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Toll Collection Technology and Best Practices

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Abstract: In this research product, tolling practices and technologies are presented. Likely developments and enhancements are reviewed, along with potential tie-ins to other Intelligent Transportation Systems (ITS) deployments. Ultimately, this research project will develop recommendations for vehicle identification/registration systems with the potential to link the tolling function to other desirable transportation system management functions.

Keywords: Tolling, tolling practice, electronic toll collection, tolling technology.

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Introduction

Tolling as a method of financing the transportation system is becoming more common in the United States. Neither the traveling public nor State Departments of Transportation want vehicles to stop or slow down to pay to use a toll facility. To this end, several technologies, collectively called Electronic Toll Collection (ETC), have been developed in the last 15 years, allowing drivers to move in and out of toll systems without delay. Open Road Tolling (ORT), with all-electronic toll collection, is now the preferred practice, being more efficient, environmentally friendly, and safer than manual toll collection.

In this research product, tolling technologies and practices are discussed. Likely developments and enhancements are reviewed, along with potential tie-ins to other Intelligent Transportation Systems (ITS) deployments. Ultimately, this research project will develop recommendations for vehicle identification/registration systems with the potential to go beyond the tolling function to include other desirable transportation system management functions.

Section 1: Tolling Practice

In this section the motivations for tolling, expected evolution of tolling systems, and the benefits and costs of tolling are reviewed.

1.1 Objectives of Tolling

There are three main reasons why tolling, or road pricing, is implemented (Wikipedia: Road Pricing, 2006):

- *Finance/Revenue Generation*: To recoup the costs of building, operating and maintaining the facility. Road pricing is becoming a more appealing means of funding transportation, since revenues from federal and state gas taxes have not kept up with growth in demand for infrastructure. Moreover, toll financing allows projects to be built sooner instead of waiting for tax revenues to accumulate.
- *Demand Management*: To moderate the growth in demand on the transportation system, and to encourage more use of public transportation and carpooling. For example, vehicles are charged to enter inner London, England, as a way of regulating the demand in the region.
- *Congestion Management*: To place a price on limited roadway space in proportion to demand. In this application the toll increases with the level of congestion. In the absence of such pricing, drivers do not appreciate the costs they impose on others as a result of the congestion they cause.

1.2 Evolution of Tolling

Roadway tolling is expected to become more pervasive over time. Four stages are envisioned as shown in Table 1.1, beginning with corridor tolling and cordon tolling, then area-wide or vehicle-miles-traveled (VMT) tolling, and ultimately an integrated system management strategy (Deloitte Research Public Sector Study, 2003). Each stage improves system efficiency over the previous one, but also has higher complexity. Each stage also requires certain conditions before implementation. Only the first two strategies, corridor tolling and cordon tolling, have been widely implemented, with ETC being a necessity to move to the next two stages. The third stage is now being pilot tested in a few areas (discussed later), while the final stage, an integrated system, lies in the future.

Table 1.1: Stages of Tolling

Tolling strategy over time	Objectives	Complexity/ efficiency	Required conditions
1. Corridor tolling	Repayment for facility	Low	Road must be exclusive to those who pay
2. Cordon tolling	Demand management	Medium	Public trust that benefits will outweigh costs
3. Area-mileage tolling	Revenue generation	High	Uniformity/interoperability
4. Integrated system management	Demand/ congestion management	Very high	Flexibility across modes; access to information

- *Corridor Tolling*: This is the most common form of tolling, in which a driver pays a fee to use a specific stretch of roadway or bridge. High Occupancy Toll (HOT) lanes, lanes designated for multi-passengers but which single-occupant vehicles can use if they pay a toll, are also included on this category. The primary objective of the toll is to repay the cost of building and operating the facility. Complexity can be as low as having the driver stop and pay cash on entry, although most systems are implementing ORT. However, the corridor is likely to be underused compared to alternative non-tolled routes and may not relieve congestion in a region. The road must be exclusive to those who pay, otherwise users do not feel compelled to pay and the program may not earn adequate revenue.
- *Cordon Tolling*: This is a charge for entering a specific area. The primary objective is to reduce the number of vehicles entering. Every entry point must be equipped with means of identifying vehicles and ensuring that they pay, have paid, or will pay. To be an effective strategy, the public must be convinced that benefits (improved mobility, lower pollution, etc.) will be realized fairly quickly. An efficient public transportation system is essential for this strategy to be effective.
- *Area-wide Mileage Tolling*: This is a mechanism whereby vehicles are charged based on VMT—a road user fee. An example of this system is the German truck toll, in which all trucks are required to pay tolls based on the distance traveled inside Germany. In some respects this strategy is analogous to the U.S. gas tax, in that, theoretically, each vehicle pays based on miles driven. The primary objective is to generate revenue for the transportation system and, to a lesser degree, to regulate the amount of driving. The complexity of distance-based tolling is relatively high and requires uniform application area-wide, as well as interoperability across borders.
- *Integrated System Management*: In this visionary concept, demand for transportation would be managed through information: users would have a choice of modes and routes and an array of ways to pay for a trip. The charge would incentivize the most efficient

transport choice and the market would drive the provision of capacity. Highly complex systems, such as roadside-vehicle-traveler communications would be required, but system usage is expected to be highly efficient. Required conditions include market flexibility and access to information.

1.3 Benefits and Costs of ETC

Electronic toll collection is now the preferred mechanism for tolling. Details of ETC technologies will be discussed in Sections 2 and 3. Benefits and costs are reviewed here.

1.3.1 Benefits of ETC
Among the benefits of ETC are:

- ETC lanes improve the speed and efficiency of traffic flow and save drivers time. Manual toll collection lanes handle only about 350 vehicles per hour (vph), and automated coin lanes handle about 500 vph. An ETC lane can process 1200 vph, with ORT lanes allowing up to 1800 vehicles per hour (Tri-State Transportation Campaign, 2004).
- As a result of better flow, congestion is reduced, fuel economy is improved, and pollution is reduced.
- Increased revenue: time savings, faster throughput, and better service attract more customers, thus increasing revenue.
- Reduced accident rates/ improved safety because of less slow-and-go driving.
- Increased efficiency of roads because of better distribution between tolled and non-tolled routes.

Two benefits of open-road tolling are especially noteworthy (Tri-State Transportation Campaign, 2004):

- <u>Safety benefits:</u> Generally, ORT facilities are nearly accident-free. ORT allows vehicles to travel at normal highways speeds, avoiding dangerous stop-go traffic and sudden merges, and eliminating the danger of drivers jockeying for lane position. ORT can also cut down on the distractions toll payers face while driving, such as fumbling for change or having to slow down or stop to pay the toll.
- <u>Economic Benefits:</u> Delays cause losses to both the driver and the overall economy. Drivers suffer direct costs of increased fuel consumption and vehicle wear and tear owing to idling and stop-and-go movement, as well as indirect costs of stress. Valuable time is spent in traffic instead of productive work. Delays also drive up the cost of shipping goods—a cost usually passed on to the consumer. ORT reduces delays and thus provides economic benefits.

1.3.2 Costs of ETC
There are several costs in implementing an ETC system. Among the major costs are:

- <u>Toll Agency Costs:</u> According to a 2002 study by the California Center for Innovative Transportation, the cost per transaction of an ETC system is between $0.05 to $0.10 (Smith, ITS Decision, 2002). A manual toll cost per transaction is $0.35 to $0.45. Not only are the costs per transaction usually lower in an ETC system, the number of transactions is far higher than in a manual system. Additionally, the number of people required to operate an ETC system is far fewer than required for a manual toll collection system. Overall costs per transaction, therefore, shrink significantly. Oklahoma Turnpike, one of the first U.S. highways to use high-speed toll plazas, saw a 90 percent reduction in collection costs on ETC lanes.

