Guide to the NMi International WIM standard

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Preface

This document is intended to serve as an informative guide to the NMi International WIM Standard developed by the NIWS-group.

The first part of the guide describes the reasons and motivation to develop a new standard and the approach selected for the NIWS-project. Next it will explain the scope and application, and how this reflects in the structure of the standard. Further it explains the different level of performance tests and a vision on how the various test will be used in the future procedures for certification of WIM systems for Legal applications and for acceptance of WIM systems for Statistics applications.

The second part of the guide gives explanations for many of the choices that were made during the development of the standard. In many cases it is not so much a matter of right or wrong but of finding the right balance between the different aspects influencing the performance of Weigh-In-Motion systems and a practical way of testing this performance.

Finally a summary is provided of the main benefits of the NMi International WIM Standard. We hope that we have been successful in finding the right balance and that the standard will be helpful for your application, projects, situation and specific conditions.

NMi Certin B.V.

Dordrecht, 2016

Head Certification Body

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1 Context of this standard

1.1 Purpose of this guide

This document is intended to serve as support document for the NMi International WIM Standard. The first general part will describe the reasons and motivation to develop a new standard and the approach selected for the NIWS-project. Next it will explain the scope and application and how these are reflected in the structure of the standard. Further it explains the different level of performance tests and how the various tests are used in the procedures for acceptance of WIM systems for Legal or Statistical applications. The second part gives explanations for choices that were made in the development of the standard itself.

1.2 Background

For many years three documents (COST-323, ASTM-1318, OIML R134) have been used as international specifications to determine the performance of Weigh-In-Motion (WIM) systems all over the world. All three documents have their own origin, purpose and area of use, each with their specific advantages and disadvantages. One of the disadvantages is that none of the three covers all the applications and operational conditions for WIM systems required by end users, e.g. for direct enforcement of overloading under regular highway conditions. In the past there have been a number of initiatives to improve one of the three documents into a comprehensive international WIM-standard (FiWi-project, NIST–Handbook 44). These initiatives had difficulties finding consensus between the opinions and/or interests of all participants.

In the meantime WIM systems have been introduced for many different applications into many different countries around the world. As a result of the lack of a comprehensive international standard, national authorities have often either adapted one of the existing standards, combined parts of different standards or developed their own specifications and test procedures. Due to the specific nature of weighing in motion this requires a specific expertise that is not available in all countries. This has led to the situation where, besides the three international documents, there are several different national standards on WIM that are not compatible and by many considered too complicated for practical use. This has resulted in unnecessary additional work and costs for both buyers/users and vendors of WIM systems and a limitation for the wider application of WIM systems in general.

All in all, there is a need for a simple and practical yet well founded international standard for Weigh-In-Motion systems that covers all applications for high (and low) speed WIM systems.

1.3 Approach

The Dutch Metrology Institute (NMi) has taken the initiative to bring together a small group of experts on legal metrology and standardisation of measurement instruments with a select number of international experts on WIM to develop this new WIM standard. The members of this project group covered the key-expertise required to develop a practical standard that in structure and content has a quality that will be suitable for international use. The experience of the group of selected WIM experts had a combined experience of over 100 years covering both the vendors and users/buyers side of WIM, different WIM technologies and systems, different applications and conditions from various countries and continents.

The expert group consisted of:

- Cock Oosterman — NMi, The Netherlands;
- Paul Kok — NMi, The Netherlands;
- Mathias Meijer — NMi, The Netherlands;
- Hans van Loo — Corner Stone International, Switzerland;
- Andy Lees — Q-free TDC, United Kingdom;
- Emil Doupal — Transport Research Centre, Czech-Republic;
- Peter Favai — Cestel, Slovenia;
- Randy Hanson — International Road Dynamics, Canada.

The members of the expert group were invited to participate in the project based on their specific personal experience, not to represent the company they work or have worked for. On the WIM side the aim was to cover different areas of experience; pavement sensors and bridge WIM, scales and strip sensors, different sensing technologies and manufacturers from different continents. Each of the members has more than 20 years of practical experience in the development, installation, application and maintenance of WIM systems. Most of them have worked both for vendors/manufacturers and buyers/users of WIM system.

For practical project management reasons the number of WIM experts has been limited to five. The members of this group cover the key-expertise on WIM required to develop a standard that in structure and content has a quality that will be suitable for international use. The document is intended to be practical, easily accessible, widely acceptable, objective and independent for technology or commercial bias.

