The Many Facets of ETC Interoperability

ITS World Congress

October, 2006

Table of Contents

Introduction

As electronic means of electronic fare collection, EFC have matured, there has developed a growing recognition that the customer should be able to use one electronic device. This is particularly true in the mature use of electronics to pay tolls. This capability has come to be known as ETC interoperability and is considered a high priority for many governments that wish to stimulate the economy through expanded transportation capacity. The free flow of freight and passenger traffic across borders is a central agenda of that economic policy. The U.S. and the European Union are in the advanced stages of implementing Electronic Toll Collection (ETC) and have attained interoperability within individual states but have had great difficulty developing a nationwide framework. This paper discusses the many facets of interoperability that must occur to accomplish the greater transportation agenda.

To create full ETC interoperability requires that it be accomplished at three levels, the technical, contractual and procedural. Each of these three levels is dependent upon the existence of the next higher level. While many have taken the first step of adopting a technical standard, in most cases the CEN 278 standard, much is yet to be accomplished as evidenced by the difficulty experienced in the European Union (EU) and Santiago, Chile. Both of these groups have adopted the CEN 278 standard and great effort has been expended to create an interoperability framework that allows for a seamless ETC system from a customer perspective. The EU has convened an interoperability committee and significant efforts are being expended to develop an EU-wide interoperable process. The various concessionaires of free flow ETC in Santiago began with the understanding that the free flow agencies would have an interoperable system from inception. While these agencies are using the same transponder, each agency is currently billing its customers separately. Apparently, the difficulties in establishing a seamless interoperability environment are more acute at the contractual and procedural levels than at the technical.

Interoperability, as it applies to ETC, encompasses a common set of processes, legal agreements, business rules and technical specifications required for a customer from one service provider's toll facility to use his/her transponder as payment on another service provider's facility. Roles in the interoperability process include the customer, the service provider (toll operator), Customer Service Center (CSC) and Violation Processing Center (VPC), Issuing Authority (IA) and clearinghouse. These responsibilities are frequently performed by several organizations: some public and some private. The essence of the interoperability issue is the coordination of participant motivations to ensure that each participant receives a fair return.

As mentioned earlier, ETC can be characterized as having three major aspects: technical, contractual and operational. Each is vital to the successful realization of a seamless method for equitable and (from the customer's perspective) effortless payment of tolls on a network of roadways. The technical challenges are typically the easiest to overcome, especially when the governing entity adopts an open equipment standard from the outset. Contractual interoperability, by contrast, takes longer to achieve. Major issues that must be resolved include how commissions will be paid, how payments will be guaranteed, how national certification will be accomplished and how a consistent level of service will be offered. In

addition, details must be worked out to resolve such complex issues as how to deal with violations and how to ensure after-service quality across toll road system boundaries.

Interoperability efforts in Europe and the U.S. have significant differences, but also many similarities. Most states within the U.S. and countries within EU have achieved interoperability within their respective boundaries. Regional interoperability is also widely supported where cross-border traffic is common. The ***E-ZPass***^{sm} Interagency Group (IAG) in the U.S. and the PISTA, MEDIA (Alpine Region) and NORITS (Scandinavia) projects in Europe are excellent examples. However, expanding interoperability throughout Europe is a bigger challenge. Obstacles such as language barriers, enforcement issues, VAT taxation policies, etc. are hindrances.

The ultimate goal for interoperability has been defined as: one on-board-unit (OBU), one contract and one invoice. While this concept appears to be straightforward, attaining the goal has proven to be elusive when applied to large governmental entities. Challenges arise largely due to the extensive number of stakeholders and their often-conflicting objectives and financial motivations, jurisdictional issues and customer service requirements.

Definitions, Acronyms and Terms

The definitions, acronyms and terms used in this document are included in the glossary below.

Term	Description
ASECAP	European association of tolled motorways, bridges and tunnels
AVI	Automatic Vehicle Identification
CESARE	A project set up by ASECAP and partially funded by the European Union with the intention of specifying, designing, developing, promoting and implementing a common interoperable Electronic Fee Collection System (EFC) on European toll roads.
Clearinghouse	The service that facilitates the routing of transactions, toll rate tables, rejection or acceptable lists and violation images.
CI	Contract Issuer
EFC	Electronic Fare Collection – Electronic collection of fares on various transport modes and ancillary services.
ETC	Electronic Toll Collection – Electronic payment for tolling.
ERTICO	A multi-sector, public/private partnership pursuing the development and deployment of ITS projects in Europe.
HGV	Heavy Goods Vehicle – typically trucks over 3.5 tons
IA	Issuing Authority
IAG	***E-ZPass***^{sm} Interagency Group – a collaborative group of 22 member agencies operating toll roads, bridges and tunnels in 11 states, mostly in the Eastern portion of the U.S.

Term	Description
IBTTA	International Bridge Transportation and Tunnel Association
OBE or OBU	Onboard Equipment – transponder (tag)
PSP	Payment Service Provider – Billing systems and account and OBU management
RCI	Road Charging Interoperability project of ERTICO
RFID	Radio Frequency ID
RSU	Roadside Unit – AVI readers and related equipment
TSP	Transport Service Provider – the organization that owns the money collected from tolling

Interoperability Roles – Who are the Participants?

Interoperability involves a number of complex relationships that are defined differently by various toll organizations throughout the world. In the early stages of ETC, the model was relatively simple, with a two-way relationship between the toll agency and its ETC customers. The toll agency assumed multiple roles including: the onboard unit (OBU) issuer; the contract issuer (CI); the payment service provider (PSP); the clearinghouse; the transport service provider (TSP); and the electronic Toll Collection (ETC) operator.

However, today's interoperability model often distributes these roles among several organizations. Transponders may be distributed at retail outlets (Florida's SunPass model) or obtained from banks (Spanish model). The contract issuer, CI can be a separate organization (such as a petrol card company) that issues the contracts and takes responsibility for payment of the transport service provider, TSP. The payment service provider, PSP (usually a financial institution such as a bank or credit card company) may be the party responsible for collecting money from the customer and handling the payment of services. Clearinghouses facilitate the transfer of transactions, toll rate tables, rejection or current lists and violation images between the TSPs and the PSPs. In the cases where the TSP and the ETC operator (or concessionaire) are different entities, the operator is empowered by the TSP to collect the toll and operate the ETC infrastructure.

As the levels of interaction increase, risk, commissions and customer service management become more complicated. Who is responsible for the level of service? Who resolves complaints? Who takes responsibility for uncollectable tolls, equipment issues in the lane, communication failures and violation enforcement? Business rules and contractual obligations must be well defined in order to assign risk and responsibility appropriately.

The draft "OmniAir Business Model for Electronic Payment Services" seeks to define both the business processes and the technical requirements for optional, complementary and evolutionary business services to support the next generation of the North American Dedicated Short Range Communications (DSRC) standards at the 5.9 GHz frequency band. OmniAir's list of participants includes the customer; the merchant or service provider; the Customer Service Center (CSC), the Violation Processing Center

(VPC); the clearinghouse and the issuing authority. While U.S. toll agencies typically operate their own CSC and VPC, these functions are expected to be more commonly outsourced in the future. It is also envisioned that the banking networks may increasingly take on the role of the IA within the U.S. and that the clearinghouse function will be handled by independent service providers who will route toll-related data between the financial institutions and the toll authorities.

The OmniAir model promotes privatization and competition in order to maximize cost reduction. The three primary goals are to: (1) encourage a broad range of issuers; (2) standardize the interoperability interfaces between issuers; and (3) standardize the service provider interfaces.