- Costs to the User: Most systems which have implemented ETC require motorists to buy or rent the equipment. In addition to the cost of the system, the motorist is also 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.
- Initial Sunk Costs: The initial costs of implementing ETC or converting a manual toll facility into an ETC can be quite high. There are also significant operational and maintenance costs to an ETC system that are difficult to predict or to figure into present worth calculations.
- Implementation and Operation Challenges:
  - Insufficient knowledge of ETC technology by consumers who fear their movements will be 'tracked'.
  - Political disinclination, also mainly because of ignorance about ETC technology, as well as a desire to avoid antagonizing voters who have a misguided notion of ETC.
  - Interoperability issues between different systems which raise costs.
  - Reconstruction of highways to include ORT lanes, build gantries, or dismantle existing manual toll collection booths.
  - Non-paying users—because of minor shortcomings of ETC technology, some users may slip through the system without paying.

1.4 Deployment of ETC in the U.S.

ETC has become the wedge for deployment of Intelligent Transportation Systems (ITS) in the U.S. In 1996, the U.S. Department of Transportation (USDOT) outlined a vision to achieve a complete ITS infrastructure in the country's seventy-five largest metropolitan areas within 10 years. As of 2004, according to USDOT, sixty-two of seventy-five metropolitan areas had met the USDOT's goals for ITS deployment, largely by implementing ETC.

At the 2006 Transportation Research Board Annual Meeting, a major theme of discussion was ETC implementation and the interest shown by private firms. The ETC market is expected to experience double-digit growth in the next decade and increasingly, investors see infrastructure tolling as a business opportunity.

There have been several recent high profile infrastructure privatization initiatives:

- The $2 billion lease of the Toronto 407ETR by the joint venture team Macquarie Infrastructure Group of Australia and CINTRA of Spain.
- The $3.8 billion lease of the Indiana Toll Road by the same joint venture.

- The recent $1.83 billion Chicago Skyway lease by the same joint venture.
- The announcement by Harris County officials, Texas, that they will study the sale or lease of the 83-mile system of the Harris County Toll Road Authority for a deal potentially worth up to $7 billion.
- The CINTRA bid of $7.2 billion for the (TTC-35) Trans Texas Corridor.

Section 2: Mature Tolling Technologies

In this section, technologies that are already widely deployed to support ETC are discussed.

2.1 Components of ETC

Electronic toll collection requires several components in order to complete a transaction. The two most important components are vehicle recognition and account identification. Vehicle recognition may be accomplished through in-road and overhead sensors, cameras, vehicle-to-roadside communication, or combinations of these. Where vehicles are charged differently according to class, vehicle classification is part of vehicle recognition. Account identification is accomplished by tying the vehicle ID to a user account, usually through a relational database.

2.1.1 In-road Sensors:
Sensor systems may be subsurface, roadside or overhead. Inductive sensors embedded in the road surface can determine the presence of a vehicle. Treadles register a count of the number of axles as a vehicle passes over them and, with offset-treadle installations, also detect dual-tire vehicles. Light-curtain laser profilers (Figure 2.1) record the shape of the vehicle, which can help distinguish trucks and trailers. Sensors can also detect gaps between vehicles to provide information on the number of vehicles crossing a location.

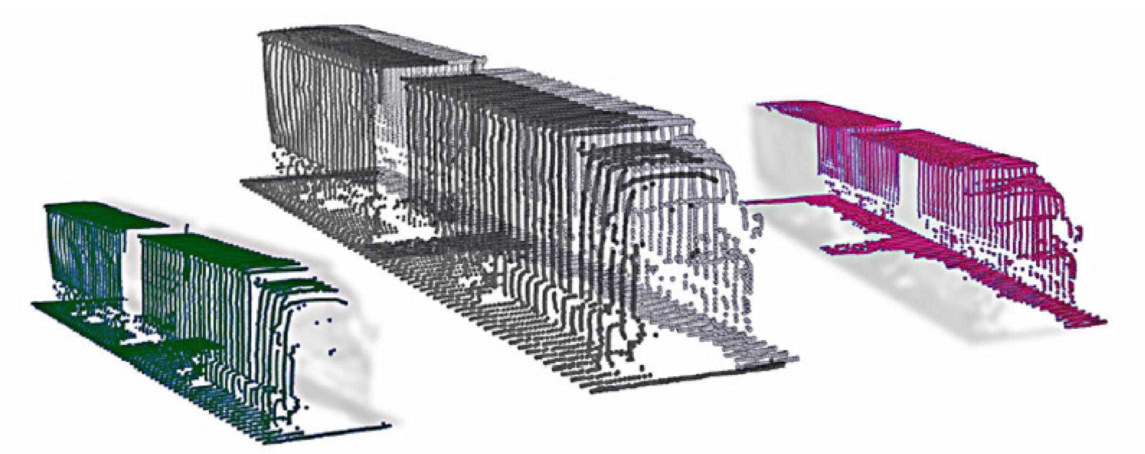

Figure 2.1 Light curtain laser profilers used in Germany (Vitronic brochure, 2004)

One example of an in-road sensor system is Traffic Reporting and Control (TRAC), which combines state-of-the-art inductive loop detection with advanced signal processing (Smith, ITS Decision, 2002). The TRAC system can perform pre-classification in both manned and unmanned toll lanes. It can also be used for post-classification for toll enforcement. The whole classification process takes 0.1 seconds. The TRAC system is packaged within a standard inductive loop detector, which:

- Identifies vehicles in twenty-three classes
- Accurately detects single-loop speeds
- Measures vehicle length and number of axles
- Provides point, toll segment, and toll regional view of traffic flow
- Provides web access to all data

2.1.2 Overhead Cameras

The use of overhead cameras for vehicle identification in tolling is referred to as video tolling (Figure 2.2). Video tolling is done by means of license plate identification/ recognition (LPI/R). As a vehicle passes through, cameras on overhead gantries take a picture of the license plate. Optical Character Recognition (OCR) software is used to *read* the picture of a plate, and the number is checked against a database to find the owner associated with the vehicle. Video tolling is usually used in conjunction with other systems as a means of enforcement for non-toll account vehicles.

Figure 2.2 Video Tolling

Despite its wide use, LPI/R has some shortcomings:

- Poor image resolution, usually because the plate is out of focus.
- Blurry images, particularly motion blur, most likely at higher vehicle speeds.
- Poor lighting and low contrast due to overexposure, reflection, shadows, or plate background color or style.
- An object obscuring (part of) the plate, quite often a tow bar, or dirt on the plate.
- A different font, as in out-of-state plates and vanity plates.
- Different plate styles, as in Federal vehicles.
- Circumvention techniques (such as reflective plates).

An example of a video vehicle identification system is TollChecker, the automatic toll charging mechanism for trucks on German highways (Vitronic brochure, 2004).

- The TollChecker captures 3-dimensional data and reads license plates regardless of lane changes and the speed of the vehicle.
- The TollChecker identifies the class of the vehicles and ascertains whether each has to pay a toll, and whether each has paid the correct amount.
- All the data for trucks that have paid the toll or vehicles that are not required to pay the toll are deleted immediately.
- It works in conjunction with both global positioning systems (GPS) and Dedicated Short Range Communication (DSRC).

Key features of the TollChecker:

- Single gantry solution: set up requires only 15 minutes shut down of lane and no sensor loops are needed.
- Determination of weight/axle count/ trailer detection: can measure accurate length, height, width, etc.
- Supports advanced enforcement such as online communication for special bookings.
- Safety:
  - Fully ORT compliable
  - No visible lighting to distract driver, even at night.
- International license plate recognition.
- Seamless integration with GPS and DSRC.

LPI/R manufacturers have touted additional uses for their technology other than for tolling. In commercial vehicle operations or secure-access control, a vehicle's license plate can be checked against a database of acceptable ones to determine whether a truck can bypass a weigh station or a vehicle can enter a restricted area. At international border crossings, license plates can be checked against a database of hot cars to locate stolen vehicles and plates or those registered to fugitives, criminals, or smuggling suspects. For example, the Mexican state of Jalisco recently instituted a vehicle sticker ID system with printed optical characters to help in identifying stolen vehicles.