This document, the NMI International WIM Standard, has been written by the members of the NIWS-project. It is published as an international NMI-standard that is open to be used by all buyers and vendors of WIM systems to facilitate their relationship. It may also be used by any National Metrology Institute or Bureau for Weights & Measures in any country as a basis for national legislation. The standard may be used free of charge and can be downloaded at NMi website (www.nmi.nl). After registration you will receive a personalised copy of the document. The website will also provide information on updates, additional background information, reference projects, etc.

1.4 Scope of the standard

- The document gives specifications for automatic instruments for measuring the vehicle weight, axle loads and classification of road vehicles when in motion, hereafter referred to as Weigh-in-Motion or WIM-systems.
    - It does not apply to individual parts of WIM-systems only, e.g. WIM-sensors.
    - It does not apply to WIM systems that require a human operator to perform the measurements.
    - It does not give specifications for other quantities that may be measured or recorded by a WIM system that are related to the vehicles passing the system, e.g. time, speed, height, pictures.
- The document specifies the performance requirements for WIM-systems.
    - It covers the requirements for accuracy and reliability of the weighing and classification related measurements of the system.
    - It covers the requirements for operational conditions that may affect the accuracy and reliability of these measurements.
    - It does not cover requirements for the durability of the system over time.
    - It does not cover requirements for operational conditions that may only affect the durability.
- The document specifies minimum testing procedures in order to determine the actual performance of a – type of – WIM-system.
    - The results of the specified test procedures will provide a reference that may be used for international comparison of the performance of WIM-systems.
    - Users and Vendors are free to use more extensive test procedures since this will only result in an even more reliable outcome of the test.
    - The main objective for the test procedures described in the document is that they are intended to be practical. This means that there is always a compromise between the confidence level of the outcome of the test required by the user and the budget and operational constraints set by the vendor or local conditions at the WIM system.

1.5 APPLICATION OF THE STANDARD

- This document applies to fixed and portable WIM systems installed on, in or under the road infrastructure including both roads and bridges independent from which type of measuring technology is used.
- This document applies to High Speed WIM-systems, i.e. systems installed directly in a normal road and operated under free-flow traffic conditions;
    - It may also be used for Low Speed WIM systems since they operate in an environment where the measurement conditions are more controlled and vehicle dynamics more restricted.
- This document applies to WIM-systems used for:
    - Statistical (e.g. Traffic monitoring, Pavement Loading, Pre-Selection) applications where the accuracy of the average measurement is important and the accuracy is specified in (2x) the standard deviation;
    - Legal (e.g. Trade, Tolling, Direct Weight Enforcement) applications where the accuracy of each individual measurement is important and the accuracy is specified in Maximum Permissible Error (MPE).
- The document consists of different parts:
    - General part, consisting of chapters 1-3 and applies to all WIM systems;
    - Part I, consisting of chapters 4-7 and applies to WIM-systems for Statistics applications;
    - Part II, consisting of chapters 8-13 and applies to WIM-systems for Legal applications;
    - Recommendations, chapter 14 with non-mandatory information on the installation and operation of WIM systems.

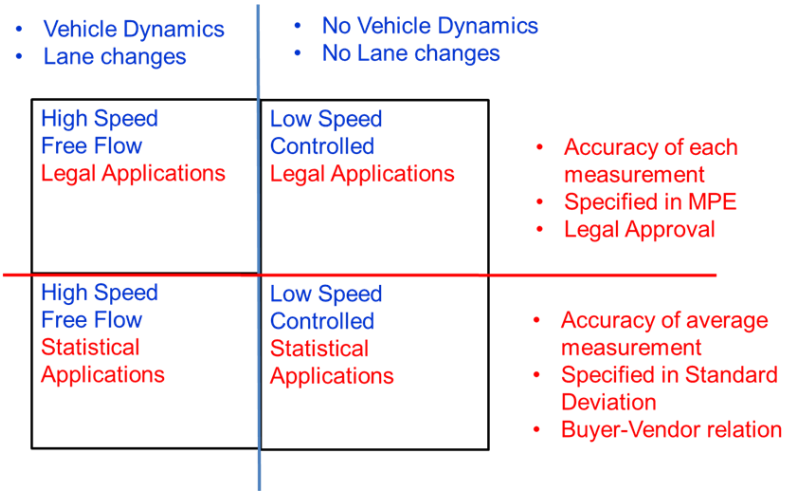

Figure 1, Applications and Conditions of WIM systems.

The aim of the document is to provide one structure for the requirements and test procedures that may be used for all four combinations of applications and conditions. This does not mean that all requirements and test procedures are the same for all applications.

