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# Vehicles in Motion Parameters Measurement Pre-Selection System

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**Abstract**

Heavy goods vehicles moving on public roads are driven by people belonging to all walks of society, including those, who for the price paid by others are ready to multiply their own profits. This problem is discussed in the article, in particular in terms of overloading car's. There is pointed out on the technical implications of such actions. Later in the paper are presented the basic assumptions of lorries pre-selection weighting, which could be treated as a potential reason to the implementation of time-consuming exact weighting procedure. The discussion of hardware-software solution of pre-selection weighing systems was related to practical applications in national conditions. The article highlighted the problem of dynamic effects, significantly influencing the process of weighting in motion.

## 1. Introduction

Participation in traffic is a present day requirement. Daily contact with traffic is both active and passive. Road transport has become an integral part of our lives. The basis in the literal and figurative sense, is a system of roads, bridges and intersections. We are dependent on road infrastructure while going to work, school, being a courier company customer, or shopping in a store. This determines (of course, sharing the tasks of the technical attributes of your means of transport), if we get on time to the office, school, how quickly we get the expected shipment or if we can find more or less interesting products on store shelves. Quality of life,

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particularly, in major population centers, to a large extent depends on the quality and throughput of the transport system.

The study focuses on the road component of the global transport system in the country, because it is an open system in terms of accessibility for holders of means of transport. The openness of the system inevitably poses the risk of easy violation of formal and legal arrangements. Adjusting with regulations and control activities is not sufficient, as everyone can easily find out, for example, staying near any road in any town in Poland close to the school at the time of the children's arrival at school.

The most important factors affecting global security and comfort of the use of road infrastructure depends on the quality of road surfaces and the participation of various categories of roads in the road infrastructure. In Poland, the share of each category of roads is as follows (Table 1):

Table 1

**The road network in Poland in 2007 broken by categories of roads [7]**

| Total [km] | | | | | | In this [km]: | |
|---|---|---|---|---|---|---|---|
| Public roads hard surface | Per 100 km$^2$ | National | Provincial | Poviat | Municipial | Expressway | Motorway |
| 258 909,7 | 82,8 | 18 521,0 | 28 455,0 | 114 357,0 | 97 576,7 | 329,9 | 662,5 |

Small share of highways, although changing with each passing day, however, remaining at 0.25%, puts Poland in one of the last places in the EU [9]. The share of expressways and motorways in the Polish road network is also low, which cumulative is the reason that road transport is chaotic on the one hand, on the other much more difficult. It is worth noting that the inclusion of another sections of road network with high utility values does not mean an immediate change in human behavior. One example is the fact that the expressway from the border crossing in Cieszyn-Boguszowice is scrupulously sidestepped by the heaviest vehicles taking local roads with low resistance in every aspect because of the implementation of an effective system of toll collection. In the case, mentioned above, formal and legal systems also prove to be ineffective in the context of the separation benefits and costs between active and passive participants of the road system. A question about the source of funding for repair of damaged adjacent buildings simply has no a recipient, although the real beneficiaries of this situation do exist.

## 2. Motivation for Effective Pre-Selection of Overloaded Vehicles Program

Quality of roads in Poland is subject to assessment by the General Directorate for National Roads and Motorways (GDDKiA) through a program of Pavement Condition Assessment System (SOSN). Reports on the activities of the program are periodically published by GDDKiA on websites. The report at the end of 2009 revealed a very disturbing figures – Figure 1. Over 40% of national roads requires a variety of repair activities. Reasons for this state of roads in Poland come from many sources. One of the main reasons for degradation of the roads is overloaded vehicles traffic.

In 1987, the United States of America initiated a research program under the name Long Term Pavement Performance (LTPP). It aims to monitor and create a database containing information about the long-term pavement performance. Message of this action is to, inter alia, to enable proper planning of repairs, or roads construction improvements. An important goal is also to support analysis of the causes of degradation of pavement.

Based on data from the LTPP created a mathematical model allowing to predict the lifetime of pavement. This model shows that pavement exposed to vehicle weight exceeded by 10%, is destroyed to a degree higher by 45% [1] [2] [4], as compared to the nominal.

The electronic tolling system started in Poland, in July 2011 may be an additional factor accelerating degradation of pavement. Many sections of roads covered by this system offer an alternative diversions by lower category roads. Carriers (wanting to "optimize" costs) can and probably in practice, direct their vehicles by diversions, leading to avoiding charges. This can cause significant degradation of the weaker roads, which are an alternative to tolled roads.

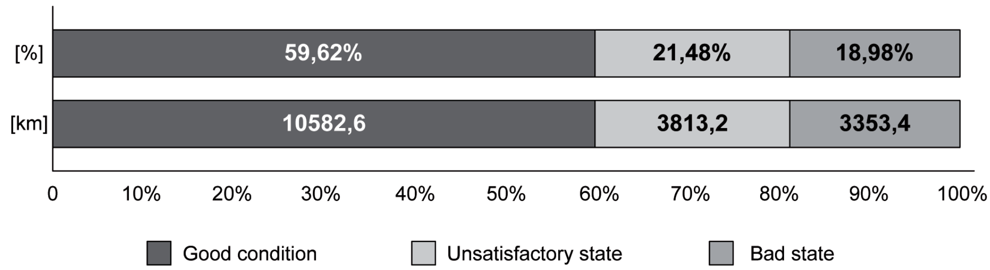


Fig. 1. Assessment of technical conditions the national road network, end of 2009, [6]

An example is the already mentioned provincial road No. 938 from Pawłowice to Cieszyn which allows to bypass part of the national road No. 81[1]. This problem, however, has not only a technical dimension, but also social, and therefore will not be considered in detail in this paper. It is worth mentioning only that application and commercialization of WIM systems can provide local authorities with a right tool to use in order to maintain public order.

