Approval of the first direct enforcement

weigh-in-motion station in wallonia

world first in terms of accuracy and confidence levels

Wallonie

Table des matières

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ISBN: 978-2-8056-0554-3
Legal deposit: D/2023/11802/157

October 2023

1. INTRODUCTION

Figure 1 - HS-WIM weigh station in Louvain-la-Neuve [4]

The sustainability of the structural network in Wallonia is a key issue in mobility and impacts both the safety of users and sustainable development. To meet this challenge, the introduction of weigh stations for trucks is essential firstly in order to increase the sustainability of the road network and infrastructure by reducing the number of overloaded vehicles, secondly to improve road safety for users by limiting accidents involving overloaded vehicles or vehicles whose load is poorly distributed on their axles and, lastly, to combat unfair competition between international road carriers.

Based on this observation, the Walloon Government decided in 2006 to set up weigh stations at various strategic locations on the Walloon road network, starting with ten «static» axle weigh stations (LS-WIM) set up in motorway service areas. These require law enforcement officers (field agents) to identify and redirect potentially overloaded vehicles to the weigh stations where they can be tested. Between 2014 and 2017, vehicle controls have been improved by the installation of five «dynamic» weigh stations (HS-WIM) whose equipment's are directly installed on the main network allowing to control vehicles directly in motion on their trajectory. These stations were initially installed for pre-selection purposes and still required the presence of field agents for ticketing.

With the goal of continuous improvement, research and development projects began in 2017 to address a new objective, that of weighing and ticketing overloaded vehicles without interception. In December 2021, the Public Service of Wallonia, together with SOFICO, issued the first model approval for a direct enforcement weigh-in-motion station on Walloon territory. This first approval concerns the slow lane of Louvain-la-Neuve station, initially installed in 2017 as an HS-WIM station.

The latter has been applied the results of two Research and Development projects as well as infrastructure work and road reinforcement, resulting in levels of accuracy and confidence that make it a world first in vehicle overload testing.

This approval model now paves the way for the direct enforcement (ASC) of overloaded vehicles in Wallonia. This currently involves three types of overloads:

- the total weight of T2S3 semi-trailers.
- the load on the second axle of T2S3 semi-trailers.
- the total weight of LCVs.

This model allows the continuous testing of vehicles passing the HS-WIM station in Louvain-la-Neuve, without requiring the presence of field agents, to identify and ticket all overload vehicles (T2S3 and LCV). Controls are 50 times more effective than those carried out by field agent using static stations.

