A FUTURE OUTLOOK FOR TRAFFIC WEIGHT MEASUREMENTS IN THE NETHERLANDS



A. VERVUURT.
The Netherlands Organisation for applied scientific research TNO

H. VAN MEERVELD
The Netherlands Organisation for applied scientific research TNO

L. AARTS
Ministry of Infrastructure and Water Management, The Netherlands

Abstract
Weigh-in-motion (WIM) systems are used by the Dutch Authorities to acquire data on traffic load in weights of moving trucks. The need for this type of data is changing. For the period up to 2025 agreements have already been to keep the current WIM systems operational. However, a substantiation is needed in order to be able to arrive at a balanced investment decision for the period after 2025. A study was carried out in which scenarios have been developed for determining strategies for traffic weight measurements in The Netherlands. It is shown that multiple interests lead to different requirements regarding weight measurements, and there are technological developments providing alternative approaches. Based on the research, it is concluded which strategy is the most future-proof. It will also become clear which strategy the Dutch government ultimately chose.

Keywords: Traffic load measurements, weigh-in-motion, Bridge design, on-board weighing

1. Background

Currently, information on the weight of (freight) traffic on the Dutch road network is obtained from 18 weigh-in-motion (WIM) systems in the main road network. The information obtained from these systems is used for various purposes, including supervision and enforcement (by the Human Environment and Transport Inspectorate, the ILT), and managing and maintaining roads (by the national road authority Rijkswaterstaat).

Agreements have already been made for the period up to 2025 to keep the WIM systems operational. Several developments, however, have raised the question what the optimal choice is regarding traffic weight measurements for the period thereafter. It is shown that multiple interests lead to different requirements regarding weight measurements, and there are technological developments providing alternative approaches. Besides that, the European Directive (EU) 2015/719 of the European Parliament requires that member states give substance to rules and enforcement, to ensure compliance with the directive.

2. Objective

The aim of the current paper is to show how the Netherlands can arrive at an appropriate strategy for measuring traffic weight. Since the European directive applies to Europe and not only to the Netherlands, the paper can contribute to the discussion with other European countries.

In the paper, insight is provided into the possible scenarios for obtaining information on traffic loads of (freight) vehicles that are based on the various considerations. To this end four application areas are distinguished for the use of traffic load information. The application areas differ in the goals that can be pursued, the activities of parties involved and the information that is needed to carry out these activities. Distinguishing the areas of application thus provides insight into the differences and overlaps in interests and needs of the organizations and organizational units involved. The application areas are elucidated in section 4.

3. Traffic weight measurements

Weigh-in-motion (WIM) was first tested in the late 1950s in the United States in the so-called AASHTO road tests (Highway research Board, 1962). The tests were initially intended for studying the behaviour of bridges under cyclic and extreme load conditions. Further developments, however, have led to an optimized WIM-system that is used for multiple purposes, such as bridge design, maintenance of roads and enforcement on too heavy loaded vehicles.

3.1 History

In 1998, Drouen and Henny (1998) conducted a pilot with a dynamic weigh-in-motion in which the use of video images was incorporated (Figure 1). The goal of this pilot was to gain insight in traffic loads on the Dutch highways, and using this insight to develop strategies for reducing damage of the road network by overloading. Moreover, it was investigated whether

WIM systems could be used effectively for identifying overloaded vehicles (i.e. selection of vehicles for further investigation).

Figure 1 – WIM system consisting of a combination of in-road sensors and video images

Over the years, the accuracy and reliability of WIM systems improved. As such, the WIM systems gained interest from asset management organizations as well as from organizations tasked with control, supervision and enforcement of regulations on traffic size and weights. As a result, currently, WIM systems have become indispensable for both purposes and various systems have been installed in the Dutch road network. At the moment, 18 systems (9 locations, devices in both directions as indicated in Figure 2) are installed. Next to preselecting possibly overloaded vehicles for further investigation, WIM systems are used to prepare the multi-year planning for the maintenance of pavements and for determining the load models for the design and assessment of the structural safety of bridges and viaducts. Moreover, with an increasing number of design and maintenance contracts for parts of the network, similar systems are used by maintenance companies for monitoring the service level agreements with respect to traffic loads that may be expected.

As mentioned, in the last decades, the accuracy and reliability of WIM systems has been improved and the systems have evolved due to new sensors such as glass fibre optic sensors. Nevertheless, the basic principles of the measurement systems have remained the same. Next to new sensors also new technologies such as in-car measuring systems for on-board weighing (OBW) have been developed. However, until now, in The Netherlands such systems are not used yet for the aforementioned purposes.

