Electronic Toll Collection Interoperability Study in Brazil

Task 1 - Data Collection

Prepared for

Associação Brasileira de Concessionárias de Rodovias

Associação Brasileira de Concessionárias de Rodovias ABCR

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SET
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PB 100 YEARS

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Subtask 1.1 - Review and Analyze Data on In-Place Systems

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SUBTASK 1.1. REVIEW AND ANALYZE DATA ON IN-PLACE SYSTEMS

Electronic toll collection (ETC) is currently experiencing rapid growth throughout the world. Existing toll agencies already have spent $3 billion on ETC. By 2007, the market potential for ETC is expected to be $13.2 billion. The current 8.6 million tags are expected to increase to 50.6 million by that time as well.

South America captures about $78 million of the existing ETC market. Approximately $71.6 million of that is in initial capital investments and integration, with the remaining $6.3 million spent on maintenance and operations. 168 toll lanes in the region are equipped with automatic vehicle identification (AVI) and 287,900 tags are currently in circulation. In Brazil, 28 lanes are equipped with AVI, representing 16.67 % of the South American market. 93,408 tags are in circulation (32.44 % of the region's market). Argentina, with the region's most extensive ETC systems, has 126 lanes equipped with AVI and 75 % of the market. 181,000 tags are in use (63.04 % of the South American market) – the majority of this from the Autopistas del Sol. Chile is in the process of implementing ETC at the Santiago airport and on route 78.

The region has a high average number of tags per AVI lane – 1,714, 22 % above the global average. This reflects the high degree of confidence in ETC by South American users. In addition to significant tag use, the cost of installing ETC is $426,200 per lane, just below the global average – making the South American ETC market fertile ground. The growth rate for ETC in the region is expected to be about 23.3 % per year for the next ten years. By 2007, it is expected that 75 % of the toll lanes in South America will be equipped with ETC. That growth is expected to level off from 2002 onward, from the growth expected in 1997-2002.

Analysts also predict an average yearly increase in the market of $17.6 million. By 2007, the total South American ETC installation market is expected to be $247.5 million with an additional $74.7 million for maintenance and $11 million for operations (total South American market $333.3 million).

The attached listing describes the in-place ETC systems around the world. In addition to these in-place systems, a number of new systems are emerging in the U.S. (Massachusetts Turnpike, Delaware, New Hampshire), Japan (Tokyo), Europe (Hungary), the Middle East (Israel), Asia (Thailand, Malaysia), and, of course, South America.

There are currently 3,757 AVI toll lanes in the United States, representing about 61.15 % of all AVI lanes in the world. The U.S. tag market is about 4,045,492, representing 46.92 % of the world market. Some of these installations, especially the California Department of Transportation, California Private Transportation Corporation, Golden Gate Bridge, Transportation Corridor Agencies and Maine Turnpike systems, may be of particular interest to Brazil. These systems use technology compatible with many systems already in place in Brazil and other parts of South America. Task 1.2 details these compatible systems.

Europe has 1,811 AVI lanes, about 29.48 % of the world market. Europeans are using 2,356,360 tags, about 27.33 % of the world market. Countries with systems potentially compatible with Brazilian systems include: Austria, France, England, Norway, Sweden, Spain, Slovenia, and Denmark. Again, the Task 1.2 report provides further details.

Asia has only 408 AVI-equipped lanes (6.64 %) and 1,932,500 tags (22.41 %) in use, but analysts predict the Asian market (along with the South American market) to be the most aggressive in the coming years, eventually surpassing the United States in terms of global market share. Systems in Hong Kong, Malaysia, and China may be compatible with a number of those in Brazil and South America. Task 1.2 has more information on this matter.

Combitech currently commands the South American AVI market, with 108 lanes worth $7.1 million. That translates into 64.29 % of the South American market. Amtech has 46 lanes worth $3 million and about 27.38 % of the market. Much of Combitech's presence is the due to the Argentinian Autopistas del Sol project.

Tag distribution is somewhat different. Amtech, with a greater number of installations throughout South America, has 140,204 of its tags in use, representing 48.7 % of the tag market, valued at $5.7 million. Combitech has 131,000 tags in use and 45.5 % of the market, worth about $9.7 million. Another 16,704 tags are in use, manufactured by unknown suppliers.

The following table provides information about various ETC installations world-wide. This table is based on published information. No additional research was conducted for this table. Some of the information not available in this table is proprietary. Concessionaires interested in further information should contact the appropriate agency listed in Appendix A.

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Subtask 1.5 - Identify the Lengths of Toll Concessions and Increments

SUBTASK 1.5 IDENTIFY THE LENGTHS OF TOLL CONCESSIONS AND INCREMENTS

The tables below highlight various aspects of the Brazilian toll road program. Table 1.5.1 provides a high-level review of the major road concession systems in the country and identifies the number of Federal, state and municipal roadway kilometers already consigned or programmed for concession.

Table 1.5.1. - Brazil road concession program

	Already Consigned (in km)			Programmed for Concession		
	Federal	**State**	**Municipal**	**Federal**	**State**	**TOTAL**
DNER	885			11,007		11,862
Sao Paulo				33	5,155	5,188
Rio Grande do Sul				2,065	927	2,992
Santa Catarina		35		707	897	2,639
Parana				2,692	651	2,343
Rio de Janeiro		60	15	272	440	787
Espirito Santo		3		472	65	540
Minas Gerais				2,460	516	2,976
				2,889		2,889
Norte Centro Oeste				859		859
Nordeste				3,437		3,437
	885	98	15	25,893	8,651	35,512

Source: Geipot/DNER/Departamentos Estaduais de Rodagem

Table 1.5.2 provides further detail on Table 1.5.1, defining the specific roadway segments for each of the major concession programs and providing a status of the concession process for each segment.

Table 1.5.2. Brazil road concession program selected roadways

	Roadway Segment	Km	Total	Status of Concession Process
DNER	Sao Paulo - Curitiba - Floianopolis	721		November 1997
	Belo Horizonte - Sao Paulo	563		February 1997
	Florianopolis - Osorio	344	1,628	Year 2000
	Rio de Janeiro: BR-101 North	315		Projected: November 1997
	BR-393	200	515	Projected: November 1997
Espirito Santo	Rodovia do Sol	65	65	Perhaps 1997
Santa Catarina	Sistema Brusque	112		Prequalification submitted: Oct. 1997
	Sistema Norte	711		
	Sistema BR-470/SC470	481		Letter of Prequalification: Sept. 1997
	Sistema Cricuma	344	1,648	
Rio Grande do Sul	9 polos rodoviarios	2,992	2,992	Commercial Proposal: Sept. 1997
Minas Gerais	9 lots	2,976	2,976	Letter of Prequalification: Oct. 1997
Parana	6 lots	2,343	2,343	Assigned contracts
Sao Paulo	Sistema Anhanguera-Bandeirantes (DERSA)	312		Contract to be signed on April/98
	Nova Odessa, Piracicaba, Rio Claro	71		In Analysis
	Catanduva, Bebedouro, Barretos, Taquaritinga, Pirangi	156		Contract to be signed on Jan/98
	Catanduva, Jales, Sta. Fe do Sul, S.J. do Rio Preto, Santa Albertina	280		
	Riberao Preto, Igarapava, Setaozinho, Bebedouro, Divisa MG	237		Contract to be signed on Jan/98
	Mogi Mirim, Limeira, Porto Fereira, Sao Carlos, Casa Branca, Divisa MG	340		Contract to be signed on May/98
	Jacarei, Campinas, Atibaia, Anel de Campinas (parte)	158		
	Limeira, Rio Claro, Sao Carlos Brotas, Jau, Bauru, Itirapina	218		Contract to be signed on March/98
	Sao Carlos, Borborema, Sertaozinho, Bebedouro, Jabiticabal	442		Contract to be signed on April/98
	Sanata Rita do Passa Quatro, Ribeirao Preto, Batatais	308		Contract to be signed on March/98
	Campinas, Mogi Guacu, Mococa, Sao Jose do Rio Pardo, SJB Vista	291		Contract to be signed on Feb/98
	Sistema Castello Branco - Raposo Tavares	162		Contract to be signed on March/98
	Campinas, Itu, Sorocaba, Tatui, Tiete, Piracicaba, Itapetininga	275		Contract to be signed on May/98
	Avare, Espirito Santo du Turvo, Ourinhos, Assis	353		In Analysis
	Espirito Santo do Turvo, Lencois Paulista, Bauru, Pirajui, Lins	172		In Analysis
	Tupa, Marilia, Assis, Taruma, Dirceu, Divisa PR	170		In Analysis
	Martinopolis, Pirapozinho, Regente Feijo, Assis, Divisa PR	244		In Analysis
	Reg. Feijo, Pres. Bernardes, Tupa, Parapua, Oswaldo Cruz, Martinopolis	89		In Analysis
	Parapua, Adamantina, Tupi Pulista	216		In Analysis
	Itapetininga, Capao Bonito, Itapeva	351		Contract to be signed on May/98

Roadway Segment	Km	Total	Status of Concession Process
Campinas, Tiete, Capivari, Piracibaba, Sao Pedro	134		In Analysis
Sistema Anchieta - Imigrantes (DERSA)	176	5155	Contract to be signed on June/98
		17,322	

Source: ABCR

Table 1.5.3 lists existing Brazilian toll roads that have been concessioned. It also notes the road lengths, vehicle traffic, number of ETC and regular plazas, and the number of toll tags in circulation.

Table 1.5.3. - Brazilian toll roads concessions

Type	Location	Length Km	Length Mi	System Name	Vehicles/day	Plazas ETC	Plazas Total	Tags
State Bridge	Espirito Santo	3.4	2.1	3o Ponte de Vitoria	41,000	---	14	
State Road	Santa Catarina	35.0	21.9	Linha Azul	17,000	2 + 2	12	1,000[1]
Federal Bridge	Rio de Janeiro	13.4	8.4	Ponte Rio - Niteroi	110,000	2 + 2	14	44,000[2]
Municipal Road	Rio de Janeiro	15.0	9.4	Linha Amarela	50,000	2 + 2	20	10,000[3]
Federal Road	Rio - Sao Paulo	406.8	254.3	Nova Dutra	22,500	8	48	?[4]
Federal Road	Rio - Minas Gerais	179.7	112.3	CONCER	21,000	2	22	8,000[5]
Federal Road	Rio de Janeiro	142.4	89.0	CRT	15,000	4	16	5,000[6]
Federal Road	Rio Grande do Sul	112.3	79.2	Freeway	12,000	8	56	10,000[7]
State Road	Rio de Janeiro	60.0	37.5	Via Lagos	11,000	2	11	20,000[8]
		968.0	605.1		299,500			

[1] COMBITECH, read/write, 2.45 GHz, ETC beginning Nov. 1997
[2] AMTECH, read only, 915 MHz, ETC began Aug. 1996
[3] AMTECH, read only, 915 MHz, ETC beginning Nov. 1997
[4] AMTECH, read only, 915 MHz, ETC beginning Dec. 1997
[5] SCHLUMBERGER, contact smart card, ETC beginning Nov. 1997
[6] AMTECH, read only, 915 MHz, ETC began Jul. 1996
[7] PHILIPS, contact smart card, ETC beginning Oct. 1997
[8] AMTECH, read only, 915 MHz, ETC began Jul. 1996
Source: ABCR

Table 1.5.4 details toll rates on the various concessioned roadways in Brazil. The chart also shows the number of toll plazas on each system, the direction of the toll (one way or two way), the length of the road and the effective date of tolls.

Table 1.5.4. - Toll rates on concessioned roadways

Types of vehicles	Axles	Ponte Rio-Nit	Via Lagos		CONCER	CRT		Nova Dutra	3° Ponte de Vitoria
			Normal	Special		Central	Auxiliaries		
Passenger cars	2	1.30	1.60	2.70	2.60	3.00	2.10	3.15	0.95
Vans, trucks buses, trailers	2	2.60	3.20	5.40	5.20	6.00	4.20	6.30	1.40
Cars, light trucks, trailers	3	1.95	4.80	8.10	7.80	4.50	3.15	4.70	1.40
Trucks with trailers	3	3.90	4.80	8.10	7.80	9.00	6.30	9.45	1.80
Cars, trucks with trailers	4	2.60	6.40	10.80	10.40	6.00	4.20	6.30	1.80
Trucks with trailers	4	5.20	6.40	10.80	10.40	12.00	8.40	12.60	2.20
Trucks with trailers	5	6.50	8.00	13.50	13.00	15.00	10.50	15.75	2.55
Trucks with trailers	6	7.80	9.60	16.20	15.60	18.00	12.60	18.90	2.95
Motorcycles	2	0.65	0.80	1.35	1.30	1.50	1.05	Free	0.50
Number of toll plazas		14	11		24	10	6	48	14
Direction of Toll		1	2		2	2	2	2	2
Length of road (km)		13.4	60		179.7	142.4		406.8	3.4
Tolls in force after		8/2/97	08/30/97		8/25/97	9/19/97	9/19/97	9/1/97	7/94

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Subtask 1.6 - Analyze Concession Requirements

SUBTASK 1.6. ANALYZE CONCESSION REQUIREMENTS

Road concession requirements vary widely. Three distinct concession programs – the DERSA program in the state of Sao Paulo, the federal PROCROFE program, and the Yellow Line Toll Road in Rio de Janeiro -- are briefly described below. Additional information on these and other road concessions will be collected during an upcoming site visit to Brazil in mid December.

