THE FIRST ELECTRONIC TOLL COLLECTION SYSTEM IN THE CENTRAL EUROPE

THE TOROVO ABC SYSTEM PILOT PROJECT - SYSTEM DEFINITION AND EXPERIENCES

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ABSTRACT

Until the end of 1995 the Toll Collection on the Slovene Freeways was manual. The European trends in the field of Electronic Toll Collection are known. Slovenia was the first Central European country which decided to stop with the manual toll collection and establish the ETC system, what was also a Slovenian Parliament decision. The main goal was to reduce vehicles stops and air pollution as a part of environmental protection. The single lane toll booth and barrier based Electronic Toll Collecting system in Slovenia will be described as the intermediate phase until the full free flow multilane multi-user tolling and enforcement system, compatible with the other European Community standards will be established in Slovenia. The system definition and users experiences of 9 month commercial use of The Electronic Toll Collection, called the ABC System pilot project on the Torovo Toll Plaza will be presented, too. The system, based on bi-directional read/write microwave 2.45 GHz link, was developed and integrated by Slovene companies. Special emphasis was devoted to the traffic arrangement of the existing toll plaza. The plans for the future expansion of the ABC ETC system will be described.
INTRODUCTION

At the end of 1995 the first pilot project for an Electronic Toll Collection (ETC) system was launched in Slovenia. At first it was single lane single users toll booth and barrier based ETC system, and was called the ABC System. This is the first such system in Central Europe. The system operates according to the principle of hindered traffic flow, meaning that on entering the region of the microwave antenna drivers must slow their vehicles to under 50 kilometers per hour but do not have to stop. The overall toll infrastructure remains as it is but is supplemented. The ABC system is similar to the Electronic Toll Collection systems already operating in Italy and France, but some original solutions have been applied (from the aspect both of traffic and of the system itself).

At the public tender for the establishment of an ETC pilot project at the Torovo toll station, which was issued by the Motorway Company of the Republic of Slovenia (DARS, joint-stock company), the consortium collected under ISKRA SISTEMI-IBC, Ltd., was selected. Other companies working in this consortium are Traffic Design Ltd. and Metra Inieniring Ltd. All three companies also employed sub-contractors; only in this way it was possible to meet the requirements of the tender within the specified period.
The ABC system was planned on the basis of a study made by the Traffic Technical Institute at
the Faculty of Civil Engineering and Geodesy of the University of Ljubljana. Specialists from
the institute also worked with the consortium led by ISKRA in realizing the ABC Torovo pilot
project.

The ABC ETC system fulfilled the requirements set out in the tender, which were:
- a reliable and effective operation in all driving conditions
- safety both for passengers and goods
- the unambiguous recognition of the ABC system by drivers, which above all depends on the
  precise arrangement of traffic flows
- a reduction in delays at the existing toll station
- a reduction in negative impacts on the environment and, through this, the protection of the
  environment, which is achieved by reducing the number of delays
- a single lane single users system at first stage, later single lane multi users
- complete user anonymity
- the possibility of upgrading the ETC system into the free flow multi lane multi user ETC system
  and,
- in the final stage, compatibility with the EU standardized ETC systems

The ABC ETC system is based on two-way communications (read/write) and proceeds via a
microwave frequency link at 2.45 GHz between the on-board unit (OBU) and the roadside
equipment. This frequency was chosen because of still undefined European standards for
communication protocols using the 5.8 GHz microwave link. Having the well operated manual
toll collection system and numerous existing toll plazas with sufficient infrastructure, the
establishment of the free-flow ETC system based on the 5.8 GHz frequency microwave link was
not necessary in the transitional period.

The Torovo toll station was selected as the trial location because it offered the best conditions for
testing the ABC system. It is located on the E61 Motorway NW of Ljubljana. Since this is an so
called open road toll system, the road toll station is frontal, due to which less equipment needed
to be installed. It is large enough, for it has 11 toll lanes, and processes over 2,500 vehicles per
peak hour in manual toll collection. The ADT is up to 15000 vpd, but the peak DT can exceed
20000 vpd.