作者/Author	所属机构/Company or Organization	日期/Date
Adri Vervuurt	**TNO**	**4-7 September 2021**
Hendrik van Meerveld	**TNO**	
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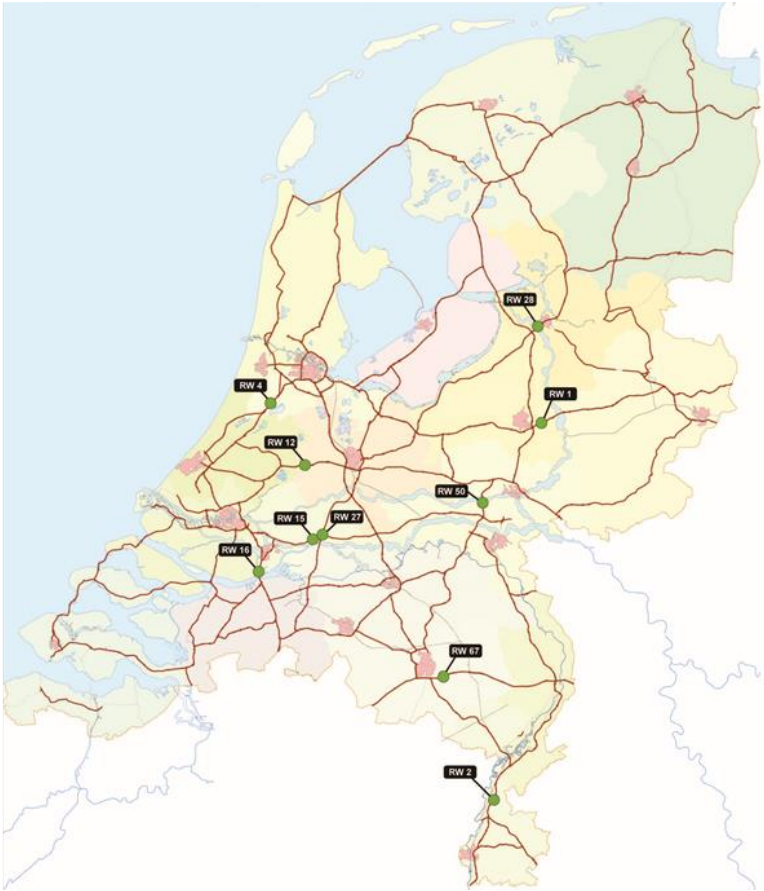

Figure 2 – Weigh-in-motion systems in the Dutch highway network (2019)

3.2 Current uses of obtained data

The current portfolio of WIM systems is used for control, supervision and enforcement of overloaded vehicles. Next to weight measurement sensors, the systems include video systems and automatic recognition of the license plates of vehicles. The system compares the measured loads to the allowed vehicle and axis loads. It does so through access to the database of the Dutch Vehicle Authority. The Dutch Human Environment and Transport Inspectorate of the ministry (ILT) keeps track of all (possible) violations. This does not entail a penalty or fine, as the system is not deemed accurate enough to automatically penalize violators. By keeping track of infringements, ILT can identify particular areas and routes where infringement is more frequent. The ILT informs offenders on infringement to influence behaviour, and follows with additional interventions when required. As such, the ILT uses different forms and levels of interventions varying from creating awareness with publications and influencing behaviour with benchmarking, to enforcement including fines.

For the design and maintenance of infrastructure, vehicle weight data is used for gaining insight in the behaviour of materials and structures under extreme and altering load conditions. This insight is used for validating and calibrating models for predicting time dependent behaviour such as fatigue of steel and concrete structures, but also of pavement

作者/Author 所属机构/Company or Organization
Adri Vervuurt TNO
Hendrik van Meerveld TNO
Loes Aarts Min. of Infra. & Water Man.

degradation. These predictions are used as a basis for the multi-year planning for replacement and renovations of bridges, viaducts and roads.

Moreover the traffic weight characteristics (axle loads, vehicle loads, intervehicle distances, etc.) are required for developing regulated traffic load models for the design and assessment of civil structures. The assessment of the structural safety requires information on the entire service life, which requires that trends over time are taken into account and that traffic load models are evaluated periodically. For that reason, periodic measurements in a representative time frame are required. Insight in the variation of traffic loads throughout the network (spatial variability) is obtained by performing measurements at different locations in the road network.

4. Purposes and altering needs

Based on the analysis of the as-is situation and stakeholder interests, four application areas for traffic weight measurements are identified. It is shown that the different application areas require different types information and sometimes even lead to conflicting requirements for the applied measuring system.