1.6.1. DER Program

The state of Sao Paulo has developed a comprehensive program to award road concessions in an effort to upgrade its transportation system. Proposals from prospective concessionaires are judged on the basis of producing better results to the transportation system (through road extensions and/or additional construction improvements). Concessions are comprised of lots to be bidded of road networks centered around highway concession junctions (complexes) – where a number of roads converge. Proposers must prove their capacity to develop quality control projects and perform both construction and service work. The concession period for these projects is 20 years.

Compensation for the project is through user tolls sufficient to cover the costs of running the toll road, plus a reasonable profit for the concessionaire. The program prohibits discounts or tariff privileges for any user segment.

Bid documents must meet legal requirements and :

- Provide current, periodical and final quality ratings for each of the complex's highways
- Provide information on additional road signaling services to be provided
- Describe the necessary emergency and backup services required (ambulances, mechanical support and telephones)
- Provide technical and economic information (pricing and costs) and established rates of return
- Describe the construction work to be done by the concessionaire
- Provide the minimal span of the complex's highway segments
- Define the segment of the highway complex to be competitively bid
- List evaluation criteria

The concessionaires are required to provide:

- Initial services: patching, shrub cutting, signal improvements, localized pavement rehabilitation, park construction, etc. within one year of the concession award.
- Improvements: pavement sealing operations, asphalt concrete overlaying, permanent

signaling, etc. over the course of the 20 year concession.

In terms of cash flow, there are two segment recovery periods: one for the first part of the concession (years 1-4) and another for the last (years 15-20). During the first recovery period, the concessionaire is required to make the necessary initial improvements to bring the complex to the desired condition. During the second recovery phase, the concessionaire is required to bring the road complex back to its "perfect" condition prior to returning the complex back to the state.

Toll plaza investments are programmed for the first six months, suggesting that toll collection should begin between 6-12 months of the concession award. The state varies the concession road segment lengths to adjust to a predetermined rate of return (e.g. 14 percent). Under the program the state participates as the concessor, and private investors are required to obtain the necessary financial resources to build their business.

1.6.2. PROCROFE Program

This federal concession program dealt first with the highway segments that were technically and economically able to function as toll roads. The first phase consists of 840 km. Each road segment concession is for a period of 20-25 years. Private investment in the program is about R$1.2 billion (US$1.8 billion). The second phase consists of 15,000 km of highways and is equal to 30 percent of the federal network. Concessionaires are required to provide road repairs, construction improvements, and equipment. Private investment in this phases is about R$6.1 billion. In pure federal privatization efforts, foreigners can purchase up to 100 percent of a company being sold by the federal government through its national privatization program (PND). But public notices setting the terms of sale for specific companies can impose limits on foreign participation because of legal considerations. This openness to foreign participation in privatization suggests that foreign participation in concessions is also welcome.

1.6.3. Yellow Line Toll Road

This $160.5 million, 15 km road is a six-lane urban highway running through Rio de Janeiro. The concession consists of three segments: one 2.1 km in length, the second 6.9 km (includes two tunnels) and a third 6 km long. The concessions are for 13 year terms. The municipality of Rio de Janeiro committed US$103.5 million for the project. Linha Amarela S.A. (LAMSA) arranged for $57 million in financing. LAMSA is a special purpose company created to receive concession rights for operations and maintenance of the road. Domestic companies supplied the construction materials for the project were supplied by domestic manufacturers. Domestic companies also provided precast concrete, while a French construction company provided molds and steel supports.

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Subtask 1.7 - Identify Potential Competitive Alternatives

SUBTASK 1.7. IDENTIFY POTENTIAL COMPETITIVE ALTERNATIVES

This report identifies competitive alternatives to ETC deployment and standardization. It includes discussions of various technology alternatives (tags, communications protocols, frequency, detection, enforcement, etc.); clearinghouse operations alternatives and issues; business and institutional approaches. The report also highlights other applications of dedicated short range communications (DSRC), short range communications devices that are capable of transferring data at high rates over an air interface between mobile or stationary vehicles and devices mounted on structures along the roadway or hand held.

1.7.1. Technology Alternatives

The basic technology elements of electronic toll collection include: tags (or transponders), communications protocols, payment transaction processors, radio frequency, and some form of payment mechanism.

Tags

The ETC tag provides the gateway for communications between the vehicle and the roadside reader. It is a processor-controlled data transfer device (referred to as a "read-only" type tag) or a low-powered transceiver (referred to as a "read-write" tag) that stores data. Some tags are designed to be mounted inside the vehicle, while some can be mounted outside. The tag responds to communications "interrogations" initiated by roadside readers (described below). How these tags function depends on their method of operation and their technical communications capability.

ETC tags can operate as either backscatter or active tags. *Backscatter tags* communicate by modulating RF provided by a roadside unit. A tag's internal circuits are energized by a portion of the radio frequency (RF) pulse received from the roadside unit. These circuits reflect back the remainder of the RF pulse, modulating it with the tag's unique identification code and other data. Because backscatter tags rely on the roadside reader signal for its communication, their operating range is dependent on the output power of the roadside antenna. Most backscatter tags require small batteries to power their operations for up to 10 years.

Active tags contain a battery or external power source to power the internal circuits and transmissions. In read-only tags, the battery is used to power only the internal circuits, leaving more of the RF interrogation pulse to be reflected. Active tags operate over a larger range, generally 20 to 50 meters, but have a life span of only 5 to 10 years if batteries are used. If an external power source is used, the tag's lifetime can be indefinite.

ETC tags have four levels of technical communications capabilities. *Type I* tags are read-only tags. When interrogated, these tags transmit their unique identification code to the roadside unit. They are factory programmed with their identification code and other data. For Type I tags, a tag database must be kept on a centralized computer to process and record activity.

Type II tags are read/write tags. They have the capability to store and transmit other information. They are commonly called transponders because they can perform two-way communication with the roadside unit. Data is read from, modified, then sent back to the tag. These tags can allow for the creation of decentralized processing systems. *Type II+* tags provide feedback to the driver using lights or buzzers to convey information. *Type II++* tags use LCD and buzzers to provide feedback to drivers.

Type III tags are also read/write tags, but feature an external interface that is used for transferring information to other on-board devices, such as computers or driver information displays. These tags are particularly useful for fleet management applications, where drivers are required to track and receive large amounts of data from a variety of sources.

Type IV tags are also read-write tags with many of the same features as Type III tags, but these tags have an integrated smart card reader, rather than simply an interface to an on-board computer or smart card reader.

All four types of tags are currently in use by various toll agencies and CVO programs across North America.

Communications Protocols

Protocols are a set of rules that allow different machines or pieces of software to coordinate with each other without ambiguity. Protocols imply that there is some common message format and an accepted set of commands that all technology involved understand, and that transactions among them follow predictable logical sequences.

A number of proprietary protocols have been developed for high-speed transactions and two-way communications with transponders. These protocols are suitable for the transportation industry as communication to vehicles equipped with transponders can be carried out at highway speeds up to 160 km/h. However, the proprietary nature of these various protocols has been one of the many stumbling blocks in developing standards for ETC applications. Often, protocols designed for one manufacturer's system do not apply to other similar systems.

Sophisticated communications protocols become even more critical when used on open road systems where the protocol must take into account the existence of multiple transponders in the communication zone of the reader antenna.

Frequency

The frequency band most often used for ETC applications in North America is the 902 to 928 MHz. Alternatives to the 902 to 928 MHz band are being sought because some feel the band will become too congested in many urban areas. There has been an explosion in the types and number of equipment operating within this band and, thus, the potential for interference is great. Other equipment, such as cellular telephones and pagers, operate just above or below the band and also can add to the amount of harmful interference. While there is less interference with the 2.400 to 2.500 GHz frequency band, it is felt there is still too much to adequately support all types of ETC applications. In the United States, the 5.850 to 5.925 GHz frequency has been identified for ETC use based in part on the need for relatively clear spectrum and a primary spectrum allocation to support safety critical function. There is currently a movement toward a world-wide standard operating at or around 5.8 GHz. DSRC applications of the future almost certainly will include those that are critical for public safety, including: warning signs, emergency vehicle signal preemption, intersection collision avoidance, and automated highway system vehicle status checking. Safety-critical operations must operate in a protected environment, where such operations can be given allocation priority. The 5.8 GHz band provides this kind of environment, but currently no United States toll system operates in this frequency. This higher frequency also would presumably be easier to dedicate for DSRC applications. ITS America has filed a petition with the Federal Communications Commission to dedicate this range for DSRC.

Stored Value/Smart Cards

Electronic payment mechanisms vary. Some systems use a tag decrementing process, whereby a patron purchases a tag with a stored monetary amount. The appropriate charges are deducted from the card as the motorist exits a facility. When the balance is low, a warning notice of some kind may alert the driver to replenish the account. If a motorist with a stored value card does not have sufficient stored funds to pay the fee, the motorist can be billed for the fee and notified to replenish the account. Stored value cards contain electronic memory to store account balances.

Some authorities are moving toward the use of "smart card" technology for fee payment. Some smart cards also contain microprocessors that have substantially more memory and can perform significant computations, such as calculating fees and maintaining customer accounts. Use of smart cards will accommodate payment of multiple transportation and other charges, such as tolls, parking fees, gasoline purchases, etc.

The data storage and computing capability of these cards are seen as the solution to the complex communication required by multiple applications expected for DSRC in the future.

Smart cards are plastic cards similar in shape and size to today's credit or bank cards, with a key exception: on-board computer chips. This gives the cards the ability to maintain information, communicate with readers and other devices, and update information if necessary. Typically, smart cards are issued by banking and credit institutions such as First /Union Bank, Visa, and Mastercard. Users may use their cards to pay for transportation, services, and merchandises at designated point of sales where appropriate readers are located. These cards are currently manufactured by various vendors such as Motorola and Gemplus.

To conduct transactions, smart cards must be inserted into, or be in the proximity of, proper readers. The readers energize the cards and a series of authentication, financial data transfer and update, and other pertinent communication takes place. Finally, the updated information is stored in the cards and the transactions are concluded.

Smart Card Concept of Operations

The physical and electrical characteristics of smart cards are specified by the International Standard Organization (ISO) known as ISO 7816. This standard defines physical attributes of smart cards from dimensions of the cards to their resistance to environmental hazards such as static electricity, electromagnetic radiation and bending forces. It also establishes the location of the computer chip, embossed data, and, as an option, magnetic stripe. Although most smart cards have eight electrical contacts to facilitate communication, only five have been defined. The standard sets voltage and current requirements, communication protocols, and message sets for use in reading, writing, find updating cards. This standard is intended to promote interopoerability. However, most carc vendors maintain their own control scheme such that interoperability among different cards is not currently possible.

Based on a technology known as Reduced Instruction Single-chip Computer (RISC), the on-board computer chip has all of the capabilities and the components of full size computers, but requires much less operating energy. Most smart cards in the market contain up to 16K bytes of information and are capable of transmitting data at the rate of 100,000 bits per second. This is a significant improvement over the early cards a few years ago. Nonetheless, many improvements are still needed to meet the multiple applications requirements for the future. Efforts has been underway to apply new technologies which will further reduce energy requirements and chip space while increasing physical durability and communication capabilities. In the near future it will be possible to build a transmission antenna into the same silicon chip which makes up the computer. This development will greatly enhance the cards' communication. Another technology known as Flash Random Access Memory (FRAM) is believed to be able to both increase memory capacity as well as data rate.

When coupled with DSRC, smart cards have the potential to bring substantial benefits to toll agencies.

1. Toll agencies will no longer have to maintain a financial structure to turn toll transactions into money. A bank, credit card provider, or a third-party service provider will handle the sale of smart cards, provide customer services, and use the banking network to deposit overnight each day's toll into the Agency's bank account. As the system become widespread, customers may be able to choose their own banks and suppliers to handle transactions. This represents not only a large cost savings but also the a means of eliminating administrative headaches by transferring backoffice operations to the banks. Assuming in-vehicle tags supplied by the auto industry, smart cards will complete the process of moving toll agencies out of banking business.
2. Smart cards will lower "shrinkage". Less money will change hands. The less the money is handled and the more secure the transaction the less likely it will be stolen or misplaced.
3. Smart cards will reduce operational and maintenance costs. Mechanical devices such as collection baskets will be phased out resulting in substantial cost savings.
4. Smart cards will also spawn other revenues. They will motivate toll road users to purchase goods and services along the road. Users will enjoy the convenient transactions why maintaining complete records. These related applications may motivate more toll road usage and indirectly expand the toll base.

There are additional costs in implementing hardware and software to support smart cards. Banks may also charge a service fee for each transactions. It is obvious, however, that the benefits far outweigh the costs. A study sponsored by the FHWA showed that smart cards application in toll collection will reduce the transaction cost to below the average of $.10 experienced today. A related study estimated a the break-even points for smart cards investment to occur around 4 to 6 years on an average toll road.

