Multi-modal

Electronic Payment Systems Best Practices and Convergence White Paper

VOLPE center

U.S. Department of Transportation
Research and Innovative Technology Administration
John A. Volpe National Transportation Systems Center

Preface/Acknowledgements

1.) The John A. Volpe National Transportation Systems Center would like to thank the numerous public sector transportation providers and the industry associations and private sector vendors from both the transportation and financial payments communities for sharing their insights and expertise which contributed to this white paper.

2.) This document was created under the sponsorship of the I-95 Corridor Coalition. It is for their sole use and dissemination

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1 Introduction

The United States transportation industry has changed dramatically in the methodologies to collect fares and fees over the past 10-15 years. Largely a cash-centric approach until the early 90s, the toll and transit industries began automating ostensibly to reduce cash handling, increase collection efficiencies, enhance customer service, and, in the case of E-ZPass® to achieve interoperability among members, thus enhancing the customer experience even further.

In recent years, many innovations in transportation payment systems are being demonstrated and proposed in the I-95 Corridor and elsewhere, including: partnerships between transit agencies and financial institutions, regional clearinghouses for transit and toll roads, dynamic pricing to reduce congestion, and applications of electronic payment systems (EPS) for public and private parking. Yet these are largely independent efforts, and few, if any, of these innovations involve multi-modal applications. What's more, as the options grow, there is confusion and a lack of objective information about the relative advantages of the various approaches, and a lack of guidance on how transportation agencies should proceed.

This white paper attempts to provide an objective description of emerging payment system alternatives and the best practices being used in transportation modalities today. Additionally, it will explore opportunities for further payment system innovations as well as convergence opportunities across modes of transportation. It is the authors' intention that the paper will provide an opportunity to begin to formulate convergence strategies from these emerging approaches and electronic payment systems best practices that look ahead to the future.

The focus of this study will be two-fold:

1. Examine advanced payment technologies currently in use or in trial stages in various transportation modes primarily in the United States, but also internationally to determine the industry best practices.
2. Examine approaches to provide the traveling public with a more coordinated approach to payment systems for all modes.

The John A. Volpe National Transportation Systems Center (Volpe Center), an independent federal research organization, will lead the compilation of comprehensive information from a wide variety of sources, and will facilitate discussions among the transportation, payment, technology and other relevant industries to collect, develop and present this information in an objective framework.

The Volpe Center has coordinated this research with the initiatives of U.S. Department of Transportation (U.S. DOT), and specifically the strategic planning undertaken at the Federal Highway Administration (FHWA), the Federal Transit Administration (FTA), and the Research and Innovative Technology Administration (RITA) Intelligent Transportation System Joint Program Office (ITS JPO).

In the first half of 2009, the U.S. DOT has spent much intellectual capital on developing a strategic approach to ITS. This strategic plan includes an area focused on ePayment applications for transportation. Stakeholder input for this strategic plan was gathered from over 200 industry members at the ITS America Annual Meeting in June 2009. This overall work shows a shift toward the creation of transportation enterprises which view coordination of and increasing access to transportation services as paramount goals. Some of the key input from stakeholders regarding ePayment goals was to engage the transportation industry as well as related industries (such as financial, payment, and wireless) to leverage technology investments and stimulate private sector interest.

1.1 STUDY OBJECTIVES

The research attempted to reveal information that addresses the most critical issues that transportation providers are likely to face now and in the near term future, such as:

- EPS best practices in use in transportation to efficiently and effectively collect fares, fees, tolls, etc. for transportation services.
- Multi-modal coordination opportunities, potential benefits to providers and to regions, and existing and emerging payment approaches to achieve overarching transportation EPS systems.
- Standards and open architecture technologies and solutions, their use (or lack thereof) in transportation payment systems, opportunities for standardization, and the impacts/benefits to use of standards.
- External partnership opportunities for transportation providers, including with financial payment industry members (such as card associations, banks, and vendors), mobile payments industry members (such as wireless providers, device manufacturers, financial institutions and other vendors), and system integrators from both the financial payments and transportation industries.
- Non-payment applications and technologies and their impact on coordinated transportation payment systems. These applications often fall into the areas of Intelligent Transportation Systems (ITS) (such as congestion mapping, trip planning, 511 systems, variable message signs, etc.), but also into applications complimentary to payment applications (such as loyalty applications, mobile parking applications, and other “value-add” types of applications.)

- Use of pricing tools such as congestion pricing programs and HOT lanes to impact congestion in regions and corridors and facilitate mode shift of travelers. These, like non-payment applications above, would be complimentary with any payment technology or application.
- Investigate usage linkages across transportation modes and determine if they are strong enough to lead to the development of multi-modal EPS.

1.2 STRUCTURE/METHODOLOGY

The research aspect of this study was conducted primarily through face-to-face and telephone interviews with experts in the fields of parking, tolling, and transit- both public sector service providers and private sector application and system providers. In addition, experts from the financial payments and mobile payments industries were interviewed.

Additionally, a scan of existing research papers, reports, and position papers from applicable industries was conducted. Much research and investigation in the financial payments, smarty card, and mobile industries has been undertaken in the past several years and provided a baseline starting point for this study.

This white paper will present the findings of the research. It will be broken into examinations of EPS best practices in each transportation mode, as well as individual examinations of specific approaches to EPS, including the use of third-party-issued payment instruments- financial payment cards, mobile devices, and employer-issued credentials. These sections examine both mature installations as well as the types of systems and approaches that innovative transportation providers are pursuing for their future systems.

Finally, examination of convergence examples in transportation are undertaken to discern lessons learned the goals and objectives service providers have for innovative EPS approaches and criteria of success or failure.

2 Synopses of Industry Best Practices

This section presents a high-level overview of collection practices in each transportation mode. This information is intended to allow the reader to understand the current state of practice in each mode, and thus create a baseline body of knowledge to examine convergence of payment systems across modes.

2.1 TRANSIT FARE COLLECTION SYSTEM BEST PRACTICES

2.1.1 Smart Cards in Transit Payments

The Transit industry was an early adopter of smart card technology; the first systems were in trials in the mid-1990's and in mainstream use by the late 1990's. Smart cards are essentially a credit card sized payment card that has a computer chip embedded in its body. Smart cards are either contact, meaning they must be physically inserted into a reader and contact made between the reader and contacts on the chip, or contactless, where the card must be within 10 cm of the reader to achieve coupling with the reader. Both variants of smart cards are covered by International Organization for Standardization (ISO) standards (ISO 14443 for contactless cards and ISO 7816 for contact cards). As the smart card industry has matured, contactless has become the overriding choice for any payment application. Therefore, throughout this document, the term 'smart card' will be used to refer to a contactless smart card unless specifically termed a 'contact smart card'.

The transit industry has always been an adopter of 'smart' payment technology as it became available. Throughout the 1990's, the technology of choice was magnetic. The rationale for the use of smart cards in transit mainly had to do with the speed and accuracy that the fare collection system could achieve using a more powerful and secure smart medium with a contactless interface. The transit industry has a strict speed requirement for smart card transactions or 300 msec (and 250 msec has been a strong requirement). Another key factor was the incredible levels of reliability of a smart card system. The card itself is very durable and not subject to degradation like a magnetic card, and the reader (or validator, in the parlance of the smart card system) is also incredibly reliable with very low levels of maintenance required.

Smart card systems also produce vast amounts of data that can be mined to develop accurate ridership reports and patterns that help agencies more efficiently plan service.

