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Research Study on Open Road Tolling in Hong Kong

Literature Review

Hong Kong Policy Research Institute
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1. INTRODUCTION

Open road tolling (ORT) is very often termed as electronic road tolling (ERT), or free-flow tolling is the collection of tolls on toll roads without the use of toll booths. ORT in today's technological level is implemented by electronic means. Therefore, the road users are able to drive through the toll plaza maintaining its car speeds without having to slow down to pay the toll. With cashless tolling, cars pass electronic readers even at highway speeds without the safety hazard and traffic bottlenecks created by having to slow down to go through an automated toll charging lane. At ORT plazas, vehicles travel at highway speeds under overhead gantries that collect tolls electronically.

There are many advantages for ORT being "open'. Firstly, there are no such obstructions for vehicles to hit. No obstructions mean fewer accidents. Fewer accidents result in better safety and reduced costs to both the tolling agency and the vehicle owners[1]. Not having vehicles slow down means that there is less congestion at ORT plazas. Secondly, eliminating slowing down of cars at toll gates brings many benefits in addition to relieving driver's stress. Thirdly, fuel consumption can be improved since vehicles do not have to repeatedly stop & go at toll road entrances and exits, ultimately contributing to the reduction of noise around toll gates and the emission of exhaust gases. Furthermore, the reduction of emission gas (CO2) directly links to the prevention of global warming. ETC removes the stress borne from traffic jams and is also a system that contributes to society and the planet in a variety of ways.

2. TECHNOLOGY OPTIONS

2.1 Overview

Electronic collection of tolls on open toll roads is usually conducted through in several means: the use of transponders, automatic vehicle identification or automatic plate recognition, etc. The vast majority utilizes an overhead gantry system above the road. While rarely used as the primary vehicle identification method, automatic number plate recognition is used on a number of different highway systems. Both methods aim to eliminate the delay on toll roads by collecting tolls electronically by electronically debiting the accounts of registered car owners without requiring them to stop.

The way these charging schemes are implemented and operated is very different, not only in terms of technologies[2]:

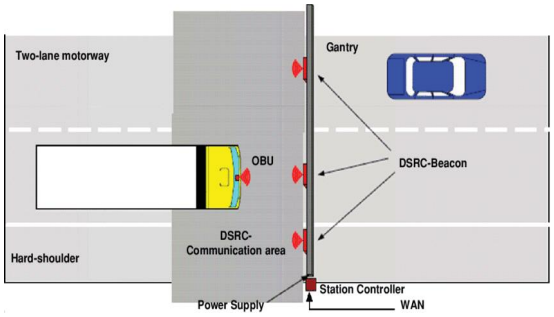
2.1.1 Distance-based charging schemes: the charge is calculated on the base of the distance travelled by the vehicle and then modulated by other parameters characterizing the vehicles;

2.1.2 Time-based charging schemes: the charge is calculated on the base of the time for which the users is paying, with the charge being again modulated along with the vehicle characteristics;

2.1.3 Access-based charging schemes: the charge is applied to a specific geographic area, typically part of a city, but could equally be applied to specific infrastructure (expressways) or other zone (e.g. an airport perimeter).

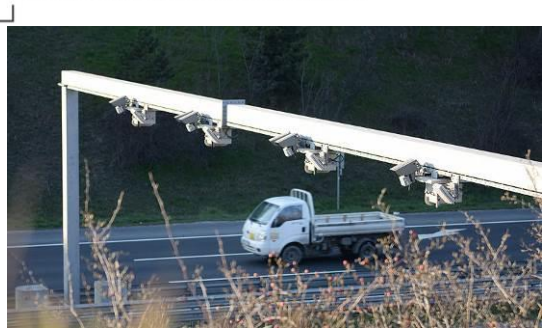
In Hong Kong, access-based charging is applied in the toll roads and tunnels. Therefore, technology options for access-based charging are discussed in this paper. There are some categories of technologies in common uses worldwide, including the Dedicated Short-Range Communications (DSRC), Automatic Number (or License)-Plate Recognition (ANPR), Global Navigation Satellite System (GNSS), etc.

Dedicated Short-Range Communications (DSRC) is a key enabling technology for many intelligent transportation systems, including vehicle-to-infrastructure integration, vehicle-to-vehicle communication, adaptive traffic signal timing, electronic toll collection, congestion charging, electronic road pricing, information provision, etc. The technology for ITS applications works on the 5.9GHz band (United States) or the 5.8GHz band (in Japan and Europe).



