White paper: EMV Payments in Transport
Consult Hyperion
info@chyp.com
Executive summary

Public transport ticketing has come a long way over the last 30 years, moving from paper-based tickets and magnetic stripe to smart cards. However, these are usually proprietary schemes developed by a single supplier, within a closed network, which require considerable capital investment and have substantial operating costs.

As technology has developed in other sectors, most noticeably through mobile communications and the switch to contactless cards in the banking industry, opportunities are opening up for operators to make public transport ticketing more convenient for users and cheaper to run. They also offer new ways of collecting revenue, breaking away from traditional ticketing methods.

The introduction of EMV based card payments in the US will provide a fast, secure and convenient method of payment to regular travellers and tourists alike. There will need to be some technical changes to current PoS devices as well as some changes in liability. However, EMV payment offers several advantages to transit, such as off-line authentication, that can increase throughput, and help Transit Agencies manage transaction charges.

This paper will address the issues that transport operators need to be aware of when making the move to an open system based on experiences from Transport for London (TfL) including:

- Developing a transaction model
- Designing technology to support the transaction model
- Developing new fare products

Background

Public transport operators are already appreciating the benefits of smart card ticketing, including faster gate entry or boarding, particularly at peak times. Ticket selling is more cost-effective, with a wider range of sales outlets, including the Internet, whilst the security advantages over magnetic stripe and paper tickets have helped to cut known fraud and highlight other fraud. More information is available about passenger movements, allowing operators to refine their services and offer loyalty products.

However, customer expectations are changing rapidly. Online retail has changed consumer buying habits and there is an expectation that all transactions can be undertaken in a fast, customer-friendly way. Standing in a queue at a ticket machine does not fit this model. Therefore, leading transit operators such as Metropolitan Transport Authority, New York (MTA), Chicago Transit Authority (CTA) and Trans-
Ticketing technology has evolved significantly over the last 100 years as the diagram below shows. This started with cash and moved through paper tickets, to smart tickets on card and mobile phones. There are also examples of identity tokens being used to indicate that the holder is entitled to travel, with payment made after the journey. This trend is starting to reflect what is happening in wider society as payment methods are beginning to change. It is not clear that there will be one “winner” with regards to the technology as some schemes, such as TfL accept multiple technologies and standards (cash, paper, magnetic stripe, proprietary smart card (Oyster), EMV smart card, ITSO smart card) in response to what the travelling public are wanting to use to pay for their journey. This means that systems become more complex in the back office as they need to process some of these transactions in a different way, e.g. proprietary smart card, EMV, ITSO. This means that transit operators, and system vendors, need to specify schemes that will be flexible enough to respond to changing requirements of payments over the coming years, to ensure that the investment is in a scheme that won’t become rapidly outdated.

**Open and closed systems**

Early smart card schemes, such as
Oyster in London and SmarTrip in Washington DC, have been based on “closed-systems” which means that they can only be used in the transport environment to pay for transit. Typically in a closed system the agency issues and manages its own media. These systems have tended to be based on proprietary systems and formats, although in Europe there have been moves to standardize these systems through the activities of Calypso, ITSO & VDV.

There needs to be an infrastructure in place to allow any stored value to be added, either through add value machines (AVM), third party agents or ticket offices. If ticket products are stored on the cards then these will need to be loaded at the point of purchase using a special POS device.

It is usually the case that all fare calculations happen between the card and reader as the fare tables are stored in every reader and need to be updated whenever changes are made, which is a costly and time consuming exercise.

In a closed system details are stored on the card, usually in terms of ticket products, stored value and audit trails. The back office has limited information about the cardholder or their recent transactions, which makes getting to know customers difficult.

With the banks’ introduction of contactless payment cards there has been a lot of interest from transit authorities in making use of the contactless capabilities of these cards without the cost of having to issue contactless cards themselves. This means that there is no need for expensive infrastructure to reload the cards as the information is held in a central account and not locally on the cards.

These types of schemes are called open-loop, which means that the card can be used outside of the transport environment, particularly in a retail environment.

In this type of scheme the card acts as a token to a centrally held account which calculates all of the fares after a journey has been made. This makes it much simpler to update fare tables as there is only one location where they are stored. The requirements for validators are also much simpler as the interaction with the card is just to check if the card is valid for payment or not and there are no fare calculations at this level.