2.1.2 Smart Cards in Non-Transit Applications

Smart Cards are also a technology that can be used in other applications such as financial payment systems (i.e. using Visa, MasterCard, American Express, and Discover to pay for goods and services in stores, over the telephone, and on the Internet), security applications as a credential for physical access control as well as access to IT networks, as well as specific industry applications such as health care credentials, professional and educational campus applications, and others. Actually, the flexibility of the smart card actually led to a retrenching in the smart card industry as the dream of 'multi-application' cards could not be realized

Early this decade however, the financial payment industry began focusing on the development of contactless payment cards. The industry had shifted from a desire for a contact smart card for financial payment cards to an acceptance of a contactless interface. This simple shift in philosophy has begun a refocus of financial industry on transit fare payment systems.

2.1.3 Traditional Approach to Smart Card Fare Payment Systems

This section will present a brief overview of the most mature technical approach to smart card fare payment systems. Figure 1 below shows traditional smart card fare payment system architecture[1]. Note that when the reference to multi-modal (in the Operator-Specific Headquarters System (Multi-Modal)) is multi-modal within a transit environment. In this sense, multi-modal refers to various transit modes – bus, rail, ferry, etc. In the case of the Washington Metropolitan Transportation Association (WMATA), one mode included in their payment system is Park and Ride parking lots, so in a very finite way, WMATA's system does have a multi-modal scope, however the parking facilities are within the transit domain.

These systems are largely owned and operated by the transit agencies themselves (one exception is the Metropolitan Transportation Commission (MTC) Translink® system in the San Francisco Bay area, which contracted with the system integrator to operate the system through 2019.

[1] Figure taken for the Smart Card Alliance Co-Branded Multi-Application Contactless Cards for Transit and Financial Payment White Paper

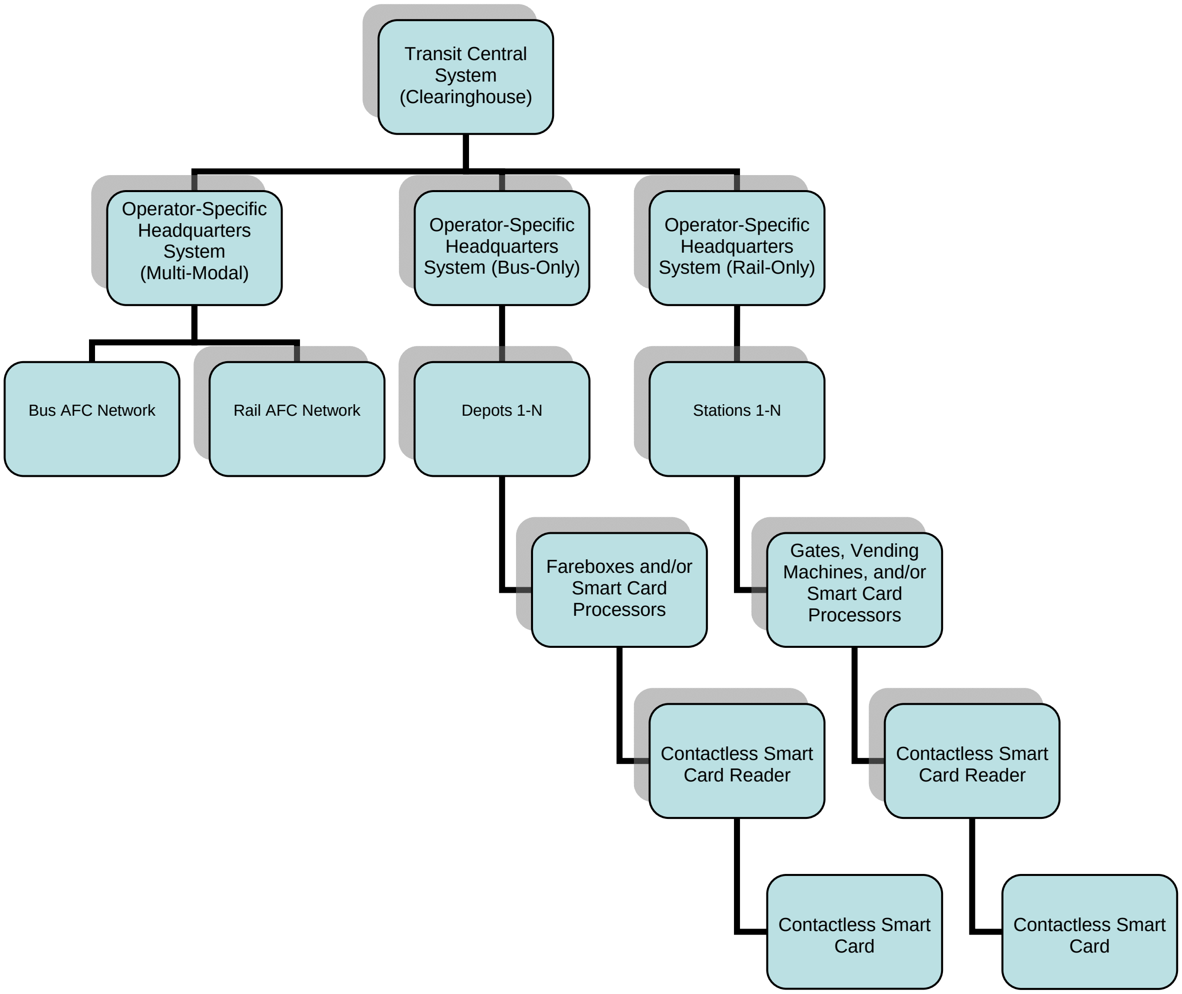

Figure 1: Sample Transit Payment System Architecture

What this system architecture shows is that in the traditional smart card system, the system is quite hierarchical and does have the ability to have multiple operators work within a regional payment system. The transaction, device health and welfare, and system control data flow up and down the system. The smart cards used in this system have the transit application specific to that system loaded on the chip. The cards are generally issued and managed by the transit agency. The hierarchy at the top two levels of the diagram shows that multiple transit providers can coexist in a regional system with clearing and settlement occurring to equitably distribute funds to providers.

The diagram shows the detailed levels of the system only on the right for clarity. These various levels would be present within all providers. From the bottom up to the top of the diagram, a customer presents their smart card to a reader at a farebox, faregate, or other reader. At this point communication between the card and reader arrange for payment of the fare from a transit product on the card chip. Funds are deducted as needed and the patron is allowed to board. Depending on the fare rules, some systems require a 'tap off' to complete the calculation of the fare (for distance-based fare structures). When the fare is variable in this way, the maximum fare is deducted, and the fare is calculated and funds are placed back on the card as required.

The transaction data then flows up the system until it reaches the clearinghouse at the top at some point in the day (based on business rules of the regional system). Please note that is the system has only one participant (one provider) the clearinghouse function is not needed.

One noteworthy aspect of the traditional smart card system is that it is a distributed or 'card-based' system. The calculation, fare payment, and transaction tracking is all done on the card at the card-reader communication. This is an important point to keep in mind when reading further in this paper and may be a key issue in the development of multi-modal payments systems

2.1.4 Standards in Transit Fare Payment Systems

At this point in time, the transit industry in North America, and really world-wide, is largely made up of proprietary, custom systems. Vendors that install the system have ownership of intellectual property within the system technology and approach. However, in the last 5-7 years, many national standards for the traditional approach described above have emerged. In The United States, the standard is an American Public Transportation Association (APTA) standard called the Contactless Fare Media System Standard (CFMS). National standards are complete in many nations, particularly in Europe, and there is also a Canadian Provincial standard for Ontario called PRESTO, which was developed in parallel to CFMS and planning is underway to examine reconciling the standards.

