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## WEIGH IN MOTION TERMS

Basic definitions of terms specially relevant to WIM and its applications are provided. This terminology of WIM is part of the work on prestandardisation developed within the framework of the COST action 323 (1996). The evaluation of WIM system performance is related to the following criteria:

- The site (road, bridge)
- Characteristics of the traffic
- The measured parameters from the WIM station
- Metrological and statistical elements
- Specific characteristics of the vehicles
- The test method used for qualification, calibration,
- The data processing method
- The required performance and applications

The glossary of terms presented in this Appendix is divided in five parts: Bridge Engineering, Metrology, Traffic and Road, Vehicle and Weighing. A more detailed document is available in different languages in the Internet<sup>8</sup> (Siffert and Žnidarič 1998).

### A.1 BRIDGE

**Abutment:** End support structure for bridge deck.

**Beam:** Structural member designed to carry loads between or beyond points of support, usually narrow in relation to its length and horizontal or nearly so.

**Bearing:** Component designed to transfer the load from a structural member onto a fixed support while allowing relative displacement.

**Bridge:** Civil engineering works that affords passage to pedestrians, animals, vehicles, waterways and services above obstacles or between two points at a height above the ground.

**Column:** Structural member of slender form, usually vertical, that transmits to its base the forces, primarily in compression, that are applied to it.

**Culvert (box):** Covered channel or large pipe that forms a watercourse below ground level, usually under a road or railway.

**Expansion joint:** Joint that permits relative movement caused by expansion and contraction of a structure.

**Girder:** Large fabricated metal beam that comprises top and bottom members and either solid or open web or webs.

**Orthotropic deck bridge:** Bridge in which the deck consists of a stiffened steel plate.

**Pier:** Column in which the breadth in one direction is in excess of four times the breadth in the other direction.

**Slab:** Thick, flat or shaped component usually larger than 300 mm square, used to form a covering.

**Stiffener:** Assemblage of metal plates used to increase the stiffness of an (orthotropic) deck.

## A.2 METROLOGY

**Accuracy:** The closeness of agreement between a test result and the accepted reference value.  $\text{Accuracy} = \text{Trueness} + \text{Precision}$

**Accuracy class:** class of measuring instruments that meet certain metrological requirements that are intended to keep errors within specified limits.

**Accuracy of measurement:** Closeness of the agreement between the result of a measurement and a true value accepted as a reference value.

**Arithmetic mean; average:** The sum of the values of a sample divided by the number of values. First moment of a (sample) distribution.

**Bias:** The difference between the expectation of the test results and an accepted reference value.

**Calibration:** Adjustment to a reference level of any measurement device.

**Calibration (correction) factor:** numerical factor by which the uncorrected result of a measurement is multiplied to compensate for systematic error.

**Coefficient of regression:** A coefficient of a variable in the equation of a regression curve or a regression surface.

**Coefficient of variation:** ratio of the standard deviation to the mean of a data sample.

**Confidence interval** Confidence interval: interval which 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. .

**Deviation:** value minus its reference value.

**Doubtful values:** Observations in a sample, far separated in value from the remainder with a weak probability of appearance.

**Drift:** slow change of the result of measurement with time.

**Durability test:** A test to verify that the equipment under test is capable of maintaining its performance characteristics over a period of use.

**Error of result:** The test result minus the accepted reference value (of the characteristic). Difference between a measured value and the true value or the accepted reference (relative and absolute errors).

**Increment:** The value of the smallest change in value that can be indicated or recorded by digital device in normal operation.

**Influence quantity:** Quantity other than that measured which affects the result of the measurement.

**Initial zero-setting mechanism:** Automatic means provided to set the indication to zero at the time the instrument is switched on and before it is ready for use.

**Measurand:** particular quantity subject to measurement.

**Measurement:** set of operations having the object of determining a value on a quantity

**Measuring chain:** series of elements of a measuring instrument or system that constitutes the path of the measurement signal from the input to the output.

**Measurement procedure:** set of operations, specifically described, used in the performance of particular measurements according to a given method.

**Outliers:** value(s) in a series of homogeneous data which has(ve) a much lower probability of occurrence than expected according to the sample size and distribution; an outlier is suspected of being an erroneous measurement, and may be eliminated under certain conditions.

**Performance test:** A test to check that the equipment under test is capable of performing its intended functions; if it is made just after the initial installation or after an important repair, it becomes an acceptance test.

**Precision:** The closeness between independent test results obtained under specified repeatability conditions.

**Random error:** A component of the error which, in the course of a number of test results for the same characteristic, varies in an unpredictable way.