Overloaded vehicles can also pose a serious traffic hazard. The increased risk of accidents due to overheating brakes or tires cracking is evident in the case of

[1] http://bielskobiala.gazeta.pl/bielskobiala/1,88025,10599736Tiry_rozjezdzaja_stara_droge katowicka.html – as at November 2011

vehicles exceeding the permissible limits and does not require statistical support. There is no doubt that if the vehicle is overloaded regularly it is exposed to much more rapid wear not only of standard replacement parts, but also the structural parts. Beside the increased wear mentioned above, over the longer term, there could occur other negative events, such as the unpredictable behavior of the overloaded vehicle especially in difficult weather conditions.

To sum up, it can be concluded beyond doubt that all the above factors related directly or indirectly to overloading, lead the conclusion that the vehicle becomes a potential source of danger on road.

## 3. General Characteristic of Weight-In-Motion (WIM) Pre-Selection Methodology

Road Transport Inspection (ITD) is responsible for the immediate elimination of traffic participants and imposing penalties on those carriers whose vehicles exceed allowable load axle or exceed gross vehicle weight. Measurements performed by the ITD are held on specially-prepared sites. Methodology of the ITD is based on the observation of vehicles (usually with binoculars) and decide (on the basis of heuristic[2]) to direct vehicle for further, detailed examination. On the basis of their professional experience or chance inspectors assess whether there are grounds for direct vehicle for further inspection.

The design of large trucks usually does not allow for proper visual assessment of congestion, not to mention the cases in the vicinity of overload, when the weight of the vehicle is a few percent higher than the limit. We should bear in mind that one vehicle control may take several hours. As a result, on a single site during a day only a few vehicles can be inspected. Taking also into account that the number of static weighing places is very limited due to the small number of suitable measurement sites and available personnel, there is a need to develop a system allowing for effective pre-selection[3], in order to continue, a precise assessment and eventual elimination of overloaded vehicles from the traffic stream. In pre-selection the possibility of directing driver whose vehicle doesn't break laws for further inspection should be taken into account. The key task of the WIM system designer is to estimate the probability at which an error can be committed, yet expensive in the specific case of the driver, who must spend a few hours to verify the hypothesis of a breach of the law. The cost of mistakes, though included in the range of activities on the macro scale, of course, eliminate the financial penalty

[2] Heuristics is defined as the ability to detect relationships between facts ... particularly the action of hypotheses formulation.

[3] This term is among others appropriate to the analyzed state of ”preliminary selection”, in which shall be non-zero probability of an incorrect estimation of vehicle mass.

imposed, but on the scale of a single inspection can be a source of unnecessary tension.

## 4. Weight-In-Motion for Pre-Selection – Functional Requirements

Pre-selection weighing system as a set of measurement is intended for use in real life situations. It must, therefore, meet very specific user's requirements. The primary function is to perform measurements of the vehicle mass in motion, in non-invasive manner, and even (in the idealistic case) latent.

The program aims to provide strong technical support for ITD patrols, allowing to increase the efficiency of their daily work while minimizing the level of interference of these patrols in traffic.

The measurement system should provide the effective pre-selection, because the results of measurement must be adequately accurate information for the computing system. Man is and will remain the most important link in the whole system, because they make the final decision. Thus, even if erroneous indications of measuring devices appear ITD inspector is responsible for stopping the vehicle or omission to direct vehicle for further inspection.

Man is able to and usually does so, to correctly convert the fuzzy information. It can be tentatively assumed following producers and sample implementations of the system at the level of accuracy class B (10) (10% deviation for the total mass of the vehicle) is the information at a sufficient level of accuracy, for man to be able to properly evaluate it[4]. With this level of measurement quality multimodal information (indication of a measuring instrument, the image of the vehicle in motion, driving behavior, driving sound of the vehicle, trying to call the potential volatility of the vehicle, distort the course of measurement, etc.), given to the inspector, should be an appropriate basis, much better, than in the past, to make the correct decision.

The main attribute of the WIM is the free drive of vehicles through pre-selection control point. The movement must be carried out smoothly, and the weighing station may not cause disturbances in the motion. Weighed vehicle has to be clearly identified, and if presumed the vehicle exceeding weight limit should be extracted and directed for further, detailed examination. Thus, the WIM system must have facilities for video-recording or even an automatic license plate recognition[5] (ARTR). The system may also have additional equipment that allows for examination of other parameters of the drive (for example, the height of the vehicle), although respect for the unlimited creativity of users for avoiding the traffic laws should be a warning prior to seeking redundant ”security”.

[4] Systems with B(10) accuracy are widely used in Britain for the purpose of pre-selection.

[5] According to the authors of good quality picture is sufficient to uniquely identify the vehicle. (The frequency of mass measurements is not inclined to overly extensive automation of measurement.)

User software for weighing system must eventually guarantee a transparent interface that allows for quick interpretation of the results of weighing. It is therefore necessary that the system weights the vehicle and immediately ranks it on the basis of a predefined table and launches an alarm, indicating that it exceeds axle or gross weight. WIM station measurements have to be made at some distance from the position of the static weight measurement, leaving adequate time for processing, sending information to ITD portable computer and interpret received information's by the user. It is the determinant of the smallest possible distance between the WIM station and control point, at known average speed of vehicles on a given road section.