2 TEST PROCEDURES

2.1 TEST LEVELS

The document distinguishes between three levels of tests in order to minimise the amount of tests that need to be carried out and at the same time provide a guarantee on the performance of a WIM system. The selected approach is based on the principle of "1 time testing" that provides maximum confidence for the buyer/user on the performance of the WIM system yet results in minimum costs for the vendor for the test procedures. The three test levels specified in this standard are generally used for measuring instruments for legal metrology around the world. The three test levels are:

2.1.1 TYPE APPROVAL TEST;

This is the first level and most extensive performance test of a new type of measurement instruments where the performance of the system is tested under the full operating ranges. This type of test is only required for WIM systems that will be used for Legal applications. It consists of both laboratory test and field tests and is always performed by NMi or a National Authority accepted by NMi. The test can be performed at any location around the world in mutual agreement between the manufacturer and the NMi, and eventually with the local authority. The results of this test will be a formal certificate stating the performance of all systems of the same type. This test will also result in an initial verification certificate for the system under test, system number #1. The certificate for type approval will serve as an international reference base for all Initial Verification tests performed on systems of the same type.

A manufacturer may apply to NMi, or a National Authority accepted by NMI, for an extension of an existing Type Approval Certificate (e.g. for a higher accuracy class or for an additional speed range). NMi may decide what tests will be needed in order to accept this extension. The certificate for type approval is valid for 10 years. A manufacturer may apply to NMi, or a National Authority accepted by NMi, for an extension of the validity period. NMi may decide what tests will be needed in order to accept this extension.

2.1.2 INITIAL VERIFICATION;

This is the second level and smaller performance test made after the first installation - or important repair - in order to verify the performance of the measurement instrument under the specific local (traffic and environmental) conditions at the site where the system is installed. It consists of field tests only with a lower number of test vehicles and passes over the system than the Type Approval Tests.

The results of this test will be a formal certificate or document stating the performance of this specific system (system number 2, 3, 4, etc.). It will serve as a reference base for the In-Service Verification Tests of this specific system at this location. This test is required for all WIM systems both for legal and statistics applications, however the content of the test procedures (number of vehicles runs) will differ between the two applications.

In case of a Initial Verification for a WIM system for a Legal application the 'System Approval Certificate' has to be issued by NMi or a National Authority accepted by the NMi. In the case for a system for Statistical application 'System Acceptance Report', the certificate may be issued by anybody as long as it has been agreed by both buyer and vendor.

2.1.3 IN-SERVICE VERIFICATION;

This is the third level and smallest performance test in order to verify if a system is still operating within specifications. This is a relatively small test executed when a system has been operational for a period of time, typically once a year. It consists of field tests only, with an even lower number of test vehicles and passes over the system than the other tests. The results of this test will be a formal certificate or document stating that this specific system still meets the required specifications. This test is required for all WIM systems both for legal and statistical applications, however the content of the test procedures (number of vehicles runs) differ between applications.

In the case of an Initial Verification for a WIM system for a Legal application, the 'In-Service Certificate' has to be issued by NMi or a National Authority accepted by the NMi. In the case of a system for a Statistical application, the 'In-Service Report' may be issued by anybody as long as it has been agreed by both buyer and vendor.

2.2 CERTIFICATION FOR LEGAL APPLICATIONS

For WIM systems for Legal application all three levels of test apply, see figure 2.