At this time there are several prospective transit agencies on track to implement CFMS standard systems. The Port Authority Transit Company (PATCO) has a system in place that used the Regional Interoperability Standard (RIS) developed by the Port Authority of New York and New Jersey for use in the New York metropolitan region. The RIS was the baseline document that led to the CFMS standard, and PATCO feels that its system is compliant with CFMS. Additionally Miami-Dade County Metro is planning to implement a CFMS compliant system and other agencies are requesting bids based on a CFMS solution in RFPs.

In addition to national standards, there is an ISO standard, ISO 24014, entitled Interoperable Fare Management Systems (IFMS). The IFMS defines a high-level architecture and a set of use cases that seek to define the traditional smart card fare system broadly enough that all national standards will fit underneath it. There is a Part 2 to the IFMS standard under development that does define technical requirements, but it is viewed as less a finite technical requirement and more as a deeper examination of high-level requirements such as the systems rules, examining migration to interoperability among national standards, and the use of other complimentary applications such as mobile payment devices.

New potential standards are emerging at this time within ISO. There is an effort underway to examine the use of bank cards in transit fare payment systems being championed by South Africa that essentially is examining standardizing the technical approach of using a non-transit issued smart card that does not have a transit application resident on it. The thought of the transit payment experts is that they need to have a secure portion of memory to read and write to track usage to calculate point to point and other distance-based fare structures. This work is ongoing and a standard is years in the future at best.

2.1.5 Emerging Approaches in Transit Fare Payment Systems

This is an exciting time in the transit fare payments industry. In addition to the maturity of the smart card as the solution of choice in the industry, there are several innovative approaches that are in various stages of development that may not only allow transit providers to increase their efficiencies and customer service, but actually place the transit industry at the forefront of revolutionary approaches to how consumers pay for goods and services in the future.

The most interesting aspect of the approaches emerging in the transit industry is that they lay outside the transit industry itself (indeed outside the transportation industry as a whole). Because of this fact, these payment approaches rise above the stove piped nature of transportation payments and bring near-automatic interoperability to the industry. The key to achieving this interoperability is to gain a level of penetration in the industry so that the chasm can be crossed on the Technology Adoption Lifecycle.[2]

As with any innovative new approach, there are still elements that must be proven and issues to be resolved, but perhaps most important is a need for education and the process of building a comfort level and rapport between executives that are not entirely familiar with new business practices.

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[2] Geoffrey A. Moore Crossing The Chasm, (Harper Business Essentials, 1991)

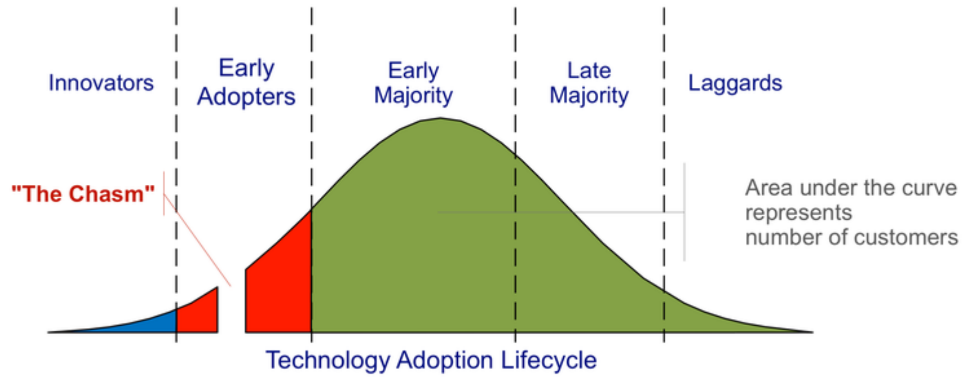

Figure 2: Technology Adoption Lifecycle

2.1.5.1 Contactless Bank Cards

The first innovative approach covered is contactless bank cards. The financial industry has a long history of work with smart cards. However, until the past 5-10 years, the industry had a strong requirement for contact smart cards, which could not meet the technical requirements of the transit industry. Therefore, the financial community largely observed as the transit industry moved forward with the tradition approach described above- privately issued cards used on a distributed system model largely owned and operated by the transit agency.

In 2005, MasterCard Worldwide began to roll out contactless bank cards called PayPass. A key element of the MasterCard strategy for PayPass is the use of the cards in transit payment systems. At a high level, the MasterCard approach is a centralized one, as opposed to the traditional, decentralized approach in transit payment systems. In the MasterCard approach, the bankcard is used as a bankcard as in any other retail environment to pay for goods and services. The system uses the power of the payment card infrastructure to obtain a guarantee to pay for the transaction, while not necessarily obtaining an authorization, as occurs at a point of sale device at a retail checkout, for instance. The cards are issues by banks, not the transit agency themselves. Any customer service issues surrounding the card would be handled by the financial institution, not the transit authority.

An interesting aspect of this approach is the way it is funded by transit agencies. In the traditional approach to transit payment systems, the agency purchases the system from a vendor, then operates and maintains it. Therefore, the bulk of the cost of the system is paid up front and this cost is tens or hundreds of millions of dollars depending on the size of the transit system. Largely this type of acquisition is done using capital funds and often a public bond must be issued to cover the cost.

The cost model for bank card systems is still a work in progress. In the back card approach, there will still be an upfront cost paid to an AFC system integrator to integrate the hardware and software that they license from MasterCard into a legacy system. In the case of a greenfield installation, it is undetermined at this point in time whether the installation cost of the bank card AFC system is less than, equivalent to, or more than that of a proprietary (or standard) traditional AFC system. One factor is the level of system customization to the needs and requirements of the purchasing transit agency. In systems in place today, costs of customization, software and hardware updates, technical refreshes, and other changes are high.

Once the system is installed, the total operating costs are not known to be less than, equivalent to, or more than that of a traditional AFC system. The bank card industry derives fees from merchants who accept bankcards. These fees vary, but are made up of a fixed and variable rate. This fee structure is still being determined for very small transactions of just a few dollars and under. Therefore, a transit agency that accepts bankcards for payment of fares agrees to pay a certain percentage of that fare in the form of a discount fee just like any merchant.

In the traditional turnkey AFC system, the transit operator generally operates the system themselves, including card issuance and management, customer service, and maintenance. Cost avoidance of these functions is perhaps the key to evaluating the relative costs of a bank card approach and a traditional, privately issued smart card system.

There are still hurdles to overcome with the bank card approach. Systems must be deployed that handle complex fare structures; issues such as unbanked patrons, which make up a large portion of transit ridership, must be serviced cost-effectively; and a cost model must be developed that allows transit executives to compare varied system approaches. These and many other issues must be addressed, and as the following bank card-based transit fare systems show, they are being examined in the field.

2.1.5.1.1 Mastercard-New York Metropolitan Transportation Authority Pilot

MasterCard, together with CitiBank and Affiliated Computer Services (ACS) has been testing the approach with the New York City Metropolitan Transportation Authority on New York City Transit's (NYCT) Lexington Avenue Subway line since 2005. Begun with a pay-as-you-go approach to paying transit fares in the a flat fare system, the pilot has progressed since its inception to trial PayPass payments on mobile phones by embedding a PayPass chip in the casing of Nokia phones (from December 2006- April 2007), and now the pilot is poised to demonstrating bank card payments in onboard buses. Additionally, MasterCard and NYCT are committed to demonstrating the ability of a bank card to pay for fares using the entire NYCT fare table.

