter and continue to do so for the duration of the monitoring service.

Where an existing monitoring site is found to be unsuitable, the *Service Provider* must submit a report to the *Employer* stating the reasons why the site is unsuitable for re-use.

Where a site is found to be suitable, the facilities that were previously installed at the site must be re-used as far as possible.

11.6 Road geometry and pavement requirements

Requirements for the geometry of a road and the quality of the road pavement are provided in the following sections of this chapter. No monitoring may be undertaken at sites that do not comply with these requirements, unless otherwise required by the *Employer*.

The *Employer* may require monitoring on road sections that do not comply with the requirements. In such cases, the *Service Provider* must select the best available sites on the road sections. However, none of the accuracy requirements affected by such non-compliance will then be applicable to the monitoring site and the *Service Provider* will not be penalised for such non-compliance.

The following accuracy requirements may be affected by the non-compliance:

a) Accuracy requirements for toll and traffic monitoring provided in Chapter 7 (Automatic traffic monitoring system requirements).
b) Accuracy requirements for HS WIM monitoring provided in Chapter 8 (HS WIM monitoring system requirements).
c) Data verification tests provided in Appendix D.

11.7 Road geometry requirements

The road geometry requirements provided in this section are applicable to monitoring sites where toll, traffic or HS WIM monitoring will be undertaken, but not to LS WIM monitoring.

The following road geometry requirements are applicable to all toll, traffic and HS WIM monitoring sites:

a) The site must not be located at a position where the accuracy of the monitoring can be affected by factors such as the following:
    i) Acceleration and deceleration caused by any permanent or temporary obstructions on the road. Such acceleration may occur near to intersections interchanges, railway crossings, toll plazas, truck stops, steep gradients, sharp curves, no-overtaking lines or any other obstructions that may result in speed changes along the road.
    ii) Stopping on the site or on the shoulder (including queue formation at a downstream location).
    iii) Lane changing and straddling due to factors such as overtaking, weaving, vehicles travelling or stopping on the shoulders. Where no suitable site can be identified, the *Employer* may consider the installation of traffic channelling devices.
b) The monitoring site must not be located close to a radio transmitter, under a high voltage power line, close to a railway track or anything else which could affect the operation of the monitoring system.

A further requirement applicable to HS WIM monitoring sites only (not to traffic and toll monitoring sites) is that the sites must not be located at positions where load transfer can occur between different axles or wheels of a vehicle. The following requirements, in addition to those listed above, are required for this purpose:

a) The road segment between 200 m upstream and 50 m downstream from the HS WIM site must comply with the following requirements:
    i) The longitudinal gradient (slope) must preferably not be steeper than 1% but gradients of up to 2% are acceptable.
    ii) The transverse slope (crossfall) must preferably be less than 2% but slopes of up to 3% are acceptable.

iii) The horizontal curve radius must preferably not be greater than 2 500 m but radii of down to 1 000 m are acceptable.
iv) There must be no changes in road width (including shoulder width) that could result in lane change manoeuvres at the site.

b) The site must be located away from the following:

i) A bridge overpass that could result in aerodynamic effects on vehicles.
ii) Any structure giving support different from that of the road pavement.

The *Service Provider* is responsible for obtaining the information required for the assessment of the above road geometry requirements. Where such information is not available, the *Service Provider* must undertake the measurements required for the assessment.

11.8 Road pavement requirements

The road pavement requirements provided in this section are only applicable to sites where HS WIM monitoring will be undertaken. The requirements are aimed at ensuring a relatively smooth road surface with a low level of flexibility that is required for accurate and reliable HS WIM monitoring.

The pavement of the road segment between 200 m upstream and 50 m downstream of the site must comply with the requirements provided in Table 11 with respect to the following pavement properties:

a) Rutting (mm)

i) Measured in accordance with the requirements of TMH13 Automated Pavement Condition Measurements (COTO, 2013).
ii) Measured at 10 m intervals (measured with a 2 m straight edge). Measured over the wheel path in which the HS WIM sensor is installed.
iii) The highest observation may not exceed the worst value given in the table.
iv) The 95th percentile observation may not exceed the allowable value in the table.

b) International Roughness Index IRI (mm/m)

i) Measured in accordance with the requirements of TMH13 Automated Pavement Condition Measurements (COTO, 2013).
ii) Measured at 10 m intervals in both wheel paths.
iii) The highest observation may not exceed the worst value given in the table.
iv) The 95th percentile observation may not exceed the allowable value in the table.

c) Maximum Deflection (μm)

i) Measured in accordance with the requirements of TMH13 Automated Pavement Condition Measurements (COTO, 2013). An axle load of 8000 kg (80 kN) must be used for this purpose.
ii) Measured at 5 m intervals in the wheel path in which the WIM sensor is installed.
iii) The highest observation may not exceed the worst value given in the table.

iv) The 95th percentile observation may not exceed the allowable value in the table.

d) Faulting (mm), in the case of jointed concrete pavements

i) Measured in accordance with the requirements of TMH9 Visual Assessment Manual for Roads (COTO, 2013).
ii) A minimum of 10 observations of joints near to WIM sensor.
iii) The highest observation may not exceed the worst value given in the table.
iv) The average of the observations may not exceed the allowable value in the table.

e) Visual assessment of structural defects (cracking, pumping, showing)

i) Determined in accordance with the requirements of TMH9 Visual Assessment Manual for Roads (COTO, 2013).

The worst and allowable values provided in Table 111 must be complied with. New monitoring sites should preferably be installed at locations that comply with the desirable values to allow for the possible deterioration of the pavement over time.

Table 11 Pavement criteria applicable to concrete and asphalt pavements

Requirement	Worst observation	Allowable value	Desirable value
Rutting, mm	≤ 12.0	≤ 7.0	≤ 4.0
IRI, m/km	≤ 3.0	≤ 2.6	≤ 1.6
Max Deflection, μm	≤ 600	≤ 400	≤ 250
Faulting, mm	≤ 5.0	≤ 3.0	≤ 2.0
Visual assessment	No cracking, pumping or shoving of *Degree 2* or higher		

The *Employer* will specify whether the measurements and assessments required for assessing the above road pavement requirements must be undertaken by the *Service Provider*. In the absence of such specifications, the *Service Provider* will be required to undertake the measurements and assessments. When required, such measurements and assessments will be paid for in terms of the pay items provided in Chapter 20 (Monitoring service specification).

11.9 LS WIM Sites

The following geometric requirements are applicable to sites where LS WIM monitoring will be undertaken:

a) The longitudinal gradient may not exceed the following:

i) A maximum of 0.1% over a distance of 2 m up- and downstream of the LS WIM sensors.
ii) A maximum of 0.5% over a distance of 25 m up- and downstream of the LS WIM sensors.

b) The crossfall over a distance of 25 m up- and downstream of the LS WIM sensors may not exceed a preferable maximum of 2% but a crossfall of up to 3% is acceptable.

11.10 Power provision requirements

The *Service Provider* is responsible for procuring the power supply required to operate the system, irrespective of where the monitoring is to be undertaken. Any power source suitable to operate the system may be used, such as electrical power, solar panels, batteries or any other suitable power system. The availability of power supply may be an important consideration in the selection of a monitoring site.

11.11 Traffic channelling devices

The Employer may consider the installation of traffic channelling devices in situations where it is not possible to identify a site where unwanted movements do not occur. Unwanted movements include movements such lane changing, weaving, straddling or vehicles travelling or stopping on the shoulder which would affect the accuracy of the traffic monitoring. Devices such as guardrails, rumble strips, road signs or road markings may be used for this purpose.

The *Service Provider* is responsible for making recommendations on the most suitable channelling devices. The *Employer* may decide to implement the devices, reject the site or continue with the monitoring without such devices. The *Employer* will be responsible for the installation of such traffic channelling devices.

11.12 Obstructions and services

The site may not be located near to any obstruction or services where it will be necessary to protect, move or relocate the obstruction or services. Where the site cannot be located elsewhere, the site must be referred to the *Employer* for a decision. The *Service Provider* will not be required to undertake any work involving the protection, moving or relocation of such obstructions or services.

It is, however, the responsibility of the *Service Provider* to locate any obstructions or services and the *Service Provider* will be responsible for any damage caused to such obstructions or services. All such damages shall be immediately repaired and reinstated at the expense of the *Service Provider* and to the satisfaction of the *Employer*.

Obstructions and services include cables, pipes and conduits for electricity, telephone and telegraph connections, water, sewage, etc. as well as any other man-made or natural structures or obstacles.

11.13 Additional considerations

The following is a list of additional considerations that should be taken into account when selecting a location for a monitoring site. These considerations, however, are not mandatory and non-compliance of these factors will not invalidate a site.

a) Availability of communication links (such as telephone or cell phone).
b) Quality of road drainage.
c) Danger of lightning strikes.
d) Infestation by vermin.
e) Risk of theft and vandalism.
f) Suitability of the location for performing installation and periodic assessments and maintenance of the system.

11.14 Site information records

The *Service Provider* is required to collect site information and maintain a record containing this information for each monitoring site. The Site Provider must make a copy of the latest record available to the *Employer* in electronic as well as hard copy format. Such a copy must be provided whenever any information is added to or changed on the site particulars.

The following information must be obtained for each site and provided in the record:

a) A scaled sketch of the layout of the site, showing the location of all equipment, sensors and auxiliary facilities. This sketch must be produced on A4 size paper.
b) Photographs of all equipment, sensors and auxiliary facilities, as well as photographs of the roadway over a distance of at least 100 m up- and downstream of the site.
c) Assessment of the road geometry and pavement requirements, together with any information or data used for the assessment.
d) Site Information as specified by the *South African Standard Traffic Data Collection Format*.

The *Service Provider* will be responsible for obtaining a site identifier for the monitoring site as specified in the *South African Standard Traffic Data Collection Format*. Once a site Identifier has been allocated to a specific site, no definition data such as traffic stream, lane definition data, and reference site definitions may be changed.

Should there be a need to change any of the site definition data (such as when provision must be made for additional lanes) a new site identifier must be assigned to the site. The site information for the old site must be retained, but the old site must be marked as “discontinued”. The old site identifier may never again be used at the particular or any other location. The information for the new site must, however, include a reference to the old (historical) site as well as lane number assignments.

Where use is made of partial sites, separate records must be kept for each partial site and for the combined site. A site identifier must be allocated to each partial site and a separate identifier to the combination site. Requirements for combination sites are specified in the *South African Standard Traffic Data Collection Format*.

12 INSTALLED AUTOMATIC MONITORING SYSTEM REQUIREMENTS

12.1 Introduction

Only monitoring systems that carry a valid *Traffic and WIM Monitoring System Certificate* issued by the *Certification Organisation* may be used for the provision of monitoring services.

Installed monitoring systems must comply with the requirements specified in this chapter in addition to relevant requirements specified in the following chapters:

- Chapter 6 (General automatic monitoring system requirements).
- Chapter 7 (Automatic traffic monitoring system requirements).
- Chapter 8 (HS WIM monitoring system requirements).
- Chapter 9 (LS WIM Monitoring system requirements).

This chapter also provides the requirements for the removal of a monitoring system installation when the monitoring service is no longer necessary.

In addition to the requirements of these specifications, installed systems must also comply with the requirements of the monitoring system manuals of the *System Supplier* as specified in Chapter 3 (Traffic and WIM Monitoring System Supplier quality assurance).

It is also the responsibility of the *Service Provider* to institute a quality control system according to the quality assurance requirements of these specifications as specified in Chapter 3 (Traffic and WIM Monitoring System Supplier quality assurance requirements) and in Chapter 4 (Traffic and WIM Monitoring Service Provider quality assurance).

12.2 Installation requirements

In addition to other requirements specified elsewhere in these specifications, installations must also comply with the following requirements:

a) There may not be any leaking or spillage of hazardous, toxic or undesirable materials, fluids or gases into the environment.

b) The installed system and sensors may not be aesthetically or visually obtrusive. All parts of the system must, as far as practically possible, be hidden from view or blended with the background.

c) There may not be any visible loose wiring or other parts protruding from the road pavement, ground surface or equipment housing.

d) Where sensors are installed in or on the pavement, care must be taken to minimise damage to the pavement surface. No unnecessary cutting or removal of the pavement may be made.

e) Where kerbs are installed along the road, cutting of such kerbs must be avoided and conduits must be laid underneath the kerbs, where possible.

f) The monitoring system or ancillary facilities, including equipment housing, enclosures, cages, poles, etc., may not create a hazard or danger to the traffic. Where possible, hazardous objects must be installed behind a safety barrier, if such a barrier is available. If not available, the clear distance between the object and the side of the travelled roadway (not side of shoulders) may not be less than the minimum distances provided in Table 12 for different speed limits.

g) No signs, notices or advertisements may be erected on or along the site without the written approval of the *Employer* as well as the *Road Authority*. Such signs, notices or advertisements may not create a danger to traffic or distract drivers. The *Employer* or *Road Authority* has the right to have any sign, notice or advertisement moved to another location or removed from the monitoring site.

h) After installation, all rubble, debris, dirt, materials or anything else that resulted from the installation must be removed and the site cleaned and finished off. Any backfilled trenches and holes must be compacted and reinstated to the original ground level. No trees, shrubs or plants may be damaged unnecessarily and any removed grass or plants must be replanted and watered.