DSRC is a subset of Radio-frequency identification (RFID) technology which used as an object (typically referred to as and RFID tag) applied to or incorporated into a product, e.g. an in-vehicle on-board unit (OBU), using electromagnetic fields to automatically identify and track tags attached to objects. The tags contain electronically-stored information. Most RFID tags contain at least two parts. One is an integrated circuit for storing and processing information, modulating and demodulating a radio-frequency signal, and other specialized functions. The second is an antenna for receiving and transmitting the signal. There are generally three types of RFID tags: active RFID tags, which contain a battery and can transmit signals autonomously, passive RFID tags, which have no battery and require an external source to provoke signal transmission, and battery assisted passive (BAP) which require an external source to wake up but have significant higher forward link capability providing great read range. Active tags have a local power source (such as a battery) and may operate hundreds of meters from the RFID readers.

Automatic Number (or License)-Plate Recognition (ANPR) is a technology that uses optical character recognition on images to read vehicle registration plates to create vehicle location data. It involves using closed-circuit television, road-rule enforcement cameras, or cameras specifically designed for capturing the vehicle identity. To determine the identification of vehicles without tags, license plate images are used commonly. Specialized cameras and lighting units capture the images at the toll zone. Many toll operators use automatic license plate reader systems that use optical character recognition software to identify license plate information, thereby reducing labor costs. ANPR is sometime called the video tolling, which is already a mature tolling solution, and has been used in a number of free-flow schemes around the world, in particular in Europe. It offers distinct benefits to schemes, particularly those involving significant numbers of occasional users.




ANPR is useful for enforcement purposes as vehicle images are the most common strategy for identifying non-payers of tolls. As there is always a need to enforce payment of a toll or charge, the usual strategy is to rely on vehicle images to provide evidence for enforcement. ANPR generally requires users to register with the system before driving on the toll road to create a payment account, or to pay per trip. Tolls can be pre-paid or post-paid. Enforcement against late payers or non-payers may take two main forms: additional fees for late payment and high penalties for non-payment. [3]

Global Navigation Satellite System (GNSS) receivers, using the GPS, GLONASS, Galileo or BeiDou system, are used in many applications. GNSS toll pricing systems charge of road users using data from GNSS sensors inside vehicles. Advocates argue that road pricing using GNSS permits a number of policies such as tolling by distance on urban roads and can be used for many other applications in parking, insurance and vehicle emissions. Critics argue that GNSS could lead to an invasion of people's privacy.

Smartphones and other mobile communications devices show great potential to be used for tolling purposes due to their proliferation in the user community, their platform structure for additional applications, and their flexible nature. However, there are limitations that would need to be overcome before they could be adopted as tolling solution. This includes ensuring that the smartphone could exchange data with the vehicle to guarantee its proper functioning in a secure mode, and that it could be plugged to an energy source. It would mean a complex integration of multiple products which have different life cycles and the benefit for the carmakers is not obvious.

Review of Current Technology[4]

- DSRC is a commonly adopted Electronic Toll Collection (ETC) technology. However, it requires the installation of costly roadside equipment and is a rigid scheme, which makes modifications difficult, and is not easily interoperable with other ETC systems.

- ANPR is a mature technology which does not require in-vehicle on-board units (OBUs) and needs "less costly" roadside equipment. If it was adopted for tolling, it would need to be supported by a shared license plate database and common transnational standardization of license plates.

- GNSS requires minimal roadside equipment, and modifications to the tolled road network can be made easily. However it may be more expensive to install and operate. Also, as location of vehicles is tracked, there will be privacy concerns for the users.

- Mobile phone and smartphone-based tolling do not require in-vehicle devices, allowing

for lower initial investment costs when compared with other technologies. On the other hand, the technology is not mature and various issues still need addressing. In addition, the development of telecommunications-based technology is very volatile. Current systems based on GSM solutions are likely to become obsolete very quickly.

2.2 Worldwide Experience

In this report, total 20 ORT/ETC systems over the world were compared and analyzed. Paragraphs below outlines a brief on the systems/countries studied.

2.2.1 Asia

The table below summarizes the technology used in different countries in Asia:

Systems	***Technology Used***	***In-vehicle On-board Unit (OBU)***	***Payment Methods***
People's Republic of China[5]	DSRC / RFID	Yes	Prepaid / credit cards
ETC, Japan[6]	DSRC	Yes	Prepaid / credit cards
Far Eastern, China Taiwan[7]	RFID (ANPR is supplementary for those cars without RFID e-tag)	Yes (e-Tag)	Prepaid / credit cards
ERP, Singapore[8]	DSRC The new Global Navigation Satellite System (GNSS)-based ERP system will be operational from 2020.	Yes	Prepaid / credit cards
Hi-pass, South Korea[9]	DSRC / RFID	Yes	Prepaid / credit cards
Autotoll, China Hong Kong [10]	RFID – toll collection system GNSS – vehicle tracking system	Yes (e-Tag)	Prepaid / credit card (Autotoll credit card issued by Dashing Bank)
Smart TAG Touch 'n Go, Malaysia[11]	Infrared light technology	Yes	Prepaid / credit cards
FASTag, India[12]	RFID	Yes	Prepaid/ credit cards
Thai Easy Pass, Thailand[13]	RFID	Yes	Prepaid/ credit cards
EasyDrive, Philippines [14]	RFID	Yes	Prepaid/ credit cards