LPI/R can be used to issue violations to speeders or simply to offer speeding drivers a reminder by displaying a plate number with the vehicle's speed on a variable messaging sign. It can facilitate emissions testing by recording a plate's alphanumeric sequence while automatically analyzing tailpipe effluents, or it can help identify and fine violators. LPI/R also can monitor the time it takes vehicles to travel from one point to another, keeping traffic management centers apprised of transit times along busy streets and highways.

2.1.3 Vehicle to Roadside Communication

Transponders have become the most common form of vehicle identification. In this technology, a radio-frequency identification (RFID) chip is embedded in a unit or sticker, called an electronic tag, which is mounted on the windshield near the rearview mirror of the vehicle. As the tag passes under a gantry with a mounted transmitter, it responds to radio signals (Figure 2.3). Laser and infrared signals have also been tested but the radio frequency spectrum provides the greatest level of accuracy. However, some windshields coated with metal do not allow the electronic tag to be read. The percentage of cars with such windshields is very low and is thought to affect only about 0.5 percent of all vehicles.

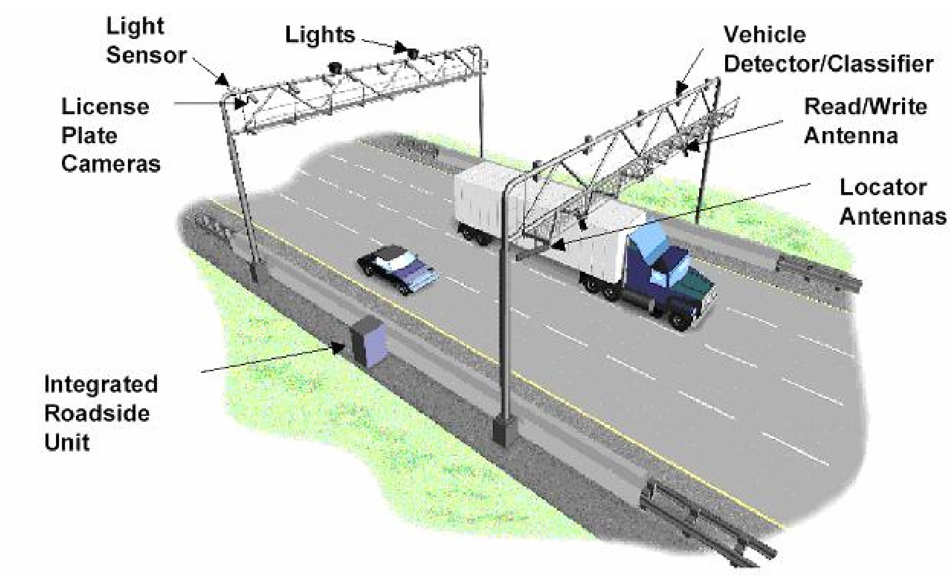

Figure 2.3: Electronic vehicle recognition by transponder

Programmability: Electronic tags can be classified according to the degree to which they can be programmed (Smith, ITS Decision, 2002):

- Type I: The chip does not have any processing capabilities and the information on it is fixed (read only)—usually just a hard-wired identification number.
- Type II: These chips have an updateable area which can be used to encode information such as time and point of entry.
- Type III: These tags contain a microprocessor. They can be used to communicate such information as account balance, and driver and vehicle information to roadside or overhead sensors. Type III tags are also called "smart" tags.

Power: Tags can also be classified by power source (Smith, ITS Decision, 2002):

- Passive: Passive RFID tags have no internal power supply. Incoming radio frequency signals are detected by the antennae, which power up the tag and transmit a response. Having no onboard power supply means that the tag can be very small, although the amount of data stored in them is also very small.

- Semi-Passive (or Semi-Active): these tags are similar to passive tags but have a battery which allows the tag to be constantly powered. Semi-passive tags respond faster and have a stronger reading than passive tags.
- Active: These tags may be connected to the vehicle power source. They are able to store more information and also receive and store additional information sent by roadside communications units. They also have a much greater range.

2.2 Enhancements

2.2.1 Interoperability

A major concern regarding electronic tags is the degree to which they are interoperable with tags from other regions. If there is to be an area-wide tolling program, a single tag must work in all jurisdictions. This is not the case with most systems. Table 2.1 shows tag operations in the U.S. currently and those that provide interoperability.

Table 2.1: Toll Tag Systems in the U.S. and Interoperability

(Source: Wikipedia)

Tag System	Jurisdiction	Interoperable with:
C-Pass	Key Biscayne, Florida	
Cruise Card	Atlanta, Georgia	
E-PASS	Orlando, Florida	SunPass
EXpressToll	Colorado	
E-ZPass	U.S. Northeast	
Fast Lane	Massachusetts	E-ZPass
Fastrak	California	
I-Pass	Illinois	E-ZPass
K-Tag	Kansas	
LeeWay	Lee County, Florida	SunPass
MnPass	Minnesota	
O-PASS	Osceola County, Florida	SunPass
PalmettoPass	South Carolina	
Pikepass	Oklahoma	
Smart Tag	Virginia	E-ZPass
SunPass	Florida	SunPass
TollTag	Texas	TxTAG
EZ TAG	Texas	TxTAG
TxTAG	Texas	EZTAG, TollTag

American Traffic Solutions plans to introduce the PlatePass®, which it says will do away with transponders (*NY Times* article, 01.10.06). The idea is that the customers would have information stored in the PlatePass database. American Traffic would then share that data with toll authorities across the U.S. Customers will be able to drive through any ETC lane without the use of a transponder. Instead of registering them as violators, the electronic toll system would scan the PlatePass, look up the customer on the database and charge the owner's credit card.

2.2.2 Rental Tags

The rental car industry is considering renting out toll tags to its customers (*NY Times* article, 01.10.06). They have found that rental car customers do not object in principle to paying tolls, but do object to having to wait in line to pay them because the car does not have a tag. Budget Rent A Car gives the option of renting a transponder for 99 cents a day, tolls not included.

2.3 Best Practices in ETC

In this section, two examples of best practices in ETC are presented.

2.3.1 Toronto 407ETR in Canada

The Toronto 407ETR is one of the most sophisticated toll roads in the world in terms of ETC (Figure 2.4). Tolling is entirely electronic, and there are no manual tolling lanes or booths (407 ETR, FAQ). Tolls are based on the number of kilometers traveled. The 407ETR ETC technology combines transponders with video enforcement. The tag readers poll the vehicle as it approaches the gantry to triangulate vehicle trajectory, get the best read, and minimize errors.

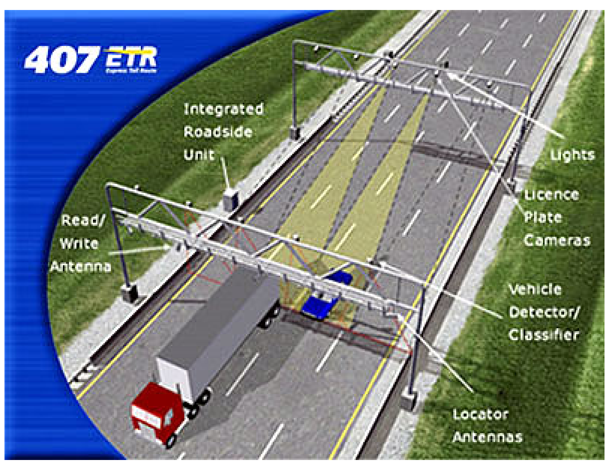

Figure 2.4 ETC on the Toronto 407ETR Highway

There are two types of transponders in use in the system: one for regular vehicles and the other for vehicles with a gross weight over 5 tons. Transponders are the property of the 407ETR and are leased for Canadian $2.15 per month or $21 per year. Using a transponder saves the customer the $3.50 video toll charge per trip. All vehicles using the 407ETR are required to be registered with the 407ETR authorities. If a person is not registered and drives on the 407ETR, the license plate number is taken and sent to the Ministry of Transportation in order to get vehicle information and classification for billing purposes. Scofflaws may have their vehicle registration revoked. If a vehicle is not registered, public sources are used to find addresses.