**Range:** The whole interval extent on which a parameter measurement is valid with a given system. The difference between the largest and the smallest measurement value.

**Raw result:** result of a measurement before correction for systematic errors.

**Relative error:** error of measurement divided by a true value of the measurand.

**Repeatability (of results):** closeness of the agreement between the results of successive measurements of the same variable carried out under the same conditions of measurement (called repeatability conditions): same procedure, same observer, same instrument in same conditions, same location, repetition over a short period of time...), homogeneous with respect to the environmental conditions.

**Reproducibility (of results):** closeness of the agreement between the results of measurements of the same measurand (variable) carried out by similar instruments under changed conditions of measurement (called reproducibility conditions): several observers, measuring instrument, locations, times etc

**Resolution:** The smallest value of a parameter that can be distinguished by a measurement device in the measurement range.

**Sensitivity:** change in the response of a measuring instrument divided by the corresponding change in the stimulus.

**Specification:** A requirement usually dealing with the design, construction, or marking of a weighing or measuring device. Specifications are directed primarily to the manufacturers of devices.

**Standard:** material measure, measuring instrument, reference material or measuring system intended to define, realise, conserve or reproduce a unit or one or more values of a quantity to serve as a reference. A technical specification approved by a recognised body for repeated or continuous application with which compliance is not compulsory.

**Standard deviation:** The positive square root of the variance. It is the quantity characterising the scattering of a sample of data (dispersion of the results).

**Systematic error:** A component of the error which, in the course of a number of test results for the same characteristic, remains constant or varies in a predictable way.

**Tolerance:** Width of a confidence level in which an error remains with a specified or required confidence level. The defined limit of allowable departure from the true value of a quantity measured or estimated by a system. Permissible variation of the specified value of a quantity.

**Trueness:** The closeness between the arithmetic mean value obtained from a large series of test results and an accepted reference value.

**Trueness:** Ability of a measuring instrument to give results free from systematic error.

**User requirement:** A requirement dealing with the selection, installation, use, or maintenance of a weighing or measuring device. User requirements are directed primarily to the users of devices.

**Variance:** Centred second moment of a (sample) distribution, which characterises the scattering of this distribution. A measure of dispersion, which is the sum of the squared deviations of observations from their average divided by one less than the number of observations.

### **A.3 ROAD AND TRAFFIC**

**Aggressivity:** Capacity of heavy vehicles to cause damage to the pavement.

**Capacity:** The maximum rate of flow which vehicles can traverse a point or uniform section of a lane or roadway during a given time period under prevailing roadway, traffic, and control conditions.

**Climbing line:** An extra traffic lane provided on long uphill gradients to allow slower-moving vehicles to be removed from the main uphill traffic stream.

**Control system:** The hardware and software used to monitor and control traffic

**Count:** The number of vehicles (or pedestrians) that have passed a point.

**Density:** The ratio of the summation of the lengths of the vehicles on a given length of carriageway or lane.

**Design capacity:** The maximum rate of flow for specified operating conditions.

**Design speed:** A design criterion used for providing a consistent and co-ordinated alignment.

**Divided road:** A highway with separated roadways for traffic in opposite directions.

**Dual carriageway:** A highway with at least two lanes for the exclusive use of traffic in each direction.

**Future design year:** The future year for which roads are designed.

**Gradient:** Rate of change of elevation in the longitudinal direction of a roadway

**Level of service:** A measure of the operating conditions which occur on a given lane or roadway when it is accommodating a specific traffic volume.

**Median:** The portion of a divided highway separating the lanes for traffic in opposite directions.

**Motorway:** High-speed road, usually divided with grade-separated intersections.

**Paved outer shoulder:** The portion of the roadway contiguous with the traffic lanes for accommodation of stopped vehicles and for emergency use.

**Pavement:** Running surface of traffic lanes.

**Standard axle:** reference axle with a unit Aggressivity (damage power value equal to 1.)

**Traffic:** Vehicles and pedestrians using the road system

**Traffic capacity:** The maximum flow of vehicles that can proceed through a certain point during a given period of time.

**Traffic engineering:** The design and application of techniques for traffic management

**Traffic flow (or traffic volume):** Number of vehicles passing a specified point in a specified period of time.

**Traffic lane:** The portion of the carriageway for the movement of a single line of vehicles.

**Traffic management:** all kind of measures to care of traffic.

**Undivided road:** A highway consisting of one roadway, with one or more traffic lanes, carrying traffic in opposite directions.

**Vehicle counter:** Device for vehicle counting. Automatic traffic flow counter that stores data during specified time.

**Vehicle counting:** Action which consists of determining automatically or manually the number of vehicles passing a specified point during a specified time.