2.2.2 Europe

The table below summarizes the technology used in different countries in Europe:

Systems	***Technology Used***	***In-vehicle On-board Unit (OBU)***	***Payment Methods***
LKW-Maut, Germany [15]	GNSS with Infrared and/or DSRC	The OBU is not mandatory and there is a manual booking alternative for occasional use	Prepaid/ credit cards Cash bills (customer portal or by post)
Kapsch, Czech Republic[16]	DSRC	Yes	Prepaid / Postpaid (bills invoicing)
TIS-PL , France[17]	DSRC	Yes	Prepaid/ credit cards
London Congestion Charging, UK[18]	ANPR	No	Autopay / payment cards
Stockholm Congestion Charging, Sweden[19]	ANPR	No	Credit card, or alternatively it can be paid at any 7-11 and Pressbyrån convenience stores in the City
Highway vignettes, Austria[20]	ANPR	No	Credit card, Paypal

2.2.3 America

The table below summarizes the technology used in different countries in America:

Systems	***Technology Used***	***In-vehicle On-board Unit (OBU)***	***Payment Methods***
E-ZPass, Midwestern and Eastern United States[21]	RFID	Yes	Credit cards and cheques
MACPASS, Canada[22]	RFID	Yes	Prepaid/ credit cards
AutoRoute 25, Canada[23]	RFID / ANPR	Yes (for those users with a e-tag account)	Prepaid/ credit cards
Quick Pass, Costa Rica [24]	RFID (same as E-ZPass technology)	Yes	Prepaid / bank auto-transfer

2.3 Key Comparisons among Different Technology Options

After studying different electronic toll collection systems, it can be found that DSRC/RFID, ANPR and GNSS technologies are most commonly used in ORT/ETC. The table below outlines the key comparisons of these three technology options:

	Dedicated Short Range Communications (DSRC) / Radio Frequency Identification (RFID)	*Automatic Number (or License) Plate Recognition (ANPR)*	*Global Navigation Satellite Systems (GNSS-based) / Global Positioning Systems*
Brief description:	Dedicated Short Range Communications (DSRC) allows high-speed communications between vehicles and the roadside. An antenna is used to scan the receiver and an transceiver with a decoder to interpret the data. Transponder - the RFID tag are available in which the data has been programmed with information. The scanning antenna puts out radio-frequency signals in a relatively short range, up to around 1,000 meters	A system that uses optical character recognition on images to read the license plates on vehicles.	Satellite positioning is used to determine the location of the In-vehicle On-board Units (OBUs) in the vehicles. The data relevant for toll collection is sent to our back office via GSM/GPRS wireless technology. As soon as a vehicle enters a toll zone, it is automatically recorded by the system and the payment process is triggered.
Privacy concern:	If an individual has a tag somewhere on his person, he/she can be tracked by anyone holding a portable reader. When the tag reveals information that is potentially sensitive, and can be used to determine the exact nature of the object.	ANPR usage raises questions over privacy and data protection. ANPR allows police to automatically compile vast databases of innocent road users' movements, thus disrupting their privacy. Another concern is that the collected data can be abused by employees or stolen by computer hackers.	Users' locational information would be disclosed via the GNSS-based / GPS technology.
Accuracy rate [25]	99% or better	>90% (London, TfL 2009) 97% (Stockholm)	99%
Strength [26]	• Widely adopted, simple and tested technology • High reliability & performance, low signal	• No need for OBU device or costly enforcement infrastructure; • Without OBUs, thus	• Flexibility to define and modify what is to be charged and how is to be charged;