4.1 Control, Supervision & Enforcement of Traffic Weight

The first application area relates to the ‘control, supervision and enforcement of traffic weights’. Directives 96/53/EC and 2015/719 lay down maximum authorised weights on traffic, and requires Member States to take measures to ensure compliance with the requirements of this Directive.

Motives for requiring compliance to the maximum authorised weights relates to three aspects. First, harmonization of weight limits ensure a level playing field within the European Union, allowing fair competition. Secondly, traffic safety as overloading can negatively influence traffic safety. Thirdly, overloading causes infrastructure damage that is disproportional compared to vehicles that meet weight requirements. Although exact figures are not known, estimates range between about 35 to in excess of 100 million Euro’s in added damages to pavement and structures to the main highway network (Staatscourant, 2011). It is estimated that around 15% of all vehicles on the Dutch highway network are overloaded (Engel, 2014). The executive agency of the Ministry of Infrastructure and Water Management (Rijkswaterstaat) assumes that reducing this percentage to 10% results in 10 to 30 million Euros saved costs due to reduced damages to pavements alone.

Directive 96/53/EC and 2015/719 requires Member States to bring into force laws, regulations and administrative provisions and to lay down rules on penalties applicable to infringement, and to adequately address infringement related to overloading. The directives requires Member States to have competent authorities perform an appropriate number of vehicle weight checks, proportionate to the total number of vehicles inspected each year in the Member State concerned.

In the Netherlands, two related but different activities can be observed in relation to the aforementioned Directives. The first activity relates to control and supervision of overloading and the second to enforcement of overloading. Control and supervision means that compliance with vehicle weight requirements is checked, and is used to inform shippers and haulers on (possible) infringements. Enforcement includes issuing penalties (fines). In the Netherlands, both control and supervision as enforcement is conducted. It should be noted that there are several approaches for enforcement, including: (1) the random selection of vehicles for checks, (2) the use of e.g. WIM and history for preselection of vehicles for checks, or (3) automated checking and penalizing with use of WIM. The first and second approach require measurement equipment to be located or placed nearby the location where checks are being executed. In the Netherlands, mainly the second approach is used.

Next to issuing fines, the ILT utilizes several other means to reduce the degree of overloading, such as creating awareness and influencing behaviour of haulers. As such, the ILT uses different forms and levels of interventions (e.g. from creating awareness and influencing behaviour, to enforcement including fines).

4.2 Design & Maintenance of the Road Network

The second application area relates to the ‘Design & maintenance of the road network’. The Dutch Building Decree of 2012 stipulates that structures must comply with the standards for structural safety and durability of structures (Eurocodes). In order to fulfil this requirement, insight is required in current traffic weights and traffic intensities. In practice, information on past and current loads significantly affects the outcome of structural assessments of structures. Insights in actual loads reduces uncertainties, thereby affecting the estimated structural safety. Generally, more precise information leads to more precise predictions that provides evidence that structures can safely be used for longer timespans. Therefore, information on the actual load may lead to savings in costs. Consequently, having no information on the actual loads may require taking measures for ensuring the structural safety and may include traffic restrictions or structural strengthening. Consequently, this may lead to traffic hinder and costs.

Maintenance of infrastructures has a large impact on carbon emissions and material consumption and (societal) costs. Moreover, maintenance activities negatively affects traffic flow. The degradation of infrastructure varies and depends on many variables. Traffic loads – in particular heavy loads – play an important role in infrastructure degradation. Consequently, traffic load information contributes to a better understanding of infrastructure degradation. In turn, this allows for better planning and execution of maintenance works. This is deemed very valuable as better planning is associated with lower costs (as less corrective actions are needed). Next to maintenance, insights in traffic weights and intensities is also used for the design of structures and roads.

In the Netherlands, as in the rest of the western world, a large part of the bridges and viaducts almost reached its service life. Accurate and early estimates of needed replacements and renovation or strengthening are required, to allocate budget accordingly and to be able to optimise the maintenance and renovation planning.

Recent developments in traffic and transport such as platooning, increasing truck loads, increasing truck sizes (e.g. road trains), and connected and automated mobility, may further contribute to increasing degradation and structural safety issues. Developments where heavy vehicles are charged additionally will likely influence the behaviour of transport companies in terms of loading and routing, which may also affect maintenance strategies for the infrastructure network. As a result more insight in actual loads is required by organisations such as Rijkswaterstaat to better asses the condition of infrastructure.

