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Electronic Vehicle Identification: Industry Standards, Performance, and Privacy Issues

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<tr><td colspan="2">Abstract: In this research product, industry standards for dedicated short range communications (DSRC) are reviewed, followed by an evaluation of costs and performance. Privacy concerns regarding collection and use of data on vehicle movements are examined in the context of existing and potential legislation, and issues in electronic vehicle registration are introduced. Ultimately, this research project will develop recommendations for vehicle identification/registration systems with the potential to link the tolling function to other transportation system management functions.</td><td>Keywords:
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Introduction

The processes for collection of distance- and location-based road use charges (RUC) are evolving with technology. Toll collection in the future will make use of multiple technologies, including dedicated short range communications (DSRC) transponders, satellite-fed location finders (i.e., Global Positioning Systems [GPS]), and cameras. 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) displacing fuel taxes.

The expected evolution to RUC ("mileage tolling") was discussed in 0-5217-P1, Toll Collection Technology and Best Practices. A review of mature Electronic Toll Collection (ETC) technologies, including sensors, video-tolling systems, and radio transponder systems was presented, along with a review of technologies with the potential for implementation in the near future, namely GPS and cellular phone tolling. The conclusion of 0-5217-P1 was that radio-frequency identification (RFID) tags with DSRC will be the dominant tolling technology in the U.S. for some time.

In this second research product, industry standards for DSRC are reviewed, followed by an evaluation of costs and performance. Privacy concerns regarding collection and use of data on vehicle movements are examined in the context of existing and potential legislation, and issues in electronic vehicle registration are introduced. Ultimately, this research project will develop recommendations for vehicle identification/registration systems with the potential to link the tolling function to other transportation system management functions.

Section 1: Vehicle Identification Technologies

In this section, technologies for identifying the presence, location, and other characteristics of vehicles, including ownership, are briefly reviewed. Apart from tolling, vehicle/owner identification has a number of applications, including:

- Controlling access to secure areas
- Pre-clearance (green line) at border crossings or other interdiction points
- Spotting stolen or wanted vehicles
- Warning speeders automatically
- Notifying truckers of load-zoned or restricted lanes
- Identifying emissions violators
- Monitoring travel times and congestion
- Feeding customized information to motorists.

1.1 Technology Review

Vehicle identification may be accomplished through sensors, cameras, vehicle-to-roadside communication, or combinations of these. Ownership identification is achieved by tying the vehicle ID to a person and contact/account information, usually through a database maintained by a vehicle registration agency. A consistent ID system for vehicles and owners is necessary.

Sensors: Sensor systems may be subsurface (e.g., loop detectors), roadside (e.g., laser profilers), or overhead (e.g., infrared beams). Their primary uses are in detecting the presence of a vehicle, counting the number of axles, helping in classifying vehicles, and counting the number of vehicles crossing a point. They also serve as gatekeepers by triggering other vehicle identification systems.

Cameras: When sensors detect a vehicle, closed circuit television (CCTV) cameras on overhead gantries can take a picture of the license plate. Optical Character Recognition (OCR) software is then used to read the picture, and the plate number is checked against a database to identify the owner associated with the vehicle. A drawback of license plate identification/ recognition (LPI/R) using OCR is the need to refer non-reads (generally due to varying license plate fonts and designs, and plate obscuration), to a human, and the resultant extra cost. However, LPI/R has been gaining support as an enforcement tool because it registers visual evidence of violations.

Transponders: Transponders are becoming a common form of vehicle identification. In this technology, an 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 near a gantry with a mounted radio transmitter, it responds to the radio signals. One drawback is masking of the signal by metallized windshields. Laser and infrared signals have also been tested, but the radio spectrum provides the greatest level of accuracy.

A key component of this use of electronic tagging is Dedicated Short Range Communications (DSRC). DSRC is a general purpose radio frequency communications link between the vehicle and the roadside or between two vehicles. The set of standards developed to support DSRC provides a short- to medium-range communications service for a variety of transportation applications, including electronic toll collection, parking lot payment, commercial vehicle applications (weigh-in-motion, inspection clearances), safety applications (obstacle detection, collision avoidance), and many others.

Global Positioning Systems (GPS): GPS uses a communications satellite system to determine exact vehicle location. Each vehicle would have an on-board unit (OBU) that records the vehicle's movements by periodically downloading satellite time-stamped location coordinates. OBU data can then be accessed by roadside readers. Drawbacks include inadequate satellite signal strength in urban canyons and forested areas, and short-term blackouts during electrical storms. However, despite some stumbles, GPS is becoming the preferred technology for vehicle identification in Europe, with the ongoing deployment of the new Galileo satellite system.

Cell Phone Technology: In this technology, a cell phone device would be installed in a vehicle, and frequent communication between cellular towers and the device would determine the vehicle's location. Given the near total coverage of cell phone signals in urban 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. Installing a cell phone in a car will likely be less expensive than installing an OBU with GPS capabilities. In addition, the infrastructure needed (cell phone towers and user/accounting systems) already exists. However, coverage in remote areas is still spotty.

1.2 Technology Comparison and Market Share

Table 1.1 shows a comparison of various radio spectrum communications technologies in terms of range, data rate (Mbps = megabits per second, kbps = kilobits per second), directionality, and rough cost per bit of data transfer. DSRC has the advantage for surface transportation applications because of data rates and cost per bit of data. Line of sight is typically not a severe constraint for roadside installations.

Table 1.1: DSRC Compared to Other Radio Communications (Source: IEEE, 2005)

	DSRC	**FM Radio**	**Cellular Phone**	**Satellite**
Range	1000 meters	Hundreds of kilometers	Kilometers	Thousands of kilometers
Data Rates	6 to 27 Mbps	>10 kbps	Present: >10 kbps Future: 2-3 Mbps	--
Directionality	Line of sight	Area	Area	Area
Cost (per bit)	Low	Low	$	$$$

Market Share: Tolling technology is likely to lead the way in transportation system communications deployment in the U.S., because the future financing of transportation infrastructure will be through some form of tolling. It is anticipated that manual tolling will be obsolete in the U.S., probably within 5 years. RFID tags, which currently account for 40-60 percent of toll transactions in the U.S., are expected to fully replace the 15-25 percent of toll transactions done manually, and thus will dominate the U.S. toll market over the next 20 years or so. Cell phone and satellite/GPS tolling will gradually create a niche in the market as more vehicles come with manufacturer-installed on-board units (OBU), and in the longer term as costs come down, may replace DSRC. However, DSRC will form the backbone of transportation communications infrastructure in the U.S. for the near future.

Section 2: DSRC Standards

In this section, the industry standards supporting DSRC deployment are presented.

2.1 Bandwidth Allocation

The 5.7 to 5.9 GHz (gigahertz) range of the radio spectrum has been designated by the International Telecommunications Union radio standards subcommittee (ITU-R) for industrial, scientific, and medical (ISM) uses. Figure 2.1 shows the bandwidth allocations in different parts of the world.