	Dedicated Short Range Communications (DSRC) / Radio Frequency Identification (RFID)	*Automatic Number (or License) Plate Recognition (ANPR)*	*Global Navigation Satellite Systems (GNSS-based) / Global Positioning Systems*
	interference; • Lower OBU operation costs (compared to GNSS); • DSRC OBUs currently are very common easily available;	providing convenience to motorists who only enter the charging area occasionally, and saving them the costs for procuring and installing OBUs which would not be low. • Most successful when combined with other technologies, subject to the additional costs of the other technologies; • The system can be implemented gradually. • Minimal performance restrictions regarding vehicle speeds	• Little need to invest in roadside infrastructure; • Once installed, it is relatively less costly to maintain;
Weakness[26]	• Necessity to install road-side infrastructure (gantries) along the road; • High capital expenditure and maintenance cost of tolling infrastructure; • Difficult to modify the tolled location once implemented. • Monitoring gantries take up land and it is difficult to find space in non-motorway.	• Requires good quality or proper license plates; • Susceptible to poor lighting and adverse weather conditions; • Access to up-to-date vehicle data needed by operators – local scheme registration or national vehicle database; • Cost of manual checking can increase operational costs;	• Higher start-up costs (OBUs, back office, etc.) compared with DSRC; • Less used and mature technology than other technologies; • Location data is required, data protection is strongly required due to the amount of information collected from the users. Detailed and careful planning is needed before starting to operate the system; • Accuracy errors in certain sections of the tolled network, such as parallel free roads and ramps. • Interference, not entirely reliable as the satellite signal may be lost at tunnel areas, urban/metropolitan

	Dedicated Short Range Communications (DSRC) / Radio Frequency Identification (RFID)	*Automatic Number (or License) Plate Recognition (ANPR)*	*Global Navigation Satellite Systems (GNSS-based) / Global Positioning Systems*
			areas with high-rise buildings and perhaps during extremely bad weathers. Additional roadside devices (video cam) may need to be installed.
Opportunities [26]	• Ability to provide/support other value-added services through the OBU (e.g. allowing instant payment of charges with anonymous payment cards inserted in the OBU);	• Continuous improvements in video camera quality;	• Ability to provide/support other need to be pursued value-added services through the OBU: traffic information, speed control, etc. • Once implemented, tolling low traffic volume is less costly; • Easily expandable to other roads (e.g. expandable to ERP in CBD in the future); • Enabling toll charging on "distance-travelled" or "usage time" basis;
Threats [26]	• There is usually long debate for whom to bear the costs of the installation, maintenance, removal and replacement of the OBUs;	• Lack of standardization of license plates (future problem of catering crossing boundary vehicles from the Greater Bay Area; • Lack of standardization of evidence requirements and privacy laws;	• There is usually long debate for whom to bear the costs of the installation, maintenance, removal and replacement of the OBUs;

3. EXPERIENCE LEARNED FOR HONG KONG IMPLMENTING ORT

3.1 User Requirement

3.1.1 Convenience of the users

Usually, DSRC/RFID technology will demand the users to purchase or rent In-vehicle On-board Units (OBUs) equipment, and also to install, replace or remove it. The users do not require to bear the cost of maintenance in most of the cases. However, the users are sometimes required to pay an amount of security deposit for the OBUs. So, DSRC/RFID technology will cause some extent of inconvenience to the users.

ANPR is already a mature technology which does not require OBUs. ANPR is able to provide a higher level of user convenience.

3.1.2 Maintenance costs of tolling equipment of users (OBUs)

In DSRC/RFID technology, the tolling equipment (usually the OBUs) is usually maintained by the toll collection system operator or the authorities. The operator should also minimize the downtime of the vehicle in the event of the maintenance/configuration of the OBUs.

In EU, the vehicle owners want the authorities who require the retro-fitting of OBUs equipment in vehicles, both hardware and software, also to be responsible for paying for the installation, operation, maintenance, repair, dismantling and replacement of such equipment, as well as for the cost of vehicle downtime resulting from such requirements for equipment. [27]

3.1.3 Customer Service Support and Complaints Handling

A key element in the ORT is the Customer Service Center (CSC).[28 & 29] The customer service can be provided at a physical CSC or by telephone hotline, or over the Internet. The CSC is the front line for toll road users seeking to manage their toll account. Among the major activities that the CSC supports are:

- Account initiation and creation including gathering payment information, name, address, and other user identifying data
- Issue transponder/OBUs to users
- Updating account information from the users such as new debit/credit card information, debit/credit card expiration dates and other data that changes over time
- Answer queries about transactions or road use
- Manage returns of defective transponders/OBUs
- Issue correspondence to the users as needed. This can take the form of violations

notices, collection notices, and other forms of correspondence
- Receive payments from the users
- Handle complaints from the users
- Other users related activities

In Belgium, any complaints from the users related to the services must be notified to the toll collection system service operator at the latest within 30 calendar days of the event giving rise to the complaint. [30]

3.1.4 Administration Fee

In Hong Kong, Autotoll Limited will charge the users an administration fee of $35 per toll tag per month.

