

# Main Roads Technical Standard

## **MRTS203** **Provision of Weigh-in-Motion System**

**October 10**

 **Queensland** Government

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# Provision of Weigh-in-Motion System

## 1 INTRODUCTION

This standard defines the design, supply, installation, testing and commissioning, performance, documentation, training and maintenance requirements for a high-speed Weigh-in-Motion System (WiM System).

A high-speed WiM System is used for collecting traffic flow data and heavy vehicle mass data.

This Technical Standard shall be read in conjunction with MRTS01 *Introduction to Technical Standards*, MRTS50 *Specific Quality System Requirements* and other Technical Standards as appropriate.

This Technical Standard forms part of the Main Roads Specifications and Technical Standards Manual.

## 2 DEFINITION OF TERMS

The terms defined in MRTS201 *General Equipment Requirements* apply to this standard. Additional terminology relevant to this standard is defined in Table 2 below.

**Table 2 - Definitions**

Term	Definition
Accuracy	The closeness or degree of agreement (within a stated tolerance and probability of conformity) between a value measured or estimated by a WiM system and an accepted reference value.
ASCII	American Standard Code for Information Interchange
Axle	The axis oriented transversely to the nominal direction of vehicle motion, and extending the full width of the vehicle, about which the wheel(s) at both ends rotate.
Axle Group Load	The sum of all tyre loads of the wheels on a group of adjacent axles; a portion of the gross vehicle weight. (An axle group can be defined in terms of the number of axles included in the group and their respective interspaces).
Axle Load	The sum of all tyre loads of the wheels on an axle; a portion of the gross vehicle weight.
Calibration	Adjustment to a reference level of values from any measuring device.
Calibration Factor	Numerical factor by which the raw result of a measurement is multiplied to compensate for systematic error.
Coefficient of Variation	Ratio of the standard deviation to the mean.
Confidence Interval	Interval that contains the true value of a parameter represented by a random variable, with a given probability.
Confidence Level	Probability that an interval contains the true value of a parameter represented by a random variable.
Data Logger	A device designed to collect, process, store and transmit vehicle data.
Gross Vehicle Weight	The total weight of the vehicle or the vehicle combination including all connected components; also, the sum of the tyre loads of all wheels on the vehicle.
Piezo Sensor	A coaxial cable containing a piezo-electric substance, which converts an applied strain or pressure into an electrical signal that is related to the magnitude and direction of the applied strain or pressure. A piezo-electric sensor is a strip sensor containing a piezo-electric cable; it may be of two types: piezo-ceramic sensors and piezo-polymer sensors. A piezo-quartz sensor is a strip sensor that uses piezo-electric crystal quartz.

Term	Definition
QTDF	Queensland Traffic Data Format
Single Axle Load	The load transmitted to the road surface by the tyres of all wheels lying between two parallel transverse vertical planes 1 m apart, extending across the full width of the vehicle; a portion of the gross vehicle weight.
Tandem Axle Load	The total load sent to the road surface by the tyres on all wheels of two consecutive vehicle axles that are more than 1 m and not more than 2.1 m apart; a portion of the gross vehicle weight
Tolerance	The defined limit of allowable departure of a value measured or estimated by a WiM System from an accepted reference value.
Triaxle Load	The total load sent to the road surface by the tyres on all wheels of three consecutive vehicle axles; a portion of the gross vehicle weight.
Weigh-in-Motion (WiM)	The process of estimating a moving vehicle's gross weight and the portion of that weight that is carried by each wheel, axle, or axle group, or combination thereof, by measurement and analysis of dynamic vehicle tyre forces.
Weight	The external force of gravity acting vertically downwards upon a body with a magnitude equal to the body's mass multiplied by the local acceleration of free fall. (The force of gravity, thus the acceleration of free fall, is different at various locations on or near the surface of Earth; therefore, weighing devices in commercial use or in official use by government agencies for enforcement of traffic and highway laws or collecting statistical information are usually used in one locality and are adjusted or calibrated to indicate mass at that locality. The indicated mass can be converted to weight (in units of force) by multiplying by the local value of the acceleration of free fall, if it is known. The conventional value adopted by ISO is 9.806 65 m/s <sup>2</sup> . Weight is a special case of force, as weight is due only to the local force of gravity that is always directed vertically downwards).
WiM System	The WiM System comprises equipment installed at the WiM site. The WiM System includes a set of sensors and supporting instruments that measure the presence of a moving vehicle and the related dynamic tyre forces at specified locations with respect to time; estimated tyre loads; calculated speed, axle spacing, vehicle class according to axle arrangement, and other parameters concerning the vehicle. The WiM System must process and store data locally, and allow transmission of this information to a locally connected laptop computer and/or remote PC.

