Journal of Civil Engineering and Architecture 16 (2022) 611-618
doi: 10.17265/1934-7359/2022.12.004

The Problem of Overloaded Vehicles in Poland

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Abstract: The international and national forecasts road transport development is optimistic, and they should promote implementations of innovations in road infrastructure. The producers of heavy vehicles and their users aim to increase total vehicle weights and axle loads. International organizations: the Joint Transport Research Committee (JTRC) and the Forum of National Highway Research Laboratories (FEHRL) study the influence of increased loads on road infrastructure and define the directions of innovative solutions for trucks and the road infrastructure. The number of registered vehicles has been growing in Poland. The reliable part of heavy vehicles is overloaded and they cause considerable damage to roads and influence traffic safety. The degradation of roads results from unacceptable axle loads and the total mass of heavy vehicles. It is necessary to introduce the weigh-in-motion system in Poland for pre-selective weighing of vehicles. The system will measure axle loads, number of axles, vehicle length and calculate its mass without stopping. For the identification of vehicles, the intelligent system ISKIP may be used, developed by the Road and Bridge Research Institute. The weigh-in-motion system is under implementation in Poland.

Key words: road transport, infrastructure, traffic safety.

1. Introduction

The road infrastructure is under substantial impact of heavy vehicles, which in practice include vehicles with weights exceeding 35 kN. In Poland, the maximum static axle loads allowed for a vehicle are 80, 100 or 115 kN, depending on the category of public roads. In moving vehicles, the dynamic loads on the road surface are significantly larger than the static loads, and the dynamic effect of moving vehicles on the road surface causes the interaction between the road surface and the vehicle. This has been confirmed in the research conducted as part of the *DIVINE (Dynamic Interaction between Vehicles and Infrastructure Experiment*) Project [1]. Formerly, the impact on road surfaces of heavy vehicles was compared to that of light vehicles using the so-called "fourth power law", i.e. the exponent $\alpha = 4$ was adopted. This meant that the passage of one heavy vehicle with a 100 kN axle load corresponded to 160,000 passages of one passenger car with a 5 kN axle load. In recent years, studies have been conducted to verify the impact of heavy vehicles on road surfaces. The results of those studies are presented in the reports prepared by *OECD/ECMT –the Joint OECD/ITF Transport Research Committee* [2]. The studies show that the impact of heavy vehicles on road surfaces is greater than the impact recognised on the basis of the previous studies, and the exponent α, which was previously deemed to be 4, is 5 for asphalt pavements and 12 for concrete pavements.

The Forum of European National Highway Research Laboratories brings together leading road research institutes from different European countries. The FEHRL is an international association established in 1989, and one of its objectives is to increase innovation in European road construction and road-using industries. During its more than 20-year-long activity, the FEHRL's research areas were defined in its consecutive Strategic European Road Research Programmes (SERRP). In 2011, SERRP V was developed scheduled for the years 2011 - 2016. Its core component is the programme that defines the road

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transport in the 21st century called The Forever Open Road. The Programme aims to develop and implement new solutions, i.e. intelligent roads that are adaptable, automated and climate-change resilient.

The condition of the road, its infrastructure and the condition of vehicles all have a significant effect on road safety. This paper presents some of the issues related to overloaded vehicles in Poland, with a particular focus on their effect on road safety.

2. Forecast of road transport

Fig. 1 shows the prediction of the index of passenger and surface freight activity in the years 2000 - 2050 prepared in 2011 by the International Transport Forum (ITF), established by the member countries of the Organisation for Economic Cooperation and Development (OECD). The transport volume in 2000 was adopted as a reference of 100. The forecast implies a significant increase in passenger-kilometres in passenger mobility and ton-kilometres in surface freight mobility in the 2000 - 2050 period. It should be noted, however, that even in the past, optimistic predictions were sometimes distorted by the effects of the crisis, which occurred for example in 2008 (Fig. 2). Such crises scenarios should also be considered in future. In the road transport sector, there has been a tendency to increase the total weights and loads in vehicles and to seek for new innovative solutions for heavy vehicles, aimed at reducing the cost and improving safety of road transport [3].