Technical Interoperability

Equipment compatibility must be achieved in order for toll agencies to become interoperable. Clearly, this requirement can be achieved when the participating toll agencies use equivalent equipment from the same manufacturer. Within the U.S., this approach has been adopted by the ***E-ZPass***^{sm} Interagency Group (IAG), which has an exclusive arrangement with Mark IV Industries. Japan and Italy have also enjoyed the benefits of interoperability from the onset of their ETC systems. Similarly, Florida and Texas toll agencies achieve technical interoperability within each state using proprietary Amtech equipment.

While these agencies have developed a form of interoperability, it has been accomplished through the use of proprietary equipment and only for a region of the country. Open standards allow for multiple manufacturers of transponders and readers and create the opportunity for competition, which can be expected to lower the cost of equipment. In the U.S., the first open standard was mandated by the State of California, through the development of the Title-21 technical specification. However, no open standard in the 900 MHz range has been developed by the U.S. overall.

In Europe, the CEN 278 standard has been widely adopted in an attempt to ensure technical interoperability and open competition for both the onboard equipment (transponders) and the roadside units (readers and associated equipment). There is some evidence that proprietary protocols have begun to be used in some CEN 278 applications that would prevent the use of other manufacturers' transponders and readers unless modifications are made.

The early interoperability adopters of RFID toll technology who failed to define a technical standard at the onset often found themselves locked into a single vendor's equipment once a substantial population of transponders and readers were distributed to their customer base. The high cost of switching out the existing units can be cost prohibitive for mature toll systems. Agencies who decide to become interoperable after introducing ETC frequently find that in order to do so, they must replace the existing population of transponders and readers with units that are compatible with their interoperable partners or make expensive changes to software and equipment.

The Illinois Tollway, America's highest volume toll agency with 2.2 million transactions per day, provides a lesson in late-adoption. In 2004, the Illinois Tollway decided to join the IAG. The IAG membership allows a single ***E-ZPass***^{sm} Mark IV transponder to be used throughout the IAG region. Prior to joining the IAG, Illinois had an ETC system called ***I-PASS*** which used Mark IV transponders that could be read by IAG agencies even though there was no financial interoperability with the IAG. Illinois customers that

traveled on IAG facilities would frequently mount both their ***E-ZPass***^{sm} tag and their ***I-PASS*** tag in the same vehicle, creating misreads, vehicle framing errors and lost revenue in some cases. After the Illinois Tollway became interoperable with the IAG, some customers still mounted both ***I-PASS*** and ***E-ZPass***^{sm} transponders in the same vehicle, resulting in the customer being double-charged and creating the issue of which agency should be responsible for refunding the customer. As part of the transition to IAG interoperability, the Illinois Tollway extended a courtesy to customers (with vehicles with 4 or less axles) who had previously purchased both an ***E-ZPass***^{sm} transponder and an ***I-PASS*** transponder and offered to buy back the ***I-PASS*** transponder. Furthermore, trucks with ***I-PASS*** were required to exchange their transponders for use on the IAG's ***E-ZPass***^{sm} system, because the ***I-PASS*** system used a different truck classification method than the IAG. In addition, commercial IAG customers are issued transponders with blue cases compared to ***I-PASS*** commercial customers who were issued pearl-colored transponders. The Illinois Tollway reportedly spent $2 million to rewrite software and upgrade hardware as part of the IAG interoperability project. Several agencies have faced similar issues in trying to establish interoperability within a single state and some have had great difficulties transitioning from one type of transponder to another.

Contractual Interoperability

States, regions and similar groupings of toll agencies must also resolve contractual and legal issues before interoperability can become a reality. Interoperability consortia typically define the contractual obligations of membership in an Interoperability and Reciprocity agreement. Often the goals are complicated by laws or governmental regulations that do not give member agencies sufficient authority to act in an interoperable manner. For example, the pursuit of violators in order to recover penalties from other consortia member agencies may require legislation or rules that the other member agency does not have or the original agency may not have the legal framework to identify violators. It is not sufficient to identify the vehicle, the address of the registered owner is required. To gain information on the owner of a vehicle, would require access to vehicle registration records and the cooperation of motor vehicle departments of various jurisdictions. When the traffic originates from different jurisdictions, interstate agreements are necessary to authorize access by those outside that jurisdiction to ensure that penalties can be assessed across borders. This is one example in which the legal framework must be clearly established and tested.

ETC interoperability is a particularly vexing issue in Europe, where past discussions have focused on technical interoperability. This focus has perhaps led to an underestimation of contractual and procedural interoperability and the need for shared legal and enforcement procedures.

The goal as described by the project leader of European interoperability, Jean Mesqui is as follows: "The development of contractual relationships as envisaged by the European Interoperability Directive includes the exchange of information between technical service providers, TSPs and customer information, CI's at an international level, and allows each actor to have access to data relating to defaulting users. The terms and conditions for accessing this information should be the same in all member states."

Operational/Procedural Interoperability

Operational interoperability applies to in-lane vehicle processing, customer service center operations, violation processing, the exchange of transactions and funds between operators, transponder distribution and account management for both private accounts and fleet operator accounts.

Customer Service Center Operations

The North American model for back office processing typically involves the use of a customer service center (CSC) to manage each toll agency's accounts. Occasionally multiple agencies will share a single CSC. Most toll accounts for non-commercial vehicles in the U.S. are pre-paid, and the majority of toll accounts are typically associated with a credit card or bank checking account. Automatic credit card replenishment is the most common payment option, wherein the CSC runs regular batch jobs to add funds to accounts that have reached a predetermined low balance limit. This is accomplished by sending the credit card clearinghouse files containing account numbers and replenishment amounts and receiving settlement reports back from the clearinghouse that indicate the status of the replenishment requests. The agencies are usually able to negotiate lower credit card fees due to the large number of transactions sent in each batch process.

Most toll agencies offer their customers a variety of methods for accessing ETC account information including interactive voice recognition (IVR) systems, websites, email, walk-in, mail-in, kiosks located in shopping malls, specially equipped vans, fax and phone.

Violation Processing

In order for electronic toll collection to work effectively, especially in high-speed lanes, toll road operators use automated violation enforcement systems (VES) to discourage scofflaws from evading toll payment. To prevent such violations, sophisticated cameras capture license plate images of toll violators that did not present a valid transponder. When the toll system does not detect a transponder on a vehicle passing though the toll lane, the camera is activated as the automobile crosses the enforcement system trigger loop. Once the picture of the car's license plate goes through either a manual operation to identify the license plate number or an optical character recognition (OCR) process to automatically obtain the plate number, it is typically matched against a Department of Motor Vehicles' database that gives the toll authority the vehicle owner's name and address. In addition to the toll due, some organizations add a penalty, which helps recoup the cost of extra work while also dissuading the owner from repeating the violation in the future. If the proper legislative authority is in place, the agency can then use this information to send a citation to the violator and collect the toll due as well as a fine.

Transaction Exchange between Operators

For interoperability to occur, toll collection systems of various toll road authorities must exchange data in an agreed-upon format. Each toll agency must exchange a list of valid tags and agree to collect, transmit and receive toll transactions according to predefined formats and business rules.

In some cases, fees, especially in the case of non-tolling services such as airport parking, are assessed for each interoperable transaction. Increasingly, toll agencies are also exchanging license plate files

associated with active ETC accounts so that video (image) tolls can be assigned to the appropriate account in the event that the transponder is not read in the lane.