One interesting new opportunity that open payment schemes present is the potential for using non-payment cards such as ID cards, campus cards or ski passes to identify holders as having the means to travel. A lot of these options have been implemented in pilots and live implementations in places such as Salt Lake City over the last couple of years.

Several major transit au-
Authorities are looking to move from closed schemes to open schemes and are working on the issues that need to be resolved to make this happen in the short term. The next diagram illustrates this.

**From owners to merchants**

By moving to open payments, operators become ‘merchants’ participating in a bank-led scheme rather than owners of a dedicated ticketing infrastructure. This could reduce costs through the use of off-the-shelf equipment from a range of suppliers, rather than bespoke equipment made to proprietary specifications.

In all the cases discussed so far, with the exception of cash, the means to distribute the travel token has had to be considered as part of the process in deciding the media type used. This broader consideration of issuing tickets, printing or personalizing them with products, and accepting them at the point of entry is far removed from the transit operator’s primary objective of running buses, trains, subways and trams.

Payment cards offer the transit authority the opportunity of relinquishing the distraction of card issuance and focuses its time on running transit systems and accepting cards.

But what is the best way of doing that? In the US, while the contactless magnetic stripe card is ubiquitous, it introduces significant challenges in acceptance for transit
merchants where there are tight transaction time constraints, and without the right level of transaction authorization, fraud can be rife.

Introduction of EMV (Europay MasterCard Visa) schemes can dramatically change the concept of ticket purchase, offering more sophisticated facilities that take advantage of being able to verify the card’s authenticity at the gate before entry.

**Sales and distribution**

There is clear evidence of a move away from a station based approach to sales and distribution of fare products to a more personalized approach. This is focused on the internet and mobile methods of distribution.

Currently it is not unusual to see a long queue of commuters during the early morning rush hour waiting to buy tickets at a ticket machine. Some operators are responding to this problem by developing solutions that allows passengers to purchase their tickets before they get to the station, so reducing queuing times and improving the overall experience. In some cases the tickets have to be collected at a Ticket Vending Machine (TVM) which doesn’t seem to produce any additional benefit as the passenger still needs to wait in line. With the introduction of print at home tickets several long distance UK rail operators have improved the experience for travellers and made it similar to airlines which have offered the ability to print out boarding cards at home based on barcode technology.

We are now beginning to see a response from transit authorities in allowing passengers to use technology they have with them, rather than issue a card or token to them. This has manifested itself in the form of contactless payment cards in London, mobile phones in Copenhagen and the proposed use of ID cards in Washington. All of these approaches mean that passengers can decide the best way for them to interact with the transit operator and the transit opera-
tor can provide the traveller with a convenient means of payment at a low operational cost.

**EMV in transport**

EMV is the technical standard that ensures chip-based payment cards and terminals are compatible around the world. The term refers to Europay, MasterCard and Visa, the three organizations that originally developed the specifications in 1994. The EMV standard is currently managed by EMVCo LLC, which is equally owned by American Express, JCB, MasterCard and Visa. Further information regarding EMVCo and the specifications can be found at [www.emvco.com](http://www.emvco.com).

An EMV payment uses a microprocessor embedded in a plastic card or a mobile device to connect to an EMV POS via a contact or contactless interface. The chip securely stores information about the payments application and performs cryptographic processing. This provides an additional level of card authentication which validates the legitimacy of the payment type being used.

EMV is more than secure retail payments. It opens the door to a range of innovative secure payment and identity solutions across multiple platforms, whilst offering a ubiquitous and low cost infrastructure through which to deliver complementary services.

Any organization considering deploying an EMV infrastructure today should consider how their products will be used in the PoS, in ATMs, at kiosks, in mobile phones, through set top boxes, at the PC and in the transit environment. With careful design the same products can be used to:

- Remotely identify and authenticate the cardholder, make local or remote payments and deliver loyalty and couponing
- Manage the Issuers exposure to fraud by limiting cardholder spend per day, per country or per transaction type (PIN, signature, or contactless) or simply by disabling the application over the air
- Deploy local or closed loop payment services, i.e. services not branded by the international payment schemes.