## 5. Fundamental Technical Requirements for WIM Application

Weight in motion system as an integral part of the road, it is sensitive to any damage of pavement. Inequality, cracks or ruts can cause damage to the sensor or lead to measurement errors. In this case, the condition of major importance is that the sensors are not unduly impaired structure of the pavement, and that interference with the road pavement at installing or replacing them did not take too much time, for example, no more than a few hours. It is important to also pay particular attention to the quality of the pavement in which sensors are mounted (also taking into account the necessity of its reconstruction or replacement).

Most of today's weight-in-motion sensors, creates a measuring system which includes the pavement located before and after installation site. In practice, this raises certain technical consequences. Not without significance is the road topology[6].

Optimum operating conditions of weight-in-motion system are disturbed by all these phenomena, which additionally burden measurement system. Dynamic axis impact force is the resultant of several factors, including (among others):

a) pavement smoothness forming a measuring system,
b) vehicle shock absorbers wear,
c) aerodynamic force (including wind),
d) a change of vehicle direction,
e) braking and acceleration.

For a more detailed analysis of the complexity of the issues on the following list are distinguished several basic groups of factors that have multifarious impact on the final measurement result in the actual conditions of installation of the sensor. Each of the following items can cause serious errors of WIM station measurement:

1. Weight-In-Motion system, sensors with pavement;
2. environmental factors such as weather conditions: temperature, ice, snow, wind;

[6] Parameters in detail that surface must meet are described in the European WIM specification, COST 323.

3. vehicle condition and the quality of cargo clamping (mass transfer between the axles);
4. human factors such as: braking, acceleration, direction changes, slow drive, ride in an appropriate measuring track.

Ad. 1. The measuring system must be located in the right place. In addition to issues of pavement[7] quality, the question of the appropriate road topology remains open and this is usually not subject to easy modification. The best WIM stations location is a straight road section, with a slight decrease in the driving direction. At such sections the driver naturally maintains a constant direction which greatly reduces the vibration of the vehicle. In addition, while a slight decline driver could effortlessly maintain constant vehicle speed.

Ad. 2. Environmental influences on the measurement should be properly estimated. Lateral gust of wind disturbs not only the track a vehicle is driving, but above all the additional aerodynamic force is exerted on the car, which may introduce an error. Ice on pavement, triggering in special situation the ABS system or another, which supports keeping of direction of motion, also can cause anomalies in measurements. The layer of snow or ice on the one hand makes it difficult to keep stability, on the other hand is an additional matter, which participates in the measurement and may thus have the effect of increasing errors. Pavement temperature (in the case of the asphalt roadway) changes the viscosity of the substrate by modifying the response of contained in it sensors to pressure given by passing car. The case shown in Figure 2 illustrates the behavior of oversteering vehicle. Speeds V1 and V2 are the resultant axis speeds. Dashed lines shows how the driver must perform the correction of the track. Fn vector represents the force of wind on the vehicle, the vector Vp indicates the direction of the vehicle.

Ad. 3 Improperly secured cargo, which during the passage over the WIM station will shift may cause inaccurate results. Technical condition of the vehicle may also affect the measurement, any defective components introductory (or improperly eliminate) vertical vibration of the vehicle must also be taken into account.

Ad. 4 Proper passage of the vehicle through measurement track in the case of the WIM is a critical factor. Primary requirement is to keep driving within lane. The vehicle must pass directly over the sensors. The second condition to minimize measurement error is elimination of such maneuvers, which result in the vertical vibration of the vehicle. In particular, it is a braking acceleration or sudden change of direction.

All the factors discussed above cause that in unfavorable conditions during weighting, measurement could be burdened with a large error. However, most of the errors due to specified causes could be effectively reduced by proper location of the WIM system and good pavement quality. The adverse effect of weather conditions or vehicle technical condition, are random and can not be easily reduced.

[7] Experience shows that it is very difficult to convince contracting entities about the importance of surface quality.

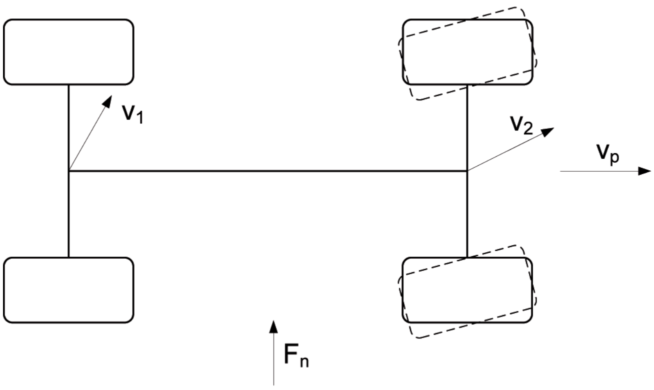


Fig. 2. Effect of gust of wind on a oversteering vehicle

The problems are discussed in detail in the WIM specification of a pan-European coverage, COST 323. It should also be noted that in above considerations, the specificity of the sensors themselves has not been taken into account, described elements relate only to environmental conditions affecting the measurement.