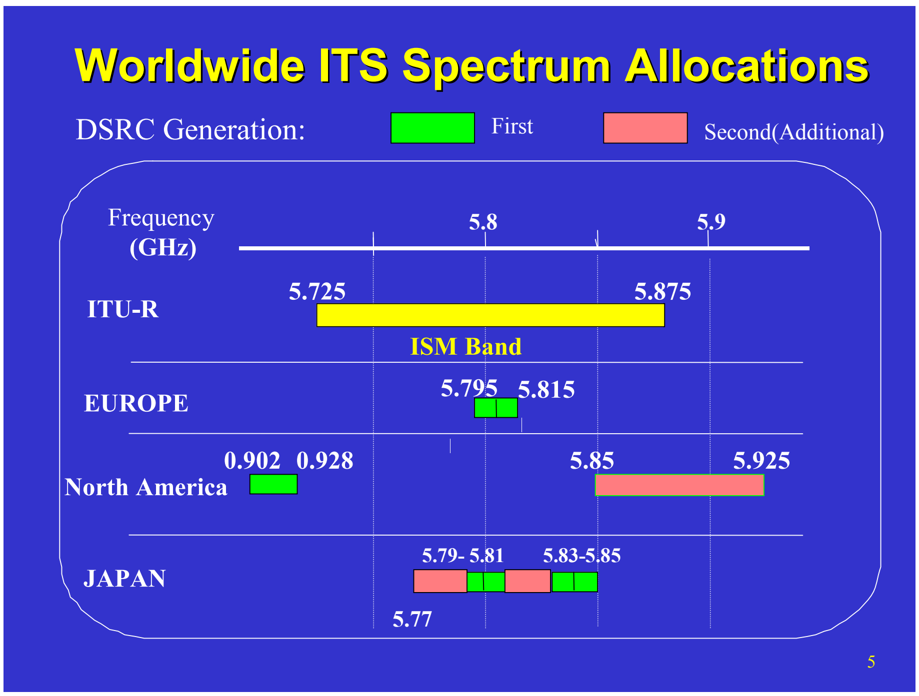

Figure 2.1: Current Worldwide DSRC Bandwidth Allocations
(Source: Armstrong, 2002)

Japan uses the 5.7 GHz bandwidth, while Europe uses 5.8 GHz. In the U.S., DSRC operates on two different levels: 915 MHz (megahertz) and 5.9 GHz. In 1999, the Federal Communications Commission (FCC) allocated the 5.9 GHz radio spectrum for vehicle-vehicle and vehicle-roadside communications in the U.S.

915 MHz versus 5.9 GHz Performance

The 5.9 GHz band level has several advantages over 915 MHz. The primary one is range: the ability to facilitate higher data rates, lower signal loss, and more accuracy over longer ranges. Table 2.1 shows the capabilities of the two bands.

Table 2.1: Comparison of 915 MHz Systems to 5.9 GHz Systems
(Source: IEEE, 2005)

	915 MHz Systems	**5.9 GHz Systems**
RANGE	< 30 meters	up to 1000 meters
DATA RATE	0.5 Mbps	6 to 27 Mbps
INTENDED USE	Designed for ETC, but can be used for other applications	Designed for general Internet access, can be used for ETC.
CHANNELS	Single unlicensed channel	7 licensed channels
IMPLEMENTATION	Requires special (custom) chip set and software	Uses open off-the-shelf chip sets and software

Performance: Figure 2.2 illustrates the effect of range on data transfer rate and shows the performance envelope of the 5.9 GHz band compared to 915 MHz. The 5.9 GHz band includes the capability to transfer data via the Internet, allowing a seamless integration of transportation applications with information applications.

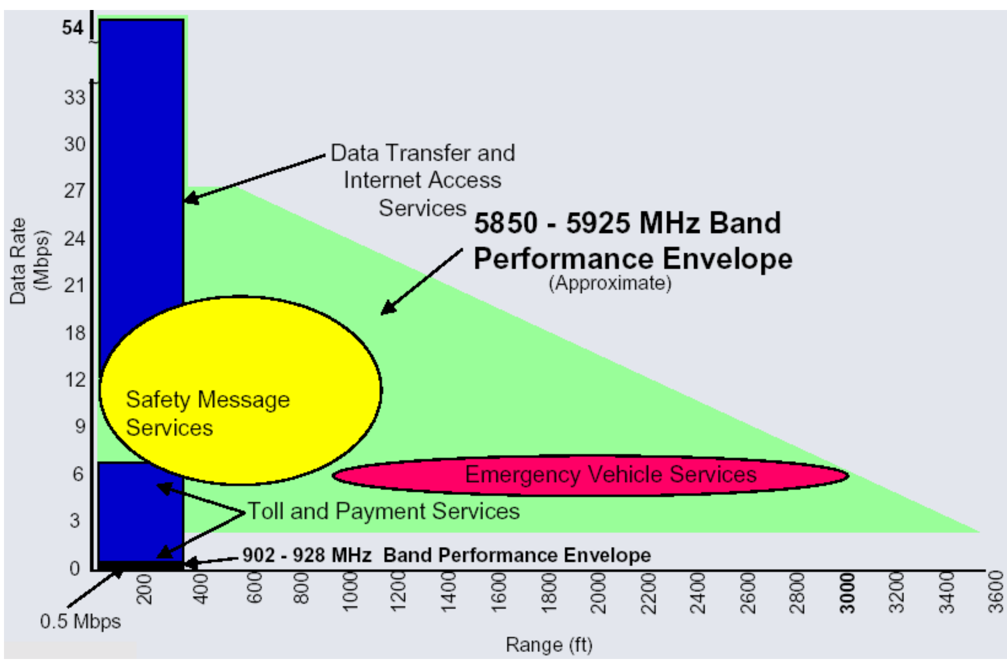

Figure 2.2: 5.9 GHz Performance Envelope (Source: IEEE, 2005)

Applications: The 915 MHz standards were completed several years ago, and are primarily used in commercial vehicle applications and ETC and can no longer sustain the demands of new applications. The 915 MHz range was the initial spectrum for toll tags in the 1990s and will be phased out as those older tags are replaced. The new set of 5.9 GHz DSRC standards supports a larger variety of applications, including advanced vehicle control, traveler information, increased freight/cargo transport support, transit, parking, and traffic management. Also, traffic safety messages will receive priority over other messages and transactions so they are delivered rapidly. These advantages, in turn, make possible the deployment of new applications, including (Mark IV, 2005):

- In-vehicle public safety warnings and alerts
- Asset tracking and new e-commerce financial services
- Vehicle-to-roadside applications, such as traffic signal prioritization
- Vehicle-to-vehicle communication for safety applications
- Internet data packet hopping
- Roadway maintenance probes

5.9 GHz Standards Development

Standardization plays a very important role in any large-scale deployment. A national deployment requires interoperability of equipment and systems coming from many different manufacturers, hardware/software certifications, compliance testing measures, and security measures. The standards for 5.9 GHz DSRC are being developed primarily by the American Society for Testing and Materials (ASTM) and the Institute of Electrical and Electronics Engineers (IEEE) committees, with additional elements being developed by the Society of Automotive Engineers (SAE), the American Association of State Highway and Transportation Officials (AASHTO), and the International Standards Organization (ISO). ITS America, an ITS industry forum, is providing the primary interface with the FCC. The following companies are participating in the effort at this time (IEEE, 2005):

1. 3-M
2. AASHTO
3. ACUNIA
4. AmTech
5. ARINC
6. Armstrong Consulting
7. Atheros
8. CalTrans
9. Daimler-Chrysler
10. DENSO
11. GM
12. GTRI
13. Highway Electronics
14. Hitachi
15. IDmicro
16. IMEC
17. Intersil
18. ITS-A
19. JHU/APL
20. King County Metro Transit
21. MARK IV
22. MiCOM Spa
23. Michigan State DOT
24. Mitretek
25. Motorola
26. Nissan
27. N.Y. Thruway Authority
28. OKI Electric
29. PATH
30. Raytheon
31. Sirit
32. Sumitomo Electric
33. TechnoCom
34. Toshiba
35. Transcore
36. Visteon
37. Washington State DOT
38. Wi-LAN

IEEE Standards: The IEEE standards aim to address the lack of high-speed communications between vehicles and service providers and the lack of homogeneous communications interfaces between different automotive manufacturers (USDOT, 2006A). The architecture, interfaces, and messages defined in the IEEE 1609 Family of Standards for Wireless Access in Vehicular Environments (WAVE) support the operation of secure wireless communications between vehicles and infrastructure, as well as between vehicles. Applications will utilize these standards to provide, for example, services to drivers, roadway operators, facility operators, and maintenance personnel.

IEEE 1609 for WAVE, approved by USDOT in 2004, consists of four standards:

1. ***IEEE P1609.1—Resource Manager:*** This describes the key components of the WAVE system architecture and defines data flows and resources at all points. It also defines the command message formats and data storage formats that must be used by applications to communicate between architecture components, and it specifies the types of devices that may be supported by the OBU resident on the vehicle or mobile platform.
2. ***IEEE P1609.2—Security Services for Applications and Management Messages:*** This defines secure message formats and processing. This standard also defines the circumstances for using secure message exchanges and how those messages should be processed based upon the purpose of the exchange.
3. ***IEEE P1609.3—Networking Services:*** This defines network and transport layer services, including addressing and routing, in support of secure WAVE data exchange. It also defines Wave Short Messages, providing an efficient WAVE-specific alternative to IPv6 (Internet Protocol version 6), which can be directly supported by applications. Further, this standard defines the Management Information Base (MIB) for the WAVE protocol stack.
4. ***IEEE P1609.4—Multi-Channel Operations:*** This provides enhancements to the IEEE 802.11 Media Access Control (MAC) to support WAVE operations.