Additionally, MasterCard teamed with VeriFone to install PayPass readers on 5000 New York City taxicabs in December 2007, demonstrating a true multi-modal system.

2.1.5.1.2 Utah Transit Authority System Roll-out

Earlier this year, the Utah Transit Authority (UTA) installed a UTA-wide bank card payment system in which bank cards of all brands and types are accepted. As an example of this acceptance of all contactless bank cards, in a February demonstration, an American Express Blue contactless bank card that had not been modified in any way for the UTA system was used to pay a fare on a UTA bus.

While UTA uses a flat fare system currently, it is their desire to investigate distance-based fares in the future. Therefore they have adopted a tap on tapoff process for fare payment. UTA feels their system, which was installed by ERG Transit Systems, is capable to handle these more complex distance-based fares.

2.1.5.1.3 Education Needed

In addition to these issues, there are hybrid approaches to implementing bank cards in a transit payment system. The Smart Card Alliance *Co-Branded Multi-Application Contactless Cards for Transit and Financial Payment White Paper* details these various approaches*,* but the transit industry is still evaluating the bank card centralized system approach and the traditional decentralized approach that has achieved maturity in the industry.

Finally, there is simply a lack of detailed knowledge on the part of the transit industry of the financial payment industry and vice versa. By examining this through the prism of a new and different approach to pay for fares and it is understandable that there is hesitation on both sides of the discussion.

It is quite encouraging that there is already a full implementation of a bank card approach (in UTA) as well as a pilot program at the largest transit provider in the U.S. (New York MTA) moving forward slowly and surely with further testing and implementation of a bank card approach. This places the bank card approach as just entering in the early adopter category of the Technology Adoption Lifecycle. And this has all happened within the last 3-5 years- extremely quickly in an emerging marketplace.

2.1.5.2 Mobile Payment Applications

The mobile payments sector is an intriguing industry segment. It is a space that is a convergence of the wireless communications, banking, financial payments and smart card industries. This sector has within it multiple potential applications; payments – retail and transportation, communications, internet, banking, and others.

The business model is a complex one and standards are still emerging. It is the realm of joint ventures, small internet starts, academia, and others vying to position themselves to partner with wireless carriers, mobile handset manufacturers, and the financial community.

At this point in time, the mobile payments sector is still a highly immature marketplace. There have been literally hundreds of trials in various countries seeking to not just prove technological viability, but consumer demand, and finally economic viability. It is not possible to pilot a business case however, and this is the need of the mobile payments industry.

The scenario of a mobile application ecosystem that includes a payment application as well as value-added applications such as loyalty, smart couponing, mobile banking, and, in the case of transportation, ITS applications. Mobile devices paint a compelling picture of a future, robust system that can not just innovate transit payments, but perhaps achieve multi-modal transportation payments.

The technological approach that seems to be the way forward is Near Field Communications (NFC). NFC uses the same contactless communication standard, ISO 14443, as smart cards. There are still some technical issues to be resolved regarding over the air (OTA) provisioning of applications. OTA provisioning essentially means loading a mobile application on your devise. The issue with OTA provisioning has been that this is a lengthy process that requires many steps and leads to customer confusion.

Many NFC trials have been performed in transit and consumer acceptance is usually quite strong. As providers of services, executives must keep their focus on the customer and realize that to the customer, there must be a seamlessness of the application. The experience to the customer should be the same and the payment must occur at the same speed with the same result (i.e. the gate opens, the light lights and the beep sounds).

Recently, APTA has been engaging both the transit industry and the mobile payments industry in workshops to determine a way forward to ensure that mobile payments will be a part of the landscape of transit payments systems. Two workshops were held – one in October 2008 and one in March 2009. The focus of the workshops was on education, and the goal was to staff an effort designed at addressing some of the issues identified that prevented the two industries from advancing past small pilots.

Unfortunately, minimal traction has been achieved in this effort. To date, the questions raised have been beyond the participants' abilities to gain insights to solutions. One approach that has been suggested and trialed has been to treat the mobile device as simply a card in another form. By placing the transit payment application on a chip on the device (either embedded in the case, using a sticker, or some other hybrid approach), the phone now simply emulates a smart card. Chip manufacturers currently have the ability to produce these 'sticker chips'.

The goal of this approach could be a larger pilot than has been seen to date; tens of thousands of units, not several hundred. Perhaps this is the approach that can move this innovative industry into the Technology Adoption Lifecycle in the "Innovators" area of the curve. APTA's efforts are ongoing with this unique cross-industry group.

2.2 TOLL BEST PRACTICES

2.2.1 Transponder-based Electronic Toll Collection

The U.S. Toll industry is quite mature in its use of Electronic Toll Collection (ETC) to collect tolls in an efficient way. ETC systems in the U.S. are currently RFID transponder technology-based. At the heart of these systems is a transponder that is placed in the windshield area of an automobile and communicates with a reader placed over the toll plaza fee payment area.

The ETC system achieves a very high speed, long distance transaction at an operating frequency of 915 MHz.

The majority of transponders are powered devices, however passive tags are coming into the marketplace that are thin and flexible and can be adhered to users' windshields. These stickers lower the cost of transponders for toll operators and the savings can be passed to users who currently purchase transponders (although they are free in some states).

Penetration of the transponders is high among daily commuters, who value the efficiency, discount, and convenience of ETC, but less so among infrequent toll road drivers. This lack of penetration of infrequent users combined with the lack of an open architecture ETC technology in the United States is leading toll operators to begin to turn to license plate recognition technology to increase penetration as well as achieve interoperability across states. Video-based license plate recognition is a mature technology that most toll operators use for violation systems, therefore it is logical for operators to leverage this largely legacy technology

The ETC business process begins with a consumer signing up for or purchasing a transponder. The transponder can either be registered or kept anonymous, but the vast majority of ETC customers choose to register their transponder. Replenishment of funds is available by electronic funds transfer from a bank account, via a credit card account, or by cash or check. Most ETC customers replenish through credit or bank account to maximize convenience. The minimum initial purchase is usually approximately $25 and, in the case of automatic replenishment, the toll operator establishes a minimum account threshold at which the account is topped up via an electronic funds transfer or credit charge.

As stated, there are customers that wish to remain anonymous. Even though toll operators do not share traveler information unless subpoenaed, privacy concerns are still present and some customers do not want their movements tracked, yet still want the convenience of ETC. This small group must purchase and replenishment their accounts via cash or check.

Figure 3 below shows a sample Electronic Toll Collection System. The ETC central system receives and processes data from the various sub-systems and ensures accurate clearing and settlement of the transactions to the appropriate accounts. The video systems that have been used for enforcement purposes are also beginning to be leveraged for payment, including enabling of interoperability of ETC systems.