4.3 Traffic & Transport Management & Policy

The third application area relates to 'traffic & transport management & policy'. National and European economies depend on infrastructure, but also on quality traffic and transport management, and traffic and transport policies. Activities related to these purposes concern traffic management, the planning of developing/improving infrastructure, and the development and improvement of new policies. Such activities require information on traffic and transport on the road network and typically involves information on traffic intensities, origin-destination-information, and type of vehicles. Traffic weights may be of interest as this provides insights to hauled tonnage and compliance to regulations. Weight information can thus contribute to making better policies.

For example, The Dutch government introduces a heavy goods vehicle charge in 2023, similar to other EU member states (Vrachtwagenheffing Nederland, 2018). The charging rate depends, among others, on the distance travelled and the vehicle type concerned (based on vehicle weight and its emission norm). To investigate if this policy affects traffic loads, routing (choice of route, shifts in choice of roads) or if the charging rate should become load dependent, information is required on the actual loads of trucks.

It is noted that the required input for the activities related to management and policy making is likely similar to the input required for the application areas mentioned before. For example, evaluation of policies regarding overloading requires information on weights of vehicles, similar to the information required to control, supervising and enforcement on vehicle loads.

4.4 Logistics

The fourth application area relates to logistics. Improving logistics means that transport sector organisations optimize the use of shipping and hauling possibilities. This means, for example, that hauling trips are planned in such a way that minimizes the time and distance travelled without cargo. Improved logistics can contribute to minimizing carbon emissions, improving profitability, and reducing the required number of trips.

For this purpose, transport companies need to know the weights of each individual vehicle in their fleet related to the routes that are planned and executed. Such information can be obtained through various means. For example, shippers and haulers can already exchange information upfront on the goods being shipped, including sizes and weights.

5. The bespoke information needs of application area's

As expected, the identified application areas all require information on vehicle and/or axle loads. In contrast, differences in the required information are also apparent. These differences manifest themselves when the information requirement is further specified. For control, monitoring and enforcement of overloading, information is mainly required on the load on trucks and the related weight of the vehicle and axles. In contrast, the design and maintenance of roads, bridges and viaducts requires information on the total spectrum of traffic loads present at certain points in the network. This is just one of the examples where specifying the information needs provides insight into the differences in the needs. In addition, it is only from specifying the information needs that it is possible to tell how suitable different technologies are.

The requirements for the information are manifested in a number of characteristics. These so-called data quality dimensions may be used to better understand the information needs for the different application areas. The following data quality dimensions may be distinguished:

- Data accessibility, where a distinction can be made between 'directly accessible', 'continuously accessible' or 'accessibility of a representative dataset' for the purpose for which it is used. The accessibility of data is also related to the authority for which the information must be accessible.
- Data accuracy, which concerns the degree to which the data approximates the actual value. For enforcement and (automatic) fining strict requirements apply with regard to accuracy, which affects the suitability of systems. For management and maintenance, accuracy is very relevant in specific cases, for example when assessing the structural safety of structures where (extremely) heavily loaded vehicles with a small chance of occurrence play a major role.
- Completeness of the information. This relates in particular to questions such as whether information is required about all traffic or just a selection of the traffic, at how many measuring points, and at what moments in time. In some cases, more information than just weight information is needed (such as maximum allowable load where specific vehicle requirements are also important).
- Consistency is important for most application areas, especially if the information is used to identify trends.
- Level of detail. Almost all application areas require that the information is detailed to the level of individual trucks and axles.
- Interoperability, i.e. to what extent data can be integrated into other data systems.
- Timeliness of the data. This ranges from seconds (in the case of enforcement) to weeks or months for other purposes.

The above criteria are mainly intended to further specify information needs in order to identify differences. That said, in general, other requirements may also be of relevance, such as data confidentiality, ownership, and data security.

6. Conclusions

In the context of EU Directive 2015/719, the European Commission has asked all member states to indicate whether they intend to enforce overloading with the help of in-road or on-board weigh-in-motion systems or a combination of both. The European Commission wants to be informed about this by 27 May 2021 at the latest. On the basis of the results of the current study a policy decision is made to continue the current situation and at the same time focus on testing and exploiting new possibilities, in order to become less dependent on in-road weigh-in-motion systems on the long term. Moreover, opportunities offered by new

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Adri Vervuurt | TNO
Hendrik van Meerveld | TNO
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technologies may be utilized. This means that at least until 2025, efforts will be made to maintain the current network of 18 in-road weighing points and, in the meantime, explorations and pilots will be carried out into alternative forms of in-road and on-board weighing systems.

Based on the results it appears that different information needs emerge from different application areas. On the long term, inevitably different types of measurements and corresponding different types of technologies are needed to meet the information needs. To provide further insight into the key trade-offs, four scenarios have been developed. In each of the scenarios the legal obligation is fulfilled.