Table 12 Clear distances for monitor housings or enclosures

Speed limit	Minimum clear distance from side of travel way (excluding shoulders)
60 km/h or less	5 m
70 km/h	6 m
80 km/h	7 m
90 km/h	8 m
100 km/h or more	9 m

Based on AASHTO (2006)

12.3 Removal requirements

The *Employer* will specify whether or not a monitoring site must be removed on completion of a monitoring service and when the site is no longer required. In the absence of such a specification by the Employer, the monitoring site must be removed when it is no longer required.

Removal of a monitoring site entails the removal of all equipment, sensors, equipment housing, auxiliary facilities, signs and notices installed by the *Service Provider* at the site. Where a concrete slab was used for the monitoring housing or enclosure, the concrete does not have to be removed if approval is obtained from the *Employer*. Otherwise such concrete must also be removed.

Non-removal of a monitoring site entails the retention of all non-movable equipment, sensors and auxiliary facilities as well as signs and notices installed by the *Service Provider* at the site. Movable equipment, sensors and auxiliary facilities as well as equipment housing are excluded and may be removed by the Service Provider. Non-movable

equipment, sensors and auxiliary facilities are those that have been imbedded in soil, the road pavement or in concrete. Movable equipment, sensors, equipment housing and auxiliary facilities are those that are either not fixed, or which are fixed by means of fasteners such as nails, screws and bolts.

Any direct or indirect damage caused by the *Service Provider* or the monitoring system must be repaired by the *Service Provider*. These include any damage to the road, the road pavement, kerbs, channels or any other structures along the road, as well as the environment. The reparation must be undertaken using materials and methods approved by the *Employer* and *Road Authority.* Damage to the road pavement may include, but is not limited to, surface ravelling (spalling), “pumping”, potholing and subsidence of the road or pavement.

13 INSTALLED AUTOMATIC MONITORING SYSTEM ASSESSMENTS

13.1 Introduction

Assessments of automatic monitoring sites and system installations must be undertaken after the installation or removal of a monitoring system, as well as periodically during the project to determine whether the site, together with the installed monitoring system, complies with the requirements of these specifications. The assessments must also be undertaken in situations where existing sites are being re-used.

This chapter describes the assessments that must be undertaken by the *Service Provider* at all installed systems, as well as assessments that will be undertaken by the *Certification Organisation* during the review of a *Traffic and WIM Monitoring Service Provider Certificate* as specified in Chapter 2 (Service provider and monitoring system certification).

13.2 Installed monitoring system assessments

The *Service Provider* is responsible for undertaking the assessments specified in this chapter, but must inform the *Employer* when such assessments will be undertaken. The *Employer* may elect to attend and monitor the assessments. The assessments must be undertaken as follows:

a) After installation of a system, but before monitoring is undertaken.
b) For systems other than those required for toll traffic monitoring, annually at 12 month intervals (with a grace period of two months). For systems used for toll traffic monitoring at three-month intervals (with a grace period of three weeks).
c) When suspect data are identified during data monitoring.
d) After removal of the system.

The *Certification Organisation* will also undertake assessments of the monitoring site and the monitoring system installation during a *Service Provider* review as specified in Chapter 2 (Service provider and monitoring system certification). Such assessments may be undertaken at specific monitoring system installations or at randomly selected installations. The assessments will be undertaken with the assistance of the *Service Provider*.

13.3 Visual assessment of the installed monitoring system

A visual inspection must be undertaken of the installed monitoring system to evaluate the following:

a) Whether the system complies with the requirements of the monitoring system manuals of the *System Supplier,* as specified in Chapter 3 (Traffic and WIM Monitoring System Supplier quality assurance).

b) Whether the system complies with the following requirements specified in Chapter 6 (General automatic monitoring system requirements) and Chapter 12 (Installed automatic monitoring system requirements):

i) Whether the system has not caused undesirable environmental effects.
ii) Whether the installed system is aesthetically or visually obtrusive.
iii) Whether the sensors are fixed to the road pavement.
iv) Whether the system and sensors will not cause a road or traffic hazard or endanger the safety of people, animals, vehicles or property.
v) Damage to the pavement surface and kerbs (where installed).
vi) Erection of signs, notices or advertisements.
vii) Removal of rubble, debris, dirt and materials and the backfilling of trenches and holes. Replanting of grass and plants.

13.4 Monitoring system accuracy assessments

In terms of these specifications, no assessments are required of the accuracy requirements specified in Chapter 7 (Automatic traffic monitoring system requirements) and Chapter 8 (HS WIM monitoring system requirements). The *Service Provider*, however, is free to undertake such assessments and to include the results of such assessments in the assessment report.

13.5 Installed measuring system assessment report

On completion of the monitoring site assessment, the *Service Provider* must prepare and submit to the *Employer* an assessment report in which it is certified that the monitoring site complies with all the relevant requirements of these specifications. No monitoring may commence without such certification by the *Service Provider*.

13.6 Remedial measures

When it is found that an installed monitoring system does not comply with the requirements of these specifications, the *Service Provider* will be required to apply remedial measures to make good any defects. These measures may include the complete replacement of a monitoring site.

The remedial measures shall ensure that the installed monitoring system complies in all respects with the requirements of these specifications.

14 SITE WORKS REQUIREMENTS

14.1 Introduction

This chapter provides the requirements for any work that is undertaken at an automatic monitoring site. Such work includes the installation, maintenance and removal of the traffic or WIM system, assessments, data extraction and any visits to the site.

The *Service Provider* is responsible for implementing all the requirements of this chapter.

14.2 Wayleave application

The *Service Provider* is responsible for applying for all wayleave applications that may be required by the *Road Authority* responsible for the road, even in situations where the *Road Authority* is also the *Employer*.

Wayleave applications are required for all new monitoring sites or at existing sites where changes to sensors and other facilities are required. Wayleave applications must also be made when the flow of traffic will be interfered with.

The *Service Provider* must obtain the wayleave from the applicable *Road Authority* and submit a copy thereof to the *Employer* before the work is undertaken. The *Service Provider* will not undertake any work without an approved wayleave.

The wayleave will allow the *Service Provider* to undertake the specified work, subject to conditions in the wayleave. It is the responsibility of the *Service Provider* to ensure that the conditions of the wayleave are complied with.

Under no circumstances will approval be given for the use of explosives during the work.

14.3 Work on properties outside road reserve

Where work must be undertaken on properties outside the road reserve or where there is a need to obtain access to electricity and communication, the *Service Provider* must enter into a written agreement with the owners of such properties, and submit copies of the signed agreement to the *Employer* before any work is undertaken on such a property.

Such an agreement must include provisions for the following:

a) The use of and compensation for electricity and communications.
b) The reinstatement of property occupied, used, damaged or destroyed, or compensation therefore, in lieu of reinstatement.

On completion of the project, the *Service Provider* must obtain a written statement from the owner concerned, to the effect that the *Service Provider* has fulfilled all obligations under the written agreement.

14.4 Traffic accommodation

The *Service Provider* is responsible for the traffic accommodation measures that are required to ensure the safe and effective passage of traffic through the site during system installation, maintenance and removal, as well as during periodic monitoring site assessments. No part of the work may be commenced with before adequate provision has been made for the accommodation of traffic.

The *Service Provider* must comply with the traffic accommodation requirements of the latest editions of the following documents:

a) SADC and South African Road Traffic Signs Manual.

b) The Standard Specifications for Road and Bridge Works for State Road Authorities of the Land Transport Officials, (COLTO).

All traffic accommodation measures and road traffic signs must be removed immediately when the measures or signs are no longer required.

14.5 Legal requirements

The *Service Provider* must be fully conversant with the latest enactments, provisions and regulations of all relevant legislative and statutory bodies and shall in all respects and at all times comply with all such enactments, provisions and regulations.

This includes any work that is undertaken adjacent to or at any infrastructure of a legislative or statutory body, such as but not limited to, roads, railway lines, electricity lines, telephone lines, water or oil pipelines, water channels or any other similar types of infrastructure.

The legal requirements include, but are not limited to the following:

a) The Occupational Health and Safety Act, 1993 (Act No 85 of 1993).

b) All municipal regulations, laws, by-laws and special requirements of the local Municipality.

Part 4
Manual Traffic Monitoring Requirements

Part 4: Manual Traffic Monitoring Requirements

Part 4 contains the requirements for the provision of manual traffic monitoring services. The requirements are provided in the following chapters:

Chapter 15 Manual traffic monitoring types

Chapter 16 Manual traffic monitoring site requirements

Chapter 17 Traffic monitoring fieldworker requirements

15 MANUAL TRAFFIC MONITORING TYPES

15.1 Manual traffic monitoring

Manual traffic monitoring is monitoring that is primarily undertaken by humans, although use may be made of mechanical and electronic equipment or devices for the monitoring.

The scope of these specifications include manual monitoring of vehicular (motorised) as well as non-motorised traffic (e.g. pedestrians and cyclists). The *Employer* will specify which traffic must be counted as well as the classification system that must be used for the classification of vehicular as well as non-motorised traffic.

15.2 Manual monitoring types

Differentiation is made in these specifications between the following manual traffic monitoring types:

a) *Type M1 video-based monitoring* in which videos are used to record traffic and the traffic is manually monitored from the videos. This method offers the highest level of accuracy and quality control that can be implemented with manual traffic monitoring.

b) *Type M2 individual monitoring* in which devices are used to register particulars of each passing vehicle on the road. This method offers an intermediate level of accuracy and quality control for manual traffic monitoring.

c) *Type M3 interval monitoring* in which cumulative counts of passing traffic are made in time intervals. This method offers the lowest level of accuracy and quality control for manual traffic monitoring.

The *Employer* will specify the monitoring type when a manual traffic monitoring service is required. In the absence of a type being specified by the *Employer*, the Type M1 manual monitoring type must be implemented.

When a manual monitoring type is specified by the *Employer* (or when required in the previous paragraph), the Service Provider will be allowed to use one of the alternative monitoring types listed in Table 13 subject to the condition that no additional payment will be made for the monitoring service and that payment for the service will be made at the tariff tendered for the specified monitoring type.

Table 13 Alternative manual monitoring types

Required type	Monitoring types that may be used by Service Provider		
	M1	M2	M3
M1	✓		
M2	✓	✓	
M3	✓	✓	✓

✓	May be used by Service Provider subject to conditions

15.3 Type M1 video-based monitoring

Type M1 video-based manual monitoring is monitoring in which videos are used to record traffic and the traffic is afterwards counted manually from the videos.

The videos must be recorded using suitable video recording devices. The recorded videos must comply with the following requirements:

a) The video must be encoded in the MPeg 4 format using the H.264 codec (ISO/IEC 14496 – Coding of audio-visual objects).
b) The video resolution must be at least 640 pixels wide and 480 pixels high.
c) The frame speed must be at least 15 frames per second.
d) The video recording may be made either in colour or in black and white (grayscale).
e) The quality of the video must be such that vehicles or non-motorised traffic can be identified and classified on the video. When monitoring is required under dark conditions, the quality of the video must also be such that traffic can be identified and classified for illuminance levels of 0.001 Lux and higher.
f) Date- and timestamps must be embedded in the video metadata to allow determination of the date and time at which each individual frame was recorded with a resolution of at least 0.1 second. The date- and timestamps must be recorded with an accuracy of 60 seconds from South African Standard Time. Where multiple recorders are used at a monitoring site, the time differences between recorders may not exceed 10 seconds.
g) The start-up and end times of the recording must be confirmed by means of a cellular telephone, GPS (Global Positioning System) unit or a Portable Personal Computer (laptop). Where a cellular telephone is used, it must be synchronised with the dates and times provided by the cellular network operator. Where a laptop is used, the laptop must be synchronised with a date and time service over the internet in the 24 hour period prior to the monitoring service.

The number of videos recorders that must be used at a site is not prescribed in these specifications. It is the responsibility of the *Service Provider* to ensure that a sufficient number of video recorders is used to ensure the identification and classification of all vehicles, pedestrian and cyclists passing through a site. No traffic may be obscured or occluded by objects such as vegetation, buildings, road signs or other vehicles.

A computerised system must be used for the capturing of the traffic data from the videos. This system must provide for the manual capturing of the data. A system may also be used for the automatic capturing of data but all such data must be verified manually. The system must extract date- and timestamps from the metadata embedded in the video.

Requirements for the data that must be captured and submitted to the *Employer* are provided elsewhere in these specifications. In addition to this data, copies of all video recordings made during a monitoring service must also be submitted to the *Employer*. The *Employer* may use these video recordings in a quality control system to verify that the traffic data have been captured correctly by the *Service Provider*. The *Service Provider* will not be involved in this verification and will not be responsible for such verification.

15.4 Type M2 individual monitoring

Type M2 individual monitoring is monitoring in which electronic recorders are used to manually record the dates and times as well as other particulars of individual vehicles or non-motorised traffic passing through a site.

The recorders used for the monitoring must comply with the following requirements:

a) The recorders must be capable of capturing the date- and timestamps of all button presses. The timestamps must be recorded with a resolution of at least 0.1 second and with an accuracy of 60 seconds from South African Standard Time. Where multiple recorders are used at a monitoring site, the time differences between recorders may not exceed 10 seconds.

b) Sufficient buttons must be available on the recorder to differentiate between the different travel directions, turning movements, lanes (when required) and vehicle types. A button must be available which can be used to cancel a previously recorded button.

c) The recorders must give either a tactile or audible feedback to the operator when a button is pressed.

d) The start-up and end times of the recording must be confirmed by means of a cellular telephone, GPS (Global Positioning System) unit or a Portable Personal Computer (laptop). Where a cellular telephone is used, it must be synchronised with the dates and times provided by the cellular network operator. Where a laptop is used, the laptop must be synchronised with a date and time service over the internet in the 24 hour period prior to the monitoring service.

