ISWIM

Practitioners' Guides

Glossary of Terms

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GLOSSARY OF TERMS

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The **International Society for Weigh-In-Motion** (ISWIM) is a global non-profit organization, bringing together all stakeholders with an interest in Weigh-In-Motion (WIM) technology, its application, data it collects and information it generates. Our members are users, researchers and vendors of WIM systems including systems in or under the road pavement, bridges, rail tracks and on-board vehicles.

The **International Society for Weigh-In-Motion** has produced and is disseminating this publication to make the information contained herein available for use by ISWIM members. The information in this publication was reviewed by the ISWIM Editorial Board. This document does not circumvent any available standard Weigh-In-Motion (WIM) specifications, international standards, or other official WIM documentation.

Preface

".. let us go down and there confuse their language,
that they may not understand one another's speech."

GENESIS 11:7

The membership of the International Society for Weigh-In-Motion (ISWIM) covers the entire globe, with language, jargon and practices differing immensely. We have witnessed the same Weigh-In-Motion (WIM) practice being called by different names and the same name being used to describe different WIM practices. The simple fact is that this is reality, and ISWIM does not have (nor does it seek) any special powers over jurisdictions. Rather, ISWIM is endeavouring to develop an ISWIM Practitioners' Guides Series and in recognising these differences has produced this Glossary of Terms.

On behalf of the ISWIM Board I would like to thank Olga Selezneva for taking on the responsibility to drive the ISWIM Practitioners' Guides Series. Her passion and endurance are both recognised and greatly appreciated. Additional thanks are due to Hans Van Loo for his effort compiling the different terms and definitions into this Glossary of Terms.

Chris Koniditsiotis
President
ISWIM

Foreword

This document is part of a series of "ISWIM Practitioners' Guides" publication series" produced by the International Society for Weigh-In-Motion (ISWIM). The aim of this publication series is to provide WIM practitioners, technicians, and end-users with a series of guides illustrating "best practices" about the various aspects of WIM technology and its applications.

This glossary was developed for the convenience of ISWIM publication readers and ISWIM publication developers. It contains definitions of common terms used in the ISWIM best practices publication series. This document does not circumvent any available standard WIM specifications, international standards or calibration procedure terminology.

This glossary is a living document, published electronically by ISWIM and updated regularly. Since ISWIM is an international organisation, and ISWIM guide contributors discuss practices used around the world, some differences in definitions and terms are expected and indeed represent the rich spectrum of WIM practitioners, technicians, and end-users.

This document is designed to capture these differences and provide clear definition of terms as they are used in the ISWIM Practitioners' Guides publication series. In situations where the same term has different definitions, multiple definitions are provided with references to the applicable standards. Furthermore, WIM data users from various industries may have their own sets of standards and the terminology they use may be unfamiliar or confusing to other user groups (terms used for metrology vs. enforcement vs. engineering vs. traffic statistics and planning). To capture these differences, explanations are added to the terms to help with their interpretation. Any comments or proposed changes to the definitions should be sent by email to: info@is-wim.net.

In this edition, the definitions in this document are divided into three parts with terms related to: 'Weigh-In-Motion', 'Measuring Systems,' and 'Calibration and Testing'.

