Electronic toll collection for efficient traffic control
Summary

Introduction ............................................................................................................................................. 3
Development of electronic toll collection in different countries ....................................................... 4
Benefits of electronic toll collection ....................................................................................................... 4
Interoperable toll systems and the European dimension ........................................................................ 5
Electronic toll collection and urban traffic control ............................................................................... 6
Electronic toll collection as an instrument of road transport policy ..................................................... 7
Electronic toll collection and the legal issues ......................................................................................... 8
Electronic Road Tolling – looking ahead .............................................................................................. 8
Pan-European Road Tolling Scheme – A Reality? ............................................................................... 8
Tailored solutions from Thales .............................................................................................................. 9
Thales references in conventional and electronic toll collection ......................................................... 9
Electronic toll collection technologies .................................................................................................10
In many countries, road tolling has developed rapidly since motorway construction began in the early 1960s. In France, for example, tolls collected between 1995 and 2003 paid for 7,600 kilometres of new motorway – 80% of the entire network. Tolls also finance major investments in existing networks, improving user safety and comfort and even environmental quality. They provide part of the financing for large projects such as bridges and tunnels, which give motorways some of their key advantages over other roads, be it safety or efficiency. The Millau Viaduct is one example. Since the world’s highest roadway opened in December 2004, motorists have had a more direct route to the Mediterranean coast, avoiding the summer traffic that can bring other roads to a standstill.

The functional concept of a basic toll system is simple: the motorist takes a ticket at the entrance to the motorway and presents it at the tollbooth at the exit. Ticketing and toll barriers can also be placed on each section of motorway. With technological progress, these systems have evolved towards electronic toll collection, allowing traffic to flow more smoothly and improving service to both users and operators.

With continued motorway construction and growing traffic volumes, toll collection has evolved in three main market segments:

1. Electronic toll collection to eliminate the need for manual operations and make life easier for motorists.
2. Congestion charging to relieve urban congestion and pollution and collect tolls for zone-based rather than route-based usage.
3. Use of advanced technologies to support ambitious new transport and pricing policies.
Development of electronic toll collection in different countries

Electronic toll collection, which allows motorists to pay tolls without stopping, has developed in different ways around the world.

Two types of systems are currently in use. The first is the single-lane system used in France and in Southern European countries such as Italy, Spain and Portugal. The second, known as the free flow system, simultaneously manages several lanes, electronically collecting tolls from cars as they pass beneath an overhead gantry. This system is used in the United States, Australia, Canada, Chile and Israel, among other countries.

The free flow system is technically more complex, but the principle is the same for both systems. Data are exchanged between a DSRC (Dedicated Short Range Communications) microwave or an infrared beacon installed above road level and a tag or badge in the motorist’s car. The badge contains all the information necessary for the transaction, i.e., details on the contract between motorist and motorway operator, and previous toll point identification.

At the entrance to the motorway, the beacon verifies the driver’s contract, records the point of entry in the badge and opens the gate. At the exit, the system reads the information in the badge, identifies the contract, calculates the amount due, opens the gate and transmits the payment data. Tolls can be paid on a subscription basis or motorists can opt for a monthly bill.

In a free flow system, there are no lane separators and therefore no gates. On each motorway segment, data are exchanged between beacons and badges in all lanes at once. Vehicles don’t even have to slow down. If a vehicle does not have a valid contract, the system recognises its licence plate automatically and the toll is collected later.

Benefits of electronic toll collection

Electronic toll systems, like conventional toll systems, generate funds for building and maintaining roads. They also offer a number of additional advantages. For example, they improve traffic flow by significantly reducing delays at the toll booth. In one hour, an electronic system allows 500 vehicles per lane to pass (1,800 in free flow) compared with just 200 for conventional systems. In addition, the transaction is much simpler for the user because it is entirely automatic. Electronic toll collection systems used today are very reliable: they have an error rate of less than 0.01%.

By making traffic more fluid and avoiding bottlenecks, electronic toll collection helps reduce the number of accidents and improves the environmental impact. It also eliminates risks inherent in transferring funds because no cash is involved.