In Poland, an increase in traffic on the road network was witnessed after 1900, caused by the economic change. On the most important network of roads, i.e. international roads, between 1990 and 1995, there was a 44% increase in traffic. In the following years, from 1995 to 2000, the traffic was found to have increased by over 31%. Then, between 2000 and 2005, the increase recorded was 18%. Finally, over the 2005 - 2010 period, the increase was found to be 22% [4].

This means that while the traffic growth rate was descending between 1995 and 2005, a certain increase in road traffic dynamics was observed between 2005 and 2010, despite the reduction in road traffic as a result of the economic crisis in the years 2008 and 2009 (Fig. 2). The rate of traffic changes between 1995 and 2010 is shown in Fig. 3. It should be borne in mind that the 1990 - 1999 period saw changes in the management

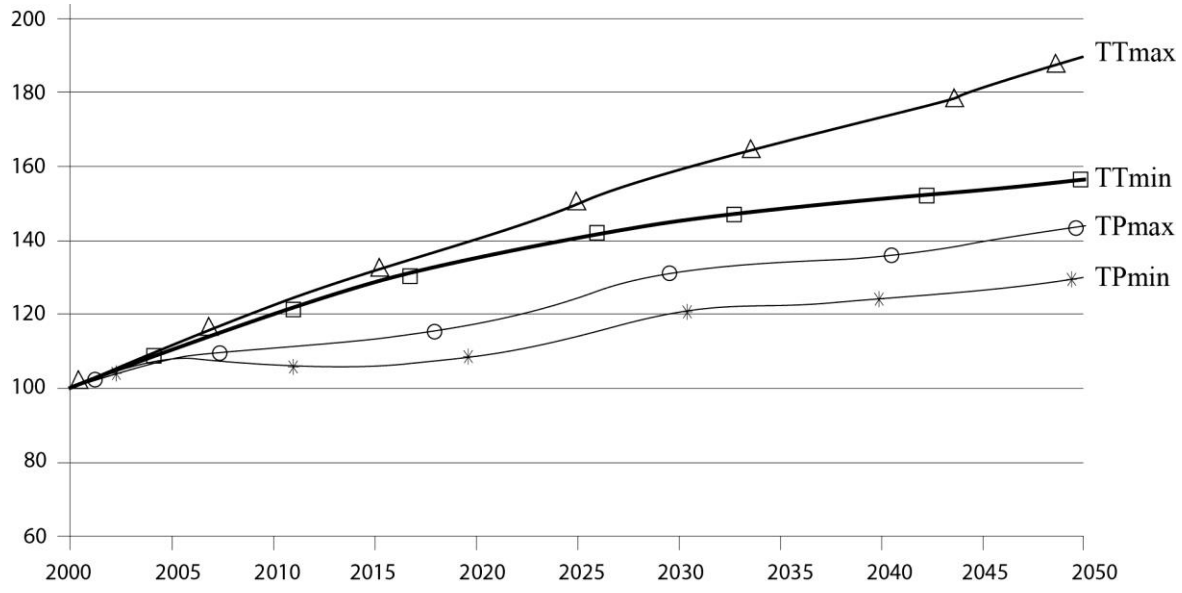

Fig. 1 Forecast index of passenger and surface freight activity, 2000 - 2050 (TTmax – maximum surface freight mobility, TTmin – minimum surface freight mobility, TPmax – maximum passenger mobility, TPmin – minimum passenger mobility) [5].