ASTM Standard: ASTM is developing ***E2213-03- Standard Specification for Telecommunications and Information Exchange Between Roadside and Vehicle Systems—5 GHz Band DSRC Medium Access Control (MAC) and Physical Layer (PHY) Specifications***. ASTM E2213-03 provides wireless wide-bandwidth, high-speed communications over short distances between information sources or transaction stations on roadside units (RSU) and OBU, between OBU, and between portable units and OBU. The communications generally occur over line-of-sight distances of less than 1,000 meters.

ASTM E2213-03 is based on and refers to computer industry IEEE standard ***IEEE 802.11—Wireless LAN Medium Access Control and Physical Layer specifications High-Speed Physical Layer in the 5 GHz band***. This standard defines the operating parameters required to implement a high-speed data transfer service in the 5.9 GHz Intelligent Transportation Systems Radio Service (ITS-RS) band.

ASTM E2213-03 describes the requirements and procedures to provide for the privacy of user information being transferred over the wireless medium and authentication of the DSRC-conformant or IEEE 802.11-conformant devices. The standard is intended for equipment manufacturers and system integrators but may also be of interest to regulatory agencies, research consultants, and turnpike agencies. The high speed, assured data-delivery nature of this standard fully supports public safety applications and private enterprise delivery of information to vehicles.

Electronic Payment Systems (EPS) Standards: OmniAir, a tolling industry consortium, is pursuing an EPS National Interoperability Specification (NIS). The EPS NIS will provide a uniform financial transaction process and network interface protocols from OBU to RSU to service provider to clearinghouse to issuer (IBTTA, 2005). Security of transactions is an essential element of EPS, and public key certificates will be used for this purpose. Figure 2.3 illustrates the anticipated EPS transaction sequence.

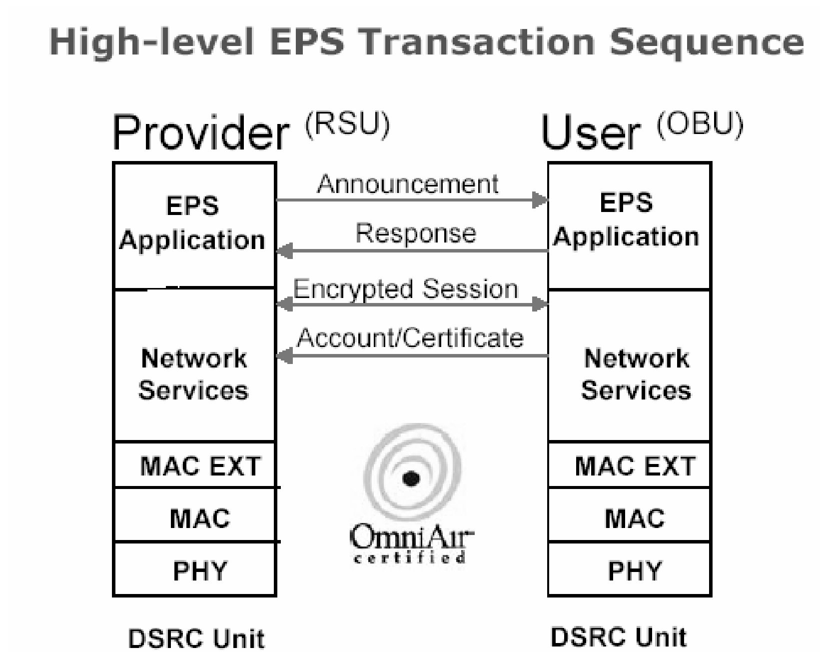

Figure 2.3: OmniAir Electronic Payment Service Transaction Process (IBTTA, 2005)

Governing principles for EPS for 5.9 GHz include:

- Nationwide interoperability
- Integration into new vehicles
- Simultaneous operation with legacy systems
- Two-way exchange with user for ordering-based systems:
    - OBU sends billing information
    - RSU optionally writes a tag.

The National Interoperability Specification has been in development since mid-2004. At present, given that the protocol stack standards are stable, the following detailed application standards need to be developed:

- OBU to RSU
- RSU to Clearinghouse
- Inter-Clearinghouse
- Security Model.

Future Standards: Standards development is a long process. It has taken more than 6 years to put together the draft standards for 5.9 GHz in the U.S., and the work is not yet completed. Development of DSRC and GPS standards in Europe is still ongoing. Given the level of effort required, it is unlikely that complete standards will be developed anytime soon to facilitate an industry switchover from DSRC to another technology. Newer technologies will have to demonstrate superior performance and cost before they can be considered viable replacements.

Section 3: DSRC Cost And Performance

In this section, the cost of DSRC systems and expected performance levels are reviewed.

3.1 DSRC Costs and Benefits

RFID tags used in tolling currently cost between $8-15 each, a cost that has been steadily falling. In fact, some toll agencies have started giving them away to attract customers. However, the cost of roadside infrastructure and software systems can be high. The Central Texas Turnpike Project SH 45 North element is now nearing completion. The year 2002 cost estimates for three main toll plazas and thirteen ramp toll plazas are shown in Table 3.1 (CTTP, 2002).

Table 3.1: SH 45N Toll System Component Cost Estimates

Toll system component	**Estimate ($ m)**
3 mainline toll plazas—structure	17
13 ramp toll plazas— structure	10
Prefab toll booths	2
Toll plaza footprints—sitework	1
Fiber optic network	7
Furniture and equipment	1
Toll collection software, etc.	23
Toll tags	8
Total	**69**

Annual operation and maintenance costs are not included. With an estimated 4 percent annual construction cost escalation factor and 10 percent construction contingency factor, the final year 2007 cost for the SH 45N toll collection system is expected to be around $90 million. That number still compares favorably with recent single toll plaza construction costs of $21 million in Lee County, Florida, and $25 million in York, Maine.

Costs for system-wide deployment of DSRC infrastructure can be expected to be similar, because tag readers and software are the same as for tolling. However, costs will also depend on the functional intent, amount of coverage desired, and the design of the roadside elements. It is anticipated that deployment will be focused in urban and congested areas initially and will gradually move to intercity corridors as benefits become manifest. Therefore the cost impact is expected to be spread over many years. Appendix A provides a review of Federal funding for deployment programs.

Benefits of DSRC Deployment: Deployment of DSRC infrastructure can provide several benefits for transportation system management, including:

- Better data for management of transportation systems through monitoring of travel times and congestion. For example, in Houston, gantries on freeways scan toll tags to record travel time.
- Better information for travelers, resulting in traffic re-routing and higher throughputs, leading to better utilization of existing systems.
- Better traffic signal coordination and prioritization
- Better reporting of infrastructure condition and maintenance
- Higher compliance with safety and regulatory requirements
- Lower costs for deployment of future ITS elements.

Likely traveler benefits include:

- Customized information on traffic conditions, e.g., in-vehicle feeds
- Time savings from higher traffic throughputs and ability to avoid congestion
- Lower fuel costs, pollution levels, and vehicle wear-and-tear

Likely commercial vehicle operator benefits include:

- Better information on travel times and preferred routes, including notification of load-zoned or restricted lanes
- In-vehicle safety warnings and alerts
- Pre-clearance (green line) at border crossings, inspection and weigh stations, or other interdiction points
- Asset tracking and e-commerce services.

In addition, the general public likely would benefit from:

- Deferred need for expansion of the system because of better utilization of existing assets
- Higher compliance with insurance and safety requirements
- Location of stolen or wanted vehicles
- Controlled access to secure areas

Benefit-Cost Examples: A few studies have been conducted on the benefits versus costs of deploying DSRC. For example, in a study by Patrick DeCorla-Souza of the Transportation Research Board (TRB), the costs and benefits are analyzed for a system-wide congestion pricing program using DSRC in a Washington, D.C. case study area (TRn, 12/03/03). The study claims that, by using dynamic tolls to reduce peak-period traffic, high levels of service can be maintained. All vehicles would be transponder-equipped and would be scanned and charged as they passed under mainline gantries at highway speed.