The benefits of road tolling are varied but achieving widespread popular support for the introduction of tolling solutions can nevertheless be challenging. In many European countries the public’s reticence to accept road user charging needs to be addressed. However there is evidence that public perception of road user charging is slowly changing. Recent public opinion surveys in Europe have indicated a general recognition of the need for tariff-based solutions to address the ever-increasing problems of congestion and road maintenance. In some countries such as The Netherlands, Norway and Sweden, there is growing political support for road tolling.
Interoperable toll systems and the European dimension

Some countries have taken steps to make the electronic toll systems of different operators interoperable. Current and future efforts in this direction will be coordinated within the framework of the 2004 European directive on European transport policy.

With France’s TIS (Télépéage InterSociété) initiative, introduced in 2000 and commercially branded as Libé-T, all French motorway operators – ASF, Cofiroute, Escota, Sanef, SAPN, SAPRR – offer their users the same badge for use on any motorway in France. At the end of 2004, the TIS system had over 1.2 million subscribers.

TIS is technically similar to the other systems described above, but it also provides the motorway operators with clearing and settlement solutions. A few tenth of milliseconds is all it takes for information to be transferred between tag and antenna. Technically speaking, data could be exchanged with a vehicle travelling at over 130 km/h (80 mph), but gates are installed for legal reasons, forcing motorists to slow down nearly to a halt.

However, the overriding challenge will be how to address the issue of interoperability of road charging between all the different European countries. To this end, the Road Charging Interoperability (RCI) project has been set up. It is tasked with running trials and demonstrating interoperability between six reference environments – Austria, France, Germany, Italy, Spain and Switzerland. The RCI will develop an open integrated framework enabling road charging interoperability at the technical level. It will be financed by the European Commission and is due to be completed by the end of 2007. The main result of the RCI project will be a set of standards that will help the European Commission define the European road charging service.

While electronic toll collection continues to develop in Europe and the United States, the biggest growth potential is in Asia (China, Thailand, India or Australia) and South America (Brazil, Chile). Asia suffers from similar problems to Europe in terms of lack of infrastructure funding and growing congestion in cities. However, Asia is generally more open to trying out the latest technology, in part to support fast economic growth in urban areas. Many public transport networks are, for example, already using contactless smart cards, at least in the large cities. As a result, widespread convergence of public transport and tolling is most likely to occur in Asia first, rather than any other region in the world.
Electronic toll collection and urban traffic control

There were 850 million private and commercial vehicles worldwide in 2005, and that number is continuing to rise sharply, particularly in previously under-equipped countries such as Brazil, China and India.

In France, the number of cars has increased by 120% in 30 years, to a total of 36 million private and commercial vehicles in 2005 (source: Info Parc Auto France). The private car is fast becoming the preferred means of transportation in every country on the planet. Particularly in urban areas, controlling or limiting the use of the automobile is a growing priority for governments and planners.

The first congestion charging system – toll collection to control city traffic – was set up in Singapore in the 1990s using Japanese free flow technology.

More recently the City of London has launched an ambitious urban taxation programme aimed at reducing traffic in the city centre by approximately 15%. The system has been in operation since February 2003 and has been generally successful in attaining its traffic goals in terms of reduction of flow.

Approximately 800 video cameras have been placed at entrances to and inside a 22 km² area of central London. The cameras recognise vehicle license plates and automatically compare them with a database of numbers for which a toll has been paid. This system has no gates or tollbooths and was chosen to avoid wasting motorists’ time as they drive into the city.

Subscribers can pay their tolls online, with a text message from a mobile phone, by regular telephone, mail or in certain shops.

In addition to cutting back on traffic, the London toll has also considerably improved the city’s environment by reducing levels of carbon dioxide in the atmosphere. The programme is part of a comprehensive policy encompassing public transport, traffic management and parking.

Transport For London, the integrated body responsible for the capital’s transport system, is already considering a more sophisticated system that combines DSRC technology (beacons and tags) for regular users with automatic licence plate recognition for occasional users. It would improve the current system efficiency and accuracy which is limited by the state of the art in video processing and license plate recognition.

