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TOLL COLLECTION SYSTEMS

Abstract

This paper presents the technologies that are used in toll collection systems. In one of them the electronic toll collection system viaTOLL. Shown viaTOLL system for emission standards.

INTRODUCTION

The development of technology in recent years has caused the spread of modern technologies in various fields. This is what happened in the field of transport. Technologies began to be used for all kinds of solutions related to traffic, including the charges for toll roads [8, 11, 12]. In addition, the European Directive makes it necessary to use at least one of the available technology, or several linked ones together (GPS, mobile phones, DSRC). Currently, there are three basic technologies that are used most frequently: Vehicle Positioning Systems, VPS- Dedicated Short-Range Communications, DSRC, Technology which automatically recognizes number plates – ANPR [1, 5, 10, 3].

Electronic toll collection system viaTOLL - a system in which through the use of modern technologies developed for convenient and often cheaper way to pay mandatory tolls paid. Such a system is quite convenient due to the fact that they do not have to remember to subscribe to the mandatory vignettes on paper. It may be cheaper because they do not pay for a given period (day, month or year), and for every kilometer driven is much, fairer "form of payment, as you pay for the actual distance traveled. This system combines modern technology, the experience of implementing it and the modernization of transport in the country [2].

1. THE TECHNOLOGY USED IN ELECTRONIC TOLL COLLECTION

Modern transport practically unable to function without telematics. Many elements of the transport interacts with each other by fitting both the infrastructure and transport equipment itself in all kinds of sensors, sensors.

1.1. VPS- Dedicated Short-Range Communications

VPS vehicle positioning system is a system operating on the basis of two technologies, GSM / GPRS modem or mobile telecommunications networks and GNSS satellite (Fig.1). It is inexpensive to put into action since it does not require the construction of a complex network infrastructure.

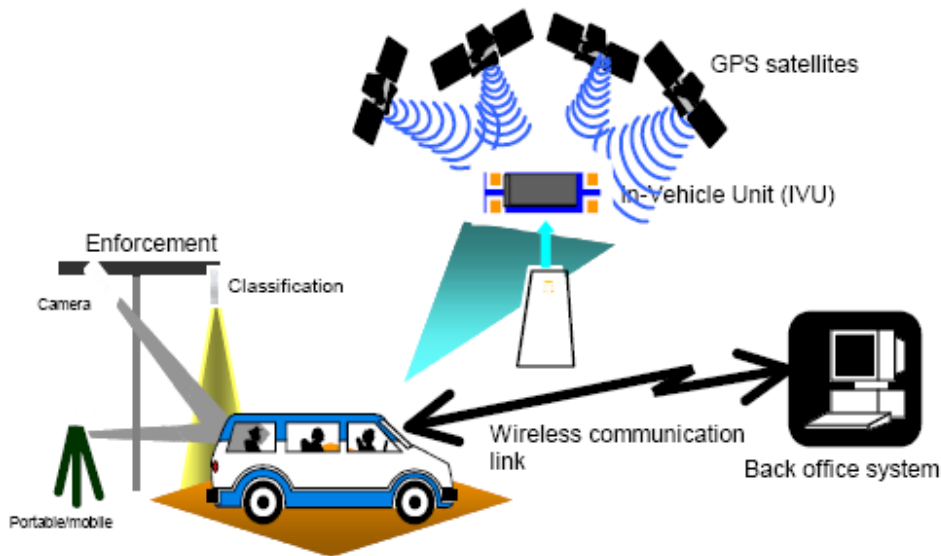


Fig. 1. Principles of VPS EFC

Source: [4]

The system consists of several devices including a device fitted in the vehicle. The equipment used in this system is complex and expensive due to the fact that it calculates the amount of the fee, and therefore must have a high power conversion etc. The OBE provides information about the location and distance between a given vehicle system in GPS technology. And with GPRS vehicle the data is sent to the central system. The lack of complicated and expensive infrastructure makes it possible to extend in a short time the new toll roads by new sections or the roads of other categories. However, in spite of not having to invest in such new gantries the development of this system carries a huge cost in terms of the same service. This is due to the fact that GPRS data transmission, service of users, accounting fees etc. are expensive and generate relatively high costs. The disadvantage of this solution is the fact that it causes high costs associated with updates such as tariffs and road network, which information must be sent to the onboard devices, but also the costs associated with maintaining the station in the vicinity of the road. Such a system is not used for passenger cars due to the high costs of operating, data transmission and purchase of the on-board equipment.