### 3 REFERENCE DOCUMENTS

The requirements of the referenced documents listed in Table 3 of MRTS201 *General Equipment Requirements* and Table 3 below apply to this standard. Where there are inconsistencies between this standard and the referenced MRTS (including those referenced in MRTS201 *General Equipment Requirements*), the requirements specified in this standard must take precedence.

**Table 3 - Referenced Documents**

Document / Source	Description
MRTS201	General Equipment Requirements
MRTS232	Provision of Field Processors
ASTM E 1318 - 09	Standard Specification for Highway Weigh-In-Motion (WiM) Systems with User Requirements and Test Methods
Austrroads 2009	Guide to Traffic Management Part 3: Traffic Studies and Analysis

## 4 QUALITY SYSTEM REQUIREMENTS

The quality system requirements defined in MRTS201 apply to this standard. Additional quality system requirements relevant to this standard are defined in Table 4 below.

**Table 4 – Hold Point and Witness point**

Clause	Hold Point	Witness Point
11.2	1. Contractor must provide adequate operating environment for the system's sensors and instruments. The final location must be confirmed by the Contractor to the Principal	
11.2.5		1. The WiM System sensors must be smooth before sensor installation. The road roughness count measured at 20 m intervals must not exceed a rate of 70 counts per kilometre
12.1	2. The Contractor must supply a certificate showing that each supplied tyre-force sensor has been tested under a simulated tyre load prior to installation.	
12.2		2. The IAT must be conducted on site by the Contractor immediately after the WiM System has been installed and calibrated to the manufacturer's specification

## 5 FUNCTIONAL REQUIREMENTS

The WiM System must collect, process, store, transmit and manipulate traffic information related to the counting, classifying and speed monitoring of all vehicles and the weighing of heavy vehicles at highway speeds.

The WiM System must be able to accommodate vehicles and vehicle combinations with up to twenty-five axles and must automatically determine for each vehicle, by lane of travel: vehicle classification, vehicle speed, axle spacing and axle/axle group weight.

The WiM System must process data in real time in the field in a data logger and provide a connection for the purposes of configuration and data retrieval. It must also allow data to be viewed in real time, both locally and remotely.

## 6 EQUIPMENT

### 6.1 General

Equipment shall be manufactured by companies that are skilled and have regularly engaged in the manufacture of equipment of the type specified herein for a period of not less than five (5) years. The supplier shall be a sales and service facility authorised by the manufacturer for the product offered. The equipment shall be established, reliable and have been used successfully in applications equivalent to those required by the Contract. Equipment of experimental or unproven design is prohibited

### 6.2 Components

The WiM System shall includes:

- weight sensors, necessary cabling and mounting hardware for each lane to be instrumented;
- sufficient axle sensors per lane to determine vehicle speed and axle spacings;
- a vehicle detector per lane, such as an inductive loop detector, to separate vehicle events;
- a data logger ; and
- all necessary interconnecting cables and miscellaneous materials to make an operational system.

The data logger must include all equipment and software required to calculate, store and transmit all data specified in this standard.

## **7 OPERATIONAL REQUIREMENTS**

The operational requirements defined in MRTS201 apply to this standard. Additional operational requirements for equipment provided under this standard are described below.