Olga Selezneva, Ph.D.
Editor-in-Chief for Practitioners' Guides Series
ISWIM

1 Weigh-in-Motion

Axle	An axle comprises of two or more wheel assemblies with centres lying approximately on a common axis orientated transversely to the nominal direction of motion of the vehicle.
Axle distance [m]	The distance between the centres of two axles.
Axle group	A set of axles on the same vehicle, defined by the total number of axles included in the group where the centres of the axles are spaced less than a specified value, e.g. <1.8 m or <6 ft.
Axle group load [kg]	The total load of all wheels included in an axle group. Following WIM daily practice, this measurement is expressed in units of mass, similar to axle group weight measurement.
Axle group weight [kg]	The portion of a gross vehicle weight attributed to one axle group of a vehicle. This measurement is expressed in units of mass.
Axle load [kg]	The sum of all wheel loads on the same axle of a vehicle. Following WIM daily practice, this measurement is expressed in units of mass, similar to axle weight measurement.
Axle spacing [m]	*See axle distance.*
Axle weight [kg]	The portion of a gross vehicle weight attributed to one axle of a vehicle. This measurement is expressed in units of mass. Note: This should not be confused with the 'weight of an axle' which is related to the mass of the axle when removed from the vehicle.
Bending plate	A plate instrumented with strain gauges and placed under wheels or axles to measure their tyre forces.
Bridge WIM (B-WIM)	A WIM system using an instrumented bridge or culvert to measure the response of the bridge to passing vehicles. From the measurements, the axle loads and gross vehicle weight of the passing vehicles are calculated.
Double axle	An axle group with two axles that are spaced less than a specified value, e.g. <1.8 m or <6 ft.
Dynamic tyre force [kN]	The vertical component of the time-varying force applied to the road surface by the tyre(s) on a wheel of a moving vehicle.
Dynamic wheel load [kN]	The vertical components of the time-varying force applied to the road surface by the tyre(s) located on one wheel of a vehicle, also see load (when used as a force).
Dynamic axle load [kN]	The vertical components of the time-varying force applied to the road surface by the tyre(s) located on one axle of a vehicle, also see load (when used as a force).
Dynamic axle group load [kN]	The vertical components of the time-varying force applied to the road surface by the tyre(s) located on the axles within an axle group of a vehicle, also see load (when used as a force).

Equivalent Single Axle Load (ESAL)	A method originally developed in North America, to represent the effects of axle loads on the pavement. This method transforms all axle loads of vehicles into their equivalent number of 18,000-pound single axle loads.
Fibre optic sensor	A strip sensor incorporating an optic fibre, the bending of the fibre resulting from the applied force modifies the light propagation conditions; the applied force is derived from this modification.
Force [N]	In physics, an influence that, when unopposed, will change the motion of an object, e.g. to accelerate a mass. A force has both magnitude and direction, it is represented in the unit Newton.
Gross Vehicle Weight (GVW) [kg]	The external force of gravity acting vertically downwards on a vehicle, including all connected components, with a magnitude equal to the mass of the vehicle and represented in the unit of mass, hence divided by the local acceleration of free fall.
Heavy Goods Vehicle (HGV)	A road vehicle used to carry cargo with a gross vehicle weight over 3.5 tonnes or 7.7 kips.
High-Speed WIM (HS-WIM)	The weighing of a vehicle in motion in the normal traffic flow conditions, using a system installed directly on/in/under an in-service road, culvert, or bridge.
In-road WIM	A WIM system where the measurement sensors are installed on, in or under the road pavement.
Legal applications	Applications of WIM systems directly connected to a legal or financial transaction, e.g. trade, tolling by weight, direct weight enforcement. Such WIM systems require legal approval by a notified body that certifies the requirements for each individual measurement.
Legal metrology	The scientific study of measurement, units of measurement, measuring instruments, and methods of measurement. These activities result from statutory requirements and are performed by competent institutes. The statutory requirements may arise from the need for protection of health, public safety, the environment, enabling taxation, protection of consumers and fair trade.
Load (when used as a force) [kN]	The vertical components of the statistical or dynamic force applied to the road surface by the tyre(s) located on one wheel, axle or axle group of a vehicle.
Load (when used as weight) [kg]	A portion of the GVW attributed to a wheel, axle or axle group and expressed in unit of mass [kg], following common WIM practice.
Load cell	A transducer that converts a load, force or pressure into an electrical signal that can be measured and standardised. The most common types of load cells used are strain gauges, pneumatic, and hydraulic.
Load Equivalency Factor (LEF)	A method to represent the effects of axle loads on the pavement. In Europe, this method transforms all axle loads of vehicles into their equivalent number of 10-tonne single axle loads. In North America, this method transforms all axle loads of vehicles into their equivalent number of 18,000 lb. single axle loads.

