Tolling – back to basics

Recent political decisions have put Road User Charging (RUC) firmly on the UK's demand management agenda and given rise to renewed interest in electronic charging options. The UK offers relatively few working examples and most traffic managers have little practical experience of the technology. The picture is quite different in the US where electronic toll collection (ETC) is a mature technology which has been in routine use for more than a decade. In this, the first of a series of articles, ***Teri England****, Idris Project Manager with Diamond Consulting Services (DCS), takes electronic tolling back to basics and provides a concise but digestible guide to the technology and its application.*

As tolling strengthens its hold around the globe, there is much the UK can learn from our counterparts overseas who have already encountered many of the pitfalls progress can bring. By taking advantage of the learning curves of others it is possible to avoid some of the failures and expense incurred when new concepts and projects are undertaken.

Any relative newcomer to tolling will discover that the industry has a language all of its own and that only time brings with it an understanding of the concepts, the operation and the terminology. In an industry with more acronyms than a dictionary has words it can take several years to understand what ETC, ORT, or OBU actually mean! Lets break tolling down into manageable sections and look in detail at each part, from the acronyms to the technology.

ELECTRONIC TOLL COLLECTION – ETC

Electronic Toll Collection (ETC) refers to the automatic collection of tolls by debiting a patron's account which may be a pre-paid 'tag' or charged to a credit card or, as in the case of 407 in Canada via user's telephone bills. This is now a globally accepted method of toll collection, a trend greatly aided by the growth of interoperable ETC technologies.

WHY AUTHORITIES CHOOSE ETC

ETC systems have improved toll collection techniques because they have the potential to:

- Reduce queues at toll plazas;
- Save fuel and reduce mobile emissions by reducing or eliminating deceleration, waiting times, and acceleration:
- Reduce toll collection costs;
- Enhance audit control by centralising user accounts;
- Increased facility throughput.

For the customer the benefits include:

- speeding their trip through the toll plaza;
- Removing the need for the customer to stop;
- The flexibility of paying their toll charge with a pre-paid card or on account;
- Automatic debit charge and top up of credit card accounts;
- Customers can receive monthly statements detailing their toll usage, no need to remember to ask for a receipt;
- Commercial customers can set up accounts for numerous drivers and vehicles.

PLANNING & DESIGN

The crucial stage of implementing a toll facility is planning and design. During this phase it is important that all parties work together as a team to ensure:

- The development of a facility that meets the accuracy levels required by the authority;
- It is realistic for the technology providers to achieve the specifications;
- The project is cost effective and revenue generating.

A toll facility team and its advisors will typically consist of:

- The authority – normally the ultimate decision makers;
- Their consultants - both general engineering and specialists;
- Facility constructors, those that physically build the lanes and infrastructure;
- The tolling technology providers, supplying the detection and classification, enforcement and tag systems;
- System integrators who put the whole system together;
- Back office operators who process the lane information;
- Toll operators who manage the facility on a day to day basis and so on.

ETC is a flexible tool wich helps operators maximise their revenue whilst delivering convenience to their customers. The fact that the technology can be deployed as part of an RUC strategy makes it important that those involved in planning and specifying systems are up to speed with the latest applications.

The type of vehicles using the road will identify the road user requirements and the toll tariff options available. (Photo credit: Hal Worrall)

All these people come to the table and work on the layout and design plans. Once design plans and concepts have been approved the request for procurement is issued 'RFP' and the physical work begins.

Of course there are companies which specialise in providing a 'one stop shop' from system design through implementation to day to day operation. Whilst this can be an elegant solution, care needs to be taken to ensure the most cost effective and technologically appropriate system is being recommended.

So procedure is underway, but what are the key considerations and decisions to be addressed when designing and writing a toll facility specification? Let's start with the lane and work on up to the back office and operations.

The lane infrastructure is like a jigsaw where each part plays a vital role in the overall picture. Each aspect from the type of road surface to the payment method needs to be selected, planned and built into the end design. What are these jigsaw pieces and associated considerations so the final picture comes together?

One consideration of great importance is the type of environment the toll facility will be situated in. Will the facility be a new build or is there existing infrastructure? What are the weather and environmental conditions? For example, in Florida all new facilities take into consideration the frequency with which the state is hit by hurricanes. Although this is perhaps not an issue for the UK, weather such as snow and fog which can cause obscuration issues do need consideration. The environment will affect whether in-ground technology such as loops or above ground technology like lasers are used. Another point to consider is maintenance. Above ground technologies require regular cleaning and maintenance, whereas in-ground technologies are more easily maintained. However a loop failure could mean a road closure.