Toll Lane Processing

Special requirements exist for agencies that participate in interoperability agreements. Depending on how transponders are validated in the lane, agencies must exchange either lists of valid transponders or lists of invalid transponders, or both. The lane processing must then validate not only the home agency's transponders but also those of the interoperable agencies. Business rules must be defined to specify how often these lists must be exchanged and how long they remain valid. For example, in Florida, a "positive list" is only valid for a 24-hour period. The IA will only reimburse transactions sent from the TSP if the transponder serial number was present in the most recent positive list transmitted by the IA. Likewise, the IA must receive the transaction files within 72 hours of the transaction date/time. If the files are delayed, and an account is no longer active, the transaction record is rejected and no reimbursement is made.

When customers complain about the accuracy of interoperable transactions, it is usually the IA's responsibility to resolve the issue. In cases where the classification of the vehicle is in question, it may be difficult to determine whether the customer is right or if the classification equipment is correct. Processes, such as independent verification of in-lane transactions, must be in place to accommodate these types of customer service problems.

Management of Fleet Operator Accounts

Private and commercial (or fleet operator) accounts are typically handled differently by toll agencies or their IAs. While private accounts are more often pre-paid, commercial customers are sometimes invoiced for their toll transactions. Agencies that do post-paid invoicing would require bonding for their commercial customers to lower risk. Special commercial discount programs may also be offered.

Current Interoperability Models

U.S. Interoperability

Interoperability in the U.S. has evolved over the years. With no national standard established, regional groupings have set up their own interoperability and reciprocity agreements to allow their customers to use their transponders across multiple bordering toll facilities. The largest U.S. tolling consortium, the ***E-ZPass***^{sm} Interagency Group (IAG), processes a majority of the toll transactions in the U.S. The states of Florida, Texas and California have also formed individual interoperability groupings within their respective regions.

E-ZPass^{sm} Interagency Group (IAG) Model

The IAG reciprocity model has been extremely successful for ***E-ZPass***^{sm} because (1) customers enjoy the convenience of non-stop tolling; (2) one tag and account can be used throughout the northeast U.S. region and now Illinois; and (3) travel is seamless across multiple IAG agencies. Transaction and account status data usually pass between agencies during the night to support a single account for participating ***E-ZPass***^{sm} agencies.

E-ZPass^{sm} agencies support 14.2 million transponders in 2,500 toll lanes and a major portion of all electronic tolling in the U.S. Mark IV Industries, a U.S. firm with its transponder manufacturing facility located in Canada, holds an exclusive contract with the ***E-ZPass***^{sm} IAG. The IAG model of interoperability currently involves three levels of corporate membership as follows:

- Full membership ($250,000 initial membership fee, $70,000 annual fee if revenue> $100 million else $17,500)
  - Can issue their own tags with their own brand
  - Can operate their own customer service center
  - One vote in the IAG
- Associate membership ($125,000 initial membership fee, same annual fees as full member)
  - Cannot issue their own tags with their own brand
  - Cannot operate their own customer service center
  - No vote in the IAG
- Affiliate membership (no initial fee, no annual fee)
  - Cannot issue their own tags with their own brand
  - Cannot operate their own customer service center
  - No vote in the IAG
  - Only financial relationship is with the sponsoring agency, does not exchange funds with other agencies.

There are currently seventeen full members, three associate members and two affiliate members. This does not imply that there are twenty-two independent operators that must clear transactions each evening. First, several agencies have joined into clearinghouse groups as defined below:

- The four NY agencies: MTA Bridges and Tunnels, New York State Thruway, Port Authority of New York and New Jersey and the New York State Bridge Authority form a single back office operation.

- The New Jersey Turnpike Authority, South Jersey Transportation Authority, Delaware River Port Authority and the Burlington County Bridge Commission are a second clearinghouse operation.
- The Delaware Department of Transportation and the Peace Bridge Authority are a third clearinghouse operation.
- The toll agencies in Virginia which consist of three public toll agencies (Virginia Department of Transportation, Richmond Metropolitan Authority and the Chesapeake Bay and Tunnel District), a private toll agency (Dulles Greenway) and a public-private partnership toll agency (Pocahontas Parkway Association) are a fourth clearinghouse operation.
- Agencies that operate and maintain their own separate clearinghouse operations include: Maine Turnpike Authority, New Hampshire Department of Transportation, Massachusetts Turnpike Authority, Maryland Transportation Authority, Illinois Tollway, Pennsylvania Turnpike Commission, Delaware River and Bay Authority, Delaware River Joint Toll Bridge Commission, and the West Virginia Parkways, Economic Development and Tourism Authority.
- The clearinghouses for the New Hampshire Department of Transportation, Delaware River Joint Toll Bridge Commission and the Delaware River and Bay Authority are all physically located in the same facility as the second clearinghouse described above, but they function independently as separate agencies.
- The Massachusetts Port Authority is an Affiliate Member of the Massachusetts Turnpike Authority, and the Chicago Skyway is an Affiliate Member of the Illinois Tollway.

Therefore, thirteen clearinghouse operations generally exchange data on a daily basis to ensure that all ***E-ZPass***^{sm} customers' accounts are properly debited for transactions throughout the ***E-ZPass***^{sm} network of toll roads.

The IAG model operates on the premise that a toll agency is responsible for calculating the toll rate for all transactions which take place on its own system and carrying out violation processing according to the policies set by the agency's own governing board. The funds are transmitted periodically by the agency that issued the transponder, which also handles clearing of financial transactions for that transponder. It is incumbent upon the issuing agency to support actions taken for calculating toll rates, violations, and other factors related to supporting the validity of the transaction. Any toll discounts are given based upon the usage by agency in accordance with the policies of that agency. Billing and customer service issues such as credits, adjustments, or lost/stolen transponders are usually handled by the customer's "home" agency (the agency which issued the transponder).

The IAG technical committee developed their file specification during the period between 1997 through 2002. Version-1 of the specification included the tag status file, which was typically exchanged nightly, the license plate file, the invalid tag customer file containing names and addresses of invalid transactions (to avoid the need for DMV lookups), transaction files and transaction reconciliation files including the disposition of each transaction. Version 1.3 added a corrections file and reconciliation file, and version 1.5 added non-toll support including an ***E-ZPass***^{sm} Plus flag indicating whether or not the transponder is valid for ***E-ZPass***^{sm} Plus applications (parking and non-parking).

The Customer Service Center (CSC) network currently utilizes a managed frame relay network. Data flow using the multi-CSC model has become more complicated as more agencies have joined the IAG.

Financial flow requires an involved weekly or monthly settlement process, depending on the agencies and amount of funds involved. While agencies have more control with the multi-service-center model, it requires a complex network, comprehensive new agency testing, somewhat costly software upgrades, more settlement issues, increased numbers of coordination issues to be resolved by the reciprocity task force and recurring issues of equity, particularly related to credit-card fees. Only those agencies operating on the same file specification version can opt to use the airport parking option. Coordination among the agencies works well, but change is made difficult because of the many political and financial considerations. There are very few issues in exchanging files and funds and any issues that arise are usually quickly resolved.

California Model and Title 21

California toll facilities are interoperable as mandated by the communications protocol for Caltrans Title 21 compliant transponders. This protocol is described in California state statutes Title 21, Chapter 16, "Compatibility Specifications for Automatic Vehicle Identification Equipment" as amended 3/18/93. The California ETC system is branded with the FasTrak name.

FasTrak transponders can be used on the Transportation Corridor Agency facilities, the 91 Express Lanes in Orange County, and the I-15 Express Lanes in San Diego County. In the Bay Area - FasTrak transponders are used on the Carquinez Bridge, Golden Gate Bridge, Benicia-Martinez Bridge, Richmond-San Rafael Bridge and the San Francisco-Oakland Bay Bridge. SR-125 in southern San Diego County will soon join the California FasTrak agencies.