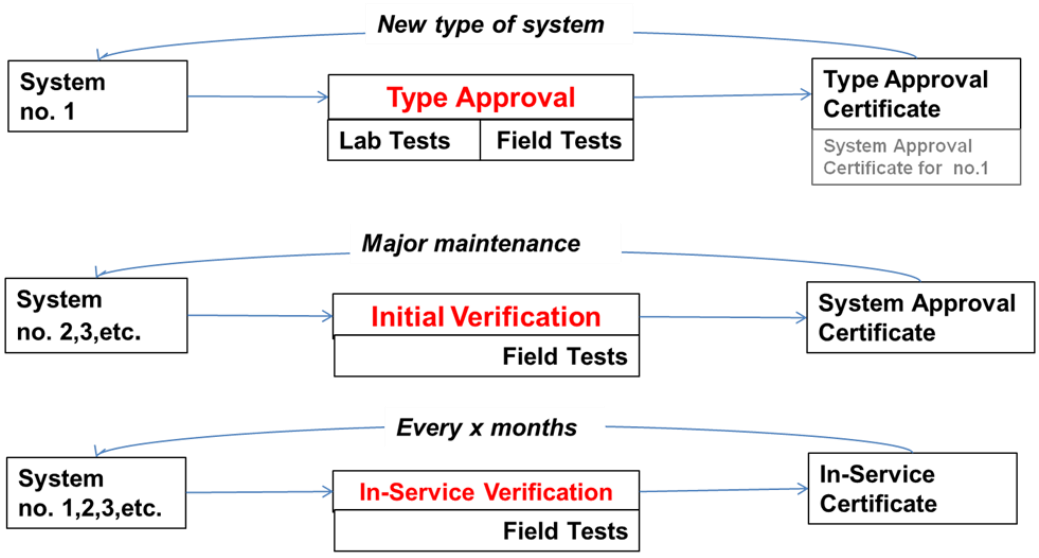

Figure 2,Test Procedures for Legal Applications

When a vendor has developed a new type of WIM system for legal application he may contact NMi and apply for a type approval test. Together they will decide on the practical conditions (when, where and how) of the test, both for the laboratory and the field part of the test. A complete system (system no. 1) shall be installed at the selected test location for the field test. After the system, under test, has passed all requirements NMi ~~the notified body~~ will issue a Type Approval Certificate. Any National Metrology Institute or Bureau for Weight and Measures may use the Type Approval Certificate as basis for national legal acceptance.

In case of adaptations to the type of system, the manufacturer must contact NMi, or a National Authority accepted by the NMi, to assess whether these changes can be made under the existing certificate or that a new or revised type approval test is required. The Type Approval Certificate is always valid for a complete accuracy class (hence Gross Vehicle Weight, Axle Group Loads and Axle Loads). Together with the Type Approval Certificate and without additional tests, a System Approval Certificate will be issued for system no1 at the test location.

For all following systems (no. 2, 3, etc.) of the same type but installed at different locations, only a "Initial Verification" shall be required. This verification will assess the impact of the local road pavement, traffic and environmental conditions on the performance of the system. The test will consist of field tests only. A System Approval Certificate may be valid for selected items of an accuracy class only (e.g. only gross vehicle weights), to be decided by the customer and should be clearly noted on the certificate.

After a certain period of time determined by the user/owner, an "In-Service Verification" has to be done in order to assess if the system is still performing within the specifications. Wear and tear of the system and surrounding road (pavement/bridge) and changes in the traffic or environmental conditions may have an effect on the measurement accuracy. The test will consist of field tests only. An In-service Certificate may be valid for selected items of an accuracy class only, to be decided by the customer and clearly noted on the certificate.

2.3 ACCEPTANCE PROCEDURES FOR STATISTICAL APPLICATIONS

For WIM systems for Statistical applications, only two levels of tests apply, see figure 3. In this case the tests may be carried out in agreement between the vendor and the buyer or by a qualified and independent third party.

After a system has been installed and calibrated by the vendor, the Initial Verification test will be done. This test will assess the overall performance of the system under the local road pavement, traffic and environmental conditions. The test will consist of field tests only. A System Approval Report may be provided for selected items of an accuracy class only, to be decided by the customer and clearly noted on the certificate.

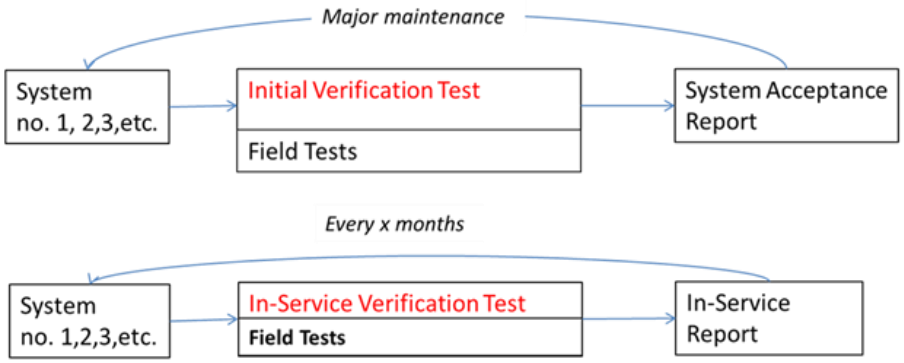

Figure 3, Test Procedures for Statistics Applications.

After a certain period of time determined by the customer an In-Service Verification Test has to be done in order to assess if the system is still performing according to the specifications. Wear and tear of the system and surrounding road (pavement/bridge) and changes in the traffic or environmental conditions may have an effect on the measurement accuracy. The test will consist of field tests only.

2.4 CHANGES TO THE SYSTEM

In case changes are made to a WIM system that has already been certified or accepted, it may mean that additional tests are required order to verify the impact of the changes. The changes that have an impact on the performance of a WIM system may result from maintenance to - parts of - the system, a change in the hardware of the system or an upgrade of the software of the system.

What are the required steps after a change has been made depends on the application (Statistical or Legal) and the design of the system. In general all changes to parts of the system that are connected to the actual measurements (e.g. signal processing, calculation algorithm, data processing) will require additional tests while changes to parts that have no connection with the actual measurement may not require additional tests.

