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COMPARATIVE ANALYSIS OF THE MACEDONIAN ROAD TOLLING SYSTEM WITH EU TRENDS[1]

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Abstract

Road tolling through the history was progressing from the manual to various forms of electronic payment. The development of electronic-payment technology is very dynamic in the recent years, with a rapid implementation of various technologies. Thus, a large number of different, mostly electronic tolling systems, are currently in use in Europe. The aim of this work is to analyze toll system in Macedonia in comparison with the EU trends. The analysis of the current toll system in Macedonia is from a financial, traffic, environmental, and socio-economic aspects. Evaluation of the existing toll system in Macedonia is conducted using SWOT method. In addition, the paper analyzes existing tolling systems in Europe, development trends, as well as EU regulations and directives on road tolling. Consequently, short-term and long-term policy recommendations for Macedonian road tolling system are provided.

Keywords–toll; pricing; ETC; SWOT; transport policy

INTRODUCTION

Among general audience as well as among experts there is discussion about existing toll collection systems and the need for improvements. This need for improvements often goes to extreme of suggesting a complete change of road tolls system. All this discussion often involves more or less

[1] Professional paper

subjective views and preferences, without distinguishing the basic types of road tolling technologies, and their traffic, technical, economic, financial, and environmental characteristics. Moreover, the discussion often does not include the trends in this field, and neglects the European common policy on road pricing.

The paper will present an overview of the existing toll collection systems in Europe, including existing technologies and development trends, as well as the EU regulations and directives related to road pricing. In addition, the paper will give an overview analysis of road tolling system in Macedonia. The paper concludes with basic recommendations for addressing negative phenomena in the current Macedonian toll system.

DEVELOPMENT OF TOLL TECHNOLOGIES AND EXISTING TOLL SYSTEMS IN EUROPE

Through the history tolling was moving from the manual to various forms of electronic technologies. The development of the electronic toll collection technology is very dynamic in recent years. This technological development has contributed to a more rapid implementation of a range of toll collection technologies. Figure 1 shows in detail the progress in the toll technology development. The following section describes chronologically toll collection technologies.

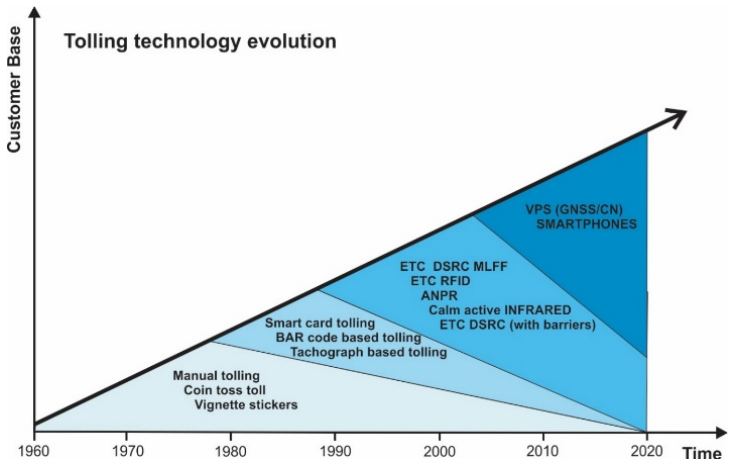

Fig. 1.Development of the toll collection by technology. (Source: author)