California Agency	% of FasTrak Transponders	Number of Transponders
TCA	42%	527,000
Bay Area Bridges (CALTRANS)	33%	412,000
OCTA/91	12%	152,000
Golden Gate Bridge	10%	130,000
I-15	2%	27,000
TOTAL		**1.25 million**

Interoperability Between California Agencies

The Bay Area Toll Authority was established in January 1998 as the entity responsible for programming, administering and allocating the revenue generated by the $1 base toll on the seven state-owned Bay Area toll bridges. Under legislation, the California Department of Transportation ("Caltrans") retains ownership and operational management of the bridges. The seven state-owned Bay Area toll bridges

consist of the Antioch, Benicia-Martinez, Carquinez, Richmond-San Rafael, Dumbarton, San-Mateo Hayward, and the San Francisco-Oakland Bay Bridge. The state collects tolls from bridge users either manually at staffed lanes or automatically through an electronic toll collection ETC system.

In 2003, BATA, Caltrans and the Golden Gate Bridge Highway and Transportation District (GGBHTD) decided to engage a single contractor to provide ETC patron services for both Caltrans and the GGBHTD. The Regional CSC (RCSC) provides customer account management, revenue and payment processing, reciprocal payment and transaction processing with other toll operators, web services, call center functions, violator vehicle image review, violation notice and payment processing, DMV interface, violation collections, and transponder issuance. It is in effect a centralized model for the region i.e., one ETC operator for multiple toll facilities.

The regional back office consolidated operations in a single facility using the new regional system, equipment, and procedures. Customer accounts that were associated with either Caltrans or GGBHTD became Regional accounts. In addition to acting as the contracting agency, BATA assumed operational responsibilities from the other agencies including investment management of regional customer transponder and prepaid toll deposits, procuring credit card contracts for processing automatic replenishments and purchasing additional transponders on behalf of the regional CSC operations.

The regional ETC Operator cooperates with other California toll agencies to identify problems and/or inefficiencies and to take action to resolve these issues. Issues related to statewide interoperability are the taken to the California Toll Operators Committee (CTOC) for consideration. Wire transfers or payments to and from reciprocal agencies are performed by each of the Customer Service Center Operators according to CTOC requirements for all California Toll Road operations throughout the state. The California model of interoperability is therefore not so different from the IAG model in the sense that standards are set by the statewide consortium board and some agencies choose to join together to have one ETC operator for a regional area. The regional ETC operator utilizes a system of reports to ensure that all transactions received by the CSC are promptly reconciled and reported back to the sending Agency.

The RCSC Operator processes the settlement of reciprocal transactions as follows.

- Generates and sends invoices to Issuing Agencies on a monthly basis.
- Receives, deposits, and enters payments by Issuing Agencies into the system.
- Reviews discrepancies between the invoice and the payment to determine how to apply payments.
- Caltrans processes its own accounts payable for the seven bridges that it operates. The acquiring agencies send invoices directly to Caltrans. Caltrans generates the appropriate reciprocity financial reconciliation reports, reconciles the invoice to the reports and sends payment (check) to the Acquiring Agencies.

The regional ETC operator provides for the timely, reliable and accountable exchange of information and funds among participating facilities including:

- Referring customers of other facilities to the appropriate contact.

- Forwarding to the proper facility, any applications, correspondence, returned tags and other items not belonging to the Agencies; and
- Implementing the policies and procedures as specified among the agencies and other toll operators.

The regional ETC operator is required to establish, manage and maintain an FTP site to support the exchange of information with reciprocal agencies in accordance with CTOC specifications. Reciprocity files are generated, distributed, received, and downloaded 365/366 days a year via automated processes requiring no routine human intervention.

In a similar manner interoperability occurs with the Transportation Corridor Agencies (TCA), Orange County Transportation Authority (OCTA), I-15 Express Lanes, and the South Bay Expressway - SR 125.

Florida Model

The Orlando-Orange County Expressway Authority (OOCEA) launched Florida's first Electronic Toll Collection (ETC) system, called E-PASS, in 1994. The original E-PASS system utilized Mark-IV bumper mounted transponders and in-pavement readers.

The next Florida toll agency to adopt ETC was Florida's Department of Transportation (FDOT), which used Amtech's windshield-mounted transponders and overhead readers. The new SunPass system and the existing E-PASS system would have been incapable of achieving interoperability if OOCEA had not replaced its entire population of transponders and readers with the same equipment selected for use by FDOT. The transition was expensive and time-consuming and required both agencies to perform extensive planning and testing. Interoperability was successfully achieved in 2001. Other Florida toll agencies soon followed, including Miami-Dade Expressway's (MDX) deployment of SunPass, Osceola County's O-PASS and Lee County DOT's LeeWay. In addition to toll interoperability, OOCEA, FDOT and Osceola ETC customers enjoy the convenience of using their transponders as a method of payment for parking at the Orlando International Airport.

One of the important lessons learned in Florida is that while interoperability has enormous customer service advantages, it also introduces constraints on the participating agencies that can have significant financial, procedural and operational impacts on all interoperable partners. Two examples of this complexity include the following:

- A significant difference between the requirements for FDOT processing and the other Florida interoperable agencies is the fact that FDOT stores customer balances and plaza locations on their patron transponders. All other Florida agencies store customer balances in their (back office) Customer Service Center's database. However, in order to support interoperability, all Florida toll agencies must include software at the lane level to support the write-back requirement for SunPass transponders. This process increases the time required to complete a toll transaction, and has resulted in a significant number of incomplete transactions processed in the lane. The state's toll agencies are currently in the process of mitigating this problem by deploying new software
- Differences between the ways the individual agencies processed their own customers and other interoperable customers when no transponder is read during a toll transaction recently resulted

in disgruntled customers and unfavorable media attention. While OOCEA, FDOT and MDX all convert violations to paid transactions when a match is found between the license plate number identified from a video image and a license plate associated with a customer's account – they do not currently extend this courtesy to other agencies' customers. OOCEA and FDOT have agreed to exchange license plate files and upgrade their system software in the future in order to support "violation conversion" for all interoperable customers.

Texas Model

Texas' effort at providing interoperability between the major ETC systems of Dallas and Houston was first achieved in 2003 with the introduction of TXTag. Before interoperability, the TollTags of the North Texas Turnpike Authority (NTTA) in Dallas and the EZ-TAGS of the Harris County Toll Road Authority (HCTRA) in Houston did not work with the equipment of the other, even though they were physically similar to previous generation Amtech passive backscatter systems.

The statewide TeamTX group provided a forum for the development of the interoperability agreements. Planning efforts took 2 years to complete. Initially launched to blend AVI transactions for the NTTA (serving the greater Dallas metroplex), HCTRA (located in the Houston area) and the Dallas Fort Worth International Airport, the state's interoperability network will be expanded in the future to include other Texas toll and parking authorities. In the Dallas area, interoperability between NTTA, the DFW International Airport, and the Dallas Love Field Airport currently permits nearly one million customers to use their TollTags for parking. This ability is expected to extend to other commercial parking operations throughout the metroplex.

Future interoperability between the newly formed regional mobility authority (RMA) toll facilities and the existing Texas toll facilities will extend over several hundred miles of toll roads. An RMA is a political subdivision formed by one or more counties to finance, acquire, design, construct, operate, maintain, expand or extend transportation projects, which may be tolled or non-tolled. To achieve the ambitious Texas interoperability goals, joint efforts have been initiated between NTTA, HCTRA and TxDOT to define a statewide interoperability solution that will be used by all Texas agencies, based on the objective of one tag, one account and use on any road, but with local autonomy maintained.

