Public Transport Automatic Fare Collection Interoperability: Assessing Options for Poland

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Acronyms and Abbreviations

ABT	Account Based Ticketing
AFC	Automatic Fare Collection
CCST	Credit Card Size Ticket
CPC	Contactless Payment Card
DfT	Department for Transport
DLR	Docklands Light Rail
EMV	Europay, MasterCard and Visa
EPC	European Payments Council
ENCTS	English National Concession Travel Scheme
ETSI	European Telecommunication Standards Institute
EU	European Union
FSP	Financial Service Provider
FTP	Future Ticketing Programme
GBP	Great British Pound
GVB	*Gemeentelijk Vervoerbedrijf*, Amsterdam Municipal Public Transport Operator
HCE	Host Card Emulation
HTM	*Haagsche Tramweg Maatschappij*, Hague Tram Public Transport Operator
ICC	Integrated Circuit Card
ICT	Information and Communication Technology
IFM	Interoperable Fare Management
ITSO	Integrated Transport Smartcard Organization
ISO	International Standards Organisation
MCP	Mobile Contactless Payment
NESTI	North East Smart Ticketing Initiative
NFC	Near Field Communications
NS-R	*Nederlandse Spoorwegen*, Dutch Railway Company
PAYG	Pay-As-You-Go
PCI DSS	Payment Card Identity Data Security Standards
PIN	Personal Identification Number
PIV	Personal Identity Verification
PTA	Public Transport Authority
PTO	Public Transport Operator
QR	Quick Responses
RET	*Rotterdamse Elektrische Tram*, Main Public Transport Operator in Rotterdam
RFID	Radio Frequency Identification
RSP	Rail Settlement Plan
SEFT	South East Flexible Ticketing
SEPA	Single Euro Payment Area
SMILE	Smart Mobility Info and Ticketing System Leading the Way to Effective E-Mobility Services
STN	Smart in the North
SWOT	Strengths, Weaknesses, Opportunities, and Threats
SWSAL	South West Smart Applications Limited
TDA	Transit Data Area
TLS	Trans Link System
TfGM	Transport for Greater Manchester
TfL	Transport for London
TRB	Transport Research Board
TOC	Train Operating Company
VDV	*Verband Deutscher Verkehrsunternehm*, Association of German Transport Companies
UK	United Kingdom

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Executive Summary

Introduction

Polish cities have followed international practice in introducing public transport smartcard ticketing that offers convenience to the passenger and savings to the operator through reduced fraud, shorter dwell times at stops, and less cash handling. Smartcards also offer more flexibility in setting and varying fares.

However, one of the main benefits of smartcard ticketing internationally is in relation to integrating fares and ticketing across operators and modes. In Poland, as in many other EU countries, there are several proprietary automatic fare collection solutions for public transport in operation in cities and regions, in the absence of national interoperability standards.

With few exceptions, a passenger cannot take a public transport smartcard from one city and use it to ride on the commuter rail system. There is no overall direction as to what these automated fare collection (AFC) systems will provide, and there is limited levels of interoperability across the public transport networks and the rail network, which makes travelling across the country difficult.
Going forward, Poland needs to consider the benefits that an integrated approach to public transport ticketing could deliver and agree a vision for delivering these benefits. This potential benefit has not been realized in Poland and little effort has been made to establish a common platform for ticketing, even within metropolitan areas.

Integrated ticketing would encourage more multi-modal trips through integration of fares and greater convenience to passengers. In many countries, it has been an important step in facilitating better integration of information provision and scheduling.

Objective of the Report

This Report focuses on options for introducing public transport automatic fare collection interoperability in Poland, building on the experience of other countries and taking into account recent changes in technology. It presents an overview of the current situation in Poland, international approaches to AFC, AFC standards development in Europe, interoperability across regions, before presenting examples of AFC interoperability in the Netherlands, UK, and Korea, as well as an example of a smartphone integrated mobility platform in Vienna, before concluding with recommendations.

International Experience

A number of European national standards for AFC have been developed—that is to say a technical platform on which interoperable smart ticketing systems can be built—including ITSO in the UK, Calypso in France, VDV in Germany, and *Ov-chipkaart* in the Netherlands. These standards were developed at a time when smartcards were emerging as a new technology and not at a time when bank cards, mobile apps, and Apple Pay were creating new opportunities for interoperability.
In the case of the UK, the ITSO specification is not used in London, which is dominated by the Oyster smartcard and bank cards. Outside of London there is limited interoperability of tickets due to the fragmented approach adopted by major operators and a lack of leadership across a deregulated environment. This means that there is no unique interoperable standard in use in the UK.
In the Netherlands, the *OV-chipkaart* was introduced in Rotterdam in 2005 and then rolled out across the country and now has country-wide coverage across all public transport modes. It is important to note that the *OV-chipkaart* system developed in a public transport system dominated

by a few large public transport operators, which made reaching consensus on a standard much easier than in a fragmented public transport market, such as the one in Poland.

Vienna has recently piloted a mobility platform, Smile Vienna, which integrates various means of transport (public transport, rail, taxis, car and bike sharing, among others) and combines them with routing information and user data to provide individual mobility offers, through a smartphone based platform. A standard interface enables all mobility partners to link their technical systems, and allows booking, payment, usage, and billing functionality. Smile Vienna provides a roadmap for multi-modal, urban smartphone based systems, which leapfrogs the need to develop a smartcard standard.

Role of New Technologies

New technologies offer a unique opportunity to leapfrog by encouraging passengers to use bank cards and smartphone apps. Operational costs and risks are significantly lower than migrating to a new Polish smartcard standard.

Mobile apps offer a number of advantages, including the redundancy of sales network and loading, ease and speed of creating new common tickets and promotional tickets. Conditions for success require (a) assuring identification of mobile tickets by controlling devices of all entities—this requires equipping each controller device with a QR code scanner and near field communication (NFC) reader; (b) processing data in all systems in order to interoperable; and (c) check-in or heck-in and check-out required for all trips, particularly when changing modes.

As with mobile app, bank cards can decrease system and operational costs and risks significantly. This has been recently initiated in London by Transport for London (TfL). The introduction of a contactless payment card (CPC or EMV) reduces ticketing costs while improving passenger experience because information is help in an intelligent back office system rather than on the card itself. This represents a move away from the transport smartcard (Oyster card) to a bank card and by moving intelligence from cards and readers to a more responsive back office.