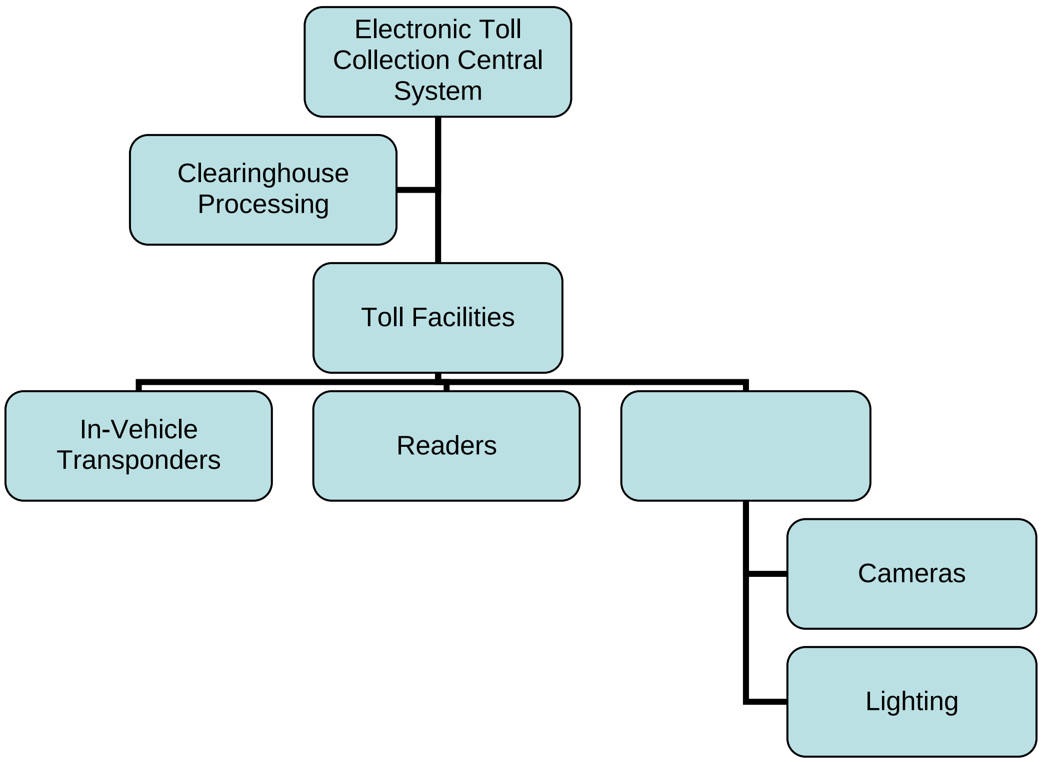

Figure 3 Sample Electronic Toll System Architecture

2.2.1.1 Movement to Open Road Tolling

To increase the advantages of ETC and encourage further penetration of electronic toll collection, toll operators are striving for open road toll collection environments. In open road toll collections, toll lanes are eliminated. Gantries over roadways are used to install ETC technology, allowing vehicles to travel at near highway speeds while paying tolls. Open road toll operations enhance throughput and lessens the congestion impact of toll collection activities.

2.2.2 ETC Interoperability

A key need in the toll industry is interoperability of ETC. Interoperability is defined as the ability of different systems to interact together; in the case of ETC, two systems operated by different entities and using technology from different vendors will be able to accept the other's technology and perform transaction clearing and settlement.

An interoperable toll system elevates traveler convenience and toll providers are formulating solutions to this problem. E-ZPass® was created to create interoperability in the Northeastern U.S. using a common proprietary technology. Legacy system infrastructure investment is a key element driving toll operators to be creative to leverage their investments. Toll providers are beginning to use video license plate recognition systems to achieve interoperability across states where differing proprietary technologies are used. These video systems are already in use to handle violations and therefore are being leveraged to achieve payment interoperability.

Standardization is underway in the industry as well. $\text{OmniAir}_{\text{SM}}$ Consortium is pursuing standards for ETC using Direct Short Range Communication (DCRS) technology. “The $\text{OmniAir}_{\text{SM}}$ Consortium, Inc. is a non-profit association created to advance the deployment of DSRC by providing third-party certification services that ensure standards-compliance and enable True Interoperability™.”[3]

DSRC technology can be leveraged for multiple ITS applications, from collision avoidance to ETC. By standardizing the toll application, $\text{OmniAir}_{\text{SM}}$ hopes to facilitate national toll interoperability. There would need to be a significant build out of DSRC infrastructure, including massive roadside equipment investments and placement of DSRC on-board units (OBUs) in vehicles. Public funds, private investment, or a combination must be identified to achieve these ends.

There are many drivers of development of DSRC technology and standards. Chief among them is its multi-application ability. The many ITS applications that can leverage DSRC include safety, payment, and traveler information. Other drivers include its national scalability as well as the technology infrastructure and application development that occurs with the advent of open architecture and standards.

The U.S. federal government is now proposing to require toll interoperability in the Surface Transportation Authorization Act of 2009. Key language of the act states that "national standard for the interoperability of electronic toll collection devices for all toll facilities on the National Highway System" within 18 months of the law's enactment.

2.2.3 E-ZPass®- A Toll Success Story

While interoperability is a challenge for toll operators, a success story is the E-ZPass® consortium along the U.S. east coast. The E-ZPass® consortium is administered by the Inter Agency Group (IAG), which is made up of all members of the consortium. The IAG sets the business rules for interoperability and financial reciprocity and contracts for clearinghouse processing services.

Established in 1994, the E-ZPass® Interagency Group (IAG) is an organization of toll facilities offering the E-ZPass® electronic tolling system. The group achieved interoperability of toll collections through the selection of an ETC vendor to provide the common technology that would assure compatibility at each of the toll facilities. The IAG’s stated goal “is to provide “One Tag – One Account” as a way to pay all toll road expenses in our region.”[4]

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[3] $\text{OmniAir}_{\text{SM}}$ Consortium website, http://www.omniair.org/

[4] E-ZPass® Interagency Group Web Site, http://www.e-zpassiag.com/

Originally created by seven toll providers, the IAG membership now includes 25 toll providers in 14 states.

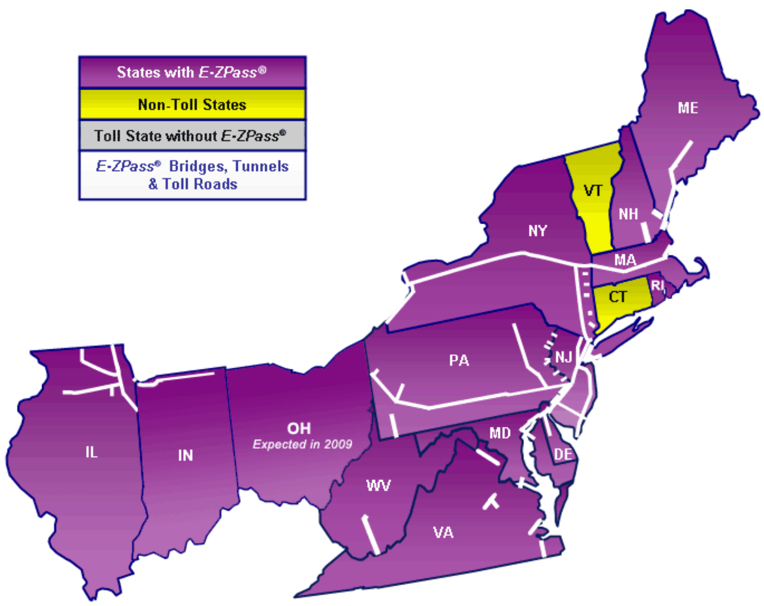

Figure 4 Map of E-ZPass® States

There are over 10 million active E-ZPass® accounts and more than 17 million tags in use and E-ZPass® provides travelers with a common toll collection experience across those 14 states. E-ZPass® users make up a majority of the toll volumes across IAG members' systems with an incredibly high rate of customer satisfaction.

The IAG also benefits its members by leveraging their aggregated transaction volumes to lower transaction fees paid to financial institutions as well achieve consensus positions on various business issues that can be leveraged to move to future technologies and business practices.