Modes of Operation

The primary role smart cards are designed for are in financial transactions. Their functions in financial truncations can be correlated to traditional instruments that fall into 3 categories:

- Credit smart cards - equivalent to magnetic based credit cards
- Debit smart cards - equivalent to checks
- Stored value smart cards - equivalent to cash

Of these, stored -value smart cards require the least infrastructure and processing support. This is why stored-value cards are the most widely used or tested. During the Olympic Games in Atlanta, GA in 1996, over 60,000 stored-value cards were distributed for use by athletes and visitors within the Olympic Village. Card holders used these cards to pay for transit fares or purchase merchandises at participated merchants instead of cash. Each time a purchase took place, the purchasing amount would be deducted from the value of the card. When completely depleted, the card could be discarded or recharged. Some of these cards still have remaining values and are used today.

Smart cards systems can be either an open or closed system. This concept may be confusing as the definitions varied depending on the card issuers' or the transactions' perspectives:

- From the card issuers' perspective, an open system is one that allows smart cards issued by multiple issuers to interoperate. The Atlanta Olympics cards were issued by 2 institutions, but could be used at all participating merchants. A single card reader interoperated with cards issued by both issuers. From this perspective, the Atlanta Olympics is an open system. On the other hand, most smart cards used by transit authorities in the U.S. are proprietary products that do not communicate with each other. These are considered closed systems.

- From the transactions perspective, an open system is one which allows smart cards to be accepted by multiple merchants and services. The Atlanta Olympic card system was used for transit fare payments as well as for goods and services, therefore it was an open system. However, this definition becomes fuzzy as one attempts to apply it beyond the limited circle of use designed for the system. Since the Atlanta Olympic system worked only within the Olympic Village, one might argue that it was a closed system if viewed from outside of the Village.

Smart cards may be contact or contactless.

- Contact smart cards must be inserted into a reader such that physical contact is made to enable proper electrical operation to take place. This type of card is most popular in transit operations where time is not critical, but positive transactions are essential. Contact smart cards may cost around $1 each in quantity.

- Contactless smart cards, also known as proximity cards, are used in limited applications where physical contact is infeasible or where speed of operation is critical. State-of-the-art contactless smart cards are capable of operating at up to 20 inches away from the reader. Communication is conducted through radio wave. Contactless smart cards are generally packaged in thicker cards and may cost up to US$5 each in quantity. Studies have shown that contactless cards are more desirable to users in toll operations.

Concept of Operations

Due to the significant range of operation and data rate required for successful toll transaction, smart cards must work in conjunction with DSRC tags capable of communicating with roadside readers. Information contained in the smart card memory will be transferred into an on-vehicle DSRC tag as the user begins the journey. Then the information will be transmitted by the tag to the roadside reader as the vehicle enters a toll area. Updated information will be transmitted from the roadside reader to the on-vehicle tag, and eventually relayed to the smart card.

Contact smart cards must be inserted into a designated slot on the DSRC tag mechanism sufficiently in advance of the toll operation for the transaction to be successful. Contactless smart cards may be required to be in close proximity of the tag for the operation to be successful. The data exchange between smart cards and DSRC tags may take place far in advance of the actual toll transactions or much later after the vehicle has passed the roadside reader.

State of the Practice

Of the estimated 100 million cards distributed worldwide, European users, led by France, have been dominating the industry both in terms of market share and expertise. Almost one out of four cards used in Europe are for mobile communication purposes. The rest is spread among banking, medical and entertainment. As the world market expands in the next few years, the total card demands are expected to be in the range of 250 million. There are a number of European transportation agencies using smart cards as an alternative to cash payments, but most of these are in transit applications. Only a few programs are dedicated to toll collection or include toll collection as one of many applications. The Telepeage Inter Societe and Marseilles Tunnel Prado Carenage in France, the Autostrade in Italy, and the AGE in Germany are some of the examples.

In Asia, the Japanese Ministry of Construction has made smart cards compatibility and element of the DSRC program to be implemented by the end of this century. The Singapore government has begun to test smart cards in toll collection and congestion pricing. Emerging economies in Southeast Asia are expected to follow.

In the U.S., smart cards are used by government agencies for mostly security and identification purposes. States including New Jersey and Utah are experimenting with smart card driver's license. The federal government has recently released a major RFP soliciting suppliers of smart cards for "benefit delivery systems" such as social security payments and food stamps.

Smart Cards in Transportation

In the transportation sector, the overwhelming majority of smart cards are used in transit operations to replace traditional ticketing systems and to expedite processing time. Smart cards are also used as communication devices for automated vehicle location to enhance efficiency and security. The San Francisco Area Metropolitan Transportation Commission (MTC) is in the process of releasing an RFP to procure a smart card system which will be used by all transit agencies in the area. Meanwhile, the U.S. DOT is unleashing the Commercial Vehicle Information and System Network (CVISN) program aimed at fostering national interoperable commercial vehicle information exchange and border crossing clearance using DSRC technology. This program is committed to applying smart cards to provide rapid and economical means of information exchange in the future. The DOT has sponsored research into smart cards in commercial vehicle operations to help plan for the migration.

Surprisingly, there is little, if any, efforts in developing smart cards for toll operations in the U.S.. Although there seems to be high interest among smart cards vendors and banking institutions, there has not been any productive dialogue among the stakeholders. Numerous conversations between toll agencies and banking institutions have led to no meaningful actions. A few years ago, the Transportation Corridor Agencies in California experimented with the early version of smart cards. That experiment provided important insight into market expectations and pertinent institutional issues related to smart cards usage. The transponder was quite expensive and the card was not usable anywhere off the toll system. Unfortunately, the experiment did not lead to implementation. When smart cards are usable for purchases Off-system" then they will be a popular option "on-system."

Recently, the bringing together of key toll agencies, banking and credit cards companies, and cards makers has been spearheaded by the ITS-America Electronic Payment Task Force. This task force will attempt to sponsor a series of talks among the stakeholders with the primary objective of jump starting the smart cards for toll operations development. The task force intend to coordinate this effort with other entities such as the American Bankers Association, the Smart Card Forum, the International Bridges, Tunnels and Turnpikes Association (IBTTA), etc.. The objective of this effort is to identify requirements of toll operations using smart cards and to identify market, economical, and institutional barriers. This series of talks may begin in the summer of 1997.

Implementation Issues

Recent DSRC procurements have included smart card capability as a system feature. This reflects the interest and expectation toll agencies have for smart card applications. But, smart card benefits will not be realized until the following are addressed:

- DSRC standard must be established so that standard smart cards can be developed accordingly.
- There are no DSRC tags in the market currently capable of communicating with smart cards. DSRC tag vendors should work with their counterparts in the smart card industry to design and develop such tags. There are prototype tags, but they are quite expensive

(approximately US$100).

- Financial institutions must have assurance from toll agencies that a critical market mass will exist.
- Smart card vendors must come to their own standards for communication protocols, especially in the contactless mode.
- The operating range of contactless smart cards must be at least double that of today's to enable in-shirt-pocket communication between smart cards and on-vehicle readers. This feature will help eliminate a major user inconvenience in making sure smart cards are close enough to the reader to complete communication while drivers are in the vehicles.
- In toll operations, smart cards are still an unproven technology. There needs to be major efforts in testing and demonstrating the reliability of smart cards to attract investments in this area. Toll operators may build a consortium of smart cards users early on to defray risk.

Lane, Plaza and Host Systems (Vehicle/Roadside Communications)

Toll collection communications generally work like this: A car, equipped with a transponder (or tag), enters a tollway. A roadside reader sends a signal to the tag via an antenna. The tag receives the signal and returns an identifying signal to the roadside reader along with other relevant data. Data collected from the tag is processed and sent to a host computer. For certain types of tags, data may be returned to the tag for storage, displayed to the driver, or transferred to another in-vehicle system.

Lane-based systems with readers for each lane detect the position of entering vehicles using detectors mounted in or adjacent to each lane. Although the read zones of adjacent lanes may overlap, cross-lane reads are prevented by time multiplexing the readers in each lane. A lane control computer correlates the tag reads with the vehicle detectors to ensure that all tags are accurately assigned to the correct vehicles and that any untagged vehicles are subject to enforcement actions.

In open road ETC systems, toll transactions take place simultaneously between roadside units and tags in multiple vehicles across multiple lanes at highway speeds with no lane or speed restrictions. The vehicle location subsystem needs to accurately locate the position of the vehicle with a tag. Triangulation using multiple angle measurements is one method used to determine the location of the vehicle on a multi-lane roadway. Vehicle detectors are another.

Many toll authorities have equipped existing toll plazas with ETC lanes, by simply adding the ETC equipment to an existing lane, while retaining some lanes for use by those without toll tags. These systems sometimes require motorists with ETC tags to pass through the toll lane at speeds lower than the posted mainline speed.

Some authorities have developed electronic toll collection systems that allow motorists to enter and exit tollways at highway speeds without stopping. These systems use overhead gantries to mount the ETC equipment and designate the tollway entry and exits. Motorists without ETC tags are directed off the main highway and onto an exit ramp, where tolls can be paid manually.

These applications of toll collection technology will allow for "virtual toll collection." Virtual toll plazas are ones in which toll barriers can be opened, closed and moved at will. While no toll agency has taken virtual toll plazas to this point, many have moved in this direction. The Georgia 400 and Oklahoma Turnpike allow ETC-tagged vehicles to proceed down the center of the roadway at full highway speed. The roadway is indistinguishable from other sections of the roadway except for the required signing and the presence of an overhead gantry on which the ETC readers and other electronics are mounted. Cash-paying motorists are directed to exit to pay the required toll.

Vehicle Classification

A video detection and classification system classifies the vehicle to make sure the correct toll is paid. It indicates a vehicle's presence, its profile for classification, and, in some cases, the vehicle speed. For most toll systems, this detection is carried out using light curtains, in-ground vehicle detectors, overhead detectors, or a combination. Using dual beam scanning lasers is one way to enable advanced electronic toll collection systems on open road systems to handle the classification of multiple vehicles in multiple lanes at highway speeds. Non-scanning laser systems can also be used. These systems detect vehicles and determine their profile and speed quickly, efficiently and accurately.

1.7.2. Business Issues

Tag Acquisition/Installation

Successful ETC systems have made tag distribution easy and convenient. These systems rely heavily on mail-order processing to distribute tags and encourage toll customers to avoid purchasing tags directly from the tag distribution center. In addition, efficient and responsive customer service is a key factor. Ensuring that customers can replace and return tags and report lost or stolen tags quickly and easily adds to the potential for increased system use. Most commuter vehicles require no installation as tags are portable. Commercial vehicles, on the other hand, generally require tag installation to ensure reliable operation in harsh environments and to be tamper-proof.

Enrollment and Payment Processing

Easy account establishment contributes significantly to a system's success. Most toll authorities allow patrons to establish accounts via telephone, mail, fax, modem, or in person. How the program's payment mechanisms are configured is also an important factor in ETC success. While virtually all toll facilities currently use a prepayment arrangement, it is presumed that systems could achieve a higher level of use by using a post-payment system. This, however, increases both cash flow costs and credit risk. It can also lead to higher costs per transaction, since this arrangement would attract a larger number of motorists with lower trip frequencies. Account renewal options (cash, check, credit card, electronic fund transfers) also play a role in public acceptance of ETC systems.

Tag Initialization

Tag initialization can be done at the ETC service center or directly by the toll agency once the tag has been purchased. Initialization simply allows the tag to be read by the roadside readers, indicating that a toll account has been established.

Account Reconciliation and Maintenance

Specific account information will change regularly. Address, vehicle registration, credit card, banking and other data must be updated regularly. Most patrons request monthly statements for all toll charges. Commercial vehicle operators are especially interested in this service. In addition, notices concerning account status or explaining new services must be generated on a regular basis. While every agency has some level of automation to support its current toll collection system, it is important that interfaces for electronic toll collection be created with existing systems in order to exchange transaction data. Most ETC operations involve some sort of pre-payment system in which customers replenish their account balances on an as-needed basis. This allows them to maintain some degree of anonymity to protect their privacy. Replenishment mechanisms normally include payments by cash or check either in person or by mail, payments by cash, credit card or debit card in designated manual toll lanes, and customer telephone call or automatic balance level initiated credit or debit transfers.

Post-paid or credit ETC transactions are not likely to be permitted by many toll agencies because of bond covenant requirements. If allowed at all, such operations will likely be limited to commercial fleets willing to arrange credit with the agencies. However, credit cards will likely be accepted by many agencies along with debit cards as means for customers to establish and maintain pre-paid ETC account balances with the agency or multi-agency clearinghouse. Again, such balances can be maintained either centrally or on smart cards.

Enforcement

Stringent enforcement of toll violations is critical to public acceptance of ETC. It is necessary to discourage attempted violations because ETC can open new avenues for toll evasion, including: passage through an ETC only lane without a tag, use of a tag with inadequate funds on deposit; use of a tag with a different vehicle classification (passenger car vs. truck), and use of a lost or stolen tag. Effective enforcement systems identify the number of good transactions and violations in high-speed open lanes by reconciling vehicle count to transaction count, then storing the details of each transaction for audit processing on a total system basis. In order to accurately identify and enforce violations, collection, validation and enforcement processes must be completed in about 500 milliseconds or the next car will be in the collection and enforcement zone before the previous transaction can be completed.