Recommendations

Based on its review of the current situation in Poland and European experience with the introduction of AFC standards, the World Bank makes the following six recommendations:

(a) **Establish a technical working group to develop a vision for AFC in Poland.** Such a working group should work with public transport organizers, operators, and industry to agree on a national vision or roadmap for the future with regard to interoperability and the associated business case and model in support of such a vision.

(b) **Support bank card, smartphone apps, and new technology developments** and determine what is achievable over the medium-term in terms of interoperability.

(c) **Develop bank card specifications.** Work with major payment card issuers to develop specifications for the use of payment cards using EMV based standards on the Polish rail network.

(d) **Do not develop a Polish AFC standard.** Instead, look to existing standards for AFC back office functions, rather than smartcard standards.

(e) **Undertake a public transport fare review.** This will maximize the benefits from the new system, both from the perspective of the passengers, and from public transport operators, as it could create enhanced opportunities for revenue generation.

Summing Up

Establishing a national smartcard standard and adopting it nationwide can be an expensive, complex, and lengthy process—as evidenced by the experience in the UK—and is not a ‘quick win’.

EMV and smartphone apps are important tools to allow interoperability across city boundaries and across modes and do not require developing a national smartcard standard. The key is moving intelligence from cards and readers to a more flexible and responsive back office, while incentivizing the use of EMV and developing and incentivizing the use of smartphone apps, and other new technologies.

Poland should consider innovative solutions enabled by new technologies and not aim to replicate approaches used in the UK or the Netherlands which were developed at a time when the technological options were different.

Introduction

Background

1. In the second half of 2013, the World Bank secured grant funding from the Korea Green Growth Partnership for analytical support and technical assistance related to sustainable urban transport systems in select cities in Eastern Poland. Established in 2011, the Korea Green Growth Partnership strengthens cooperation between the Government of Korea and the World Bank Group to help countries achieve sustainable and inclusive development by developing and sharing practical knowledge around innovative green growth solutions. The objective of the first phase of this technical assistance involved assessing the urban transport sector in the selected cities—Białystok, Lublin, Olsztyn, and Rzeszów—with a primary focus on public transportation and the aim of identifying areas for improvement. One of the outputs of the first phase of work, the report, *Urban Mobility in Eastern Poland, The Way Forward*, provided a set of recommendations related to the legal and institutional framework for urban transport in Poland; summarizes the assessment of urban mobility for Białystok, Lublin, Olsztyn, and Rzeszów; and assesses the framework for inter-municipal coordination in Poland.

2. Polish cities have followed international practice in introducing smartcard ticketing that offers convenience to the passenger and savings to the operator through reduced fraud, shorter dwell times at stops, and less cash handling. Smartcards also offer more flexibility in setting and varying fares. However, one of the main benefits of smartcard ticketing internationally is in relation to integrating fares and ticketing across operators and modes. This potential benefit has not been realized in Poland and little effort has been made to establish a common platform for ticketing, even within metropolitan areas. Integrated ticketing would encourage more multi-modal trips through integration of fares and greater convenience to passengers. In many countries it has been an important step in facilitating better integration of information provision and scheduling.

3. For a cross-network or multi-modal journey or one crossing multiple scheme borders, there are options open to transport operators— to offer the customer the simplicity of holding just one single ticket for the entire journey or to offer separate tickets within a single secure Smart Ticketing Wallet. A Single Through Ticket offer obliges transport operators to develop a common ticketing scheme or interface between different ticketing schemes enabling both to work interchangeably. Issuing multiple tickets avoids much of the complexity, data handling, settlement, and clearing for the transport operator but brings inconveniences for the customer. Smartcard ticketing allows the inconvenience of this issue of multiple tickets to be mitigated by loading them all into a single smartcard or smart ticketing wallet.

4. Interoperability of tickets needed for cross-scheme journeys can either be a single shared ticket where the data elements, ticket specifications and smartcard keys are shared between all parties and settlement is made through a common third party, or a Smart Ticketing Waller is used to hold all the individual tickets needed for the journey in a manner that appears seamless to the end user. Each of these approaches requires the definition of specifications. A key issue in all of this is that urban and national transport decision makers support the development of specifications to ensure mutual compatibility of all schemes. The use of international and open standards can facilitate interoperability and compatibility between devices produced by different ticketing suppliers.

5. Introducing integrated public transport ticketing can have both demand and revenue implications. An important concern regarding the introduction of integrated ticketing is the potentially negative impact on

revenue. The literature suggests that the final impact depends on the combination of fare levels for different ticket types and on user distribution according to rates of use. For example, in a study reviewing the introduction of an integrated ticket offer in the Madrid metropolitan region, the analysis suggested that the new ticketing succeeded in reversing the declining patronage trend, in line with similar results in German and Swiss cities and in London.[1] However, in the case of Madrid the high market penetration rate of low-cost travel cards had a negative effect on company revenues. This Report focuses on the alternative AFC options for introducing an integrating public transport offer in Poland, but does not delve into issues concerning revenue, whilst recognizing that there could be trade-offs between increased public transport patronage and revenues arising from low cost integrating ticketing.

Common Technical Platform for Tickets

6. A commitment to integrated ticketing in Poland would require the Government of Poland to set a common technical platform that transport providers would be obliged to subscribe to for all new ticketing schemes. Such a national standard would not restrict transport providers to purchase from a single supplier, but would require all suppliers to the Polish market to meet the same standard. International suppliers of ticketing equipment and systems might oppose such restrictions and would argue that modifications to their proprietary technology would increase the cost to the operators, but they have accepted such policies in other countries and the net cost to transport in these countries has not increased as a result of common standards.

7. Integration of new ticketing systems with legacy schemes adds complexity to integrated ticketing and it may be argued that such integration in Poland may not be practical considering that ticketing schemes on municipal transport in Polish cities were introduced only recently and in some cases are still under implementation. It is true that the cost of integrating new schemes with the range of proprietary technologies now in place could be very high, but this should not discourage the Government of Poland from implementing a national standard. Rail services and most commuter and regional bus services in the four cities studied do not have smartcard ticketing, but are likely to upgrade their ticketing systems at some point in the near future. A national policy that would require all new PSO services for buses and any new rail-ticketing system to adopt the national standard would give critical mass to such a standard. Moreover, the expected life of all ITS systems is shortening as new systems offer better functionality at lower prices. Some European transport authorities are adopting Account-Based Ticketing (ABT) in partnership with financial institutions and mobile phone operators. ABT systems require less technical sophistication on readers and smartcards with fare processing taking place remotely or cloud-based. It would be appropriate for the Government of Poland to adopt a common ticketing standard now before cities embrace a next generation of technology in an uncoordinated way.

