Conversion to electronic toll collection: a Puerto Rican case study (part II)

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The following article is the second of two to be published in TEC. Last month, Robert Bain introduced us to the toll road network on the Caribbean island of Puerto Rico; a large and highly profitable system, especially given the relatively small size of this US territory. He also explained why the toll authority was upgrading to electronic toll collection (ETC) and started to introduce some of the 'issues for consideration' that needed to be addressed before the procurement process could be adequately defined. In the following pages Robert continues with his issues for consideration, and draws some conclusions from his experience about making ETC a success.

MORE THAN JUST TECHNOLOGY

Last month I introduced the first issue that we addressed in Puerto Rico before preparing the ETC procurement documentation; which technology should we employ? In brief, we settled for a radio frequency solution for vehicle to roadside communications. However a number of other fundamental matters still had to be addressed:

- Legislative issues;
- The appropriate 'level' of violation enforcement;
- Customer support operations;
- Design issues;
- Interoperability issues;
- Technology applications beyond ETC;
- Making ETC a success.

Each of these issues is described in the following paragraphs.

LEGISLATIVE ISSUES

Early discussions revealed three legislative issues that would have to be explored before ETC could be deployed in Puerto Rico:

- The wording of existing traffic laws regarding toll operations and toll payment;
- The specific provision for a violation (video) enforcement system (VES);
- The wording of existing bond covenant documentation.

Existing Traffic Laws

Existing traffic laws were extensively reviewed to identify any wording or phraseology that did not conform with the general operational requirements or objectives of an ETC system. A number of instances were isolated and, as a result, revised terminology was proposed for lawyers to carry forward for legislative amendment. For the purposes of illustration, one example, Article 23.02 of the Traffic Law of Puerto Rico (1998), is translated from Spanish below:

> Article 23.02: Stopping in the toll collection stations and payment for passage.
>
> It will be an obligation of every person who drives a motorised vehicle and wishes to use a tolled highway to stop at each of the toll collection stations installed on that highway and pay the correct toll.

Clearly this had to be amended as the very purpose of ETC is to avoid the need for ETC customers to stop to pay the toll. Working closely with government attorneys, careful cross-referencing was used to identify and propose modifications to any such text.

In a country such as Puerto Rico that has had toll roads for nearly 30 years, laws regarding toll roads and their usage already exist. Our task was to update these laws. In countries where toll roads do not currently operate, new legislation may be required prior to their opening.

Video Enforcement System

Video enforcement systems record the licence plate of violators and, as such, these violations can not be treated as toll evasion is normally handled. Evading the payment of a toll contravenes traffic regulations and typically leads to punishment of the driver (such as having 'points' put on one's licence). However a video enforcement system is designed to identify the vehicle and not, largely because of privacy considerations, the driver. This effectively decriminalises ETC toll violations, making them a contravention of some municipal, state or commonwealth code, and allows for initial enforcement outside the normal judicial process. This is similar to, for example, parking tickets (insofar as the owner – not the driver – of the vehicle is penalised, and administrative procedures are used initially to collect the fine).

Violation enforcement legislation is required to support the process outlined above, in particular to allow for recourse

to the judicial system should the administrative procedures fail to collect the penalty. Most critically, the legislation needs to establish registered-owner liability, the use of vehicle registration data to identify the owner of a vehicle and the acceptability of digital images [22] – typically time, date and lane-stamped – as evidence of an ETC violation. Additionally, the schedule for fees and fines needs to be established.

In our study, we reviewed legislation from various countries and certain US states to suggest how local statute should be amended to permit violation enforcement in Puerto Rico.

Text of Bond Covenant Documentation

All of the toll roads in Puerto Rico have been funded by municipal, tax-exempt bonds, typically pledged against the Highway and Transportation Authority's revenues from petroleum product-related taxes, vehicle licence fees, toll charges and certain investment earnings. The associated bond disclosure documentation describes (and quantifies) these revenue sources in detail, including the manner in which these revenues are collected. Our task was to ensure that the move to a new form of toll collection (ETC) did not contradict any of the wording or guarantees incorporated in the bond disclosure documentation.

THE APPROPRIATE 'LEVEL' OF VIOLATION ENFORCEMENT

The broad principles behind a violation enforcement system (VES) were outlined in last month's article. The system has two main components: a front-end image capture component, and a back-end violation processing function. The ways in which the systems are operated individually and together introduce a spectrum of possible approaches to VES.

At one end of this spectrum, most of the violators would have an image of their licence plate captured and a sample would be carried through to violation processing. At the other, all violators' licence plates would be recorded and as many as practical (given system limitations) would be pursued for payment.