### **7.1 General**

Installed equipment must meet ASTM E-1318-09 tolerances for Type I equipment based on axle weights, gross vehicle weights, speeds and axle spacings.

The WiM System must provide for single threshold weighing, and operate over a speed range of 16 km/h to 130 km/h.

Single threshold weighing will be performed by weigh sensors in each lane of measurement. The weight sensors must cover the entire lane width.

### **7.2 Environmental Requirements**

The Contractor must supply evidence that the offered WiM System has previously performed satisfactorily (within accuracy tolerances specified in Clause 7.3) throughout the specified ambient air temperature range expected at the site.

### **7.3 Accuracy**

The WiM System must be capable of performing the indicated functions within the accuracy tolerances described in 7.3 within a 95% Confidence Level of error.

**Table 7.3 - Accuracy**

<b>Function</b>	<b>Accuracy Tolerance</b>
Single Axles	±20%
Axle Groups	±15%
Gross-Vehicle Weight	±10%
Speed	±2 km/h
Axle-Spacing	±150 mm

The WiM must provide calibration features such that the required accuracy can be met and maintained.

### **7.4 Recorded Data**

The data logger must store the following data:

- Vehicle counts by vehicle class and by speed range summarised to a quarter hour interval;
- Individual vehicle records for all heavy vehicles, that is: Austroads Class 3 and above with the option of collecting all vehicles.

Individual vehicle records must be classified in accordance with Clause 7.5. Such classification parameters must be programmable by the Principal's operator. Each vehicle record must include, as a minimum, the following data:

- Date and Time (Time to a resolution of at least two decimal places of a second);

- Lane Number;
- Vehicle Speed;
- Vehicle Classification;
- Axle Load;
- Axle Group Load;
- Gross Vehicle Weight; and
- Spacings in between each sequentially numbered axle.

The data logger of the WiM System must calculate and store all specified data with the capacity to store a minimum of seven days of vehicle count data and individual vehicle records. The data logger must continue to calculate and store data for all vehicles passing through the system during periods of access for purposes of programming, real-time view and downloading of data.

Data must be calculated, recorded and formatted such that it can be intuitively understood when viewed in an ASCII text editor.

### 7.5 Vehicle Classification

Vehicle classification must be accomplished by the WiM System by the following data:

- Number of Axles;
- Axle spacing; and
- Number of axle groups.

The Contractor must incorporate software within the WiM System for using the axle count and axle spacing information to classify the Austroads vehicle types as described briefly below. Refer to Austroads Guide to Traffic Management Part 3: Traffic Studies and Analysis for the complete description of vehicle types. The axle spacing values used for this process must be associated with each vehicle type as listed in Table 7.5. These values must be readily viewed and updated by the Principal's operator. The classified vehicle type must be indicated by the 2-digit code shown in Table 7.5.

**Table 7.5 - Austroads Vehicle Types**

2-digit code	Brief Description
01	Short Vehicle
02	Short Vehicle Towing
03	Two Axle Truck or Bus
04	Three Axle Truck or Bus
05	Four Axle Truck
06	Three Axle Articulated Vehicle
07	Four Axle Articulated Vehicle
08	Five Axle Articulated Vehicle
09	Six Axle Articulated Vehicle
10	B Double
11	Double Road Train
12	Triple Road Train

## 8 CONTROL SYSTEM

The control system must be furnished as part of the WiM System and must facilitate communications between a locally connected laptop computer and the data logger and a remote PC and the data logger.

The control system must process downloaded data to generate the specific ASCII files. Although referred to herein as a single software program, communications functions and data processing functions may be provided as two separate programs as long as all functional requirements are met.

It shall be possible to perform all configurations and download tasks locally from a laptop computer running Microsoft Windows® XP-Professional or Windows® 7 Professional.

## **8.1 Communications**

The communications portion of the control system must include the applications listed in Sections 8.1.1 to 8.1.3 of this Standard.

### **8.1.1 Real Time View**

The real time view application must support on-line monitoring of traffic. The display must depict the axle configuration of each vehicle passing through the site. The user must have the options of displaying either all traffic or only vehicle types 3 through 12, as well as the option of displaying a selected individual lane or all lanes.