8. In traditional smartcard-based fare payment systems, the transit value resides in a contactless chip inside the transit card, and transactions are managed and tracked on the card. With account-based payment or ticketing, the transit value resides in a transit account and is accessed via a digital signature read from a transit card by the fare payment system. Adoption of an account-based system also enables open payment and lets consumers directly use their bank-issued contactless cards to pay for trips. In this way consumers will pay for transit services just like they pay for any other retail purchase, using their contactless credit or debit cards as they board buses or pass through metro turnstiles, eliminating the extra step of buying a transit fare card or token. For transit agencies who do not want to issue their own fare cards, moving to open payment reduces the need to procure, encode, distribute, and support literally millions of magnetic tickets or contactless smartcards.

[1] Anna Matas (2004), "Demand Revenue Implications of an Integrated Public Transport Policy: The Case of Madrid", Transport Reviews, Vol.24, No.2, 195-217, March 2004.

9. One of the significant outcomes of implementing a smart ticketing system is that there are opportunities to introduce new fare products that never previously were possible, for example Pay-As-You-Go (PAYG), which is impossible with paper tickets, or fare capping which is impossible with magnetic strip tickets. If an organization is just looking to transfer existing ticketing products to a new media it will be a very costly exercise that will provide limited benefits. There are different types of solutions that best meet the requirements of different types of journey, for example, smartcards in urban heavily used transport networks where throughput and speed of transaction is important, bar codes on inter urban railways where ease in purchasing a ticket is important. Any developed standard will need to incorporate all of these requirements and be looking towards changes in technology, particularly in the field of mobile technologies and tokenization.

10. There are two ways to approach the development of a standard: spend significant time any money developing one from scratch, or as was the case in the Netherlands, and as is currently being done in Colombia, take a working system specification and convert that into a national standard, with suitable accreditation and certification processes in place. An alternative approach is to re-consider the need to sell tickets altogether and look to develop an account based system that utilizes the payments technology that is currently being developed by other parties and building a fare structure around those. One assumption with the development of a standard is that the requirements for the system are fully understood—this would require looking at what the requirements for an interoperable system should be, before attempting standardization.

11. The Ministry of Infrastructure and Development has expressed interest in the World Bank support on developing integrated ticketing schemes and developing standards that would facilitate fare integration, within and across such schemes, including unification of technical standards. There are many ways to do this. Countries in the EU have devised alternative approaches to avoid the uncoordinated and non-interoperable ticket schemes to develop. In the case of the UK, the Integrated Transport Smartcard Organisation (ITSO) was formed in 1999 to address integration and interoperability issues between operators, and at the EU level, the Smart Ticketing Alliance is working with national transport smartcard organizations and standard making bodies in order to develop specifications to support transport smartcard interoperability.

12. These European Countries have realized that there is no one standard that will address all of the needs of public transport operators everywhere due to the differing approaches to public transport, and the expectations from any fare collection system. For this reason, there is a recognition that multiple standards will exist, and each country is free to adapt or implement such a standard as it sees fit for its transport system.

13. New technologies for public transport smart ticketing systems are gaining importance. When abroad the user travel experience should be as easy as for local travelers. The vision is one of seamless travel and seamless ticketing. Today ticketing applications can be routinely loaded on smartcards or mobile telephones. Similar issues of technical and contractual interoperability arise. Current electronic ticketing schemes rely on media and ticket contracts designed for geographically limited fare systems. Future developments will not replace integrated ticketing systems, but will open up their boundaries and make them interoperable with each other and with other customer applications.

14. Across Europe there has been a significant amount of activity in the development of national standards, and a focus on interoperability of ticketing systems. The developments in Europe (especially in Germany, France, United Kingdom and the Netherlands) have pushed European standardization. Three standards have been published so far: on data elements (EN 1545), on a framework for interoperable ticketing (EN 15320), and on the fare management system architecture (ISO 24014-1)[2].

[2] http://ec.europa.eu/transport/themes/its/road/application_areas/electronic_pricing_and_payment_en.htm

Scope of this Report

15. The need for more sustainable and integrative processes as a way of dealing with the complexity of urban mobility has been widely recognized. Within the EU there has been an enhanced focus on urban mobility solutions where local authorities move away from past 'silo approaches' and develop approaches that can stimulate a shift towards cleaner and more sustainable transport modes, in line with the EU's 2013 Urban Mobility Package.[3] As populations move to the periphery or to neighboring municipalities, it becomes critical that the organization of urban transport services is coordinated within functional areas based on travel-to-work patterns and not be limited to a city's administrative area.[4] Interoperability of automated fare collection systems becomes an important means to support efforts of integration of the public transport offer across local administrations and public transport modes.

16. This Report focuses on options for introducing public transport automatic fare collection interoperability in Poland, building on the experience of other countries and taking into account recent changes in technology. It presents an overview of the current situation in Poland, international approaches to AFC, AFC standards development in Europe, interoperability across regions, before presenting examples of AFC interoperability in the Netherlands, UK, and Korea, as well as an example of a smartphone integrated mobility platform in Vienna, before presenting a roadmap of how to introduce public transport AFC standards. It concludes with recommendations.

[3] http://ec.europa.eu/transport/themes/urban/urban_mobility/ump_en.htm
[4] This is the approach adopted by the Sustainable Urban Mobility Plans. See:
http://www.eltis.org/sites/eltis/files/guidelines-developing-and-implementing-a-sump_final_web_jan2014b.pdf

Current Situation in Poland

Background

17. In the second half of 2015 the World Bank conducted a detailed survey of public transport authorities in Poland in order to understand the existing ticketing off and usage of Automatic Fare Collection (AFC).[5] The survey covered the 28 largest urban transport systems in Poland – all transport systems around core cities with over 100,000 inhabitants. All authorities answered the survey, although not all questions to the survey were answered in all cased. This chapter summarizes the key finds of the survey.