- **Manual road toll** relies on cash payment for motorway usage which is conducted manually by tolling staff. Since paying takes significant time, queuing is usual for this tolling type. This results in high Opex, as well as low toll both capacity, thus resulting in a low LOS [1].
- **Automated coin machine (ACM)** is a machine with a slot for inserting coins or paper money. This technology has better service time when compared to the manual road toll collection, consequently resulting in lower delays [1].
- **The vignette** is the sticker by whose purchase and sticking to a windshield a toll is paid for a certain period of time. This duration can vary, including 7, 10, 30, or 365 days [2]. The vignette is suitable for every day users, but occasional users are facing unfair pricing. In addition, frequent buying of sticker can lead to a decreased sight through the windshield, having both esthetic and safety consequences.
- **ETC DSRC with barriers** is a contactless toll technology, not requiring the vehicle's stopping. However, the vehicle is required to decrease the speed to 10-40 km/h in order to establish communication and identify the on-board unit (OBU) when passing through tollbooth [3]. Consequently, users have higher LOS compared to the manual, ACM, or smartcard technology. This system has no enforcement costs.
- In the **ETC DSRC MLFF** system, antennas are placed on gentries above the motorway. MLFF system is designed in such a way that vehicles maintain their speed and can change lanes (including the emergency lane) when passing under the toll portal. Toll paying is contactless, not requiring the driver to take any action besides driving [1][3]. As a result, drivers have high LOS, and practically do not notice tolling operation. However, this system has significant enforcement costs.
- **ETC BAR CODE** based toll technology is a subcategory of ETC. The barcode label is fixed to the windscreen of the vehicle and it is read by laser scanner on gentry when the vehicles pass through the toll gate or by hend reader device if tolgate is with barriers. It is the simplest and oldest technology but very unreliable [1][4]. Drivers have low LOS.

- **ETC radio frequency identification (RFID)**toll technology contains RFID sticker installed on the vehicle's windscreen. The communication is established through the RFID reader frequency at the toll stations. ETC RFID can be prepaid or postpaid, with a ramp or without. Technology is similar to ETC DSRC, but OBU is cheaper and can be in form of RFID sticker [5].
- **Vehicle Positioning System (VPS, GNSS/CN)** toll technology bases on the global satellite navigation system, combined with a GSM/3G/4G communications. The Global Positioning System (GPS/Galileo/GLONASS) installed in the OBU device stores the coordinates of the vehicle and sends transaction information to the relevant toll center over GSM/3G/4G network [6][7]. This technology has high LOS, many other benefits regardless tolling, but simultaneously high Opex-operational expenditure and Capex-capital expenditure.
- **Automatic Number Plate Recognition (ANPR)** toll technology uses a stationary camera to record license plates of vehicles passing through the toll gate. Identified license plates are recognized in the database, and toll is charged automatically or by paper billing [5][8].This technology is unreliable in bad weather conditions. ANPR technology is not widely spread due to a difficulties in charging foreign vehicles which one are not in country's database.
- **Calm active infrared** toll technology is similar to RFID and ETC DSRC toll technology. The only difference is that it has an active infrared OBU installed in the vehicle, which contains all the needed information for charging [9][10][11].
- **Tachograph toll** technology records the mileage of motorway users via the OBU device that is connected to the vehicles odometer [1][3]. Tachograph toll is mainly used in trucks. Correct pricing can be questionable, since Tachograph measures all millage not only millage spent on motorways.
- **Smart card** toll technology represents the memory card in which are stored data about a particular person and vehicle, as well as a certain amount of money. Smart card can be with physical contact or contactless [12]. Drivers' LOS is low since they need to stop to conduct toll transaction.
- **Smartphones** toll technology is still in its initial stage. Example of ETC integration of mobile phones and smartphones is M-toll project and GEO toll project [1][3].

EXISTING TOLL TECHNOLOGIES IN EUROPE

Current European toll systems, i.e. toll technologies, could be explained by the term "toll chaos". This does not just refer to tolling between countries but also within one country. The term chaos could be used also for pricing and tariff policy. In certain countries, the road pricing issues are even more complex because toll for passenger and commercial vehicles are totally different systems. For example, Austria and Slovenia have a vignette system for passenger vehicles, while for trucks, they used ETC system. Next figure shows toll systems in Europe for toll category I, including road tolling for passenger vehicles. This figure shows the variety of toll systems across Europe. Yellow colourindicates the countries that apply the toll per kilometre using different ETC technologies, mostly DSRC or VPS. Countries that have the country symbol shown in the white box have a special toll for some infrastructure facilities, such as tunnels or bridges. Countries depicted in the blue colour apply only special road tax for particular infrastructure. Countries that are marked green apply time-dependent toll by using stickers or vignettes. Finally, countries marked in gray do not have tolling for passenger vehicles.