The customer information collected and retained on records includes:

- Name
- Mailing address
- E-mail address
- Telephone number
- Vehicle plate number
- Driver's license
- Transaction history

The 407ETR does not share information with third parties except:

- It is a legal requirement.
- There is a serious emergency situation.
- With collection agencies for the purpose of collection on past accounts.
- For commercial reasons, such as surveys, etc.

The following types of vehicles are exempt from tolls:

- Law enforcement
- Fire fighting
- Ambulances/medical services
- National defense
- Diplomatic vehicles

Some other facts about the 407ETR are (TollRoad News: IBTTA Conference, 2005):

- 77 percent of transactions are now by transponder (up from 65 percent in 2000)
- 650,000 transponders support about 230,000 transactions per day
- the customer service center has 140 seats (versus forty at privatization)
- customer service calls have declined from a peak of 160,000 per month in 2003 to 70,000 in April 2005
- Optical Character Recognition (OCR) software, roadside processing, and cameras and their housings are being upgraded
- all vehicles owned by the toll agency, including ice and snow units, are being tracked by GPS and their movements are being logged to improve efficiency and provide better evidence in case of criticism or lawsuits
- problems with vehicle classification (based on laser profilers) are being addressed
- images of non-payers are being kept longer to establish a databank

- police working on enforcement now have transponder readers in their vehicles
- roadside signs warning that rear license plates must be visible have reduced violations by plate obscuration
- training and better equipping of police have increased prosecutions
- safety has been addressed by improving traction at several places and accidents have been reduced

The Toronto 407ETR has an impressive collection rate. A concerted, multi-faceted effort at cracking down on violators over 4 years has seen the percentage of "unbillables" go from about 8 percent in 2000 to about 3.1 percent in 2004. There is also discussion of switching from the current system of flat rates per-km to differential toll rates in different segments of the 41-interchange pike, with higher per-km tolls for the busier sections.

2.3.2 London Cordon

A best practices example of video tolling is the London Congestion Charge Scheme (Wikipedia: London Congestion Charge, 2005). The program requires motorists entering the 22 square km of the Central London area (Figure 2.5) to pay a fee. Singapore was the first city to adopt congestion charging in 1998, (followed by others, including Bergen and Trondheim), but as of 2006, London is the largest city to do so. The organization responsible for administering the charge is Transport for London (TfL).

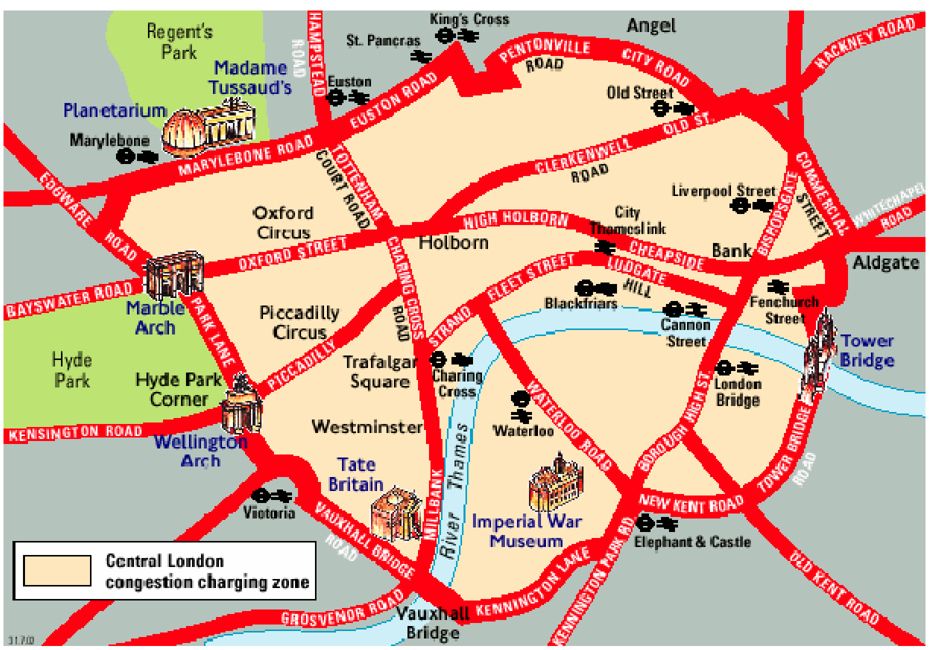

Figure 2.5: The city of London, England, showing the toll cordon

London currently relies exclusively on LPI/R technology for vehicle identification. There are 230 CCTV-style cameras, which are able to monitor approximately 98 percent of all vehicles inside the zone. One hundred eighty of these cameras are lined along the edge of the congestion zone. Fifty others are placed within the zone to capture the vehicles not picked up by cameras at the edge or those vehicles moving exclusively within the zone. Mobile camera units are also deployed within the zone. The video streams are transmitted to a central data center, where a computer system equipped with OCR software detects the registration plate of the vehicle. A second data center provides a backup location for image data. This list is then compared with a list of cars whose owners/operators have paid to enter the zone. Those that have not paid and are seen are fined.

The daily fee of £8 must be paid by the registered owner of a vehicle that enters, leaves, or moves around within the Congestion Charge zone between 7 a.m. and 6:30 p.m., Monday to Friday. If the charge is not paid by 10 p.m. on the day of travel, the charge is increased to £10: this is intended to cut the number of last-minute payments. Failure to pay by midnight results in a fine of at least £50. Businesses are given a special rate of £5.

The main aims of the project were to:

- reduce congestion by reducing the number of private vehicles entering the city and encourage the use of public transport, bicycles, etc.
- make the distribution of goods and services more reliable, sustainable, and efficient.
- improve journey time reliability for car users.
- make radical improvements in bus services.
- generate revenues to improve the transport in London more generally.

According to a study commissioned by the TfL, 6 months after the scheme was implemented, traffic delays had decreased 30 percent inside the congestion zone (Transport for London report, 2003). Time spent traveling under 10 km/hour was reduced by 25 percent, and trip time reliability increased about 30 percent. About 60,000 fewer car movements were entering the charging zone daily. Of those 60,000, 50-60 percent had switched to public transport, 23-30 percent diverted around the zone, and 15-25 percent switched to carpooling, bicycles, or mopeds. The congestion charging program is expected to earn revenues of 80-100 million pounds in future years. London is considering adding transponders for a wider toll cordon.

Section 3: Upcoming Tolling Technologies

There are also some ETC technologies that are currently being considered as possible alternatives to transponders and video tolling and that may find applications in area-wide mileage tolling programs and in integrated system management, including:

- Odometer Tolling
- Vehicle Positioning Systems
    - Satellite Tolling
    - Cell Phone Tolling

Odometer tolling is in the test phase in Oregon, while GPS tolling is already in partial implementation in several countries across Europe. Phone tolling is another ETC option which has possibilities but has not been tested.

3.1 Odometer Tolling

The Oregon Department of Transportation (ODOT) is conducting a pilot project on odometer tolling (Oregon Department of Transportation, 2005). In 2001, the Oregon State Legislature created the Road User Fee Task Force (RUFTF) to look at means to raise revenue as a replacement for Oregon's gas tax. RUFTF looked at twenty-eight different options and focused on a distance-based charge on the number of miles traveled in Oregon. The Road User Fee Pilot Program was created to examine the technical and administrative feasibility of implementing a per-mile fee. The program uses on-board mileage-counting equipment to keep track of the number of miles traveled. Based on the results of the pilot test, ODOT will draft legislation to be put before the state legislature in 2009.

During the fall of 2005, a *pre-pilot* program of twenty volunteers started the program to work out any unexpected issues that could occur. Volunteers' cars were equipped with on-board mileage-counting equipment (Figure 3.1). In spring 2006, 280 volunteers in Portland had the equipment added to their vehicles. For a period of one year, volunteers will pay a fee equal to 1.2 cents a mile and will not pay the gas tax. There will be two service stations in the Portland area equipped with mileage reader devices and pilot participants will be asked to fill their vehicles at these participating service stations when convenient. When refueling, the on-board mileage counter will communicate with the mileage readers placed at the pumps. When the purchase is totaled, the gas tax will be deducted automatically and the road user fee will be added automatically.