In the case of changes to a system for Statistical applications, the Vendor shall inform the buyer/customer and explain the impact of the changes on the performance of the system. The Buyer and Vendor should then decide if and what additional tests are required. This is further is explained through a number of examples:

- For a WIM system based on pavement sensors where one of the sensors had to be replaced by a new one, then a complete new Initial Verification test will have to be done since the replacement may have affected the local pavement conditions and calibration setting of the system;
- In the case where a system was re-calibrated after a year, and one or more calibration factors were changed, then only an In-Service Verification will have to be done;
- In case an update was made to the user interface software that displays the measurement data on screen then no additional tests will have to be done.

In case of changes to a system for Legal applications the Vendor shall inform NMi and explain the impact of the changes on the performance of the system. NMi and Vendor will then decide if and what additional tests are required. This is further explained through a number of examples:

- In case a the data processing unit was replaced by a different type, a new measurement calculation algorithm was implemented or changes to the data security then – a part – of the type approval test will have to be done, e.g. only the field tests;

- For a WIM system based on pavement sensors where one of the sensors had to be replaced by a new one or configuration parameters of the system (e.g. sensor distances) were changed, then a complete new Initial Verification test will have to be done;
- In case the system was re-calibrated and one or more calibration factors were changed then a In-Service Verification will have to be done;
- In case an update was made of the user interface software that displays the measurement data on screen then no additional tests will have to be done.

2.5 CALIBRATION

Calibration is defined as the process of comparing a measuring instrument against a traceable standard or another accepted reference. Formally this does not include the "adjustment" which is defined as the set of operations on a measuring instrument to reduce the measurement error. In legal metrology 'Calibration' and 'Adjustment' are separate processes that may be executed by different parties. In daily practice of Weighing-In-Motion the combination of Calibration and Adjustment is seen as one process and often – incorrectly - referred to as 'Calibration'.

In this document both processes are considered as one, always executed by one party and referred to as 'Calibration + Adjustment'. Calibration + Adjustment is defined as the combined process of comparing a measuring instrument against a traceable standard and the set of operations to reduce the measurement error.

The 'Calibration + Adjustment' of a WIM system should always be done before performing a test on a system. The 'Calibration + Adjustment' is always the responsibility of the vendor/manufacturer of the WIM-system even though the actual process may be done by a third party. For any of the tests the vendor/manufacturer has to provide a system that is and remains in conformity with the requirements.

3 MOTIVATION

This chapter describes the motivation for a number of key choices that were made in the development of the document.

3.1 ACCURACY REQUIREMENTS

The main difference between WIM systems for Statistical and for Legal applications lies in the definition of the measurement accuracy. For Legal applications the accuracy of each individual measurement has to be guaranteed, while for Statistical applications the average accuracy of all measurements has to be guaranteed.

In order to have the same structure in the document for both groups of applications the Accuracy Level is defined as: Integer value used to quantify the maximum allowed error. However the interpretation of the accuracy level is different:

- For Statistical applications (chapters 4-7 of the document) is used to specify the maximum size of **the two Standard Deviation Interval [-2σ, +2σ]**. This means that for 95 % of all measurements the (unknown) true value lies within ±2σ % from the measured value. The use of the 2 Sigma (95%) interval as the accuracy level is internationally recognised for the interpretation and definition of accuracy for WIM systems used for Statistics applications;
- For Legal applications (chapters 8-12) is used to specify the size of **the Maximum Permissible Error [-MPE, +MPE]**. This means that for all (100 %) measurements the (unknown) true value lies within ±MPE% from the measured value. The use of the MPE interval as the accuracy level is the most commonly applied in international Legal Metrology, hence also for WIM systems that are used for Legal applications.

3.2 ACCURACY CLASSES

The Classification used in the document for the used weighing accuracy classes is based on a combination of a letter (**S** for Statistics or **L** for Legal) for the Application Group and a number for the Accuracy Level. For example:

- Accuracy class S(10) means a WIM system for Statistical applications where the accuracy - defined as the 2 Sigma interval - of the Gross Vehicle Weight measurement during operation is [-10 %,+10 %];
- Accuracy class L(5) means a WIM system for Legal applications where the accuracy - defined as the Maximum Permissible Error interval - of the Gross Vehicle Weight measurement during operation is [-5 %,+5 %];

Within an accuracy class, there is a fixed relationship between the requirements for measurement of the GVW, the Axle Group Loads and the Axle Loads. A free relationship between the weight measurements would have allowed for more flexibility in the testing and acceptance of different systems. However this would greatly reduce the standardisation of the accuracy classes and the possibility of comparing the performance of different systems

The ranges for the accuracy classes (S(5) to S(20) and L(3) to L(10)) are based on current applications and currently available WIM systems. However, the addition of one high accuracy class (S(5) and L(3)) for both applications has been created as these may be required, and be feasible, in the future, this makes document future-proof for the coming years. In case developments in the future create the need for additional accuracy classes NMi may decide to update the document.