Types of Tickets

18. The majority of ticket sales in Poland are 30-day and single tickets. Usually 30-day tickets cover the entire city—rarely only selected lines—and are non-transferable; surcharges for suburban zones are typical. Single tickets can allow transfer within a given period of time (20-, 30- or 60-minutes), or do not allow transfer – although the latter situation becomes rarer. Long-term tickets (mostly 30- and 90-days) constitute usually between 35 to 40 percent of sales, but are used by the majority of travelers. Their share of total sales depends mostly on the city size – in bigger cities, the share is higher. Most cities care about attractive prices of long-term tickets, in order to increase customer loyalty. Long-term tickets are mostly sold in a selected network of newsagents, own customer care centers, and ticketing machines. Medium term tickets (mostly 24-hours) constitute usually about 5 percent of sales, but the share varies strongly, depending on pricing and distributions strategies. They are usually sold in a wide network of news agents, ticketing machines and in smaller cities, also by bus drivers.

19. Single tickets constitute over 50-60 percent of sales volume and are distributed in a wide network of newsagents. Popularity of ticketing machines varies, between cities, although increasing number of cities aim to introduce ticketing machines on board of every vehicle and on main stops. Most cities aim to reduce ticket sales by drivers and use it as emergency-solution only, in order to speed-up boarding. In some cases, surcharges apply or limited range is offered. Polish customers are used to re-purchasing long-term tickets every month; long-term contracts with automatic charging are not used. Ticket validation at entry of a public transport vehicle during each trip is generally not accepted by passengers, as evidenced by the fact that transport authorities have usually tried to introduce it, unsuccessfully.

20. In all cases ticket sales over internet and mobile apps is insignificant, below 1 percent. Internet sales is rarely available and has poor user experience. For example, in Warsaw only long-term internet tickets are available and they require having a smartcard and 'activation' in a narrow network of activation terminals after every charging. Mobile apps are usually available, often more than one in a city, offered by partner companies, but they also have not achieved popularity among customers, mostly because of high availability of other distribution channels and no customer benefits—for example, no capping or best pricing.

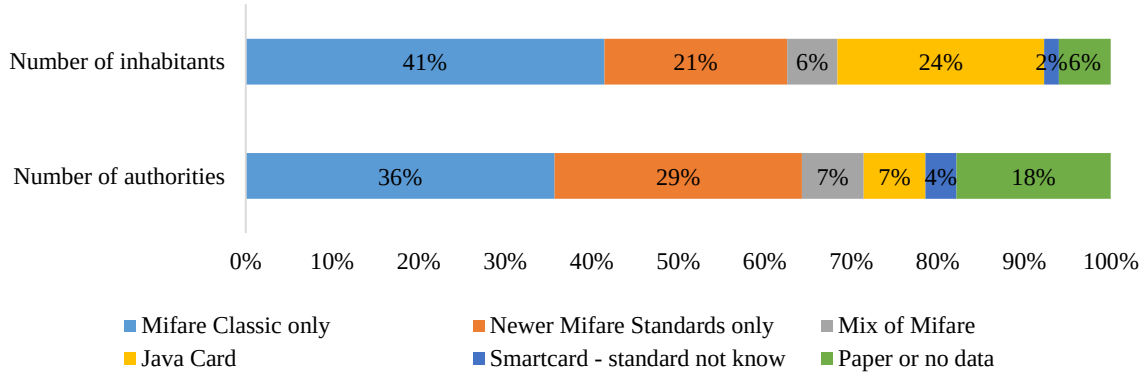
[5] AFC in the public transport context includes tickets, but also the whole area of journey logging, revenue allocation and subsidy claim, on the basis of accounting for every leg of a journey by making and storing transaction records

21. A relatively high share of passengers—including elderly people, children under 4 years old, blood donors, among others—are allowed to travel for free. Detailed regulation varies between cities, but usually only a personal ID is required. All tickets, as well as eligibility to free travel, are checked in random by plain-clothes inspectors, only in smaller cities ticket inspection during boarding may be used. Some cities with unemployment problems tried to re-introduce conductors on major routes, but without success. Passengers are allowed to board with every door, in order to speed-up buses.

Technology

22. The survey confirmed the high popularity of smartcard ticketing in Poland. Out of 28 authorities surveyed, at least 23 had smartcard solutions. Those authorities cover 94 percent of the population of researched cities (Figure 1). Mifare standards are widespread in most of the cities—they cover over 70 percent of population and a little below 70 percent of the total number of public transport authorities; Mifare classic covers 41 percent of population and 36 percent of authorities (Box 1). In two authorities, covering 24 percent of the surveyed inhabitants, Java Open is used. Those are Poznań and Silesia, the latter is an industrial conurbation in Southern Poland, grouping a number of cities. Both systems were rolled-out in 2015 and had poor publicity, because of delayed implementation and/or low reliability in the initial phase. In Poznań Java Open system replaced and older Mifare system and in Silesia – is a first smartcard solution.

Figure 1. Smartcard Structure of Surveyed Cities



Source: World Bank.

23. Different parts of a smartcard system may be owned by different entities, often based on long-term contracts with public transport authorities, which initially made the systems affordable, but now makes upgrade and exchange difficult, especially when contracts expire at different moments. For example, in Warsaw, Mifare Classic system (introduced in 2001) validators and on-board ticketing machines are owned or leased by vehicle operators—three municipal companies and a number of private firms. Ticketing machines on stops, as well as vendor terminals at newsagents', and post offices are usually provided by external companies, specialized in ticket distribution, based on long-term contracts and commission from sales. In newer system, the share of publicly owned hardware is higher, through EU co-financed purchases. The hardware and services may be provided by multinational firms, but also a strong domestic market of domestic providers has developed.

Box 1: Smartcard Technologies in Poland

MIFARE® Initially a proprietary contactless card security protocol (Crypto-1) based on ISO14443 type A, developed by Mikron AG in Graz, Austria in the 1990's. The brand and IP is now owned by NXP and is incorporated into various smartcard chips and reader ICs. Several card and chip suppliers have licenses from NXP to include Mifare® in other chips. The initial chip product line is now known as Mifare® Classic and is becoming obsolete because of the weakness of the security protocol. The current chip ranges offer a variety of chip capabilities and security protocols.

Java is a programming language loosely based on C++ and designed primarily for dynamic and changeable hardware. In reduced form, applications written in Java may be run in smartcards. The specification is owned by Sun Microsystems, but others participate in its development.

Java Card: A derivative of original Java, for use in the restricted environment of the smartcard

2D Barcode: A digital data string represented as shown below:

Otherwise known as a QR code.

Contactless Card: A smartcard with no visible module contact area, but which transfers data using RF technology. Such cards are generally used for transport and ID applications. Data is transferred by modulation of the RF field. See Proximity card (ISO/IEC 14443) and Vicinity card (ISO/IEC 15693); there is also a Close-coupled card standard (ISO/IEC 10536), but no evidence of its use.