A federal requirement of the Pilot Program is to test the ability to count separately the miles traveled during rush hour within a congested area. Some of the pilot volunteers will be in a rush hour pricing group to test this concept. Because the pilot is a test, many policy options remain for decision-makers, such as charging a lower rate-per-mile for vehicles that achieve a certain fuel efficiency, for motorists that avoid rush hour zones, or for those participating in other environmentally-friendly activities. The road user fee program does not track, store or collect private information. There is a switching device that counts the number of miles the vehicle has traveled. The device cannot record the location of the vehicle except when the vehicle passes through certain designated rush-hour zones. The device counts only the number of miles traveled within the zone, not the time of day, location in the zone, or even the day.

Figure 3.1: On-board mileage-counting equipment in the Oregon Pilot Project

There is also a GPS receiver in the cars that simply tells the electronic odometer whether to count the miles as *in state* or *out of state*. This is to prevent Oregonians from being charged for miles driven outside the state. No location data is transmitted anywhere or stored in the device or elsewhere; since vehicle location data is not collected, it cannot be accessed. The only data collected and transmitted is the mileage, which is sent to the gas pump reader through a radio frequency that can only travel about 8 to 10 feet. As the driver fuels up, the VMT is calculated and the gas tax is deducted.

The Oregon Road User Fee concept recommends that only new vehicles be equipped with the on-board technology. All of the technologies being used in the pilot program are already being manufactured in cars today. Some automobile manufacturers have already announced that key components will be standard equipment on all models within the next few years. The Federal Highway Administration (FHWA) and transportation standards organizations are working to adopt universal standards for the same technologies being used in the pilot program. In the near future, therefore, it is very likely that a state adopting a GPS-based mileage fee would not need to require additional hardware to be installed in vehicles. Some sort of software upgrade seems more likely.

With the Road User Fee Pilot Program, Oregon is not looking to raise revenue but to look at options for the inevitable future road revenue decline. The ODOT is obliged to test congestion pricing in the pilot program (as a requirement of ODOT's FHWA Value Pricing Pilot Program grant). It is not an indication of a specific policy directive adopted by the Oregon DOT or the state legislature. Any future policy decision Oregon may make on the mileage fee does not necessarily translate into application of congestion pricing, as these two policy decisions are separate. The pilot program will simply test whether or not an electronically collected mileage fee could technologically include congestion pricing, should policymakers ever decide to go in that direction.

3.2 Cell Phone Tolling

Cell phone tolling is a concept that this has potential for mileage-tolling. Essentially, a chip similar to a cell phone chip would be installed in a vehicle, and frequent communication between cellular towers and the chip would determine how far the car has moved and would assess a toll. Given the near total coverage of cell phone signals in urban (and congested) areas of the U.S.

and the deployment of GPS capabilities in cell phones for 911 phone locating, this technology appears to be technically feasible. It is likely to be less expensive than satellite-based systems because the infrastructure needed (cell phone towers) already exists. In addition, installing a cell phone chip in a car will likely be less expensive than installing a GPS unit capable of picking up satellite signals.

The proof of viability of the concept is in a recent marketing campaign by telecommunications firm Sprint to help parents keep track of their children. The service lets parents look at maps on their cell phones to locate their children, who also carry cell phones. Sprint's service shows data such as street addresses to which a child is in close proximity and the estimated accuracy of the reading, which could range from a radius of 2 yards around the child to hundreds of yards. There is also an experiment in Missouri, using cell phones to monitor traffic congestion. Conducted by the Canadian firm, Delcan, the operation uses the frequent signals relayed between the cell phones and cell phone towers to map traffic flows and congestion patterns. With adaptations, this technology can be used to charge a VMT toll.

Clearly, this ability to track a cell phone position must be marketed carefully to avoid a backlash, hence the initial focus on traffic congestation and paranoid parents. At the same time, cell phone companies are already entering the market for driver services such as subscription packages for traffic and weather reports and emergency assistance such as OnStar®.

3.3 Satellite Tolling

Satellite tolling uses a satellite-based vehicle-tracking system to determine exact vehicle location while using mobile communication technology to compute toll charges. Each vehicle has an on-board unit which records the vehicle's movements by periodically downloading satellite time-stamped location coordinates. Satellite tolling is considered the most promising technology for ETC because it allows for accurate, distance-based tolling. It is also flexible, allowing for time- and location-variable tolls. Satellite tolling is touted to become the preferred method of ETC, especially in Europe.

Satellite technology is improving rapidly. With the launch of the European Galileo system (beginning in 2008), the technology will improve further. Galileo is the next generation of satellites and will overcome most of the shortcomings of the current GPS system, being more accurate and reliable. It will also be interoperable with existing systems, allowing for greater access and backup ability. The project is being managed by the European Commission and European Space Agency. Galileo will include thirty satellites by the end of 2010 and will be compatible with the U.S. GPS and Russian Glonass systems. It is reputedly more accurate than current GPS, with real-time positioning down to less than a meter. It is also guaranteed to operate under all but the most extreme circumstances.

The Galileo system will work as shown in Figure 3.2 (BBC: Europe's Galileo Project):

Figure 3.2 The Galileo Satellite system for Global Positioning

- Satellite navigation systems determine a position by measuring the distances to at least three known locations—the Galileo satellites.
- The distance to one satellite defines a sphere of possible solutions; the distance to three defines a single, common area.
- The accuracy of the distance measurements determines how small the common area is and thus the accuracy of the final location.
- In practice, a receiver captures atomic-clock time signals sent from the satellites and converts them into the respective distances.
- Time measurement is improved by including the signal from a fourth satellite. *Galileo time* is monitored from the ground.

3.3.1 Advantages of Satellite Tolling:

- Faster, hassle free and less paperwork: A GPS system will involve less paperwork and lower transaction costs than other forms of tolling. All a driver has to do is drive through a toll station and his driving distance and toll information can be uploaded into the system automatically through wireless connection. If the driver has a prepaid account, the toll charge can be deducted automatically.
- Ancillary services could be provided through transponders and GPS: A GPS system will not only allow collection of tolls, but other information and services can be passed along to the driver as well. For example, the driver will be able to receive real time weather and traffic information. In case of an emergency, his position and situation can be accurately monitored.
- Negates the necessity of investing in expensive roadside infrastructure: Once the infrastructure is in place, there are few costs involved in the operation of a GPS-based tolling system

- More flexibility in variable tolling: Tolls could be levied differently based on road traveled, time traveled, and so on. For example, a vehicle traveling on a busy road during rush hour would be tolled more than a vehicle traveling a country road.
- Built-in OBUs: Currently, vehicle owners have to buy or rent OBUs for GPS tolling. In the near future, cars are likely to come with OBUs as a standard feature.

3.3.2 Disadvantages of Satellite Tolling:

- Phase-in period: At present, an OBU has to be installed for a vehicle to use GPS tolling. It is expected that it will be another 10–15 years before OBUs become standard equipment on cars. In the meantime, deployment is proceeding in the trucking industry because of the desirability of tracking shipments.
- Interference in certain situations: At present, GPS is not entirely reliable because there can be situations where satellite signals are lost (such as in *urban canyons*, or heavily forested roads, and during lightning storms). The technology, however, is getting more accurate and these problems are expected to be, for the large part, resolved with Galileo.
- Public reluctance of being tracked: GPS is, in fact, a passive system and cannot track individuals themselves. Just because someone carries an active receiver does not mean his every move can be followed. This only becomes possible once positional information is forwarded to a third party. For use in road pricing, where a vehicle's movements are built from satellite-navigation data, the data needs to be passed to roadside beacons or reported over cellular phone networks.
- Start-up costs: Some of the start-up costs such as distribution of OBUs and installation of payment booths may be expensive. The German TollCollect system, for example, went well over budget. Once installed, however, it is not as expensive to maintain as other forms of toll collection methods.
- Need to provide transponders and OBUs at a cost of up to $350 per OBU. These costs will go down, however, with mass use.
- Manual system may be needed despite GPS: This is perhaps the greatest obstacle for GPS tolling. There may still be the need for manual lanes despite the use of GPS. This is because the out-of-state vehicles may not have GPS units. One solution would have drivers inform the toll stations in advance that they are planning to come through and pay for their tolls online beforehand. This solution also has some potential problems. First, the driver would have to know the exact route he would be traveling. This could be a problem for out-of-state drivers who are not familiar with the roads. Also, all of them might not have access to computers to book online. Such a system is also very rigid. A driver might change his travel plans and travel on another day or take another route. Manual tolling might also have problems with the driver paying the toll for one trip and using it for two or more trips. Manual tolling has to give the driver a time window to take into account contingencies such as traffic jams, rest stops, flat tires etc. A driver might still be able to use that time window to make more than one trip. There might also be language difficulties in the U.S. for visitors from Mexico trying to book manual tolls over the phone.