### **8.1.2 System Data Configuration**

The control system must support on-line modification to the data logger's software parameters such as speed and weight calibration factors, vehicle classification parameters, weight violation table parameters, and front axle weight threshold.

### **8.1.3 Data Transfer**

The control system must support the downloading of files from the data logger. The system must provide for the downloading of the current day's data stored as of the time of downloading.

## **8.2 Data Processing**

The control system must provide for the processing of downloaded files to an ASCII format compatible with TMR's QTDF data format. Details of this data format can be obtained from the Principal.

## **9 ELECTRICAL REQUIREMENTS**

The WiM system shall be powered by an ELV power supply.

## **10 TELECOMMUNICATIONS REQUIREMENTS**

The telecommunication requirements defined in MRTS201 apply to work provided under this standard.

In addition, the WiM system shall be equipped with at least one EIA RS232 serial port and desirably include an Ethernet port using industry-standard secure shell FTP.

The connection must cope with high latency network connections.

## **11 INSTALLATION REQUIREMENTS**

The installation requirements defined in MRTS201 apply to work provided under this standard. Additional testing and commissioning requirements relevant to work provided under this standard are described below.

### **11.1 General**

The Contractor must provide full-time on-site supervision during weigh-in-motion system installation and system start-up.

### **11.2 WiM Site Selection**

In order for the WiM System to perform properly, the Contractor must provide and maintain an adequate operating environment for the system's sensors and instruments. Selection, construction and continuing maintenance of each WiM site, as well as continuing maintenance of the sensors, are extremely important considerations. The following site conditions, or better, must be provided by the Contractor to meet the performance criteria specified herein consistently. The final location must be confirmed by the Contractor to the Principal. **Hold Point 1**

### 11.2.1 Horizontal Alignment

The horizontal curvature of the roadway lane for 100 m in advance of and 50 m beyond the WiM System sensors must have a radius not less than 1700 m measured along the centreline of the lane.

### 11.2.2 Longitudinal Alignment

The longitudinal gradient of the road surface for 100 m in advance of and 50 m beyond the WiM System sensors must not exceed  $\pm 2\%$ .

### 11.2.3 Cross Slope

The cross-slope (lateral slope) of the road surface for 100 m in advance of and 50 m beyond the WiM System sensors must not exceed  $\pm 3\%$ .

### 11.2.4 Lane Width and Markings

The width of the paved roadway lane for 100 m in advance of and 50 m beyond the WiM System sensors must be between 3.5 and 4.3 m inclusive. The edges of the lane throughout this distance must be marked with solid white longitudinal pavement marking lines 100 to 150 mm wide.

### 11.2.5 Surface Evenness

The surface of the paved roadway for 100 m in advance of and 50 m beyond the WiM System sensors must be smooth before sensor installation and maintained in a condition such that the deviation from a 3 m straightedge placed anywhere within a lane must not exceed 7 mm. The road roughness count measured at 20 m intervals must not exceed a rate of 70 counts per kilometre. **Witness Point**

## 11.3 Field Cabinet

All electronics associated with the WiM System must be housed in a telecommunications field cabinet that complies with MRTS201.

## 12 TESTING & COMMISSIONING

The testing and commissioning requirements defined in MRTS201 apply to work provided under this standard. Additional testing and commissioning requirements relevant under this standard are described below.

### 12.1 Factory Acceptance Test (FAT)

The Contractor must supply a certificate showing that each supplied tyre-force sensor has been tested under a simulated tyre load prior to installation and found to produce an output signal that was linear within 2% of the applied load up to 90 % of the sensor's rated load capacity throughout the lateral extent of the sensor. **Hold Point 2**

### 12.2 Installation Acceptance Test (IAT) and Commissioning Test (CT)

The Contractor must demonstrate that the WiM System is available for use by successfully completing the IAT for each lane of data collection at each WiM site.

The IAT must verify accuracy of the recorded data as described in Clause 7.3.