2.2.4 Congestion Pricing Programs and High Occupancy Toll (HOT) Lanes

In addition to traditional toll collection activities, regional transportation bodies and state departments of transportation are beginning to develop variable pricing programs that incent drivers to travel on highly congested toll ways at non-peak times. Congestion pricing programs can take several forms. One is the additional of a cordon fee to enter a central business district (CBD) at peak times. The goal of this approach is to shift demand into a CBD to non-peak times. This cordon fee approach was successfully implemented in London, UK, but unsuccessfully attempted in New York City, NY.

A more common approach is to implement High Occupancy Toll (HOT) lane programs. These approaches charge a premium fee for travelling on HOT lanes that are segregated from regular toll lanes. The goal is to adjust pricing to keep traffic in the HOT lanes travelling at a noticeable higher rate of speed in order to incent drivers to enter the lanes and pay the additional toll fee to shorten their commute.

2.2.5 Use-based Pricing

There is a strong inertia to transition ETC to a Vehicle Miles Traveled (VMT) (alternatively known as Mileage Based User Fee, or MBUF), approach which ensures that motorists pay for their usage of roadway infrastructure. Research and evaluation of this toll pricing approach is being included in the U.S. DOT ITS Joint Program Office strategic plan for as a way to pay for transportation infrastructure without an exorbitant increase to the federal gasoline tax as well as to enable variable pricing schemes to mitigate congestion and smooth demand on roadways.

This movement to a VMT/MBUF system may require a technology change away from RFID transponders to an on-board unit (OBU) that utilizes other communications and positioning technology to calculate fees based on distance traveled. These systems are becoming increasingly common in Europe and Asia. One example is the LKW-MAUT system in Germany, which has been used for VMT/MBUF for commercial trucks on the entire 12,000km Autobahn since 2005. The systems used GPS, GSM and DSRC technologies. Over 650,000 OBUs had been installed in commercial vehicles in four countries by early 2008. There are now plans expand the system to include passenger vehicles.

2.3 PARKING BEST PRACTICES

The parking industry is, like toll and transit, historically a cash-intensive business. However, parking is embracing very innovative approaches to automation through multiple payment applications, multiple communication protocols, and even multiple power applications. What is interesting, however, is the general lack of a critical requirement such as rapid throughput, which is a key in the toll and transit modes. Rather, it seems the overriding requirement is flexibility of payment systems. Some of the overarching goals for parking management systems are:

- Increased throughput
- Enhanced customer service (information, payment choice, etc.)
- Accurate accounting
- Increased maintenance efficiency
- Increased management efficiency/decreased cost

2.3.1 Varied parking industry segments

Adding to the interesting nature of the parking industry are the very distinct segments in the parking marketplace. The list below shows the distinct types of parking applications each with their own requirements.

1. Municipal Parking (in business districts)
    - On-Street Parking
    - Off Street Lots
2. Airport Parking
3. Park-and-Ride
4. Private Off-street Parking Lots

2.3.1.1 Municipal Parking

Municipal parking providers tend to be state or local government or quasi-government entities. While they have a goal of maximizing their economic business case, unlike private sector parking operators, they do not have a profit motive. Rather, municipal parking operators are focused on enhancing regional mobility, providing customer convenience, and ensuring compliance with parking fee payment.

The parking industry, perhaps more than the other transportation modes, is leveraging existing technologies such as Wi-Fi, cellular, GPS, video, Wi-Max, etc. in parking applications in urban areas to align stakeholder requirements and enhance customer service, improve efficiency, and mitigate congestion as well as leverage non-payment ITS applications.

In order to achieve their business goals, municipal parking providers use Parking Management Systems that provide accurate accounting, enhanced maintenance efficiency, ability to manage fee structures based on time of day, day of week, hourly/daily, etc. and leverage multiple applications in a central system (vehicle counters, POS (booth/kiosk), video, variable message signs (VMS), etc.). Parking providers must concern themselves with these many applications, not just fee collection.

Figure 4 below shows a sample parking management system for municipal parking. In this system architecture diagram, the Central Parking System receives and processes data from all parking facilities and can control parking lots, parking meters, or both. The system facilities can have various sub systems as shown. The meter application can also interface with a violation management system to facilitate enforcement operations using handheld devices. The central system processes payments and transactions and ensures customer accounts, if used, are accurately reconciled. Points of sale and payment tokens can include RFID, Smart Card, credit/debit, cash/coin, transponder, and mobile payments.

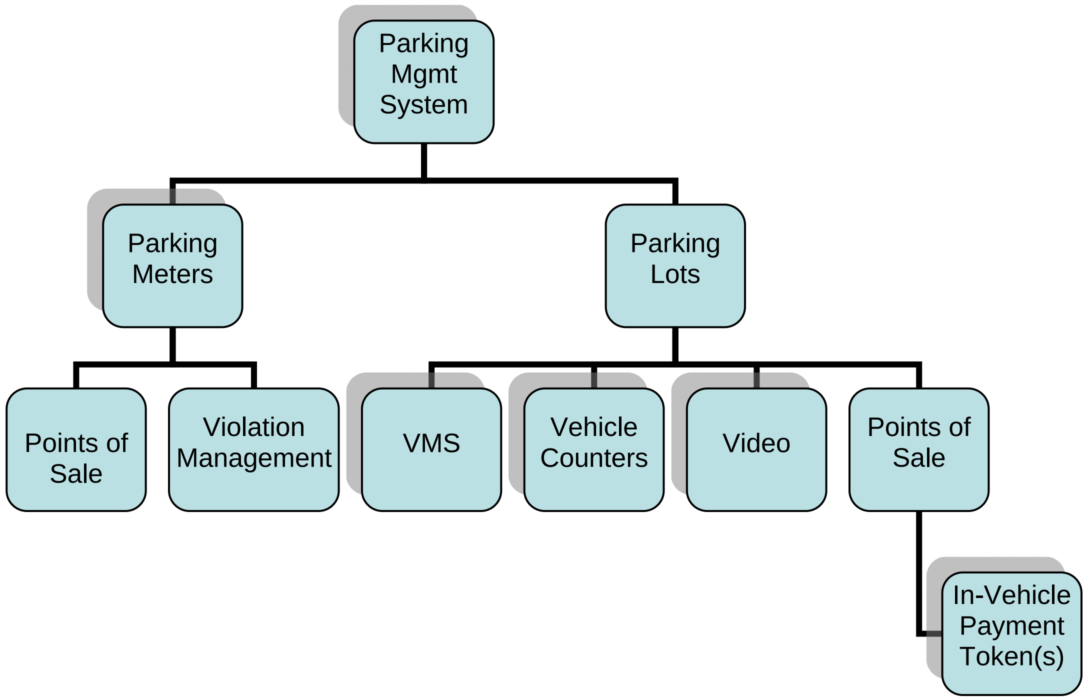

Figure 4 Sample Parking Management System

2.3.1.2 Advanced Parking Management Systems

Additionally, large urban areas are developing advanced parking management systems (APMS). The following is are excerpts from the January, 2007 ITS Joint Program Office study entitled *Advanced Parking Management Systems- A Cross-Cutting Study*:

> *Advanced parking management systems include elements from traditional traveler information systems, as well as specialized parking management applications. The applied traveler information concepts cover a wide range of applications, from pre-trip Web-based information systems to navigation systems that provide turn-by-turn directions all the way to an individual parking space.*
>
> *Advanced parking management systems have been operational in Europe and Japan since the early 1970s to reduce the congestion, environmental impact, and driver frustration associated with trying to find parking in city center areas. In the U.S., however, the use of ITS technologies to distribute parking information to travelers is still in its infancy. The primary reason that APMS applications in the U.S. have been limited to airports, CBDs, and park-and-ride facilities is the level of infrastructure required to make the systems work. Many advanced parking management systems in the U.S. rely on fixed-location, dedicated components that*

include vehicle detection, space inventory management, and communication equipment. [5]

Advanced parking management systems, and their inclusion of regional ITS applications is echo one of the key findings of this white paper: that electronic payment systems are intelligent transportation system applications. Further, to have any degree of success in achieving multi-modal convergence of EPS, there must be a high-level goal of enhanced mobility in a region and that a multi-modal EPS is part of a regional ITS strategy. By weaving traveler information applications via internet, mobile applications, 511 systems, VMS, etc., a compelling case can be made for travelers to view transportation as a regional system.