- User anonymity is difficult to guarantee: This is the case with many other ETC technologies.

3.4 Application of GPS Tolling in Germany

3.4.1 Overview of Toll Collect

The German federal government has introduced a distance-based truck toll for all heavy commercial vehicles and vehicle combinations with a permissible total weight of 12 tons or more (Toll Collect website FAQ, 2005). The road toll covers over 12,000 km of German highways and is applicable to German and foreign road users alike. Toll Collect, a private company, was awarded a contract by the German federal government to develop a toll system capable of calculating and collecting road use charges based on the distance traveled. In addition, the Toll Collect system ensures that the collection of road tolls does not disrupt traffic flow. Toll Collect is a form of open road tolling and does not require vehicles to slow down or stop or restrict them to a designated lane.

3.4.2 Participation

Automatic Log-in: The automatic log-in is based on a combination of the GSM and GPS systems. In order to avail the automatic log-on service, the driver must get an On-Board Unit (OBU). With the aid of GPS and other positioning sensors, the OBU automatically determines the number of miles driven on the toll road, calculates the toll amount to be paid, and transmits the information to the Toll Collect computer center. The driver is not required to book the route himself, as all the key data is stored in the OBU.

In order to participate in the automatic log-in, the transport company and the truck must register with Toll Collect. After registration, the truck receives a vehicle card for the truck, on which the most important vehicle information is stored. Then an OBU is installed in the truck. The OBUs are the property of Toll Collect and are free to registered users. After the termination of the contract, the OBU must be handed back to Toll Collect. There are two types of OBUs available, the slot-mounted OBU (in the DIN slot) and the surface-mounted OBU (on the dashboard). Only one OBU can be used per vehicle, and the vehicle's license plate information is stored in the individual OBUs during installation.

Manual Log-in: The alternative to the automatic log-in is the manual log-in. Under this system, users must prepay for the use of a planned toll route. The drivers can log in either at a toll station terminal or over the Internet.

Logging in at a toll station terminal: Truck drivers can log in manually at toll station terminals in one of the 3500 registration points in Germany and neighboring countries. It is possible to log-in in German, English, French and Polish. The log-in procedure at a toll station terminal is similar to purchasing a ticket. The driver enters all the relevant vehicle information, departure time, starting point and destination. The toll station terminal then calculates the shortest route within the toll road network. The user can accept this route or choose an alternative one by entering other waypoints. The user then confirms the route, selects the desired payment method, and receives a log-in receipt upon payment. This ticket should be kept in the vehicle. The receipt contains:

- vehicle information
- selected route
- length of the route
- amount of the toll
- a sixteen-digit log-in number
- the period of validity

Registration with Toll Collect is not required to log-in at a terminal.

3.4.3 Payment

There are several alternative ways in which toll fees can be paid:

- LogPay plan (direct debit)
- Fuel Card payment
- Credit account payment
- EC card payment
- Credit card payment
- Cash payment

<u>LogPay plan (direct debit):</u> For registered users, fees are debited monthly directly to the bank account provided. The user, however, must have sufficient credit, based on the monthly toll road use, plus a security premium. The credit rating is evaluated by a credit bureau and stored in the Toll Collect system for operational control purposes. Credit rating information and toll road use is re-evaluated at regular intervals and modified as necessary. To use the LogPay plan, drivers need to provide Toll Collect a Direct Debit authorization.

<u>Fuel card payment:</u> Users can settle open accounts with a fuel card company when the fuel card issuer provides a line of credit high enough to cover the user's monthly mileage. Users send the registration form to the fuel card issuer listed on the form. The fuel card issuer will then evaluate the user's credit rating and inform Toll Collect in writing of the approved credit limit when the completed registration forms are forwarded. Alternatively, users can send the registration forms directly to Toll Collect. In that case, Toll Collect will contact the fuel card issuer directly and inquire about the approved credit limit. This system allows users to pay toll fees on a monthly basis in accordance with the toll statement, which outlines the amount of toll road use.

<u>Credit account payment:</u> Registered Toll Collect users can use a credit account payment system. Users pay a specified amount in advance from which road tolls are subsequently deducted. It is the user's responsibility to ensure that the account contains sufficient funds. Users can request information on their account balances by telephone from the Customer Service department.

<u>Credit card and EC card (debit card):</u> All users can make non-cash payments at any of the toll station terminals.

Cash payments: Drivers can pay toll fees at the toll station terminals in euros or in the local currency at toll stations located outside Germany.

3.4.4 Enforcement

Automatic controls: Around 300 fixed overhead gantries are used to enforce compliance with the duty to pay the toll. The gantries span the entire road and determine whether a passing vehicle is required to pay the toll and if the toll has been duly paid. Each vehicle is recorded by a detection and tracking unit, which classifies the vehicle and determines whether it is required to pay a toll. Classification is done by scanning the vehicle three-dimensionally to check the contour of the vehicle, which determines whether it is required to pay a toll and also determines how many axles it has. If no toll is due, the data is immediately deleted.

Stationary team controls: The Federal Office for Goods Transport (Bundesamt für Güterverkehr, BAG) employees engage in stationary enforcement on parking lots in the vicinity of the control bridges.

Mobile team enforcement: BAG has approximately 300 control vehicles throughout Germany 24 hours a day to provide mobile toll enforcement.

Company-level enforcement: BAG employees perform company-level enforcement by randomly checking freight transport companies on site to determine if they have paid the required toll.

3.4.5 Data Protection and Security

The German government is responsible for the truck toll system and Toll Collect is a subcontractor for BAG. As the client, BAG defines the requirements to be implemented and issues instructions. The data protection policy is continuously coordinated with BAG and the Federal Commissioner for Data Protection and Freedom of Information (Bundesbeauftragter für den Datenschutz und die Informationsfreiheit, BfDI), which are the oversight authorities.

Permission to process data for the toll system is provided primarily by the BfDI and the Truck Toll Regulation. However, the provisions not only permit data processing, but at the same time prescribe strict earmarking for specific purposes and short deletion deadlines for the operator. This data is processed by the operator, acting on behalf of the BAG, “strictly in accordance with data protection guidelines and exclusively for the statutorily prescribed purpose of toll collection.”

Vehicle information is recorded at the control bridges in accordance with the legislative guidelines. The drivers cannot be recognized in the photos. When vehicles are determined not to be required to pay the toll, the photo is not evaluated with respect to the plate number, but is deleted immediately. Personal data is transmitted to the extent “necessary to fulfill statutory toll collection purposes or to perform tasks set forth in the contract with the user.” Toll Collect Short Message Service (SMS) messages are encrypted and the communications partner is authenticated. A closed (end-to-end) security chain is always formed with cryptographic functions to prevent the manipulation of data and any "listening in" on information.

It is not possible to access and read information in an OBU. Modified single in-line memory module (SIMM) cards designed solely for data communication are used, and speech communication is also not possible. Only authorized service stations have the capability to work on terminals. Reading out data from an OBU requires an access code, which may not be given to third parties. If an attempt is made to manipulate an OBU or if it is stolen and re-installed, the control technology will automatically recognize this.