Consider, the physical impact the plaza will have on the environment, the number of lanes the facility is to have, potential traffic build up (congestion). Also the type of lanes and the payment method; manual, Automatic Coin Machines (ACM), express lanes or even open road tolling (ORT) with vehicle tags or on board units (OBU).

Another consideration must be vehicle mix. It's important to understand the type of vehicles using the road as this will identify the road user requirements and toll tariff options available to the authority. Considerations are:

- Is the mix mostly heavies (articulated trucks or rigid bodies)?
- Or are the vehicles mainly light vehicles such as cars and cars towing trailers?
- Does the area have a high tourist population who will not have OBU's?
- Is the mix mainly regular users or occasional?

All these types affect the lane structure.

The vehicle mix will also help to determine the most suitable toll tariff. The majority of damage done to roads is caused by the weight of the vehicles using it, for this reason most ETC tariffs are based around an axle classification table. In general the more axles a vehicle has the heavier it is and the more road damage it will cause. Therefore tolling authorities tend to have tolling tariffs which are divided into a number of axle categories.

Below is a typical 8 class table;

- Motorcycle;
- Car;
- Light goods vehicles (LGV) (typically under 3.5t);
- Bus;
- Rigid goods vehicle;
- Articulated vehicle;
- Car / LGV with trailer;
- Other.

Another influence the vehicle mix may have on the tolling facility is whether it is a pre or post classification facility, but this is probably a topic best saved for a future article.

IN THE LANES

In general, tolls are roughly distance-based and the toll collection system can be either open or closed. A closed system is one where all entrances and exits have tollbooths, and the toll is determined at the point of exit, given the point of entrance to the facility. On an open system, toll stations are located along the facility, so that a single trip may require payment at several toll stations. Toll lanes may by operated in several ways. Lanes may be dedicated to ORT, ETC and manual toll collection or they may be a mix of lane types.

This leads on to how the user is tolled. Is it a single flat rate or a charge by vehicle type? Traditionally, tolls have been differentiated by vehicle class. A vehicle's class can be determined by the physical attributes of the vehicle, the length, number of axles, height etc. Some toll agencies use as many as 15 or more vehicle classes to assess tolls. If tolling by vehicle type then what will the class table be and can the available technologies meet with the class table specification? Remember it is easier and more cost effective to use a class table that is technologically achievable, therefore attaining higher accuracy levels, rather than issuing a class table that will require considerable research and development (R&D) work to try and attain a desired level of accuracy. Consider what, is already on the market, is proven and in operation at present.

AUTOMATIC VEHICLE CLASSIFICATION

The Automatic Vehicle Classification (AVC) system is a crucial part of the facility. An accurate AVC generates the correct vehicle class, demanding the appropriate toll. The AVC component of a system consists of in-lane sensor devices that record the physical characteristics of vehicles. It also includes a processing unit, which aggregates input from the sensor device and interprets this input to assign a class to each vehicle passing through the lane. Most AVC technologies work from the detection of vehicles whether from a vehicle signature as with loops or radar which uses a physical presence. No technology currently can detect whether a vehicle has its rear seats laid flat thereby constituting a commercial vehicle against that of a vehicle with it's seats upright which may incur a non-commercial charge. However, certain technologies can differentiate between types of vehicles, the loop detection technology, Idris, is able to identify specific vehicles of interest. For example, South New Jersey Turnpike Authority (SJTA) have a considerable number of stretch limousines using their facility. Due to the fact their AVC system is

so configurable it was possible to write a rule file to enable them to identify these specific vehicles. Class tables can vary from country to country – even states within the US may vary – so it is important to consider how configurable your detection technology is.

AUTOMATIC VEHICLE IDENTIFICATION

Where express or ORT lanes are a requirement of the facility, then some form of Automatic Vehicle Identification (AVI) is required and an AVI correlation method.

The AVI component of a system refers to the technologies that determine the ownership of the vehicle so that the toll will be charged to the corresponding customer. Automatic vehicle identification entails the use of an electronic tag installed in the vehicle. This communicates with roadside readers to identify vehicle ownership.