The decision as to where, on that spectrum, an authority focuses its attention is an important policy decision, and one that can have significant resource implications in terms of equipment and personnel. Like all penalty systems, punishment has two objectives. The first is to reprimand the offender. The second is to deter others from offending. If the revenue from offenders (fines) covers or exceeds the enforcement and processing costs, then a sensible policy would be to record and process all violations. If it does not (and, the author would suggest, it invariably does not) and given the diminishing returns (revenues) that increasingly expensive VES solutions would realise, the key is to identify an 'optimal point' on the spectrum that would meet the twin objectives of deterrence and revenue (plus costs) recovery.

Assuming that all of the costs associated with violation enforcement could be quantified, a cost/benefit model could be applied to identify this optimal strategy however strict application of this approach would probably simply result in the reinstatement of gates in toll lanes! An alternative approach, given the policy decision to provide a gate-free highway-speed ETC system, is to outline alternative violation scenarios in the RFP and to review the costs associated with each as presented by bidders. This is the approach being taken in Puerto Rico. The cost differentials will be used to guide the final VES decision in terms of the provision and use of recording equipment and the extent of resources allocated to violation processing.

Payment processing is labour-intensive.

CUSTOMER SUPPORT OPERATIONS

Successful customer support operations represent one of the biggest challenges for toll authorities new to ETC. Traditionally, toll authorities have gained considerable experience in the engineering side of the business; specifically, the operation and maintenance of their roads. The concept of 'customers' is foreign to many. However, consider the summary list below:

- Customer Service
  - patron enrolment
  - initial payment applications
  - transponder ('tag') distribution
  - account management
  - incoming and outgoing mail processing
  - managing customer enquiries and changes to accounts

- Violation Processing
  - licence plate identification
  - interface with the motor vehicle registration system
  - control of collections
  - denial of licence plate renewal

- Financial Controls
  - lane operations monitoring
  - cash control
  - management controls
  - revenue reconciliation
  - Authority reporting
  - overall system control (eg. price database and system access control)

These onerous and commonly labour-intensive responsibilities are not the traditional concerns of highway authorities. New skills have to be acquired and procedures adopted to ensure that the customer interfaces are effective and efficient. In a number of respects, it is more useful to look outside the highway arena to learn from other disciplines more exposed to customer service and the rigours of dealing with large volumes of transactions and accounts. In this respect, much can be learned from utilities such as electricity companies and the telecommunication industry.

DESIGN ISSUES

Under this heading, the design of toll collection facilities (plazas) for ETC operations is considered. As part of our work

in Puerto Rico, we arranged a study tour for senior PRHTA officials. This study tour visited a number of locations in New York and Georgia to look at existing ETC-equipped toll roads and speak to managers and operations staff about their experiences. New York was selected primarily because of the size of the ETC operation – and ETC retrofits [23] – and Georgia because of its highway-speed tolling facility [24].

Design issues are considered here under two headings:

- Design of new toll plazas;
- Reconfiguration of existing toll plazas.

Design of New Toll Plazas

The Georgia-400 toll road in Atlanta incorporates a 'split plaza' design, with conventional toll collection facilities (attended and ACM-equipped lanes) sitting to the right of the plaza apron, and highway speed lanes to the left. The attended and ACM lanes are covered by a canopy very much like a typical toll plaza. The highway-speed lanes, however, have been made to look markedly different to approaching drivers and have only a space-frame gantry across the highway (which supports the ETC equipment for the AVI, AVC and VES functions described last month). This highly functional and attractive design was well received by all participants on our study tour and hence forms the basis for much of the toll plaza design work currently being progressed in Puerto Rico.

Transponders waiting to be mailed to new customers.

Our task was to define the lane configurations required at three plazas on new toll roads currently being constructed in Puerto Rico and to advise on detailed design features (plaza geometry, type and positioning of equipment, lighting, signage and so forth).

The required lane configurations considered the appropriate mix of attended lanes, ACM lanes, mixed-use lanes and highway-speed lanes at each plaza. A spreadsheet based model (TollPLAM [25]) helped to define this mix by taking account of the following factors:

- Opening-year and design-year traffic volumes;
- Traffic mix;
- Present payment mix;
- ETC market penetration (with sensitivity tests);
- Future payment mix;
- The throughput that could realistically be achieved in different lane types.

The spreadsheet model allowed us to 'map' the required lane configurations under different ETC scenarios and through time. This lead to the derivation of particularly flexible plaza designs which could be modified with minimal cost/disruption in future years to reflect different patterns in demand (eg increased ETC market penetration).