For most toll booth systems, a conventional, single frame enforcement camera is sufficient. But for open road systems, a set of high performance digital video cameras to cover the roadway is required. In order to capture an offender's license plate, the ambient lighting and position of the vehicle is critical.

Legislation is often necessary to allow for enforcement, while protecting the privacy interest of the public. Such legislation generally identifies the allowable uses of information obtained from enforcement systems, along with safeguards for how the information is to be handled and stored to prevent the information from being obtained by unauthorized personnel.

Marketing Issues

In order to attract customers to electronic toll roads, toll agencies must apply basic marketing principles: they must know their product, know their customer, and bring them together. Three issues must be addressed by ETC marketing efforts. The first is convenience. Electronic toll collection makes, or should make, highway travel easier. In addition to promoting the convenience and time savings gained by using ETC, authorities must also make obtaining transponders, establishing and maintaining accounts and addressing problems, easy and convenient for customers as well.

Toll authorities must recognize and address concerns among the public regarding the safety of ETC systems. There is a public perception that using the technology could lead to harmful radiation effects on motorists. Although DSRC use produces radiation levels far below that of common household items such as microwave ovens, many people still have reservations about such effects. In addition, many people have a general "phobia" about new technology, another issue that marketing efforts need to address.

Privacy concerns (addressed more fully in section IV) may also discourage wide acceptance of electronic toll collection. Systems should be employed to assure driver privacy, and this information should be communicated effectively to potential users.

In addition, estimating market penetration is extremely important in planning for ETC. Indeed, the extent to which motorists can be expected to shift from cash to electronic payment options may well affect the overall viability and justification of implementing ETC. The success of ETC projects depends on whether the public clearly recognizes the benefits of the system -- and if the tag acquisition, installation and account payment methods are simple and efficient. Market research on several North America toll projects suggests that the probability of using ETC is a function of a number of factors, including: 1) the trip characteristic demand profile, 2) the program parameters of a particular ETC application, and 3) the implementation strategy used by the agency.

There is a relatively high correlation between the reasons for travel and the use of ETC. In general, commuter trips to and from work have the highest probability of ETC use, followed by trips made for company business. Other types of trips show considerably less likelihood of ETC use.

Business Arrangements and Options

It might be best to begin a discussion of possible business arrangements with a capsule review of existing arrangements between United States toll authorities and their ETTM providers. This is an easy review to present because virtually all ETTM systems are still in revenue service and their history in the U.S. is less than 10 years old.

The first ETTM system was installed on the Dallas North Turnpike and it was a complete turnkey operation with installation, operations and maintenance provided by the tag manufacturer. A surcharge was added to each toll transaction and that formed the basis for the contractors compensation. Since then toll agencies have developed a more detailed understanding of these systems and have divided the work into several different contracts.

Early installations divided the work into 3 areas: hardware, integration and financial transaction processing. Agencies received technical support from consulting firms on developing their plans, preparing technical specifications and providing assistance during the procurement process. Early on that assistance included actual performance tests of tags and readers.

Tags and readers and other in-lane hardware have always been provided by manufacturers. One U.S. toll agency developed its own tag/reader combination but determined that it was inferior to available technology.

Integration of in-lane equipment and plaza computers is virtually always provided by outside vendors. In at least one case agency technical staff have performed their own integration .

Financial transaction processing is usually third party provided as well. Several agencies have opted, after some period of time and experience with a vendor to perform this function themselves, using vendor supplied software and systems.

Toll agencies have utilized consulting firms to provide technical advice, but now they are retaining consulting firms to provide program management of complete ETTM systems, serving as the owners representative in overseeing the installation and of systems.

The way in which service is provided for ETTM can be seen in the broader context of how the public sector obtains service from the private sector. More agencies today are trying to develop public private partnerships to respond to market forces shaping government. This is especially true in South America, where infrastructure needs and significant changes to the region's economic structures are occurring at a rapid pace.

These trends as well as a policy view that the private sector should perform many functions, previously only performed by government employees, lead to an increased reliance on private companies.

To support this increased reliance two issues have been considered: the nature of the contract payment terms and performance measurement. The more risk the private sector assumes, the more it expects to be rewarded. On the other hand increased payment to a private company can increase the political risk to a government agency. Over the last few years several ETTM operators have evolved a sophisticated approach to contract terms and performance measurement.

Contract terms have traditionally been based on cost plus a fixed fee. In this way the risk of additional expense falls largely on the government agency. One way to encourage greater private sector efficiency is to include a variable fee, where the fee is related to cost savings and other possible efficiencies. One way to shift risk and reward to the private sector is with a fixed price contract.

Further and careful investigation into existing concession agreements in Brazil and elsewhere will be necessary to provide critical assessments of these approaches and, if necessary, recommend modifications to support successful implementation.

Performance Standards

The ETTM system, which includes lane and plaza installation as well as financial transaction processing, must be installed in a way that minimizes operational disruptions, meets an acceptable level of performance, performs well over time. To assure this agencies have developed a set of system criteria that can provide these assurances.

In-Lane Equipment

Agencies generally specify operating requirements for in-lane equipment. These requirements can include:

- Lane Controller: processing rate in transactions per hour, storage capacity, ability to serve multiple functions.
- Violation Enforcement System: license plate capture rate, accuracy rate
- Vehicle Classification System: accuracy rate
- Tags and Readers: accuracy calculations of mis-reads and non-reads
- SmartCard: migration path

Plaza System

Plaza requirements can include:

- System Architecture: design requirements
- Communications Network Architecture: capacity and cost requirements
- Security: database protection, environmental protection, system access
- System Performance: system availability, system reliability
- Failure handling and recovery procedures
- System Installation: requires a maintenance and protection of traffic plan

Customer Service Center

The customer service center must be developed and installed to a regional set of standards. These operating characteristics will be the basis for payment. The other hand the auditability of the system is critical to agency achievement of financial goals.

- Tag Handling: ordering procedures, tag testing, inventory and stocking controls, tag security
- Customer Service: type and number of complaints, number and type of customer service calls average call hold time, maximum hold time, mail processing, quantity and average response time
- Customer Account Management: applications received, accounts opened, tolls per account, transactions per account

- Violation Processing: number of violations, amount of fees billed and collected
- System Operations: availability percentage to and user and to operator
- Revenue Reconciliation: daily wire transfers, customer account reconciliation, credit card reconciliation

Other Business Considerations

Another aspect of a third party provider to all agencies is how "float" is handled. Float is the interest earned on account balances. If a customer service center is providing service to one agency this float can be a revenue to the agency. If the service center is serving multiple agencies then the agency earns the revenue based on transaction volume. In this case the float provides an offset to vendor costs and can be clearly defined this way in the contract documents.

Service centers can operate to serve only one agency or multiple agencies. With multiple agencies, a form of an "irrevocable offer" of contract terms is made by the vendor in the proposal. This offer can be accepted by any participating agency at any time in the future. This allows new agencies to join when they are ready.

Settlements between agencies and the service center-occur on a scheduled basis, with volume being the criteria for frequency. Settlement can occur directly between agencies or between agencies and the clearinghouse.

A well-designed customer service center will produce a wealth of data on customer behavior, valuable for agency planning purposes. Toll authorities, even well managed ones, rarely have good information on customer behavior. ETTM provides data that helps to shape future marketing programs.

1.7.3. Legal and Institutional Issues

Procurement

Brazilian procurement practices will play a critical role in how these ETTM systems are set up and in their ultimate success. In many instances, the procurement policies and procedures used by a public agency will have a significant impact on private sector interest and participation in the project. If the procurement process is unwieldy, slow, risky, or costly, private involvement and interest may be suppressed.

Intellectual Property

Intellectual property refers to patentable inventions, copyrights and trade secrets, as well as compilations of data derived from the operation of ITS technologies, which may or may not be subject to copyright protection. ITS applications raise challenging new questions regarding intellectual property. The allocations of sufficient contractual IP rights to enable the private sector firms to make a profit are critical.

There is much opportunity for creative procurements involving IP. The private sector is generally in a better position to exploit technology innovations than the public sector.

Institutional issues regarding IP can be an area of tension between the public and private sectors. The opportunity to exclusively apply intellectual property rights over an extended period of time is the private sector's incentive to invest in research and development. The public sector, on the other hand, encourages competition and resists creating monopolies.

Liability

Liability in ITS is the result of new roles and responsibilities of stakeholders. Deploying ITS technologies to proactively improve traffic operations raises new issues as to duties of the providers and minimum standards of care owed to ITS consumers. Stakeholders in both the public and private sectors have concerns that they will become "deep pockets" vulnerable to costly litigation that could more than offset profits.

Deployment of ITS may involve putting in place complex contractual relationships which allocate roles, responsibilities and intellectual property rights among multiple parties; more than one agreement is often required. By coordinating and integrating the language of development, licensing, installation and other contracts, liability can be managed utilizing clauses such as waivers, disclaimers, indemnities, releases and limitations of liability.

Litigation/Protests

The toll industry is a hotly competitive one. Without standards, the rush to capture more and more market share by competing equipment vendors is fierce. The objective is to gain a large enough portion of the market to essentially force a de facto standard or to earn oligopoly profits. In addition, ETTM technology is rapidly evolving and many agencies have, to date, not been faced with procuring communications and electronic equipment, making detailed and realistic specification writing difficult. Unfortunately, as a result of this competition and technology evolution, litigation and protests regarding ETTM procurements are common. Getting details on these matters is often difficult. Agencies are reluctant to go on record about such matters for fear of future protests.

1.7.4. Applications

Electronic Toll Collection

In electronic toll collection, data is transferred to and from the vehicle's tag, and the toll or parking fee is either automatically decremented from the tag, or a financial transaction occurs in which the fee is deducted from an account. Through use of electronic toll collection technology, congestion pricing schemes can also be implemented in which toll fees can be varied to discourage use of the facility at certain times (e.g., peak periods).

Traditional toll collection requires motorists to slow down or stop at designated toll plazas, deposit cash or tokens at the plaza, then wait to be cleared through. Electronic toll collection (ETC), in its various forms, has reduced or eliminated these barriers and expanded the opportunities for using toll collection technology as an aid in traffic management, as well.

Single Occupant Vehicle Express Lanes

Motorists in San Diego are experimenting with buying permits for single occupant vehicles (SOVs) to drive in high occupancy vehicle (HOV) lanes. When the project is fully implemented in late 1997, fully automated toll collection and enforcement technology will be used. This will allow motorists to only pay for trips they actually make, rather than a flat fee to use the lanes. Variable message signs will provide information on the current travel time savings and the toll. The transponders used will be interoperable with other existing and planned ETC systems in the State. Cars that travel in the HOV lanes without a permit or at least two occupants will be assessed a fine.

Congestion Pricing

Congestion pricing is the variation of the toll rate based on traffic volume or time of day. A typical time-of-day congestion pricing program charges a motorist a variable toll rate to reduce or balance overall travel demand during peak periods. Existing toll facilities can vary their rates or non-tolled facilities can implement electronic toll collection as a means of discouraging travel on a particular roadway at peak travel times. ETC technology makes more comprehensive and complex congestion pricing possible. Such technology enables verifying the authenticity of vehicles traveling in HOV lanes and the lowering or removing of tolls for HOVs. In a "true" congestion pricing system, rates vary dynamically, based upon actual delay conditions.

California's SR 91 is the world's first fully automated, privately-owned, congestion-priced toll road. The road was built down the median of one of Southern California's most congested freeways, which bends through the hills of the Santa Ana Canyon. It stretches through a 16km portion of the road, where congestion is most severe and there are no alternative routes. It comprises two lanes in each direction. When the motorist approaches the entrance to the toll lanes (there are no toll booths), a variable message sign (VMS) explains how to use the road. A second VMS displays the exact fare for that particular time. The system is designed to handle over 2500 vehicles per hour per lane.

Because of early morning and evening rush hour travel patterns, fares are adjusted to maximize the system's efficiency, charging higher tolls at peak travel times in peak directions and lower tolls at off-peak times and directions. For example, motorists traveling westbound (toward the job market) pay a peak toll of $2.50, beginning at 5 a.m. By 9 a.m., the toll would be decreased to $1.50, and by 11 a.m. the toll would be decreased further to 50 cents. An inverse fare schedule has been developed for the eastbound traffic, with its highest fares being charged during the afternoon rush hour. Since late night traffic is virtually non-existent, fares are set at 25 cents. Figure 1.7.1 shows a SR 91 Toll Plaza.