3.4.6 Facts and figures about the German system one year on (Kossak, A.TRB 2006):

- About 500,000 trucks equipped with onboard units (160,000 foreign).
- About 110,000 companies with about 735,000 trucks registered.
- 1,931 workshops licensed for OBU service (435 in foreign countries).
- Shares of booking alternatives: 86 percent OBU, 14 percent POS/ Internet.
- About 1 million tolling transactions per day.
- About 1 million toll bills dispatched; rate of complaints /appeals: 0.7 percent.
- About 23 billion vehicle-kilometers in 11.5 months / 35 percent by foreign trucks.
- 2.86 billion € revenue ($3.45 billion) in 12 months > expected: 3 billion €.
- Toll-violator-rate: < 2 percent.
- System availability: > 99 percent; demanded by contract: 95 percent.
- No traceable increase of freight-charges.
- No traceable impact on consumer prices.
- No significant impact on the structure of the logistic industry.
- No significant shift from road to rail or inland waterways.
- A reasonable number of trucks use/ used alternative toll-free routes.
- Tendency to buy trucks with higher environmental standards.
- No significant shift from heavy trucks to light trucks.
- Significant tendency to a higher average load factor.
- Truck-kilometers on Autobahns without cargo decreased by 15 percent.

Section 4: Trends And Initiatives

4.1 Trends

ETC is paving the way for deployment of Intelligent Transportation Systems (ITS). ETC technologies, namely in-road systems, video systems, and electronic tags, are competing among themselves for the expected growth in ITS.

4.1.1 More In-vehicle Features

According to *The Economist* magazine, several changes are likely to occur with the implementation of ETC (*The Economist* 06.10.04). Future vehicles are likely to include a standard OBU with multiple capabilities:

- Give real-time information on traffic and weather conditions as well as toll rates and conditions on roads
- Inform the driver about gas stations, shopping, restaurants etc
- Upload diagnostic data about the car
- "Smart box" would automatically transmit location of vehicle
- Emergency request could be triggered at airbag inflation
- Number and location of passengers, e.g., in buses
- Real-time traffic data would guide others away from emergency or accident scenes
- Future systems could warn of road dangers and take control of the vehicle, e.g., limiting speed
- Car insurance premiums charged by distance
- OBU could be a virtual back seat driver, giving instructions (e.g., if driver crosses over onto different lane, exceeds speed limits)

4.1.2. Automatic taxi dispatching and vehicle monitoring

About 7500 taxis in Singapore have been equipped with GPS in recent years. GPS provides spatial coordinates of these taxis and their positions are sent to a central dispatch center. When a customer calls for a taxi, the request is sent to all taxis within a 2 km radius of the customer. If a taxi driver accepts the fare, he alerts the call center. The benefits of this system for the taxi driver are shorter cruising times, while the customer benefits from shorter waiting times and quieter taxi rides because of the absence of in-taxi communication with the dispatch center.

4.1.3 Speed Detection

The PoliScan from the German firm Vitronic is a system for digital speed detection and recording (see Vitronic Poliscan website). This system can simultaneously record and measure several vehicles in parallel lanes.

- The PoliScan uses a high-resolution digital camera to take an overview picture of the vehicle, including the driver. It identifies vehicles by license plate recognition and the license numbers are cross-checked with a database. The data are then encrypted and stored digitally.
- In contrast to laser-based systems, the speed measurement is target selective, enabling the monitoring of multiple lanes simultaneously.
- Digital image recording is possible regardless of weather conditions.
- The data from PoliScan can be transmitted immediately to relevant traffic control officers who can then stop offenders.

- PoliScan can either be used as a moving or a stationary device—it can be put on the back of a police van or mounted on an overhead gantry.
- Information for vehicles raising suspicions can be given to the proper authorities, and information for those vehicles causing no alarm is deleted.

4.1.4 Emissions Inspection

Mark IV Industries, one of America's leading electronic technology firms, is actively looking at Automated Vehicles Emissions Inspection (AVEI). At present Mark IV has wireless technology that is capable of transferring diagnostic engine data from a vehicle's on-board interface to the roadside. Thus, toll transponders can double as emissions readers. This technology would allow people to drive through an emissions inspection checkpoint and have the condition of their cars assessed right away instead of having to wait in line. The basic idea is to replace the manual OBD inspections with wireless, electronic data extractions from vehicles' on-board computers using E-ZPass-like transponders.

Mark IV believes there would be several benefits for enforcement, including faster, more thorough and more uniform inspections, increased customer satisfaction, and better utilization of staff resources. Consumers would also benefit because inspections would be uniform and less time-consuming. It would also be more cost-efficient and provide a cleaner environment. Features of the AVEI would include:

- Transponder linked to vehicle computer
- Drive-through inspection booths with electronic readers
- Real-time data extraction
- Software for analyzing and determining pass/fail
- Financial settlement
- Open road speeds
- Possibility of manual override by staff at the booth.

In March 2005, Mark IV conducted an experiment of this technology in New Jersey, with officials from the NJ Department of Environmental Protection and NJ Motor Vehicle Commission present (Manuel, P. Mark IV IVHS). In the experiment, the following were demonstrated:

- Accuracy: At vehicle speeds up to 100 mph, the capture rate was 99.99 percent +.
- Range: demonstrated at 125 ft and 75 ft.
- Vehicle position
- Private memory pages
- Read-write transponder technology (i.e. type II)

4.1.5 Roadside Beacons

In this application, beacons are buried under the pavement and the transponder picks up the signals as vehicles pass along. The signals can transmit a wide variety of data ranging from traffic reports ahead, weather information, blind curves ahead, and so forth. It can also be used in toll collection. As the vehicle passes the beacon, its information is recorded in the on-board transponder/unit in the car. This can later be uploaded to calculate the tolls to be paid. This system can also work well in areas like cities and tunnels where GPS signals are weak or inaccurate.

4.1.6 Driver Information

"Otto" is a 5.9 GHz Dedicated Short Range Communication (DSRC) from MARK IV designed to provide warnings or alerts to drivers, allowing them to take evasive actions, as well as providing real-time information such as weather conditions, congestion, and traffic accidents. On-the-go communication between vehicles could significantly increase highway safety. Otto uses digital radio technology to pass information over distances of up to 1 km between roadside communicators and the on-board imbedded DSRC device on the vehicle. The technology uses WAVE (wireless access in a vehicular environment).

4.1.7 Next Generation Transponders

The Austrian firm EFKON is developing an OBU that is essentially a computer capable of communicating with a regional server (see Efkon Multi-Lane Sensor). It will also include capabilities to communicate with the road, other vehicles, and the driver. EFKON's current transponders allow communication at high speeds, even while changing lanes and overtaking. Some of the solutions require minimal infrastructure, and some are completely infrastructure-free. EFKON offers three groups of "MultiLane Free Flow Systems":

- Traditional gantry–based systems
- Semi-autonomous toll systems with minimized infrastructure (ECOTOLL®)
- Autonomous wide area pricing systems

These systems are used in the following basic applications:

- wide area truck tolling (lorry road user charging) systems
- tachograph based charging schemes
- highway or other discrete tolling systems
- toll enforcement systems and audit systems
- traffic counting
- shadow tolling systems
- section speed control systems
- customer specific

4.1.8 Multi-Use Payment

Future uses for the electronic tag may also include the universal tag, which can be used for multiple purposes (e.g.,, on subways and other public transit systems, as well as for purchases in stores and restaurants). Although the universal tag is not widespread in the U.S., there is in use the multi-use payment system that makes transit payment more convenient. Payment for bus, rail, and other public or private sector goods and services can be made using transit fare cards at terminal gates or at check-out counters and phone booths of participating merchants located near transit stations. Multi-use systems may also incorporate the ability to pay highway tolls with the same card. Table 4.1 shows U.S. metropolitan areas with multi-use payment systems.