In the spring of 2011, Visa issued a road map for the U.S. adoption of a smartcard-based payments ecosystem. Since then, the other three major U.S. payments networks have followed suit. These road maps provide milestones for merchants, acquirers, and processors, along with dates on which these milestones are expected to be met. This includes a liability shift for merchants, which is illustrated
Transaction models

Three key areas to consider when designing a new ticketing infrastructure are the scope of the network, interoperability and the likely cost savings. Urban operators have different priorities to their inter-urban or rural counterparts. Speed and self-service are priorities in the urban environment, while inter-urban operators need to offer a greater range of customer-focused products and services, perhaps including integrated ticketing with connecting urban or rural services.

‘Pre-issued’ media, such as the bank credit or debit cards, offer the opportunity to develop a ticketing or payment strategy with zero issuance costs, making use of a device that the passenger already carries and is fully interoperable worldwide. But current payment cards are read-only; as a result, transaction data, value top-ups and ticketing products cannot be stored on the card. Plans are in place to introduce payment cards that can hold transient data, supporting possible future ticketing applications. Meanwhile, the operator can choose to use the card to collect a payment at the ‘point of tap’ or sometime later. In this case, a new ‘middle-office’ infrastructure would
collect the taps and charge an ‘end-of-day’ amount.

Mifare media, used in a closed network, can use the card as the primary device and maintain shadow data in the back office. In this case all tickets and value are held on the card and the fare calculation is carried out by the reader at every tap. If payment cards are selected, two basic options are available. In a reader-focused model, a payment transaction is performed and value taken from the card’s offline balance. At the end of the day, the transactions are settled via a merchant acquirer. In a back-office model, the tap would authenticate the card and harvest payment data, but the real transaction would be performed later, after the fare had been calculated.

Another important consideration is the communications requirements. Can the reader be offline or does it need a direct fast connection to a back-office system? All of the models discussed could operate in either mode, although the primary benefit of the card-based mode is to operate completely offline. The reader and middle-office models can also work offline but they may need occasional network access to pass data, such as hotlists to manage fraud and payment card authorization requests.

Once EMV technology is available to the transit operators there are a number of models available to meet the fares policy in operation. Simple, fixed fare implementations, on buses for example,

<table>
<thead>
<tr>
<th>General Contactless Payment rules</th>
<th>Agreed new rules for transport PAYG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price is known before the card is presented</td>
<td>Each tap is £0, then operator back-office calculates price at end of day</td>
</tr>
</tbody>
</table>
| Use of card counters to manage risk & occasionally fall-forward to Chip & PIN | Operator manages risks to provide equivalent protection within the 500ms time limit:  
  - Offline data authentication of card  
  - Deny Lists (DLs) in terminals  
  - Online authorizations from the back-office |
| Terminal field is activated manually by store staff | Terminal field is always active to maximize throughput |

*Visa and MasterCard have agreed a transaction model for Europe*
could just offline authorize against the balance on the card. Conversely, complex transit agencies such as MTA in New York and Bay Area Rapid Transit (BART) in San Francisco would need to use the authenticated tap as an ID and perform delayed online authorizations and aggregations.

**Operational costs**

The introduction of payment cards can lead to a number of areas of cost reduction. The most significant of these include the reduction of card issuance to zero, the end of dealing with issues raised around the management of a proprietary system and the end of the card and ticket distribution networks.

Based on the information in the above chart TfL considers it a realistic to achieve savings of 4% on the current cost of sales, with further savings likely over the medium to long term.

A recent significant cost to Mifare classic issuers was as a result of the hack on the MIFARE Crypto-1 algorithm that is used to secure the data on the card [http://eprint.iacr.org/2008/166](http://eprint.iacr.org/2008/166). This forced expensive migration in some cases to more secure platform utilizing publicized cryptographic mechanisms.

The fact is that all of these cost pass to the card issuers and the payment schemes who manage the reader and card specifications. But these are costs they are paying now anyway – so they see benefits too!

However, you get nothing for free in this world. The cost of acceptance is interchange; the charge the schemes make for processing the payment which is passed to the transit merchant through the acquirer. And there are other costs.

**Reader certification is expensive**

Reader design is critical to the successful implementation of any project to accept new media. Bad design would increase the cost through unnecessary rounds of recertification and could affect its vulnerability to security attacks, service denial or data harvesting.