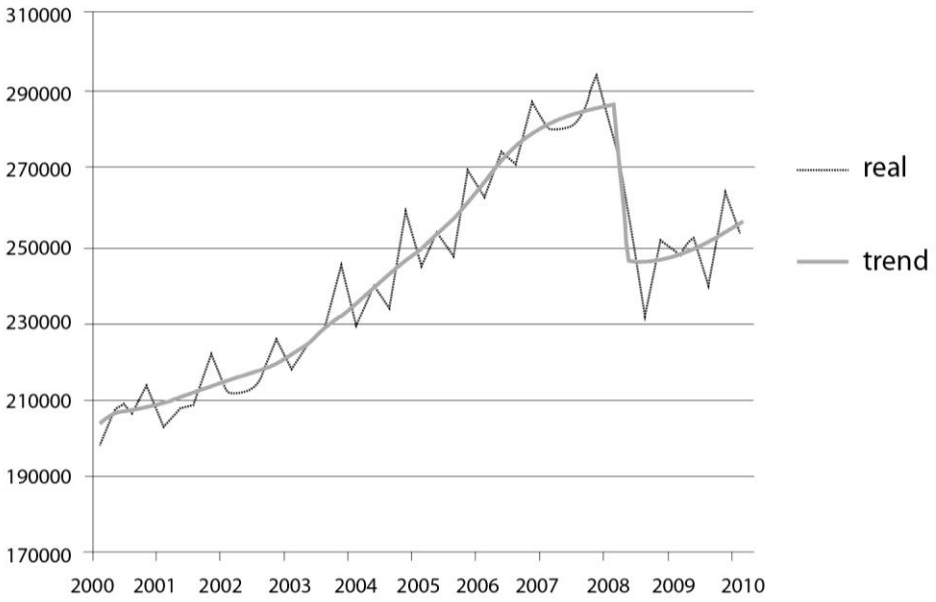

Fig. 2 Road Transport in the European Union, 2000 - 2010, in millions of ton-kilometres.

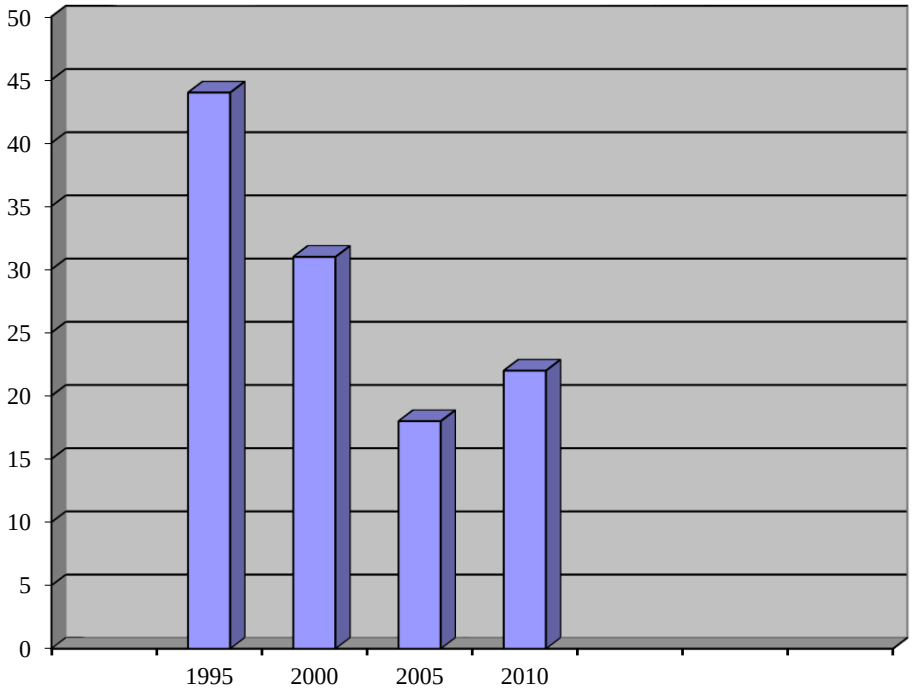

Fig. 3 Rate of change in road traffic on the national road network in 1995, 2000, 2005 and 2010.

of roads, which means that the traffic data relate to different road categories. However, the data presented relate to average traffic, which shows the actual trends in traffic on the road network.