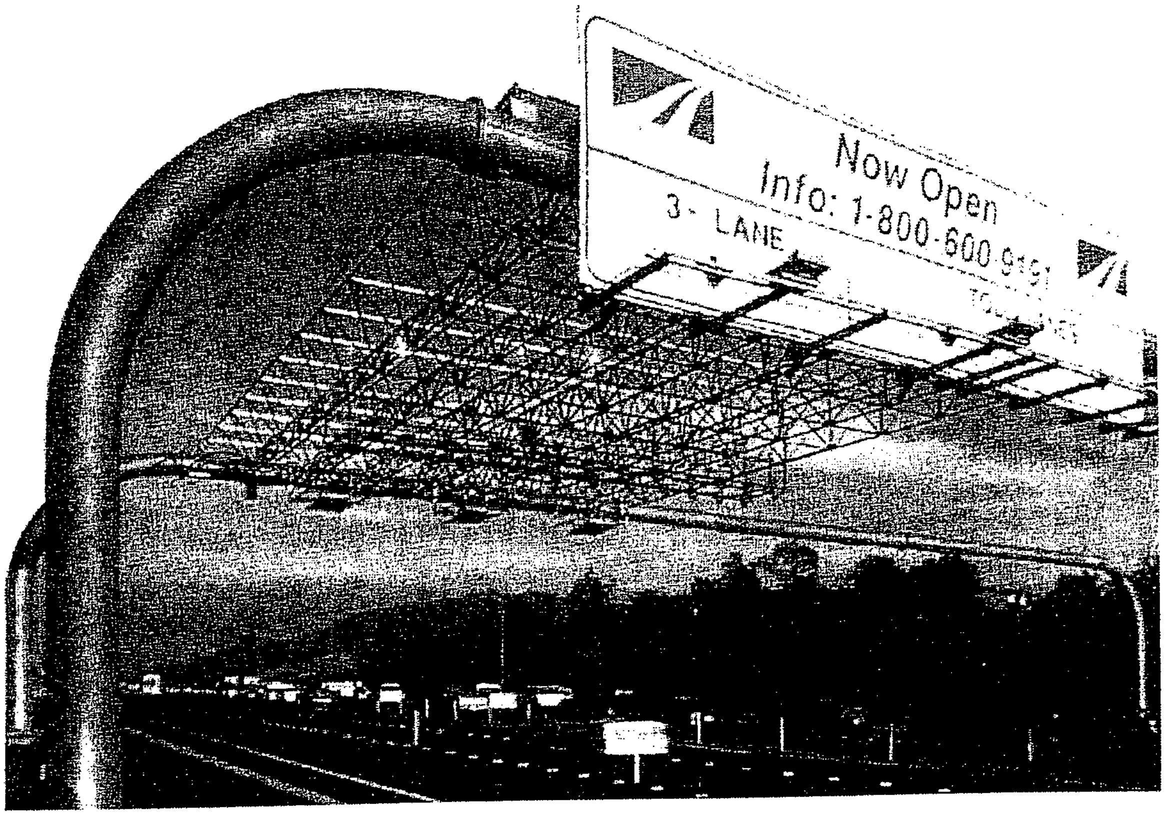

Figure 1.7.1 - SR 91 Toll Plaza

The system is completely automated, so every motorist using the road must have a transponder. Non-compliance is handled using vehicle detection to capture license plate images of violators.

A planned agreement between the California Private Transportation Company (CPTC) and the California Transportation Corridors Agency (TCA) will allow transponders used on the SR 91 lanes to eventually be accepted on most of California's toll roads and bridges as part of a seamless toll network.

Traffic Management Applications

With the introduction of ETC tags and readers, it is now possible to obtain more and higher quality real-time transportation information. By tracking probe vehicles, higher quality, real-time information on travel time, delay, congestion, incident occurrence and restoration can be obtained. By assigning an anonymous identification number to each vehicle, its location, arrival time and speed rate can be determined. Travel time between two reader locations with a known distance provides the statistical speed and delay information.

A relatively small sample of tagged vehicles can provide enough data to reasonably characterize the vehicles traveling within the road network. A minimum tag population of 10 percent is necessary to achieve reasonable system accuracy.

DSRC technology allows for travel times to be predicted accurately for the population of vehicles within the corridor equipped with tags. Such data can be periodically transmitted to variable message signs and highway advisory radios at various key locations around the system. This will allow motorists to get information on travel conditions ahead and make strategic decisions on route choice, etc., based on real-time information. Traffic volume can be determined using a statistical analysis of probe data. Traffic probes also assist in detecting incidents. Incident detection algorithms require a continuous calculation of expected arrival of a traffic probe at the next downstream reader. If a significant sample of the vehicles appears to have been delayed, a potential incident is flagged.

In the New York City metropolitan area, the E-ZPass system uses DSRC technology for toll collection as well as traffic management. The New York State Thruway Authority reports that approximately 40 percent of all toll transactions are made using E-ZPass. It is expected that the total number of E-ZPass tags in the region will hit 1 million by year's end.

The TRANSMIT system, currently operating in the New York metropolitan area, uses toll collection technology for traffic management purposes. Vehicles equipped with these transponders are used as traffic "probes." When a vehicle with a tag passes an overhead antenna placed along the roadway, a signal is sent to the roadside equipment and then is sent by modem over leased telephone lines (along with a date and time) to a central site in Jersey City, New Jersey. The vehicle tag is scrambled to assure owner privacy. The data is processed in the Operations Information Center (OIC) to derive travel time and to detect incidents. The processed information is then forwarded to other remote sites in the TRANSMIT network.

When a vehicle does not arrive within a specified time, the system records it and increases the confidence level on an "incident thermometer," used to gauge the likelihood of incidents on the system. The more vehicles that are late, or the longer the time vehicles do not arrive, the higher the confidence level. When this level gets to a user-defined threshold, the system triggers an alarm alerting the operator that there may be an incident. The operator then pulls up a screen, analyzes the data, and determines whether to call the Thruway or Parkway personnel to verify the incident at that location.

System planners intend to expand the system and use it to provide real-time traffic information to travelers, use the historical data for planning and incident management purposes, and facilitate the efficient movement of freight and goods.

The Houston metropolitan area has approximately 30,000 cars and buses equipped with toll tags. When these vehicles pass automatic vehicle identification readers, messages are transmitted to the traffic management center (TMC). There, computers determine vehicle travel times and speeds and display freeway conditions on maps. When operators detect yellow and red areas, indicating problems, TMC operators can alter video cameras along the roadway to assess the cause of the problem. The data, updated minute-by-minute, 24 hours a day, also is available to drivers through traffic reports and through a site on the Internet.

Parking Applications

A number of parking facilities also incorporate DSRC into their management operations to improve operational efficiency and, more importantly, reduce congestion often associated with parking. Like electronic toll collection, "smart parking" uses windshield tags programmed with user identification and authorization information. As a vehicle approaches a reader, the system makes an identification of the vehicle within one-tenth of a second. Within one second, the parking gate opens and allows the vehicle access. The system can assign access to vehicles by specific lots and for various time periods. Some systems can electronically report attempts to use an invalid tag to parking managers, giving the location of the attempted entry and the name and card number of the violator. An anti-pass back feature can require the smart tag to exit before reentering the lot, making it impossible for one user to pass a tag back to another. This process is illustrated in Figure 1.7.2.

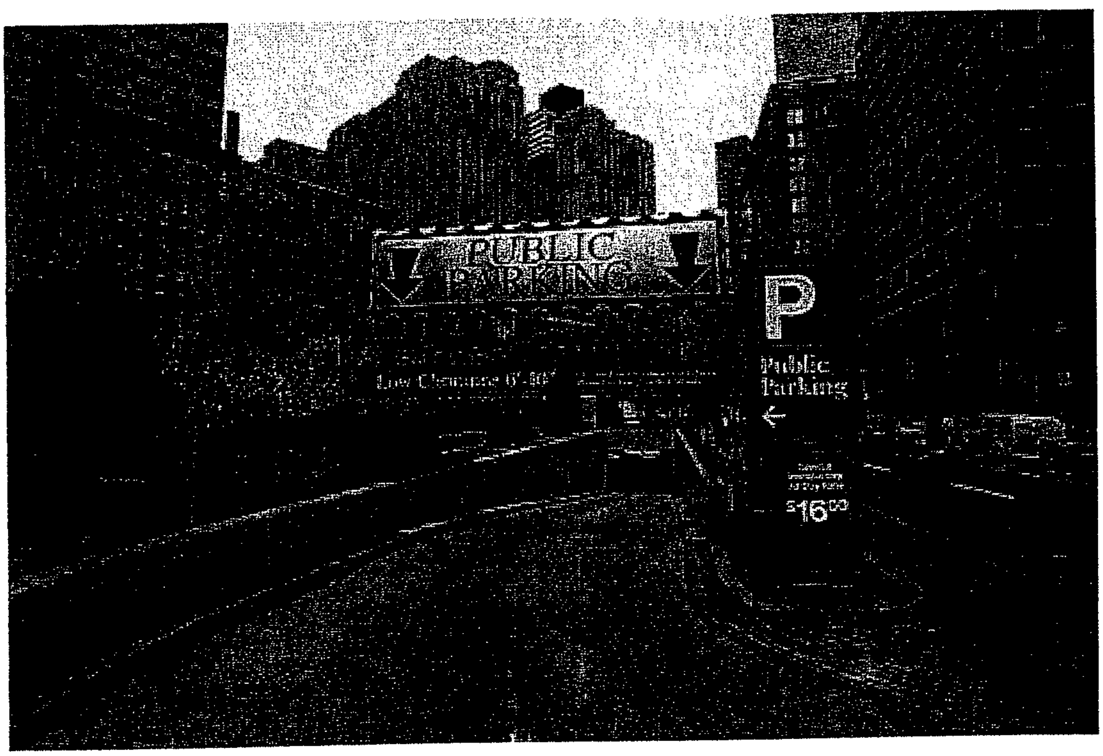

Figure 1.7.2 - Parking Payment/Access Control

The Louisiana State University (LSU) Medical Center Parking Facility handles 5,000 users every day. Before adopting a DSRC system, the parking facility used magnetic stripe card readers. Humidity, dirt, and grime damaged the systems and caused numerous errors. Even when the system worked, queuing at the parking entrances caused traffic to back up on streets where the entrances were located. The LSU parking facility uses vehicle tags mounted with Velcro inside a vehicle's windshield. As the vehicle approaches within 12 to 16 feet of the entrance, the card is read and access is granted. The entire transaction takes about one second. While the city of New Orleans (where the Medical Center is located) has a number of toll facilities that employ ETC, the parking and toll facilities are not currently interoperable.

In Costa Mesa, California, employees at the South Coast Office Plaza are using toll tags that operate on the San Joaquin Corridor to enter and exit the plaza's parking facility. Parking fees are charged in the same manner as tolls. This is a limited pilot project that may provide the impetus for widespread use of DSRC in parking services if proven successful. The results of this pilot will be known early in 1997.

Commercial Vehicle Operations

The following functions are encompassed by CVO services:

- Electronic Clearance - This is the process of transferring data between a commercial vehicle and a beacon in advance of a roadside checkpoint so that trucks and drivers that are legal and properly credentialed can bypass the checkpoint without stopping.
- International Border Crossings - This is the process of transferring data between a commercial vehicle and a beacon in advance of an international border crossing so that trucks and drivers that are legal and properly credentialed can pass through the crossing with minimal delay. International border crossing applications involve multiple Federal and State agencies including customs, immigration, toll and transportation departments.
- Automated Roadside Safety Inspections - This is the process of conducting safety inspections of a sample of the vehicle fleet strategically selected based on past safety record. Needed information for the inspection will be accessible via a tag and transferred to the inspector via a DSRC link. Results data will then be uploaded through the tag after the inspection also using DSRC.
- Fleet Management - Fleet operators will use DSRC to obtain or send data to individual vehicles for fleet management purposes. Beacons for this purpose may be located at terminals, warehouses, fueling facilities, truck stops, etc.
- Off-Line Verification - Using hand-held readers, enforcement personnel will use DSRC links to obtain information stored in an on-board computer or on a tag.
- Hazardous Material Incident Response - When an incident involving hazardous materials occurs, information identifying the type of load will be available to emergency response personnel through use of a hand-held device, a DSRC link and the vehicle's tag. It should be noted that tracking of hazardous material shipments will be supported by wide-area wireless communications, not DSRC.

Transit Operations

DSRC communications may be used to transfer data between a transit management center and individual transit vehicles. Beacons mounted at or near stops may be used for fare transactions, and to monitor ridership, location and on-time performance, vehicle faults, and to communicate instructions to drivers.

Transit and emergency vehicles may also use DSRC technology to communicate with traffic signal control systems to request priority signal treatment (e.g., extended green times), or in the case of emergency vehicles, signal preemption (i.e., the signal remains or turns to green as soon as it is safely possible to do so).

Transit managers in North America are employing DSRC technology as a tool to assist them in tracking and communicating with their fleets. Transponders on buses allow them to track location, determine ridership, and alter traffic signals to keep high ridership buses on schedule. Most transit fleets are equipped with AVI technology that uses GPS. However, GPS technology requires unobstructed relay between the vehicle and GPS satellites in order to accurately locate the vehicle. Because DSRC communications take place within a shorter distance, such obstacles are not a factor. DSRC, in combination with GPS technology, can provide reliable, accurate location information.

DSRC is most commonly used by transit managers for signal priority systems. In a typical signal priority system, a bus fitted with a transponder passes by a reader that reads its ID code. The reader sends a message to the traffic signal control center that a bus is coming. The message may also indicate other information about the bus, including the number of passengers on board, its route, etc. The traffic signal control center collects the information, determines the need for signal priority, and, if necessary, turns the traffic signal green as the bus approaches. Information from the transaction is downloaded and recorded at the control center.