Preliminary analysis of the impact of adverse factors in measuring the weight of the vehicle in motion allows for the supposition that the attempt to formalize the automatic penalize overloaded lorries only on the basis of indications WIM stations in class B + (7) may be ineffective. Weighing of this kind is a good measurement for the initial settlement of binary type, with a sufficient for the class of measurement errors margin. The possibility of disorder result of measuring through factors belonging to the wide (fuzzy classified) distortions spectrum may form the basis to potential penalty remission.

## 6. Proposal of Practical Conception of WIM System

It would be worthwhile to start design of a weight-in-motion system by looking for the appropriate sensor. For the real life construction an inevitable necessity of laborious measurements, thermal sensitivity analysis, parametric stability analysis and final validation in case of independent studies on the physical quantity sensor should be definitely a strong argument for the solution commercially available. According to this logic for WIM system reported below draft construction began on the choice of an appropriate sensor. both the performance criteria as well as economic were taken into account – [10]. The final choice was piezoelectric sensors made of the PVDF (polyvinylidene fluoride) strips[8].

Literature studies in the field of weighing in motion have confirmed the belief that the market trend in Poland expects the operating characteristics of WIM systems

[8] Sensor taken into account is called Roadtrax® BL from MSI.

will be designed in class B + (7), and this accuracy level was taken as a technical requirement.

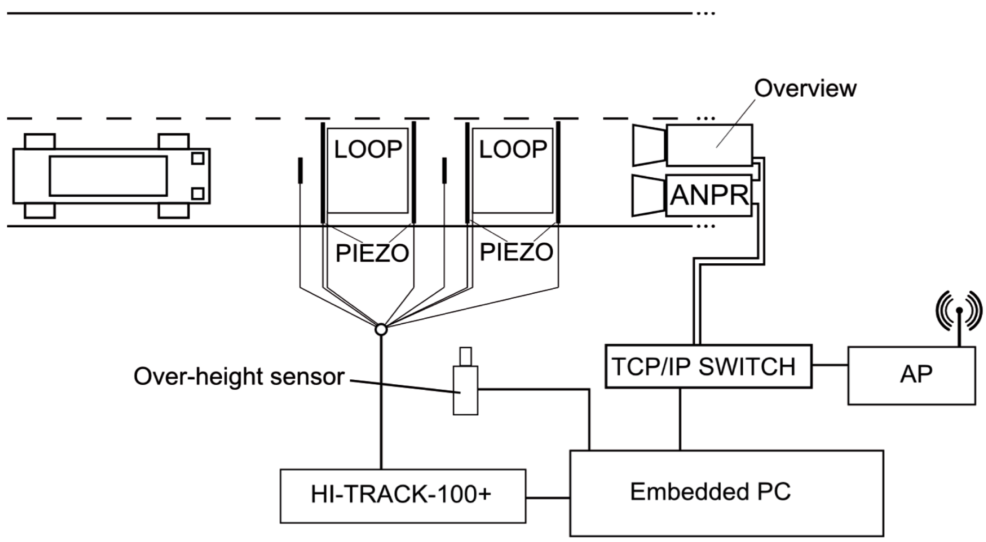


Fig. 3. Example WIM system architecture

To ensure the level of accuracy at the level of 7% of the vehicle gross weight, system uses four piezoelectric sensors with two temperature probes. In addition, induction loops were used, representing a system component, necessary for the proper recognition of selected characteristics of vehicles by magnetic profile. The key to the proper inference in described measurement system layout is data acquisition and processing[9]. Unit proposed in solution is dedicated to piezoelectric sensors and has effective mechanisms for semi-automatic correction of temperature characteristics of these sensors.

The automatic number plate recognition camera (ANPR) and the overview camera are designed to allow the identification of the vehicle passing through weighting area. An additional element of the system is a laser sensor, indicating vehicle overheight.

Example of WIM system architecture is composed of four subsystems – Fig. 3:

1. Road sensors, along with data acquisition and processing system;
2. Automatic number plate recognition camera (ANPR) and/or color overview camera;
3. Vehicle overheight sensor;
4. Embedded PC.

Embedded PC with appropriate software, form a system of data acquisition and processing for the subsystems. Software performs data flow, this is presented in

[9] HI-TRACK® 100+ was selected.

Fig. 4. Data collection takes place in two stages and involves three data buffers. Pairing takes place in the time domain. Knowing the dynamics of traffic and delays associated with specific subsystems, we are likely to determine membership of individual data. The accumulated information is then sent to two recipients.

Current data about overloaded vehicles are sent to the client application on request, a global information about all vehicles, is archived at defined intervals on an external server.