Proximity card is a contactless smartcard that can be read without inserting it into a reader device. Proximity cards are part of the contactless card technologies. Held near an electronic reader for a moment they enable the identification of an encoded number. Proximity cards typically have a read range up to 50 cm, in comparison with contactless smartcard which have a range of 2 to 10 cm.

Source: World Bank.

24. Smartcards are mostly used for long-term tickets. Depending on the city, single and medium-term tickets may be available on smartcards, but are mostly sold on paper, as casual users do not want to acquire a smartcard. In Warsaw, they are sold on single-use magnetic cards and in Wrocław – 2D barcodes are used. Nevertheless, in most cases public transport vehicles are equipped with a high number of smartcard validators; often there is one validator for every door. In urban transport, single and medium term paper tickets are usually printed by the authority and sold to the vendors (not produced by the vendor during purchase), which reduces hardware costs and increases the distribution network.

25. Railway operators mostly use on paper ticketing, with an increasing share of internet and smartphone app sales (2D barcodes of different standards), especially in case of intercity services. Long-term tickets are also usually paper ones—only in case of *Koleje Mazowieckie*, the rail company operating around Warsaw—they may be coded on a smartcard. This system is interoperable with Warsaw Public Transport; Warsaw Public Transport and *Koleje Mazowieckie* tickets may be coded on one card. Railway tickets are checked during the

trip, and in some cases, train staff is equipped in smartcard validating terminals (this refers to *Koleje Mazowieckie* as well as some integrated offers – for example in the region of Gdańsk). Future plans of railway operators are usually based on standards, determined by the existing validating terminals. Passengers on regional bus operators mostly use paper single tickets purchased from drivers, using electronic cash registers, required by law for fiscal reasons. Season tickets may be paper or smartcard.

26. The newest development is a ticketing system in Świebodzice, where at the beginning of 2016 a group of Polish firms, introduced a system allowing to purchase a ticket, by a proximity bank card – a passenger does not need a paper ticket nor a transport specific smartcard. This system co-exists with classic paper systems. This means that the operator does not need to issue transport specific cards, the passenger is free to pay for the journey with his bank card

Summing Up

27. As is the case in several European countries, multiple proprietary AFC solutions have been implemented in Polish cities in recent years. There is no overall direction as to what these systems will provide, and there is limited levels of interoperability across the rail network, which makes travelling across the country difficult. There appear to be limited distribution channels for ticket sales, which mainly focus on stations. Except for long distance trains, there is very limited internet sales capability, or uptake evident. Given large recent investments in smartcard technology, existing public transport operators may be wary of adapting to a new interoperable smartcard standard.

28. There is the potential to build on the new systems, such as those implemented in Świebodzice, and develop an interoperable standardized system for Poland that builds on the benefits of smart media for passengers and operators alike. With the development of new technologies, as will be discussed later in this Report, there is the potential for Poland to be at the forefront of developing standards for the next generation of smart ticketing systems that will be implemented.

International Approaches to Automatic Fare Collection

Introduction

29. Public transport ticketing has come a long way over the last 30 years. The major technology back then was paper based but there has been a gradual change as new technologies, ranging from magnetic stripe tickets to smartcards, have been developed and successfully implemented in many major cities worldwide. Historically, transport operators have only considered smartcard systems to pay for transport, so called closed schemes. The resulting system was built, in the majority of cases, to a proprietary specification by a single supplier. These schemes required a considerable capital investment for the infrastructure, as well as on-going operational costs.

30. Customer expectations have changed significantly in recent years, especially with the advent of the internet and online retail. There is a general expectation that all transactions can be undertaken in a fast customer friendly way. Standing in a queue for a ticket machine does not fit this model. The introduction of smartcards has meant that customers no longer need to queue at the ticket office window to renew their monthly or annual season ticket. This can be done online and the new ticket delivered the next time the card is passed over a reader. Auto-top-up is also available in many schemes to registered users who can get their pre-paid balance automatically topped up when it falls to a pre-defined threshold. All the payment is dealt with in the back office. This chapter looks at worldwide approaches to AFC in public transport.

Ticketing Technologies

31. Based on a review of international experience, it can be concluded that no unified, standardized solutions have emerged with regard to existing AFC systems in major cities covering the totality of the operation of the system. Instead, there is competition between alternative models that include national standards, (e.g. ITSO, Calypso, *OV-chipkaart* in the Netherlands) and proprietary systems. (e.g. Oyster in London, Octopus in Hong Kong). The travel media that passengers use in public transport can vary significantly, and also some locations accept multiple technologies—in the case of London Transport for London (TfL) magnetic stripe, smartcard (Oyster), EMV bank cards and mobile EMV (for example Apple Pay).[6] Travel media are always devised and developed in accordance with the business and security demands and IT capabilities of the time. The different fare media do not need to be considered in isolation, as there is no one technology that can address all the needs of users of urban and inter-urban transport. The technologies complement each other, and several examples exist of cities or regions successfully implementing multiple technologies across multiple modes of transport.

[6] EMV chip technology is becoming the global standard for credit card and debit card payments. Named after its original developers (Europay, MasterCard® and Visa®), this technology features payment instruments (cards, mobile phones, etc.) with embedded microprocessor chips that store and protect cardholder data. This standard may also be referred to as chip and PIN or chip and signature. Payment data is more secure on a chip-enabled payment card than on a magnetic stripe card, as the former supports dynamic authentication, while the latter does not.

Figure 2: Evolution of Ticketing Technology

Source World Bank.