Plans for the new Texas interoperability model include the following innovative operational concepts:

- Unregistered accounts
- In-lane account service
- Mass distribution of unregistered transponders
- Retail and kiosk distribution and replenishment
- No waiting period for transponder usage

Recent discussions with other states have led to a pending proposal for NTTA and the Oklahoma Turnpike to become interoperable. If this is accomplished it will begin a process similar to that which ultimately created the IAG in the northeast portion of the U.S. If this occurs, an Amtech-based consortium in the south and a Mark IV-based consortium in the northeast may be the result leaving the U.S. with three distinct and incompatible technologies by region, Mark IV, Amtech and Title 21. Title 21 is the only open standard technology at 915 MHz.

European Interoperability

Europe has been in the toll road business for many years, and it continues to expand and mature. New concession processes offer a competitive approach for supporting critical infrastructure needs.

Interoperable electronic fare collection – as covered by the European Directive 2004/52 – is an important, yet complicated goal. Challenges range from technical issues to contractual matters, legal constraints and varying enforcement policies. The European Commission's Road Charging Interoperability Directive 2004/52 establishes this common position and states that the contract and OBU must be available for payment of any applicable toll, fee or tax on the entire EU tolled network. In addition, the quality of service must be the same regardless of the country where the contract was issued or the nationality of the driver.

The Interoperability Directive requires a single OBU and contract by July 1st, 2007. While the conditions for technical interoperability have been essentially achieved, the contractual challenges persist. There has been some concern that even though the CEN 278 standards are universally accepted in the EU, some applications of that technology have had proprietary attributes introduced. However, the most pressing issue involves commercial risk management in a complex chain of players including the Transport/Taxation Service Provider (TSP), the ETC Operator, the Contract Issuer, the OBU Issuer and the Payment Service Provider (PSP). Major questions that remain unanswered include how commissions will be paid, how payments will be guaranteed, how international certification will be accomplished and how a consistent level of service will be offered. In addition, details must be worked out to resolve such complex issues as how to recover the VAT in all countries traveled, how to enforce toll collection at the European level, and how to ensure after-service quality across borders.

Interoperable EFC and Road Pricing in Europe Directive 2004/52 [1]

The Interoperable EFC and Road Pricing in Europe Directive 2004/52, which has been in force since May 2004, provides a regulatory 3-stage framework for the deployment of EFC services. The first stage, which is scheduled for completion in July 2006, defines the service. The second stage applies to heavy goods vehicles (HGVs) and long distance coaches and is due by mid-2009. The third and final stage applies to all vehicles and is planned for completion in mid-2011.

The Directive leaves the pricing policies up to the Member States, but requires the systems to be capable of handling any of the national-level charging policies.

The basic principle for the Directive is one single contract and one single OBU. In addition, a single invoice is desired, but it is not mentioned in the text of the Directive. The contract and OBU must be available for payment of any applicable toll, fee or tax on the entire tolled network. In addition, the quality of service must be the same regardless of the country where the contract was issued or the nationality of the driver. Today when a truck travels between neighboring countries, they may have up to 4 different units. And the same applies to the contract (means of payment).

[1] Information based on 2004 IBTTA Technology Workshop presentation by Philippe Hamet, an officer with the European Commission – DG TREN, Brussels, Belgium.

Two basic technologies are available: 5.8 GHz microwave or GNSS/GPRS satellite. Other technologies are also allowed as long as they do not discriminate against non-equipped customers. However, the EFC Directive strongly favors satellite-based tolling systems for a number of reasons including the fact that it is considered to be the only solution that can meet the political requirements of the European Commission (EC) and the Member States. Satellite systems have an added advantage in that they support other applications such as monitoring dangerous goods and automatic emergency handling.

In order to fulfill the needed link with the private sector, the road operators' association (ASECAP) has launched a Road Platform with support from the EC DG TREN. This organization links the decision makers with the private sector (road and service operators, car manufacturers, equipment providers) to discuss specific ITS issues and expects to eventually launch joint actions.

The work program seeks to develop a precise and concrete definition of the European EFC Service based on CESARE III, to explore the evolving technologies that will support the EFC service including GNSS/CN, CEN DSRC and Telepass. UMTS, Galileo and other technologies may be included in the future.

The work program will be accomplished using the Road Platform to coordinate activities with industry. Working groups will study proposals submitted to the Comité Telepeage on these issues, and the RCIPP Project will demonstrate that transactions work at different sites. Other groups will tackle issues such as enforcement of offenses, vehicle classification and the integration of OBUs in vehicles. Procedural interoperability will be addressed through CESARE III, which aims to adapt CESARE II.

Many countries are currently working together to define contractual and procedural interoperability based on Memorandums of Understanding (MoUs) between operators. These MoUs will take into account the different clearing elements and the contract between client and operators. Special consideration will be given to the fact that a contract signed with one operator will also apply to all operators. There is also a need to work on other issues such as certification procedures to ensure that the OBU is suited to all operators. For example, when someone enters Portugal, the operator needs to know that the OBU is suitable for his national requirements stamp that certifies equipment for all of Europe.

Exception handling and the enforcement of violations are being addressed through a project called VERA 2, which has a draft directive in progress.

ASECAP

ASECAP is the association of tolled motorways companies in Europe, representing 126 organizations from 17 different countries that manage more than 24,000 km of toll roads. It participates actively in the ETC Expert Group, and a number of important projects including RCI, MEDIA, PISTA, NORITS and CESARE III.

Under a grant from the European Commission, ASECAP leads the CESARE project, whose goal is to achieve interoperability for non-stop tolling systems in Europe at contractual, procedural and technical level.

ERTICO

ERTICO – ITS Europe is a multi-sector, public/private partnership pursuing the development and deployment of Intelligent Transport Systems and Services (ITS). Following the vision of several leading members of European industry, Ministries of Transport and the European Commission, ERTICO was created in 1991 as a cooperative company with equal shareholding Partners.

ERTICO's mission is to promote and support the efficient research, development and implementation of Intelligent Transport Systems and Services in Europe, contributing to better sustainable mobility, environmental and societal aspects and user satisfaction, with acceptable economic returns for its Partners.

ERTICO's new Road Charging Interoperability (RCI) project addresses interoperability for road charging between European countries and the testing and demonstration of interoperability between six key neighboring countries – Austria, France, Germany, Italy, Spain and Switzerland. The RCI project aims to contribute to this objective by demonstrating how any road charging transaction in Europe can be carried out with a single set of in-vehicle equipment.