One final issue worth noting here is our team's strong advocacy for toll lane access tunnels to be provided at new plazas. These tunnels run under each of the toll lanes across the full extent of the plaza and allow personnel to access lanes/booths on the side of the highway opposite the plaza administration building without having to cross the highway-speed lanes at grade. Aside from providing this safety feature, the tunnels also can be used for utilities (including ventilation), ACM vaults and lane controller equipment. Under normal circumstances, the provision of an access tunnel adds only marginally to the total costs of new plaza construction, however retro-fitting such facilities would be highly disruptive and expensive.

Reconfiguration of Existing Toll Plazas

One of the biggest challenges faced by our study team was how to retro-fit ETC equipment at the 17 existing plazas on the Island with minimal disruption to traffic. Even allowing for weekend and night-time works, the task of installing an array of new in-pavement and in-lane equipment at facilities where traffic demand exceeds 100,000 vehicles/day requires careful consideration and co-ordination.

A number of solutions are to be employed during the retro-fit programme, including the operation of reversible lanes, the conversion of some plazas to one-way tolling, staged deployment and the pre-marketing of transponders before plaza opening (so that capacity can be increased before installation is carried out one lane at a time).

INTEROPERABILITY ISSUES

Interoperability is a term that covers a range of arrangements whereby drivers with one authority's transponder can use the facilities operated by another. This becomes an issue when markets overlap ie. where a significant number of drivers registered with one authority are 'in scope' for using roads operated by another/other (usually adjacent) authority(ies). Typical examples could include countries with toll facilities near borders, countries (like Puerto Rico) where there is a mix of public and private sector toll operators or the US where each state may have its own operating agency. The aim of interoperability is to avoid drivers having to deal with duplicate systems (duplicate registration procedures, duplicate accounts, even duplicate transponders).

Although seamless for the driver, the 'back office' arrangements required to service interoperability are considerable. For example, the correct revenue needs to be apportioned to each participating authority (reflecting travel on their toll roads), data files containing tag information (such as details of valid tags) need to be shared and customer service functions need to be co-ordinated.

One example of interoperability at work is the Inter-Agency Group (IAG), located in the north-eastern states of the US. Here, twelve neighbouring toll authorities co-ordinate their ETC systems such that their toll roads can be used by drivers registered with any one of the participants. The combined 'power' of this Group enables it to negotiate bulk deals with suppliers, such as the purchase of transponders at prices lower than any single authority could negotiate.

The simplest form of interoperability arrangement is probably most appropriate where a small toll road authority operates within or near the jurisdiction of another, larger agency. This is the situation in Puerto Rico. Although final details are

E-ZPass toll plaza, New York.

yet to be established, one model would have a single customer service centre (CSC) and that centre would treat the 'minority participant' (in this case, the Teodoro Moscoso Bridge) simply as another plaza on the network. PRHTA would collect all ETC revenues and would transfer that due to the Bridge electronically. In turn the Bridge would pay a small administrative fee for customer support operations and transaction processing.

In a country like the UK, interoperability could become an important issue if, for example, cities started establishing their own electronic road pricing systems.

MAKING ETC A SUCCESS

Having spoken with a number of US toll authority managers and industry experts, the keys to making a success of ETC are summarised below, under the following headings:

- Approach to roll-out;
- Marketing and transponder penetration;
- Pricing considerations;
- Signing and general design issues;
- Customer service centres.

Approach to Roll-Out

Traditionally, there have been two approaches taken to the roll-out of ETC technologies. The first, the gradualist approach, mixes ETC and conventional toll collection (eg. ACMs) in the same toll-lane. This has the initial disadvantage of giving ETC customers only marginal benefits as they may be caught behind (slower) cash-payers. ETC-only lanes can later be introduced once market penetration has reached levels at which the provision of dedicated facilities become justified in traffic terms (probably around 20% - 30% of users).

The second, more aggressive approach – and the one being pursued in Puerto Rico – is to start off with dedicated ETC lanes. This has the advantage of confirming ETC customers as members of some 'exclusive club' who can enjoy unhindered travel through a plaza, usually passing queues of drivers waiting to make their cash payment. Market penetration grows far faster under this scenario.

A possible disadvantage associated with the second approach is that it can lead to an immediate reduction in plaza capacity for cash-customers, thus aggravating congestion levels. At its worst, this congestion can even block back past the plaza's approach zone, thus preventing ETC customers from accessing their exclusive lanes. Effective pre-marketing of ETC to customers is a key preventative measure in this respect.

Marketing and Market Penetration

Our ETC strategy for Puerto Rico includes a strong ETC patron outreach and marketing programme that will be initiated several months before ETC is rolled out. The marketing programme consists of two streams. The first is an advertising campaign designed to ensure that people become fully aware of the advantages of ETC and has been developed to enhance the speed and 'depth' of market penetration – thus advancing the time at which dedicated lanes can be justified in traffic terms.