The IAT must be conducted on site by the Contractor immediately after the WiM System has been installed and calibrated to the manufacturer's specification. **Witness Point**

The following steps are required for each instrumented lane:

#### 12.2.1 Test Vehicles

The test vehicles must consist of two loaded, pre-weighed (on a suitable static scale or weighbridge) and measured vehicles that will make multiple runs over the WiM System sensors in each lane at prescribed speeds and lateral positions. One of the loaded test vehicles must be a two-axle rigid truck (Class 03) and the other must be a six axle articulated vehicle (Class 09). The six-axle articulated vehicle must be equipped with air suspension.

Two load conditions are required for each vehicle. They must be loaded to approximately 50%, and at least 90%, of their respective registered gross-vehicle weight with a non-shifting, approximately symmetric (side-to-side) load. The test vehicles must be in sound mechanical condition. Special care must be exercised to

ensure that the tyres on the test vehicles are in sound condition, dynamically balanced and inflated to recommended pressures.

### **12.2.2 Procedure**

After the settings have been installed on the WiM System, each of the two test vehicles must make five or more runs over the sensors in each lane at a minimum of two speed points over a speed range covering 80% of the truck traffic stream. For this project, these points will be 95 km/h and 70 km/h. At each speed, one or more runs must be made with the test vehicle tyres near the left-hand lane edge, and one or more runs with the test vehicle tyres near the right-hand lane edge. The other runs must be made with the test vehicle approximately centred in the lane. With a calibrated radar speed meter, or by some other means (such as wheelbase/time) that is acceptable to both the Principal and the Contractor, the speed of each test vehicle every time it passes over the WiM System sensors must be measured. All data must be recorded, and the vehicle record number must be noted for every run of each test vehicle. The radar speed meter, if used, must be calibrated by the method recommended by its manufacturer within 30 days prior to use.

### **12.2.3 Acceptance Criteria**

All specified data collection features, data processing features, and options of the system described herein must be fully documented and demonstrated to function properly before the systems are released for the CAT. If any part of the WiM System fails to function properly, or if more than 5% of the calculated differences for any applicable data item resulting from all passes of the two test vehicles exceed the tolerance specified herein, the WiM System will be deemed to have failed the IAT and/or CAT.

### **12.3 WiM System Customer Acceptance Test (CAT)**

The CAT requirements defined in MRTS201 apply to this standard.

## **13 DOCUMENTATION**

The documentation requirements defined in MRTS201 apply to work provided under this standard. Additional minimum documentation requirements relevant under this standard are described below.

### **13.1 Operations Manual and Maintenance Manual**

The WiM System sections in the operations manuals and the maintenance manuals must detail all WiM System assets including the data logger, sensor units and software. The manuals must include, as a minimum, the following items:

- Specifications;
- Design characteristics;
- General operation theory;
- Function of all controls;
- Signal responses and acceptable thresholds;
- List of component parts with stock numbers;
- Documentation for the control system;
- Documentation for all protocols used for communications with the data logger; and
- Documentation for all data formats utilised by the data logger.

## **14 TRAINING**

The training requirements defined in MRTS201 apply to work provided under this standard. In addition 2 full days of onsite training for a least 3 operations personnel nominated by the Principal must be provided.

## **15 MAINTENANCE**

The maintenance requirements defined in MRTS201 apply to work provided under this standard. Additional maintenance requirements relevant under this standard are described below.

### **15.1 Pavement**

The surface of the paved roadway at each WiM site must be maintained in a condition that meets or exceeds the surface evenness requirements specified in Clause 11.2.5. The Contractor must verify pavement smoothness following any significant pavement maintenance but no less frequently than annually. The Maintenance Plan must incorporate such tests.

### **15.2 Recalibration**

The Contractor must recalibrate the WiM System following any significant maintenance. Recalibration must be performed no less frequently than annually. The Maintenance Plan must describe the required recalibration.

## **16 HANDOVER**

The handover requirements defined in MRTS201 apply to work provided under this standard.