2. DESCRIPTION OF THE CERTIFIED MODEL

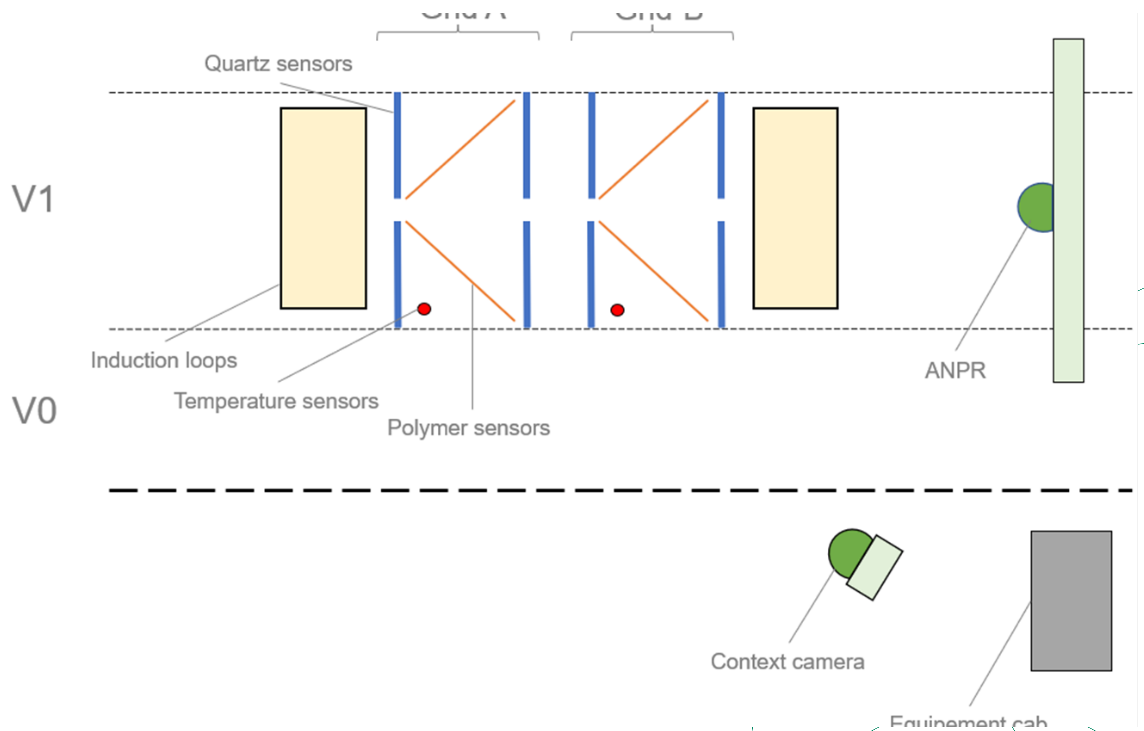

Figure 2 - Installation plan of the certified model weigh system

2.1. Weighing equipment

For each traffic lane, the weigh system consists of:

1. Two magnetic induction loops to detect the passage of vehicles.
2. Eight quartz piezoelectric sensors to calculate the wheel load of vehicles.
3. . Four polymer-based piezoelectric position sensors to determine the lateral position of vehicles in the lane and to distinguish between single and dual wheels.

2.2. Related field equipment and computer equipment

For each lane, the weighing equipment is supplemented with the following equipment:

1. Two temperature sensors to determine the road temperature.
2. A context camera to obtain a general picture of the vehicle and placement characteristics.
3. An ANPR system to obtain a picture of the vehicle number plate and its identification.
4. An equipment cabinet which includes a weighing module that calculates the raw vehicle data and an industrial computer that associates the photos and data to the vehicle. The file created per vehicle is encrypted and sent to the central servers.
5. Two central servers to process the data received from the station and subsequently create a violation file. Data protection systems are integrated to secure the data obtained.

2.3. Constraints on road quality

To meet the metrological requirements for a direct enforcement weigh-in-motion station, special attention had to be paid to the quality of the road in the weighing area and its surroundings.

As shown in Figure 3, since vehicles arrive at high speeds (> 30 km/h), any irregularity in the road will significantly influence the load felt by the sensors. The irregularities will create oscillations in the vehicle, distorting the load captured on each wheel compared to their static load.