Load sensor	A sensing element installed in or under the road pavement, under a bridge or under rail tracks measuring the dynamic force exerted by the wheel or axle of a vehicle on the road.
Low-Speed WIM (LS-WIM)	The weighing of a vehicle in motion in a controlled weighing area and under controlled traffic conditions, such as limited vehicle speeds to minimise the dynamic effects.
On-Board WIM (OBW)	A WIM system installed on a vehicle that will constantly measure the wheel/axle forces whilst stationary or during travel.
Pavement WIM	See in-road WIM.
Piezo-electric sensor	A strip sensor containing a piezo-electric material that converts an applied tyre force(s) or pressure applied by tyre(s) into a proportional electrical signal. The sensing material used may be piezo-ceramic, piezo-polymer, or piezo quartz.
Rail WIM	A WIM system installed on a railway track to measure the dynamic wheel forces and characteristics of passing trains such as speed, number of axles, axle spacing, number of carriages, train length and total train weight.
Sensor	Part of a measuring instrument directly affected by the parameter to be measured and produces a related signal.
Sensor array	Physical arrangement of the sensors, including the number of the different types of sensors and their mutual position and distances.
Single axle	An axle on a vehicle, where the spacing between the centre of that axle and the centres of the neighbouring axles is more than a specified value (e.g. >1.8 m or >8 ft.).
Static axle group load [kg]	A portion of the GVW attributed to the axles in an axle group of a vehicle and expressed in unit of mass [kg], following common WIM practice, also see load (when used as a weight).
Static axle load [kg]	A portion of the GVW attributed to an axle of a vehicle and expressed in unit of mass [kg], following common WIM practice, also see load (when used as a weight).
Static gross vehicle weight [kg]	See gross vehicle weight.
Static scale	A weighing instrument that measures the static wheel or axle loads or the complete vehicle weight at once. Certified permanently installed static scales are used to measure the reference values for the testing or calibration of WIM systems.
Static tyre force [kN]	The portion of the gross vehicle weight imposed upon a weighing instrument by a single tyre 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.
Static weighing	Weighing of gross vehicle weights, axle loads, and/or wheel loads of vehicles that are stationary.
Static wheel load [kg]	A portion of the GVW attributed to the tyres of a wheel of a vehicle and expressed in unit of mass [kg], following common WIM practice, also see load (when used as a weight).

Statistical WIM applications	Use of WIM systems for weight data collection purposes not directly related to a legal or financial transaction, e.g. traffic monitoring, pavement loading; also includes pre-selection for weight enforcement. Such WIM systems do not require legal approval by a notified body.
Stress-In-Motion (SIM)	WIM systems capable of measuring the individual multi-dimensional (3D) tyre-road contact stresses (the tyre profile) under moving tyres.
Tandem axle	See double axle.
Tridem axle	An axle group with three axles spaced at a close distance to each other.
Tyre force [kN]	The vertical component of the statistical or dynamic force applied to the road surface by the tyre(s) on a wheel of a vehicle.
Vehicle class	Group of vehicles with similar physical characteristics such as the number of axles, number of axle groups, vehicle length, axle distances, etc.
Vehicle length	Distance between the front and the back of a vehicle.
Vehicle signature	Measured electromagnetic or optical characteristics of a passing vehicle providing a unique identification of the vehicle.
Weighbridge	A weighing instrument that measures the complete stationary vehicle weight in one reading. Weighbridges are generally used to measure the gross vehicle weight reference value for the testing or calibration of WIM systems.
Weigh-In-Motion (WIM)	The process of estimating the wheel and/or axle loads and gross weight of a moving vehicle, by measurement and analysis of the dynamic vehicle tyre forces.
Weigh-In-Motion (WIM) system (instrument)	A set of mounted sensors and electronics with software which measures dynamic tyre forces and vehicle presence of a moving vehicle with respect to time and calculates wheel and/or axle loads and gross vehicle weights, as well as other vehicle parameters such as speed, axle spacing, vehicle class, etc.
Weight [kg]	The external force of gravity equal to the body's mass multiplied by the local acceleration of free fall acting vertically downwards upon a body with a magnitude. Following common weighing practice, a WIM system will indicate the measured weights in units of mass [kg].
Wheelbase	Distance between the centre of the first and last axle of a vehicle.
Wheel load [kg]	The sum of all the tyre loads of a wheel of a vehicle. Following WIM daily practice, this measurement is expressed in units of mass, similar to wheel weight measurement.
Wheel weight [kg]	The portion of a vehicle's static gross vehicle weight attributed to one wheel of a vehicle. This measurement is expressed in units of mass. ***Note:*** *This should not be confused with the 'weight of a wheel' which is related to the mass of the wheel when removed from the vehicle.*
WIM	See weigh-in-motion.