1.2. DSRC technology

An important element in terms of the management and control of transport is a possibility of precise location of the vehicle. This is possible thanks to DSRC, i.e. dedicated short-range communication. Currently this technology is used to determine the location of units, control units, to improve transport safety, car navigation and toll collection.

The implementation and subsequent use of DSRC technology for the use of charging the road fees enforces the need to build infrastructure from which it operates accurately and correctly. At some sections of toll roads there are built gantries; the vehicle passes under the structure and at this moment the charge is taken. This is done thanks to the vehicle on-board equipment and satellite antennas mounted on the gantries.

Importantly, this solution does not generate high maintenance costs but only the high cost of the deployment and a possibility to expand the system. An important aspect of showing the benefits of using this system is the fact that these devices also have a full control function. The device itself mounted in the vehicle is much easier, and therefore cheaper to produce. It does not require the constant current source which is important in motor vehicles. It provides a smooth movement of vehicles as it is typically an electronic system, so one does not need to

stop at the point and pay the fee. All these advantages show that the system is more friendly to the user.

From the point of view of an entity that receives revenues from fees paid by road users this system also brings many advantages. In theory, there is little margin for error when charging tariffs change, and any change is in the control system and does not need to be sent to each device. Also, when the toll road network is complete that further investment will be needed then there is a possibility for a relatively cheap expansion of users by introducing a system, e.g. in passenger cars or motorcycles.

1.3. ANPR technology

ANPR technology (Automatic Number Plate Recognition) is the automatic recognition of number plates. It is a modern technology based on the application of specialized cameras and software which allows to take photos and to identify the vehicle and its plate number. Thanks to the implementation of such a systems it is possible to record and identify the vehicles on the road. Also the control of vehicles that drive along the toll roads is becoming easier and more efficient.

2. VIATOLL SYSTEMS

Electronic toll collection system - a system in which through the use of modern technologies there was developed a possibility for convenient and often cheaper way to pay mandatory tolls. Such a system is quite convenient due to the fact that one does not have to remember to subscribe (as it was in the case before the introduction of Polish viaTOLL) mandatory vignettes on the paper. It may be cheaper because drivers do not pay for a given period (day, month or year), but for the mileage, which is much fairer 'form of payment' as they pay for the actual travelled distance. This system combines modern technology, the experience of implementing it and the modernization of transport in the country.

The first attempts to introduce road pricing in Poland were in the eighties of the last century. The idea was to introduce a voluntary toll in the form of vignettes. Potential drivers who had to pay such charges stuck on the windscreen the proof of payment of the tax. However, due to the fact that the charges were voluntary the system had never come into widespread use.

On 2000 people started to use compulsory vignette system. The obligation to pay a fee was only for heavy vehicles such as trucks with a maximum total weight (GVW) of more than twelve tones and the buses. DMC is the sum of the vehicle plus trailer / semi-trailer. It involved buying a card (vignette) which was also the proof of payment. The rates were estimated and dependent on the permissible gross vehicle weight, "EURO" fumes emission standards and the length of validity of the card. It was possible to purchase it for a period of one day, followed by seven days, one month and one year.

On July, 2011 in Poland it began to operate a new toll collection system "viaTOLL". It is a modern system with which it is possible to pay the tolls for the paid sections of national roads in an electronic form, which replaces the previous vignette (obligatory from August 2, 1997 for vehicles registered outside the Republic of Poland and since 2002 for vehicles registered in the country). ViaTOLL system has been developed by the company Kapsch but it is managed by GDDKiA (General Directorate of the State Roads and Motorways).

In order to use the system one needs to register the vehicle in the system. This can be done in one of more than 180 points of distribution (PDs) (mainly petrol stations) or Customer Service Points- CSPs - there are about 16 of them. In the system there is an obligation to register the following vehicles: trucks, tractor-trailer, trailer, passenger vehicles > 3.5t GVW , coaches / buses .