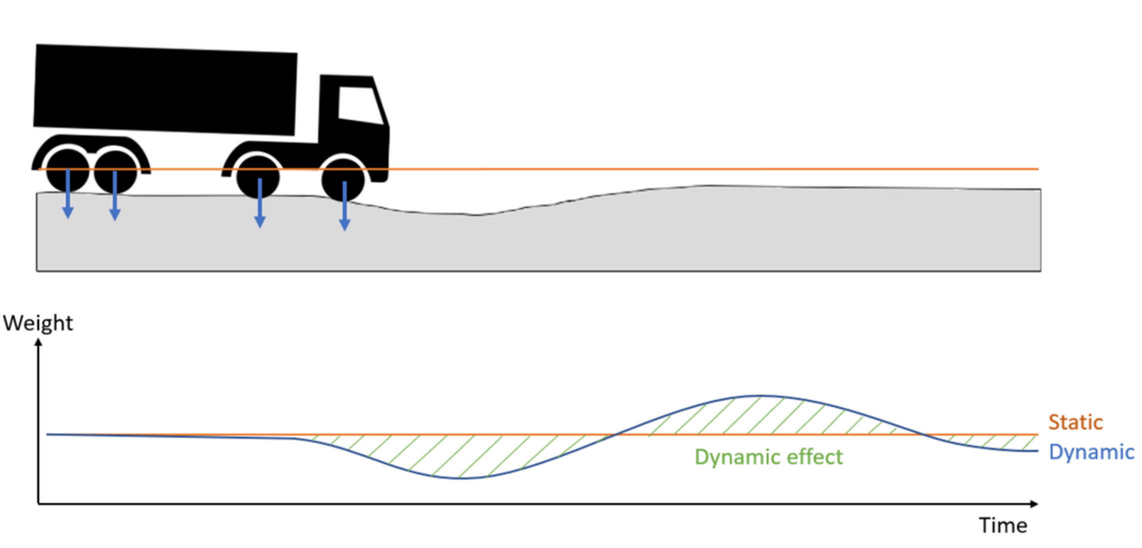

Figure 3 - Dynamic effect during weighing in motion.

To obtain the highest possible accuracy (i.e. to have in-motion weighing as close as possible to static weighing), different criteria have been established regarding the quality of the road [2]. For 200 metres upstream of the sensors and 50 metres downstream, the road must meet the following criteria [6]:

- a longitudinal slope < 2% and constant as much as possible;
- a transverse slope < 3%;
- a bend radius > 1,000 m;
- homogeneous constituent layers;
- a thickness of the bound layers greater than 10 cm;
- a structure free of hard and soft spots;
- a structure free of any iron-containing material;
- a surface free of road surface damage such as cracking, crazing or stripping;
- a longitudinal evenness < 2 mm;
- a transverse evenness (rutting) < 4 mm.
- have a rigid and homogeneous road foundation, laid on a sub-base with a bearing capacity of at least 50 MPa.

In addition, the station must be located more than 200 metres from any elements that may generate industrial interference (antennas, power lines, etc.) and problems related to vibrations (bridges, tunnels, etc.).

For all these reasons, the road was completely rebuilt (up to the sub-base) over a distance of 250 metres so that the station would have a sufficient level of accuracy.

2.4. Operation of the measuring system

2.4.1 Data calibration

The data configuration is integrated into the industrial computer and makes it possible to take account of the weighing coefficients, the adjustment coefficients related to the lateral position deviation of the vehicles, the data associated with the verification of measurement validity, and the calibrations due to the intrinsic characteristics of the loops and sensors.

The configuration of this data is obtained by several passages of trucks, previously weighed on an LS-WIM station to find their weight as accurately as possible, on the sensors of the HS-WIM station, over several days of tests to refine the system calibration.

2.4.2 Validity of the measurements

There are several testing systems to verify the validity of the data from the certified model [5].

First of all, it should be noted that the placement of the cameras on each lane and the synchronisation of the clocks on the weighing station equipment with the industrial computer ensure that the data collected is associated with the correct vehicle.

A first testing element comes from the industrial computer which periodically verifies that no component of the station is altered. If a fault is detected, no more data is sent to the central servers.

A second testing element is the filters applied to the industrial computer, which allow different checks to be made on the measurements obtained:

- •erification of the consistency of the measurements to verify the validity of the measurements of each control grid. If irregularities are detected, no data file is created for the vehicle concerned.
- Vehicle positioning verification to invalidate data when a vehicle is incorrectly positioned in its lane (e.g. straddling lanes).
- Verification of the dynamic effect of the vehicle as it passes over the weigh grids.

In addition to the above, an independent calculation method is used to check the data. The weigh system consists of two independent sensor grids (Grid A and Grid B in Figure 2), namely a main weigh grid and a control weigh grid identical to the main grid. The measurements of the control grid are used to validate or invalidate the measurements of the main grid. As a result, any deviation between the values of the two grids that is greater than the defined thresholds leads to the invalidation of the vehicle's measurements. The thresholds set are as follows [2]:

- 4% for the second axle load of the T2S3
- 2.5% for the total mass of T2S3
- 10% for the total mass of the LCV

A final point to emphasise is the sealing of the equipment to prevent the modification of the certified model:

- The sensors are sealed into the road by resin.
- The weighing module is digitally sealed (checksum protection) and physically sealed to the equipment cabinet.
- The industrial computer is digitally sealed (checksum protection) and physically sealed to the equipment cabinet.