The second is a driver education programme aimed at reinforcing the violation enforcement system. This will alert drivers to the 'hidden' powers of video imaging, the rigours of the violation processing system and the scale of fines/penalties.

Pricing Considerations

The community of drivers 'in scope' to sign-up for an ETC system can be divided into three categories. The first segment is attracted by the 'gee whizz' factor and will register simply to embrace the ETC technology. This segment – perhaps 2% - 5% – is too small by itself to justify ETC.

The third segment will never sign-up to an ETC system, almost irrespective of the benefits. These are people who, for one reason or another, will remain with the cash-payment system. Many transportation examples exist where the benefits of a particular payment medium – such as monetary savings – are very significant yet a proportion of users continue to pay by cash. The mag-stripe MetroCard in New York City is just one. Marketing campaigns will have little impact on this segment. This segment could be as large as 30%.

The second segment may respond to marketing but will probably need further encouragement. The time-saving and convenience benefits associated with ETC will not be enough, by themselves, to achieve significant market penetration. This segment will, however, react to innovative pricing and cost savings.

Almost all of the ETC systems in the US that have achieved significant market penetration (typically 20% - 75% of users, depending on the time of day) maintain a price differential between their ETC and non-ETC customers, often by increasing the toll charge for those who choose not to participate in the ETC programme. This approach is the one that is being advanced for Puerto Rico.

Signing and General Design Issues

A strong marketing identity for the ETC system in Puerto Rico is currently being considered. This title (and logo) will be used to reinforce the presence and attributes of the system. Furthermore signs on the approaches to plazas and on the plaza canopies are being designed to be simple and clear, with a minimum of text and consistent usage of colour and symbols.

The plazas and lane configurations are being developed to offer a consistent and predictable environment to approaching drivers and to simplify their lane-choice selection process.

Customer Service Centres

A centralised Customer Service Centre (CSC) will be located in San Juan to support the ETC system. The key customer support functions of the CSC were listed earlier. The CSC will provide a walk-in service and an extensive phone-based enquiry system with voice-response capabilities. Additionally, customers will be able to use the internet to open and query accounts.

Prior to (and during) the ETC roll-out period this centralised facility will be supplemented by the use of temporary enrolment centres (TECs). These mobile facilities will be located at popular sites (such as shopping malls and existing toll plazas) to provide information and advice about ETC, to register new users and to raise the profile of new system.

CONCLUSIONS

Electronic Toll Collection is big business, it is getting bigger and it is here to stay. In the US, some 5 million transponder-equipped vehicles use toll roads, bridges and tunnels (an increase of nearly 50% since last year) and estimates suggest that globally between 20m and 25m transponders are currently in use.

Electronic Toll Collection is not cheap. Our system in Puerto Rico will cost over $100m for acquisition, operation and maintenance over a five year period. However a well specified ETC system will be less expensive than a conventional toll system and there may be few alternative courses of action for toll authorities that wish to meet the demands of

users without (potentially even more costly) infrastructure enhancements.

Although the individual technologies behind RF-based ETC systems are largely mature and risk-free, the challenge of integrating them within existing systems and getting them all to work together – the task of systems integrators – can be significant and can slow the roll-out process. Furthermore, as these articles have hopefully demonstrated, technological considerations are only one component of a much broader set of issues to be addressed before ETC can become a reality.

In terms of systems procurement, our work in Puerto Rico highlighted the central role of the functional specification sections of our RFP. The functional specification needs to clearly state the objectives for the system and broad performance criteria, while remaining forward enough looking so as to ensure that future developments (such as extension of the technology for other, related applications) are not precluded.

In closing, it is worth drawing some lessons about ETC which could have a far broader applicability – especially in countries currently less exposed to tolling practices than North America:

- Typically, the public resists the concept of toll roads and criticisms relating to double taxation are common. Studies (op cit) have demonstrated, however, that the customer-orientated attributes of ETC (eg. time savings, comfort and convenience) make ETC-type tolling more acceptable, particularly in instances where the revenues are explicitly ear-marked for specific purposes (repair and maintenance of toll-free roads, revenue support for public transport services etc.).

- In a number of (particularly European) countries where tolling is not prevalent, environmental considerations and space constraints at many points on already well-developed urban highway networks preclude the construction of traditional toll collection facilities such as plazas. In terms of infrastructure, at its simplest ETC only requires a space-frame gantry to be constructed over the highway.