3.3 WEIGHING RANGES

The weighing ranges are defined as the minimum ranges that should be covered by the system.

- For the GVW only a lower end of the range is defined since it is calculated as the sum of the axle loads and there is no technical limitation on the higher end of the range.
- For Axle load, a range from min. to max. is defined here with the higher end of the range of 15 ton should be considered as a design limit.
    - The Initial Verification and In-Service Verification Test will only go up to the local legal limits at the WIM site. Only during the Type Approval Test should the full specified weighing range be tested and overloaded vehicles may have to be used.

- For Axle Group Loads no separate range is defined because it is already covered by the other ranges.

3.4 OPERATIONAL CONDITIONS

The operational conditions are the ranges for different aspects from the environment where the WIM system is specified to perform. The document only specifies conditions that may have an effect on the measurement accuracy. The included conditions are Speed, Temperature, Humidity, Electromagnetic Fields and Mains variations.

Operating conditions that may have an effect on the durability of the system are not specified or tested in the document, e.g. resistance to dust, water, mechanical vibrations, etc. The reason for this is that such durability tests would require long term and consequently expensive tests. The durability may be assessed through a separate Research and Development project or reference projects/installations with the same or similar systems.

The operating conditions are specified for the outside conditions of the system, for the sensors in/under the road and for the road side system (cabinet + data processor and other electronics). Hence the conditions inside the cabinet are not specified or tested in this document.

The document also does not specify requirements or tests for the conditions of the road, pavement and/or bridge at or before (upstream) the location of the WIM system. Specifying these conditions was considered unwanted since it is often technology and location dependent and may form an unwanted limitation for future developments. The effects of the conditions of the road, pavement and/or bridge at or before a WIM system are tested in the Initial Verification Test. Since road conditions may have a major impact on the performance of a WIM system the standard does contain recommendations for the selection of a suitable site for the installation of WIM systems. These recommendations are non-mandatory however do contain practical and useful information based on international experience that may help a user with the successful implementation and use of WIM systems.

Variation in weather conditions, especially the temperature, may have an effect on the characteristics of road pavements or bridges at and before the WIM system. This may have an effect on the measurement performance of the WIM system. National authorities may add tests to assess the effect of variations in weather and temperature on the site (pavement and /or bridge) over time.

3.5 TRAFFIC VOLUME

No maximum traffic volume or intensity (in vehicles per hour or per day) is specified in the document. The reason is that there are two performance issues related to the traffic volume and intensity:

- The number of passing vehicles; at this moment the processing power of modern systems is more than enough to process the highest number of passing vehicles and the processing power will only increase with time and is not considered a limiting factor. Hence no requirements or tests are needed;
- The distance between vehicles; a WIM system may have difficulty to discriminate two vehicles that are driving very close after each other. However this performance is already specified in the completion rate and classification rate. Hence an additional requirement for a minimum distance between vehicles is not really needed and will be very hard – and potentially dangerous – to test in practice.

3.6 SPEED RANGES

The speed range for a WIM system should be determined by the conditions at the site of installation and should be freely set by the user of the system. However during the tests only a limited number of test runs at three different speeds (v_{min}, v_{med} and v_{max}) are used. These speeds should be representative of the full speed range. Due to the impact of the speed on the measurement accuracy such a test can only represent a limited speed range. For this reason a number of default speed ranges have been defined. To avoid the possibility of introducing an unnecessary limitation, two series of partially overlapping speed ranges have been defined.

The performance of a system will be tested for each of the speed ranges. In case it is required by the user, more than one of the defined speed ranges all speed related tests must be done for each of the speed ranges. The result of the test (test report, certificate) will indicate the overall operating speed range of the system.

3.7 FIELD TESTS

All field tests are a compromise between the statistical wish to have a large number of test samples - hence a large test – in order to have a test result that is statistically fully reliable and the practical wish to have a financially affordable test – hence small test – in order to make sure that the test procedure will be used in daily practice. Experience has shown that users and vendors will define their own reduced version of test plans when the original test procedures are considered too extensive, hence too expensive or too cumbersome. Using the same minimum test procedure is essential for an international standardised assessment and comparison of the performance of WIM systems. It is always allowed to use larger, more extensive test (e.g. using more vehicles, more runs, more speeds, etc.) since this will only result in a higher confidence of the test result.