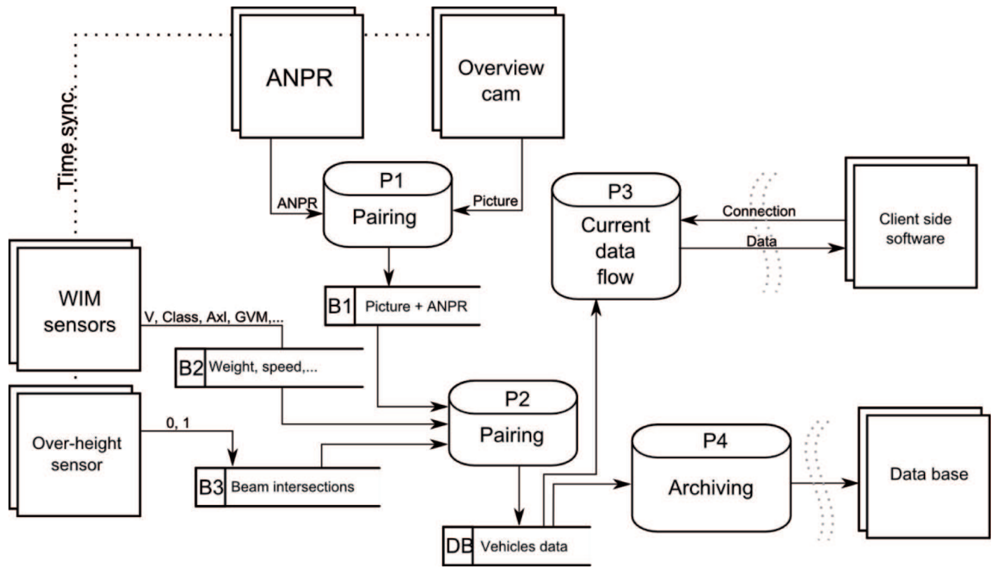


Fig. 4. Data flow diagram

## 7. Analysis of Vehicles Movement Dynamics Impact on Accuracy

System operation requires designation of time intervals and formulas, allowing for pointing out these time intervals in which it is possible to pair individual events. Trivial task from the viewpoint of the observer, becomes a complex technical problem, if one takes into account the considerable differences in the construction of cars, the possibility vehicles to drive one after another, whose drivers extremely violate safe distance between vehicles or similar factors, whose origin is often impossible to determine and the occurrence of such phenomena as artifacts can't be predicted.

Therefore, the designation of the time relations are crucial in determining the presence of a vehicle over sensors array. Technically this is possible, thanks to the fact that each module of WIM system has the ability to transmit timestamp, and

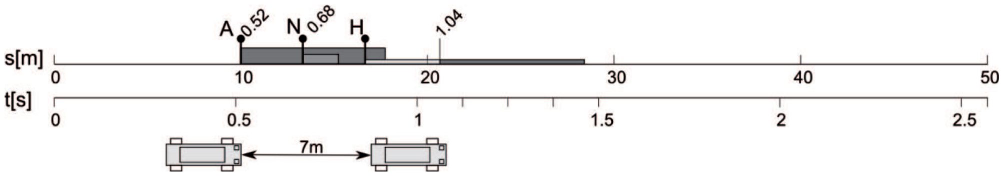


Fig. 5. Vehicle length 4m, speed 70 kph

the task of mutual time synchronization is transferred to the autonomous industrial computer.

Figure 5 shows a timing diagram allowing to determine occurrence of individual events in time. The upper axis shows the distance in meters from a contractual point of "0", the bottom axis shows the elapsed time, when the vehicle speed is $V_p$ = 70 kph, in seconds expressed in relation to the front of the vehicle. Points A, N, H, are contractual points in which data registration of the respective modules occurs:

a) "A"- ANPR (Automatic Number Plate Recognition),
b) "N"- overheight sensor,
c) "H"- weight-in-motion system.

They are located at points distant about $l_A$ = 10m, $l_N$ = 13m and $l_H$ =16m. An example vehicle has length of $l_P$ = 4 meters. Let as assume that the delay of the respective systems is:

a) ANPR $t_{OA}$ = 0,4 s;
b) Overheight sensor $t_{ON}$ = 0,1 s;
c) weight-in-motion system $t_{OH}$ = 0,4 s.

The gray rectangles on the graph illustrate the delays associated with data processing timings. In the case of the weight-in-motion data is processed after the vehicle left the area of sensors. This delay is illustrated by the white rectangle.

Let us assume that the weight detection time designate a point of reference. From the chart, you can read that data from weight-in-motion is last to get. These data contain key information such as vehicle speed $v_p$, and its length $l_P$. Based on these data, we can then calculate the time intervals in which other information about vehicle should appear.

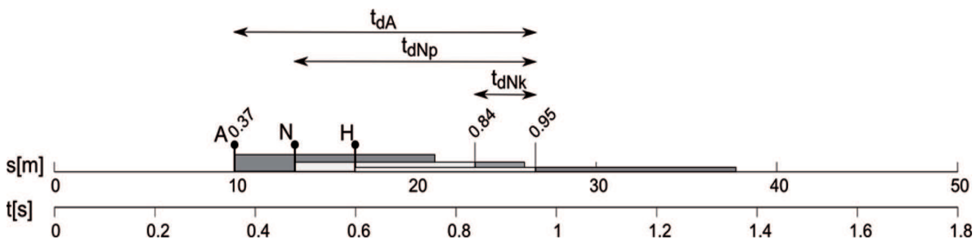


Fig. 6. Vehicle length 10 m, speed 100 kph

Figure 6 presents the timing diagram for a vehicle with a length of 10 meters and a speed of 100 km/h and graphically shows the sense of the importance of formulas (1), (2) and (3). Time $t_{dA}$ determines the difference between weight time stamp and ANPR device time stamp. Times $t_{dNp}$ and $t_{dNk}$ determine range in which you may receive the intersection signal of the laser beam, respectively, designating the possibility of exceeding the height at the beginning or the end of the vehicle. Further calculations according to the algorithm used in the design leads to appropriate aggregation of incoming data.

$$t_{dA} = \frac{(l_H - l_A) + l_P}{v_P} \tag{1}$$

$$t_{dNp} = \frac{(l_H - l_N) + l_P}{v_P} \tag{2}$$

$$t_{dNk} = \frac{l_H - l_N}{v_P} \tag{3}$$

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## 8. Analysis of WIM Measurements Results

Table 2

**Car classification**

| Classification (chosen categories – [3]) | |
|---|---|
| Category | Description |
| 1 | Cars, cars + light trailers or caravans |
| 2 | Two axle rigid lorry |
| 3 | More than 2-axle rigid lorry |
| 4 | Tractor with semi-trailer supported by single or tandem axles |
| 5 | Tractor with semi-trailer supported by tridem axles |
| 6 | Lorry with trailer |

Based on data obtained from the weight-in-motion system described in Section 6 we present an analysis of the vehicle gross weight distribution by categories. The division into classes shown in Table 2. Data covers days 1-9.12.2011.