The number of recorders that must be used at a site is not prescribed in these specifications. It is the responsibility of the *Service Provider* to ensure that a sufficient number of operators with recorders is used to ensure that all vehicles or non-motorised traffic passing through a site are recorded.

A computerised system must be used for the extraction of the traffic data from the recorders. This system must be capable of extracting the date- and timestamps and to convert the button presses to the required traffic data.

Requirements for the required data that must be extracted and submitted to the *Employer* are provided elsewhere in this chapter and specifications.

15.5 Type M3 interval monitoring

Type M3 interval monitoring is monitoring in which individual events are not recorded and only cumulative counts are obtained during time intervals. Counts can be made of vehicles or non-motorised traffic passing through a site.

The following equipment must be used for the cumulative counts:

a) Manually operated counters are used to record vehicles or non-motorised traffic. Either mechanical or electronic equipment may be used. The equipment must be able to continually display the cumulative count. The counters must provide audible or tactile feedback to the operator when a button is pressed.

b) At least one cellular telephone or Portable Personal Computer (laptop) must be used by the survey team at the site. Where a cellular telephone is used, it must be synchronised with the dates and times provided by the cellular network operator. Where a laptop is used, the laptop must be synchronised with a date and time service over the internet in the 24 hour period prior to the monitoring service. The telephone or laptop must be capable of emitting an audible sound at the time when the count must commence and then at the end of each time interval during the traffic count.

c) Each fieldworker must be issued with one or more data forms on which the cumulative traffic counts are captured. The capturing must be done by means of pens using indelible (permanent) ink. At least two pens must be issued to each fieldworker.

d) Unless otherwise specified by the Employer, the traffic counts must be captured in 15-minute intervals.

A GPS enable camera capable of taking geo-tagged photos of the completed data forms at the monitoring site. The camera must also be capable of authenticating the photos. Alternatively, a portable personal computer (laptop) may be used for such authentication.The number of fieldworkers that must be used at a site is not prescribed in these specifications. It is the responsibility of the *Service Provider* to ensure that a sufficient number of fieldworkers is used to ensure that all vehicles or non-motorised traffic passing through a site are recorded.

The data forms that must be used by the fieldworker will be prescribed or issued by the *Employer*. In the absence of such prescribed or issued forms, the Service Provider may use its own forms provided that all relevant data are captured. The data forms must, as a minimum, provide for the capturing of the following information and data:

a) Location at which the monitoring service is provided (including GPS coordinates).
b) Date of the monitoring service (including the day of the week).
c) Weather condition during the monitoring service.
d) Times for each time interval over which traffic is monitored.
e) Travel directions, turning movements and lanes for which counts are recorded.
f) Different vehicle types for which counts are recorded.
g) Cumulative traffic counts.
h) Signatures of the fieldworkers undertaking the count.
i) Signature of the supervisor.

A computerised system must be used for the capturing of the traffic data from the data forms. This system must provide for the manual capturing of the data. A system may also be used for the automatic capturing of data but all such data must be verified manually.

Photos of the data forms must be taken at the monitoring site on completion of the monitoring service. The purpose of these photos is to verify that the forms have not been amended or changed after completion of a traffic monitoring service. A GPS enabled camera capable of taking geo-tagged photos must be used. Each photo must be date- and timestamped and the GPS location must be included in the metadata of the photo. The photos together with the metadata must also be authenticated in accordance to the requirements of Chapter 19 (Monitoring data requirements). The quality of the photos must allow the required verification of the data forms. Photos must be taken and submitted in the JPG Joint Photographic Experts Group Format.

Requirements for the required data that must be captured and submitted to the *Employer* are provided elsewhere in this chapter and specifications. In addition to this data, the Service Provider must also submit the original data forms (as completed during the monitoring service) together with the authenticated photographic images of the data forms to the *Employer*.

The *Employer* may use the submitted forms and photographic images in a quality control system to verify that the traffic data have been captured correctly by the *Service Provider*. The *Service Provider* will not be involved in this verification and will not be responsible for such verification.

15.6 Employer quality control measures

The *Employer* may implement a quality control system that is aimed at verifying that traffic data have been captured and submitted correctly by the *Service Provider*. The *Employer* will be responsible for the implementation of such a quality control system or may employ the services of another service provider for this purpose. The *Service Provider* providing the monitoring service will not be involved or responsible for this quality control. The *Service Provider*, however, is responsible for implementing quality assurance measures that are aimed at ensuring that data are captured correctly and may not rely on the quality control measures of the *Employer* for this purpose.

Accuracy requirements are provided in this section for the verification of the captured data. Should any non-compliance with these accuracy requirements be found, the *Employer* may request the *Certification Organisation* to review the quality assurance measures implemented by the *Service Provider*. Such review will be considered to form part of the normal review process by the *Certification Organisation* and the *Service Provider* will be responsible for all costs and submissions required for such review.

The *Employer* may undertake the following verification as part of the quality control system (note that no verification is required for Type M2 individual monitoring):

a) For Type M1 video-based monitoring, verification of whether vehicles and vehicle categories have been captured correctly from video recordings.
b) For Type M3 interval monitoring, verification of whether traffic data have been captured correctly from the data forms. A separate verification will also be undertaken to compare the data forms with the photographic images to determine whether the forms have been amended or changed after completion of the monitoring service.

A sample of vehicles or data entries will be randomly selected from the videos or the data forms for the verification of whether data have been captured correctly. The sample can be selected from either one video or data form or from a multiple of videos or data forms. Recommended sampling rates are given below but the Employer may select any other rate that is considered appropriate:

a) Type M1 video-based monitoring: 1% of vehicles or non-motorised traffic.
b) Type M3 interval monitoring: 10% of data entries.

The accuracy requirements for the captured data are specified in terms of the maximum allowable limit for the number of errors found in a count, expressed as a percentage of the total count in the sample. The total count in a sample will be determined as follows.

a) Type M1 video-based monitoring: The total number of vehicles or non-motorised traffic that have been included from the videos in the sample.
b) Type M3 interval monitoring: The total number of vehicles or non-motorised traffic obtained from the different entries selected from the data forms for inclusion in the sample.

Erroneous counts will be determined as follows:

a) Type M1 video-based monitoring: The number of vehicles or non-motorised traffic that were missed (not counted), created (invented) or which has been incorrectly classified by the *Service Provider*.
b) Type M3 interval monitoring: The sum of the absolute values of the differences between the actual count in the different data entries and the counts submitted by the *Service Provider*.

The proportion (percentage) of erroneous counts in the sample is determined by means of the following formula:

$$P = 100 \cdot \frac{E}{R}$$

In which:

P = Proportion (percentage) of erroneous counts in sample
E = Error count in sample
R = Total count in sample

The percentage of erroneous counts determined by means of the above formula may not exceed the maximum allowable percentages provided in Table 14 for different types of errors. The minimum sample sizes that must be used for the verification are also provided in the table.

Table 14 Manual monitoring maximum allowable percentage errors

Monitoring type	Error description	Minimum sample size (number)	Max allowable error (%)
Type M1 video	Vehicles or non-motorised traffic missed (not captured) or created (invented)	2000	0.5%
	Vehicles or non-motorised traffic not categorised, or wrongly categorised	2000	1.0%
Type M3 interval	Absolute differences between actual and submitted counts	5000	0.5%

15.7 Traffic data requirements

Requirements for the submission of traffic data to the Employer are provided in Chapter 19 (Monitoring data requirements) of these specifications. Requirements are provided for the format in which data must be submitted as well as the authentication of the submitted data.

Manual traffic count data must be submitted in the format specified in the *South African Standard Traffic Data Collection Format*, including all the data required to produce the header records defined by the format. Individual counts must be provided in the individual vehicle data format while cumulative counts must be provided in the summary data format specified in the format.

Traffic data must be captured and recorded when traffic crosses a specific line at the site. On road links, imaginary lines must be identified over the full width of the road. At intersections, the traffic must be recorded when crossing the stop or yield lines at the intersection or imaginary lines when such lines are not available. Vehicles must be captured when the rear axles of the vehicles cross the lines.

The following data must be captured and provided for individual traffic data:

a) *Departure date and time*. The departure date and time on and at which the rear axle of the vehicle crosses a specific line on the site. Dates and times must be recorded in South African Standard Time, which is the Universal time (Greenwich Mean Time) plus 2 hours. The recording may not change should Daylight Saving Time be introduced in the country.

b) *Lane number (physical or virtual)*. Lane numbers must be defined in accordance to the requirements of the *South African Standard Traffic Data Collection Format*. For traffic monitoring in which per-lane capturing is not required, the different travel directions or movements must be handled as traffic lanes.

   When required by the Employer, reversing vehicles will be captured in virtual lanes. In situations where overtaking occurs, overtaking vehicles must not be handled as reversing vehicles and must be captured in the appropriate direction of travel (using virtual lanes if required by the *Employer*).

c) *Vehicle class*. The classification of the vehicle as specified below.

Cumulative counts must be converted to non-cumulative counts per time interval before it can be provided in accordance to the format. The following data are required:

a) *Date and time*. The date and time must be provided for the end of each time interval.
b) *Interval duration*. The duration of the each time interval.
c) *Lane number (physical or virtual)*. Lane numbers must be defined in accordance to the requirements of the *South African Standard Traffic Data Collection Format*. Lane numbers can also be used to define the different turning movements at an intersection.
d) *Classified counts*. The non-cumulative count per vehicle class as specified below.

Vehicles must be classified in accordance to the vehicle categories as specified in the *South African Standard Traffic Data Collection Format*. The Employer will specify the required vehicles categories for each count (including any non-motorised traffic). In the absence of such specification, no classification will be undertaken.

16 MANUAL TRAFFIC MONITORING SITE REQUIREMENTS

16.1 Link and intersection monitoring

Requirements are provided in this chapter for the monitoring sites at which manual traffic monitoring services may be provided. Differentiation is made between the following site types:

a) Link monitoring sites.
b) Intersection monitoring sites.

When specifying a manual traffic monitoring service, the Employer must specify whether link or intersection monitoring is required.

16.2 Link monitoring sites

Link traffic monitoring is undertaken on road sections between intersections. A link monitoring site is a single location where all lanes of traffic are monitored as specified by the *Employer*.

The link monitoring site may be either some distance from an intersection or directly adjacent to the intersection. The *Employer* must either specify the location of the site or the road link on which the monitoring must be undertaken. When a road link is specified, the *Service Provider* is responsible for identifying the location of the monitoring site on the link. In such cases, locations must be selected which are reasonably representative of average traffic volumes on the road link.

The following requirements apply to link monitoring sites:

a) The link monitoring must be undertaken for both directions of travel and the monitoring must differentiate between the two directions.
b) On double carriageway roads, the monitoring must be undertaken on both carriageways, even if the carriageways are some distance apart.
c) Traffic counts must be made of traffic (vehicles or non-motorised traffic) travelling over an imaginary straight line over the width of the roads. For vehicle counts, the counts must be made when the rear axles of the vehicles cross this line.
d) The Employer may specify that the monitoring be undertaken per lane. Such monitoring must differentiate between the different lanes in the two directions of travel (unless otherwise specified by the Employer).

16.3 Intersection monitoring sites

Intersection traffic monitoring is undertaken at intersections. An intersection monitoring site is a single intersection where all lanes of traffic travelling through the intersection are monitored as specified by the *Employer*.

These specifications only provide for manual traffic monitoring at priority or signal controlled intersections. Roundabouts and interchanges are excluded from the scope of these specifications. Manual monitoring of individual intersections forming part of roundabouts or interchanges are, however, included in the scope of the specifications.

The following requirements apply to intersection monitoring sites:

a) The intersection monitoring must be undertaken for all approaches to the intersection and must differentiate between the different turning movements from each approach.
b) For intersection consisting of three or four approaches, differentiation must be made between left-turn, straight-through and right-turn movements. For intersections with five or more approaches, the turning movements must be identified in terms of the exit legs from the intersections.
c) Traffic counts are made at the stop or yield line positions on the approaches to the intersection. Where no such lines are provided, an imaginary line over the width of the road must be selected. For vehicle counts, the counts are made when the rear axles of vehicles cross this line.
d) The Employer may specify that the monitoring be undertaken per lane. When specified, the count must differentiate between the turning movements possible from each lane on each approach to the intersection. When lane monitoring is not specified, differentiation is only required between the possible turning movements from each approach.

16.4 Monitoring site stratification

Manual traffic counts must be expanded to equivalent annual traffic characteristics using expansion factors derived by means of a stratification system. The stratification systems (one or more) that must be used for this purpose is defined in TMH 8 (COTO, 2015).

The stratification system requires that monitoring sites must be grouped into stratification strata and clusters consisting of one or more monitoring sites with similar characteristics. Each stratum must contain at least one long-term monitoring site. For each stratum or cluster, a set of expansion factors and typical traffic characteristics must be derived from the long-term sites that can be used for deriving equivalent annual characteristics at the short-term sites.

The *Service Provider* in co-operation with the *Employer* will be responsible for implementing the stratification system, including the grouping of monitoring sites in strata and clusters (unless otherwise specified by the *Employer*). The Employer will specify the software that must be used by the *Service Provider* for this purpose. In the absence of such specifications, the software specified by the South African National Road Agency Ltd (SANRAL) shall be used for this purpose.