To facilitate both the statistical and practical sides of testing, the approach of the three - or two subsequent in case of Statistical applications - tests has been chosen. This approach is also common in international standards for measurement instruments for legal metrology. Ranging from the extensive Type Approval Test, the limited Initial Verification to the most limited In-Service Verification, the results of the limited tests are supported by the larger one(s). The relative scope of the different test for Legal applications is shown in figure 4.

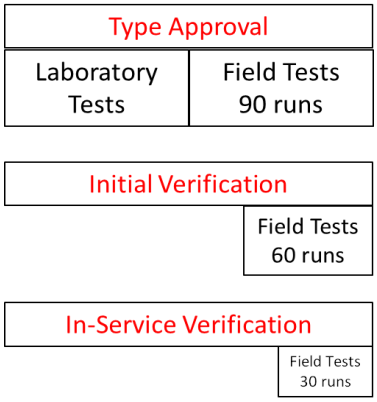

Figure 4, Number of runs per Field test.

For WIM systems that will be used for Statistical applications, no Type Approval test is required since this would lead to additional costs and has no added value, neither for the buyer/user nor for the vendor/manufacturer.

For most field tests different test vehicles should be used, this is to make sure the WIM system is capable of accurately measuring different types of vehicles. Again a compromise had to be found between testing with all possible types of vehicles and the practical limitations of organising field tests.

The general rule is that for all tests those types of vehicles should be selected that are most common at that specific WIM site. The specification for the number of different vehicles and number of runs is based on the experience of the members of the project group. The minimum number of different types of vehicles and minimum number of runs per type of test is shown in table 3.1.

Application\Test	Type Approval	Initial Verification	In-Service Verification
Statistics	n.a.	2 Vehicles, 10 runs each Total: 20 runs	1 Vehicle, 10 runs Total: 10 runs
Legal	3 Vehicles, 30 runs each Total: 90 runs	2 Vehicles, 30 runs each Total 60 runs	2 Vehicles, 15 runs each, Total 30 runs

Table 3.1, Test Procedures for Statistics Applications.

3.8 VEHICLE LOADING

During the field tests, only fully loaded (loaded close to their legal limit) reference vehicles will be used. This is because of a combination of reasons:

- Most application (e.g. pavement loading and weight enforcement) the heavy fully loaded vehicles are more relevant than empty vehicles;
- Empty vehicles will introduce additional disturbances because of higher vehicle dynamics that will reduce measurement accuracy and are unwanted during a performance test;
- Reloading a test vehicle – from empty to fully loaded or vice versa - during a field test is often complicated and will always lead to additional costs.

3.9 ACCEPTANCE CRITERIA

The test described in the document will answer the question: "Can the system under test be accepted for the specified requirements?" Or in other words: "When it meets all criteria, the system under test has a performance that is equal to - or better than - the required level, e.g. the accuracy of this system is at least ±5.0 %. The tests in this document will not provide an exact number on the actual performance, e.g. the accuracy of this system is ±4.73 %.

The criteria for acceptance are stated as a minimum percentage of valid test results that should be within a certain interval. For Statistics applications this percentage is always 95 % which is common practice for these applications, while for Legal application this percentage is always 100 % which again is common for legal applications. For all tests the interval equals the specified accuracy interval (±δ), except for Type Approval Tests where the interval is ±½ δ, see table 3.2

Application\Test	Type Approval	Initial Verification	In-Service Verification
Statistics	n.a.	95% in ±δ	95% in ±δ
Legal	100% in ±½δ	100% in ±δ	100% in ±δ

Table 3.2,Test Criteria

3.10 UNITS

The document is based on SI-units only and by default all requirements, specifications, test procedures, criteria, documents, certificates, reports will be provided in SI-units.

Users and Vendors are free to use other units for their purposes; on demand conversion to other units can be added or included.

3.11 DETECTION AND COMPLETION RATE

All (100 %) vehicles passing over the instrumented lane of the WIM system should be detected by the system and result in a vehicle record independent of the application. The WIM system should be able to detect if a vehicle was passing correctly over the system. Non-correct vehicle passages include the following conditions to be detected by the system:

- Vehicles changing lanes, in between lanes or partially on the instrumented lane;
- Vehicles passing the system with too high acceleration or deceleration;
- Extreme weather conditions like snow and heavy rain and/or winds.

The Error-rate, the percentage of vehicle that passing not-correctly over the system, depends on local traffic conditions, driving behaviour, the environment, etc. In any case it does not depend on the performance of the WIM system. Hence the performance of a WIM system cannot not be assessed by testing the percentage of correct vehicle passages.