DeCorla-Souza's estimates of costs and revenues (2003 $) are shown in Table 3.2. His toll rates are based on the value of time savings. At a value of time of $8.40/hour (compared to $13.80 estimated for the SR 91 Express Lanes in California) and an average time savings of 1 min/mi (60 mph versus 30 mph), an average toll rate of 14c/mi is used, resulting in a revenue/cost ratio of 2.12 : 1.00. The study only counts as benefits the value of time savings to motorists yet still shows a positive return.

Table 3.2: Cost and Revenue Estimates for EVI-based Congestion Pricing

(TRn, 2003)

Annualized Costs:	**$ million (2003)**
400 gantries at 3 mi apart at $60K ea.	24
DSRC equipment at $46K ea.	19
Video cameras at $24K ea.	10
System costs	17
Staff and equipment	10
Transaction costs @15c x 2.4 m trips/day for 250 days	90
Total cost per year	**(170)**
Annual Revenue:	
Total revenue for 2.4 m trips/day x 5.4 mi./trip x 14c per mi. x 250 days	450
Less 20% discount for toll-exempt vehicles	(90)
Total revenue per year	**360**
Revenue/Cost Ratio:	**2.12 : 1.00**

Another study, conducted by the San Francisco Bay Area Toll Authority, found benefit cost (B/C) ratios as high as 14.0 for freeway ramp metering projects using EVI. Newly designed HOV toll lanes and mixed free flow lanes also showed positive B/C ratios, as listed in Table 3.3. From the two studies reviewed here, it can be concluded that the benefits of DSRC deployment in transportation system management outweigh the costs.

Table 3.3: Bay Area Toll Authority: B/C Ratio for Projects Using EVI

Project	Benefit / Cost Ratio
Freeway Ramp Metering	14.0
New HOV Lanes	2.0
New Mixed Flow Lanes	1.2
Auxiliary Lanes	5.0

3.2 Performance

The accuracy of DSRC for EVI has been validated in many studies. For example, DSRC vehicle positioning accuracy is ±1.5 m or better, according to research in Japan (ACHSRA, 2003). The testing was conducted with vehicles cruising at up to 120 km/h, and it also measured the influence of nearby vehicles. In addition, processing speed was tested. The sensor, mediated by the road-to-vehicle communications device, had a lag time of 20 ms or less for completion of processing by an OBU. Other tests have confirmed DSRC data transmission accuracy, even at vehicle speeds as high as 120 mph.

Of all current toll technologies, RFID tags have the highest accuracy, while camera/ plate reader systems have the lowest accuracy and highest cost, according to a World Bank study (World Bank, 2006). Table 3.4 shows the accuracy levels and transaction costs of current toll technologies. In addition, the vehicles per hour (VPH) processed by each technology are shown, with RFID able to handle 1800-2400 VPH, i.e., free flow conditions, with 99.25 percent accuracy and lowest cost per transaction. Clearly, electronic vehicle identification can now be conducted at highway speeds with very high accuracy.

Table 3.4: Current Toll Technology Costs and Accuracy Levels
(World Bank, 2006)

Toll options	Toll Volumes (VPH)	Cost per Transaction ($)	Accuracy (%)
Manual	250–350	0.35–0.45	98.0
Automatic Coin Machine with barrier (five coins)	450–550	0.28–0.35	98.5
Automatic Coin Machine without barrier (one coin/token)	500–700	0.28–0.35	95.0
Voucher Script	500–900	0.37–0.48	98.5
Automatic Number Plate Recognition (ANPR)	600–1000	2.25	85.0
Smart Card	700–900	0.10–0.19	99.5
RFID: Dedicated lane with barrier	900–1100	0.10–0.19	99.96
RFID: Free flow lane	1800–2400	0.07–0.15	99.25

Section 4: Privacy Issues With EVI

This section addresses the privacy issues associated with electronic vehicle identification systems. There still remains a great deal of uncertainty regarding privacy issues stemming from EVI. Current laws barely address electronic privacy, and given the rapidly changing nature of technology, interpreting the law with respect to privacy is becoming ever more challenging.

4.1 Issues Regarding Electronic Monitoring

Government agencies generally support more widespread use of electronic monitoring of public activities and communications in the interest of efficiency, public safety, and security.

- *Efficiency:* Better information on the use of infrastructure allows for better management of limited resources, planning for future needs, and preventive maintenance.
- *Safety:* Remote *patrolling* using cameras and listening devices deters scofflaws in the same way regular police patrols do. Visual or audio evidence helps trace violators and increases the likelihood of conviction.
- *Security:* Criminals increasingly communicate and transfer funds electronically. Terrorists also tend to target transportation infrastructure, where people gather in large numbers, such as planes and trains. Monitoring transportation networks, analyzing unusual patterns, and profiling likely culprits are all tools for disrupting such activity.

On the other hand, civil liberty advocates and many members of the public are disquieted by *Big Brother* government. They argue that the monitoring of legal activities is equivalent to unwarranted search and seizure.

- *Civil liberties:* Surveillance chills legitimate dissent. The same technology used for monitoring terrorists and criminals can be used for tracking and persecuting people who disagree with the government.
- *Secret records:* Collecting data, e.g., where individuals have traveled or where they stopped, could be potentially embarrassing if disclosed to employers or opponents. The commercial value of such data raises the potential for corruption by officials. Identity theft is also possible.
- *Monitoring displaces scofflaws:* Violators may simply move their activities to areas where monitoring is not in place.
- *Cost:* Advanced technology is expensive and requires high skill levels for installation, maintenance, and operation. With so many social needs under-funded, monitoring of the public without due cause should not be a priority.

4.2 Constitutionality of Automated Enforcement

Automated enforcement programs have raised concerns about the violation of an individual's right to privacy, as inscribed in the First and Fourth Amendments of the Constitution. In addition, the programs may raise other constitutional issues, such as the right of free association (First Amendment), the right to equal protection (Fourth Amendment), right to present a defense (Sixth Amendment), and the right to due process (Tenth Amendment). Similar concerns apply to EVI. A study conducted by the University of California at Davis looked at the legal and constitutional framework regarding automated enforcement checkpoints (UCD, 2005).

Privacy: Regarding the First Amendment, no court case has yet established an individual vehicle driver's right to privacy. Legal scholars also assert that automated enforcement does not violate Fourth Amendment protections against unreasonable searches, based on Supreme Court cases that find that vehicle drivers and occupants have a diminished legal expectation of privacy.

Speedy Trial: Alleged violators have the right to be notified promptly, under the Sixth Amendment. The right to present a defense may be infringed upon when there is a time lag between the alleged violation and the receipt of a citation, because defendants may forget important details needed to defend their case, especially when they are unaware that they were caught in a violation. However, the courts have ruled that due process rights are not violated if a citation is issued within 1 year, as long as the delay is not deliberate. Still, it is in the interest of the issuing agency to be as speedy as possible, from a public acceptance standpoint.

Public Perception: Most people have the perception of privacy while driving, and consider electronic monitoring of that activity a violation of privacy. Therefore, agencies planning to deploy such systems must address those privacy concerns and market the benefits of the program before deploying it. Moreover, the program should be tailored expressly to further the efficient operations of the agency and not exceed the agency's mission. In executing the program, it is critical that targets for fines are notified as soon as possible, with clear guidelines for appeal and resolution.

4.3 Privacy Laws in the U.S.

While automated enforcement has been regarded as constitutional, such programs must be consistent with existing federal and state privacy laws. The following describes the most important federal laws regarding privacy.