16.5 Site information records

The *Service Provider* is required to collect site information and maintain a record containing this information for each monitoring site. The *Site Provider* must make a copy of the latest record available to the Employer in electronic as well as hard copy format. Such a copy must be provided whenever any information is added to or changed on the site particulars.

The following information must be obtained for each site and provided in the record:

a) The site information specified by the South African Standard Traffic Data Collection Format.

b) Scaled sketch of the site. This sketch must be produced on an A4 size and must show the following information:

   i) Site ID Number.
   ii) Route, road and section numbers and kilometre markers.
   iii) Travel directions, turning movements and destinations.
   iv) Carriageway, lane or turning movement numbers.
   v) North direction arrow.

   The sketch showing the above information must be prepared before commencement of the traffic monitoring. On the day of the monitoring service, the following information must be manually added to the sketch by the monitoring team:

   i) Date of the monitoring service.
   ii) The position of each fieldworker or recording equipment on the site. The fieldworkers or recording equipment must be marked by means of a letter code (e.g. A, B, C etc).
   iii) The lanes of traffic (directions or turning movements) that were monitored by a specific fieldworker. The letter codes must be used to indicate the monitored lanes.

c) Photos (one or more) of the site showing sufficient detail to allow identification of the site from the photos. The purpose of these photos is to verify that the manual traffic service has been provided at the correct location. The photos must be taken by the monitoring team at the site on the date the monitoring service is provided. The photos must be taken with a GPS enabled camera capable of taking geo-tagged photos. Each photo must be date- and timestamped and the GPS location must be included in the metadata of the photo. These images must also be authenticated in accordance to the requirements of Chapter 19 (Monitoring data requirements). Photos must be taken and submitted in the JPG Joint Photographic Experts Group Format.

The *Service Provider* will be responsible for obtaining a site identifier for the monitoring site as specified in the *South African Standard Traffic Data Collection Format*. Once a site Identifier has been allocated to a specific site, no definition data such as traffic stream, lane definition data, and reference site definitions may be changed.

Should there be a need to change any of the site definition data (such as when provision must be made for additional lanes) a new site identifier must be assigned to the site. The site information for the old site must be retained, but the old site must be marked as “discontinued”. The old site identifier may never again be used at the particular or any other

location. The information for the new site must, however, include a reference to the old (historical) site as well as lane number assignments.

17 TRAFFIC MONITOR FIELDWORKER REQUIREMENTS

17.1 Traffic monitor fieldworker requirements

Requirements are provided in this chapter that are applicable to fieldworkers involved with the provision of manual traffic monitoring services.

In addition to the requirements provided in this chapter, the *Service Provider* must in all instances be fully conversant with the latest relevant enactments, provisions and regulations of all relevant legislative and statutory bodies and shall in all respects and at all times comply with all such enactments, provisions and regulations. The legal requirements include the following:

a) All relevant national and provisional legislation that are applicable to the employment and safety of fieldworkers.
b) All municipal regulations, laws, by-laws and special requirements of the local Municipality.

17.2 Communication facilities

At least one cellular telephone must be made available to fieldworkers at each monitoring site that can be used for emergency (and other) purpose. The following telephone numbers must be made available to the fieldworkers:

a) Service Provider.
b) South African Police.
c) Ambulance services.

17.3 Relief fieldworker

The requirements of this section are applicable to Types M2 and M3 manual monitoring. For these types of monitoring, the *Service Provider* must, at all monitoring sites, make at least one relief fieldworker available that can take over the duties of other fieldworkers in situations where a fieldworker needs a break or where the fieldworker cannot continue with the traffic monitoring due to an emergency situation.

The *Service Provider* must issue instructions to fieldworkers that no fieldworker is allowed to stop the traffic monitoring unless the duties of the fieldworker is taken over by the relief fieldworker. A sufficient number of fieldworkers must be available at all times to undertake a complete monitoring service.

17.4 Ablution facilities

The *Service Provider* is responsible for making ablution facilities available to fieldworkers. These facilities must include the following:

a) A toilet (any type).
b) A facility for cleaning or washing hands (any type of facility).

The facilities may be one of the following two types:

e) A facility that is open to the public (e.g. at a filling or service station).
f) Portable facility with some form of enclosure (such as a tent).

The ablution facilities must be available at a walking distance of not further than 500 m from the site.

17.5 Road safety

The *Service Provider* is required to institute measures that are aimed at ensuring that traffic monitoring does not create a traffic hazard or which endangers the safety of the public, fieldworkers, animals, vehicles and property.

Fieldworkers must be instructed to position themselves as far as practically possible from the travelled roadways, including paved shoulders. The distance between the fieldworkers and the travel way (excluding shoulders) may not be less than the minimum distances provided below for different speed limits. Where a safety barrier is available, the fieldworkers may position themselves behind the barrier at distances closer that that provided in the table.

Speed limit	Minimum distance from side of travel way (excluding shoulders)
60 km/h or less	3 m
70 – 90 km/h	5 m
100 km/h or more	7 m

Part 5
Monitoring Service and Data Requirements

Part 5: Monitoring Service and Data Requirements

Part 5 contains the requirements that are applicable to the provision of monitoring services and the data that must be collected and provided as part of automatic and manual traffic monitoring and WIM services. The requirements are provided in the following chapters:

Chapter 18 Monitoring service requirements.

Chapter 19 Monitoring data requirements.

18 MONITORING SERVICE REQUIREMENTS

18.1 Introduction

This chapter provides the requirements applicable to the provision of automatic as well as manual traffic monitoring services. These requirements relate to the type, start date and duration of the monitoring services and the programming of the services.

18.2 Monitoring service types

The types of monitoring services that can be provided in terms of the specifications are the following:

a) Automatic monitoring services

   i) Traffic monitoring using one of the monitoring system types and accuracy levels defined in Chapter 7 (Automatic traffic monitoring system requirements).
   ii) Toll monitoring according to one of the traffic monitoring types and accuracy levels defined in Chapter 7 (Automatic traffic monitoring system requirements).
   iii) Integrated Traffic and HS WIM monitoring. The type and accuracy level of the traffic monitoring system must be specified as defined in Chapter 7 (Automatic traffic monitoring system requirements).
   iv) HS WIM monitoring without traffic monitoring. Where the system will be used for screening purposes, the required screening facilities must be specified.
   v) LS WIM monitoring.

b) Manual traffic monitoring services

   i) Manual link traffic monitoring in which traffic is counted on road links between intersections.
   ii) Manual intersection traffic monitoring in which traffic is counted passing through intersections.

18.3 Monitoring start dates

The *Employer* will specify the date on which specific automatic or manual monitoring services must be started. The start date may be specified as a specific starting date or over a period of time. Alternatively, the *Employer* may also specify a period during which the monitoring services must be undertaken and completed.

The *Service Provider* will not be required to start more monitoring services per month than the following during any month of the contract period (unless otherwise agreed to by the *Service Provider*):

a) Automatic monitoring

   i) Twenty equivalent monitoring services per month, when the required total number of equivalent services is less than 200.
   ii) Ten per cent of the total number of equivalent monitoring services per month, when the required total number of equivalent services is 200 or more.

b) Manual traffic monitoring

   i) Forty manual traffic count services per month, when the required total number of equivalent services is less than 400.
   ii) Ten per cent of the total number of manual traffic count services per month, when the required total number of services is 400 or more.

The Employer may require that the above maximum number of equivalent monitoring services be started in consecutive months or over different months during the contract period. The requirements, however, imply that the *Service Provider* may be given the following minimum number of months at the start of the project for the commencement of all the required monitoring services:

a) Automatic monitoring

   i) The total number of equivalent monitoring services divided by 20, when the required total number of equivalent services is less than 200.
   ii) A period of 10 months, when the required total number of equivalent services is 200 or more.

b) Manual traffic monitoring

   i) The total number of manual traffic monitoring services divided by 40, when the required total number of services is less than 400.
   ii) A period of 10 months, when the required total number of services is 400 or more.

For automatic monitoring, the equivalent number of monitoring services will be determined by means of the following formula:

Equivalent number of monitoring services =
1 x No of traffic monitoring services without HS WIM monitoring +
2 x No of monitoring services with HS WIM monitoring +
2 x No of Toll traffic monitoring services

The *Service Provider* must start a service during the period specified by the *Employer*. Where a service is started earlier than the specified date, no payment will be made for services provided before the required start date (unless otherwise agreed to by the *Employer*). Where a service is started later than the specified date, such monitoring will be regarded as missing data in terms of the requirements specified in Chapter 19 (Monitoring data requirements).

18.4 Monitoring durations

In terms of these specifications, automatic traffic and WIM monitoring services can be provided over the following durations:

a) *1-Day monitoring*. One full 24-hour Normal day must be monitored. The day must be a Normal Monday, Tuesday, Wednesday, Thursday or Friday. Saturdays or Sundays may not be monitored except when otherwise specified by the Engineer.

b) 2-Day Monitoring. Two Normal days must be monitored. The days may be any Normal weekday (Monday to Fridays). Saturdays or Sundays may not be monitored except when otherwise specified by the Engineer. The two days do not have to be consecutive but may not further than 3 months apart. Both days must be from the same calendar year.

c) *7-Day Monitoring*. A total of 7 Normal days must be monitored. Each day of the week (Mondays to Sundays) must be counted at least once on a Normal day. The monitoring does not have to be undertaken on consecutive days but none of the days may be further than 3 months apart. All days must also be from the same calendar year.

d) *14-Day Monitoring*. A total of 14 Normal days must be monitored. Each day of the week must be counted on at least two Normal days. The count does not have to be taken on consecutive days but none of the days may be further than 3 months apart. All days must also be from the same calendar year.

e) *3-Month Monitoring*. The monitoring must be undertaken over a period of 3 consecutive calendar months. Such monitoring must be undertaken on Normal and Abnormal days. Unless otherwise required by the *Employer*, all months must be from the same calendar year.

f) *1-Calendar Year monitoring*. This monitoring must be undertaken over a period of one calendar year starting on 1 January and terminating on 31 December in a specific year. A grace period is allowed in which the monitoring may be started not earlier than 1 November in the previous year or not later than 1 March in the following year and continued for a period of 12 months. The monitoring must be undertaken on *Normal* as well as *Abnormal Days*.

g) *Long-term monitoring*. The monitoring must be undertaken in periods specified in 6-month duration intervals (e.g. 6, 12, 18 … months). The monitoring will start on dates specified by the *Employer* and continue for the specified durations. The monitoring must be undertaken on *Normal* as well as *Abnormal Days*.

h) *Toll traffic monitoring*. The monitoring must be undertaken in periods specified in 6-month duration intervals (e.g. 6, 12, 18 … months). The monitoring will start on dates specified by the *Employer* and continue for the specified durations. The monitoring must be undertaken on *Normal* as well as *Abnormal Days*.

Manual traffic monitoring must be undertaken on days as specified by the Employer. When not specified, the count must be undertaken on a Normal Monday, Tuesday, Wednesday, Thursday or Friday. Monitoring may be undertaken over the following durations:

i) Specific hours. Traffic monitoring will be undertaken over one or more specific hours of the day as specified by the *Employer*. These hours may be either

continuous or discontinuous over the 24 hours of one calendar day. When discontinuous, the traffic monitoring for the day will be regarded as a single monitoring service.

j) 12-Hour monitoring. Monitoring must be undertaken over a continuous period of 12 hours. The start and end times will be specified by the Employer. When not specified, the monitoring must start at 06:00 and end at 18:00.

k) 18-Hour monitoring. Monitoring must be undertaken over a continuous period of 18 hours. The start and end times will be specified by the Employer. When not specified, the monitoring must start at 04:00 and end at 22:00.

Definitions of Normal and Abnormal Days are provided in Appendix B of these specifications.

The *Service Provider* will be required to submit "complete" data sets (as defined in Chapter 19 (Monitoring data requirements) for the full monitoring durations as defined above. In situations where the *Service Provider* was unable to provide such complete data sets for the full monitoring durations, payment will only be made for the complete data sets as specified in Chapter 21 (Payment requirements)). The *Service Provider* may, however, make an offer to either repeat or extend the monitoring at its expense in order to achieve complete data sets. The *Employer* may either accept or reject such an offer.

The *Employer* may change the required duration of a long-term or a toll traffic monitoring service at a site at any time before or during the monitoring service. The duration may be changed to any of the 6-month duration intervals provided for in the tender. Payment for the service will be made in terms of the changed duration as specified in Chapter 21 (Payment requirements). In situations where a long-term or toll traffic monitoring service has already started, the start date may not be changed. The duration may also not be decreased to a period shorter than the duration of service that has already been provided.

The *Employer* may discontinue any monitoring service at any time during a monitoring service. Payment for such discontinued services will be made in terms of the requirements provided in Chapter 21 (Payment requirements).

18.5 Monitoring programme

The *Employer* will specify the monitoring (automatic or manual) sites, types, start dates, as well as monitoring durations at the start of the project. The *Service Provider* is responsible for preparing a detailed programme according to which the monitoring will be undertaken over the project period and must submit the programme to the *Employer* for approval. The programme must be submitted to the *Employer* before monitoring may commence.

The *Employer* may change the monitoring locations, types, dates and durations at any time during the project (including after a monitoring service has already commenced) in which case the *Service Provider* will be required to submit a revised programme. The *Service Provider* will inform the *Employer* if it is not possible to revise the monitoring programme to accommodate the changes. In such cases, the *Employer* and the *Service Provider* must cooperate to establish the changes that can be accommodated.