<table>
<thead>
<tr>
<th>Transportation</th>
<th>1997</th>
<th>2002</th>
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<tr>
<td>(in billions of passenger-kilometres)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cars</td>
<td>660</td>
<td>734</td>
</tr>
<tr>
<td>Buses</td>
<td>042</td>
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<tr>
<td>Trains</td>
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<td>081</td>
</tr>
<tr>
<td>Airplanes</td>
<td>013</td>
<td>015</td>
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(Source : CCTN)
Electronic toll collection as an instrument of road transport policy

With increased circulation of people and goods throughout Europe, transport policies now need a European dimension. This is the logic behind the European Commission’s white paper “European transport policy for 2010: time to decide”. The 2004 electronic toll collection directive based on this white paper recommends an interoperable electronic toll collection system covering all toll roads in Europe, and sets out the conditions needed to make this system a reality. For example, the technologies adopted for the interoperable system should be capable of covering all types of infrastructures (roads, tunnels or bridges) as well as all types of vehicles (commercial vehicles, private cars, or motorcycles).

Increasingly sophisticated techniques are being developed to meet these complex needs.

In addition to controlling and reducing road traffic, electronic toll collection technologies can now be used to implement transport and pricing policies based on actual use. This is one of the thrusts of the European Commission’s strategy, and some countries have already begun to move in this direction by applying tolls based on the number of kilometres travelled in a given geographic zone – a practice known as ‘road user charging’ or RUC. The principle of raising funds according to the infrastructure usage rather than through a set of public taxes should help to boost public acceptance of the strategy.

Since January 2001, Switzerland has applied a distance-based tariff to all trucks using its roadways. Swiss trucks are equipped with a dashboard device that uses both tachography and GPS geo-location to reliably measure distances travelled. Sixty thousand vehicles are now equipped with the system. Foreign trucks are not required to install the device, however: drivers declare kilometres when entering Switzerland and pay tolls at customs when leaving.

On 1st January 2005, Germany set up a special toll collection system for trucks weighing over 12 tons, which is now fully operational. It is based on GPS geo-location and a digital map of the country’s entire motorway network, and beacons have been installed in certain zones to improve accuracy and reliability. As in Switzerland, occasional users will declare the number of kilometres travelled and pay a charge based on usage.

Similar initiatives in other European countries – the Austrian system, in operation since January 2003, for example – illustrate how toll payment systems are becoming a pivotal tool in all transport policies.
Electronic toll collection and the legal issues

Whilst there is no doubt that the technology exists to enable a pan-European road tolling scheme, in many instances, the technological solutions are ‘jumping ahead’ of other issues that must be taken into consideration, notably legal ones. European tolling schemes can only exist if they are supported by an effective enforcement system. The European Commission has concluded that there is much work still to be done to harmonise European legal enforcement systems. A legal problem in some member states is the inability to install free flow tolling systems, as these systems use automatic number plate recognition (ANPR) for enforcement purposes and the use of ANPR by anyone other than the police is currently illegal. EU projects have started to look at such issues, but Europe still has a long way to go to address the problem in full. In the long-term, the solution will involve the modification of national laws, and in some cases of the constitutional issues, so there is no ‘quick-fix’.

Electronic Road Tolling – looking ahead

The Continuous Air-interfaces Long and Medium (CALM) architecture and its protocols are being proposed for the international standardisation of next-generation telematics. It would allow IT solutions and services, such as navigation, safety and road-tolling applications, to be provided directly to car drivers through a number of wireless media systems. The communication platforms are factory-fitted by the vehicle manufacturers directly into the cars and will start being used when this technology is fully mature.

Whilst this universal technology platform works in theory, it can only work in practice if the vehicle manufacturers are willing to go down this route. Today, the car industry does not see the value of building such devices into cars, for several reasons, the most prominent being the lack of a stable business model for most of the expected services.

Pan-European Road Tolling Scheme – A Reality?

The drivers for a pan-European road tolling system are present: there are huge needs for road infrastructure funding, particularly in Eastern Europe, and for congestion charging, especially in Western Europe. There is little doubt that a tolling and tax system will be introduced but whether it will be truly pan-European remains open to question. The main challenges will be standardisation of the technology and ensuring that this standardisation occurs quickly enough before individual countries invest too heavily in their own solutions. Broad political support from national political parties will also prove valuable necessary if the scheme is to succeed. However, should a pan-European scheme fail, tolling and tax systems will, at the very least, exist on a national level.
**Tailored solutions from Thales**

Thales is one of the world’s leading players in the field of electronic toll collection. Unlike many competitors, the company offers proven expertise in all the different technologies required to set up an electronic toll collection system, and has direct access to all the necessary building blocks, from DSRC radio link to billing and CRM software solutions.