It should also be noted that the Polish accession to the European Union did not result in an increase of the road traffic growth rate, which is confirmed by a 2005 study. In addition, in 2009, a decrease in heavy traffic was observed due to the economic crisis, which also applies to our country [6, 7].

One can observe very different changes to certain categories of vehicles, especially heavy vehicles, which have a material impact on the condition of road surfaces. Between 1990 and 1995, only a 5% increase in traffic of heavy vehicles was observed. A gradual substitution of light goods vehicles with tractor-semi-trailer units was observed, while the heavy vehicle traffic was increasing only slightly, in parallel with the gradual increase in overall weights of freight. In the following years, from 1995 to 2000, the largest increase in the traffic of heavy vehicles with and without trailers was observed, which increased by as much as 44% (with the increase of the total road traffic by 31%). At the same time, over those years, the number of heavy vehicles towing trailers went up by as much as 68% and heavy vehicles without trailers by 17%. Significant changes also occurred in the light goods vehicle traffic, which increased by 43%. However, between 2000 and 2005, the largest increase in traffic involved vehicles towing trailers, amounting to 49%. Also in the years 2005 - 2010, a very large increase in the traffic of vehicles towing trailers was observed, amounting to 43% [4].

It should be noted that the number of vehicles registered in Poland is still on the rise. At the end of 2011, there were about 24 million vehicles registered, including

- passenger cars – 18.125million,
- buses and coaches –0.1 million,
- heavy vehicles and road tractors – 3.131million,
- ballast tractors and agricultural tractors – 1.614million,
- motorcycles – 1.069million.

3. Characteristics of road safety in Poland

The condition of the roads and the large number of vehicles significantly impinge on road safety. The data on road accidents in Poland are illustrated in a synthetic way in Figs. 4 and 5. In recent years, the impact of the condition of the road on traffic safety has been repeatedly discussed. The frequent cause of many accidents is the incorrect behaviour of road users. However, in a number of court judgments it was an inadequate condition of the road that was deemed to be a major cause or prerequisite of a road accident.