The correct tag must be correlated with the AVC data to ensure the correct vehicle is charged the appropriate toll by the back office. Once the ownership is determined, the toll cost can be deducted from the corresponding account. The tag compatibility to the whole system is vital.

There are various tags on the market these days and consideration to their interoperability with other toll facilities is important. Are the tags read-write (tags which contain an updateable area on which the antenna/reader may encode information such as point of entry, date/time of passage, etc.) or read only (the information stored in these tags is fixed and the tags do not have any processing capabilities). Tags can also be 'pay as you go' or invoiced periodically. At E470, Denver Colorado, they have a pre-paid tag which is debited each time a user passes through a collection point. Their classification system carries out the correlation to ensure the tag and vehicle match and then forward that information to the relevant operation so that the tag is updated.

AVI tags are electronically encoded with unique identification (ID) numbers. These tags are usually about the size of a credit card and placed on the vehicle's windscreen. Roadside antennas are located along the road, in overhead structures or as part of the electronic toll collection booth. The antennas emit signals (radio frequency, laser or radar) across the toll lanes. When the vehicle approaches a tag reader site, the roadside antenna emits a signal that is reflected back by the tag on the windshield. This signal is slightly altered by the vehicle's tag, giving the vehicle a unique tag ID number. This captured ID number then receives a time, date, and location stamp from either the roadside reader or the AVC system. A central computer uses the code to identify the account from which to deduct the toll. When the toll is distanced-based, the computer stores the vehicle's point of entry, so that the toll can be calculated and assessed when the vehicle exits the toll facility. Otherwise the entire transaction is performed while the vehicle is within the antenna's reach.

Antennas and readers are typically connected by coaxial cables. Reader units are often tied into the central computer facility by leased telephone lines. One telephone line is necessary for each reader unit in the field. Fiber optic cables offer a much quicker but costlier alternative to telephone lines. Various wireless cellular systems (ie GSM - Global System for Mobile Communications) are now widely used to facilitate communication between the in-vehicle transponder and the central control center. Wireless communications tend to have greater data transmission capabilities and require less costly infrastructure.

VEHICLE ENFORCEMENT SYSTEMS

With tolling comes the requirement for enforcement. Effective enforcement increases revenue. Enforcement also raises questions regarding legal issues and there is no uniformity of the legal framework even across Europe.

The vehicle enforcement system (VES) captures images of the licence plates of vehicles which pass through a toll facility without a valid tag or paying the appropriate fee. Video-based digital imaging cameras allow for images to be captured, stored electronically, and sent to remote locations. These devices read plates automatically 24 hours a day, seven days a week and operate at all speeds. They capture vehicles licence plates as they travel in any lane or on the hard shoulder. In addition to the licence plate number, some systems can provide state and country information and compare each potentially violating number plate against a list of registered users.

The lane issues of a VES would be; what will trigger the VES system and how accurate is that trigger? In order to maximise the capture rate of licence plates the trigger position must be precise in all traffic conditions and for all vehicle types. For example, a facility with an Idris AVC system would trigger the VES, typically accurate to +/-15cm for all vehicle types and speeds, from stop-go to high speed. Other AVC systems would use their associated vehicle detection sensor such as lasers.

CONCLUSION

The USA has been tolling for many years now and some of the technologies incorporated into their toll facilities have been in use for over a decade. As tolling starts to push through into the UK we would be well advised to look at some of these long standing facilities as well as any new plaza builds to see what has been achieved in terms of 'what works' and the 'learning curves'! Valuable knowledge already exists and organisations planning toll facilities may consider adapting this knowledge for use in their own tolling development. There are many experts available to offer knowledge on all aspects of the industry from consultants such as US based Traffic Technologies Inc., system integrators like ACS State & Local Solutions, technology providers Peek Traffic Corporation & OSI Laserscan as well as organisations like IBTTA (International Bridge Tunnel & Turnpike Association) that can supply a wealth of knowledge to aide any new tolling venture.

Diamond Consulting Services (DCS) has been involved with the evolution of ETC since the first installation of their tolling technology, Idris, in 1998. The technology, widely used as the Automatic Vehicle Classification (AVC) system for ETC facilities within the USA, was recently specified as the AVC of choice for Illinios in their conversion of mainline toll plazas to open road tolling (ORT).

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