Houston METRO's Smart Bus system provides Transtar, Houston's transportation and emergency center, with on-the-street traffic information throughout the 3300sq km service area. Each bus has a network of on-board wiring, which provides electronic links between the various components of the Smart Bus, including an on-board computer that serves as the "brain" of the system. Each bus is equipped with automatic vehicle identification and location and automatic passenger counting systems. The buses use Harris County Toll Authority EZ Tags and, like toll patrons, serve as vehicle probes for the transportation network.

King County Metro has employed a transit signal priority system that uses DSRC technology. The system currently covers two intercounty roadways. But the county has established cooperation with several stakeholders including Community Transit, Washington State Department of Transportation, City of Seattle, Snohonish County and the cities of Everett and Lynnwood. The initial system provides recognition of the bus and a log of the signal priority transaction. Subsequent phases will include the run number, route number, and other bytes of information about the bus. This information will be used to determine whether the bus needs signal priority treatment.

Automatic Fare Payment for Transit

Many public transit operators are using, or planning to use, integrated, automatic fare collection systems (AFC). An integrated AFC system may use DSRC technology (for example, contactless "smart cards") to collect fare payments electronically on two or more transit-related modes.

The implementation of AFC systems generally follows an evolutionary path. Transit operators often begin to automate fare collection with the use of time-based, read-only tickets or magnetic stripe cards. They may then go to an enhanced magnetic stripe card with read/write capabilities that allow value to be stored and later deducted from the card. These cards also allow for the collection of distance-based fares and transfers. Smart cards have more powerful and flexible data processing and security features, enabling the use of larger amounts of stored value, more diverse fare programs and transfer schemes among modes and the potential for other non-transportation and non-fare applications.

The Washington Metropolitan Area Transit Authority has equipped 19 rapid transit stations, 21 buses and several parking lots with proximity smart card read-write turnstiles and fare boxes. The system uses battery-powered smart cards, eliminating the need for power conditioning circuitry on these cards.

The Ventura County Transit Commission is linking the operations of eight transit agencies in the county. The system employs contactless smart cards and a countywide distance based fare structure. Buses in the system are linked by radio to a central facility and riders are able to request upgrades in fare card stored values by phone, chargeable to their credit cards. Upgrade information is communicated to all buses and the augmentation takes place automatically when riders use their fare cards. The system also incorporates automatic vehicle location, automatic passenger counting and an advanced spread spectrum radio system for automated data download and upload.

Interoperability is an important concern for transit and transportation planners. Given the diversity of payment systems both within a given transportation system and among various systems across jurisdictions, adopting technology that is capable of accepting a variety of payment schemes (magnetic stripe cards, contact cards, smart cards, cash, etc.) is challenging. Some equipment vendors expect that economical combination cards that are both contact and contactless will be available in the near future. If such cards are put into widespread use, it would enable transit systems to accept fare media from a variety of sources. Transit operators want future smart card technology to use an open system architecture to allow interoperability and compatibility among different vendors' products and facilitate the migration to new technology as it evolves.

Emergency Vehicle Operations

Emergency vehicle operations employ DSRC for signal preemption, allowing an emergency vehicle to receive or hold a green light and speed its travel to its final destination. However, most emergency vehicle operations using signal preemption employ infrared technology to change signals, as opposed to RF-based DSRC. Since signal preemption does not require the amount or detail of information necessary for transit signal priority systems, sophisticated DSRC systems are not necessary. Emergency vehicles requiring signal preemption simply activate the preemption signal from their vehicles and change the signals automatically.

In-Vehicle Information Systems

Type II tags and beyond have the ability to not only transmit information in response to the reader command, but also to receive and store information for subsequent use. Strategically located roadside readers can broadcast safety-related information to vehicles through tags. This may prevent incidents and assist drivers in avoiding hazards on the road. Future development may make possible in-vehicle information on inclement weather, railroad crossing warnings, and road signage. The information may be displayed on the tag or in conjunction with other on-board display systems. A railroad crossing warning system will be demonstrated in Minnesota. Although this application is still in the early stage of development, the interest is expected to grow along with the proliferation of DSRC products as it holds great potential for saving lives and operating costs. This application is particularly dependent on standards. As the proliferation of in-vehicle systems increases, end users will expect them to operate seamlessly throughout the nation, and perhaps internationally.

Airport Access and Other Applications

A number of airports are using DSRC technology to improve security. Tags are installed on taxi, shuttle and other fleets with regular airport business and used to automatically identify and verify the authorization of those vehicles to be in certain locations in and around the terminal. Additional applications include: automatic staging and call up for taxi queuing systems, automatic billing and variable pricing for different classes of vehicles, multiple read points that verify compliance with commercial roadway assignments, and dwell time features (which keep vehicles from staying beyond the normal amount of time required to load and unload passengers and charges a fee to tagged vehicles which exceed a set limit).

DSRC has the potential for upgrading or replacing current commercial transaction methods such as those used in fast food restaurants, gas stations, parking and other roadside services. In fact, there exists the infrastructure for such transactions, which may simplify DSRC application in this area. For example, magnetic-based credit card payments are available at most fast food restaurants and gas stations that are tied to banks and credit card clearing houses. DSRC can replace the magnetic cards and enable accurate and more convenient transactions to take place while payments can be drawn directly out of bank or credit card accounts. Assuming the emergence of clearinghouse services in the near future, these cashless services can and will be integrated into the mainstream DSRC applications. Widespread use of DSRC for these purposes may also set examples for other services to follow.

Electronic Toll Collection Interoperability Study in Brazil

Task 1 - Data Collection

Subtask 1.8 - Perform Market Demand Analysis

SUBTASK 1.8. PERFORM MARKET DEMAND ANALYSIS

1.8.1. Introduction

The use of ETC to collect tolls is in the period of its greatest growth since the installation of the first ETC systems 30 years ago. This phase of growth is in its infancy and is expected to continue for the next few decades. North America is the leader in the number of ETC installations. However, the greatest potential for future ETC growth may exist in Latin American and Asian countries with rapidly expanding economies. This is because of the unique opportunities ETC offers in revenue generation using toll collection. The developed countries may also see a steady growth in ETC installations with innovative uses such as congestion pricing.

The present surge in ETC installations can at least partly be attributed to the proliferation of build-operate-transfer (BOT) projects around the world. The BOT model in infrastructure projects and ETC offer a unique opportunity to meet some of the transportation infrastructure resource needs of developing countries.

1.8.2. The global market

There are in excess of 17,000 toll lanes in the world. Of these, 36% are equipped or are planning ETC. The past few years have seen a growth of the number of ETC lanes at 4% per year. From 1994 to 1997 alone, the number of lanes using ETC has increased from 1,100 to 6,100. This increase has been unprecedented and has been matched by the growth in the number of in-vehicle tags. The number of tags worldwide during the same period has seen an increase from 1.5 million to 8.62 million.

The worldwide market for installed and committed ETC equipment including in-lane equipment for ETC operations, tags, systems integration and back office operations comes to approximately $2.7 billion. This is the cost of the main ETC components and does not include civil engineering work or installation of conventional toll collection equipment.

The largest component of the ETC installation costs is in the systems integration and back office operations. The systems integration cost per lane has been approximately $160,000 worldwide. Development of back office operations per lane have also been observed to average approximately $160,000 worldwide. The installation of automatic vehicle identification (AVI) capabilities in the form of AVI antennas comes to around $65,000 per lane. Other components that command a significant share of the market include the in-vehicle tags, enforcement systems and classification systems.

The next decade is expected to produce maturity in the ETC market. The rapid growth observed in the past few years is expected to continue for at least another five years.

Correspondingly, the ETC market is expected to grow to $10 billion in the next decade. Some toll facilities will see the implementation of ETC in excess of 90% of the toll lanes. The ETC market worldwide is expected to grow at a rate in excess of 25% per year. The number of tags in use is expected to grow to 50 million in the next ten years. As the ETC market matures, maintenance and running costs will represent an increasingly significant portion of the ETC market.

1.8.3. The Brazilian market

The Brazilian situation is unique in that it encompasses the first time that the highway infrastructure is being privatized on such a large scale. Toll collection provides the most convenient way to gather the resources required for developing and maintaining the highway infrastructure. The terms of forming highway concessions mandates that ETC be implemented six years into the concession. This mandate will provide a major impetus to the implementation of ETC in Brazil.

By 1997 there were 28 AVI lanes and approximately 95,000 tags in use in Brazil. This represented around 17% of the market in terms of AVI lanes and 32% in terms of number of tags in Latin America. With the rapid implementation of the highway concessions program, this represents only the opening of the ETC market in Brazil. With the completion of concessions for 30,000 Km of highways, the ETC market in Brazil is expected to be the largest in South America.

By observing Brazil's experience with ETC until the present, and keeping in mind the ETC related mandates in the highway concessions program, Brazil might experience the installation of up to 1000 AVI lanes over the next seven years. Correspondingly, the number of tags in use may be expected to increase to approximately 2 million. As observed in Table 1.8.1, traffic on concession highways has been observed to grow at approximately 7% per year. This can reasonably be expected to continue to grow at this rate for the foreseeable future. This will translate into even greater increase in tag sales. Table 1.8.1 shows the traffic volumes and growth rates on existing highway concessions.

Table 1.8.1 - Brazil highway concession market demand analysis

Facility/Concessionaire	Market Demand Analysis				Planned or Expected System Expansion
	Annual Actual or Estimated Traffic Volume	Annual Growth Rate	Average Vehicles During Peak-Hours	Market Data Avail.	
Ponte S.A.	7,200,000	7-8%	AM Peak/ Niteroi to Rio – 6257 PM Peak/ Rio to Niteroi – 5234	No	Increasing number of ETC lanes to 6 Commercial Vehicle Operations and Credentials Traffic Management
Concer	500,000	5%	1500	No	ETC
Nova Dutra	Plaza 1/ 6,553,759 Plaza 2/ 8,245,899 Plaza 3/ 9,012581 Plaza 4/ 7,435,964	Plaza 1/ Auto 7.57% - Comm. Veh 7.72% Plaza 2/ Auto 7.17% - Comm. Veh. 9.14% Plaza 3/ Auto 8.58% Comm. Veh 8.89% Plaza 4 Auto 9.00% - comm. Veh. 9.03%	Plaza 1/ 1900 Plaza 2/ 2250 Plaza 3/ 2000 Plaza 4/ 2500	No	ETC
CRT	6,210,000	To be determined as system matures	To be determined as system matures	No	ETC
LAMSA	LAMSA study estimates 15,100,000 Study completed by municipal engineers estimate much higher	1.35%	350	No	Traffic Management ETC
Ponte de Vitoria	480,000	8%	3,200	No	ETC using Smart Cards
Rodovia Dos Lagos	4,321,600	4.9%	To be determined	No	Traffic Management Smart Cards Parking and Access Control
Linha Azul	6,500,000	4 to 5%	2,400	No	Smart Cards Parking and Access Control
CONCEPA	17,823,000	N/A	5600	No	Smart Card Traffic Management Transit Interoperationss

ETC experience around the world suggests that vehicle equipped with AVI transponders account for approximately 50% of the toll transactions during the peak hours. The same can be expected to occur in Brazil at highway concessions where commuter trips dominate. Concessions in Rio de Janeiro and Sao Paulo are urban in nature and may expect to see half of all toll transaction during the peak hours, conducted electronically. This may occur after the ETC systems are in place and have reached maturity. This percentage is expected to be considerably lower in rural areas. The rural highway concessions may see the ETC share of toll transactions as low as 10%.

Interoperability is a critical factor for the use of in-vehicle tags on highway concessions within close geographical proximity. Often a single trip may include travel over several concessions. The penetration of this market by ETC will depend on whether a common tag can be used across several highway concessions. Interoperability will provide a strong incentive to the user to use in-vehicle tags in terms of convenience.

Electronic Toll Collection Interoperability Study in Brazil

Task 1 - Data Collection

Subtask 1.9 - Identify Existing and Potential Concessionaires

SUBTASK 1.9. IDENTIFY EXISTING AND POTENTIAL CONCESSIONAIRES

1.9.1. Overview of Privatization

The National Privatization Program (PND) is an essential part of the reforms implemented by the Brazilian government in order to modernize the Brazilian economy. The PND is a forward thinking program and is the key to this modernization. The PND allows the role of the State to change by focusing its actions and scarce resources on pressing social issues. The PND allows a major fiscal adjustment by the State by reducing the public debt. It also revitalizes the economy by fostering market competition and improving the quality of goods and services offered to the population.

Privatization has been part of the Brazilian national agenda for many years. The 1980s saw reprivatization of 38 companies generating USD 780 million. The main goal of this phase was to prevent the government from expanding its presence in the production sector even further, and not to generate substantial revenues for the treasury.

The 1990s saw the establishment of the PND. The PND was set up by means of legislative action in 1990. Subsequent legislative updates and actions have kept the effort relevant. The new government in 1995 assigned an even higher priority to the privatization program. More sectors and industries have been added to the program and a greater emphasis has been placed on generating revenue for the treasury.