- Estimates of the costs per ETC transaction (over the full-life of a system) suggest that these costs may be lower than the costs associated with more traditional, taxation-based forms of highway-related funding.

- ETC introduces the potential for demand management through congestion pricing and, as such, tolling becomes a more flexible and powerful instrument of public policy for balancing the increasing demands for travel with limited highway capacity.

Taken together, these issues could form the basis of a public awareness campaign designed to challenge preconceived notions about tolling and reassess its role as a part of modern transportation policy.

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Applications of the technology beyond ETC

ETC technology can be used for other vehicle-roadside communication purposes.

The primary function of the ETC technologies discussed in this article is to automate the toll collection process. However, once established, these technologies – specifically the transponder-related ones – can be employed for a number of other vehicle-roadside communication purposes. These purposes or functions are described in this section under the following headings:

- Parking;
- Traffic management;
- Commercial vehicle operations;
- Congestion pricing;
- Lessons for Puerto Rico (and elsewhere).

Parking

With the correct equipment (ie. readers) located at the entrances and exits of parking facilities, an in-vehicle transponder can be used to open gates, access the establishment (or designated lots within the establishment) and deduct the appropriate charge from a customer's account upon leaving. For example, transponders used on the North Dallas Tollroad can also be used for parking at Dallas/Fort Worth Airport.

Traffic Management

In New York and Houston, transponder-equipped vehicles are used as 'probes', conveying information (such as the average vehicle speed between two roadside readers) back to traffic management centres. Average vehicle speeds give an insight into levels of congestion or the occurrence of incidents on the network. Strong market penetration clearly improves the quantity (and hence quality) of the data relayed to such centres, however estimates suggest that if 10% of all vehicles are transponder-equipped, reasonable system accuracy can be achieved.

The Buchanan Toll Plaza, Puerto Rico.

Transponders can also be used by emergency services and buses for vehicle location purposes and to call priority at traffic signals.

Commercial Vehicle Operations

Aside from vehicle tracking, transponders are used for commercial purposes in the US for weigh station bypass (assuming that the truck has been checked earlier) and to facilitate/speed data-exchange at the US-Canada and US-Mexico border crossings.

Congestion Pricing

Electronic Toll Collection can be employed not only for fixed-price tolls, but also for toll rates that can easily be varied by the toll authority, typically by time-of-day or day-of-week. Variable tolls have been used for some time in Norway, France and Singapore and, more recently by certain authorities in North America for peak-period pricing. The privately-financed and owned SR91 toll road in California is a good example. On SR91 the toll charge varies between 60c (midnight) and $3.50 (weekdays 7:00am – 8:00am).

In fact, ETC can be used to offer truly dynamic pricing to customers, where the toll charge is adjusted in real time to reflect current levels of congestion on the road. On I-15 in San Diego, the express lanes employ dynamic pricing and the toll is recalculated every six minutes depending upon traffic volumes.

However market research tends to show that drivers prefer to know in advance what the toll charge will be (or, in the case of I-15, what the maximum charge will be) so that, equipped with that information, they can make decisions about their travel arrangements prior to trip departure. Hence the publication of fixed toll schedules showing the toll charge (or maximum charge) for different times of the day and days of the week.

Lessons for Puerto Rico (and Elsewhere)

The applications described above are clearly secondary to the main objectives behind ETC deployment. The list is not complete and it will continue to evolve. However it serves to illustrate the fact that, at the stage of defining a functional specification for an ETC system, it is important to remain forward-thinking. There may be certain secondary applications that could become important in the future and the system specification should not preclude those developments.

For example, in Puerto Rico, companies replying to our RFP are required to describe the price and availability of low-cost readers, such as those that could be deployed at parking facilities in the future.

Notes:

22. In common with many US states, licence plates appear only on the rear of cars in Puerto Rico. Thus a VES camera pointing at the rear of vehicles is required. However some trucks (ie. tractor-trailer units) have both front and rear plates and they commonly differ. Therefore VES cameras pointing at the front of trucks also requires installation.

23. MTA Bridges and Tunnels operates seven bridges and two tunnels in New York. Part of the E-ZPass ETC system, it handles over 750,000 vehicles/day and has distributed over 1.5m transponders to its customers (the first authority in the world to exceed 1m). Transponder sales continue at 7,000/week.

24. The mainline plaza of the Georgia-400 toll road in Atlanta was one of the first (after the Oklahoma Turnpike) to offer highway-speed tolling at a new plaza, specifically designed with ETC in mind.

25. TollPLAM (Toll Plaza Lane Allocation Model) was developed jointly by Al Schaufler of Parsons Brinckerhoff, Huy Nguyen of Steer Davies Gleave and the author of this article.

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