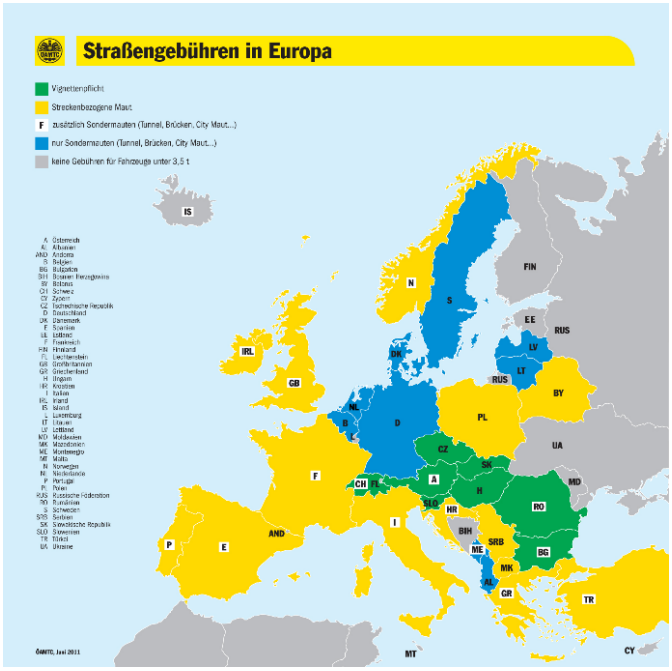

Fig.2.Status of toll collection technology by European countries for the I toll category (Source: ASFINAG)

FUTURE OF TOLL COLLECTION IN EUROPE

The EU is aiming to introduce order in road tolling, both in terms of tolling technology and charging systems. The actions are primarily focusing on policies and directives. The main EU objective is interoperability, which aims to achieve a single toll market policy, through the following policy: **one OBU, one contract for all Europe** [13]. Other objectives relate to the prices and vehicle categories, congestion charging, and environmental charging.
The two main directives of the EU road pricing policy are:

- **Directive 2004/52/EC.** This directive prescribes the conditions necessary to ensure the interoperability of electronic road toll systems in the EU. Recommendations apply to the electronic collection of all types of road fees, on the entire road network, urban and intercity, motorways, and various infrastructure and road facilities such as tunnels, bridges, and even ferries.
- **Commission Decision 2009/750/EC.** This decision provides a description of the technical systems and interfaces necessary for European Electronic Toll Service (EETS).

Next picture illustrates EU policy toward tolling defined as one OBU one contract for all of Europe.

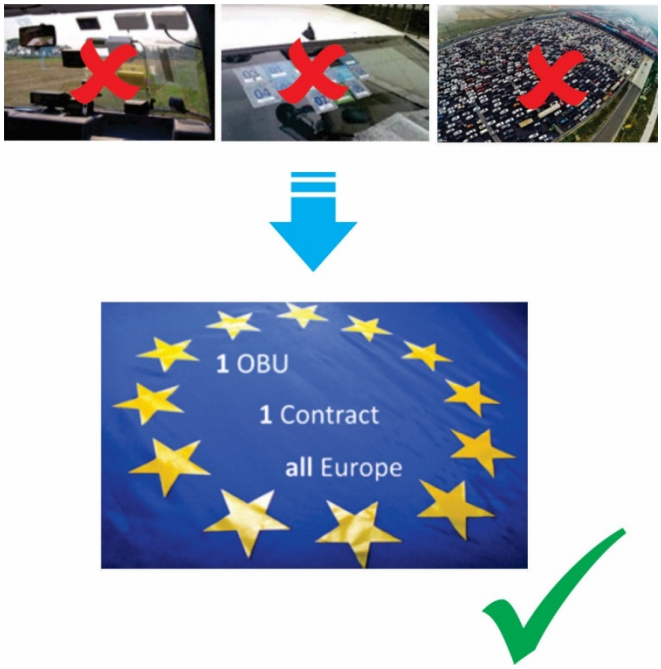

Fig. 3.EU policy for development of EETS (Source: author drawing)

ANALYSIS OF EXISTING TOLL IN MACEDONIA

The procedure for determination of the fee for usage of the motorway sections (motorway toll) for vehicles with foreign and domestic license plate is established with the Decision on toll payment amounts and methods, published in the Official Gazette of the Republic of Macedonia No. 103/14 of 10.07.2014. Toll collection for motorway usage in the Republic of Macedonia bases on manual toll booths with barriers in open system. Toll for motorway use in the Republic of Macedonia is paid manually at the toll stations, in cash or by bank cards. The following figure exemplifies one toll station from Macedonia.