The programme must provide details on the following aspects of the monitoring services:

a) Automatic monitoring (these are not required for manual traffic monitoring)

i) Dates on which wayleave applications will be made.
ii) Dates on which monitoring sites will be constructed and installed.

b) Automatic and manual monitoring
i) Dates during which the sites will be monitored.
ii) Expected dates for road construction and rehabilitation on specific roads.

The programme must make provision for any construction or rehabilitation work that may be planned for a particular road. It is the responsibility of the *Service Provider* to regularly obtain information regarding planned roadworks from the *Road Authority* concerned. The programme must have sufficient flexibility to accommodate possible changes to the roadworks programme and must be adjusted when such changes occur. No extension of time will be given as a result of the roadworks, and if monitoring cannot be undertaken during the required time, the specific monitoring will be considered as not being required.

The programme must also allow some flexibility for the possible impact of adverse weather conditions, including abnormal rainfall, on the monitoring site construction and installation. No extension of time will be given as a result of adverse weather conditions.

Monthly reports on the progress with the programme must be submitted to the *Employer*. The monthly reports must show the following information for each of the monitoring service types:

a) Wayleaves (automatic monitoring only)
i) The total number of wayleaves that are required.
ii) The number of applications for wayleaves that should have been made.
iii) The number of wayleave applications that have actually been made.
iv) The number of approved wayleaves.

b) Monitoring sites
i) The total number of monitoring sites that will be required.
ii) The number of monitoring sites that should have been installed.
iii) The number of monitoring sites that have been installed and which have been certified by the *Service Provider*.

c) Monitoring services (quantities are either number of days or hours)
i) The total quantity of services that is required.
ii) The quantity of services that should have been completed.
iii) The quantity of services that have been completed.

Should the *Service Provider* fall behind the approved programme, the programme must be adjusted and resubmitted to the *Employer* for approval. The revised programme must be submitted within seven days of the date on which the *Service Provider* received a notice to this effect from the *Employer*. Proposed revisions to monitoring types, start dates and durations must be approved by the *Employer*. The adjusted programme must reflect how the monitoring will be completed within the required project time period.

18.6 Monthly meetings

When required by the *Employer*, the *Service Provider* must attend monthly meetings with the *Employer.* The purpose of these meetings is to evaluate the progress that has been made with the traffic monitoring and to discuss any matters pertaining to the traffic

monitoring. The venues, dates and times of such meetings shall be determined by the *Employer*.

18.7 Non-performance

The *Employer* may, at its discretion, terminate the contract in the event that the *Service Provider* falls behind the monitoring programme to the extent that:

a) Less than 85% of the monitoring sites that should have been installed according to the monitoring programme have been installed; or

b) The quantity (measured in terms of days or hours monitored) of monitoring services that have been completed is less than 85% of the services that should have been completed according to the monitoring programme.

The latest monitoring programme that has been approved by the *Employer* shall be used to determine the above percentages.

19 MONITORING DATA REQUIREMENTS

19.1 Introduction

This chapter provides the requirements for the automatic and manual traffic monitoring data that must be submitted, the format of such data, as well as the verification and analysis required for such data.

19.2 Data collection and extraction

The automatic and manual traffic monitoring data that must be collected are specified in the different chapters of these specification. All traffic data must be collected for individual vehicles and not in summary formats (except for manual interval traffic monitoring).

The *Service Provider* is responsible for the extraction and collection of the data collected at monitoring sites. Such data collection can be undertaken by any method deemed suitable by the *Service Provider*.

Where a Traffic and HS WIM system is used for the screening of vehicles at a static weighbridge, the data must be extracted and submitted to the weighbridge control system by means of a data communication system.

19.3 Data conversion

The data collected during the automatic or manual traffic monitoring service must be converted to the format specified in the *South African Standard Traffic Data Collection Format* by the *Service Provider*. The data that are required include the following, as specified in this Data Collection Format:

a) Header records.
b) Individual vehicle data.
c) Site definition data.

19.4 Data authentication

This section provides requirements for the authentication of data that are submitted to the *Employer*. Any data that are not authentication in accordance with these requirements will be regarded as missing data by the *Employer* (unless otherwise agreed to by the Employer).

The *Employer* will specify the data authentication software that must be used by the *Service Provider* for the authentication of collected data. In the absence of such specifications, the software specified by the South African National Road Agency Ltd (SANRAL) shall be used for this purpose. Authentication software will be provided for the following two purpose:

a) Authentication of traffic data
b) Authentication of photographic images

Traffic data authentication must be undertaken after conversion of the data to the format specified in the *South African Standard Traffic Data Collection Format*. The authentication must be completed within a period of one hour after data were extracted from the monitoring system. The following data authentication is required:

a) Automatic traffic monitoring. Data authentication is required for all automatic traffic monitoring types and systems.
b) Manual traffic monitoring, Data authentication is only required for manual Type M2 individual monitoring and not for other manual monitoring types.

Photographic image authentication is only required for manual traffic monitoring and not for automatic traffic monitoring. The authentication must be completed within a period of two hours after completion of the monitoring service. Authentication is required of the following photographic images:

a) Site photographs required for the verification of the location of the monitoring service. This authentication is required for all manual monitoring types.
b) Photographic images of traffic data forms completed as part of Type M3 interval monitoring.

The period of one hour specified for traffic data authentication is measured from the time of commencement of the extraction until the authentication by means of the software is completed. Within this one hour period, the data must be extracted, converted to the format specified in the *South African Standard Traffic Data Collection Format* and authenticated by means of the provided authentication software.

The period of two hours specified for photographic image authentication is measured from the time of completion of the monitoring services until authentication by means of the software is completed. Within this two hour period, the photographs must be taken, date and timestamped, GPS coordinates added to the photo metadata and the photos authenticated by means of the provided authentications software.

In situations where it is not possible to authenticate the data within the above periods, the *Service Provider* may submit reasons to the *Employer* for the late authentication. The Employer, will at its discretion, accept or reject such late authentication.

The authentication software will require a connection to either the Internet or to a GPS (Global Positioning System) unit. The GPS unit must be used in situations where Internet services are not available. Such a connection is required to verify the date and time at which the authentication was undertaken.

The authentication software will append an encrypted code to the converted data file that will authenticate the contents of the data file, as well as the name of the file. Neither the contents nor the name of the file may be changed after the data file has been authenticated. Such a change will invalidate the authentication of the data file.

The names of the submitted data files must comply with the requirements of the *South African Standard Traffic Data Collection Format*.

19.5 Data submission

The Employer will specify the time period in which authenticated data (automatic or manual) must be submitted to the *Employer*. In the absence of such a specification, the authenticated data must be submitted within a period of 24 hours after extraction.

Unless specified otherwise by the *Employer*, the data must be submitted over the internet via a Hypertext Transfer Protocol Secure (HTTPS) based Representational State Transfer (REST) type Web Service with authentication headers. The data exchange format must be based on the JavaScript Object Notation (JSON) as specified by the *Employer*. Where the *Employer* does not have such a service available, the *Service Provider* must provide the *Employer* with a service to be used for the downloading the data over the internet.

19.6 Data verification

The *Employer* will specify the data management software that must be used for the verification and analysis of collected data (automatic or manual). In the absence of such a specification, the software system specified by the South African National Road Agency Ltd (SANRAL) shall be used for this purpose.

The purpose of data verification is to determine whether the submitted data are correct and error free. The data management software will verify the data on three levels, and the *Service Provider* will be required to undertake all three levels of tests. Payment will be made for monitoring services if the data passes the first two levels of tests.

The test levels are as follows:

a) First level tests are undertaken on submission of data to the software. The tests include the authentication of the submitted data.
b) Second level tests are undertaken on a monthly basis (calendar months) or when the monitoring duration is shorter than one month.
c) Third level tests are usually undertaken on an annual basis (calendar years) but may be undertaken over a shorter period when data are not available for a whole year. These tests will not affect payment for monitoring services.

An overview of the above tests is provided in Appendix D to these specifications.

Some of the tests include tests that are undertaken to verify that the data comply with the requirements of the *South African Standard Traffic Data Collection Format*. Tests will also be undertaken to authenticate the data. Should any data fail these tests, then the whole file will be rejected and will not be processed further.

Some of the tests also include tests that are undertaken to identify “suspect” and “bad” data. When such data are identified, a report will be created listing the data and this will be made available to the *Service Provider*. It will be the responsibility of the *Service Provider* to investigate the data and to identify possible causes or reasons why the data are suspect, and to make recommendations on whether the data should be accepted or rejected. The *Employer* will decide whether the *Service Provider* will be allowed to mark accepted data as “good” and rejected data as “bad”.

The Service Provider may also submit recommendations for amending submitted data. The Employer will decide whether the Service Provider will be allowed to amend the data (and

if necessary resubmit the data). Where the Service Provider is allowed to amend and/or resubmit the data, the full set of verification tests must be repeated for amendment data.

In situations where the Employer requires a monitoring service at a monitoring site that does not comply with the road geometry and pavement requirements specified in Chapter 11 (Automatic monitoring site requirements), the *Service Provider* will indicate whether data marked as "bad" have been affected by such non-compliance. Such data will then be marked as "uncertain" rather than "bad". For payment purposes, such data will be considered to be "good" data.

Some of the tests also include tests that are undertaken to identify periods with "missing" data. These are periods in which no data have been collected, or periods in which complete data sets are not available.

19.7 Data verification periods

The data verification specified in the previous section must be completed by the *Service Provider* within the following time periods:

a) For monitoring durations shorter than one month, the data verification must be completed within three weeks after the monitoring has been undertaken.
b) For monitoring longer than one month, the data verification must be undertaken at monthly intervals. The verification must be completed within three weeks after the end of each month in which the data were collected.
c) For toll traffic monitoring, the data verification must be undertaken at monthly intervals. The verification must be completed within four days after the end of each month in which the data were collected.

In situations where suspect data have been identified and investigations are required to establish the cause of such data, the *Service Provider* must inform the Employer accordingly who, at its discretion, may allow a time extension for the submission of the verified data.

19.8 Complete data sets

In terms of these specifications, a data set for a specific monitoring period is defined as a "complete" data set for the period when it does not contain any missing or bad data during the period. No data may be missing or bad for any of the lanes of a monitoring site, even if the monitoring system has been subdivided into partial sites. This requirement also applies where the *Employer* has specified that data must be submitted for each individual partial site.

Complete data sets must be provided as follows for all the lanes of a monitoring site:

a) Automatic traffic monitoring. Full data sets must be provided for monitoring intervals of 24 hours of a day (subject to the grace period specified below). There may be no data identified as missing or bad over the full day.
b) HS WIM Monitoring. Full data sets must be provided for monitoring intervals of one hour. There may be no data identified as missing or bad over the hour.

c) LS WIM Monitoring. Similar to HS WIM Monitoring, except that data sets must only be provided for vehicles that were monitored.
d) Toll Traffic Monitoring. Full data sets must be provided for monitoring intervals of one hour. There may be no data identified as missing or bad over the hour.
e) Manual traffic monitoring. Full data sets must be provided for the full specified monitoring duration. No grace periods are allowed and no data may be identified as missing or bad over the monitoring period.

For automatic monitoring, no grace periods will be allowed for data collection that is undertaken in monitoring intervals of one hour. For monitoring intervals of 24 hours of the day (traffic monitoring), a maximum of two grace periods of 5 minutes will be allowed during any two of the 24 hours of a day, subject to the requirement that such grace will not be allowed for more than a maximum of two days when the monitoring duration is shorter than 30 days. For monitoring durations longer than 30 days, a maximum of two days will be allowed for each calendar month of monitoring. Days will be considered to be completed even if data are missing or bad during these two 5-minute grace periods, subject to the maximum allowance of two days.

~~Time of day~~	~~Grace period per hour~~
~~04:00 to 12:00~~	~~5 Min/hour~~
~~12:00 to 04:00~~	~~10 Min/hour~~

19.9 Daily count classification

The *Service Provider* is responsible for classifying daily traffic counts in accordance with the "day classifications" provided in the *South African Standard Traffic Data Collection Format*. Two classifications are required, namely:

a) Normal/Abnormal classification (non-holidays, holidays and influenced days).
b) Traffic pattern classification.

The classification must be undertaken using the data management software, but the classification must be manually verified and adjusted where necessary.

19.10 Data calibration

The purpose of data calibration is to adjust collected data using calibration factors. The *Service Provider* will be responsible for undertaking the data calibration by means of the data management software. The following calibration must be undertaken:

a) WIM systematic calibration on a monthly basis with the purpose of establishing monthly calibration factors.
b) WIM load correction calibration on an annual basis with the purpose of correcting axle load distributions for dynamic loads.

19.11 Data summaries

The *Service Provider* is responsible for preparing data summaries. These summaries must be prepared using the data management software.

For short-term (shorter than one year) monitoring data summaries, the software must be used to expand the short-term traffic characteristics to equivalent annual characteristics. Such expanded data are reported as part of the data summaries. For this purpose, the *Service Provider* in cooperation with the *Employer,* must group monitoring sites into traffic strata and clusters of sites with similar annual traffic patterns in accordance with the requirements of Chapter 11 (Automatic monitoring site requirements) of these specifications.

For long-term (one year or longer) monitoring, a data summary must be submitted for each year of observations. For short-term monitoring, a data summary must be submitted for each period during which the monitoring was undertaken.

19.12 Data ownership and copyright

The ownership of all collected data vests in the *Employer* and any copyright or intellectual property that the *Service Provider* may have in terms of South African or international law is transferred to *Employer* when data are submitted. This data include both the original logger data, as well as any converted or derived data that may have been made available by the *Service Provider*.

