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Vehicle Load Management — Equipment Verification — Weigh-in-Motion System Verification

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Foreword

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This African Standard was prepared by the ARSO Technical Committee Number 29 on Road, Rail, Air and Water Transport Infrastructure (ARSO/TC 29).

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Introduction

The main goal of a Weigh Station is effective and efficient vehicle load management by way of accurate screening results of vehicles without requiring vehicles that are not overloaded to be weighed on the static scale.

Accurate screening results of both domestic road transport and international cross border road transport call for the verification of the Weigh in Motion (WIM) Systems to be performed in a consistent manner to ensure reliable screening results irrespective of the weigh station at which the WIM System is installed.

This standard specifies the WIM System verification process to ensure the continuous effective and efficient overload control that conforms to legal requirements.

This procedure may also be used during the calibration of the WIM System prior to the verification thereof, by repetition of the procedure until the required accuracy is reached, for verification to be performed.

Vehicle Load Management — Equipment Verification — Weigh-in-Motion System Verification

1 Scope and application

1.1 Scope

This document:

- Indicates the schedule and frequency of verification operations to be performed on WIM Systems.
- Gives specifications for Verification Vehicles to be used for verification of a WIM System.

1.2 Application

This document applies to:

- Automatic WIM Systems, but does not apply to individual parts of WIM Systems.
- WIM Systems used for Statistical (e.g. Traffic Monitoring, Pavement Loading, Pre-selection), and Legal (e.g. Trade, Tolling, Direct Mass Enforcement) applications.
- WIM Systems installed on, in or under the road infrastructure including both roads and bridges independent from which type of measuring technology is used.
- High Speed WIM Systems (in a normal road and operated under free flow traffic conditions).
- Fixed as well as portable WIM Systems installed in or under road pavement bridges.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ARS 1372-1: Vehicle Load Management – Accreditation – Part 1: Weigh Station Layout and Design

ARS 1372-2: Vehicle Load Management – Accreditation – Part 2: Vehicle Load Management Information System

ARS 1373: Vehicle Load Management – Equipment Verification – Static Scale Verification

ASTM International Standard E 1318-09 – Standard Specification for Highway Weigh-In-Motion (WIM) Systems with User Requirements and Test Methods

3 Terms and definitions

For the purpose of this standard the following definitions and abbreviations apply.

3.1 Definitions

3.1.1
accuracy of a measurement
The degree to which a measured value can be equated to the true value or a value accepted as reference.

3.1.2
accuracy of a measurement instrument
The degree to which measurements from a specific measurement instrument can be equated to the true value or a value accepted as reference.

3.1.3
accuracy
δ
Value defined for the specific WIM System Class, used as a percentage to quantify the maximum allowed relative error.

3.1.4
accuracy range
The range of measurements acceptable for a specific reference value based on the accuracy level. [Reference Value – (δ/100)*Reference Value, Reference Value + (δ/100)*Reference Value]

3.1.5
adjustment
An operation or change made to a measuring instrument to reduce the error of measurement.

3.1.6
axle
In relation to a vehicle, means a device or set of devices, whether continuous across the width of the vehicle or not, about which the wheels of the vehicle rotate and which is so placed that, when the vehicle is travelling straight ahead, the vertical centre lines of such wheels would be in one vertical plane at right angles to the longitudinal centre-line of such vehicle.

3.1.7
axle distance
The distance between the centres of two axles, parallel to the nominal direction of travel of the vehicle.

3.1.8
axle unit
In relation to a vehicle means a set of two or more parallel axles of such vehicle that are so interconnected as to form a unit.

3.1.9
axle unit load
The sum of the wheel mass of all wheels on any axle unit.

3.1.10
axle load
The sum of the wheel mass of all wheels on any axle.

3.1.11
axle spacing
See axle distance.

3.1.12
bias
See mean error.

3.1.13
calibration
The process of comparing a measuring instrument against a traceable standard or another accepted reference and adjust the measuring instrument to reduce the error of measurements.

3.1.14
confidence level
The chance that, in reality, the measurement errors of the system under test lie within the accuracy interval [-δ, +δ], expressed as a percentage. The confidence level is used to qualify the reliability of the outcome of a test procedure.

3.1.15
dynamic vehicle tyre force
The component of time-varying force in N applied perpendicularly to the road surface by the tyres on a wheel of a moving vehicle.