Freedom of Information Act (FOIA) (1966): It was the Founding Fathers' view that the American government should be subservient to the individual. Thus, court rulings have generally held that the American public has the constitutional and inherent right to be allowed access to information held by the government. However, the sensitivity of some government information and a private interest's desire to have access often clash. Therefore, in 1966, Congress enacted the Freedom of Information Act (FOIA) to deal with requests for government records, consistent with the people's "right to know."
The FOIA explicitly applies only to federal government agencies. These agencies are under several mandates to comply with public solicitation of information. Along with a requirement to make public and accessible all bureaucratic and technical procedures for applying for documents, agencies are also subject to penalties for hindering the processing of a petition for information. Thus, there is recourse for someone to go to a Federal court if suspicion of illegal tampering or delayed sending of records exists. However, there are nine exemptions, under which the President has unlimited power in declaring something off-limits or necessarily classified as a matter of national safety. This loophole has presented numerous problems for individuals seeking information under the FOIA.

The Privacy Act (1974): The Privacy Act of 1974 is an act regulating government control of documents that concern a citizen. It states that a person has the right to:

- see records about himself, subject to the Act's exemptions,
- amend that record if it is inaccurate, irrelevant, untimely, or incomplete, and
- sue the government for violations of the statute, including giving others access to his records unless specifically permitted by the Act.

In conjunction with the Freedom of Information Act (FOIA), the Privacy Act advanced the rights of an individual to influence personal information held by the government.

Electronic Communications Privacy Act (ECPA) (1986): The ECPA was enacted by the U.S. Congress to extend government restrictions on wire taps to include transmissions of electronic data by computer. Specifically, the ECPA was an amendment to Title III of the Wire Tap Statute of 1968, which was primarily designed to prevent unauthorized government access to private telephone communications. Later, ECPA was amended by some provisions of the USA PATRIOT Act (2001). ECPA creates standards and procedures for court-authorized electronic surveillance, regulates when electronic communication firms may release information, and provides legal protection of the privacy of stored electronic communications from outside intruders and unauthorized government officials.

At present, revisions of the ECPA are under consideration, including privacy protection for toll road customers. It should be noted, though, that in most places toll road use is essentially voluntary because toll roads usually run parallel to a free facility. Participation in an electronic toll collection system, therefore, can also be considered voluntary. Drivers who have fears about being tracked or photographed can use the free facility or pay in cash.

The Patriot Act (2001): The Patriot Act was passed by Congress in 2001 as a response to the terrorist attacks of September 11, 2001. This act has tremendous ramifications for privacy in the U.S. While the Patriot Act has ten titles and numerous sections, Title II: Enhanced Surveillance Procedures, which gives increased powers of surveillance to governmental agencies, is the most relevant with regard to the issue of privacy. In particular, there are several sections in Title II that have been criticized by civil rights and privacy groups as being too vague and intrusive (Wikipedia: USA Patriot Act, Title II).

Title II sections have the potential to affect privacy in the use of traditional information sources such as telephones, to newer communication methods such as the internet and also EVI practices. In general, opponents of the Patriot Act argue that the government is given too much unchecked power. Government authorities, they argue, do not have to show enough evidence to obtain warrants or personal information. They also argue that the new powers given to agencies are essentially violations of a person's First and Fourth Amendment rights, and that judicial oversight is almost non-existent.

Some of the sections of Title II that could affect EVI are:

- Section 203, which gives authorities the ability to share information regarding criminal activity. Opponents believe that the section will not limit disclosure solely to information relating to investigations of terrorist activities, because the term "foreign intelligence information" is too vague.
- Section 206, which allows for the roving surveillance of targets and allows a government agency to require full assistance to perform such surveillance. Opposition groups believe that this statute gives too much free rein to government authorities and that lowering standards leads to abuses of the Fourth Amendment. In the opinion of the Electronic Frontier Foundation, section 206 allows the FBI to "wiretap every single phone line, mobile communications device, or Internet connection that a suspect might be using without ever having to identify the suspect by name…for a year" (Electronic Frontier Foundation: Patriot Section 206).
- Section 212, which allows the emergency disclosure of electronic communications to protect life and limb. At present disclosure is limited to phone companies and ISP handing over a customer's personal records to authorities

when there is reasonable belief that lives are in danger, but disclosure might be expanded to include EVI data as well.

- Section 220, which gives the power to Federal courts to issue nationwide search warrants for electronic surveillance—which could possibly include warrants for EVI information. Section 220 deals with criminal cases as well as terrorism, something opponents believe should not have been specified in the Act. They believe that agencies will be able to find sympathetic judges who will issue warrants even if the warrants do not completely satisfy the strict requirements of the Fourth Amendment to the Constitution. Additionally many warrants are issued *ex parte*, which means that the party being served need not be present when the order is issued.
- Section 216, which is an expansion of pen register laws. Opponents of the law believe that pen register laws were designed to be used specifically for wiretaps and not for more modern communications modes such as the internet.

There is overwhelming consensus that appropriate safeguards and guidelines on the control and use of information must be established to protect the privacy of individuals.

4.4 Additional and Enabling Legislation

At present, most countries, including the United States, have not passed laws specifically governing the use of RFID. In many cases, existing privacy laws are interpreted to cover the use of data collected by RFID systems, as well as bar codes and other systems. Some U.S. states have considered enacting new laws that deal with issues particular to RFID, such as the surreptitious scanning of RFID tags by retailers or people with criminal intent.

State Laws: The implementation of EVI programs usually requires special amendments to state law. According to the Insurance Institute for Highway Safety, nineteen states and Washington, DC currently have some form of local or statewide enabling legislation for automated enforcement. However, long-standing programs in Arizona operate without a specific statute. Such enabling legislation is typically necessary to establish a number of important legal conditions necessary for the effective operation of EVI.

Legal Authority: States need to enact laws giving agencies the legal authority to institute EVI. An example of the lack of legal authority comes from California. Under California law, the use of camera technology in red-light and grade-crossing violations programs, and photo-radar for speeding enforcement are specifically prohibited. In effect, there is no legal authority to directly issue citations from such EVI programs. Instead, *notices* of violations can be issued to the registered vehicle owners, beginning the process of legal service for an eventual court citation.

Until the owner signs the notice of violation, the county does not have jurisdiction to issue a citation. If the alleged violator ignores the notice, staff of the agency must make a positive license photo match and submit a formal request to the court to have a citation issued. Photographs that do not match the ones on file or are blurry must be thrown out.

This procedure is labor intensive and costly. Eight of the nine defunct automated speed enforcement programs in California noted lack of legal authority as a major factor in their demise.

Requirements for Enabling Legislation: The specific elements of the enabling legislation are usually determined in cooperation with the courts, enforcement agencies, state transportation department, motor vehicle departments, and other entities whose operations may be affected by the program, such as insurance companies and vehicle user associations. The basic framework is one that typically establishes infraction types, procedures, deadlines for service of citation, liabilities incurred, and defense procedures. Authority may be delegated to a civilian contractor for some enforcement duties, penalty and fine provisions, and admissibility of evidence.

Voluntary electronic screening programs may not require enabling legislation because their rules and procedures are established through voluntary contracts among agencies, vendors, and the carriers. However, non-voluntary screening applications may require legislation that addresses a broad range of issues, depending on the type of data collected. For example, commercial vehicle screening may raise issues of business confidentiality and trade secrets.

The lack of legislation regarding electronic vehicle identification in general, and DSRC in particular, has to be addressed. Transportation system managers are planning an electronic future, in which DSRC would link all segments of transportation, as well as commercial activity; and a legal framework is necessary for the process to move forward successfully.

Section 5: The Role of EVI in Transportation System Management

This section describes the concept of an integrated transportation management system and sketches the role of EVI in such a future system.

5.1 ITS Architecture

At present, the USDOT and several state departments of transportation (DOTs) are in the process of designing and implementing an all-inclusive, interconnected regional transportation system management network that incorporates travelers' needs, vehicle needs, and roadside requirements. The idea is that every user on the transportation system will be interconnected, resulting in greater safety, efficiency, and maximization of utility for the traveler and transportation system alike (PennDOT, 2005). This system is referred to as ITS Architecture. Figure 5.1 shows a partial diagram of ITS architecture.