The cost of driving 1 km toll road is conditional upon:

- fumes emission (depending on the carrying out standard 2 Euro, 3 Euro 4, 5 Euro)
 - class and type of roads A and S -class and G and GP class roads
 - mass of the motor vehicle (truck):
 - of $> 3.5 \text{ t GVW} < 12 \text{ t GVW}$
 - $> 12 \text{ t GVW}$
 - buses regardless of the maximum permissible weight.
- GVW of the vehicle concerns the truck vehicle or passenger car / truck plus trailer

2.1. ViaTOLL - how it operates

The principle of operation of charging system in theory is simple, but in practice the whole system is based on DSRC technology. Fees for the distance travelled on a toll road are charged while the vehicle equipped with on-board device passes for a specified waypoint. At the same time the vehicle must be equipped with on-board equipment, which in the case of operating systems on Polish territory is viaBOX . It is a small electronic device installed in a vehicle that is subjected to a fee (Fig. 2).



Fig. 2. The device viaBOX

Source: [6]

In this device the battery is mounted which allows for simple use and does not require additional power source or interference with the vehicle electrical system. Each viaBOX is assigned to a specific vehicle and therefore it contains the information about that particular car. The only downside is the need to mount the device on the windscreen of the vehicle, in the center but in a way that does not interfere and does not restrict visibility. It is one of several components of the system that allows it to operate effectively.

Another equally important part of this system are the gantries, the elements permanently attached to the ground above the road on which there are mounted antennas which are responsible for collecting data from viaBOX or they charge a fee for certain section of the road and then transfer this information to the toll center (Fig. 3).



Fig. 3. Lifting frames viaTOLL

Source:[6]

There is also another kind of gantries mounted on the roads which only serve to control the vehicle passing underneath. This part of the system checks whether the toll collection process is carried out in a proper way.

Nowadays, any service, product or supply of a different kind is paid, so the same it is in the case of the toll road. Because of that this generates additional costs for the service provider in the form of inspection, in this case the inspection of carriers. In the viaTOLL system the control of vehicles on toll roads concerns the payment of fees in accordance with the tariffs. The authority controlling the carriers, and in fact the specific drivers and vehicles is GRTI (The Main Road Transport Inspectorate). This body was equipped by KAPSCH in specialized vehicles which are fitted with modern equipment allowing for accurate, precise, rapid and effective control of the vehicle.

Another tool to facilitate the work of the ITD are gantries. It works on a principle similar to the same payment of fees, i.e. the vehicle passes through the control point or gantries and when it should but does not have a viaBOX device or it ran out of funds in the account, the device is not working properly and the photo of the front and rear of the vehicle is taken. This information is automatically transferred to the next mobile units of ITD. Inspectors who received information about this vehicle perform the inspection and they are eligible for imposing appropriate financial penalties appropriate to the offense. The diagram of the system is shown in Fig. 4.

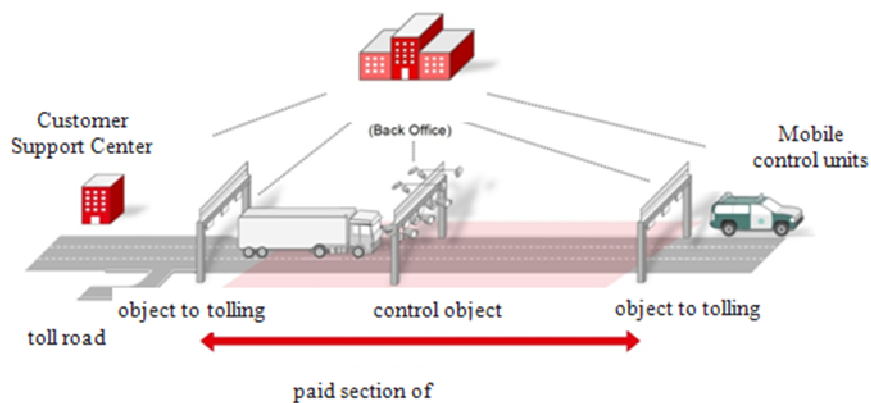


Fig. 4. Diagram of the system viaTOLL
Source: [7]

The control of the users and the system is a difficult task that requires the use of specialized equipment and highly qualified and experienced staff.

2.2. ViaTOLL system and exhaust emission standards

Almost 2,000 km of roads are charged, about 900,000 purchased viaToll devices and revenues of about 890 million is the number which the viaToll system can boast about within only 13 months from the date of its implementation in the Polish road system. It is a very good result due to the fact that it was observed an increase in the number of vehicles that meet the higher and higher emission standards, i.e. the norms of Euro 4 and Euro 6. It means for our country a significant improvement in the destruction of the environment due to the heavy transport. In Figure 5 shows the percentage of each category of vehicles registered in the EURO.