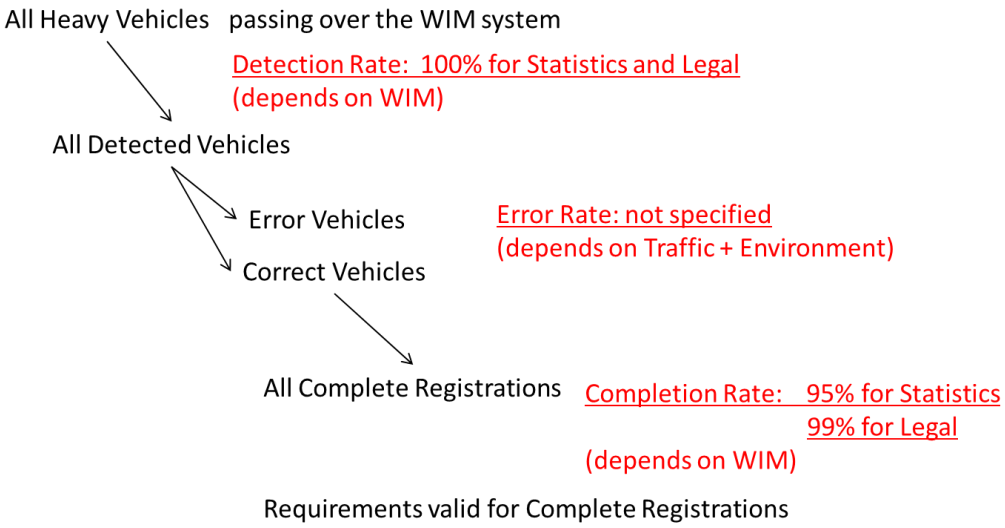

Figure 5, Detection, Error and Completion Rate.

However the Completion Rate, the percentage of correct vehicle passages that result in a complete registration, does depend on the WIM and on the application. The document specifies different minimum levels for the Completion Rate, 95 % for Statistical applications and 99% for Legal applications.

3.12 VEHICLE CLASSIFICATION

The vehicle classification scheme normally depends on the location and the application of the WIM system and many different schemes exist around the world. The document does not specify any specific vehicle classification scheme, it does specify the minimum percentage of vehicles that should be classified correctly by the system. The test report should describe to what classification scheme the system was tested, later additional classification schemes may be added.

3.13 RECOMMENDATIONS

Chapter 14 of the documents contains recommendations on the installation, operation and maintenance of WIM systems. These recommendations are non-mandatory however contain practical information that may help a user with the successful implementation and use of WIM systems.

It was decided to include a number of recommendations on key aspects surrounding WIM that are not part of the main document but may have a significant impact on the success of the installation and operation of any WIM system.

Finally a link is included to the calculation of Equivalent Single Axle Loads (ESALs) that are widely used to calculate the impact of heavy vehicles on the road pavement: https://www.astm.org/Standards/E1318.htm.

4 BENEFITS

This chapter gives an overview of the possible benefits of using the NMi International WIM Standard as identified by the members of the NIWS-project. No comparison is made with existing national or international standards or specifications for WIM systems. The assessment of which of the available documents is most suitable is up to the users and vendors to decide. This may depend on a combination of the specific project, application, local conditions and national legislation.

4.1 COMPREHENSIVE

The International NMi WIM Standard is a comprehensive document. It covers a combination of:

- Statistical and Legal Applications
- High Speed and Low Speed systems
- Requirements and Test Procedures
- a Framework for Certification
- Standard and informative Guide

4.2 INDEPENDENT

The International NMi WIM Standard is an independent document. It is independent of:

- Technology, the type of system or sensors. It is applicable for scales, strips and bridge WIM
- Vendor or manufacturer
- Buyer or user
- Country or region

4.3 PRACTICAL

The International NMi WIM Standard is intended as a practical document. Practical because:

- It is a relatively Short document
- with a Clear and Simple Structure
- that is Easy to use since
- it is based on >100years of combined experience

4.4 BALANCED

The International NMi WIM Standard is a balanced document. Balanced because it is a compromise between:

- The Interests of Vendors and Buyers;
- The characteristics of Weighing In Motion and the procedures in Legal Metrology;
- The need for test procedures that have a high Statistical Certainty and are realistic from a practical, financial point of view. E.g. Number of test runs in a test procedure should be:
    - Large enough to provide sufficient confidence;
    - Small enough to be realistic in daily practice.

4.5 OPEN STANDARD:

The International NMi WIM Standard is an open document. Open because:

- Its use is free of charge;
- A personalised copy can be obtained after registration at NMi-website;
- Voluntary use of standard:
    - As reference;
    - In tenders.
- More information at: www.nmi.nl.