2.3.1.3 Multi-Space Kiosks

The use of multi-space kiosks for both on-street meter and off-street applications is becoming more common in the U.S. The devices are parking kiosks that allow customers to pay for parking in a multitude of ways. In addition to the payment application itself, these multi-spice kiosks use innovative technologies such as solar or advanced battery technologies, various wireless communications, and the ability to accept payment from smart cards, RFID, credit/debit and even cell phones.

The devices used in on-street applications are multi-space meters that are placed on a block to handle many parking spaces. In this application, they are used in a pay and display mode. The device prints a receipt that can be adhered to the window or placed on the dashboard of the vehicle. When used in a parking facility, the devices are used in a pay by space mode. The customer enters their parking space number then makes payment, again by many payment methods.

The mobile payment applications are quite interesting, freeing customers from even visiting the kiosk in a pay by space application, instead allowing the customer to send the payment via cellular network. In the pay and display application, the meter can send the customer's cell phone a text message warning them of impending violation.

From an operational standpoint, these automated multi-space devices can aid in enforcement operations. They increase efficiency of handling violations through automated ticket writing as well as by communicating wirelessly with handhelds. Additionally, in on-street settings, the enforcement application can include the feature of informing parking enforcement personnel of violation locations via wireless communications.

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[5] Advanced Parking Management Systems- A Cross-Cutting Study; January, 2007, US DOT, ITS Joint Program Office

2.3.1.4 *Airport Parking*

Airport parking is a unique parking application. Very high volumes, very high parking fees, and very large facilities require robust parking management systems as well as staff at exit booths as well as for security and customer service requirements.

In the northeastern U.S., there is a convergence between toll and parking using the E-ZPass® transponder to pay for parking at airport parking facilities. The transponders can be used at John F. Kennedy International Airport, LaGuardia Airport, Newark Liberty International Airport, Albany International Airport in Albany, New York, Syracuse Hancock International Airport in Syracuse, New York, and the Atlantic City International Airport near Atlantic City, New Jersey. Additionally, the New York Avenue Parking Garage in Atlantic City, New Jersey and the Atlantic City Surface Lot in Atlantic City, New Jersey accept E-ZPass® Plus.

2.3.1.5 *Other Innovations*

There are various Mobile Parking applications to find and reserve as well as pay for a parking space. The internet is a natural resource for transportation to leverage and traveler information, trip planners, and transportation web sites provide useful information on transit schedules, roadway congestion, and transportation incidents. The internet is being used extensively as a way to access and replenish automated transportation accounts.

3 EPS Convergence

The extensive research done in this study has revealed very little multi-modal convergence. The most noteworthy is the ez-Link program in Singapore.

3.1 Convergence Example: ez-link SINGAPORE

ez-link was formed by the Land Transport Authority (LTA) on January 8 2002, to manage Singapore's single largest contactless stored value smart card system that has been mainly used for payments on public buses and Mass Rapid Transit (MRT) trains since April 2002. Since its initial introduction, the ez-link program has grown rapidly, and currently there have been over 10 million cards issued and ez-link cards are the preferred contactless card in Singapore, with over 8 million transactions processed on the ez-link system daily.

Due to its appeal, the ez-link card has been expanding its range of services beyond local transit into the food and beverage, retail, and entertainment markets. The next generation of ez-link cards is Contactless e-Purse Application (CEPAS)-compliant and can also be used to make payments in Electronic Road Pricing (ERP) and Electronic Parking Systems (EPS) facilities. The card is married with an ETC transponder in-vehicle to enable tolling fee collection.

This example of toll-transit convergence seems to be a very isolated one. The incredible success of the ez-link electronic purse seems to be the driver for the expansion of its acceptance.

3.2 Lack of Convergence Examples: Germany, the Netherlands

There are examples, however, of conspicuous lack of convergence. The Netherlands (OV Chipcard for transit and a national road pricing system for toll) and Germany (VDV for Transit and LKW-MAUT for toll) are both rolling out national VMT/MBUF toll systems as well as national transit payment systems. Yet in neither country is there any thought being given to convergence of these two programs. Additionally, the countries are quite opposed to the pursuit of bank card solutions for use in public transit payment systems as currently being examined in the International Organization for Standardization (ISO).

The leading factor for this lack of connectivity is the disparity of use case in toll (very long range, hi-speed transaction using a transponder) and transit (short range, proximity transaction using smart cards with a requirement for transactions in less than 300 milliseconds). Another factor may be the political will to create national standards and leverage them to create national transportation payment systems using private-issued devices to achieve national interoperability within a mode. Without the need to leverage systems from outside the transportation mode (such as from the financial payment industry) to achieve national interoperability, there is little incentive to link these private transportation systems together, leaving them isolated.

3.3 Modal Convergences

In this study, the current state of EPS convergence has been examined but in addition, past unsuccessful convergence attempts were also examined. Two examples exist of FTA-funded Field Operational Tests (FOTs) that attepted to show payment system convergence across modes. One was in the State of Delaware in the Delaware Valley Multimodal Electronic Payments System Demonstration Program; a second was the Orlando Regional Alliance for Next Generation Electronic Payment Systems (ORANGES) program in Orlando, FL. Both FOTs showed that the time was not ripe for multi-modal convergence.

In the case of the Delaware program, there were two issues seen as hurdles that could not be overcome:

1. A lack of linkage between transportation modes

2. A lack of open architecture standards

In the case of the ORANGES program, the lack of linkages was also present, but the small size of a pilot was also a factor.

One final example showed largely a difference in the use cases across modes as well as a difference in business philosophy. The E-ZPass® IAG together with New York MTA led a pilot showing convergence of toll and transit payments using a smart card and an E-ZPass® transponder. In the end, a lack of consumer demand as well as lack of institutional desire for the convergnce prevented the program from advancing. Transit providers and toll providers have different approaches to electronic payment systems. The transit community, until very recently, was committed to a decentralized system architecture where the power of the system is in the smart card. The toll industry uses a centralized, account-based approach.

The decentralized transit approach is now being reconsidered with the advent of bank card solutions for transit. The account-based approach is championed by the bank card industry, and it is being implemented increasingly in the U.S. transit industry. As covered previously, UTA has implemented an account-based bank card system and the New York MTA is expanding piloting of a bank card system onto buses late this year. Further, major requests for proposal are emerging that either specify a bank card system approach (Washington Metropolitan Area Transit Authority) or ask for innovative system approaches including bank cards (Southeast Pennsylvania Transit Authority and Dallas Area Rapid Transit). This movement to a centralized, account-based system will undoubtedly help bring together modal leaders for convergence discussions.