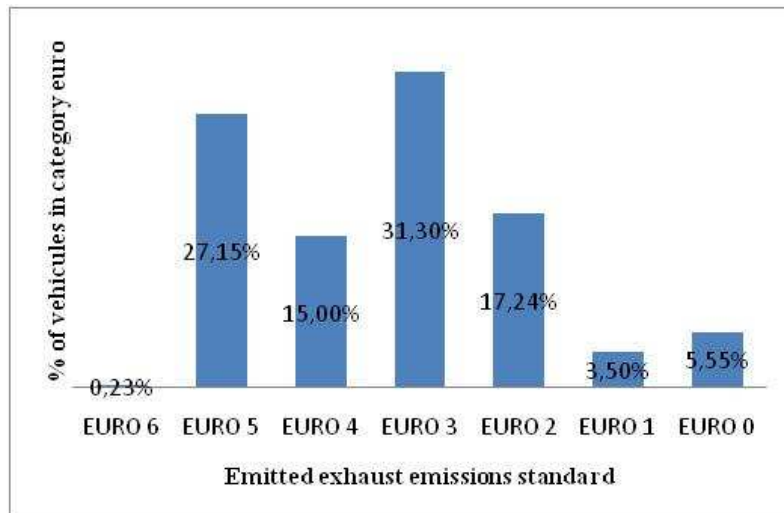


Fig. 5. Percentage of vehicles in terms of categories EURO (August 2012)
 Źródło: [9]

As shown in Figure 5 on the Polish roads the vehicles registered in viaTOLL are mainly cars complying with EURO 3 (more than 30 % of vehicles) and Euro 5 (almost 27% of all vehicles). Vehicles of the lowest category EURO 0 occupied before the last place (over 5%) just before the vehicles category EURO 1 (3.5%). This is a good result and it is a positive aspect that on our roads are not only the vehicles that generate fewer harmful emissions but modern vehicles. Unfortunately the vehicles of Euro 6 stand for only 0.23 % of all the vehicles, but this is due to the fact that this standard will be obligatory for the vehicle manufacturers in 2014 due to the stringent conditions and because the last change or the introduction of Euro 5 was held in 2011. Figure 6 shows the percentage increase in the number of vehicles of a particular category of EURO .

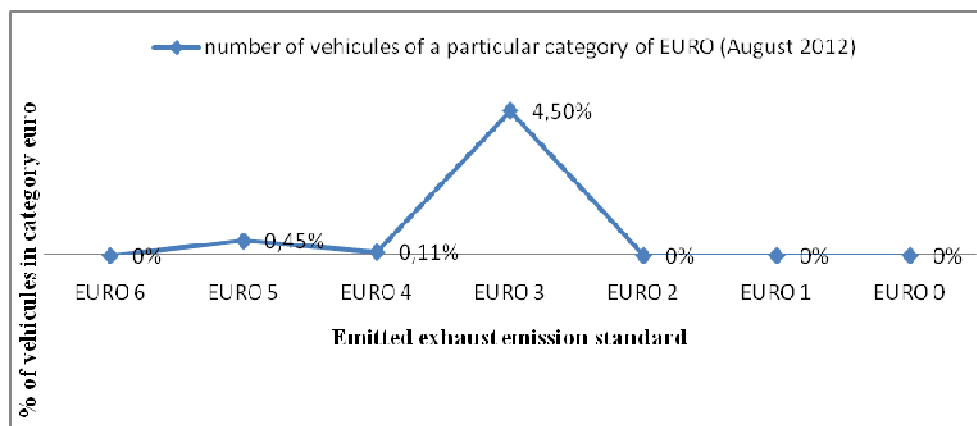


Fig. 6. Percentage of vehicles in terms of categories EURO (August 2012)
 Sources: [9]

Figure 6 shows that carriers using toll roads began to invest in more and more modern fleet. The fact that there has been no increase in the number of vehicles of EURO standards 2.1 and 0 does not show that the import of the second-hand vehicles older than 12 years virtually disappeared, these are only suppositions but such a statement is justified by the fact that the Euro 3 standard which saw the largest increase in the last 13 months was introduced in 2000. Figure 7 shows a decrease in the number of vehicles of a particular EURO category for all the vehicles registered in viaTOLL expressed as a percentage.