2 Measuring Systems

Accuracy	A qualitative term describing the closeness of a measured value to a known true value. When the term is applied to sets of measurements of the same measurand, it involves a component of random error (see precision) and a component of systematic error (see mean error). ***Example:*** *If the result of weight measurement is 6,000 kg, but the actual or known weight is 5,000 kg, then the measurement is not accurate.*
Accuracy of a measurement instrument	A qualitative term to indicate the closeness of the measurements by a certain instrument. ***Note:*** *frequently the accuracy of an instrument is specified in terms of bias and precision.*
Accuracy level	The acceptable maximum range of measurement errors of a measurement instrument, also see tolerance.
Average error	*See mean error.*
Bias	*See mean error.*
Confidence interval	An estimate computed from a test sample that provides an expected range of values that likely would contain an unknown mean value of the parameter being measured (e.g. the mean measurement error). The range of values is bounded above and below the parameter's mean value by a margin of error. The confidence interval has an associated confidence level.
Confidence level	Refers to the probability that the associated confidence interval contains the mean value. ***Note:*** *In WIM, the combination of confidence interval and level is often used to quantify WIM system performance based on a test sample and to compare it with an acceptable tolerance range.*
Error of measurement	*See measurement error.*
Influence quantity	The quantity that is not subject to the measurement but which influences the value of the measurement and/or the indication of the measurement instrument. For WIM systems, the influence quantities are temperature, humidity, EMC, vehicle speed and traffic intensity
Gaussian distribution	*See Normal distribution.*
Margin of error	The size of the confidence interval on each side of the mean measurement error. The range of values below and above the mean measurement error.
Maximum Permissible Error (MPE)	The extreme value of the measurement error permitted by specifications for a given measurement instrument. For a measuring system, it means that for all measurements, the (unknown) true value lies within ±MPE% from the measured value.

Mean measurement error (μ)	The average difference between the measurement results and the true value(s) or accepted value(s).
Measurands	The quantities to be measured by a measurement system. In WIM, they include axle load, gross vehicle weight and, when required, wheel load, axle spacing, vehicle length, vehicle class, time, speed, etc.
Measurement error (for an individual measurement)	The difference between the measured value and the true value or accepted reference value.
Normal distribution	A probability distribution that is symmetric about the mean, showing that data near the mean are more frequent in occurrence than data far from the mean. In graph form, the Normal distribution will appear as a bell curve.
Operating range	Range between the minimum and maximum value of influence quantities where the system performs according to its specifications. For WIM systems, the influence quantities are temperature, humidity, electromagnetic compatibility (EMC), vehicle speed and traffic intensity.
Outlier	A measurement that is numerically distant from the rest of the data in a series of homogenous data with a much lower probability of occurrence.
Precision	The statistical quantification of the variation in the measurement results when doing the same measurement repeatedly. ***Note 1:*** *Measurement precision is frequently expressed by a margin of error, which is a product of a constant value and standard deviation from the mean measurement error, such as ± two standard deviation intervals (±2σ).* ***Note 2:****This approach typically assumes that the data distribution around the mean value follows properties of the Normal distribution (for sample size >=30).*
Rated operating conditions	Conditions of use of a measurement instrument which give the ranges of the influence quantities for which the performance of the system lies within the specifications. For WIM systems, the influence quantities are temperature, humidity, electromagnetic compatibility (EMC), vehicle speed and traffic intensity
Relative measurement error	The error of measurement divided by the accepted reference value. This parameter can be expressed as a fraction or as a percentile value.
Resolution	The smallest value of the scale interval that a measuring instrument is capable of discriminating.
Scale interval (d)	The difference between two consecutive values indicated by a measurement instrument.
Standard Deviation (SD or σ)	The measure of the data variation or dispersion about a mean value. It describes the spread of data on either side of the mean value and assumes that the data distribution follows properties of the Normal distribution.

Tolerance

A range of values ($\pm\delta$) used to quantify the maximum allowed difference between a measured value and the true value or a value accepted as a reference. For WIM measurements, the tolerance is typically expressed in terms of percentile relative error.

Note 1: *for statistical applications, the tolerance ($\pm\delta$) is used to specify the maximum size of the acceptable confidence interval around the measurement value. For example, the two standard deviation interval (-2σ, $+2\sigma$) means that, for roughly 95 % of all measurements, the (unknown) true value likely lies within $\pm\delta$ % from the measured value. This approach assumes that the distribution of relative errors around the mean relative error value has properties of Normal distribution and the mean relative error is equal to zero.*

Note 2: *for legal applications $\pm\delta$ is used to specify the size of the Maximum Permissible Error (-MPE, +MPE). This means that for all measurements, the (unknown) true value lies within $\pm\delta$% from the measured value.*

True value

The actual value accepted as a reference for a measurement. For HS-WIM measurements, generally, a certified static or LS-WIM system is used to measure the reference value.