TRAFFIC ARRANGEMENTS

Traffic arrangements at the Torovo toll station are planned within the framework of the ABC
system in such a way that it allows
- all users clear and direct information about the ETC system, especially users of the ABC
  system
- safe lining up of all vehicles, especially those with on-board units, which also has to take into
  account that not all drivers have sufficient credit
the least hindrance to drivers using the ABC system who fulfill all conditions for undisturbed tolling
- the possibility of ordering reversible lanes in rush hours
- the transport of extraordinary freight loads
- the physical restriction of clearance before a classification system is established making automatic tolling possible for all categories of vehicles.

In the ABC system, which is totally anonymous, the on-board unit is the carrier of the credit. If there is not enough credit the system rejects the vehicle. The driver has to drive to the combined lane and cover the lack of credit or pay the toll manually.

At the Torovo toll station one fast and one combined lane was set up for each direction. The combined lane is proposed for drivers:
- who want to pay the toll manually
- who do not have enough credit on their on-board unit and want to buy more
- for whom the system discovers irregularities in operation
- who pay the toll with chipcards, which was also used during the period the ABC system was being tested (but which shall not be described in greater detail in this article).

This lane is also equipped with all electronics, but a road toll employee is present in the toll booth as well. Transport through this lane is not proposed for driving without stopping.

The fast and the combined lanes are divided by a special islet made of fitted plastic curbs. The fast lane is specially marked for vehicles with on-board units. Since there is no classification system yet (it is to be installed by the end of 1996) it was necessary to lower the clearance of the fast lane to 1.9 meters. In Fig. 3 we can see the entrance to the fast lane, where drivers receive information on who the lane is for on an illuminated sign, while the hanging signs notify of the clearance. The microwave antenna made by Combitech Traffic Systems (Sweden) is located on the post situated on the left-hand side of the fast lane, behind the notification table.

THE OPERATION OF THE ABC SYSTEM

In the fast lane, where there are no staff, the vehicles with on-board units are tolled during driving and do not stop. The prescribed speed in the fast lane is 40 km/h, but the communication and transaction is possible also at higher speeds, up to 55 km/h. When a vehicle drives into the active zone of the system it is registered by means of an inductive detector and the tolling is executed via the microwave antenna. During this time the system checks the validity of the record on the on-board unit through a controller, deducts the credit and writes the new credit level, the road toll code and the time of crossing. At the end the correctness of the written records is verified and the quick response ramp opens. The ramp remains open until the vehicle passes the closing detector.

If the vehicle in the fast lane was positively tolled the driver can still decide to drive into the combined lane (for confirmation, purchase of extra credit, etc.).
If the vehicles are at a distance of more than 3 m from each other the tolling proceeds without disturbance. If a driver attempts to avoid paying the toll by driving immediately behind a car in front which has an on-board unit, the ramp remains closed for both vehicles. If a transaction is negative (not enough credit, error in the on-board unit, the on-board unit is blacklisted, etc.) the vehicle is directed to the combined lane where the toll employee checks the on-board unit. In such cases, the vehicle is directed from the fast lane to the combined lane with a changing signal light which is fixed on the portal. If the transaction was positive the LED display shows a green arrow; if it was negative a red cross lights up, as well as a yellow flashing light showing the direction to the combined lane (Fig. 4).

In the trials also the use of contact less chipcard as the carrier of credit was tested. Communication with chipcards proceeds in the combined lane without contact. The PC cash register in the booth is the basic accounting element and the link between the controller of the lane and the server. The PC cash registers are linked to each other by means of a computer network with a cash register which is envisaged to perform periodic accounts at the end of a shift and supervise directly the work of the toll station staff.

All automatic transactions are noted on the network server through the master controller, which links all four controllers in the network. A Motorola 68000 microprocessor is used in the controllers. The server performs the function of servicing the cash register network and the network of lane controllers.