Users are required to pay a security deposit, keep a minimum balance in his account, and, in some cases pay a monthly fee for the ETC equipment. Some systems also require motorists to keep a credit card balance.[31]

3.1.5 Privacy Concerns

The privacy of the ETC user is a frequently stated automatic vehicle identification (AVI) concern.[32] Authorities think users will not accept an ETC system if the system is rumored to operate as "big brother," the all-seeing, omniscient government. People perceive that ETC systems threaten their individual freedom of movement, since travel information may be recorded.

User's privacy may be invaded through maintaining toll records for billing and audit purposes and through video/picture enforcement. Users are concerned that the system may capture the "errant spouse" (someone being somewhere they are not supposed to be), personal use of a company vehicle, travel movements of a driver who borrows a transponder-equipped vehicle, or the for-hire individual who does not want others to know his/hers trips.

Most of these concerns can be addressed by authorities. First, the basic practice is to make participation voluntary. If the ETC system is accepted voluntarily by users, then the user has made the choice to accept whatever loss of privacy may occur. Second, anonymous pre-paid accounts can be established; however, if the transponder is lost or stolen, the account balance is lost. Third, the toll authority maintains user privacy by separating accounting from transponder identification from personal identification functions. This separation allows traffic management to use transponders to monitor traffic without any personal monitoring. Fourth, the authority maintains non-ETC lanes that permit users to have non-ETC trips.

Other ways to ensure privacy require new legislation. The laws cover the deletion of travel records within 24 hours (billing shows number of trips, not when/where information), the

requirement to keep trip information and records private, and the limiting of enforcement photographs to only that purpose.

When performing customer relations, the privacy issue should be addressed. ETC users need to know how the system works, what information is stored and for how long, and any supplementary transponder uses.

3.1.6 Payment Method[33]

In Portugal, there are different payment methods in All-Electronic Tolling. They are direct collection (without surcharges) and post-payment collection (with surcharges).

The direct collection (without surcharges) includes:

- Fully electronic payment through OBU issuer (debit card)
- Pre-payment with client identification
- Anonymous pre-payment supported

The post-payment collection (with surcharges):

- Anonymous post-payment using license plate – available for payment at postal offices, and Internet.

3.2 Specification and System Accuracy Rates

3.2.1 High accuracy rate in DSRC

Successful transactions tend towards 100%, as observed in Austria (99.9%), the Czech Republic (99.7%), Poland (99.9%) and Santiago (99.5%)[34]. In Japan, the DSRC technology of ETC achieved a 99.999% accuracy rate. [35] In Taiwan, the RFID technology of ETC achieved a 99.97% accuracy rate[36]. These cases demonstrated the DSRC ETC is a highly reliable technology.

3.2.2 Confusing Vehicle Detection Capability with ANPR capability

The rate that one should normally examine in a free-flow ANPR situation is **the number of plates read correctly out of the total number of vehicles that passed the system**. What confuses the issue here is that most companies quote the ANPR rate as **number of plates read correctly out of the number of vehicles detected** (aka ANPR rate).[37] To get to the overall useful rate you need to multiply two rates: overall ANPR rate = vehicle detection rate * image ANPR rate.

3.2.3 Accuracy and measurement of ANPR system performance

A few ANPR software vendors publish accuracy results based on image benchmarks. These results may vary depending on which images the vendor has chosen to include in their test. In 2017, Sighthound reported a 93.6% accuracy on a private image benchmark. In 2017, OpenALPR reported accuracy rates for their commercial software in the range of 95-98% on a public image benchmark. April 2018 research from Brazil's Federal University of Paraná and Federal University of Minas Gerais that compared both systems reported median recognition rate of 93.53% and stated significant improvement from the 81.8% rate obtained in previous works.

The most advanced cameras currently achieve an automatic read rate up to 99% when mounted on gantries over unidirectional carriageways. However, read rates can be lower. Thus, 98% is the minimum permissible reading service level at Dartford Crossing (Highways Agency, 2012); 97% in Stockholm (Q-free, 2013); or better than 90% in London (TfL, 2009).[38]

Perceptics - It is the brand name of the ETC system. With intensive education in the challenges of reading varied plate types across North America, it offers a host of benefits in electronic toll collection (ETC). It designed for optimal results with an average 95% attach rate and 99% accuracy rate in reading full license plate.

3.3 Implementation and Execution Details of full ORT

3.3.1 Different Approaches in ETC Implementation[39]

Electronic toll collection can be implemented in several different ways. The traditional approach makes use of a toll plaza with individual lanes separated by barriers. As vehicles pass through the toll plaza, their transponders are read and the tolls are deducted from user accounts. The toll lanes may or may not have barriers installed to prevent vehicles from passing through if the toll has not been paid. With this approach, vehicle flow rates tend to be approximately one-half of free-flow capacity. These systems tend to be highly accurate, and they lend themselves well to violation enforcement. However, the reduced flow rate necessitates additional lanes and an expanded footprint.