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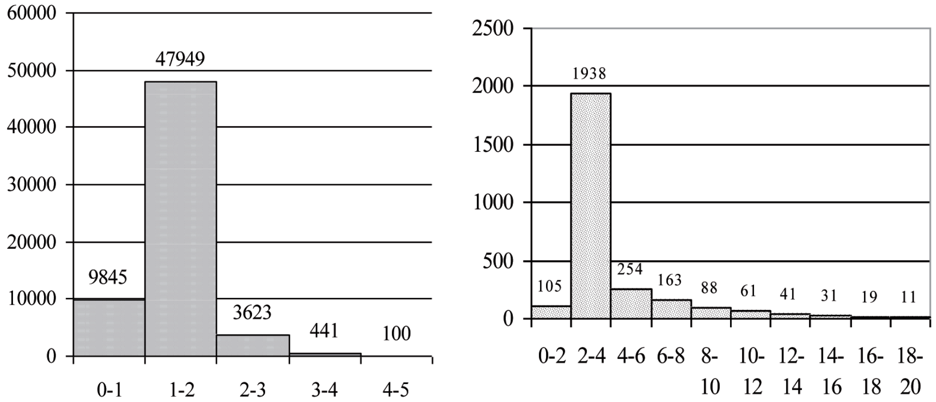
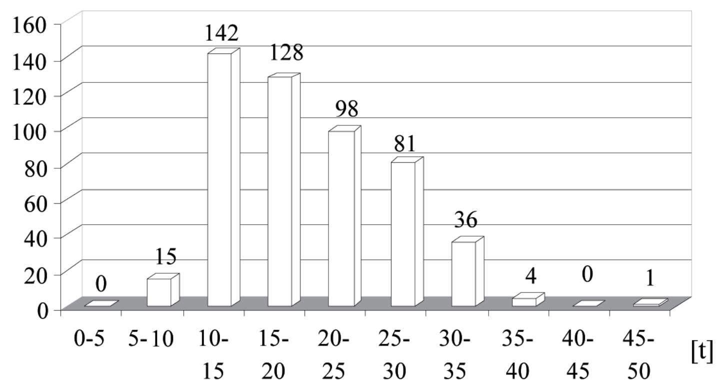
Figures 7, 8a, 8b and 9 present the distribution of data count depending on the current vehicle gross weight, which is measured by the WIM system. Categories of vehicles are tested as in reference [3]. Due to heavy traffic can be assumed that even if we need long-term calibration of the measuring system, the instantaneous data, potentially burdened with constant measurement error is reliable and can be the basis for further inference.




Vehicle count versus gross weights [t]
on left cat. „1” on right cat. „2”

Fig. 7. Histograms of gross weights for vehicles passing through the point of measurement in days 1-9.12.2011 for lower categories




Vehicle count versus gross weights [t]

Fig. 8.a. Histograms of gross weights for vehicles passing through the point of measurement in days 1-9.12.2011 for category ”3”

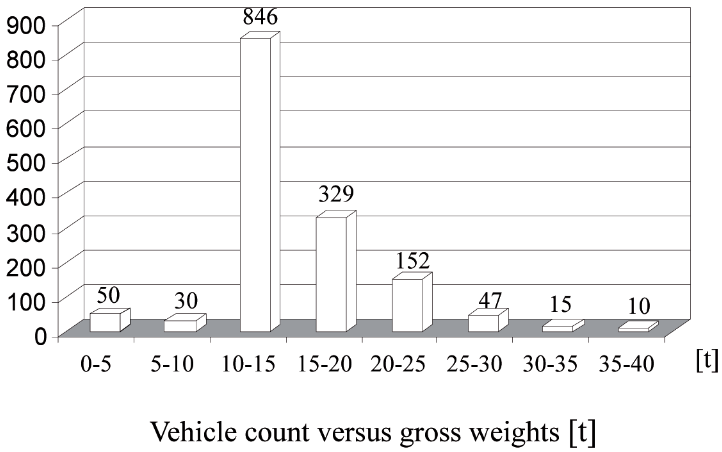



Fig. 8.b. Histograms of gross weights for vehicles passing through the point of measurement in days 1-9.12.2011 for category "4"