The *Service Provider* shall not divulge, or provide to any organisation or person any of the data without the prior knowledge and written approval of the *Employer*. Where allowed by the *Employer*, such data may be made available to other organisations or persons and the *Service Provider* will be entitled to charge a reasonable fee for the cost involved in the provision of the data.

Part 6
Service Specification and Payment Requirements

Part 6: Monitoring Service and Payment Requirements

Part 6 contains the requirements that are applicable to the specification of monitoring services to be provided and the payment for such services. These requirements are applicable to the provision of automatic traffic and WIM monitoring services as well as manual traffic monitoring services. These requirements are provided in the following chapters:

Chapter 20 Monitoring service specification.

Chapter 21 Payment requirements.

20 MONITORING SERVICE SPECIFICATION

20.1 Introduction

This chapter specifies the method that must be used for specifying automatic and manual traffic monitoring services for tender purposes. Tender rates must differentiate between the different monitoring services on the basis of the requirements specified in this chapter.

20.2 Optional specifications

The *Employer* may specify the following requirements for a particular project. In the absence of such specifications, the requirements provided in these specifications will apply:

a) The Certification Organisation that must be used for the certification of *Service Providers* and monitoring systems as required in Chapter 2 (Service provider and monitoring system certification).

b) Whether or not automatic monitoring systems must be removed on completion of monitoring system as required in Chapter 12 (Installed automatic monitoring system requirements).

c) Whether or not assessments of the road pavement requirements specified in Chapter 11 (Automatic monitoring site requirements) and Chapter 12 (Installed automatic monitoring system requirements) must be undertaken.

d) The data management and authentication software that must be used for the verification and authentication of data as required in Chapter 19 (Monitoring data requirements).

e) The country or countries in which the monitoring services must be provided as required in this chapter.

20.3 Schedule of quantities

The monitoring services that are required by the *Employer* will be specified by means of a schedule of quantities. The schedule will list the required monitoring services, as well as the number (quantity) of the required services.

The quantities set out in the schedule of quantities are estimated quantities and are used for the comparison of tenders. It must be clearly understood that only the actual quantities of services provided will be measured for payment, and that the scheduled quantities may be increased or decreased as provided for in these specifications and in the general conditions of contract.

20.4 Pay items for monitoring services

The schedule of quantities will provide for the following pay items for monitoring services:

Pay item	Unit
Per monitoring service location, characteristics, type, size and duration:	
a) New automatic monitoring sites	Number of days/hours
b) Existing automatic monitoring sites	Number of days/hours
c) Manual traffic monitoring sites	Number of days/hours

The unit of measurement for payment shall be the following:

a) Number of days for traffic monitoring. A day shall consist of the 24 hours from midnight to midnight of a calendar day and shall include all the days of the week. Automatic traffic monitoring must be undertaken over all 24 hours of the day while manual traffic monitoring are required for specific hours of the day.

b) Number of hours for HS and LS WIM and toll monitoring. An hour shall be a full hour of a day.

The measurements for payment purposes shall only include the following:

a) Where required, only Normal days will be measured (Abnormal days are excluded even if monitoring was undertaken on such days).

b) Days or hours for which “complete” data sets have been submitted as specified in Chapter 19 (Monitoring data requirements).

20.5 Pay items for road pavement tests

The schedule of quantities will also provide for pay items for the following road pavement tests that may be required at monitoring sites:

Pay item	Unit
Per monitoring service location:	
a) Rutting measurements and tests	Per monitoring site
b) International Roughness Index measurements and tests	Per monitoring site
c) Deflection measurements and tests	Per monitoring site
d) Faulting measurements and tests	Per monitoring site
e) Visual assessment of structural defects	Per monitoring site

The unit of measurement for payment shall be the number of monitoring sites at which the different road pavement tests are required.

20.6 Monitoring service locations

The pay items will differentiate between different monitoring service locations. The locations may be specified either specifically or generally (or both).

Specific monitoring locations are specific road sections or toll plazas on or at which the monitoring services must be undertaken. The precise positions of the monitoring sites will, however, not be given since the *Service Provider* is responsible for determining the exact location for the monitoring site, as specified in Chapter 11 (Automatic monitoring site requirements) of these specifications.

General locations give a general indication of the areas in which sites will be required as well as the general characteristics of the monitoring sites. One or more of the following area definitions will be used:

a) The *Employer* will specify the country or countries in which the monitoring services will be required, in which case the *Employer* may select monitoring locations on any road in the country or countries (irrespective of the authority that has jurisdiction of the road). In the absence of such specifications, the monitoring services will be undertaken in the Republic of South Africa.
b) The *Employer* may also optionally specify provinces, municipalities, regions or sub-regions in which services will be required. Where specified, the *Employer* may select monitoring locations on any road in the province, municipality, region or sub-region (irrespective of the authority that has jurisdiction of the road).

The Employer will also differentiate between locations with a low or high risk of theft or vandalism. The Employer will decide on the risk classification applicable to a monitoring service location.

20.7 Monitoring site characteristics

In situations where monitoring site locations are specified generically, the *Employer* may also optionally specify the following monitoring site characteristics:

a) Communications availability. In such cases the *Employer* may differentiate between sites on the basis of the availability of communication facilities.
b) Electricity availability. In such cases the *Employer* may differentiate between sites on the basis of the availability of electricity.
c) Road types on which monitoring services are required. In such cases, the *Employer* may differentiate between road types such as two-lane and multilane roads (including freeways).
d) Pavement types on which monitoring services are required. In such cases, the Employer may differentiate between pavement types such as gravel, asphalt and concrete pavements.

If the above characteristics are not specified, then the monitoring service must be provided irrespective of the characteristics of the monitoring sites.

20.8 Monitoring service type, size and duration

The pay items will differentiate between monitoring types, sizes and durations as follows:

e) The types of monitoring services.
f) Sizes of the required services (the number of lanes that must be monitored).
g) Durations of the monitoring services.

The monitoring types and durations will be specified in terms of the requirements specified in Chapter 18 (Monitoring service requirements).

20.9 New and existing monitoring sites

The pay items will differentiate between new and existing monitoring sites. Where an existing monitoring site is available on a road section or at a toll plaza, the *Service Provider* will be required to re-use such sites unless the site is found unsuitable.

Tender rates must be provided for new and existing monitoring sites. The tender rate for an existing monitoring site will be used when an existing site can be re-used. The tender rate for a new site will be used when the existing site cannot be re-used or where a suitable existing site is not available.

The tender rate for an existing site shall not be higher than the rate for a new site. Tenders in which such tender rates have been provided will be invalidated and disqualified.

21 PAYMENT REQUIREMENTS

21.1 Introduction

This chapter provides requirements for the payments of the *Service Provider* for traffic and WIM monitoring services delivered in terms of these specifications.

21.2 Contract rates

In computing the final contract amount, payment shall be based on the actual quantity (days of hours) of authorised work done in accordance with the specifications, irrespective of whether the actual quantities are more, or less than the scheduled quantities. Where allowed by the *Employer*, the *Service Provider* may either repeat or extend a monitoring service (as specified in Chapter 18 (Monitoring service requirements)) at the expense of the *Service Provider*.

Where no rate or price has been entered against an item in the schedule of quantities by a tenderer, even where no quantity is given, it shall be taken that the *Service Provider* does not require any compensation for such work and zero payment will be made for the service.

The schedule may include items for which no quantity is given against and item. In such cases, tender rates must be entered for undertaking the services should such services become required during the project. Payment for such services will only be made if the services are specifically provided.

21.3 Rates to be inclusive

The rates submitted in a tender must provide for the full execution and completion of the traffic monitoring services as specified, including the procurement, provision, supply, furnishing, placement, installation, maintenance, operation and removal (where required) of all labour, supervision, plant, tools, equipment, material, transport, loading and off-loading, handling, wastage, temporary work, testing, assessment, quality control, overheads, guarantees, risk, insurance, profit and obligations or incidentals required for the provision of the services. This also includes but is not limited to the following:

a) Certification of *Service Providers* and monitoring systems, including the procurement of the services of the *Certification Organisation* for such certification.
b) Provision of the monitoring systems, equipment, sensors, software, software that is made available to the *Employer*, ancillary or auxiliary facilities, materials, assessments, quality control and assurance, reports and manuals.
c) Site selection, site assessments, assessment tests, site information records, implementation of the stratification system, wayleave applications, work on properties outside the road reserve, site establishment, removal, accommodation of traffic, health and safety obligations and all other work required on site.

d) Assessments of installed monitoring system and assessment reports.
e) Data collection, extraction, conversion, submission, verification, calibration, analysis, and preparation of summaries. It also includes the development and updating of the traffic monitoring programme.
f) The attendance of any required meetings with the *Employer*.
g) Compliance with all legal and other requirements of these specifications.

21.4 Payments for services

Monitoring services will be paid for as follows:

a) For monitoring shorter than or equal to three months, payment will only be made when a complete data set has been submitted for the full duration of the service.
b) For monitoring longer than three months, monthly payments will be made for completed data sets that have been submitted. The first payment will only be made when complete data sets have been submitted for a period of 30 days or 720 hours.

No payment will be made unless the following information and data have been submitted to the *Employer*:

a) Site information records as specified in Chapter 11 (Automatic monitoring site requirements) of these specifications.
b) The assessment record for the monitoring site by the *Service Provider* as specified in Chapter 13 (Installed automatic monitoring system assessments).
c) Data sets submitted as specified in Chapter 19 (Monitoring data requirements).

Payment for monitoring durations of 3 months and shorter and for the last 30 days or 720 hours of monitoring services longer than 3 months will only be made after removal of the monitoring system (if and where required by the *Employer*) in accordance with the requirements of Chapter 12 (Installed automatic monitoring system requirements) of these specifications. The final payment will only be made when the *Employer* is satisfied that the removal complies with the requirements of this chapter.

21.5 Changed monitoring durations

The duration of long-term and toll traffic monitoring services may be changed by the Employer in accordance with the requirements of Chapter 18 (Monitoring service requirements). Where the duration has been changed, payment for the changed service will be made in terms of the pay item and tariff applicable to the changed duration.

Where payments have already been made for a partially completed service, the payments will be adjusted in accordance with the payments already received by the *Service Provider*. The adjustment shall be made as a single-sum addition to or subtraction from the next payment due to the *Service Provider*.

21.6 Discontinuation of monitoring services

In situations where a monitoring service has been discontinued by the *Service Provider* before completion of the service, payment will only be made for complete data sets in accordance with the requirements of this chapter.

However, in situations where the Employer has issued an instruction for the discontinuation of the monitoring service before completion of the service, the hourly or daily tariff rate for the services that have already been delivered will be increased in accordance with the following formula:

$$R_{Adjusted} = \frac{T_{Completed} + T_{Outstanding}}{T_{Completed}} \cdot R_{Tender}$$

In which:

$R_{Adjusted}$ = Adjusted hourly or daily rate
R_{Tender} = Tendered hourly or daily rate
$T_{Completed}$ = Duration of services that were delivered before discontinuation
$R_{Outstanding}$ = Duration of services not delivered due to discontinuation

In situations where the instruction was issued after a monitoring system was installed but before the service could commence ($T_{Completed} = 0$), a value of $T_{Completed} = 1$ shall be used to calculate the adjusted rate and payment due to the *Service Provider*.

The above adjusted hourly or daily rate shall be applied to the duration $T_{Completed}$ of services that were delivered before the service was discontinued. The adjustment shall be made as a single-sum addition to the next payment due to the *Service Provider*.

Where a long-term or toll traffic monitoring service is discontinued, the duration of the service must be reduced to the minimum required to cover the completed service. Payment for the service will be made in terms of the pay item and tariff applicable to the reduced duration.

Part 7
Appendices to the Specifications

Part 7: Appendices to the Specifications

Part 7 contains the appendices to the specifications. These appendices are the following:

Appendix A Methodologies for determining tolerance limits and intervals.

Appendix B Definitions of Normal and Abnormal days.

Appendix C Monitoring system accuracy assessment method.

Appendix D Data verification tests.

Appendix E List of references.

APPENDIX A

TOLERANCE LIMITS AND INTERVALS

A.1 Introduction

The requirements that are provided in the specifications for the accuracy of traffic and WIM monitoring systems are only applicable when a very large number of observations, representative of the population are made. In practice, this is not possible and the assessment of accuracy can only be determined on the basis of a sample containing a limited number of observations. Statistical methods must be applied to account for the uncertainty introduced by sampling.

It is important to note that the statistical tests provided in this appendix are used to either accept or reject traffic or WIM monitoring equipment. When a test results in a rejection, the *System Supplier* is allowed to increase the sample size by means of additional measurements which may result in the acceptance of the equipment. This, however, is subject to the requirement that no adjustments are made to the equipment and that the additional measurements are undertaken as if part of the original test.

The statistical procedures that must be applied are provided in the following two sections:

- A.2 Tolerance limits tests for proportions
- A.3 Tolerance intervals for percentages within limits (PWL)

The statistical background to these tests is provided in other sections of this appendix.

A.2 Procedure: Tolerance limit tests for proportions

Tolerance limit tests for proportions are used for testing the number of “failed” or “erroneous” observations on the basis of a sample. Table A1 is used to determine the maximum failure count for different tolerance limits and sample sizes. The equipment is accepted if the failure count obtained by means of a sample is less than or equal to the maximum count in the table, otherwise it is rejected:

The following is an example of how the table is applied. Suppose that a sample is taken and the following is found:

- Sample size is 200.
- Number of failures in sample is 13.
- The specified tolerance limit is 10%.