An alternative approach, which has become increasingly common in recent years, is open-

road tolling. This approach uses no barriers, and no toll booths. Overhead gantries are typically used for mounting the DSRC readers, cameras, lighting, and any other overhead equipment that may be needed. With this approach, there is no impediment to traffic, so lane volumes are equal to free-flow capacity. These systems provide high accuracy and highly efficient operations. However, they have no direct provision for dealing with non-equipped vehicles, and the open-road environment can make violation enforcement more difficult.

A third approach is called a hybrid implementation. Hybrid systems provide open-road tolling for those vehicles that are equipped and enrolled, and they also provide conventional toll booths (with manual collection and/or automated coin machines) for non-equipped vehicles. This approach provides many of the advantages of open-road tolling (unimpeded flow, high capacity, accuracy, and efficiency), while also accounting for the non-equipped vehicles and providing improved violation enforcement. The primary disadvantage of hybrid systems is the expanded footprint required for the toll plazas.

3.3.2 Eligibility of Public Funding[40]

All-electronic tolling (AET), also known as open road tolling (ORT), uses electronic toll collection (ETC) systems to charge tolls on a facility without the need for a motorist to stop at a toll booth. The memorandum from US Department of Transportation provides guidance on the eligibility of AET systems for Federal-aid highway funds.

Toll authorities conduct AET through the use of vehicle-mounted transponders and/or cameras to capture license plate images. Gantries suspended above the roadway record the transponders or photograph the license plates as vehicles pass beneath at free-flow speeds, allowing the authority to charge the toll to the appropriate motorist.

Federal-aid highway funds may be used to implement an AET system on any toll facility eligible under Title 23, including the capital costs for construction and the public outreach costs associated with educating the traveling public on how to use the system, provided the activities are necessary to meet the objective of the Federal award.

In reviewing such costs for eligibility, division offices should ensure that these costs conform with allowable advertising and public relations costs under 2 CFR 200.421(b)(4) and (d)(3). The period of eligibility for public outreach costs is limited to the development phase and to the initial implementation phase of AET on a facility until steady-state operations begin, typically within the first 6 months of operation. The division office and the project sponsor should establish this time period and the end date for eligibility before procuring public outreach services.

The discussion below provides further detail on the eligibility of public outreach costs for the implementation of AET systems.

All-electronic tolling (AET), also known as open road tolling (ORT), uses electronic toll collection (ETC) systems to charge tolls on a facility without the need for a motorist to stop at a toll booth. Toll authorities conduct AET through the use of vehicle-mounted transponders and/or cameras to capture license plate images. Gantries suspended above the roadway record the transponders or photograph the license plates as vehicles pass beneath

at free-flow speeds, allowing the authority to charge the toll to the appropriate motorist.

Compared to traditional toll booth systems, AET reduces the labor and land required to collect revenue, significantly decreasing the operating costs of toll facilities. By enabling the free-flow of traffic, AET also reduces congestion, enhances safety, and improves fuel economy. In addition, AET permits agencies to implement dynamic pricing and congestion-management strategies that are not feasible with traditional toll collection. Due to these significant benefits, the FHWA has encouraged project sponsors to adopt AET. In fact, FHWA's ETC regulation (23 CFR 950.5) requires projects that received tolling authority under the Value Pricing Pilot Program to use this technology. The adoption of AET has been widespread on Federal-aid (and all other) toll facilities throughout the United States since its introduction on the Dallas North Tollway in 1989.

Implementation of AET requires careful consideration of the operational and policy goals of tolling the facility as well as appreciation of the needs of users. Public outreach activities that inform motorists of the upcoming implementation of AET are vital to the efficiency, reliability, and safety of the roadway in question. Public outreach efforts to increase awareness of a new AET facility can help motorists learn how to use the roadway and assist them in making routing choices, improving both efficiency and safety. For example, public outreach activities that raise awareness of the benefits and availability of AET transponders may result in more road users obtaining such transponders, thereby mitigating potential congestion and safety issues associated with new user confusion.

The Surface Transportation Block Grant Program provides for "operational improvements and capital and operating costs for traffic monitoring, management, and control facilities and programs" (23 U.S.C. 133(b)(2)), and "projects and strategies designed to support congestion pricing, including electronic toll collection and travel demand management strategies and programs" (23 U.S.C. 133(b)(12)).

The National Highway Performance Program allows Federal-aid highway funds to be used for "capital and operating costs for traffic and traveler information monitoring, management, and control facilities and programs" for facilities on the National Highway System (23 U.S.C. 119(d)(2)(J)). The costs of informing and educating the traveling public about the use of a newly implemented AET system may constitute an operating cost of a control facility.