Table 4.1: U.S. Metropolitan Areas with Multi-Use Payments

(Source: USDOT 2004)

Metropolitan Area	**State**	**Number of Agencies**	
		Surveyed/Returned Survey	*With Shared Transit Fare Payment/ Toll Collection*
Albany, Schenectady, Troy	NY	1 / 1	1
Baltimore	MD	3 / 3	1
Chicago, Gary, Lake County	IL	11 / 11	1
Dallas, Fort Worth	TX	6 / 6	1
Greenville, Spartanburg	SC	3 / 3	1
Harrisburg, Lebanon, Carlisle	PA	1 / 1	1
Los Angeles, Anaheim, Riverside	CA	22 / 22	2
Miami, Fort Lauderdale	FL	4 / 4	1
New York, Northern New Jersey, Southwestern Connecticut	NY	22 / 21	2
Orlando	FL	1 / 1	1
Pittsburgh, Beaver Valley	PA	5 / 5	1
Richmond, Petersburg	VA	2 / 2	2
San Francisco, Oakland, San Jose	CA	17 / 17	2
Sarasota-Bradenton	FL	2 / 2	1
West Palm Beach, Boca Raton, Delray	FL	1 / 1	1

4.2 Initiatives

There are currently several government and private initiatives facilitating a move towards integrated transportation system management. Among the most prominent of these are the European Electronic Vehicle Consortium, the USDOT Vehicle Infrastructure Initiative (VII), and the Car2Car Consortium, composed of some of the world's leading car manufacturers.

4.2.1 Vehicle-Roadside Communication

A study conducted by the European Electronic Vehicle Consortium looks into two main approaches for realizing Electronic Vehicle Identification (EVI). The first is the EVI as a stand-alone technology. This would involve having roadside gantries and checkpoints that would communicate with the vehicle. The communication methods could involve RFID, mobile communications, DSRC broadcast, infrared, or CALM technological standardization. The second approach is to have EVI embedded into in-vehicle telematics, that is, cars will come with standard built-in telematics supporting EVI (EVI Consortium, 2004).

4.2.2 Vehicle Infrastructure Initiative (VII)

This is an initiative undertaken by the US Department of Transportation to deploy advanced vehicle-vehicle and vehicle-infrastructure communications that keep vehicles from leaving the road and enhance safety movement through intersections (US DOT, ITS: Vehicle Infrastructure Initiative, 2005). This wireless communication is supported by Dedicated Short Range Communication (DSRC).

The VII aims for the coordinated deployments of communication technologies:

- In all vehicles by the automotive industry, and
- On all major U.S. roadways by the transportation public sector.

Data transmitted from the roadside to the vehicle could warn a driver that it is not safe to enter an intersection. Vehicles could serve as data collectors and anonymously transmit traffic and road condition information from every major road within the transportation network. Such information would provide transportation agencies with the information needed to implement active strategies to relieve traffic congestion.

The VII vision for USDOT is that every car manufactured in the U.S. would be equipped with a communications device and a GPS unit so that data could be exchanged with a nationwide, instrumented roadway system. According to USDOT, a well-functioning vehicle-to-vehicle and vehicle-to-roadside communications system could halve the 43,000 deaths that are caused by vehicles leaving the road or traveling unsafely through intersections. In addition, traffic delays could also be cut down significantly.

Protection of privacy is paramount. The intent is that general data collected by the public sector would be anonymous and used only for safety purposes and for efficient management of transportation operations. It is expected that this technology will facilitate a number of uses that drivers may choose, such as electronic toll collection or telematics services for which some private information might be required. For those services, the intent is that the owner or driver would have to "opt in" and give permission for that information to be shared.

A VII consortium has been established to determine the feasibility of widespread deployment and to establish an implementation strategy. The consortium consists of the vehicle manufacturers already involved in the IVI, American Association of State Highway and Transportation Officials (AASHTO), ten State Departments of Transportation, and USDOT.

4.2.3 Car2Car Consortium

The Car2Car Communication Consortium is a non-profit organization initiated by vehicle manufacturers, which is open for suppliers, research organizations and other partners (Car 2 Car Communication Consortium, 2005). The Car2Car Communication Consortium is dedicated to the objective of further increasing road traffic safety and efficiency by means of intervehicle communications. The members at present include: Audi, BMW Group, DaimlerChrysler, EPA, Fiat, Honda, IHP, NEC, Opel, Philips, Renault and Volkswagen.

The mission of the consortium is to create and establish an industry standard for car to car communications based in wireless local area network (LAN) components. Although this is primarily an initiative for the European market, there is a push to make this Car2Car standard interoperable worldwide. The radio system for the Car2Car Communication is derived from the standard IEEE 802.11, also known as Wireless LAN. As soon as two or more vehicles are in radio communication range, they connect automatically and establish an ad hoc network (Figure 4.1). As the range of a single Wireless LAN link is limited to a few hundred meters, every vehicle is also a router and allows sending messages over multi-hop to farther vehicles. The routing algorithm is based on the position of the vehicles and is able to handle fast changes of the ad hoc network topology.

Figure 4.1 Car-to-car ad hoc networks

The timeline for Car2Car wireless implementation is as follows:

July 2005:	Basic concept, first prototype
January 2006:	Research and Development (R&D) guidelines, recommendations
December 2007:	Draft of full specification, demonstrators, interoperability field trial
December 2008:	Specifications as input to standardization
December 2010:	Frequency allocation

In the U.S., DaimlerChrysler is working on the vehicle-vehicle and vehicle- infrastructure short range communications system. As a result of these technological improvements in passenger vehicles expected over the next few years, it is foreseeable that cars will also come equipped with OBUs, which can be used for tolling purposes.

4.2.4 Title Information

The American Association of Motor Vehicle Administrators (AAMVA) is a non-profit organization that develops programs in motor vehicle administration, police traffic services and highway safety. One of the issues they are looking at is the National Motor Vehicle Title Information System (NMVTIS)—legislation invoked by the DOTs Anti Car Theft Act of 1992. NMTVIS will allow state titling agencies to verify the validity of the owners' documents before it grants titles. Not only will law enforcement officials be able to obtain information on any vehicle, they will also get junkyard and salvage yard information related to the vehicle. Potential consumers would also get data on odometer readings, title history, and brand data on the vehicle, which will allow them to make more informed decisions about purchases and insurance. If the car has an OBU, this information (stored on it) would be downloaded directly.

Section 5: Conclusion and Recommendations

At the 2005 International Bridge Tunnel and Turnpike Association (IBTTA) conference in Toronto, there was widespread agreement that tolling in the future is likely to make use of multiple technologies, including dedicated short range communications (DSRC) transponders, satellite-fed location finders (i.e., GPS), and cameras for enforcement. Ed Regan, head of Wilbur Smith's Traffic and Revenue Department, believes that within 10 to 15 years there will be widespread road pricing throughout the U.S., with distance- and location-based road use charges (RUC) or tolls displacing fuel taxes.

In this research product, technologies and practices for tolling were presented. The motivations for tolling were reviewed, and the stages in the evolution of tolling were discussed. Benefits and costs of ETC were presented, followed by a review of current deployment of ETC in the U.S. Mature ETC technologies were discussed, including sensors, video-tolling systems, and RF transponder systems. Examples of best practice in the application of these technologies were evaluated. Next, some ETC technologies with the potential for implementation in the near future were presented, namely odometer, phone, and GPS tolling. Tie-ins to Intelligent Transportation Systems (ITS) deployments and an ultimate integrated transportation system were discussed. Ultimately, this research project will develop recommendations for vehicle identification/registration systems with the potential to link the tolling function to other ITS functions.

Based on the foregoing, the research team has concluded that the next stage of tolling deployment is likely to be a mileage-based system, i.e., the driver pays periodically for miles driven in a region. While odometer, phone, and GPS systems all have the potential for mileage tolling, RFID tags with DSRC are also capable of similar functions, are already in use, and will be the dominant technology in the U.S. for some time. They will, however, require significant roadside infrastructure to accomplish area-wide tolling. The researchers recommend that TxDOT continue to deploy TxTAG, the standard in RFID transponder technology. In the continuing work in this research project, the requirements to link that technology to area-wide tolling and ultimately, integrated system management, will be investigated.

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