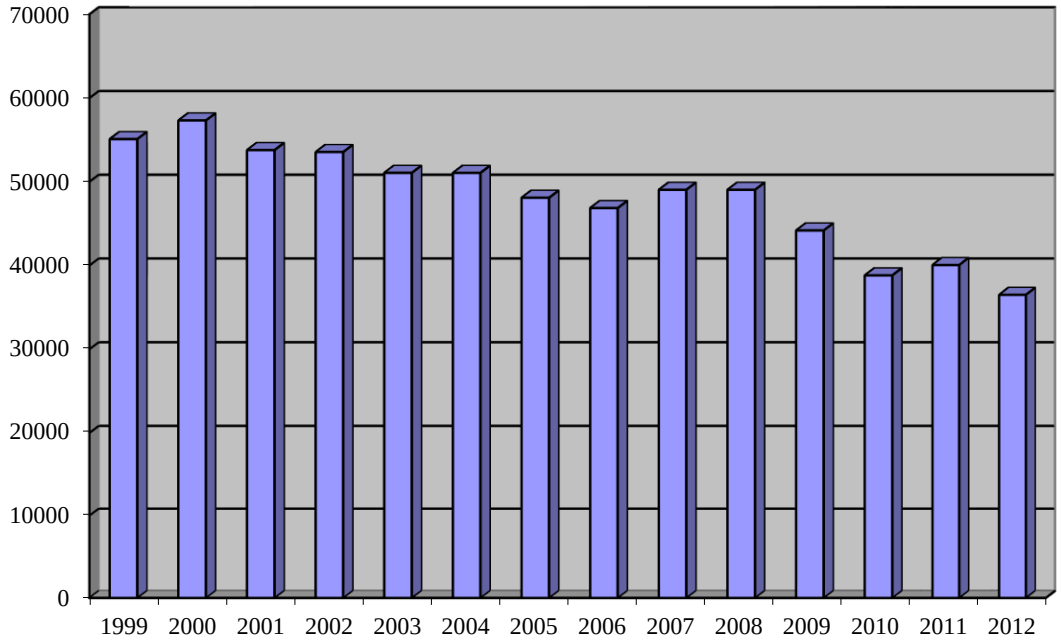

Fig. 4 Number of road accidents in Poland, 1999 - 2012

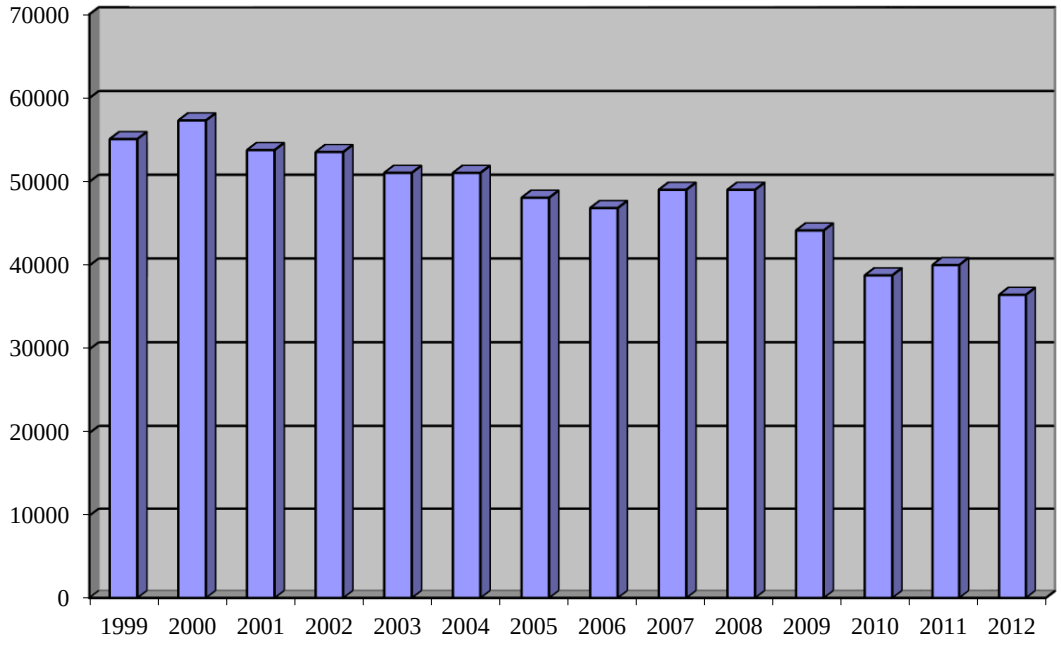

Fig. 5 Number of fatal casualties in road accidents in Poland, 1999 - 2012

It is difficult to assess, in percentage terms, the impact of the road condition on the number of road accidents, but there is no doubt that in a number of cases the condition of the road as the cause of an accident is of vital significance. It can be noted that between 1999 and 2012, as a result of a number of legislative initiatives as well as various awareness-building measures and campaigns, the safety on our roads was successfully improved. The total cost of road accidents in Poland is estimated, depending on the methodology adopted, at PLN 19 to 30 billion per year. There are intensive efforts to maintain the positive trend of improving safety on Polish roads.

4. Weigh-in-Motion Detection of Overloaded Vehicles

According to the report of the General Directorate for National Roads and Motorways on the condition of the national road network at the end of 2011, it is necessary to allocate the amount of over PLN 7 billion to clear the road surface maintenance backlog [8]. The wear and tear of roads is to a great extent attributable to the movement of largely overloaded heavy vehicles with excessive axle loads and total weights. The number of overloaded vehicles detected by the weight-in-motion installed in Pułkowa Street in Warsaw is given in Table 1.