3.1.16
error of measurement
The difference between the measured value and the true value or an accepted reference value for an individual measurement.

3.1.17
Gross Combination Mass
GCM
Maximum design mass of a combination of vehicles and their load as specified by the manufacturer of the drawing vehicle on the vehicle plate.

3.1.18
Gross Vehicle Mass
GVM
Maximum design mass of a vehicle and its load as specified by the manufacturer of the vehicle on the vehicle plate.

3.1.19
legal applications
Applications of WIM Systems with a direct connection to a legal transaction, such as mass enforcement. Such WIM Systems require a legal approval by a notified body that certifies the requirement for each individual measurement.

3.1.20
load sensor
A sensor installed in or under the road pavement measuring the dynamic force exerted by a vehicle on the road.

3.1.21
measurement error
Difference between the measured value and the accepted reference value.

3.1.22
operating ranges
Range between the minimum and maximum value of influence quantities where the system performs according to its specifications.

3.1.23
rated operating conditions
Conditions of use that give the ranges of the influence quantities for which the performance of the system lies within the specifications.

3.1.24
reference conditions
Conditions of use prescribed for testing the performance of a measuring instrument or for inter-comparison of measurements.

3.1.25
reference mass
The unknown actual value or the known value in kg accepted as a reference value for a mass measurement.

3.1.26
reference spacing
The unknown actual value or the known value accepted as a reference value for a spacing measurement.

3.1.27
relative measurement error
Error of measurement divided by the accepted reference value.

3.1.28
sensor
Part of a measuring instrument that is directly affected by the parameter to be measured and produces a related signal.

3.1.29
standard deviation
σ
The measure of the distribution of data about a mean value. It describes the dispersion (spread) of data on either side of a mean value.

3.1.30
static weighing
Weighing of a vehicle while that vehicle is stationary relative to the scale.

3.1.31
statistical application
Application of WIM Systems without a direct connection to a legal or financial transaction, e.g. traffic monitoring, pavement loading, pre-selection or screening for mass enforcement. Such WIM Systems do not require legal approval by a notified body.

3.1.32
total vehicle mass
The total mass of a vehicle or combination of vehicles in kg, measured as the sum of the loads on all the wheels of the vehicle that are in contact with the road surface.

3.1.33
true value
The unknown actual value or the known value accepted as a reference value for a measurement. For HSWIM measurements generally, a static scale measurement is used as a reference value.

3.1.34
validity of measurement
An indication of confidence in the quality of a measurement determined by a WIM System itself intended to filter measurement that were disturbed by external factors such as driver behaviour.

3.1.35
vehicle length
See wheel base.

3.1.36
Vehicle Load Management Information System
VLMIS
The computerised information system contemplated in ARS 1372-2: Vehicle Load Management – Accreditation – Part 2: Vehicle Load Management Information System.

3.1.37
verification
The process of comparing a measuring instrument against a traceable standard or another accepted reference.

3.1.38
verification vehicle
Combination of a drawing vehicle and semi trailer, also referred to as an articulated vehicle.

3.1.39
Weigh-In-Motion
WIM
The process of estimating the wheel and/or axle loads and gross mass of a moving vehicle, by measurement an analysis of the dynamic vehicle tyre force.

3.1.40
WIM System (Instrument)
A set of sensors mounted in conformance with the manufacturer's specifications and electronics with software which measures dynamic vehicle tyre forces and vehicle presence of a moving vehicle with respect to time and calculates wheel and/or axle loads and gross mass estimates, as well as other vehicle parameters such as speed, axle spacing, category, etc.

3.1.41
weighing range
Range between the minimum and maximum value of the measured variable where the system performs according to its specifications.

3.1.42
wheel base
The distance between the centres of the first and last axle of a vehicle.

3.1.43
wheel load
The portion of the gross mass in kg imposed upon a weighing instrument by the tyre(s) of a stationary wheel at the time of weighing, due only to the vertical downward force of gravity acting on the mass of the vehicle.

3.2 Abbreviations

HSWIM high speed weigh in motion

kg kilogram

m metre

N newton

4 Verification Procedure

4.1 Introduction

The function of verification is to define factors that influence the accuracy and reliability of the measurements made by the WIM System. It is necessary to recognise the effects of these site-specific, speed-specific, and vehicle specific influences on WIM system performance and attempt to compensate for their adverse effects as much as is practically possible via on-site verification.