The PND allowed for the first time, the participation of foreign capital in the sale of state owned enterprises. Initially this participation was limited to 40 percent of the company being privatized; however, this limit has since been lifted. The PND program was initiated as part of a larger push by the Collor government to open up the Brazilian economy by introducing market-oriented reforms that included deregulation and the reduction of tariff barriers. The advantages of such an effort were seen in attracting foreign capital in sectors that the Brazilian government could not support due to lack of resources. The privation effort was also anticipated to promote efficiency and competition.

1.9.2. The Goals of the Privatization Program

The goals of the PND program are:

- The transfer of economic activities that are currently unnecessarily carried out by the Brazilian government
- Reduction of public debt
- The modernization of the Brazilian industrial sector by the infusion of technology, capital, efficiency and competitiveness

- To focus the involvement of the federal government to sectors where its involvement is essential
- To strengthen the Brazilian capital markets, increase the public offering of shares and hence provide for a democratization of the capital of the firms privatized

1.9.3. Steps in the Privatization Process

The privatization process for most Brazilian state owned companies generally follows the following steps:

- Selection of the company to be privatized
- Creation of a privatization fund into which the shares of the company are contained
- Selection of consultants and auditors
- Completion of consulting work
- Approval of share prices and methods of sale
- Publishing of sales notices
- Public auction in a stock exchange

1.9.4. Acceptable Means of Payment

The PND mandates the use of Privatization Certificates in an amount proportional to the purchase. All financial institutions are required to have Privatization Certificates.

The means of payment accepted in the PND are:

- Real, the Brazilian currency.
- Certificates of agrarian debt (TDA)
- Obligations of the National Fund of development (OFND)
- Securities of Siderbras (SIBRAR)
- Privatization certificates (CP)
- Renegotiated internal debts from the federal government (DISEC)
- Housing saving agency certificates (CEF)
- Foreign debt certificates (Divex)

1.9.5. The Highways Concession Program

The highways concession program (PROCROFE) dealt first with highway segments that were technically and economically able to function as toll roads. This program is under way, several highway sections have been contracted and others are in the bidding stage. The PROCROFE program provides concessions of 20 to 25 years for highway restoration, expansion, maintenance and operation.

The highways concessions program is a part of the larger Brazilian privatization effort. The program has a relatively short implementation time. Tolls are being collected on a number of facilities. Out of a total of approximately 35,000 Km, approximately 30,000 Km are expected o be converted to concessions by the end of 1997 or early 1998. Six new concessions are planned in the state of Parana. These will start collecting tolls in February 1998. Nine new concessions with a total of 3,000 Km will be signed in the state of Rio Grande do Sul. The highway concessions in the state of Minais Gerais are in the pre-qualification stage. These are expected to be signed by June/July of 1998.

All contracts in the state of Parana are required to implement ETC by the sixth year of operations as a concession, thus providing the concessionaires a short time to implement ETC at their concessions. Figures 1.9.1 shows the Nova Dutra toll facility and figure 1.9.2 shows the Concer toll facility, both developed by concessionaires in a short time frame.

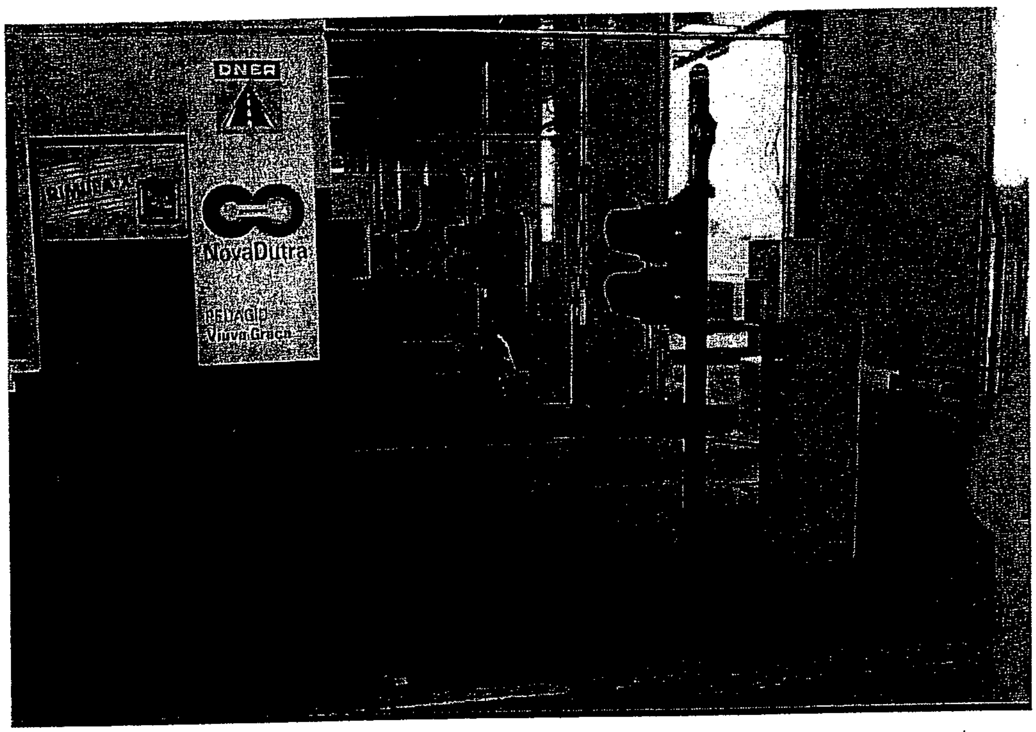

Figure 1.9.1 - The Nova Dutra toll facility toll lanes

Figure 1.9.2 - The Concer toll facility toll plaza

The following tables show the lengths of each toll concession and the potential increments to these concessions:

Table 1.9.1. - Brazil road concession program

	Already Consigned (in km)			Programmed for Concession		
	Federal	State	Municipal	Federal	State	TOTAL
DNER	885			11,007		11,862
Sao Paulo				33	5,155	5,188
Rio Grande do Sul				2,065	927	2,992
Santa Catarina		35		707	897	2,639
Parana				2,692	651	2,343
Rio de Janeiro		60	15	272	440	787
Espirito Santo		3		472	65	540
Minas Gerais				2,460	516	2,976
				2,889		2,889
Norte Centro Oeste				859		859
Nordeste				3,437		3,437
	885	98	15	25,893	8,651	35,512

Source: Geipot/DNER/Departamentos Estaduais de Rodagem

Table 1.9.2 provides further detail on Table 1.9.1, defining the specific roadway segments for each of the major concession programs and providing a status of the concession process for each segment.

Table 1.9.2. - Brazil road concession program selected roadways

	Roadway Segment	Km	Total	Status of Concession Process
DNER	Sao Paulo - Curitiba - Floianopolis	721		November 1997
	Belo Horizonte - Sao Paulo	563		February 1997
	Florianopolis - Osorio	344	1,628	Year 2000
	Rio de Janeiro: BR-101 North	315		Projected: November 1997
	BR-393	200	515	Projected: November 1997
Espirito Santo	Rodovia do Sol	65	65	Perhaps 1997
Santa Catarina	Sistema Brusque	112		Prequalification submitted: Oct. 1997
	Sistema Norte	711		
	Sistema BR-470/SC470	481		Letter of Prequalification: Sept. 1997
	Sistema Cricuma	344	1,648	
Rio Grande do Sul	9 polos rodoviarios	2,992	2,992	Commercial Proposal: Sept. 1997
Minas Gerais	9 lots	2,976	2,976	Letter of Prequalification: Oct. 1997
Parana	6 lots	2,343	2,343	Assigned contracts
Sao Paulo	Sistema Anhanguera-Bandeirantes (DERSA)	312		Contract to be signed on April/98
	Nova Odessa, Piracicaba, Rio Claro	71		In Analysis
	Catanduva, Bebedouro, Barretos, Taquaritinga, Pirangi	156		Contract to be signed on Jan/98
	Catanduva, Jales, Sta. Fe do Sul, S.J. do Rio Preto, Santa Albertina	280		
	Riberao Preto, Igarapava, Setaozinho, Bebedouro, Divisa MG	237		Contract to be signed on Jan/98
	Mogi Mirim, Limeira, Porto Fereira, Sao Carlos, Casa Branca, Divisa MG	340		Contract to be signed on May/98
	Jacarei, Campinas, Atibaia, Anel de Campinas (parte)	158		
	Limeira, Rio Claro, Sao Carlos Brotas, Jau, Bauru, Itirapina	218		Contract to be signed on March/98
	Sao Carlos, Borborema, Sertaozinho, Bebedouro, Jabiticabal	442		Contract to be signed on April/98
	Sanata Rita do Passa Quatro, Ribeirao Preto, Batatais	308		Contract to be signed on March/98
	Campinas, Mogi Guacu, Mococa, Sao Jose do Rio Pardo, SJB Vista	291		Contract to be signed on Feb/98
	Sistema Castello Branco - Raposo Tavares	162		Contract to be signed on March/98
	Campinas, Itu, Sorocaba, Tatui, Tiete, Piracicaba, Itapetininga	275		Contract to be signed on May/98
	Avare, Espirito Santo du Turvo, Ourinhos, Assis	353		In Analysis
	Espirito Santo do Turvo, Lencois Paulista, Bauru, Pirajui, Lins	172		In Analysis
	Tupa, Marilia, Assis, Taruma, Dirceu, Divisa PR	170		In Analysis
	Martinopolis, Pirapozinho, Regente Feijo, Assis, Divisa PR	244		In Analysis
	Reg. Feijo, Pres. Bernardes, Tupa, Parapua, Oswaldo Cruz, Martinopolis	89		In Analysis
	Parapua, Adamantina, Tupi Pulista	216		In Analysis
	Itapetininga, Capao Bonito, Itapeva	351		Contract to be signed on May/98
	Campinas, Tiete, Capivari, Piracibaba, Sao Pedro	134		In Analysis
	Sistema Anchieta - Imigrantes (DERSA)	176	5155	Contract to be signed on June/98
			17,322	

Source: ABCR

Associação Brasileira de Concessionárias de Rodovias ABCR

Table 1.9.3 lists existing Brazilian toll roads that have been concessioned. It also notes the road lengths, vehicle traffic, number of ETC and regular plazas, and the number of toll tags in circulation.

Table 1.9.3. - Brazilian toll roads concessions

Type	Location	Length Km	Length Mi	System Name	Vehicles/day	Plazas ETC	Plazas Total	Tags
State Bridge	Espirito Santo	3.4	2.1	3o Ponte de Vitoria	41,000	---	14	
State Road	Santa Catarina	35.0	21.9	Linha Azul	17,000	2 + 2	12	1,000[1]
Federal Bridge	Rio de Janeiro	13.4	8.4	Ponte Rio - Niteroi	110,000	2 + 2	14	44,000[2]
Municipal Road	Rio de Janeiro	15.0	9.4	Linha Amarela	50,000	2 + 2	20	10,000[3]
Federal Road	Rio - Sao Paulo	406.8	254.3	Nova Dutra	22,500	8	48	?[4]
Federal Road	Rio - Minas Gerais	179.7	112.3	CONCER	21,000	2	22	8,000[5]
Federal Road	Rio de Janeiro	142.4	89.0	CRT	15,000	4	16	5,000[6]
Federal Road	Rio Grande do Sul	112.3	79.2	Freeway	12,000	8	56	10,000[7]
State Road	Rio de Janeiro	60.0	37.5	Via Lagos	11,000	2	11	20,000[8]
		968.0	605.1		299,500			

[1] COMBITECH, read/write, 2.45 GHz, ETC beginning Nov. 1997
[2] AMTECH, read only, 915 MHz, ETC began Aug. 1996
[3] AMTECH, read only, 915 MHz, ETC beginning Nov. 1997
[4] AMTECH, read only, 915 MHz, ETC beginning Dec. 1997
[5] SCHLUMBERGER, contact smart card, ETC beginning Nov. 1997
[6] AMTECH, read only, 915 MHz, ETC began Jul. 1996
[7] PHILIPS, contact smart card, ETC beginning Oct. 1997
[8] AMTECH, read only, 915 MHz, ETC began Jul. 1996
Source: ABCR

Electronic Toll Collection Interoperability Study in Brazil

Task 1 - Data Collection

Subtask 1.10 - Identify Existing Clearinghouse Operations

SUBTASK 1.10. IDENTIFY EXISTING CLEARINGHOUSE OPERATIONS

1.10.1. Introduction

For toll agencies, DSRC systems are revenue collection systems and their heart is financial transaction processing. This processing can be performed by the agency itself, by another agency on a service basis, by a regional clearinghouse, or by a national service. Processing can be provided by either a public agency or a private provider. With the exception of a national service, all of the above examples can be found today.

Interoperability opens up a wide range of issues that must be addressed by the operating agencies. Most toll operators will state that the technology selection and implementation were simple compared to the business issues raised by account maintenance. If customers will be able to use any DSRC system, how will the business issues be addressed?

It is accepted that a national standard will create greater impetus for the financial community to take greater interest in transportation services. The sooner regions become compatible, the sooner financial institutions will be willing to create clearinghouses to handle transactions. In addition, the larger the regions, the greater the likelihood that the banking industry will consider creating clearinghouses. National compatibility will likely create the "critical mass" required by business to warrant handling small transactions, such as toll collection and automatic fare payment.