Table 1: Strengths and Weaknesses of Ticketing Technologies

Technology	Technology Description	Transaction Speed	Possibility of Counterfeiting	Feasibility for time based tickets	Interoperability	Allows for flexible fares strategy	Multiple Sales Channels	Investment and operational costs	Speed of implementation
Cash	Passenger would pay driver on entry to the bus / tram	○	○	○	◑	○	◑	◑	◕
Token	Metallic token only for use in transport. Passenger pays on entry	○	○	○	◑	○	○	◑	◕
Paper	Passenger issued a paper ticket for the journey	○	○	○	◔	○	○	◑	◕
Magnetic Stripe	Journey information is encoded on a magnetic strip on the back of the ticket, similar to a US credit card	◑	◑	◔	◔	◔	◑	◔	◕
Transport Smart Card	Memory chip embedded in a plastic card with a contactless interface that carries passengers tickets. By presenting the card to a reader the passenger can enter the transport system	◕	◕	●	●	◑	◕	◑	●
2D Barcode	2D barcode is either printed by the passenger before the journey or carried on a mobile device, similar to airline tickets.	◕	◕	●	●	◑	◕	◑	●
Contactless Payment Card	Use of a bank issued card to pay for journey by the passenger tapping in and out of the transport system. Payment is calculated in the back office	●	●	●	●	●	◕	●	◕
Mobile	A mobile device can be used to carry a ticket which is then presented visually, or via a 2D bar code	◕	◕	●	●	◑	◕	●	●
Identity Token	Passenger presents a trusted token, e.g. contactless bank card, PIV card, ID card, or similar and back office calculates the payment	●	●	●	●	●	◑	●	◕
Near Field Communication (NFC)	This functionality allows a mobile phone to communicate in the same way as a contactless transport card or a bank card	◕	◕	●	●	◑	◕	◑	●
Biometrics	In its infancy in the transport space but uses biometrics to indicate a right to travel. The back office calculates the fare	◕	●	●	●	◕	◑	◑	◑

Source: World Bank.

Box 2: ITSO, ENV, Apple Pay

ITSO Ltd (ITSO) is a UK non-profit distribution technical, standardization and interoperability membership organisation with objectives to: (a) maintain and develop the ITSO specification for transport smartcards; (b) operate and manage an interoperable smart media environment; and (c) facilitate and support development of interoperable smart ticketing schemes that comply with the ITSO specification.

ITSO was established as a result of discussions between various UK passenger transport authorities concerning the lack of standards for interoperable smartcard ticketing. These discussions grew to include other authorities, transport operators and government. ITSO membership covers the breadth of the transport sector including transport operators (bus, tram and train operating companies), suppliers to the industry, local authorities and public transport executives. Supported by the Department for Transport, ITSO has links with major transport industry organizations and established smartcard schemes in the UK and overseas.

ITSO started out as the Integrated Transport Smartcard Organisation but this has been dropped and is now just 'ITSO'. That is because the specification covers other forms of ticketing besides smartcards and transport. The Department for Transport introduced in 2008 the English National Concessionary Travel Scheme for all people of retirement age and eligible disabled persons (according to the Transport Acts 1985 and 2000) using buses, which uses ITSO smartcards. Transport Scotland and the Welsh Government have implemented ITSO in their concessionary travel schemes. Transport authorities and operators are now rolling out commercial uses for ITSO-based smartcards throughout the country.

The ITSO specification is a technical platform on which interoperable smart ticketing schemes can be built. It defines the key technical items and interfaces that are required to deliver interoperability between both, components of a ticketing system – smart media (smartcards), points of service and back offices – and separate ticketing systems. ITSO smartcard specifications covers card, point of service and back office systems.

EMV. Originally a joint working group set up in December 1993 by Europay International, MasterCard International and Visa International, to develop a common set of technical specifications for the use of IC cards by the payment industry. Responsibility for the specification has now passed to a management company, EMVCo LLC (www.emvco.com), so that EMV is now used to refer to the group of specifications produced by that company.
EMVCo members worked jointly over the last few years to develop specifications that define a set of requirements to ensure worldwide interoperability and acceptance of secure payment transactions using integrated circuit cards. It accomplishes this by managing and evolving the EMV® Specifications and related testing processes. Today there are EMV Specifications based on contact chip, contactless chip, common payment application (CPA), card personalization, and tokenization. There are also EMV documents and materials regarding mobile payments.
Apple Pay is a mobile payment and digital wallet service by Apple that lets users make payments using the iPhone 6, 6 Plus, and Apple Watch-compatible devices (iPhone 5 and later models), iPad Air 2, iPad Pro and iPad Mini 3 and later. Apple Pay does not require Apple Pay-specific contactless payment terminals, and can work with existing contactless terminals. Transport for London accepts Apple Pay.
Sources: EMVCo and Wikipedia.

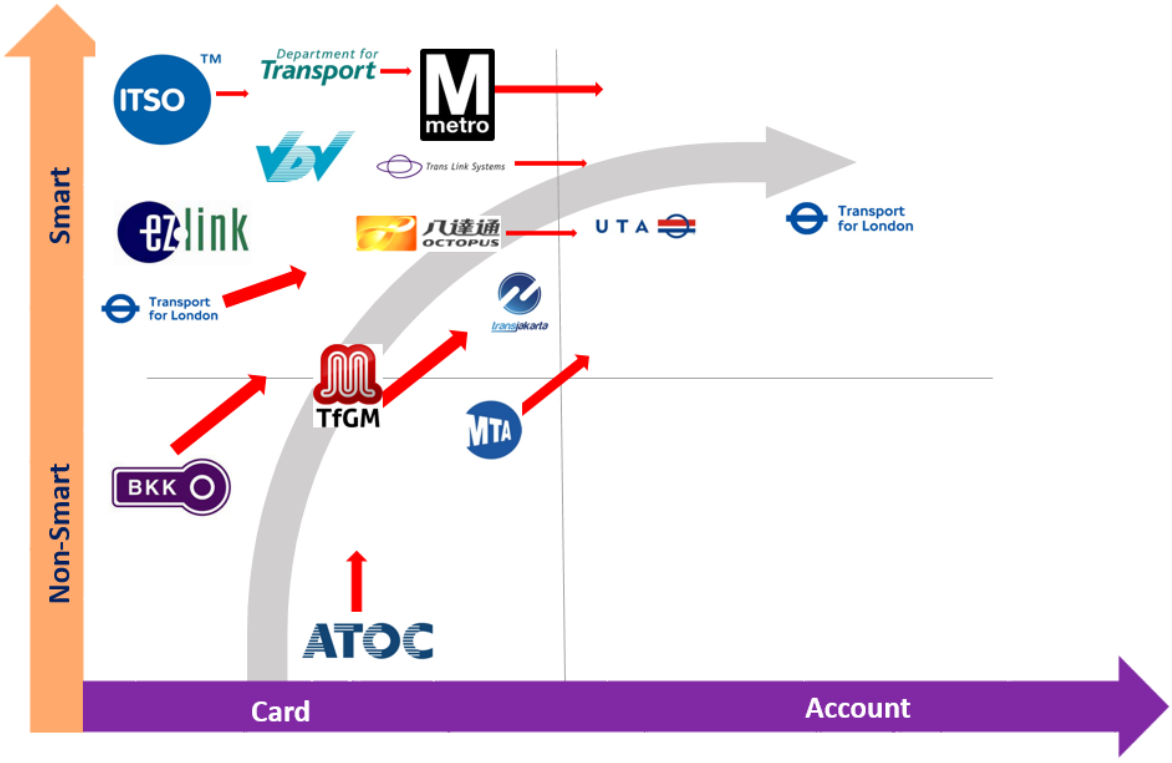
32.