This procedure shall be conducted by a verification agent with cooperation of the vendor, or by their authorised representatives. It requires that one loaded, pre-weighed and measured test vehicle make multiple runs over the WIM System Sensors in each applicable lane at specified speeds.

4.2 Schedule and Frequency of Verification

The verification procedure shall be applied within 6 calendar months after the initial verification of a WIM System. A WIM System shall be verified at least once in every 6 calendar months. The verification procedure shall be applied again when a WIM System is reinstalled or whenever site conditions or WIM System components (including software and settings) have changed significantly.

Where large inaccuracies are observed when the WIM System is verification after the initial installation or reinstallation, likely due to high traffic volumes or other environmental factors, the next verification may be scheduled sooner than 6 months.

Where the VLMIS allows active monitoring of the WIM System by way of comparison of the Static Scale axle unit and total vehicle mass relative to the WIM axle and total vehicle mass recorded for the same vehicle, the verification may be extended to intervals of 12 months.

4.3 Verification Vehicle

One verification vehicle is required for the verification procedure. This vehicle should be selected specifically to conform to the following characteristics for a verification vehicle:

1) The vehicle shall be an articulated vehicle with five (5) axles.

2) The vehicle shall be between 2.4 m and 2.6 m wide.

3) The vehicle shall have a non-shifting static load.

4) The vehicle shall be loaded to at least 90% of its allowable GCM.

5) The vehicle shall be loaded in order to balance the load across all axles or axle units, not including the steering axle.

6) The vehicle shall be in excellent mechanical condition.

The characteristics of the verification vehicle shall be carefully documented for the verification procedure and recorded for future reference.

4.4 Procedure

The following procedure shall be followed to verify the calibrated accuracy of a WIM System. A WIM System Verification Field Sheet template is supplied in Annex B. This field sheet may be used as is, or as a guide for documentation used by a WIM System Verifier.

1) The Verification Vehicle shall be weighed on a Static Scale. The Static Scale used shall conform to the verification standard set out in ARS 1373: Vehicle Load Management – Equipment Verification – Static Scale Verification. The mass of each axle shall be recorded to the nearest 20 kg. The following axle masses shall be recorded:

    i) The front axle (single axle).

    ii) The drive axle unit (dual axle).

    iii) The trailer axle unit (dual axle).

    iv) The Total Vehicle Mass shall be calculated by adding the three masses together.

2) The Axle Distances from the steering axle to the driving axle unit, from the steering axle to the trailer axle unit, and from the driving axle unit to the trailer axle unit on the truck shall be measured and recorded to the nearest 0.05 m. These measurements shall be regarded as the Reference Spacing.

3) The WIM System settings shall be set in accordance with the WIM System vendor's recommendations.

4) The Verification Vehicle shall make three (3) test runs over the WIM System at the selected speed indicative of the traffic at the site. In the application of this procedure for purposes of calibration prior to verification, adjustments must be made by the authorised calibration agent to fine tune the axle distance and mass measurement of the system until the desired accuracy is achieved.

5) The Verification vehicle shall complete an additional two (2) runs over the WIM System at the selected speed that is indicative of the traffic at the site to confirm the accuracy of the adjustments. If the user is satisfied that the measurements fall within the Accuracy Range, the test may continue. If this is not the case, additional adjustment is required and the Vehicle shall make two (2) more confirming runs.

6) The Verification Vehicle shall make ten (10) runs over the WIM System, divided into runs at selected speeds:

    i) Three (3) runs at the minimum rated speed of the WIM;

    ii) Three (3) runs at the maximum rated speed of the WIM; and,

    iii) Four (4) runs at the speed indicative of the average speed of traffic over the WIM.

7) All the data of each run shall be recorded on the datasheet provided in Annex B.