The RCI project goal is to develop an open, integrated framework enabling road charging interoperability at the technical (and related procedural) level based on the key existing and planned road charging deployments in Europe (AUTOPASS, EUROPPASS, LSVA, TELEPASS, TIS, TOLL COLLECT, VIA-T and VIA VERDE) and will implement and test this framework in field trials at six sites. In the future RCI may extend its range of test sites to other key European interoperability deployments

The main tasks that will be conducted in the RCI project is:

- Description of the general framework in terms of use cases and requirements for interoperability
- Definition of the framework in terms of procedural context and technical
- Architecture – this includes specifications for in-vehicle equipment
- Demonstration on the networks of selected operators (Austria, France, Germany, Italy, Spain and Switzerland), by relying on several prototypes of RCI-compliant open platforms, of:
  - The ability to execute transactions in the context of the existing road charging contexts
  - The ability to run other services on the same in-vehicle platform
  - The ability to use a single equipment between customer/user and operators/authorities
  - The ability to produce the road charging transaction data, which will be at
  - The disposal of the "service provider" (SP) for invoicing the users/customers).
- Proposal for a type approval and certification process in terms of:
  - Overall framework
  - Test plan
  - Exemplary type approval

The objectives of the RCI project are to specify and implement the RCI prototype that operates in any of the existing RCI road charging environments:

- Austria (EUROPPASS)

- France (TIS)
- Germany (TOLL COLLECT)
- Italy (TELEPASS)
- Spain (VIA-T)
- Switzerland (LSVA)

The underlying specifications of the RCI prototype should:

- Define interfaces that can "open existing systems" by allowing different suppliers to manufacture equipment that can be certified against these specifications and that can operate in different contexts (CEN DSRC/CARDME, Autostrade DSRC, "Multi technologies" as in Germany and in Switzerland);
- Contribute to the convergence of future tolling systems and the evolution of existing tolling systems as such allowing for a greater re-usability of standard components across different systems;
- Be open, public and available on a non-discriminatory basis to any stakeholders including all system suppliers;

The prototyped OBEs (to be delivered by the two consortia) will operate in three existing procedural contexts for all classes of vehicles. Thus, a "unique" OBE (OBEs based on a common architecture) will be handled in the following contexts:

1. Systems based on 5.8 GHz CEN norm:
    - Running in the CESARE/CARDME context as existing or planed in France, Austria, Spain, Sweden, Slovenia,
    - Not running in the CESARE/CARDME context, which could also use these OBE if they would agree to implement in their lanes the ability to work in CESARE/CARDME context (UK, Denmark, Portugal, Norway,)
    - Running in Switzerland in the LSVA context
2. Italian system: 5.8 GHz DSRC Telepass as used by all Italian Motorway Operators
3. German system, based on three technologies:
    - GPS/GNSS
    - GSM/GPRS
    - Infrared used for vehicle positioning, mobile and stationary enforcement and communication between the OBU and RSU - the system is defined according to TOLLCOLLECT specifications and includes a 5.8 GHz CEN DSRC interface.

The interoperability will be defined and specified in order to demonstrate the ability of the OBEs/RSE to produce the "transaction" data for the "Service Provider" and/or for the "Contract Issuer". The prototyped road charging OBE should be capable of operating in any of the existing RCI road charging environments as identified above. The enforcement issues (for non-equipped vehicles) will not be implemented and tested.

Via T Business Model

The Via T business model was created with support from the existing Spanish concessionaires. Based on the CEN standard, Via T is compliant with the transaction model from CESARE I.

The Via T business model is based on the concept that banks are the clearing agencies for ETC transactions. Such an approach capitalizes on existing clearing infrastructure. The following contractual rule set is used in this model:

- Multiple equipment manufacturers were certified to provide transponders and ETC equipment for Via T.
- All Spanish banks and several transport-related companies were authorized to issue transponders.
- The Via T transponder is accepted in all Spanish motorway toll facilities.
- The three major Spanish payment organizations perform transaction clearing in accordance with operational regulations.

Eighteen concessionaires and thirty-four banks participate in the Spanish model through a series of MOUs.

PISTA Project

The PISTA Project is a major demonstration of ETC interoperability between five European countries. The project, which began in 2002, was financed by the European Commission and was based on the CEN standards. Implementation of interoperable ETC has been demonstrated by PISTA using real traffic conditions. This required migration from existing heterogeneous, non-interoperable systems. The project was divided into 7-work packages and was built on the work of other European research projects.

Pilot tests were conducted using pre-qualified EFC equipment using real and simulated toll transactions to demonstrate technical, procedural and contractual interoperability including funds and data exchange. Common file formats and three different contracts (between operators, issuer/operator and users) were developed and successfully tested as part of the pilot test project.

Following the main principles defined in the first two CESARE projects, PISTA supports a non-corporate organization based on a MOU between the TSPs and eventually the road authorities and other system operators.

The organizational model will need to integrate the different existing models used by the participating European countries. Main functions of this MOU include:

- Common technical and operational management
- Uniformity of service
- Marketing services, which encourage users to join the EFC system.

The participants in the PISTA project have gained valuable knowledge that can be applied to their actual commercial EFC implementations. As a result, a significant number of European toll operators have indicated a strong commitment to the deployment of cross-border interoperable EFC systems.

NORITS Project (Nordic Interoperability for Tolling Systems)

The NORITS Project incorporates over a million OBUs and over 24 operators involved in both existing projects and others under construction. The goals of NORITS are to provide convenience to customers traveling by car in the Scandinavian countries and to fulfill the EU-directive.

The basic principle of NORITS is to integrate a single OBU based on the CEN DSRC standard, a single contract and a single invoice. Each operator is responsible for determining the toll based on its own classification structure. Agreements and contracts that are based on CESARE II and local laws include the NORITS agreement and agreements between issuers and operators and issuers and customers.

The issuer assumes the payment risk, which is complicated by legal restrictions regarding the export of pictures and other customer regulations between the operator and the issuer. In addition, direct contracts between operators now offer more favorable discounts than through NORITS – making it impossible to achieve the goal of one user having a single contract.

Procedures are under development to resolve questions related to individual operator's prices and conditions, contractual and payment inquiries, complaints related to fines or penalty fees and requests for VAT refunds.

CESARE III Project

The CESARE III method for resolving the common European problems of different actors, charging schemes and enforcement services associated with the goal to develop a common EFC System. The goal of CESARE III is to integrate three interoperability levels (technical, procedural and contractual), three actors (users, issuers and operators) and three contract levels between those actors. Objectives are to:

- Create a suite of documentation that will facilitate inter-operation of different charging schemes in Europe with minimal user inconvenience at borders; and to
- Minimize the number of business relationships between users and charging bodies, the number of invoices, and the number of OBUs that must be carried in a vehicle.

MEDIA Project – Alpine Region Interoperability

The MEDIA (Management of EFC through DSRC Interoperability in the Alpine Area) Project is focused on defining an interoperable EFC service for heavy vehicles (>3.5 tons) using a central account. Participants include Austria, France, Italy, Slovenia and Switzerland. It is envisioned that the project will (1) directly lead to implementation; (2) be operational, concise and understandable; (3) be integrated into the European process; and (4) lead to additional services for the customer.

Major issues related to the member nations include:

- User declaration of the number of axles in Austria;
- Several EFC operators with no centralized organizational structure in France;
- Different DSRC technology in Italy;
- Post-payment processes in development in Slovenia; and
- Tachograph reading declarations used on entry and exit in Switzerland

The proposed solution will use a special "Alpine OBU" that is logically bound to the vehicle. The OBU will support dual DSRC interface (CEN and Telepass) and will utilize a simple keyboard and display for kilometer registration and trailer declaration.

Contract issuers will be required to guarantee payment to the EFC operators. The MOU specifies contractual obligations for both the contract issuer and the EFC operator and defines rules for the MEDIA EFC service. Local contracts may also be associated with the MEDIA OBU.

TelePass

Autostrade manages 61% of the Italian toll road network, with "closed" tolling accounting for 98% of the toll collection. The process of Italian interoperability began with the consideration of legal issues, followed by procedural and financial considerations, and finally, the service and technology challenges. The major objective was to maximize communications and procedural agreements, define common rules and the legal and financial framework, and then standardize the technical aspects associated with interoperability.

Enforcement is accomplished by automatic detection and uses a national database of plates.