Public outreach costs "to keep the public informed on matters of public concern," are allowed under 2 CFR 200.421(d)(3). To the extent that public outreach costs are related to safe, convenient, and efficient use of the facility, they fulfill a significant public purpose.

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development phase and to the initial implementation phase of AET on a facility until steady-state operations begin, typically within the first 6 months of operation. The division office and the project sponsor should establish this time period and the end date for eligibility before procuring public outreach services.

While there is no specific rule for these public outreach costs, extending eligibility for public outreach costs beyond the typical 6-month implementation period would primarily benefit the owner-operator of the toll facility and thus would likely be treated as non-eligible operating costs that do not benefit the Federal-aid highway program. Where the project sponsor and State DOT seek to charge outreach costs to Federal-aid beyond the typical 6-month implementation period, the division office should review the proposal, make a determination that the work and the costs are necessary and reasonable for successful accomplishment of the AET facility, and document that determination.

Elimination of Cash Option for Paying Tolls in New York[41]

There is a famous saying that for motorists in New York, the only things that may rival death and taxes as certainties are traffic and tolls — the latter of which, for the better part of the last 80 years, have been collected by hand. Those near-certainties are soon to change.

In an effort to reduce congestion, tollbooths will be eliminated at all Metropolitan Transportation Authority bridges and tunnels in 2017, and replaced with automatic tolling.

Instead of charging drivers who are stopped at toll plazas, the authority will use sensors and cameras to automatically charge cars that have been equipped with E-ZPass; those without it will have their license plates recorded by camera, and a bill will be mailed to the registered owner of the vehicle.

The move is part of a national trend, with tolling authorities adapting to E-ZPass or similar electronic toll systems, allowing participating drivers to whisk through toll plazas as the ever-shrinking cash-only lanes pile with traffic.

The conversion to automatic tolling, along with changes to the lighting of the bridges and tunnels, will cost $500 million from the authority's capital budget. The electronic tolling will begin in January 2017 at its two tunnels — the Brooklyn-Battery and Queens-Midtown Tunnels — and will be completed at all its toll bridges by the end of 2017.

On average, 800,000 vehicles use the authority's seven bridges and two tunnels each day, and as a whole, New York drivers spend more than 6,400 hours per day waiting to pay tolls. Commuters were projected to save 21 hours of driving time each year as a result of the electronic tolls. In addition, eliminating tollbooth delays will conserve about one million gallons of fuel and save $2.3 million each year.

Automated tolls have already been in place on the Tappan Zee Bridge and the Henry Hudson Bridge, a smaller Metropolitan Transportation Authority crossing. Collisions on the Henry Hudson have been reduced after automatic tolling.

Of the vehicles on the Henry Hudson Bridge, 94 percent had E-ZPass and 6 percent were billed by mail. Only two-thirds of those drivers paid their tolls by mail, but, Mr. Cuomo said, penalties made up for the loss.

Likewise, the transportation authority did not anticipate a loss in revenue as a result of the elimination of cash fares. Beth DeFalco, a spokeswoman for the authority, added that no jobs would be cut as bridges and tunnels transitioned to automated tolls; tollbooth personnel will be reassigned to other posts focused on safety, security and enforcement.

New Hampshire lawmakers approve planned changes to toll collection[42 & 43]

The New Hampshire legislature has reached agreement on the latest version of the state's 10-year transportation plan.

New Hampshire lawmakers have approved a 10-year transportation plan that would expand electronic tolling.

The bill, which passed the state Senate and House of Representatives Wednesday, would authorize the New Hampshire Department of Transportation to implement all-automatic tolling "if feasible." The measure also would fund construction of electronic tolling or open road tolling plazas on the New Hampshire Turnpike system.

The latest strategy sent to the governor's desk would authorize the state Department of Transportation to move forward with plans to eliminate toll booths on the state's turnpike system in favor of all-electronic tolling.

Supporters say improvements to the Dover and Rochester toll plazas are scheduled to begin soon. Instead of investing millions into facilities that will soon be obsolete, they said the state would be better served to modernize toll collection and do away with the plazas.

Estimates provided to state lawmakers show that all-electronic toll facilities would be nearly one-fourth the cost of toll plazas.

Sensors and cameras will be suspended over the highway to capture E-ZPass transactions and record license plate numbers at each tolling site. Along with the additional security personnel, each crossing will incorporate new facial recognition software and equipment.