8) The Mass Error and Spacing Error Percentage for all recorded measurements shall be calculated at the end of the ten (10) runs. The calculations shall be performed as follows:

    i) For mass measurements, the percent error for each test run shall be calculated using the following formula:

$$Mass\ Error\ \% = \frac{Measured\ Mass - Reference\ Mass}{Reference\ Mass} \times 100\%$$

ii) The error for Axle Distance shall be calculated using the following formula:

$$Spacing\ Error\ \% = \frac{Measured\ Spacing - Reference\ Spacing}{Reference\ Spacing} \times 100\%$$

9) A check shall be made of the calculated results against the accepted Accuracy Range for the WIM System. There will be one of two results for each of the applications:

i) For Statistical Applications the confidence level shall be 95%:

I) If 95% of all recorded test results (single axles, axle units, Total Vehicle Mass and axle spacing) fall within the specified Accuracy Range, the system have passed the requirements;

II) If less than 95% of the calculated differences fall within the specified Accuracy Range, the system have failed the requirements.

ii) For Legal Applications the confidence level shall be 100%:

I) If 100% of all recorded test results (single axles, axle units, Total Vehicle Mass and axle spacing) fall within the specified Accuracy Range, the system have passed the requirements;

II) If less than 100% of the calculated differences fall within the specified Accuracy Range, the system have failed the requirements.

10) A Verification Certificate in conformance with Annex A shall be issued upon confirmation that the WIM System passed the requirements.

11) In the application of this procedure for purposes of calibration prior to verification, the system must be re-adjusted by the authorised calibration agent and an additional ten (10) passes shall be required to retest the system after the adjustment. The calibration testing shall continue until the system passes all requirements.

Annex A
(normative)

Verification Certificate

Verification Certificate			
Verification performed in compliance with ARS 1374 Weigh-in-Motion System (WIM) for use by Weigh Stations and Road Authorities			
Certificate Number:			
Verification Laboratory:			
Address:			
Owner of WIM:			
Location of WIM:			
Details of WIM			
Manufacturer:		Model:	
Serial Number:		Measurement Interval:	
Maximum Capacity (kg):			
Details of Verification Vehicle			
Plate Number(s):		Axle Configuration:	
		Tare:	
		Total Vehicle Mass:	
Mechanical Inspection Performed on (Date):			
I hereby certify that the above WIM System conforms to the verification requirements as set out in ARS 1374, passing all tests as shown on the Verification Field Sheet attached.			
Date:		Time:	
Name of Verification Officer:			
Signature of Verification Officer:			
Verification Seal Identification Number:			

Annex B
(normative)

WIM System Verification Field Sheet

WIM Verification Field Sheet

Verification performed in compliance with ARS 1374

Test Conditions and Variables

WIM System			
WIM Type		Accuracy	

Vehicle Reg. No.			
Statically Weighed Masses		**Axle Spacing**	
Steering Axle		From Steering Axle to Driving Axle Unit	
Driving Axle Unit		From Driving to Trailer Axle Unit	
Trailer Axle Unit		From Steering Axle to Trailer Axle Unit	
Total Vehicle Mass			

Test Run Results

Test Run 1					
Mass loads	**Measured**	**Error %**	**Axle Spacing**	**Measured**	**Error %**
Steering Axle			From Steering Axle to Driving Axle Unit		
Driving Axle Unit			From Driving to Trailer Axle Unit		
Trailer Axle Unit			From Steering Axle to Trailer Axle Unit		
Total Vehicle Mass					

Test Run 2					
Mass loads	**Measured**	**Error %**	**Axle Spacing**	**Measured**	**Error %**
Steering Axle			From Steering Axle to Driving Axle Unit		
Driving Axle Unit			From Driving to Trailer Axle Unit		
Trailer Axle Unit			From Steering Axle to Trailer Axle Unit		
Total Vehicle Mass					

Test Run 3					
Mass loads	**Measured**	**Error %**	**Axle Spacing**	**Measured**	**Error %**
Steering Axle			From Steering Axle to Driving Axle Unit		
Driving Axle Unit			From Driving to Trailer Axle Unit		
Trailer Axle Unit			From Steering Axle to Trailer Axle Unit		
Total Vehicle Mass					

Test Run 4					
Mass loads	**Measured**	**Error %**	**Axle Spacing**	**Measured**	**Error %**
Steering Axle			From Steering Axle to Driving Axle Unit		
Driving Axle Unit			From Driving to Trailer Axle Unit		
Trailer Axle Unit			From Steering Axle to Trailer Axle Unit		
Total Vehicle Mass					

Test Run 5					
Mass loads	**Measured**	**Error %**	**Spacing**	**Measured**	**Error %**
Steering Axle			From Steering Axle to Driving Axle Unit		
Driving Axle Unit			From Driving to Trailer Axle Unit		
Trailer Axle Unit			From Steering Axle to Trailer Axle Unit		
Total Vehicle Mass					