6.1 Possible scenario's

The zero scenario assumes a continuation of the use of the current WIM systems. It is assumed that certain developments (whether technology-driven or not) will take place more or less autonomously, as a result of which the current systems will eventually be replaced by systems with better performance, additional functionality, and/or lower costs. In the base, however, such a scenario is similar to the current situation.

A second scenario depicts a situation in which the number of in-road measurements is intensified. As a result more information is gathered, which may positively affects limiting overloading and provides more insight into the traffic load at various points in the road network for management and maintenance purposes. The increase in costs can be extrapolated from the current situation, the (extra) benefits as a result of the increase in information has not been studied.

Another scenario may be a situation in which information is based only on on-board measurements. This assumes that all load information is obtained from the (freight) vehicles themselves. This is a development that is already partly taking place for logistic reasons and where there is a clear parallel with the truck toll, for example. The idea behind this scenario is that this information will also become available for purposes such as enforcement and management & maintenance. Because it is likely that this will not provide insight into the traffic spectrum at different points in the road network, this scenario gives less substance to the information needs with respect to design and maintenance of infrastructure.

Finally a situation is possible in which both in-road measurements and on-board measurements are taken. A logical point of departure is that this scenario is based on the basic scenario and that, over time, more and more data is obtained from on-board systems.

The function of the above mentioned scenarios is to provide a better understanding of the most important considerations at stake. When making decisions, the costs and benefits obviously play an important role, but so does the distribution of these. In the case of on-board systems, for example, the costs are partly borne by private parties such as truck manufacturers, while government parties also benefit from the data (for enforcement and management and maintenance). In on-road systems, it is the other way around: the costs are mainly allocated to the government, while private parties also benefit.

6.2 Scenario's per application area

The most likely scenarios for the four application areas are given in Table 1. In the table the application areas are combined with the current scenario (base scenario) and the possible scenarios for the future (far right column). The black shaded scenario in the far right column indicates the most likely scenario, while the promising scenarios are shaded gray. The scenarios shaded in gray are less likely.

Table 1 – Summary of results – expected scenario's per application area

Application area	**Expected scenarios**	
	Base scenario	**Future (beyond 2025)**
1. Control, supervision & enforcement	Main source: currently 18 WIM-stations in highway network.	Base scenario Intensify in-road On-board In-road & on-board
2. Design & maintenance	Main source: currently 18 WIM-stations in highway network.	Base scenario Intensify in-road On-board In-road & on-board
3. Traffic management & policy	Current sources include data from e.g. WIM-stations and induction loops in highway network.	Base scenario Intensify in-road On-board In-road & on-board
4. Logistics	Private information sources (on-site WIM, fleet management systems)	Base scenario Intensify in-road On-board In-road & on-board

The following general conclusions can be drawn from a review of the trade-offs by application area.

The number of vehicles with embedded sensors is increasing. This information can be used for multiple application areas but is mostly privately owned. If the government can (and is allowed to) obtain this information, this offers opportunities for enforcement but also for the design, management and maintenance of roads, bridges and viaducts.

The degree to which the government wishes to control overloading largely determines the suitability of various scenarios. If the number of currently recorded violations related to overloaded vehicles is considered acceptable, then the current situation can also be considered satisfactory. More control, supervision and enforcement can be obtained, among other things, by more measurements (either on-board or in-road).

作者/Author
Adri Vervuurt
Hendrik van Meerveld
Loes Aarts
所属机构/Company or Organization
TNO
TNO
Min. of Infra. & Water Man.

In the current situation, the government relies mainly on in-road systems for weight information. For management and maintenance, it is expected that this will continue to be an important source of information in the future, also in light of the advent of new transport concepts. For enforcement, on the other hand, it is not inconceivable to expect that more use will be made of on-board systems based on built-in sensors. As a result, a different (or differently designed) system may be better suited to specific needs for management and maintenance.

7. Future outlook

From the previous section it may be clear that there are opportunities for the scenarios with embedded (on-board) sensors. However, it is unclear to what extent this can replace the primary data sources currently used (in-road WIM-stations), and in what time frame. More broadly, as a result of digitization (such as the digital waybill), there are increasing opportunities to collect, manage and analyse data. These capabilities can add value in any of the scenarios described earlier.

For the next few years, most stakeholders consider continuation of the current situation to be appropriate, but great opportunities are attributed to on-board technologies for the future. This also gives time to further explore the possibilities offered by the new technologies, together with other information sources, such as the truck toll monitoring system. and to more clearly specify the information needs of the various stakeholders.

Since the issues addressed in this document are not limited to the borders of (European) countries, it makes sense to join forces.

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