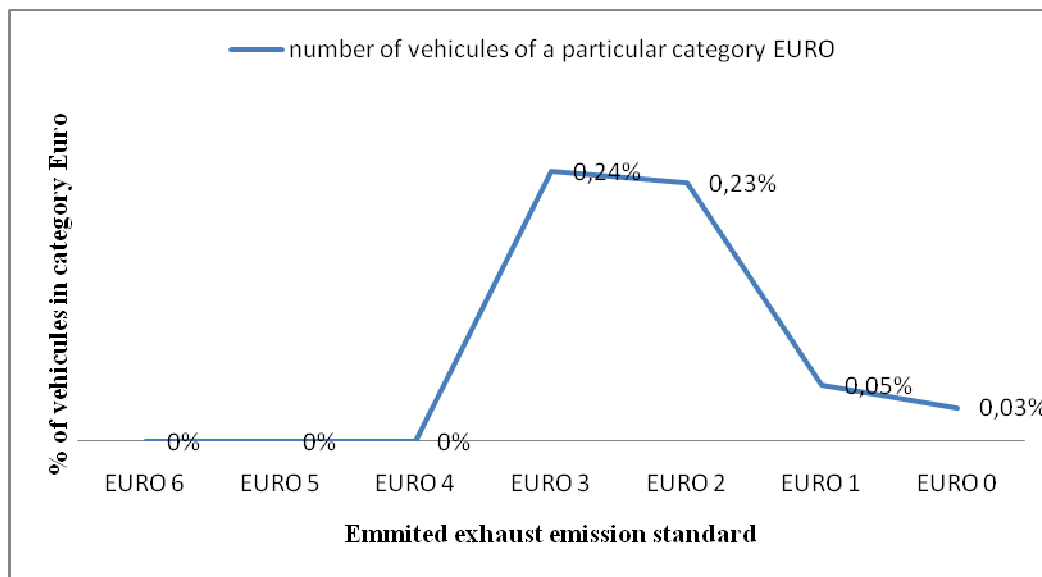


Fig. 7. Percentage of vehicles in terms of categories EURO (August 2012)
Source; [9]

Figure 7 illustrating the percentage decrease in the number of vehicles registered in viaTOLL shows that older vehicles of Euro 0.1 and 2 are slowly being phased out of use. Also, in spite of an increase in the number of registrants vehicles of Euro 3 (Fig. 6) also these vehicles are removed, as it can be assumed that sold and replaced with newer vehicles, which of course gives the same benefits.

While analyzing the statistical data it can be seen an interesting increasing trend in the number of registrants in the vehicles registered in Germany which is nearly 8 % of all new users. And the lowest number is in Latvia of just over 1% of all users. Vehicles with a maximum authorized mass exceeding 12 tones and assemblies of such vehicles have the highest number of users, while the smallest group of the registered vehicles are vehicles with a GVW less than 12t and a total GVW of a trailer or semi-trailer over 12t.

SUMMARY

The introduction of the system into our country was a good solution. Undoubtedly, it is a modern system that brings many advantages, but also disadvantages. This system is an opportunity to improve the safety and quality of service and modernization of transport.

The implementation of the system prevents to a large extent from avoiding charges for road sections covered by the toll thanks to cooperation with the Road Transport Inspection, as opposed to how it used to be in the vignette system. These vignettes, superseded by the use of the viaTOLL system were outdated and cumbersome to transport. The downside of viaTOLL system for carriers is that if you have a large fleet of vehicles the costs associated with driving the roads covered by the system are often several times larger than it used to be like in the case vignette.

A good and “fair” solution is the introduction of the obligation to pay the toll for all vehicles exceeding 3.5 tones GVW. As it results from the analysis of selected transport companies, in the case of large companies whose vehicles move on roads with high frequency this system results in higher costs. However, with the money earned for the fees, in the future there is a real opportunity for the development of infrastructure, improving road safety and quality, and thus improving the quality of transport services. Higher costs for older vehicles may cause the purchase of more and more modern fleet, and thus also improve the safety, environmental protection etc.

This system contributes to some extent to improve the ecology and safety on Polish roads. This is due to the fact that modern vehicles meet the stringent exhaust emission Euro standards and the vehicles are modern and greener. The higher Euro standard, the lower is the cost of the toll on the toll road sections.

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SYSTEMY POBORU OPŁAT

Streszczenie

W artykule przedstawiono technologie, jakie są stosowane w systemach poboru opłat drogowych. Zaprezentowano sposób działania elektronicznego systemu poboru opłat viaTOLL. Pokazano system viaTOLL w odniesieniu do norm emisji spalin.

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