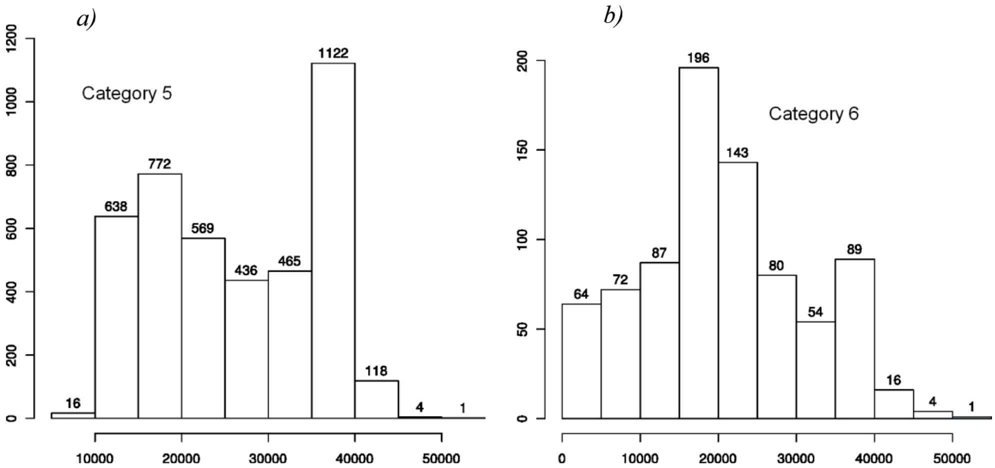



Fig. 9. Histograms of gross weights for vehicles passing through the point of measurement in days 1-9.12.2011 for category a) 5 and b) 6

After data reduction for vehicles with a higher probability of overloading (categories 5 and 6), it appears that vehicles with gross vehicle weight around limit are arranged in a ratio of 10:1. Following analysis presents justification of pre-selection sense, the probabilities are assigned by frequency definition. It should be noted that the multiplicity of vehicles sets in the relevant groups are significant, which authorizes use of mentioned before definition and use it to estimate yield. It is proposed that a measure of the yield was the ratio of the probabilities of random indications and indications of an overloaded vehicle after pre-selection (i.e., after fixing membership to the range in the vicinity of the maximum permissible weight).

Based on the above reasoning the following probabilities are designated:
a) for the unconditional case for category ”5”

$$P5' = \frac{118 + 4 + 1}{16 + 638 + 772 + 569 + 436 + 465 + 1122 + 118 + 4 + 1} = 0.015 \quad (4)$$

b) for the unconditional case for category ”6”

$$P6' = \frac{16 + 4 + 1}{64 + 72 + 87 + 196 + 143 + 80 + 54 + 89 + 16 + 4 + 1} = 0.026 \quad (5)$$

c) if there is initially determined the vehicle weight is close to the weight limit for the category ”5”

$$P5'' = \frac{118 + 4 + 1}{1122 + 118 + 4 + 1} = 0.098 \quad (6)$$

d) if there is initially determined the vehicle weight is close to the weight limit for the category ”6”

$$P6'' = \frac{16 + 4 + 1}{89 + 16 + 4 + 1} = 0.19 \quad (7)$$

If eventually a chance to improve extracted factor of overloaded vehicles we specify as ratio of probabilities:
a) point out the vehicle at random,
b) point out the vehicle in the group of vehicles with a similar weight (both sides) to the limit,
then in particular case examined above it will be appropriate for the category ”5” and for the category ”6”:

$$K5 = P5''/P5' = 6.5 \quad (8)$$

$$K6 = P6''/P6' = 7.3 \quad (9)$$

Numerical result for the analysis clearly indicates the high profitability of pre-selection weight-in-motion system. It is also worth noting that this result was achieved assuming the unknown stability of the weighting system. If as a result of further measurements, in practice it is found that specified in datasheet factors stability (eg. temperature) are consistent with the real life data, then the yield will be even larger because potential measurement error decreases. In addition, we could analyze the axels loads and axels group load. Exceeding the axle loads is much more common. We can analyze the various relationships of probabilities associated with overloaded axels and exceeding gross weight limit. Figure [10] illustrates a axle mass histogram a) the drive axle and b) tridem axle for category ”5” (semi-trailer axles). Exceeding the driving axle load is related to violation of gross weight limit, this could be seen when comparing figures 9a and 10a. There is comparatively the same amount of excess of 11.5 tones for drive axle and 40 tones for gross weight.

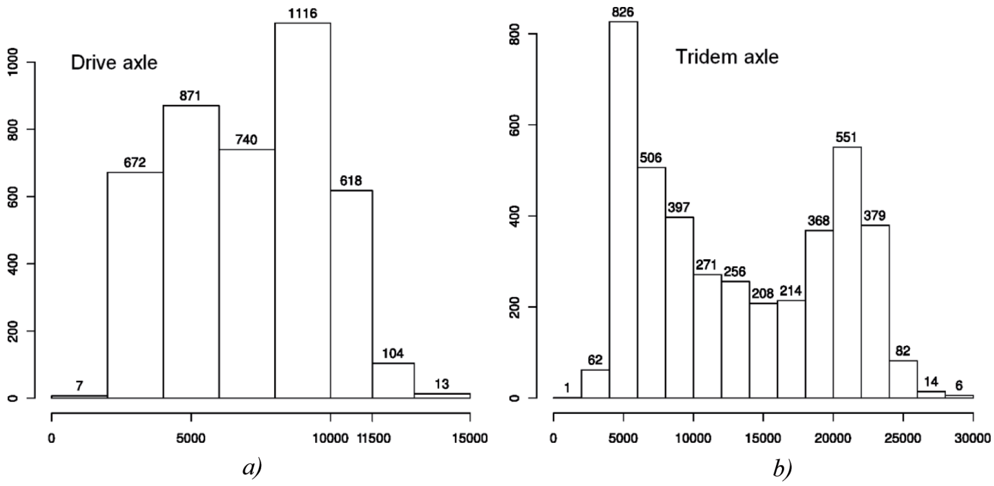



Fig. 10. Axle load histograms for vehicles passing in 1-9.12.2011 for vehicles category "5"