From the table, for a tolerance limit of 10% and a sample size of 200, the maximum allowable failure count is given as 12. The number of failures obtained from the sample is 13, which exceeds this maximum and the equipment therefore fails the test.

The *System Supplier* is allowed to increase the sample size if the test is failed. Suppose the sample size is increased to 300 and the number of failures is now found to be 21. According to the table the maximum allowable failure count is 21 and the equipment therefore, passes the test.

Table A1 is restricted to a limited set of tolerance limits and sample sizes. Additional values for the allowable failure count may be calculated using the following Microsoft Excel spreadsheet function (inverse binomial distribution):

x = BINOM.INV(n, p, 0.05) – 1

in which:

x = Maximum allowable failure count
n = Sample size
p = Tolerance limit (as a fraction)

A.3 Procedure: Tolerance Intervals

Tolerance interval tests are used to test the percent-within-limits obtained from a sample. Table A2 is used for this purpose. This table provides minimum z-values for different sample sizes. The equipment is accepted if the calculated z-value is equal to or greater than the minimum z-values. The equipment is otherwise rejected.

The z-value is calculated by means of the following formula:

$$z = \frac{T - Abs(m)}{s}$$

in which:

z = Calculated z-value
T = One half the tolerance interval width
m = Sample mean
Abs(m) = Absolute value of mean
s = Standard deviation

The sample mean and standard deviation are determined by means of the following formulae:

$$m = \frac{\sum D_i}{n}$$

$$s = \sqrt{\frac{(D_i - m)^2}{n - 1}}$$

In which:

D_i = “Deviations” between measured and reference values
n = Sample size

The following is an example of how the table is applied. Suppose that a sample is taken and the following is found:

- The specified tolerance interval is 15% (half width).
- Sample mean is -3.25%. The sign is removed and the mean is taken as 3.25%.
- Sample standard deviation is 5.00%.
- Sample size is 30.
- The z-value is calculated as (15 – 3.25)/5.00 = 2.25

From the table, for a tolerance interval of 15% (half width) and a sample size of 30, the minimum z-value is given as 2.356. The equipment is therefore rejected.

The *System Supplier* is allowed to increase the sample size if the test is failed. Suppose the sample size is increased to 50 but it is found that the mean and standard deviation have not changed (the calculated z-value is still 2.25). From the table, the minimum z-value is given as 2.246 and the equipment now passes the test.

Table A2 is restricted to a limited set of sample sizes. However, for sample sizes not covered by the table, the z-values can be linearly interpolated from the table. For sample sizes of greater than 10 000, a z-value of 1.960 may be used.

A.4 Statistical methodology: General overview

The statistical methodology that is used in the acceptance/rejection tests is based on standard statistical approaches used in hypothesis testing and quality control. In the application of hypothesis testing in quality, the null and alternative hypotheses are stated as follows:

- H_o: The product is of an acceptable quality.
- H_1: The product is not of an acceptable quality (and therefore rejected).

In the development of a quality assurance plan, use is made of operating characteristic (OC) curves which are used to determine the probability of accepting a product as a function of its true or population quality. These probabilities are also the “client” risk of making a Type II error where a product is accepted while it has a true quality other than hypothesised. It is also possible to determine the “producer” risk of a Type I error where a product is rejected while it in fact has an acceptable quality.

In the development of a quality assurance plan, two levels of quality may be established, namely the Acceptable and Rejectable quality levels (AQL and RQL). The AQL is the level which would be preferred by the client, while the RQL is the level at which the product is considered unacceptable to the client.

The statistical tests provided in this chapter are solely based on the consideration of the RQL level at which a product is considered unacceptable to the client. The product is considered acceptable when the quality level is better than the RQL.

In the development of the quality control plans, consideration was only given to the Type II risk of accepting a product which is considered unacceptable to the client. This level was fixed at a maximum of 5%. This implies that 1 in 20 unacceptable products will pass the test.

No consideration was given to the producer risk which can be reduced by increasing the sample size. Should a product fail a test, the producer will be allowed to repeat the test to increase the sample size, thus reducing the risk of a Type I error where an acceptable product fails the test.

A.5 Statistical methodology: Tolerance limits for proportions

The purpose of the tolerance limit test for proportions is to determine the probability of an unacceptable proportion of failures or erroneous observations being accepted. This probability is determined by means of the cumulative Binomial distribution:

$$F_B(x; n; p) = \sum_{i=0}^{x} \binom{n}{i} \cdot p^i \cdot (1-p)^{n-i}$$

With:

$$\binom{n}{i} = \frac{n!}{i! \cdot (n-i)!}$$

In which:

x = Number of failures or erroneous observations in a sample
n = Sample size
p = True or population proportion (tolerance limit)
$F_B()$ = Probability of accepting the product

Table A1 provides values of failure counts x for different sample sizes n and tolerance limits p which would not result in a probability $F_B(x;n;p)$ greater than 5%.

A.6 Statistical methodology: Tolerance intervals

The purpose of the tolerance interval test is to determine the probability of accepting a product with an unacceptable population percent-within-limits (PWL). A population PWL of 95% is prescribed in the specifications for all tolerance interval tests.

A further requirement that is introduced is that not more than 2.5% of the population may be lower than the lower tolerance limit and not more than 2.5% of the population higher than the upper tolerance limit. This means that even if the population PWL of 95% is achieved, a product will fail the test if the 2.5% requirements are not met.

The test is performed by means of a z-value calculated from the sample mean and standard deviation. In the development of the quality assurance plan, the z-values are actually used to obtain an estimate of the population PWL. The so-called The Uniformly Minimum Variance Unbiased Estimator (UMVUE) estimate of this PWL can be obtained by means of the Student's t-distribution:

$PWL = 0$ for $z \leq -\frac{n-1}{\sqrt{n}}$

$PWL = 1$ for $z \geq \frac{n-1}{\sqrt{n}}$

$PWL = F_T(t; n-2)$ otherwise

In which:

$F_T()$ = Cumulative Student's t-distribution
n = Sample size
t = t-value

The t-value required in the above formulae is determined as follows:

$$t = z \cdot \sqrt{\frac{n \cdot (n-2)}{(n-1)^2 + n \cdot z^2}}$$

The 2.5% requirement means that two tests must actually be applied, namely, a lower as well as an upper one-side test. These two tests are effectively achieved by using the absolute value in the formula to determine the z-value (as described previously).

The probability of accepting a product with an unacceptable population PWL was determined by means of Monte Carlo simulation. In this simulation, samples are repeatedly taken from a population with a known true PWL. For each sample, the acceptance test (as described previously) is applied. The number of samples in which the product is accepted is determined, and the probability of acceptance is determined. This probability must then be less than the required 5% risk. The simulations are repeated for different minimum z-values until a z-value is obtained for which the risk is approximately 5%. The minimum z-values obtained in this manner are provided in Table A2.

Table A1: Tolerance limits for proportions

Sample	Maximum failure count (provided in table) for the following tolerance limits and sample sizes:															
size	0.5%	1.0%	2.0%	2.5%	3.0%	3.5%	4.0%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%	12.0%	15.0%	20.0%
100	N/A	N/A	N/A	N/A	0	0	0	1	1	2	3	4	4	6	8	13
150	N/A	N/A	0	0	0	1	1	2	4	5	6	7	8	11	15	21
200	N/A	N/A	0	1	1	2	3	4	6	7	9	11	12	16	21	30
250	N/A	N/A	1	2	2	3	4	6	8	10	12	14	16	21	27	39
300	N/A	0	1	2	3	5	6	8	11	13	16	18	21	26	34	48
350	N/A	0	2	3	5	6	7	10	13	16	19	22	25	31	41	57
400	N/A	0	3	4	6	7	9	12	15	19	22	26	29	37	47	66
450	N/A	0	3	5	7	9	10	14	18	22	26	30	34	42	54	75
500	-1	1	4	6	8	10	12	16	21	25	29	34	38	47	61	84
600	0	1	6	8	10	13	15	20	26	31	36	42	47	58	75	103
700	0	2	7	10	13	16	19	25	31	37	43	50	56	69	89	122
800	0	3	9	12	15	19	22	29	36	43	51	58	65	80	103	141
900	0	3	10	14	18	22	26	34	42	50	58	66	74	91	117	159
1000	1	4	12	16	20	25	29	38	47	56	65	74	84	102	131	178
1100	1	5	14	18	23	28	33	42	52	62	72	83	93	113	145	197
1200	1	6	15	20	26	31	36	47	58	69	80	91	102	125	159	216
1300	2	6	17	23	28	34	40	51	63	75	87	99	111	136	173	235
1400	2	7	19	25	31	37	43	56	69	82	95	108	121	147	187	255
1500	2	8	20	27	33	40	47	60	74	88	102	116	130	159	201	274
1600	3	9	22	29	36	43	50	65	80	94	109	124	139	170	216	293
1700	3	10	24	31	39	46	54	69	85	101	117	133	149	181	230	312
1800	3	10	26	33	41	49	58	74	91	107	124	141	158	193	244	331
1900	4	11	27	36	44	53	61	79	96	114	132	150	168	204	259	350
2000	4	12	29	38	47	56	65	83	102	120	139	158	177	215	273	370
2200	5	14	32	42	52	62	72	92	113	134	154	175	196	238	302	408
2400	6	15	36	47	58	68	79	102	124	147	169	192	215	261	330	447
2600	6	17	40	51	63	75	87	111	135	160	184	209	234	284	359	486
2800	7	19	43	56	68	81	94	120	147	173	200	226	253	307	388	524
3000	8	20	47	60	74	88	102	130	158	186	215	243	272	330	417	563
3200	9	22	50	65	79	94	109	139	169	200	230	261	291	353	446	602
3400	10	24	54	69	85	101	116	148	180	213	245	278	310	376	475	641
3600	10	25	57	74	90	107	124	158	192	226	260	295	330	399	504	680
3800	11	27	61	78	96	114	131	167	203	239	276	312	349	422	533	719
4000	12	29	65	83	102	120	139	177	215	253	291	329	368	445	562	758
4200	13	31	68	88	107	127	146	186	226	266	306	347	387	469	591	797
4400	14	32	72	92	113	133	154	195	237	279	322	364	406	492	620	836
4600	14	34	76	97	118	140	161	205	249	293	337	381	426	515	649	875
4800	15	36	79	101	124	146	169	214	260	306	352	399	445	538	679	914
5000	16	38	83	106	129	153	176	224	272	320	368	416	464	561	708	953

Table A2: Tolerance intervals (double one-sided)

Minimum z values for acceptance for different sample sizes				
Sample size	Minimum z-Value			
10	2.833		1100	2.012
20	2.487		1200	2.010
30	2.358		1300	2.008
40	2.289		1400	2.006
50	2.246		1500	2.004
60	2.218		1600	2.003
70	2.196		1700	2.001
80	2.177		1800	2.000
90	2.164		1900	1.999
100	2.150		2000	1.998
120	2.132		2500`	1.995
140	2.117		3000	1.991
160	2.106		3500	1.988
180	2.096		4000	1.987
200	2.089		4500	1.985
250	2.075		5000	1.984
300	2.063		6000	1.982
350	2.055		7000	1.980
400	2.049		8000	1.979
450	2.044		9000	1.978
500	2.038		10000	1.977
550	2.034			
600	2.032			
650	2.028			
700	2.026			
750	2.023			
800	2.021			
850	2.020			
900	2.018			
950	2.016			
1000	2.014			

APPENDIX B

DEFINITION OF NORMAL AND ABNORMAL DAYS

B.1 Introduction

Daily traffic patterns may vary significantly on different days of the year. Differentiation is made between two basic classes of traffic patterns, namely those counted on Normal and those counted on Abnormal days. Normal days are days of the year during which traffic patterns tend to be stable and where these patterns are not affected or influenced by Abnormal or exceptional events.

Abnormal days are days on which the traffic patterns deviate from Normal days due to events such as school and public holidays (including influenced days). Although Abnormal, these days can be predicted from published information on holidays.

Exceptional days are Normal days on which some unpredictable event occurred that affected the traffic pattern. These include events such as road closures, construction, accidents and adverse weather conditions.

B.2 Normal and Abnormal day definition

Abnormal days can be identified by means of the definitions provided below. Days that are not Abnormal can be assumed to be Normal but care should be taken to ensure that unpredictable events have not occurred which could affect the traffic monitoring.

Abnormal Days are defined as the following days of the year (Papenfus and Van As, 2014):

- Public holidays.
- Days influenced by public holidays, as defined in the table below.
- School holidays in any of the provinces of the country, measured for the full duration of the holiday (i.e. from the first to the last day of the holiday) and including the last and first school days before and following the holiday.
- December recess, measured from the last (seven-day) week in November up to the end of the school holidays in January of the following year in any of the provinces and including the first school day following the holiday.

Weekday of Public Holiday	Days influenced by Public Holidays							
	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed
Sunday								
Monday								
Tuesday								
Wednesday								
Thursday								
Friday								
Saturday								

Public Holiday Influenced Days

APPENDIX C

MONITORING SYSTEM ACCURACY ASSESSMENT METHOD

C.1 Introduction

This appendix describes the assessment methodology that must be followed when assessing the accuracy of a monitoring system. This methodology is aimed at simplifying the process of data verification required by the Certification Organisation for the certification of a monitoring system.