Test Run 6					
Mass loads	**Measured**	**Error %**	**Axle Spacing**	**Measured**	**Error %**
Steering Axle			From Steering Axle to Driving Axle Unit		
Driving Axle Unit			From Driving to Trailer Axle Unit		
Trailer Axle Unit			From Steering Axle to Trailer Axle Unit		
Total Vehicle Mass					

Test Run 7					
Mass loads	**Measured**	**Error %**	**Axle Spacing**	**Measured**	**Error %**
Steering Axle			From Steering Axle to Driving Axle Unit		
Driving Axle Unit			From Driving to Trailer Axle Unit		
Trailer Axle Unit			From Steering Axle to Trailer Axle Unit		
Total Vehicle Mass					

Test Run 8					
Mass loads	**Measured**	**Error %**	**Axle Spacing**	**Measured**	**Error %**
Steering Axle			From Steering Axle to Driving Axle Unit		
Driving Axle Unit			From Driving to Trailer Axle Unit		
Trailer Axle Unit			From Steering Axle to Trailer Axle Unit		
Total Vehicle Mass					

Test Run 9					
Mass loads	**Measured**	**Error %**	**Axle Spacing**	**Measured**	**Error %**
Steering Axle			From Steering Axle to Driving Axle Unit		
Driving Axle Unit			From Driving to Trailer Axle Unit		
Trailer Axle Unit			From Steering Axle to Trailer Axle Unit		
Total Vehicle Mass					

Test Run 10					
Mass loads	**Measured**	**Error %**	**Axle Spacing**	**Measured**	**Error %**
Steering Axle			From Steering Axle to Driving Axle Unit		
Driving Axle Unit			From Driving to Trailer Axle Unit		
Trailer Axle Unit			From Steering Axle to Trailer Axle Unit		
Total Vehicle Mass					

Annex C
(informative)

Example of a Completed WIM System Verification Field Sheet

WIM Verification Field Sheet

Verification performed in compliance with ARS 1374

Test Conditions and Variables

WIM System			
WIM Type	HSWIM	Accuracy	4

Vehicle Reg. No.			
Statically Weighed Masses		**Axle Spacing**	
Steering Axle	3860 kg	From Steering Axle to Driving Axle Unit	5.95 m
Driving Axle Unit	10200 kg	From Driving to Trailer Axle Unit	14.47 m
Trailer Axle Unit	9000 kg	From Steering Axle to Trailer Axle Unit	20.42 m
Total Vehicle Mass	23060 kg		

Test Run Results

Test Run 1					
Mass loads	**Measured**	**Error %**	**Axle Spacing**	**Measured**	**Error %**
Steering Axle	3860 kg	0,00*	From Steering Axle to Driving Axle Unit	5.78 m	-2.86*
Driving Axle Unit	10400 kg	1.96	From Driving to Trailer Axle Unit	14.37 m	-0.69
Trailer Axle Unit	9100 kg	1.11	From Steering Axle to Trailer Axle Unit	20.68 m	1.27
Total Vehicle Mass	22880 kg	-0.78			

Test Run 2					
Mass loads	**Measured**	**Error %**	**Axle Spacing**	**Measured**	**Error %**
Steering Axle	3800 kg	-1.55	From Steering Axle to Driving Axle Unit	6.08 m	2.18
Driving Axle Unit	10220 kg	0.20	From Driving to Trailer Axle Unit	14.19 m	-1.94
Trailer Axle Unit	8880 kg	-1.33	From Steering Axle to Trailer Axle Unit	20.56 m	0.69
Total Vehicle Mass	23120 kg	0.26			

Test Run 3					
Mass loads	**Measured**	**Error %**	**Axle Spacing**	**Measured**	**Error %**
Steering Axle	3980 kg	3.11	From Steering Axle to Driving Axle Unit	6.06 m	1.85
Driving Axle Unit	9960 kg	-2.35	From Driving to Trailer Axle Unit	14.42 m	-0.35
Trailer Axle Unit	9260 kg	2.89	From Steering Axle to Trailer Axle Unit	20.40 m	-0.10
Total Vehicle Mass	22920 kg	-0.61			