Video message boards at tunnels and bridges will display real-time communication to update drivers on routes and accidents. In addition, as part of the transportation authority's adoption of LED lighting at bridges and tunnels, each crossing — as well as the George Washington Bridge — will be illuminated in multicolor light shows from dusk until dawn, similar to those displayed on the San Francisco-Oakland Bay Bridge and the Benjamin Franklin Bridge in Philadelphia.

Funding for all crossing transformation projects is already secured as part of the Metropolitan Transportation Authority's $27 billion capital plan. Many of the contractors have already been selected, and much of the work is already underway.

Massachusetts All Electronic Tolling Starts in October 2016[44]

In October 2016, crews stationed at each toll location will begin setting up the new traffic patterns, laying new pavement markings, and turning on electronic message boards for the initial stage of toll plaza demolition. Various signs related to manual toll collection will be covered, and new signage for AET will be uncovered. The appropriate toll demolition configurations will be in place at every toll plaza location statewide, where vehicles will be channelized to the outer lanes of the toll plaza.

Work will begin to demolish the center lanes of the toll plazas and reconstruct portions of the roadway. The *stage 1* demolition will include relocation of utilities, removal of concrete pads, the filling of tunnel areas, (passages manual collectors use to travel between booths and buildings), and the paving of the center lanes of travel after center plaza infrastructure is removed and tunnels are filled in. During this period, vehicles will be channeled into lanes and guided through the former toll lanes.

Stage 2 is scheduled to begin after *stage 1* when demolition work will begin on the toll plaza booths and tunnels to the right and left of center. In this phase, toll administration buildings will be demolished, ramp geometry and pavement will be reconstructed, and signage and pavement markings will be modified for a final configuration.

Drivers will begin to gain the benefit of this project during stage 2, and will gain the full benefit of AET once the toll booths have been removed and they can use the highways, bridges, and tunnels at safe highway speeds.

Massachusetts – Unpaid tolls[45]

Drivers without E-Zpass transponders racked up $32 million in unpaid tolls and late fees during the first 11 months of all-electronic tolling on all toll roads in Massachusetts. The $32 million consists of $16.6 million in actual tolls, $14.3 million in late fees, and $1.1 million in administrative fees accrued for the period from November 1, 2016, to September 22, 2017.

State transportation officials said the numbers are in line with their forecasts, but the money going uncollected is still substantial. Department of Transportation, said a portion of the $32 million will eventually be paid to the state. It was estimated that over time 35 percent of unpaid tolls and fees will go uncollected, which would represent about 5 percent of all the toll revenue collected with the all-electronic system.

The state moved to all-electronic tolling on all toll roads on Oct. 28, 2016. About 86 percent of drivers pay their tolls electronically using E-ZPass transponders, but the remaining 14 percent are tracked down via photographs taken of their license plates and then sent bills through the mail.

So-called pay-by-plate drivers pay more than those who use transponders. For example, drivers of cars with transponders pay $1.50 to use the Sumner and Callahan Tunnels each way, while their pay-by-plate counterparts pay $2.95 — almost 100 percent more.

Department of Transportation's personnel said the pay-by-plate tolls were set higher to make up for the losses associated with drivers who don't pay. Department of Transportation projected what the leakage would be and it was compensated for it when they set the pay-by-plate fees.

4. CONCLUSION

With the above discussion, the main concluding points are summarised in the following table.

Attributes	Key findings
User requirements	*Convenience* • ANPR and GNSS are able to provide a higher level of user convenience; • DSRC technology requires OBUs; *Maintenance* • Installation, configuration, updates of software, and maintenance of OBUs will bother users; • Authority and operator should consider minimizing downtime in whatever situation and particularly important to the commercial vehicles; *Customer Service & Complaints Handling* • In different kinds of technology, the customer service aspect is more or less similar and it should support major activities usually initiated by the users; • Complaints initiated from the users related to ORT services must be notified to service operator within a certain reasonable period the event giving rise to the complaint; *Privacy* • The privacy of users is always a controversial issue in ORT implementation and it is worth for further studying in future; *Administration Fees* • In ORT system, users may be required to pay monthly administration fees or security deposit for OBUs; *Payment Method* • Pre-payment (by debit card associated with transponder) together with post-payment (with surcharges, "pay-by-plate") methods are adopted in ORT;
System and System Accuracy Rate	• It is quite common that ORT system consists of both DSRC and ANPR technologies; • The high accuracy rates of different technologies are comparable (>95%), whereas DSRC is outstanding (>99.9%);
Implementation and Execution	• Strategies regarding public outreach need to be formulated by the authority carefully;

Attributes	Key findings
	• Implementation of ORT system is preferable going through by phases; • Removal of tollbooths may spare out the land at toll plaza and administration building; • The detail administration and collection of unpaid tolls under ORT system is worth for further studying in future;

- End -

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