33. Table 1 indicates the strengths and weaknesses of the available technologies. The criteria identified in the table are generic and can be applied to any ticketing scheme across the globe. What this shows is that technologies such as smartcards, mobile phones and identity tokens provide the best potential for interoperable smart ticketing systems. Indeed, these technologies have been successfully implemented in cities such as London, Amsterdam, Washington DC, and Boston. As can also be seen from the table, there are a large number of technologies that are being used for automatic fare collection, which means that Public Transport Operators (PTOs) have difficult decisions to make as to which technologies to support in the medium to long term.

Future Developments

34. Many major cities have invested significant sums in bespoke smartcard based ticketing systems that have delivered major benefits to both operators and the travelling public. Some of these schemes, such as Oyster for Transport for London (TfL) in London, are beginning to look at the next generation of open payment systems to build on current successes and look at how new technologies can be used to support them in this transition. A significant trend is the move away from issuing tickets to the use of more advanced forms of payment, including contactless bank cards and Apple Pay, in London amongst others, and the use of identity tokens, such as government issued PIV cards in Washington DC, to show that a passenger has a right to travel.[7] This has meant that we are seeing a movement away from bespoke ticketing systems to the adoption of retail solutions to meet transport requirements (Figure 3).

Figure 3: Trends in Automatic Fare Collection



Source: World Bank.

35. AFC should not be seen as a simple replacement for traditional paper or magnetic ticketing. The introduction of AFC systems is also an opportunity to rethink the current fare policy and to offer additional or alternative fare possibilities to customers. This is because there is a clear link between fare collection technology and fare policy. The technology that has been in place for several years has been developed to implement the existing fare policies and products. As technology has developed it has allowed different fare policies to be implemented that were not previously possible due to the limitations of the technology, for example daily fare capping in London on Oyster cards. Public transport is notoriously slow to instigate change.

[7] A PIV card is a United States federal smartcard that contains the necessary data for the cardholder to be granted access to federal facilities and information systems and assure appropriate levels of security for all applicable federal applications.

As a consequence, there is a tendency to continue with existing fare policies and implement new technology, the result being a far more expensive way of providing fare collection than previously.

36. **Business models**. Smart ticketing is a global business and is, for the first time, being driven by standards. This allows off-the-shelf technology to be adopted with only limited local tailoring to reflect specific fare structures and cross-modal opportunities. By using open national standards for smart ticketing, payment systems, and communications infrastructure, public transport operators can access supply chains that are responsive, cheaper and address industry best practice. However, the use of new technology now allows for post-payment of travel, if passengers have a valid token, such as a contactless bank issued credit or debit card, and the journey is recreated from the taps in and out of the network. Payment is then calculated according to several variables including, time of day, zones crossed, applicable discounts, e.g. capping, and mode of transport.

37. **Distribution channels**. New fare collection systems must allow passengers to plan and book their travel through a wide range of sales and distribution channels and move away from a station centric approach. This goal requires a new system that can accommodate the speed, power and flexibility necessary to handle multiple distribution channels for ticket sales. There is a significant move away from traditional retailing at stations to more user centric approaches as shown in Figure 4.

38. **Organizational and legal issues**. There is a need for leadership in this area, which could come from national governments or operator supported groups, to provide confidence that when new AFC systems are introduced there will be a degree of interoperability to enable passengers to travel across several modes across a wide area. Legislation would be necessary to give any such proposals a strong foundation and ensure a level of compatibility between AFC systems.

39. **Integration with travel information and traffic management**. By creating a linkage between Travel Information, Journey Planning, Payment and Smart Ticketing, including a liaison with compatible mobile phone and contactless bankcard schemes, new AFC systems can ensure the passenger experience consistently meets the highest expectations. It can also break down barriers to usage of public transport systems and assist in obtaining a modal shift by making access to public transport easier.

Figure 4: Trends in Sales and Distribution

Source: World Bank.

40. **Development of smart ticketing standards**. A common feature that has enabled the uptake of new technologies is the development of standards that can be directly applied to the transport sector, or require adaption for solutions to be implemented. The latter is particularly true for payment systems that have been adapted to meet the requirements of transport, which requires a high throughput of passengers at peak times, and cannot perform on-line authorization at the point of entry. Also, the underpinning mobile and communications technologies are all based on internationally standardized solutions.

41. **Data privacy**. Protection of customers' privacy is enshrined in the EU Data Protection Act, which AFC systems need to comply with. Additionally, where payment cards are used there are requirements to tokenize the card details, in compliance with Payment Card Industry Data Security Standards (PCI DSS) requirements to minimize the potential for fraud.[8] All of these issues are key to the successful implementation of a smart ticketing scheme, as any loss of trust in the system by users would damage passenger acceptance.

Summing Up

42. As more and more cities adopt the use of these disruptive technologies, there will be a need to standardize the approach used, so that passengers have the same user experience across the country. There are two avenues, which are not mutually exclusive, for Poland—take part in the development of smartcard standards, either building on existing specifications, or through developing new standards and to focus on interoperability across modes and local administrations through development of new technologies, such as EMV cards or Apply Pay.

43. As technology evolves in this sector there will be a need to have a standard approach, or passengers will be less likely to use it if the experience is different in different locations. For example, cell phones work in the same way all over the world, so the user experience is the same. Apple Pay is the same in the UK and the US and China. As a consequence, users know what they have to do each time they want to use the service

44. The current trend is towards making payment of transport fares simpler, and allow the passenger to choose which payment product or device he wishes to use to identify himself to the network, to indicate that he is eligible to travel on that network. This simplifies the front-end systems significantly and moves a lot of the decision making as to which fare is best, from the passenger and into the back office.

45. New technologies have a cost (production and distribution) and a robust strategy for managing the cost and deployment is a critical issue within some existing systems. It is also important to bear in mind that there will be a substantial customer base for the smart-ticketing end product, and their needs must be considered during the process otherwise take up rates and acceptance of the scheme may be low. After sales issues and data security are also important attributes to consider, as this ensures the customer will feel confident when using the smart ticketing.