**Verge:** An unpaved level strip contiguous with the outer shoulder.

## **A.4 VEHICLE**

**Axle:** an axle consists of two or more wheel assemblies lying approximately on a common axis oriented transversely to the nominal direction of motion of the vehicle.

**Axle group-Group of axles:** Set of axles in the same lorry, tractor, trailer or semi-trailer, spaced less than 2m each from the next one.

**Axle of a group:** Axle of a vehicle that belongs to a group of axles.

**Elementary axle:** axle from a vehicle An elementary axle can belong to a tandem or tridem axle.

**Passenger Car Unit (PCU):** Used to express in comparable fashion volumes of traffic of dissimilar make-up.

**Silhouette:** Category of vehicle defined by different parameters concerning the vehicle such as axle number and spacing..

**Single axle:** axle separated by 2 metres or more from the nearest axle of the same vehicle.

**Tandem axle:** group of two non isolated axles. Group of two axles, spaced less than 2m each from the next one.

**Tridem axle:** group of three non isolated axles. Group of three axles, spaced less than 2m each from the next one.

**Twin wheel:** group of two wheels fixed under a half axle.

**Wheel assembly:** half axle with one or more tyres.

## **A.5 WEIGHING**

**Axle group load:** Sum of loads of an axle group.

**Axle-load scale:** A scale installed in a fixed location, having a load-receiving element specially adapted to determine the combined load of all wheels or a single axle or on a tandem axle of a vehicle.

**Bar sensor:** sensor in form of a bar containing piezoelectric or piezo-quartz sensor. A bar is generally installed in a groove in the pavement and is smaller than a tyre imprint length. Therefore, if used as a weighing sensor, the signal must be integrated during the time where the tyre applies a pressure on it.

**Bridge WIM (system):** WIM using an instrumented bridge (measuring strains) as a large scale. The response measured in some of the bridge elements are used to determine throughout software the gross weights and sometimes the axle loads of vehicles crossing the bridge.

**Capacitive mat or strip:** a mat or strip sensor which measures an applied force by the variation in capacitance (dielectric coefficient) of isolated plates.

**Detector:** device or substance that indicates the presence of a phenomenon without necessarily providing a value for an associated quantity. The detector organise the information providing from sensors.

**Distance between axles or axle spacing:** distance measured centre to centre between axles.

**Distance between vehicles:** distance separating two vehicles moving in the same direction. Distance between the rear bumper of the first vehicle and the front bumper of the second vehicle. Unit: meters

**Dynamic load** = Impact force: Force applied to the pavement by a wheel/axle while the vehicle is travelling at speed; by extension, sum of the forces applied by all the axles of a vehicle (may be measured at the same time or at the same place).

**Fibre optic sensor:** strip sensor incorporating an optic fibre; the fibre bending resulting from an applied force (by a wheel or an axle) modifies the light propagation conditions; the applied force may be derived from this modification.

**Force:** Product of mass and acceleration due to gravity.

**Gap:** The interval of time or distance between the rear of a vehicle and the front of a vehicle immediately following it.

**Gross vehicle mass:** mass of vehicle and its content. (kilograms or tons)

**Gross vehicle weight:** Static gross weight = mass of a whole vehicle multiplied by the acceleration due to gravity. Dynamic (or in motion-) gross weight: Sum of the forces applied by all the axles of a vehicle (may be measured at the same time or at the same place).

**Headway:** The interval of time or distance between the front of a vehicle and the front of a vehicle immediately following it.

**High Speed WIM (HS-WIM):** Weigh in motion under usual traffic speed conditions.

**Impact factor:** ratio of the force applied to the pavement by a wheel/axle while the vehicle is travelling at speed to the static wheel/axle load; by extension, gross impact factor = sum of the forces applied by all the axles of a vehicle (may be measured at the same time or at the same place) divided by the static gross weight.

**Influence line:** Graph of response such as strain or moment versus location of an applied unit point force.

**Influence surface:** Two dimensional graph of response such as strain or moment versus location of an applied unit point force.

**Load:** Force that acts on a structure or a member. Unit: Newton

**Load cell:** A device, which can be electrical, hydraulic... that produces a signal proportional to the load applied to it.

**Low speed WIM:** Weigh in motion in such particular conditions, as to minimise the effects of accelerations, (difference between static and dynamic load). That is obtained by using a specific weigh-area outside of the usual traffic lanes, an horizontal pavement with good evenness and vehicles moving at uniform and low speed (1 to 25km/h).