Several banks provide points of assistance to deal with the legal and financial issues associated with interoperability. Customer service centers support the significant front-end requirements. However, users can also register on the Internet.

A new embedded electronic purse feature has been planned. The existing prepaid solution will support a central account, and the OBU will have an icon display.

"3G" represents the future of Telepass as it extends to satellite communications compliant with the Italian DSRC[2] standard. Interfaces to other devices such as GPS LED and GSM LED on a single unit are currently underway. Services to be offered by the new Telepass include Electronic Toll Collection (ETC), vehicle tracking, mayday, and information management (e.g., notifying users of situations on stretches of motorway) where Telepass 3G handles the communications between remote sensors, remote users and the operators.

The UK DIRECTS Project

The DIRECTS (Demonstration of Interoperable Road-user End-to-end Charging and Telematics Systems) is designed to provide a framework for interoperable road user charging in the United Kingdom (UK). Authorized by the Transport Act of 2000, the DIRECTS program allows local road authorities to charge for road usage. Strategic objectives include the desire to utilize a single OBU per vehicle and a single source of billing for customers, to provide cost effective systems and operations and provide an environmentally acceptable transportation solution.

The DIRECTS on-road demonstration project involved free-flow, multi-lane charging on various roads in Leeds, England. This end-to-end system included in-vehicle charging, billing and enforcements using three technologies:

- DSRC (Microwave)

[2] DSRC – Dedicated Short Range Communication

- GNSS/Cellular (MPS)
- License Plate Recognition

Tariffs were calculated by time of day, vehicle class, zones, "virtual" gantries, distance, grid and road type. Dummy bills and penalty notices were sent to over 500 volunteers who took part in the demonstration. The key project deliverable was an 'Open' Preliminary Minimum Interoperability Specification Suite (OPMISS).

The basis for the DIRECTS business model includes an open standard, integration of multiple technologies for road user charging and the utilization of hybrid DSRC/GNSS/Cellular technologies to resolve enforcement issues associated with pure MPS systems.

Australian Interoperability

Australian toll roads in Sydney, Melbourne and Brisbane have encountered numerous challenges in their efforts to incorporate interoperability across the country's 13 different toll facilities. The various combinations of suppliers, integrators, toll roads, systems and owners, together with differences in roaming and clearing agreements; business relationships; partnerships; fee arrangements; and project deeds have created a complex set of challenges.

Despite the fact that Australia envisioned an open system, integration between the first ETC systems took two years to accomplish. Suppliers posed one of the most significant obstacles because they aggressively protected their territory.

Their definition of interoperability is that a toll road customer can operate their vehicle on any toll road facility within a defined geographic region without having to establish individual arrangements with each toll road agency. In their view, interoperability occurs at a number of levels. At the most basic level interoperability occurs by support for a 'standard' vehicle identity device. This has traditionally been the DSRC tag compliant with international standards such as CEN. From the Australian perspective, there is also a need to identify vehicle class by a standard framework for the purposes of determining the toll rate in a barrier system or a rate per mile on an open road tolling systems such as Melbourne CityLink. These classes should at a minimum include car, commercial and heavy commercial.

The best interoperability systems would allow the customer to choose both the roadway to travel and the payment arrangements. Interoperability Standards which were considered in the Australian model are given below.

Physical	Height clearance standards, lane widths, signage, terminology
Communications	DSRC tag standards are applied to permit interoperability of compliant DSRC tags from various suppliers
Classification	Vehicle Class definitions are generally consistent between jurisdictions (Car - Class 2, Truck - Class 4)

Vehicle - Tag	Tag issuers have independent numbers so that the liability for collecting the toll remains with the customer account owner
Vehicle - LPN	License plate numbers are not unique within a jurisdiction or between jurisdictions. (this creates some minor overlaps)
Transactions	Tag transactions have identifying data that makes them unique. Video transactions (LPN) are generally unique but could occasionally be duplicative
Interoperability	Tag interoperability exists throughout Australia but not so for video. Video interoperability is planned for full video (no tag) tolling
Enforcement	Each jurisdiction is currently different but they are attempting to develop interchangeable enforcement between states

This interoperability framework is the result of an industry initiative designed to improve customer service. The Association of Toll Road Owners and Operators, along with Government participation, administer the definition of interoperability Policies and Procedures. The governance framework is documented in a Memorandum of Understanding (MOU) and all concessionaires are signatories. The MOU group established two working sub-committees that develop and endorse the interoperability framework. These committees are:

MOU Appendix A - Policy and Procedures
MOU Appendix C - Technical Interface and Data Definition

Interoperability in Chile

There are approximately five urban concessions in the Santiago area and all of them are free flow, open road tolling applications. The concessions are made up of companies from throughout Europe and Latin America. They're a very diverse group and yet have been working very diligently to ensure interoperability in Santiago. Transponders are provided free to anyone who requests one and to date there are approximately 1.3 million transponders in circulation. They are provided through various outlets as well as directly by some concessionaires. About 85% of the accounts are cash rather than credit card accounts.

The government adopted the CEN 278 standards for frequency and protocol as a first step to interoperability. At the beginning of the concessions in Santiago, there was great interest on the part of the government as well as the concessionaires, to ensure that interoperability would exist. The original vision was to have a central database of information on all customers and to have a central clearinghouse for processing transactions. It was envisioned that the various concessionaires would jointly own a separate entity that would form the customer service center and clearinghouse functions.

As the various projects developed and the requirement to issue tags to the community became more crucial, the central clearinghouse concept was tabled. The issues which hampered the central clearinghouse were more institutional and time sensitive than technical in nature.

Although, the concessionaires still desire a single central clearinghouse, the current process is quite different. Tags are being distributed free to the entire community surrounding Santiago and the five concessions share a single database of information on customers. The majority of customers in Santiago are not credit card customers but rather cash customers. In addition, collections for toll payment are postpaid rather than prepaid. At the end of each month, each concession accesses the central database and sends a billing to its customers. While this is intended to be a temporary measure, it is taking on greater permanence as the concessions expand. Therefore, at the end of each month the customer receives a separate billing from each of the concessions upon whose roads they traveled that month. In essence, the concessions in Santiago are primarily in the receivables business. Each billing must be tracked and followed up to ensure proper payment.

The Chilean experience is a good example of the power of institutional arrangements. It remains to be seen whether the dream of a central clearinghouse and billing process will be a reality. It is important to note that the legal framework that permits post-payment and the business environment wherein the majority of customers are cash customers has a strong influence on the ultimate interoperability model that occurs.

OmniAir Vision for Interoperability

OmniAir's mission is to promote public awareness and market growth of next generation telematics services (5.9 GHz) in the U.S. through the use of unbiased, independent and centralized performance certification that ensures an OmniAir Transaction.

OmniAir has two committees working at the equipment level and the back office level:

- Certification Committee (5.9 GHz), which provides testing, validation, and certification, as well as interoperability credentialing.
- Electronic Payment Services Committee, which is working to develop a National Interoperability Specification (NIS).

US 5.9 GHz Project

5.9 GHz DSRC is the targeted next generation of short-range communications for the USA. The US DOT has provided significant funding for this high profile project that is now in the prototype development stage.

Benefits of the 5.9 GHz project include a single nationwide open standard for wireless communications that maximizes private sector competition and provides for a secure transaction.

Aspects of the project that add complexity include the fact that the communication points are moving at high speeds requiring millisecond acquisition speeds and the requirement to have "bulletproof" communications security.

Key requirements have been defined and major system elements (including the radio chipset, microprocessor and operating system) have been selected. Numerous tasks are currently underway such as the prototype packaging concept, the definition of the software functionality and determination of the test methodology.