The reader will be required to support numerous applications, so the software for each one – be it card detection, payment card applications such as Visa, MasterCard, American Express, Discover or a proprietary application – should be developed and installed separately, in a way more akin to loading applications onto a mobile phone. Otherwise, changes to one application could result in a need to retest the complete reader. And the high cost of certification will ensure that developers seek to minimize the number of times the reader is submitted, both initially and when changes are made to specifications and code.
If the reader is, or might be, handling payments data, the implications of PCI-DSS (Payment Card Industry Data Security Standard) must be considered. Payments data cannot be held or transmitted in a format that would allow it to be intercepted in plain text form. The most secure method for securing compliance would be to encrypt all transactional data at source before it is stored and transmitted.

But, how would operators know that everything will work to specification, and that transactions will not take minutes instead of milliseconds?

The answer is to prototype the system, and test the more complex processing which the reader must undertake. This includes activating the card and selecting the correct application, deny-list processing and other management processes required to meet PCI-DSS. This is the time to make mistakes and fix them.

There are still many challenges to implement readers that are capable of accepting cards from several schemes as contactless EMV is introduced and older technologies are phased out.

Some transit operators such as Utah Transit Authority (UTA) have successfully implemented open payments and other operators such as TfL have just implemented them and will start to collect large amounts of data on how the proposition is received by travellers.

As the convergence of payment methods begins, bringing together payment card schemes and transport operators, there are many institutional issues that need to be addressed.

But in the long term, convergence will produce benefits for all stakeholders and passengers.
Conclusions

Multiple technologies exist that can be used in automatic fare collection systems, ranging from paper tickets through, smart cards, mobile phones and identity cards. Operators are looking to maximize revenues and generate increases in ridership; by making payment simple and convenient for passengers, that is one less barrier that needs to be overcome.

A challenge that equipment vendors and scheme operators will face is to make the multiple technologies work together while being aware of new payment methods and which of these the travelling public will wish to use to pay for their travel.

When a new technology is implemented it should be put in place to support the fare policy. With new technologies it is possible to develop a new range of fare products from those currently available to transit schemes. With this in mind it is important that as part of any new scheme there is a thorough review of the fare policy and the new possibilities are identified and understood.

Developments in mobile provide a wide range of benefits to all parties.

Much discussion has been ongoing around NFC in transit, but there are many other opportunities to use mobile devices as portable TVMs, which when combined with their GPS capabilities and ability to send and receive data provide the potential for many new and varied services.
Who are we?

Founded in 1985, Consult Hyperion offers consultants and associates expert in the design and implementation of mobile payments and POS, ticketing products and services, contact and contactless based payment, NFC, identity and internet. We are supported by Hyperlab - software and design engineers practised in the development and implementation of pilot and commercial grade products and services with expertise in standard programming and software development and management tools as well as technologies including: Microsoft .NET, Windows Phone, Android and iOS development (cross platform development with Xamarin tools), BlackBerry, embedded C, Java, JavaCard, MULTOS, HTML5 and Python, and by an extensive test laboratory used to optimize or certify the operation of these systems.

Why work with Consult Hyperion?

We are independent - we have no off-the-shelf products. Nor do we sell or promote third-party solutions, partner or form strategic relationships with third-party vendors. We are expert, understanding in great detail secure payments, identity management and fixed and mobile communication technology. We have detailed knowledge of the associated technical standards, regulations and business models and how they can be used to secure future revenue streams. We are globally recognised as thought leaders and experts within the areas of mobile, identity, contactless and NFC payment, EMV and ticketing. Our clients consistently praise us for being flexible, responsive, trusted, technically expert and thought leaders.

Our involvement in your project team will ensure that you deliver a marketing leading solution, underpinned by global best practice, readying you for the expected evolution of future technology.
More information

For more information about how Consult Hyperion can help your organization transform its payments capabilities, strategies and operations and make informed and positive business decisions, please contact:

Lanny Byers
Managing Director, CHYP USA
USA
lanny.byers@chyp.com

Mike Burden
Principal Consultant,
Transit Practice
UK
mike.burden@chyp.com

Simon Laker
Senior Consultant, Transit Practice
UK
simon.laker@chyp.com

CHYP USA Inc.
535 Madison Avenue, 19th Floor,
New York, NY 10022
USA
Tel: (888) 835-6124
Fax: (212) 207-1019

Consult Hyperion
Tweed House
12 The Mount
Guildford
Surrey GU2 4HN
UK
Tel: +44 (0) 1483 301 793
Fax: +44 (0) 1483 561 657

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