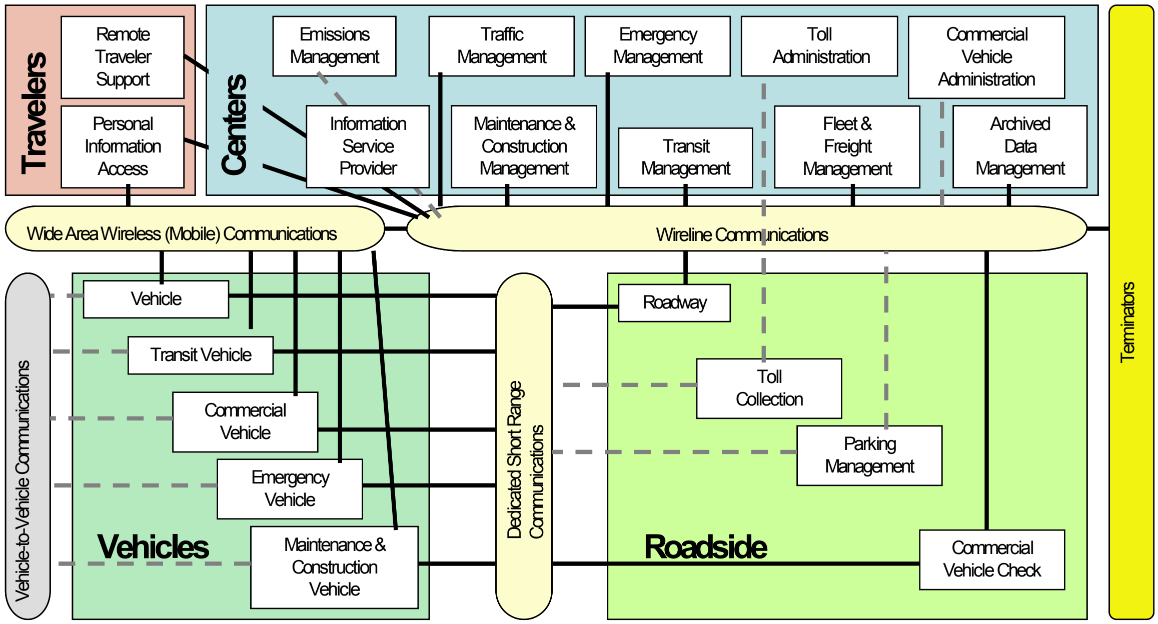

Figure 5.1: Partial "Sausage Diagram" for ITS Architecture
(Kimley-Horn & Assoc., 2005)

Travelers: Two subsystems, *Personal Information Access*, and *Remote Traveler Support*, would provide the capability for travelers to receive traffic information at home, on portable devices, or at en-route locations such as transit stops. The system would also support public safety monitoring, using surveillance equipment, and also support emergency notification within public areas. Tracking vehicle location is an essential requirement for collecting and distributing information.

Vehicles: This system would provide vehicle-vehicle and vehicle-roadside communications to support efficient, safe, and convenient travel. For the *Vehicle* subsystem, functions would reside in OBU, and will eventually include automated vehicle operation. The *Transit Vehicle* subsystem would include signal prioritization functions, while the *Commercial Vehicle* subsystem would include cargo contents information, vehicle and driver safety data, and communications with inspection facilities. The *Emergency Vehicle* subsystem would provide coordination among police, fire, incident response, and medical services and would include signal preemption. Feedback processing would assist in re-routing traffic around incidents. The *Maintenance Vehicle* subsystem would provide location and condition information as well as environmental sensors for reporting infrastructure condition and weather information. Each vehicle would require an ID and the means to continuously monitor its location and condition.

Roadside: This system would monitor and control traffic through vehicle identification, automatic credentialing, and pricing, and would manage the condition and performance of roadside elements. The *Roadway* subsystem would include monitoring of equipment, such as signs, signals, and sensors, and would be able to deploy automated systems for de-icing or closing flooded lanes. Work zone surveillance would include driver warnings and violation enforcement. Safety features would include collision avoidance controls. The *Parking* subsystem would support electronic payment of parking fees, monitoring of parking lot usage, feedback to approaching vehicles, and dynamic pricing of parking. The *Commercial Vehicle Check* subsystem would support credentialing of vehicles, safety and emissions inspections, weigh-in-motion, and pre-clearance at interdiction points. The *Tolling* subsystem would allow open road tolling, toll system interoperability, feedback to customers of account status, and records of transactions. The Roadside system would require that the movements of each vehicle be recorded, and that an accountholder be identified for payments.

Centers: The Transportation Management Centers would provide the data processing required for ITS. The *Archived Data* subsystem would capture and maintain data. The *Information Service Provider* subsystem would collect, process, store, and disseminate transportation information to system operators and the traveling public. The information would be provided to the traveler through the Traveler system and various Vehicle subsystems through communications links. The *Emergency Management* subsystem would coordinate the activity of incident response services, including selection of responders, routing, and traffic control.

The *Traffic Management* subsystem would communicate with the Roadway subsystem to monitor and manage traffic flows. Incidents would be detected and the information provided to the Emergency Management subsystem, travelers, and third party providers. The subsystem would coordinate traffic information and control strategies with neighboring jurisdictions and with rail operations to support highway-rail interactions. The subsystem would also support demand management policies such as managed lanes. The *Transit Management* subsystem would manage transit vehicle fleets and coordinate with other modes and transportation services, including providing customer information. The *Maintenance and Construction Management* subsystem would manage construction and maintenance activities through continuous monitoring of infrastructure conditions and assignment of resources.

The *Freight Management* subsystem would provide information to commercial operators and researchers on routing/restrictions, and cargo/driver conditions. In addition, it would support connections to financial institutions and regulatory agencies, allowing seamless transactions. The *Commercial Vehicle Administration* subsystem would support credentialing, permitting, taxation, and safety regulation. The *Emissions Management* subsystem would monitor emissions and provide feedback on demand management needs. It would also flag emissions violators while providing automated inspections by data extraction from a vehicle's OBU. The *Toll Administration* subsystem would provide general payment administration capabilities and support the electronic transfer of funds from the customer to the transportation system operator. All of these subsystems would require electronic vehicle identification and user/account holder recognition/registration.

5.2 Vehicle Registration Requirements

Vehicle Registration: It is a legal requirement in the U.S. for most types of motor vehicles to be registered with a state DOT or Motor Vehicle Division (MVD) if they are to be used on public roads. The DOT records the vehicle's details (make, model, vehicle ID, etc.), details of the party currently responsible for the vehicle (name, address, and other contact information), and the registration expiration date. The DOT provides a unique registration number on specified registration plates that must be displayed on the vehicle. In addition, most DOTs now provide a sticker showing the expiry month/year of registration, plus other data and require that the sticker be visibly displayed, either on the plate or inside the windshield.

Vehicle Titling: Issuing vehicle titles (proof of ownership) is another function of state DOT registration offices. A vehicle owner files proof of purchase documents (bill of sale from dealer, signed transfer of title from previous owner, lien release from financial institution, etc.) and receives a certified title document. The National Motor Vehicle Title Information System (NMVTIS)—legislation invoked by the USDOT Anti Car Theft Act of 1992—allows state titling agencies to verify the validity of the owners' documents before it grants titles. Potential buyers can get data on title history, vehicle history, and odometer readings for a vehicle. On vehicles with OBU, this information can be downloaded directly.

Vehicle Identification Number (VIN): Vehicle data sharing among state DOTs is an issue. However, each manufactured vehicle in the world has a unique ID. The VIN is a combination of numbers and letters imprinted by vehicle manufacturers on the engine, frame, and other parts of a vehicle. Newer vehicles have a 17-character VIN consisting of:

- 1st character- Identifies the country in which the vehicle was manufactured. For example: U.S.A.(1or 4), Canada(2), Mexico(3), Japan(J), Korea(K), England(S), Germany(W), Italy(Z)
- 2nd character- Identifies the manufacturer. For example; Audi(A), BMW(B), Buick(4), Cadillac(6), Chevrolet(1), Chrysler(C), Dodge(B), Ford(F), GM Canada(7), General Motors(G), Honda(H), Jaguar(A), Lincoln(L), Mercedes Benz(D), Mercury(M), Nissan(N), Oldsmobile(3), Pontiac(2 or 5), Plymouth(P), Saturn(8), Toyota(T), VW(V), Volvo(V).
- 3rd character- Identifies vehicle type or manufacturing division.
- 4th to 8th characters- Identifies vehicle features such as body style, engine type, model, series, etc.
- 9th character- Identifies VIN accuracy as check digit.
- 10th character- Identifies the model year. For example: 1994(R), 1995(S), 1996(T), 1997(V), 1998(W), 1999(X), 2000(Y), 2001(1), 2002(2), 2003(3), etc.
- 11th character- Identifies the assembly plant for the vehicle.