Prototypes will have capabilities that go beyond present-day systems. These prototypes, expected to be available in late 2005, will feed into other application evaluation programs,

The US government and vehicle Original Equipment Manufacturers (OEMs) are committed to a deployment decision in mid-2008. However, 2011 is the earliest it would become feasible for toll collection.

OmniAir Back Office Model

The National Interoperability Specification (NIS) targets the standardization of the payment application for 5.9 GHz interoperability, which will be required to support recognition of transponder accounts issued across regional borders – or even outside the toll industry.

The concept is similar to a Financial Clearinghouse Network where toll operators send transactions to one of several competitive clearinghouses, which in turn forward the transaction to the appropriate issuer as shown in Figure 1. Each Operator receives funds for transactions on their facility.

Processing costs are expected to be similar to those charged by other financial networks. The model targets an open protocol at the back office level resulting in multiple options for selecting a vendor. Customers benefit from having the opportunity select an issuer. While the NIS specification targets a standardized account data exchange, there are no plans to include violation processing.

Recommendations for Promoting Interoperability

Based on the information shared by the practitioners of interoperable electronic tolling worldwide, a number of recommendations can be derived to effect interoperability. These recommendations include:

- Adoption of an open equipment standard;
- Selection of a protocol capable of expansion to support non-tolling applications in the future
- Adoption of standards for software interfaces and security architecture guidelines necessary to support business objectives and to guarantee secure data transfer at all levels;
- Consideration of the interests of all participants including: concessionaires, private and commercial electronic tolling customers, service providers (toll operators), issuing authorities (IAs), and clearinghouses;
- Open competitive transaction services to maximize flexibility at the back office level;
- Provisions for using license plate data as part of the electronic tolling equation – either at the onset or in the foreseeable future; and
- Establishment of a common file transfer hub that will ensure data transfer integrity between toll operators, issuers and clearing institutions.

These recommendations are discussed in more detail in the following sections.

Technical Interoperability

The selection of a standard for frequency, messaging protocol, format, and content is but the first step necessary to ensure interoperability. However, ETC interoperability will also require the development of an ETC framework in the form of a Memorandum of Understanding that governs a range of activities performed by tag issuers, toll road operators and financial clearinghouses.

Equipment Standards

Development of an open, integrated framework and associated architecture should include DSRC specifications for in-vehicle equipment available from multiple vendors who meet certification requirements. Similarly, providers of roadside readers must also be certified to these same specifications. The DSRC standard should be open, public and available on a non-discriminatory basis to any stakeholders including equipment suppliers. Certification testing must be conducted to ensure that contractor's equipment meet the standards defined.

Ideally, the DSRC standard should accommodate non-tolling applications in addition to the primary objective of toll collection. Care must be exercised to ensure that the standards selected are not limited for future applications beyond the ETC application.

Software Interface Standards and Security Guidelines

Standards for software interfaces and security architecture guidelines should be adopted to ensure that the transaction data produced by each tolling entity can be exchanged between toll operators, tag issuers and clearinghouse institutions in a consistent, timely and secure manner.

Interface Control Documents (ICDs), which describe the content and structure of data records, as well as the associated processing required, should be defined for each level of peer-to-peer data exchange including the format of the file header and the associated transaction data files to ensure that they are constructed, transferred and received reliably. Data records must be designed such that the origin of the transaction, the issuing agency and the transponder are determinant. ICDs should also be drafted to define the protocols used to exchange financial transactions, reconciliation data, and AVI tag status information.

Security is a high priority for any payment system. For tolling applications, this extends to all communication levels including roadside to tag, roadside to back office, and back office to other agencies or a central clearinghouse.

Contractual Interoperability

Because contractual interoperability has many facets, it could be one of the most challenging aspects of interoperability. The joint authority to establish contractual rules should be formulated as a memorandum of understanding early in the process to provide a forum for overall decision making.

A strawman for contractual interoperability roles is shown below:

Role	Function	Contractual Relationship
Service Providers	Toll Road Operators	The Service Providers would establish a business relationship with the Clearinghouse where all requests for authorization and payment processing would be routed.
Customers	Toll Road Users	Customers would establish an account and obtain transponders through a network of Issuing Authorities.
Issuing Authorities (IAs)	Responsible for distributing tags, establishing and maintaining customer accounts, managing risks and processing transactions	The IAs would establish contractual relationships with customers and with the Clearinghouse. If prepaid accounts are used, the IA would act as a merchant for the purpose of funding those accounts (e.g., credit card, ACH, debit.)
Clearinghouse	Provides the middleman function by receiving transactions from the toll operators and routing them to the IAs. The Clearinghouse would process transactions and handle billing, reporting, settlement and operational services for both the toll operators and the IAs.	The Clearinghouse would establish a business relationship with the Service Providers and the IAs.

The joint authority would provide oversight and direction to manage the system standards, legal obligations and interoperability between the various players. Because certain functions may already be

provided private toll operators and concessionaires, petrol companies, credit card companies and banking institutions, any of these organizations might be considered for issuing transponders. The Clearinghouse function might be provided by the central authority or by a private entity licensed by the central authority.

A violation processing service provider may also be required to process images, interface with the Department of Motor Vehicles to obtain the name and address of vehicle owners, issue citations, and track payments associated with violations. Legislative statutes are key to the ability to deter violators by creating a clear legal framework that sanctions enforcement, defines the rights and duties of users and delineates the consequences of violations.

Operational Interoperability

Operational interoperability applies to in-lane processing, clearinghouse operations, violation processing, the exchange of transactions and funds between IAs and toll operators, transponder distribution and account management for both private accounts and fleet operator accounts. If technical and contractual interoperability are defined properly, operational interoperability becomes possible. It is not however guaranteed by the previous two levels of definition. Smooth and efficient operational interoperability has been rarely attained in the ETC industry worldwide.

As the levels of interaction increase, risk, commissions and customer service management become more complicated. Details that must be determined and negotiated include (1) the level of service required by each group of participants in interoperability; (2) how complaint resolution is to be accomplished; (3) how clearinghouse fees will be paid; and (4) how violation enforcement will be performed. Violation enforcement is a good example of detail operational issues that must be resolved in a uniform manner to effect a seamless environment for the traveler.

Formulation of an Interoperable ETC Framework

The process of formulating an interoperable ETC framework will require the participation of toll operators, tag issuers, financial clearing institutions, systems integrators, video/transaction processing service providers and others. These participants must work together to formulate a formal and documented ETC framework. This framework must be a living document that can be modified and approved through a predefined process that incorporates the views and positions of the major participants and is managed by a central authority. This document should contain sections to specifically address the following:

- Identification of the key principles of interoperability
- Definition of participants roles and responsibilities in ETC
- A statement of objectives
    - National interoperability
    - Multiple manufacturers of equipment

- Maximum private sector competition
- Secure transactions
- Single account, single invoice, single OBU

- Procedures and methods by which the ETC framework can be modified
- Establishment of a standards body
- Technical interoperability section
  - Equipment standards and specifications
    - OBU
    - Readers
    - Cameras
- Contractual interoperability section
  - Customer service standards
  - Service provider standards
  - Account management practices and tag issuance
  - Financial transaction processing
  - Violation processing standards
- Operational interoperability section
  - Customer relations
  - Merchant/Service provider procedures
  - Customer service center operations
  - Retailing of OBU
  - Tag issuance procedures
  - Financial transaction processing
    - Fee sharing arrangements for credit and debit transactions
  - Violation processing procedures

- Collection process definition