The driver is notified of the amount of credit by means of a display located in the fast lane. During a positive transaction a green light is seen on this display, too. (a fast ramp opens and the driver can continue his journey undisturbed), or a red light (the ramp remains closed and the vehicle is directed to the combined lane). On this display (Fig. 4) all other notifications are given to the driver, such as:
- any defects in the on-board unit (i.e. that the on-board unit is broken or that the speed of the vehicle during the transaction was faster than 50 km per hour, etc.),
- no on-board unit (if a driver without an on-board unit is in the lane, etc.).

THE STATE OF THE ABC SYSTEM AFTER THREE MONTHS OF ITS COMMERCIAL FUNCTIONING

The number of users of the ABC system has exceeded the expectations, since there are presently already more than 2000 users of the system. The number of transitions through fast lanes is increasing from one day to another. In the weekdays the number is already up to 1200 vehicles/day. Also the reliability of the system is increasing, since in the first twenty days of September 1996 out of the total of 15,657 only 17 transactions were “incorrect” (0.1 %), which means that the system can be ranked to the very top of similar systems.

Based on experience and results of the pilot project the investor DARS decided on gradual expansion of the ABC system. According to the plan five toll stations (TS) on E61 and E57 Motorways in Slovenia will be equipped by the ABC ETC system by early 1997. Since the ABC
The system is intended for the multiusers (all vehicle classes), the system will have to be improved by a subsystem for automatic classification of vehicles (SLKE - Single Lane Categorisation Unit). This system also functions in such a way that vehicles are classified according their length and height. The category of the vehicle, i.e. the vehicle class, will be written to an OBU already when the vehicle enters the toll station, which means that in the closed road toll system the automatic vehicle classification system (VCS) will be installed only in the entering lanes of the toll stations. If the category written in the OBU does not match the category detected by the VCS, alarm goes off (the ramp does not open). The OBU of individual vehicle classes will be equipped by labels of different colours with adequate markings, which makes any coincidental exchange of first class plates with plates of other classes practically impossible.

With the expansion of the system, where the so-called closed type of toll collection has been introduced, the ABC system will have to be adequately adapted. The entrance into the toll collection system will run over two fast entrance lanes where the code of the entrance station, the date and time of the entrance into the system will be written to an electronic tag. Fast entrance lanes will not be functioning according to the system of vehicles diversion to the combined lane, since the credit at the plate at the entrance is not necessary. In case a vehicle equipped by electronic plate is not tolled for any kind of reason (too high speed, etc.), the system will warn the driver with light signalling, so the driver can lower the speed significantly when approaching the ramp. The entrance lane will have at the ramp another microwave antenna which will carry out the transaction.

CONCLUSION

The ABC ETC System at Torovo toll plaza has fulfilled all the expectations. Since it meets Slovene standards it was awarded the SIQ (Slovenian Insurance Quality) certificate. All conditions needed for the transition from test to commercial use have been fulfilled. At present the system is used by over 2000 users and interest in it is increasing daily. There is no doubt that we were right to opt for the read/write two-way microwave communication frequency of 2.45 GHz between the vehicle and the roadside equipment. As expected the use of contact less chipcards as carriers of credit has not for now shown itself to be successful. The chipcard will assume a significant role only in multilane, multiusers free traffic flow ETC systems, using the microwave frequency 5.8 GHz for the transfer of information. Slovenia will upgrade the ABC system after the EU standards will be accepted.

The overall knowledge we have acquired during the testing period is viewed as positive. It has been proved that traffic through fast lanes proceeds safely and quickly. The notification of drivers is adequate, as is the information they receive from the LED display and illuminated signs. The ABC system will spread to the remaining road toll stations in the Slovene motorway system this year.
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V1: 1. Transition unit
V2: 2. Transition unit
Fig. 2: The Torovo toll station

Fig. 3: Entrance to the fast lane, information to drivers via an illuminated sign and the hanging clearance sign at 1.9 m. The lane is bordered on both sides with fitted plastic curbs.

Fig. 4: The signs on the semi-portal which operates in combination with the ramp, preventing the driver from entering the fast lane in the event of a negative transaction. Display for driver showing the amount of credit and possible defects in the electronic on-board unit.

Fig. 5: Microwave antenna on post

Fig. 6: The PC cash desk with the printer in the combined toll booth