- 12th to 17th characters- Identifies the sequence of the vehicle for production as it rolled off the manufacturer's assembly line.

Several Internet sites provide vehicle data when a VIN is entered. In effect, a national database of VINs exists. The VIN can serve as a common link among state DOT databases without compromising the data stored in each.

Online Registration: Use of automated ways to transact business is a growing trend. In 2001, TxDOT's Vehicle Titles and Registration Division (VTR) started online registration of motor vehicles. Users in participating counties can renew their vehicle registration via the Internet. The county tax collector's office (point-of-sale or POS) verifies payments, then prints and mails the registration renewal stickers. Information required for vehicle registration include county of residence, address, credit card number, license plate number, last 4 digits of the VIN, and insurance information. Registration information from VTR's mainframe Registration and Title System (RTS) is exchanged with a webserver, Texas Online (TxO), and the user's browser. TxO communicates with credit card providers to transfer funds to the county's bank account. The county also maintains a local database of registration data, payments, and refunds.

5.3 Introducing EVI for Registration

In this research project, the possibility of using smart stickers for vehicle registration is being explored. In addition to imprinting required registration information on a sticker, it may be possible to code the data onto a built-in RFID tag in the sticker, which can then be read and/or written to remotely. Currently, RFID toll tags are affixed inside the windshield and are similar to a registration sticker in appearance. A typical size is 85mm x 76mm (3.3in. x 3in.), consisting of two layers of film housing a tiny antenna connected to a chip that integrates both processor and memory (1 kb). Toll tags are now paper-thin except at the chip, where they are 1 mm thick. Figure 5 shows a toll tag from TransCore, maker of TxTAG, now being deployed by the Texas Turnpike Authority Division (TTA).

Figure 5.2: TransCore Toll Tag: Full Size (TransCore, 2006)

Required Data on Sticker: Currently, Texas registration stickers are inscribed with the last 8 digits of the VIN, the license plate number, the county of registration, and the registration expiration month/year. The same information is also printed in bar code form on the sticker to discourage counterfeiting. Texas Department of Public Safety (DPS) officers are able to scan the bar code and verify validity. They also have live access to the VTR database to check ownership.

Tag Initiatives: Apart from the recent implementation of bar coding, there are two initiatives regarding sticker tags. The first is a joint effort of DPS and VTR to implement recent legislation that requires vehicle/ motorist insurance information be available to DPS. The idea is that the officer can automatically verify whether the vehicle has current insurance. The second is an idea by the Texas Commission on Environmental Quality (TCEQ) to merge the emissions/inspection sticker with the registration tag. TCEQ has not yet approached VTR with its proposal.

Initiative in China: Validation of registration, insurance, and inspection can all be accomplished by DSRC as an alternative to bar codes. RFID tags can also be printed with familiar information for normal reading. Several provinces of China now use RFID tags for vehicle registration. In 2000, TransCore entered a contract with Sichuan Province in China to implement RFID tags for vehicle registration. To begin rollout of the system, Sichuan is using 1 million of TransCore's Intellitag windshield sticker tags and several hundred universal access point RFID readers in roadside-fixed, mobile, and handheld configurations. Initially, all vehicles in Yibin City were issued tags. Wireless inquiries of passing vehicles provide vehicle registration information and status of annual vehicle inspection, vehicle emissions, taxation, and traffic record—all within 0.1 s. The technology also supports dynamic management of traffic intersections to control traffic, speed, and safety. In the future, the technology will be adapted to the growing demand for mobile commerce, such as electronic payment at gas stations.

5.3 Electronic Vehicle Registration (EVR) Benefits for Texas

EVR using RFID tags to replace current registration stickers would provide benefits to VTR:

- *Increase compliance and lower the cost of vehicle registration transactions.* Government agencies lose millions of dollars each year because an estimated 3 to 10 percent of vehicles are not compliant with annual registration requirements, a cost which then trickles down to taxpayers and law-abiding citizens. On the other hand, because drivers would know how easily they could be spotted by remote scanners, they would be more likely to register. Savings could also accrue if a new sticker is not issued each time registration is renewed—instead, a database update would be sufficient.
- *Improve the integrity of titlin*g. Many DOTs do not have an effective way to ensure that the new owner of a vehicle purchased in a private transaction will file the paperwork to transfer the title. Electronic monitoring would make it easier to identify vehicles that have not had a complete transfer of title if the previous owner files a notice of transfer but the new owner fails to complete the transfer.

In addition, EVR would further two other initiatives in which VTR is involved:

- *Reduce the number of uninsured vehicles.* Uninsured motorists are a significant problem for the road system. The 79th Texas Legislature passed Senate Bill 1670, which provides that the Texas Department of Insurance (TDI), in consultation with DPS, TxDOT, and the Texas Department of Information Resources (DIR) "shall establish a program for verification of whether owners of motor vehicles have established financial responsibility." The goals of this Financial Responsibility Verification Program (FRVP) are as follows: to reduce the number of uninsured motorists in this state; to have vehicles operate reliably; to be cost-effective; to sufficiently protect the privacy of the motor vehicle owners; to safeguard the security and integrity of information provided by insurance companies; to employ a method of compliance that improves public convenience; to provide information that is accurate and current; and to have the capacity to be audited by an independent auditor. Most of the bidders for the contract (TransCore is one of them) are also affiliated with the toll tag industry, so it is possible that the program will involve RFID tags. Database sharing is a major concern for the insurance companies.
- *Increase compliance with vehicle inspection requirements.* Annual vehicle inspection is required in most jurisdictions to protect public safety. A windshield sticker is issued to verify compliance. In addition, several counties require emissions inspections to screen for vehicles that pollute excessively. However, a significant segment of vehicles on the road have expired inspection stickers. Manual compliance monitoring methods are sporadic and usually depend upon other incident detection events, resulting in minimal sampling of the total vehicle

population. RFID scanning would replace labor intensive and expensive manual, visual-based identification, tracking, and enforcement systems.

Furthermore, EVR would strengthen law enforcement capabilities by enabling:

- Easy access to, and sharing of, interagency information, including alerts, prior to approaching a vehicle with a history of incidents
- Automated detection of non-compliant vehicles
- Faster apprehension of dangerous vehicles.

Finally, apart from other previously discussed generalized benefits of DSRC and EVI that would be achieved through EVR, EVR would also deter motorists from being non-compliant with legal requirements. Subsequently, agencies can allocate resources to higher-priority concerns.

5.4 Drawbacks of EVR

There are some drawbacks associated with deployment of EVR (CUTR, 1993). Chief among them are:

- *Specialized methods, personnel, and equipment.* Deploying EVR will require a change in the way VTR operates and will require new equipment and personnel with specialized skills. Initial costs and training requirements will be significant. Databases and database security will also have to be upgraded. In addition, county offices that now handle online registration will have to be reconfigured to deal with the new tags. DPS will require different scanners than the ones now used for bar code reading.

- *Data privacy and information exchange.* Both public and private sectors are concerned about the potential numerous uses of data obtained from roadside scanners. The public sector does not want any information generated by electronic screening to be misused. The potential for hackers to capture data or alter records must be addressed. Some private companies may be wary of losing business secrets inadvertently when they share data, while others will want to get free access to data for commercial purposes.

- *Acceptance by enforcement personnel.* Many enforcement personnel do not trust automated inspections, and believe it is necessary for officers to be seen doing their work in order to serve as a deterrent. Some jurisdictions may not be able to afford the scanning equipment or the computer systems required to provide access to statewide databases.

- *Acceptance by the public.* As was seen in the discussion on privacy issues with EVI, the public is concerned about systems that allow them to be tracked. However, significant benefits, convenience, and low cost often trump these concerns. For example, credit card use continues to grow even though the data makes it easy to trace where, when, and what business individuals transact. Regardless, an outreach program would be needed to alleviate fears of *Big Brother*.