However, DSRC operating agencies will need their own procedures for out-of-system vehicles using their system, both those that register and those that do not. They will need access to registration information from other jurisdictions. This is an area where the federal government can provide needed coordination with CVO programs to make available registration data and to assist in the development of ways to address "deadbeat" users from other jurisdictions.

1.10.2. The State of Practice in Brazil

Currently, all backroom operations in Brazil are performed manually. Money collected at various toll booths is counted on site and later transferred to a bank for deposit. These manual collections are compared to toll collector forms for reconciliation. Each toll system has its own "proprietary" method of handling backroom operations. Figure 1.10.1 shows the interior of a manual toll terminal at CRT.

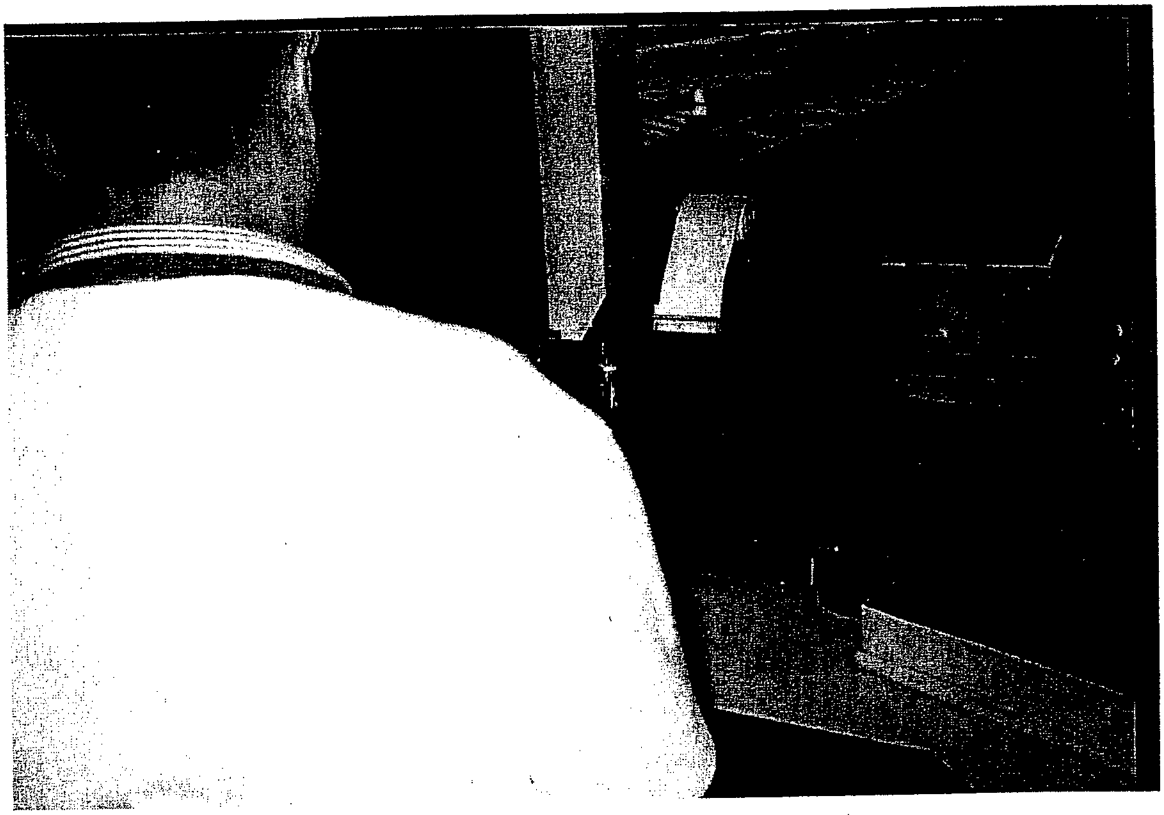

Figure 1.10.1 - Interior of a manual toll terminal at CRT

However, the use of electronic toll collection can provide excellent tools for more efficient and safer account processing and management. Centralized operations for a number of individual systems can provide travelers with the ability to travel throughout parts of Brazil using only one tag, rather than having to purchase separate tags for different facilities or establishing separate accounts with each facility.

1.10.3. Clearinghouse Functions to be Considered in Developing Backroom Operations

Backroom operations represent the heart of electronic toll collection systems. Such operations "make sense" of the various data collected, ensure payment transactions are conducted properly, and link the various components of the ETC system together. Below are the specific functions that must be considered in developing backroom operations.

Account Processing Center Operations

<u>Promotion and Marketing</u>

ETC requires a marketing and promotion plan that will engender widespread knowledge of the ETC system, interest in the use of the ETC system use and sale of tags, and opening of accounts. The campaign should include paid media, mass mailings and other methods.

Tag Handling

Processes must be established for ordering, stocking/inventory, testing, encoding, and distribution of tags.

Customer Service

A critical element of the ETC system is customer interaction. Customer satisfaction must be maintained for the system to be successful. Procedures must be established to maintain a standard of excellent customer service, including: phone and in-person contact points for customer service; resolution of disputed items; quick response times to customer complaints and inquiries; and accessible locations and hours of operation. These services should provide assistance to customers who have problems installing their tags and to customers who may suspect that the installed tag is not functioning properly.

Easy enrollment is a key component of ETC customer service. Many agencies establish walk-in Account Processing Centers that provide information on the system; applications for the system; enrollment of customers in the system and issuance of tags; acceptance and processing of payments; customer access to account balance information; copies of account statements; timely resolution of disputed items; testing of tags, closing accounts, obtaining funds and customer inquiries.

Customer Account Management

Required Functionality

Backroom operations also require an account management system to maintain and update individual and commercial customer account information. The customer account management system generally includes the following functionality:

1) Searchable databases for customer accounts alphabetically by last name, or by account number, tag number, or license plate number.

2) Ability to view data on individual customers on-line as follows:

   - Customer name, address, and any other demographic information included on the application form, including home and work telephone numbers

   - Vehicle information as included on the application form

   - Information on tags assigned to the account including number of tags, tag number(s), tag revenue type or class, date assigned, date/location where last used, current tag status (i.e., good, lost, stolen, etc.), vehicle to which assigned (license plate number)

   - Payment information, including payment method, date and amount of last payment, usual payment amount (replenishment amount), the level at which the balance is considered low (replacement point), current account balance, service center where account was opened, date and period covered of last customer statement, account anniversary date

- Current account status, including but not limited to good, low, negative, suspended, revoked, closed
- Discounts and other account plan options applicable to the account
- Flags indicating whether the account-holder has incurred a violation due to speeding or insufficient funds and, if so, the detailed information
- Begin and end dates of account suspension (voluntary or involuntary), if applicable
- Account history including payments, user-entered notes regarding any customer contact or inquiry to provide tracking of resolution of inquiries and discrepancies, and violations over the previous twelve months
- History and description of all payments, charges, and updates to any of the customer information in the database, including date and time updated and identification of the user who did the update, for the preceding twelve months or any range thereof (i.e., allow a selectable period of time), including data on closed accounts
- History of toll transactions posted to the account by transaction or posting date, including date, time, plaza, lane, tag number, tag class, AVC or collector-indicated class, tag read performance, amount of toll, tag status at the time of the transaction, lane operation mode, vehicle speed, and type of transaction for the preceding six months or any range thereof and by any specific tag or by all tags
- Details regarding any unique plan features, such as the number of trips taken in the current month towards minimum usage requirements, expiration dates of discounts, or specific locations where a tag may be invalid while valid at other locations

3) Capability to generate automated credit card authorization and replenishment transactions.
4) Capability to adjust credit card automatic replenishment amounts based on actual monthly usage.
5) Ability to generate automated routine notifications for mailing to customers, including the following situations: when a credit card used for automatic replenishment is about to expire or is declined; when the payment amount needs to be increased due to average monthly charges, when the account has been inactive (no "the ETC system" transactions for the last 90 days), etc.
6) Ability to allow assignment or removal of one or more tags from an account and must allow multiple tags to be assigned to a single account.

7) Ability to allow both limited manual and automated updates to account or tag status.

8) Ability to allow financial adjustments to accounts, e.g., manual posting of toll transactions.

9) Ability to allow for inclusion of license plate information against tag number and account number.

10) Ability to allow for inclusion of speed enforcement activity, including speed history or data for six months, all toll transaction information with the speed highlighted for as far back as six months and also the type of penalty imposed (e.g., warning, suspension), the dates of notices generated and mailed, the history of status changes on the violation including identification of the person updating the status, and the current status for six months.

Account management functions are usually required for individual customers, prepaid commercial customers, post paid commercial customers, and non-revenue account handling

Account Processing Center System Requirements

Backoffice operations also require toll agencies to develop, maintain, and operate systems required to perform account process center (APC) operations. In addition, systems should be developed to take into consideration the need for flexibility to accommodate potential future requirements.

System requirements are divided into six categories:

- Hardware/software
- Functionality
- Features
- Configuration Management
- File Transmissions
- Administration

Detailed requirements are identified below.

<u>System Hardware and Software</u>

Required components include:

- Computers
- Tag encoding workstations and portable tag readers
- Application processing workstations
- Image processing workstations for violations processing
- Image scanning workstations for document storage
- Network components

- Communication lines
- Printers
- Phone system equipment
- Credit card processing equipment
- Label printing equipment
- Bar code readers
- Operating system software
- Layered software products
- Application software for account management
- Application software for violations processing
- Mail processing equipment
- Possible tag readers
- Uninterrupted power source for critical components
- All consumables, including paper, opticals, diskettes, tapes, etc.

System Functionality

Based on the size and scope of the ETC system account processing operations, all system hardware and software should be sized carefully to ensure that they can accommodate the program operation throughout the contract term by meeting all performance requirements and functionality requirements.

<u>System Features</u>

Account processing system features include:

- Databases
- Menu-driven user friendly system or graphical interface
- Double key entry where applicable and/or appropriate
- Modular system design to allow for cost effective and expeditious changes
- Security measures, including such features as user passwords and network security
- Ability for customer service representatives to type text notes on accounts to track various situations
- Audit trail for all database changes
- Data redundancy (e.g., disk shadowing, mirroring)
- Use of data validation techniques and file transmission verification techniques in all data communications between all locations to assure validity of all user programs and data
- Storage of all data in a database that provides a Structured Query Language (SQL) for

access

- Inactivity time-outs in application software, both user defined and system defined
- Reasonableness checks on the data received from agencies and on information provided to customers. Recovery or investigation procedures shall be established for the cases when "unreasonableness" is indicated by such checks.

System Configuration Management

Agencies also should establish a formal Configuration Management process for handling all system changes over the course of the concession.

These changes should include the following:

- Fixes: corrections of malfunctions ("bugs") that are required in order to meet performance and functional requirements as specified in the Statement of Work
- Updates: new software releases provided by the Contractor whether for application software, operating system software, or third party software
- Enhancements: changes necessitated by program changes
- Modifications: changes necessitated by program changes
- Upgrades: augmentation and/or replacement of any system hardware which may be required (e.g., to accommodate changes or to increase size or capacity of the system)

The Configuration Management process should include a strict testing procedure to be followed before any system change is implemented in production. The Configuration Management process should also include a plan for implementing – on a scheduled basis as appropriate (e.g., monthly) – system changes that incorporate all categories explained above.

File Management

File transmissions are critical to the daily operation of the system. As such, strict processing procedures need to be developed to ensure uninterrupted service. Among the filing systems necessary are:

- Tag Validation Files
- Tag Validation Incremental Update Files
- Tag Exception Files
- Transaction Files
- Transaction Exception Files
- Image Files

System Administration

It also is necessary to establish communications, procedures, support facilities, documentation and personnel to operate all system hardware and software. These system operations can take place either at one of the specific facilities for the program, or at a separate data processing facility. Data processing system operations must be 24 hours a day, 7 days a week.

System administration includes the following:

- System monitoring and recovery
- System and data security
- System redundancy, back-up and archiving

System Monitoring and Recovery

This requires diagnostic equipment to monitor communications lines to detect problems. The toll agency should establish routines to monitor running of batch jobs (e.g., account postings). The agency also should establish procedures to report problems and implement recovery. Such procedures can be automated or through operator notification.

It should establish procedures to facilitate rapid resolution of problems that might be related to communications, including calling appropriate personnel in such situations, and procedures on when and how to retransmit/re-receive files when problems are identified.

System and Data Security

Procedures should be developed to describe how system communications, programs and data will be protected, how access and other security arrangements will be monitored, and how the agency will protect customer data from unauthorized disclosure and use.

System Redundancy, Back-up, and Archiving

Redundant features such as dual processing facility, back-up communication lines, automatic backup procedures, error correction protocol, and additional removal storage media should be built into the system. Agencies also should provide redundancy or back-up connections for the connection between the automated phone system and the computer; all network connections amongst APC facility locations; and all communication lines.

Revenue Handling Requirements

Revenue handling requirements include four major areas:

- Bank account deposit procedures
- Refund handling
- Funds security
- Other banking services associated with collection of customer funds