# 9. Summary

Analysis of factors determining the traffic safety by contemporary researchers in the field of transport is carried out in different directions. Examples for this thesis can be found in the review work [9]. Highlighted aspects of the analysis relate in each case to the individual and social actions of human in imposed conditions of artificial and natural environment. This structure can thus be defined as a system with biocybernetic feedback, in which signals from the human, control objects with significant impact on its immediate surroundings. If we divide the factors into three groups, associated with:

a) a man and his psychological and physical condition;
b) the various weather conditions on the road;
c) the technical state of road and vehicle,

then subject division of road safety issues become evident. Of course, in a closed environment individual departments interact with each other, and interactions are a separate field for research.

From the viewpoint of the authors of this study in the summary should be noted about both of these issues that relate to the immediate control of the driving style with the use of electronic medical equipment - [13], as well as discussed in [11] weather conditions undoubtedly affecting traffic safety.

Technical condition of the modern road transport systems equipment, which is the principal point of the work [12], may be in the long term related to issues discussed in this article. Selected aspect of weight-in-motion, focused on a reasonable need for faire sharing of social resources in the form of public roads, is, as shown, only a small slice of a multi-faceted reality. It should be noted that the WIM systems are somehow ideal tool for supporting the activities of the Road Transport

Inspection. Often the introduction of new technologies is not very enthusiastically accepted; reasons for this has very different origins, however, will not be discussed this article.

Currently, we can assume that in Polish reality supporting role may be in practice the only imperative to mount WIM systems. The motivation for investment is the need for effective elimination overloaded vehicles from traffic. To accomplish this task a substantial development of WIM network, which eliminates the possibility of avoiding the weighting points, is needed. Local attitude approach to rules of social coexistence (here in the traffic law) is shown in Figure 9.

In countries with a higher degree of economic development, for example in the United States, uses the information from the WIM[10] systems to:

- design more durable roads,
- planning repairs,
- the creation of systems for pavement performance prediction, etc.

WIM network development in Poland will allow to collect sufficient data to initiate a similar research program. However, it is now to pay close attention to whether the information collected is sufficient to perform given analysis. Perhaps with a little effort we can significantly increase the cost of the scientific value of these data by installing the WIM sensors set along with weather sensors.

Effective elimination of overloaded vehicles will increase traffic safety, reduce damage to roads and reduce this type of competition, which is an apparent reduction in costs by overloading vehicles.

The problems raised in the paper are associated, in many aspects, with manifold matters related to road safety. The problem of overweight vehicles has twofold importance:

a) short-term,
b) long-term.

The interference level of overweight vehicle in motion stems not only from the infringement of high (of catalogue) transport efficiency conditions, but also affects the driver's sense of security. In technical aspect research shows clearly excessive wear of suspension components, which influences the ability to keep the desired drive direction. The analysis of changes in traction parameters should be made the subject of simulation studies in this context, as a result of force distribution constantly drifting from the designed one. A part of the indicators in the motor vehicle has already "gained" adequate attention from the user, including mainly the RPM counter. An average driver knows quite certainly that keeping the engine speed while driving within the "red", or even longer within the "yellow" range, will negatively affect the engine durability. Users have no association in case of overload. Drivers community awareness of the technical subject matter in this regard could serve not only as the field of simulation, but also sociological studies. Transposition

[10] Example is previously mentioned LTPP research program.

of these issues on road safety is evident and the level of this impact should be the subject of research.

Road surface wear in function of vehicles overloading, as well as the above problems, require separate treatment in terms both of technical and sociological meaning. Active scientific community cooperation in this field of research seems to be indispensable, because you do not only have to overcome the technical problems in the scientific context, but also, and perhaps mainly, the problems resulting from the specificity of the social development of our country. Some excessive freedom in interpreting the rules by drivers travelling on Polish roads does not raise much surprise, because most of them come from the Eastern Europe, that is from an area of disturbed perception of the idea of ”common good” which are undoubtedly the public roads.

In scientific and technical terms research leading to assessing impact on traffic safety of damages caused by impaired or uneven road surface or holes are attention worthy. A damage to the wheel due to a hole is not separately classified as a cause of road accidents and the authors point of view is not uncommon. ”Aqua planning” is a phenomenon that probably is not even properly understood by drivers, not to mention its impact on safety. Meanwhile, the car drift on the water film, formed on the deformed road surface, certainly belongs to the experiences of most drivers.

These problems of the scientific research, although of varying importance, have a cumulative significant impact on traffic safety. Their common denominator is also significant interdisciplinarity, involving not only the dynamic and static aspects of the presence of a vehicle on the road with specified structure design, but also research in the social area, often defined together as ”technical culture” and here particularly the ”automobile culture”.

## 10. Conclusion

The problem of overweight vehicles on public roads is evident. Costs arising from this are not adequately shared with benefits, moreover the yield is due to excessive destruction. The above statistics are forcing to take an action. According to the authors an interesting question about in scientific dimension would be attempt to apply fuzzy inference system based on knowledge and experience of experts, performing a routine inspection activities, to direct vehicles to static weighting sites. The intentions of the authors is also a further, thorough analysis of the loads distribution on the vehicles axles, which is crucial in the context of potential importance for designing roads in the future.

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