Test Run 4					
Mass loads	**Measured**	**Error %**	**Axle Spacing**	**Measured**	**Error %**
Steering Axle	3800 kg	-1.55	From Steering Axle to Driving Axle Unit	6.03 m	1.34
Driving Axle Unit	10420 kg	2.16	From Driving to Trailer Axle Unit	14.81 m	2.35
Trailer Axle Unit	9260 kg	2.89	From Steering Axle to Trailer Axle Unit	20.49 m	0.34
Total Vehicle Mass	22760 kg	-1.30			

Test Run 5					
Mass loads	**Measured**	**Error %**	**Spacing**	**Measured**	**Error %**
Steering Axle	3860 kg	0.00	From Steering Axle to Driving Axle Unit	6.04 m	1.51
Driving Axle Unit	9980 kg	-2.16	From Driving to Trailer Axle Unit	14.61 m	0.97
Trailer Axle Unit	8860 kg	-1.56	From Steering Axle to Trailer Axle Unit	20.42 m	0.00
Total Vehicle Mass	23400 kg	1.47			

Test Run 6					
Mass loads	**Measured**	**Error %**	**Axle Spacing**	**Measured**	**Error %**
Steering Axle	3900 kg	1.04	From Steering Axle to Driving Axle Unit	5.95 m	0.00
Driving Axle Unit	9980 kg	-2.16	From Driving to Trailer Axle Unit	14.72 m	1.73
Trailer Axle Unit	8860 kg	-1.56	From Steering Axle to Trailer Axle Unit	20.58 m	0.78
Total Vehicle Mass	22700 kg	-1.56			

Test Run 7					
Mass loads	**Measured**	**Error %**	**Axle Spacing**	**Measured**	**Error %**
Steering Axle	4000 kg	3.63	From Steering Axle to Driving Axle Unit	5.94 m	-0.17
Driving Axle Unit	10080 kg	-1.18	From Driving to Trailer Axle Unit	14.23 m	-1.66
Trailer Axle Unit	8840 kg	-1.78	From Steering Axle to Trailer Axle Unit	20.66 m	1.18
Total Vehicle Mass	23340 kg	1.21			

Test Run 8					
Mass loads	**Measured**	**Error %**	**Axle Spacing**	**Measured**	**Error %**
Steering Axle	3940 kg	2.07	From Steering Axle to Driving Axle Unit	6.07 m	2.02
Driving Axle Unit	10180 kg	-0.20	From Driving to Trailer Axle Unit	14.47 m	0.00
Trailer Axle Unit	8780 kg	-2.44	From Steering Axle to Trailer Axle Unit	20.54 m	0.59
Total Vehicle Mass	23020 kg	-0.17			

Test Run 9					
Mass loads	**Measured**	**Error %**	**Axle Spacing**	**Measured**	**Error %**
Steering Axle	3980 kg	3.11	From Steering Axle to Driving Axle Unit	5.78 m	-2.86
Driving Axle Unit	10120 kg	-0.78	From Driving to Trailer Axle Unit	14.14 m	-2.28
Trailer Axle Unit	8960 kg	-0.44	From Steering Axle to Trailer Axle Unit	20.45 m	0.15
Total Vehicle Mass	23220 kg	0.69			

Test Run 10					
Mass loads	**Measured**	**Error %**	**Axle Spacing**	**Measured**	**Error %**
Steering Axle	3780 kg	-2.07	From Steering Axle to Driving Axle Unit	5.79 m	-2.69
Driving Axle Unit	10100 kg	-0.98	From Driving to Trailer Axle Unit	14.62 m	1.04
Trailer Axle Unit	8860 kg	-1.56	From Steering Axle to Trailer Axle Unit	20.48 m	0.29
Total Vehicle Mass	23620 kg	2.43			

*The calculations to calculate the Error%:

$$Mass\ Error\ \% = \frac{3860\ kg - 3860\ kg}{3860\ kg} \times 100\%$$

$$Mass\ Error\ \% = 0\%$$

$$Spacing\ Error\ \% = \frac{5.78\ m - 5.95\ m}{5.95\ m} \times 100\%$$

$$Spacing\ Error\ \% = -2.86\%$$

Bibliography

TRS-007, Standard Design Specification and Technical Requirements of a Weigh Station, *Version 002 or later*, www.tttfp.org

URS-007, Standard Specification for a Vehicle Load Management Information System, *Version 004 or later*, www.tttfp.org