It is necessary to prevent the movement of overloaded vehicles or reduce their numbers. For this purpose, it is necessary to control the weights and axle loads of vehicles in road traffic. These vehicles not only contribute to the destruction of the road surface, but they also represent a serious threat to road safety (e.g. extension of the braking distance in overloaded vehicles). According to the Police and the Road Transport Inspectorate, in the 2009 - 2011 period, there were about 8,000 accidents caused by drivers of heavy vehicles, which killed nearly 600 people and injured more than 10,000 [9].

In order to reduce the wear and tear of the roads and improve road traffic safety, it is necessary to continue the introduction (e.g. initiated by the Road and Bridge Research Institute) of the Weigh-in-Motion pre-selection of overloaded vehicles in Poland, referred to in this paper as "the WIM system". In this system, every

Table 1 Number of overloaded vehicles pre-selected with the static scale installed in Pułkowa Street in Warsaw.

Number of heavy vehicles	One day	One week	One month
with total permissible weight of 40 tons	754	5,123	20,453
exceeding the total permissible weight of 40 tons	236	1,184	4,257
exceeding the permissible axle load of 11.5 tons	167	636	2,352

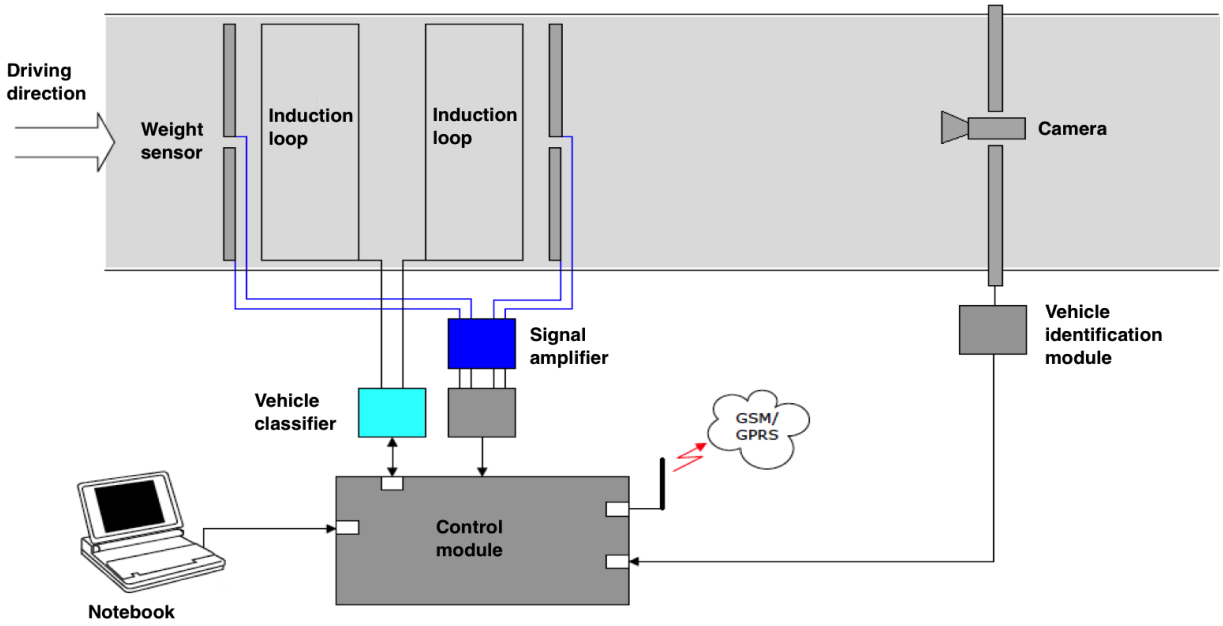

Fig. 6 Diagram of the WIM system.

vehicle traveling along the lane is weighed without having to stop. The WIM system makes it possible to select vehicles in the stream for which there is a reasonable suspicion of overload. Such vehicles are directed to a station equipped with a validated scale and weighed accurately with the use of a static scale. The WIM System allows the measurements of individual axle loads, number of axles and length of vehicle to be made without stopping, which enables the weight and speed of the vehicle to be calculated and the type of vehicle to be identified. The difference between the vehicle weight measured with the use of the WIM system and the one measured with the use of the static scale is at most 3%. In order to allow identification of the vehicle passing over the WIM scale, the system may be equipped with a camera and software to identify the plate number and other characteristics of the vehicle (including its make and colour). The combination of a vehicle's photographic image, plate number, individual axle loads, total weight and speed makes it possible to obtain information on the vehicle and to effectively intercept overloaded vehicles. Fig. 6 shows a diagram of the WIM system.