The tests described in the chapter are mainly based on video and camera recordings but other data are also required. Manual assessments are still required but the aim of the method is to minimise such assessments.

C.2 Certification Organisation

The *Certification Organisation* will be responsible for verifying that the accuracy assessments have been undertaken in accordance with the specifications and that the assessments have not been falsified or fabricated. For this purpose, it is not necessary to verify all the data collected by the *System Supplier,* and only a random or specific sample of data needs to be reviewed and verified.

The *Certification Organisation* therefore does not have to attend the assessment for the full duration of the test and will only attend the assessments on a sampling basis. For this purpose, the *System Supplier* must make arrangements with the *Certification Organisation* regarding the assessment programme and the dates and times on and during which the tests will be undertaken. The *Certification Organisation* will attend the tests without prior notification to the *System Supplier*.

C.3 Assessment tests

The following assessment tests must be undertaken as part of the assessment methodology:

a) *Video recordings of vehicles travelling over the monitoring system*. These video recordings are used in all the assessments that must be undertaken. Most of the data required by the assessments will be captured from these videos and it is therefore important that the video recordings must be of a high quality.

Two videos must be recorded for the following purposes:

i) One video for the assessment of vehicle detection and classification accuracies. This video must show the whole vehicle as well as the axles of the vehicle as it crosses the monitoring site.

These videos must be taken over a continuous period of time and not be triggered by the presence of vehicles on the monitor site. The videos must continue even if no vehicles are detected on the site. The continuous recording is required to determine whether there were any false vehicle detections by the monitoring equipment and whether there were any vehicles missed by the equipment.

A system must be used which will allow the determination of the date and time of each individual frame in the video recordings to at least the nearest second. This is required to allow later matching of the video recordings with data collected by the monitoring system.

ii) A second video used for assessments in which registration number recordings are required, such as assessments of vehicle lengths and WIM loads. This video must clearly show the registration numbers of the vehicle. If possible, the quality of the video should provide for optical character recognition of the registration numbers.

The videos should preferably be triggered by the presence of vehicles on the monitoring site. For these assessments it is not necessary to make video recordings when no vehicles are detected on the site.

b) *Speed camera recordings of speeds of vehicles travelling over the monitoring site*. The vehicle speed recordings must be made with the same accuracy required for speed law enforcement. Photographs taken by the camera must show an image of the vehicle together with the date, time and speed of the vehicle (and optionally the registration number). It should also be possible to search for a photo with a specific date and time by means of a computer.

The photographs are required to serve as verification that the speed measurements have been undertaken while the date/time stamp is required to link the data to the monitoring system data (the registration number may also be used for this purpose).

c) *Measuring tape and camera recordings of vehicle length and axle spacing*. These measurements should preferably be undertaken at locations where vehicles are already stopped for another purpose, such as at toll gates or weighbridges. At toll gates or weighbridges, the authority of the operator must first be obtained before measurements are undertaken. The measurements taken at weighbridges will only provide data for heavy vehicles, and additional surveys will be required for light vehicles. Law enforcement officers must then be used in such additional surveys to stop vehicles.

Vehicle manufacturer information on vehicle lengths and axle spacing must be used as far as possible. Tape measurements should only be used when such information is not available.

A measuring tape may be used to measure the vehicle length and axle spacing, but electronic distance measurement equipment may also be used for this purpose. At least five persons are required for the measurements: one person to inform the driver and vehicle occupants about the purpose of the measurements and to exercise control over the vehicle, two persons to hold the tape, a fourth person to read the distance from the tape and the fifth to record the distance on a form. The distances must be read cumulatively from the tape.

Cameras must be used to record images of the vehicle together with the registration number, date and time. It should also be possible to search for a photo with a specific date and time by means of a computer. The photographs are required to serve as verification that the vehicle length and axle spacing measurements have been undertaken while the registration number is required to link the data to the monitoring system data.

d) *Weighbridge* (static) load measurements are required for the assessment of HS and LS WIM monitoring systems. The *System Supplier* must make arrangements with the weighbridge operator to obtain the load records from the weighbridge. The *Certification Organisation* will also independently obtain the weighbridge load records for the purpose of verifying the records. The load records must include the registration numbers of vehicles.

C.4 Accuracy assessments

The accuracy assessments must be undertaken as follows:

a) Videos must be used for the manual assessment of vehicle, trailer, axle, wheel and dual/tyre detections and for the manual classification of vehicles.

b) Vehicle speeds must be obtained from the speed camera photographs, together with the date and time (and optionally the registration number). The speeds must be linked to the vehicle data captured using either the date/time or registration number recordings. All photographs must be submitted to the *Certification Organisation* immediately/shortly after the speed observations. This is to ensure that no vehicles are excluded from the assessment (an explanation is required should any vehicles be excluded).

c) The vehicle length and axle spacing data must be manually captured together with the data/time and registration number obtained from the photographs. The data must be linked to the vehicle data captured by means of the video recordings using the dates, times and registration numbers. The original, on site measurements must be submitted to the *Certification Organisation* immediately/shortly after the manual measurements were taken. This is to ensure that no vehicles are excluded from the assessment (an explanation is required should any vehicles be excluded).

d) The load data required for the assessment of HS and LS WIMs are obtained directly from the weighbridge load records. This data must be linked to the video data by means of the dates, times and registration numbers. The weighbridge load records must be obtained from the weighbridge operators. Where such weighbridge records are available, all vehicles measured at the weighbridge must be included in the assessment. An explanation is required for vehicles that are not included (e.g. triggered the off-scale sensor, travelled in the non-WIM lane, etc.).

The *System Supplier* must develop a computerised database in which all the data are captured, including the data obtained from the monitoring system and the weighbridge. The database must also provide links to the video recordings and camera images.

C.5 Certification Organisation review

The *System Supplier* must make a computer system and software available to the *Certification Organisation* for the verification of the data. This software must allow for the viewing of the captured data, as well as the video recordings and camera images.

The *Certification Organisation* must be able to select a random sample of vehicles to review. Provision must also be made to select a period of time over which the videos can be viewed for possible false vehicle detections. Provision must be made in the software and database to capture the results of the review by the *Certification Organisation*.

The functionality of the software must provide for the following:

a) The viewing of all captured data that are required for the assessment. This data should, where possible, be shown in a graphical form (e.g. against a drawing of the vehicle).
b) The viewing of the video recordings and camera images of the vehicle on a computer screen. Two or more screens may be required to allow simultaneous viewing of all the data and images.
c) The software must automatically link recorded data with the video recordings and camera images. Provision must also be made for the synchronised paging (up and down) through the data, video recordings and photo images.
d) Provision must also be made for a search facility to search vehicles by means of the date/time stamps or registration numbers.

Provision must also be made to export the database together with the results of the review to a spreadsheet. This spreadsheet must also show all the calculations required for the accuracy assessments, together with the results of the assessments. This spreadsheet must be made available to the *Certification Organisation* for review.

APPENDIX D

DATA VERIFICATION TESTS

D.1 Introduction

The data management software specified by the *Employer* shall be used for the purposes of data verification and calibration. An overview of the tests that must be undertaken is provided in this appendix.

The software provides for three levels of verification tests and the *Service Provider* will be required to undertake all three levels of tests. The test levels are as follows:

a) First level tests undertaken on submission of data to the software.
b) Second level tests undertaken on a monthly basis (calendar months) or when the monitoring duration is shorter than one month.
c) Third level tests are usually undertaken on an annual basis (calendar years) but may be undertaken over a shorter period when data are not available for a whole year.

The following general procedure is followed during the three levels of verification tests:

a) Tests are first undertaken to verify that the data comply with the requirements of the *South African Standard Traffic Data Collection Format*. Tests will also be undertaken to authenticate the data. Should any data fail this test, then the whole file will be rejected and not processed further.
b) Tests are then undertaken with the purpose of identifying "suspect" and "bad" data. When such data are identified, a report will be created listing the data and made available. It will be the responsibility of the *Service Provider* to investigate the data and to identify possible causes or reasons why the data are suspect and to make recommendations whether the data should be accepted or rejected. Rejected data must be marked as "bad" data. Data may also be marked "uncertain" in situations where the monitoring services have been undertaken at sites that do not comply with the road geometry and pavement requirements of these specifications.
c) Tests will also be undertaken with the purpose of identifying periods with "missing" data. These are periods in which no or partial sets of data have been collected.

D.2 First level tests

First level tests are undertaken on submission of data to the software. The following tests are required:

a) *Data format tests*. These tests are undertaken to determine whether data have been provided correctly according to the requirements of the *South African Standard Traffic Data Collection Format*. These tests include inter alia the following:

    i) Tests that individual data items comply with the specified format.

ii) Tests that data items are within the minimum and maximum ranges specified in the format.
iii) Tests that data separators (e.g. commas) comply with the format.
iv) Tests for whether header data have been provided and whether this data are correct.

Data that do not comply with the format requirements will be rejected and not processed further.

b) *Lower and upper bound tests*. These tests are undertaken to determine whether individual vehicle data falls outside lower and upper bounds. Vehicles that fail these tests are marked as suspect. The tests are undertaken on data items such as the following:

i) Total vehicle length. This is the measurement from the front to rear bumpers of the vehicle, including any trailers.
ii) Number of trailers. This is the number of trailers counted per individual vehicle.
iii) Number of axles. This is the total number of axles counted per individual vehicle.
iv) Number of steering axles. An axle on a vehicle is considered to be a steering axle when the first group of axles are spaced less than 1.6 m apart.
v) Axle spacing. The axle spacing test is applied per axle. A vehicle fails a test if any of the axle spacing measurements exceed the thresholds.
vi) Average axle load (per axle). The average axle load is the total load of the vehicle divided by the number of axles.
vii) Individual axle load. This test is applied per individual axle. A vehicle fails the test if any of the axle loads exceed the thresholds.
viii) Axle load/average load ratios. These ratios are determined as the individual axle load divided by the average axle load of a vehicle.

D.3 Second level tests

Second level tests are undertaken on a monthly basis, or when a full data set has been provided for a monitoring duration shorter than one month. The following tests are undertaken:

a) *Traffic pattern tests*. These tests are undertaken per traffic stream using hourly traffic counts for the 24 hours of the day. A pattern matching algorithm is used for these tests and will group the patterns in similar clusters. The tests are used for the identification of suspect or missing data as well as for the classification of the data as Normal, Abnormal, etc. The software will undertake the classification, but each classification must be confirmed manually.

b) *Daily traffic count tests*. These tests are undertaken per traffic stream using total 24-hour counts. The counts are compared with previous counts and any outliers will be marked as suspect for further investigation.

c) *Monthly failure rate tests*. Tests are undertaken of the percentage of vehicles that fail the lower and upper bound tests previously described. Should these percentages exceed the maximum allowable percentages, then the data are

marked as suspect for the whole month. The tests are undertaken separately for each lane of traffic.

The minimum sample size for the test is 500 vehicles. Where necessary, vehicles from a previous month(s) will be added to the sample to ensure this sample size.

d) *Systematic calibration tests*. These tests are performed as part of the systematic calibration of axle loads. The tests are only applied to trucks selected to form part of the calibration. The tests are undertaken separately for each load sensor. The following tests are undertaken:

   i) Allowable range for the calibration factors.
   ii) Maximum standard deviation for the total tractor load.
   iii) Allowable range for average front axle load.
   iv) Maximum standard deviation for the front axle load.
   v) Average axle spacing between 2nd and 3rd axles.
   vi) Standard deviation of axle spacing between 2nd and 3rd axles.

e) *Recalibration tests*. These tests are applied on a monthly basis to determine whether any changes may have occurred that may affect the system calibration. The tests are undertaken separately for each load sensor.

D.4 Third level tests

Third level tests are undertaken on an annual basis (calendar years) but may be undertaken over a shorter period when data are not available for a whole year. The purpose of the tests is to determine whether possible changes have occurred over the long term. The tests are undertaken for each traffic stream at a monitoring site.

Use is made of daily or monthly averages which are plotted over time to establish whether there are any unexpected changes or trends in the observations. Observations are usually required over a period of several months before it would be possible to identify such changes or trends.

The following characteristics are included in the tests:

a) *Traffic count tests* (daily and monthly). The traffic count tests are undertaken for daily traffic counts, as well as the average daily count for the month.

b) *Percentage composition* (monthly). The percentage composition test is used to check the consistency of the percentage of heavy vehicles classified as short, medium and long.

c) *Systematic calibration factor* (monthly). This factor should normally remain constant over time, but it could be affected by the recalibration of equipment in the field. It is also possible for the calibration of the equipment to “drift” over time. Any unexpected changes in the calibration factor should be investigated to establish the reasons for such changes.

d) *Average front axle load* (monthly). The average front axle load consistency check uses the average observed load of the front axle of the 6- and 7-axle trucks used in the calibration method, but without the application of the average axle load criterion of 6.5 to 8.5 tons. The front axle loads are adjusted using the calibration factor.

e) *Standard deviation in front axle load* (monthly). The front axle load standard deviation consistency check uses the same trucks and axles as for the average front axle load test.

f) *Average number of axles per vehicle* (monthly). The averages are determined for heavy vehicles classified as short, medium and long.

g) *Average number of E80's per axle* (monthly). The tests are undertaken for each of the short, medium and long heavy vehicle classes.

h) *Average vehicle length* (monthly). The tests are undertaken for the short, medium and long heavy vehicle classes.

i) *Percentage unclassified vehicles* (monthly). Unclassified vehicles are those that could not be classified by the equipment.

APPENDIX E

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