5.5 A Possible EVR Timeline

Given the various changes that are currently occurring and are likely to occur in the future regarding EVR, a timeline matrix diagram was developed in this research to provide a sense of the direction and rate of change. The matrix, shown in Table 5.1, is split into three time periods, beginning at the present and stretching out to 2025. The primary driving forces are technology, standards and legislative changes, state DOT plans, and public attitude towards the changes.

Table 5.1: EVR Timeline Matrix

Driving forces	Timeframe: Present -2010	2010- 2015	2015- 2025
Technologies	• Phase out of manual tolling and 915 MHz tags • Domination of toll market by 5.9 GHz DSRC tags • Growth of AVI for commercial vehicle credentialing • ITS deployment • Introduction of EVR in some U.S. states	• Mileage tolling using DSRC • Growth of tolling via cell phone • Completion of ITS deployment	• Satellite/GPS for mileage tolling • ITS integration
Standards	• Implementation of 5.9 MHz DSRC standards • Interoperability of toll tags within regions	• All toll tags interoperable in U.S. • Worldwide DSRC standards	Standards for GPS in traffic management
Legislation	Unsettled law regarding privacy and electronic communications. Attempts by state DOTs and Congress to enact laws.	Test cases and challenges on electronic monitoring. Supreme Court rulings.	Settled law on privacy and electronic data.
Interactions, impacts, opportunities			
DOT plans	• Deployment of ITS in metropolitan areas • Use of tolling to expand system capacity • Interoperability of toll systems • Managed lanes and congestion pricing • Separation of trucks from cars	• Mileage tolling and variable pricing • Toll interoperability with Canada and Mexico • EVI and EVR	Integrated system management using ITS.
Public response	• Outreach programs to market the benefits of EVI and EVR. • Public opposition to *Big Brother* • Political opposition to some initiatives	Benefits of EVR in terms of convenience and lower costs start to accrue.	Public should have internalized the benefits EVR.

Section 6: Conclusions and Recommendations

At this stage of the research project, three conclusions can be drawn:

1. Tolling with DSRC will become dominant. RFID tags will replace manual tolling in the U.S. within a few years and will therefore be the preferred technology for tolling.
2. Scanning of toll tags for other traffic management applications will increase. As toll tags become more commonplace, DOTs will start introducing systems to monitor travel times and other operations data.
3. Other benefits of EVI will drive deployment. As the benefits become clearer, users will want the technology. For example, trucking companies that have equipped some of their fleet with transponders report that those drivers seem to enjoy higher status and are more likely to remain employed with that company.

In addition, two recommendations are evident:

1. Even though EVI is legal, public concerns over privacy make it necessary for DOTs to market the benefits before initiating programs. Moreover, the program should be limited to the agency's mission, with clear guidelines for appeal and resolution of citations.
2. Legislation to codify agency authority and procedures is desirable. Cooperation will be needed among DOTs, vehicle user associations, insurance companies, legislators, enforcement agencies, and the courts. It is necessary to establish the legal authority to conduct the program, to determine the types of infractions and liabilities incurred, to process and determine deadlines for serving citations, and to determine defense/ resolution procedures.

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Appendix A: Federal Funding For ITS

The Transportation Equality Act (TEA-21), a major piece of legislation provided to fund the federal Intelligent Transportation Systems program, dealt primarily with research, training, and standards development. It was succeeded, in 2005, by the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), which sets out the parameters for federal transportation funding until 2010.

Transportation Equity Act-21

As per TEA-21, a total of $1.282 billion in contract authority was provided for FYs 1998-2003 to fund the Intelligent Transportation Systems (ITS) program (US DOT TEA-21 Factsheet). Of this total, $603 million was targeted to research, training, and standards development. Programs to accelerate integration and interoperability in the metropolitan and rural areas and to deploy commercial vehicle ITS infrastructure were established and funded at $482 million and $184 million respectively.

In addition to the funds authorized specifically for ITS, ITS activities were eligible under other programs. Both NHS and STP funds could be used for infrastructure-based ITS capital improvements, and CMAQ funding could be used for the implementation of ITS strategies to improve traffic flow that contributes to air quality improvement. Transit-related ITS projects are defined to be capital projects and are therefore eligible for related funding.

The legislated purposes of the program were, among others, to expedite integration and deployment, improve regional cooperation and operations planning, develop a capable ITS workforce, and promote innovative use of private resources.

SAFETEA-LU

SAFETEA-LU is the most recent legislation enacted for U.S. transportation funding, governing the federal surface transportation spending through 2010 (Wikipedia: SAFETEA-LU). Signed into law in 2005, it is a $286.4 billion measure containing a host of provisions designed to improve and maintain the transportation infrastructure in the U.S., especially the highway and interstate road system

Basic points in SAFETEA-LU regarding ITS (US DOT SAFETEA-LU Implementation: ITS and Operations):

- Strong support for ITS R&D.
- ITS Deployment mainstreamed.
- Significant focus on congestion mitigation, including:
    - Congestion management
    - Real-time information

    - ITS
- Incorporation of system management and operations.

ITS R&D

- Research and Development
    - Program reauthorized and expanded.
    - $550 million over 5 years.
        - Road weather—$20 million
        - I-95 Corridor—$35 million
        - Rural and Interstate Corridor Communications Study—$3 million
    - New advisory committee required.
    - New 5-year program plan required.

ITS Deployment Funding

- Mainstreamed throughout Federal-aid program; including high priority projects.
- Eligible under National Highway System (NHS), Surface Transportation Program (STP), and Congestion Mitigation and Air Quality (CMAQ).
- Categorical National Environmental Policy Act (NEPA) exclusion.
- ITS Deployment funds in 2005 only.
- $100 million, over 4 years, for Commercial Vehicle Information Systems and Networks (CVISN) deployment.

Congestion Management—Pricing

- Continues Value Pricing Program
    - $59 million in new funding, including $12 million for projects not involving tolls.
- New Express Lanes Demonstration Projects
    - Allows tolling of new or existing lanes to reduce congestion and/or improve air quality.
    - Fifteen projects, no separate funds.
    - DOT to establish interoperability requirement for automatic toll collection.
- High Occupancy Toll (HOT) Lanes Mainstreamed
    - Requires States to certify that they will monitor operational performance, enforce High Occupancy Vehicle (HOV) restrictions, address seriously degraded operations.

Congestion Management—Research

- Surface Transportation Congestion Relief Solutions
  - $36 million over 4 years for research.
  - $3 million over 4 years for training and technical assistance.
  - Focus on:
    - Congestion management system effectiveness
    - Congestion measurement and reporting
    - Effective congestion relief strategies
- Future Strategic Highway Research Program (SHRP)—SHRP II
  - $205 million over 4 years for research.
  - Managed by National Academy of Sciences.
  - Four focus areas, including:
    - Improving reliability

Real-Time Information:

- Real-Time Systems Management Information Program
  - Establish capability in all States to provide real time:
  - Sharing of information
  - Monitoring of traffic conditions
  - Purpose—ease congestion, improve response to severe weather, accidents, and other incidents; and enhance security.
  - Eligible for funding under NHS, STP, and CMAQ.
  - Must be part of regional ITS architectures.
  - DOT to establish data exchange standards within 2 years.

- Transportation Technology Innovative Demonstration Program
  - Two-part extension and expansion of Intelligent Transportation Infrastructure Program established by Transportation Equity Act for the 21st Century (TEA-21).
  - $2 million per city available to support deployment of traffic monitoring infrastructure and commercialization of data.
  - Twenty-two new cities + thirteen original cities that have not received prior funding are eligible.
  - Part I: Existing contract with Mobility Technologies will be completed as planned (eleven additional cities).

- Part II: Create and complete new program to use any unobligated and any new appropriated funds.

Implications of SAFETEA-LU on ITS and Operations

- More funding for ITS and Operations.
- Maintains strong ITS R&D program.
- Increases focus on congestion relief.
- Puts strong focus on managed lanes and pricing.
- Establishes nationwide requirement for real-time information systems.
- Advances system management and operations.