2.5.System accuracy

The model is certified for the vehicle categories listed in Table 1 below:

Vehicle category	Class*
LCV (total weight)	10
T2S3 (total weight)	5
T2S3 (load for axle 2)	E

** in accordance with points 7.2.1 and 7.2.2 of Annex N2/1 of the Royal Decree of 12 October 2010 [1]*
Table 1 - Vehicle Class

The nominal operating conditions of the weigh system are as follows:

- Measurements: from 20 kg to 20,000 kg
- Value of the measurement range: d= 20 kg
- Speed: from 70 km/h to 135 km/h
- Operating temperature: -10°C to +50°C
- Storage temperature: from -20°C to 70°C

Vehicle overloads are based on the data in Table 2.

Vehicle category	Allowed maximum load	Maximum ticketing threshold
LCV (total weight)	3,500 kg	/
T2S3 (total weight)	44,000 kg	/
T2S3 (load for axle 2)	12,000 kg	20,000 kg *

** When the measured axle load is higher than the operating threshold, it is automatically brought back to this threshold.*
Table 2 - Ticketing thresholds

Thanks to the independent calculation method defined in the previous section and the data processing algorithm implemented, the certified model is a world first for the testing of moving vehicle overloads in terms of the levels of accuracy and confidence achieved! These results can be seen in Table 3.

Vehicle category	Accuracy (EMT)	Confidence level	Maximum error
LCV (total weight)	±10%	99.960 %	4.82%
T2S3 (total weight)	±5%	99.997 %	2.72%
T2S3 (load for axle 2)	±10%	99.850 %	3.73%

Table 3 - Accuracy levels [4].

3. STATISTICS

The number of non-compliant vehicles passing through the Walloon network is extremely high. To illustrate, Table 4 shows the number of overloaded vehicles by vehicle category and by measurement type in the slow lane (V1) of the Louvain-la-Neuve station over a period of one year:

Vehicle category	Number of overloaded vehicles by overload percentage slow lane (V1) of the Louvain-la-Neuve station over one year						
	0-5 %	5-10 %	10-15 %	15-20 %	20-30 %	30-40 %	>40 %
LCV (total weight)	7,485	3,883	2,819	1,592	1,989	1,307	2,248
T2S3 (total weight)	2,084	286	138	21	5	0	0
T2S3 (load for axle 2)	1,751	783	243	101	37	0	0

Table 4 - Overload statistics

These figures, for a single traffic lane at a single station for one year, can be put into perspective in relation to the objective of the Walloon Government’s recovery plan, which involves extending direct enforcement to the four existing weigh-in-motion stations and installing new stations on the Walloon network to reach a total of ten direct enforcement weigh-in-motion stations on the Walloon main road network, on one or more traffic lanes.

4. CONCLUSION

After many years of research and work, the Walloon Region has made major progress in the testing of overloaded vehicles by approving a direct enforcement weigh-in-motion station with levels of accuracy never before achieved in the world. This certification paves the way for new objectives for the future.

The first objective of the Walloon Government for the next few years is to duplicate this certified model on all the traffic lanes of the other four existing weigh-in-motion stations on the territory of Wallonia.

Subsequently, the Walloon Government's recovery plan includes the objective of adding five new stations based on the certified model to cover the road network and the borders of Wallonia.

Lastly, research and development work must also be continued to extend the testing to other classes of vehicles (T2S2, T3S2, C2, C3, C2R2, C2R3, etc.) in addition to semi-trailers and light commercial vehicles, and to develop solutions to certain avoidance manoeuvres (e.g. a vehicle intentionally «straddling» the slow lane and the middle lane).

ACRONYMS

BAU	Hard shoulder
COST	European Cooperation in Science and Technology
MPE	Maximum Permissible Error
HS-WIM	Weigh-in-motion station
LS-WIM	Static weighing station
RDP	Research and Development Partner
SMARTWIM	Trade name of the industrial computer
SOFICO	Walloon Company for the Supplementary Financing of Infrastructure
SPW	Public Service of Wallonia
T2S3	2-axle articulated tractor with 3-axle semi-trailer
WIM	Weigh In Motion
WIMRAW	Trade name of the weigh module
LCV	Two-axle light commercial vehicle
VL	Slow lane

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