**Magnetic (or inductive) loop:** Electric cable buried in the pavement or bonded on the pavement surface and used for vehicle detection and counting. A metallic mass passing the loop changes the magnetic field, that causes a signal(frequency) send through the cable.

**Mass:** Constant ratio between applied forces and corresponding accelerations. The mass unit is the kilogram.

**Mean speed:** It is the covered distance divided by the time of course.

**Monitoring:** Permanent checking of the integrity of a system.

**Occupancy (or detection) rate:** The proportion of time during which a detector detects.

**Piezo-electric cable:** coaxial cable containing a piezoelectric substance, which converts a strain or pressure applied into an electrical signal which may be related to the applied strain or pressure.

**Piezo-electric sensor:** strip sensor built in with a piezoelectric cable. Types of piezoelectric sensors are:-piezoceramic: sensors containing a piezo-electric substance in form of ceramic powder.-piezopolymers sensors: multilayer coaxial cable or strip containing piezo-polymer substance.

**Piezoquartz sensor:** strip, bar or plate with incorporated piezoelectric quartz.

**Piezo-resistive sensor:** sensor which measures an applied force through a variation in its electrical resistance.

**Pneumatic axle detector:** Axle detector made from road hose or hoses.

**Pneumatic converter:** Device for the conversion of an high-pressure pulse of air into an electronic pulse.

**Presence time:** Presence time: the time during which a vehicle is continuously present within the detection zone.

**Response time:** The period of time between activation of the detector and the arrival of the signal in a traffic information system (or into digital memory)

**Road hose/tube:** Rubber tube which responds to the passing of a wheel or axle by the emission of a high-pressure pulse of air.

**Sensor:** element of a measuring instrument or measuring chain that is directly affected by the parameter to be measured.

**Static load:** Force applied to a structure which is static and not generated movements. Force due to the gravity exerted from a body or a part of them(vehicle, axle..). Example: For a wheel or an axle: force applied on the pavement by the wheel or by all the wheels from an axle when the vehicle is not moving.

**Static weighing:** measuring of mass or load of a static object; by extension, measuring of a vertical force of a no moving body (wheel, axle from a vehicle).

**Strain amplifier (mechanical):** (mechanical) Device which responds to the application of a strain with the generation of a larger strain.

**Strain gauge:** Device for measuring small displacements from which strains can be calculated.

**Strip sensor:** sensor in form of a strip containing piezoelectric or piezo-quartz material. It bar is generally installed in a groove in the pavement or bonded on the pavement surface. If used as a weighing sensor, the signal must be integrated during the time where the tyre applies a pressure on it.

**Tape switch:** Axle detector made from two strips of metal which make an electrical contact in response to an applied impact force.

**Tyre load:** Force applied by a tyre to the pavement (in Newtons).

**Vehicle on-board weighing system:** A weighing system designed as an integral part of or attached to the frame, chassis, lifting mechanism, or bed of a vehicle, trailer etc.

**Vehicle speed or velocity:** Measured distance divided by a time unit. Unit: meter/second or km/hour.

**Vehicle weighing:** To measure weight or mass of vehicles considered as a unique body. Estimation of the weight by addition of the results of weighing all the wheels or axles from a vehicle.

**Weigh:** to measure mass or weight.

**Weigh bridge:** large scale which measures the complete vehicle weight statically at once (approved for legal weighing and generally used as a reference).

**Weigh zone:** Zone in which a vehicle must be located when it is weighed.

**Weighing instrument:** Measuring instrument that serves to determine the mass of a load by using the action of gravity.

**Weighing of wheels or axles:** To measure the force applied by a wheel or an axle on the pavement.

**Weighing plate:** Plate fitted with sensors (example: a bending plate fitted with strain gauges). According its size, the device is adapted for weighing a wheel, a half axle, an axle or an axle group.

**Weigh in motion:** The process of estimating the mass or weight of a moving vehicle. To measure the impact forces or dynamic load produced by a moving system (wheels, axles of a vehicle)

**Weight:** Force equivalent to the product of mass and acceleration due to gravity. Unit: Newton

**Wheelbase:** distance measured centre to centre from the front axle to the rear axle.

**Wheel load:** the sum of the tyre loads on all tyres included in the wheel assembly which comprises a half axle).

**Wheel-load weighers:** Compact, self-contained, portable weighing elements specially adapted to determining the wheel loads or axle loads of vehicles on highways for the enforcement.

**WIM system:** Consists of sensors and supporting instruments. It detects the presence of a moving vehicle and evaluates tyre loads, axle loads, total weight and other information such as speed, axle spacing and silhouettes