Fig.4. Example of toll plaza in Macedonia
(Source: various internet addresses)

Toll plaza	Road: section
"Romanovce"	A-1: Kumanovo-Mil.
"Sopot"	A-1: Perovec-Veles
"Otovica"	A-1: Veles-Petrovec
"Stobi"	A-1: Veles-Gradsko
"Petrovec"	A-4: Skopje-Petrovec
"Miladinovci"	A-2: Skopje-Milad.
"Glumovo"	A-2: Skopje-Grupcin
"Zelino"	A-2: Grupcin-Tetovo
"Tetovo"	A-2: Tetovo-Gostivar
"Gostivar"	A-2: Tetovo-Gostivar

Toll plazas on the Macedonia Road network

Fig. 5. Toll plazas in Macedonia (Source: http://www.roads.org.mk/en)

Road tolling system in Macedonia is organized as an open toll collection system, consisting of 10 toll plazas total. The tolling system is often facing congestion. For example, one trip of 50km require 3 or 4 stopping at toll plazas and waiting in queue to pay tolls.

Fig.6. Toll operation conditions in Macedonia

Evaluation of the existing toll system

Evaluation of the existing toll system in Macedonia is conducted using SWOT analysis and is presented in table below.

Table 1. SWOT analysis of Macedonian toll system

Aspects	Strengths	Weaknesses	Opportunities	Threats
Financial aspects	No	Discouragement of the everyday users to use motorways; High opex and capex; Lower incomes	Temporary tolls; Additional toll system for certain vehicle categories	Thefts and toll avoiding; More expensive for occasional users.
Traffic aspects	No	High delays; High number of stopping Low LOS Low passenger comfort	-	Toll avoiding Usage of longer and non-adequate alternative roads
Environmental aspects	No	Increase of air pollution Increase of noise Increase emission of greenhouses gases	-	High negative influence on environment

Socio-economic aspects	No	Payment with stopping; Queuing; Increase of VOC; Increase of TTC	-	-

According the table 1 we can conclude that current situation the toll system in Macedonia is on a very low level of development, resulting in a low comfort for motorway users and low income for toll authorities.

PROPOSED IMPROVEMENT MEASURES WITH CONCLUSIONS

Proposed improvement measures

Analysis of the situation toll in Macedonia indicates basic shortcomings in the functioning of the existing system of road tolls in Macedonia.Analysis results in the following short-term and long-term recommendations for improvement of the tolling system:

I. Short-term improvement measures

- ✓ There is a need for reconstruction on existing toll both gates with the ANPR or similar ETC. If ANPR is used, the system could use registered users (prepaid or postpaid) and in that way eliminate queues, stoppage and waiting.
- ✓ There is a need to develop a new tariff policy to include different user categories. This could increase the revenue from tolling. In addition, improved tariff policy could encourage some users to return to using the motorway, from using the lowest rank road network which is not designed for that type of traffic. Consequently, this could prevent further rapid deterioration of the secondary highway network.
- ✓ The existing system needs to transform in the USER FRIENDLINES system allowing payment by smart phones, via Internet and other systems.
- ✓ There is a need for engaging with the public and informing about the toll system without manual payment and waiting.

II. **Long-term improvement measures** → perform a scientific-expert study of selection of the optimal system toll for Macedonia. This kind of study will help decision-making based on the expert analyzes. Consequently, this study should aid decision-making and help in maximizing income for roadway authority and maximize comfort of motorway users.

CONCLUSIONS

We conclude that the current toll system is on the lowest technical level, not developed or upgraded since it was constructed. This fact results in the negative effects for both motorway toll authorities and for motorway users. The paper concludes that the existing system of road tolls in Macedonia with often waiting in queue at the toll does not encourage motorway users to use the motorways.

On the contrary, users often prefer alternative road network, thus decreasing revenue needed for infrastructure maintenance, as well increasing the deterioration of the secondary roadway network. Having this in mind, we encourage toll authorities to upgrade Macedonian toll system. The upgrade of the tolling system has the potential to satisfy both the users and roadway authority criteria.

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