Weighing range

The range between the minimum and maximum value of the measured variables (e.g. axle load, gross vehicle weight) where the system performs according to its specification.

3 Calibration and Testing

Adjustment	A set of operations on a WIM system to reduce the measurement error - determined during calibration - such that afterwards, the system provides measurements that meet the specified user requirements.
Calibration (in legal metrology)	The process of comparing the measurement values of a WIM system against traceable and accepted reference true values to determine the measurement error. ***Note:*** *This definition is most common in international legal metrology, national metrology institutes, formal test and certification organisations. The adjustment and verification are considered separate steps in the procedure.*
Calibration (in common WIM practice)	The process of comparing the measurement values of a WIM system against traceable and accepted reference values to determine the measurement error, followed by adjusting the WIM system to reduce the measurement error and provide measurements that meet the specified users' requirements. ***Note 1:*** *This definition is most common in the international daily practice of WIM among end-users, road authorities, enforcement agencies, manufactures, vendors, engineers and researchers;* ***Note 2:*** *ISWIM does not take a position on what is included in calibration; however, ISWIM strongly recommends making clear in any document, report, manual or procedure related to WIM which operations are included in the calibration.*
Calibration factor	*See correction factor.*
Confirmation	*See validation.*
Correction factor	A factor used in processing raw WIM measurements to correct the results for the average measurement error.
Initial verification	The performance test made, after installation or important repair, toverify the performance of the measurement instrument under the specific conditions at the site.
In-service verification	The performance test made to verify if a system is still operating according to specification. Compared to type approval and initial verification test, this relatively minor test is executed when a system has been operational for some time.
Performance test	A verification to determine whether a measurement instrument can perform according to its specified functions.
Reference conditions	Conditions of use prescribed for testing the performance of a measuring instrument or for inter-comparison of measurements.
Reference Data Set (RDS)	A set of statistical parameters related to gross vehicle weights, axle loads, axle spacing, vehicle length, speed, and vehicle class computed based on a WIM data set collected 2 to 4 weeks after a successful calibration.

Reference values	The values determined to represent the "true" values for calibration of each measurand. The reference value of each measurand should be defined and approved by all involved parties. Typically, the reference values are based on the multiple weight measurements using certified static scales.
System approval test	*See initial verification.*
Test truck	A heavy goods vehicle used in WIM calibration that meets the requirements specified in the calibration procedure, e.g. with a gross weight of at least 13.5 tonnes or 30 kips.
Type approval test	The first extensive performance test of a new type of measurement instrument where the system's performance is tested under the full operating conditions by a(n) (inter-)nationally approved authority. The results of this test may be a formal document stating (inter-)national type-approval of the system.
Unit	A unit of measurement is a definite magnitude of a quantity, defined and adopted by convention or by law, which is used as a standard for measurement of that quantity. ***Note 1:*** *By default, this document refers to the International System of Units (SI) to express metrological units. The SI recommends to express forces in N and kN, and masses in kg (1000 kg = 1 metric ton = 1 tonne);* ***Note 2:*** *Most common weighing measurement units in daily WIM practice, among end-users, road authorities, enforcement agencies, researchers, manufacturers, vendors, engineers and in legal documents, is the metric ton (or tonne);* ***Note 3:*** *In several countries, especially the USA, non-SI units are used, such as inch, foot, pound, kip and (imperial) ton. A list of the conversion factors to the SI for these units can be found at the end of this document;* ***Note 4:*** *ISWIM does not take a position on which units should be used; however, ISWIM does strongly recommend making clear in any document, report, manual related to WIM which units are used.*
Validation	*See verification.*
Verification	A set of operations that confirms that a WIM system meets specified users' requirements (e.g. maximum permissible errors or tolerance range).

4 References

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5 Unit Conversion

(Metric - Imperial)

1 metric ton	=	1000 kg	=	2205 lbs.
1 tonne	=	1000 kg	=	2205 lbs.
1 US ton	=	2000 lbs.	=	907.2 kg
1 kip	=	1000 lbs.	=	453.5 kg
1 imperial ton	=	2240 lbs.	=	1016.1 kg
1 kN	=	1000 N	=	224.809 lbf.
1 meter	=	1000 mm	=	1.0936 yd.
1 cm	=	10 mm	=	0.3937 in.
1 yard	=	3 ft.	=	0.9144 m

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