In the field of electronic toll collection and DSRC technologies, these building blocks are part of the Thales Interoperable Line of secure, multi-operator products including vehicle tag, microwave beacons, communications gateways and badge management terminals.

Thales is also one of the world’s leading suppliers of satellite-based positioning GPS systems for both professional markets such as vehicle fleet management, and consumers (Magellan brand GPS receivers). Based on this expertise, Thales electronic toll collection solutions can incorporate GPS geo-location capabilities, and will ultimately also include Galileo satellite navigation services. Thales is a key player in one the consortia chosen to develop and operate the Galileo system.

With proven results in the two main technologies underpinning future electronic toll collection systems – DSRC and geo-location – Thales is in a position to offer its customers mix-and-match solutions that really meet their specific needs.

Thales leverages a unique combination of system design, implementation and operation capabilities for complex and secure systems (including billing and CRM software solutions) to provide turnkey solutions for both large urban congestion charging systems and country-wide road user charging schemes.

**Thales references in conventional and electronic toll collection**

Thales has provided toll collection equipment of all types for over 4,000 lanes on some 30 motorways throughout the world. One of the best illustrations of the company’s experience in this field is the TIS (Télépéage Inter Société) project, one of the largest interoperable electronic toll collection system in the world. The system provides any motorist with a Liber-T badge on the windscreen with direct, cashless access to any French motorway. Thales installed nearly 2,500 microwave beacons and provided over 325,000 badges for the TIS project, which involves all the French motorway operators, including ASF, Cofiroute, Escota, Sanef, SAPN and SAPRR.

Other important projects have been carried out in Spain, Belgium and Croatia. In North America, Thales equipped motorways operated by Capufe, the company that manages public motorways in Mexico.
Electronic toll collection technologies

**DSRC**
Dedicated Short Range Communications (DSRC) use microwave, or sometimes Infrared technology to transmit data over short distances between motorway systems and mobile units. Operating in the 5.8 GHz frequency range, the microwave DSRC data transmission technology is similar to the technology used in RFID smart tags, which will replace bar codes at some future time.

**GPS**

GPS is the geo-location system developed by the United States and first used in the 1980s for military applications. At the end of 1993, the US Department of Defense made the technology accessible to civilian users, and GPS is now used throughout the world for geo-location, positioning and navigation. Europe is developing its own geo-location system, Galileo, which is expected to be operational in 2008. Galileo will use a constellation of 30 satellites orbiting at an altitude of 24,000 km. It will be more precise than GPS and will also offer a number of other benefits to subscribers.

**GSM**

GSM (Global System for Mobile communication) is a digital mobile telephone system that has become wireless telephone standard in Europe. In the 1980s, prior to standardization, numerous systems were in use, for example, Radiocom 2000 systems in France, NMT 450 in the Benelux and Scandinavian countries, TACS in Britain and C-Netz in Germany. Standardisation around GSM technology was the catalyst for the cell phone’s immense success in Europe. In September 2001, the number of French mobile phone subscriptions surpassed the number of regular telephone lines in France. In electronic toll systems, mobile phone technologies can be used for payment transactions, be it through SMS/GSM or GPRS / Edge.

**Digital tachography**

Tachographs are installed in trucks weighing over 3.5 tons, as well as in vans and buses with more than 9 seats. Similar to the “black boxes” installed on aircraft, tachographs are used to verify drivers’ compliance with regulations, for example by recording the distance driven in a given period of time. Most tachographs still rely on analogue technology, with the data recorded on a paper disk. Forthcoming European regulation will require all new vehicles in this category to be equipped with digital tachographs from August 2006 and will apply to approximately 300,000 vehicles each year. A number of non-EU member states, including Brazil, India and the countries of North Africa, are also expected to adopt the same rule.