3.4 KEYS TO ACHIEVING MULTI-MODAL EPS CONVERGENCE

There are several keys to achieving any level of convergence of electronic payment systems across transportation modes. They are discussed here in no particular order of importance.

3.4.1 Regional Transportation Enterprises

Transportation executives have a responsibility to make decisions in the best interests of their company and its stakeholders. This does not mean that the best decision for that transportation provider is one that will be seen as beneficial to a leader of a different modal provider. Therefore, in a region, the transit leaders will operate in the manner that best benefits them and their stakeholders, as will the parking leaders and the toll leaders. This is only logical, but it creates a highly stove piped approach when considered in the context of regional transportation.

Various issues have been stated throughout this paper that hinder convergence: use case divergence, different business approaches, lack of open architecture and standards. Perhaps the issue that is most difficult to overcome is the creation of customized solutions that use a privately managed payment system, with privately issued payment tokens (smart cards, RFIDs, transponders, magnetic stripe cards, etc.)

However, if a region can examine their various transportation services as a regional enterprise and manage it with common goals of enhanced mobility, decreased congestion, and better livability and access to transportation services, then multi-modal EPS begins to have more value. Cost sharing options among transportation providers can begin to emerge to more equitably create and maintain regional transportation.

A key is the need for a regional champion that can overlay the various stove piped transportation modes and help drive decisions that may not be the best for each mode, but is better for the region.

3.4.2 ITS Applications that converge with EPS

EPS will become a much more powerful tool for both operators and consumers when combined with effective and timely ITS applications. traveller information applications such as 511 systems, VMS, multi-modal trip planners, and traffic alerts that can provide robust information to travelers in time for them to make modal decisions will provide the "stickiness" to EPS that will create a pull from consumers for a multi-modal EPS. When a consumer is able to see real time transit schedules and parking availability fused with road congestion information and pushed to smart phone, then perhaps using that phone to pay for parking, transit and tolls will become closer to reality. Goals such as congestion mitigation and mode shift can be enabled with loyalty applications that provide benefits to consumers for behavior change (like switching from driving at peak times to commuter rail because of a half fare offer.)

3.4.3 Emergence of Contactless Financial Payment Applications

Another key is the emergence of payment applications that are beginning to achieve the specific requirements of transportation industry. Among these are a contactless interface, high throughput, open architecture and high levels of security. As the bankcard industry lays the infrastructure for contactless points of sale and the mobile payment sector overcomes the challenges to their business case, there is a great opportunity for the transportation industry to leverage these payment systems to achieve not only interoperability with their mode, but across modes.

Proprietary systems as well as the lack of an acceptable payment system from outside the transportation domain prevent multi-modal EPS from emerging. There is limited incentive for a provider of one transportation service to become a member of another modal provider's system, whether open architecture or not. However, financial industry payment systems are emerging quickly. There are concerns to address and business issues to solve such as servicing un-banked patrons and clearly delineating the cost model, but these things are being addressed in the transit systems being implemented now and those that will be implemented in the next 12-24 months.

3.4.4 Open Architecture technologies

While E-ZPass is an outstanding example of overcoming proprietary technology challenges, essentially the key is to all agree to the same proprietary technology. Outliers must be brought in using alternative, open technologies (for instance video/license plate recognition to achieve interoperability).

This approach is needed both for the payment application itself as well as the underlying communications and IT infrastructure needed. There are many unique approaches to public-private partnerships happening in the FHWA's Integrated Corridor Management (ICM) program. Leveraging mature and robust technologies such as cellular, GPS, video, Wi-Max, etc. can bring solutions to market more quickly than laying new infrastructure. Additionally, short-range communications protocols such as RFID (125 KHz), and ISO14443 (13.56 MHz for contactless smart card), NFC (ISO 14443 for mobile), Wi-Fi, and Bluetooth are all open architecture protocols that can provide device coupling to leverage payment and ITS applications.

3.4.5 Regional Mobility Accounts

Related to the discussion of transportation as a regional enterprise, is the potential to create a mobility account that can link disparate from end payment devices and create a convergence in a central account. Some advantages of this approach are its maturity in the toll and financial payments industries as well as its emergence in the transit industry.

This concept can leverage more than just a payment application, but also include complementary applications such as loyalty (couponing, discounting, etc.) as well as Electronic Benefits Transfer (EBT) programs.

4 Conclusions

Transportation providers in the United States and abroad have moved toward various forms of EPS over the past two decades. Although adopters have been rewarded with a number of benefits there has been an overriding lack of convergence across transportation modes to date. The reasons for this lack of convergence are:

1. Lack of linkage across modes
2. Use case differences
3. Use of proprietary technologies
4. Lack of a "big picture" focus on transportation as a regional enterprise

The state of transportation payments may be at a crossroads. Emerging approaches from outside the domain of transportation are taking hold in public transit and parking. Installation of contactless bank card-based systems is increasing rapidly in public transit, whether purely a financial bankcard or a hybrid card that hosts both a transit application and a bankcard application.

Additionally, the mobile payments industry continues to move forward steadily, and the functionality of mobile devices (powered devices with displays, data as well as voice capability, near-ubiquity of use by consumers) are incredible advantages that can be leveraged by transportation EPS as well as other ITS applications.

A non-transportation domain payment application may provide a vital overlay to stove piped, proprietary, legacy systems in transportation. If real linkages can be found between modes, perhaps through a common transportation account, and the payment application can be merged with valuable ITS applications such as multi-modal trip planners, mapping applications, and the ability to leverage loyalty, EBT, and other "value-add" applications, a compelling story can be told to consumers, who will in turn drive implementation.

Finally, the need to view transportation as a regional enterprise and not as individual modes may be necessary and finding a champion who can overlay individual modes and show benefits to convergence of EPS a key to success.

APPENDIX A. List of Acronyms

AFC	Automated Fare Collection
APMS	Advanced Parking Management System
APTA	American Public Transportation Association
CFMS	Contactless Fare Media System Standard
DMS	Dynamic Message Signs (or Variable Message Signs (VMS))
EBT	Electronic Benefits Transfer
EPS	Electronic Payment Systems
FHWA	Federal Highway Administration
FOT	Field Operational Test
FTA	Federal Transit Administration
HOT Lanes	High Occupancy Toll Lanes
IFMS	Interoperable Fare Management Systems
ISO	International Organization for Standardization
ITS	Intelligent Transportation Systems
ITS JPO	Intelligent Transportation System Joint Program Office
LTA	Singapore Land Transport Authority
MBUF	Mileage Based User Fee (or Vehicle Miles Traveled (VMT))
MRT	Singapore Mass Rapid Transit
New York MTA	New York Metropolitan Transportation Authority
NFC	Near Field Communications
NYCT	New York City Transit
OBU	On-board Unit
ORANGES	Orlando Regional Alliance for Next Generation Electronic Payment Systems
PMS	Parking Management System
PATCO	Port Authority Transit Company
RFID	Radio Frequency Identification
RITA	Research and Innovative Technology Administration
MTC	San Francisco Metropolitan Transportation Commission

VMS	Variable Message Signs (or Dynamic Message Signs (DMS))
VMT	Vehicle Miles Traveled (or Mileage Based User Fee (MBUF))
Volpe Center	John A. Volpe National Transportation Systems Center
U.S. DOT	United States Department of Transportation
WMATA	Washington Metropolitan Transportation Association