In order to identify the plate number, make and colour of a vehicle the Intelligent Comprehensive Vehicle Identification System (ISKIP) can be used, developed by the Road and Bridge Research Institute as part of the implementation of a research project. In European countries, the number of the WIM systems in operation varies, e.g. in France it is 120. As part of the implementation process, the Road and Bridge Research Institute has installed and launched 7 weight in-motion pre-selection systems for weighing vehicles on the domestic roads. The installation of weight in-motion pre-selection systems Poland should be carried out gradually and concurrently with monitoring the effectiveness of their application.

The current experience related to the use of the WIM systems shows that there is an additional need to develop an automatic methodology for the detection,

recording and documentation of the offences mentioned above, which will make it possible to increase road users' awareness of the importance of compliance with the regulations concerning the acceptable vehicle weights and axle loads - in a manner similar to the system now in place concerning the detection of speeding offences.

At present, the Road and Bridge Research Institute carries out a research into the development of an autonomous dynamic vehicle weight measurement system which meets the metrological requirements of the International Organization of Legal Metrology concerning the systems permitted for automatic law enforcement (type: WIM-E, *Weigh-in-Motion Enforcement*). Research is now planned involving work on a new multimodal measuring system consisting of three rows of highest-accuracy piezoelectric sensors, an inductive loop system, a stereo vision module for monitoring vehicle motion within the weighing field and a set of sensors for monitoring atmospheric parameters. All such data collected and synchronized will be used to compensate the measurement error.

It is expected that the knowledge obtained will provide capability for the development of a system which meets the metrological and technical requirements for the weigh-in-motion measuring systems in the context of automatic law enforcement defined by the International Organization of Legal Metrology (OIML) and formulated as a set of specifications defining the properties of a measurement system, but which do not indicate the implementation technology [10]. As is the case with other types of measurement of physical properties, the standard designated by the OIML is currently the basic standard recommended in the European Union - it is expected to be approved as such by the relevant bodies responsible for legal metrology in Poland.

5. Summary

International and domestic transport development forecasts are optimistic and the producers of heavy vehicles and their users seek to increase total weights and axle loads.

In Poland, the number of registered vehicles is growing, and at the end of 2011 it amounted to around 24 million. The condition of the roads and the large number of vehicles significantly impinge on safety on the roads. Over the 1999 - 2012 period, as a result of a number of legislative initiatives and various awareness-building measures and campaigns, the safety on our roads was successfully improved. There are intensive efforts to maintain the positive trend of improving safety on Polish roads. Depending on the methodology adopted, the total cost of road accidents in Poland is estimated at PLN 19 to 30 billion per year.

A number of heavy vehicles using the Polish roads are overloaded. The wear and tear of roads is to a great extent attributable to the movement of heavy vehicles with excessive axle loads and total weights. In order to reduce the wear and tear of the roads and improve road traffic safety it is necessary to introduce the Weigh-in-Motion pre-selection of overloaded vehicles in Poland, referred to as "the WIM system". The WIM System makes it possible to measure measurements individual axle loads, number of axles and vehicle length without stopping, which allows the weight and speed of the vehicle to be calculated and the type of vehicle to be determined. In order to identify the plate number, make and colour of a vehicle, the Intelligent Comprehensive Vehicle Identification System (ISKIP) can be used, developed by the Road and Bridge Research Institute under a research project. It should be noted that the installation of pre-selection scales in Poland should be carried out gradually and concurrently with monitoring the effectiveness of their application.

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