46. In many cases it is true to say that schemes continue to remain beholden to past decisions, where fare collection technology imposed significant limitations. This drove the need for zonal-based structures to support fares integration with multi-ride and periodical fare products, to operate in 'open' fare collection environments. These fare structure and fare product concepts are often subject to widespread public and political acceptance and support. New paradigms offered by Near Field Communication (NFC) and bank-issued smartcards opens

[8] PCI DSS are mandatory information security standards for organizations handling cardholder information in the payment card environment. Those organizations are required to demonstrate compliance on a periodic basis.

up new horizons.[9] Through the integration of fare collection systems and mobile. This means that there is a link between location, payment and information which can be combined to improve the travelers experience and provide the operator with more information about what type of service passengers want.

47. This poses challenges public transport authorities and policymakers to rethink how to best deliver customer service and offer different value propositions off the back of these new technologies. Based on the past, this would tend to suggest that an ongoing evolution rather than a revolution will occur from a policy perspective. A further implication may well be an extremely pragmatic approach to business case development associated with next generation fare collection systems.

[9] Near Field Communication (NFC): An extension of the Proximity Card (ISO/IEC 14443) contactless technology, allowing both ends of the communication channel to be self-powered and providing enhanced functionality, primarily in mobile telephones. Colloquially also used to describe the incorporation of unpowered 14443 compliant chips into other devices (e.g. stickers applied to mobile phones that do not have inbuilt 14443 compliant functions, touch areas on posters that can be interrogated by NFC enabled mobile phones). Relevant standards are ISO/IEC 18092, 21481, ETSI TS 102190 as well as ISO/IEC 14443.

European AFC Standards Development

Introduction

48. There are many reasons why standardization of systems is beneficial. The reasons outlined by the European Telecommunication Standards Institute (ETSI) [10] are: (a) safety and reliability; users perceive standardized products and services as more dependable, this in turn raises user confidence, increasing the take-up of new technologies; (b) support of government policies and legislation; frequently referenced by regulators and legislators for protecting user and business interests, and to support government policies. Standards play a central role in the European Union's policy for a single market; (c) interoperability or the ability of devices to work together relies on products and services complying with standards; and (d) business benefits – provide a solid foundation upon which to develop new technologies and to enhance existing practices. Standards open up market access, provide economies of scale, encourage innovation, and increase awareness of technical developments and initiatives. This chapter provides an overview of AFC standards development in Europe.

Standards

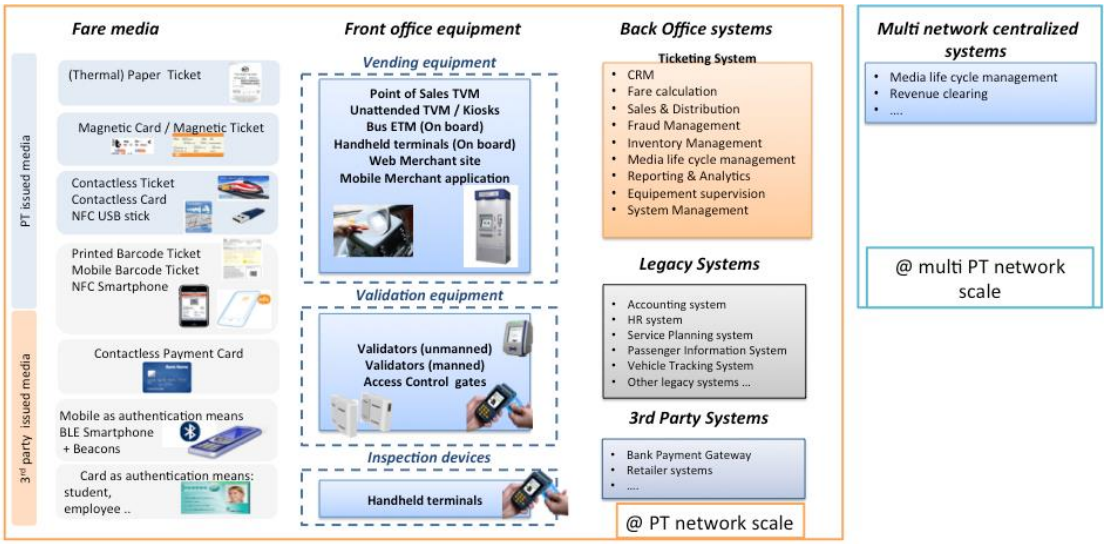
49. When considering AFC systems, it is necessary first to consider what the system comprises, in order to understand what can be standardized. Figure 5 illustrates the scope of a generic AFC system. As can be seen, there are a wide range of technologies that comprise an AFC. Much of the back office systems are generic IT systems that comply with industry wide standards. The front office and fare media equipment can comprise equipment such as mobile phones, contactless payment cards, and smartcards that comply with international standards. Standards for card devices fall in to two camps, proprietary or open.

50. **Proprietary standards**. Proprietary products such as Oyster in London and Octopus in Hong Kong have been developed for the urban transit environment out of a requirement to provide fast throughput at peak times and an all in one media, meeting the needs of multi-mode transport operators. These proprietary standards can be simple and cheap to develop as they only work within the remit of a single transit operator and do not have to conform to any other interoperable standards.

51. **Open Standards**. Open standards such as ITSO, VDV and Calypso and the EMVCo payments specifications are designed for interoperability across national or global acceptance. They are each primarily designed for a target environment, so ITSO is a transit specification and EMV is a payments specification, but both can be used to cross the boundary between transit and payments. These standards, while not as flexible as the bespoke closed standard, do offer the transit operator to leverage some benefits that come with these standards such as interoperability with other schemes, low or no issuance costs, and improved security.

Figure 5: Generic Automatic Fare Collection Architecture

[10] http://www.etsi.org/standards/why-we-need-standards



Source: Nextendis, France, 2015.

Table 2: Applicable Standards for AFC Systems

Smart Card Standards	Additional System Standards for:
Contactless Cards – ISO/IEC 14443	Communications Networks
File Structure - ISO/IEC 7816-4	Ticket Vending Machines User Interfaces
Architecture - EN ISO 24014-1 (IFM)	Data Protection
Applications - EN 15320 (IOPTA)	Payments (EMV, PCI DSS)
Data Elements - EN 1545	Banking
Security - ISO 15408 (Common Criteria)	Near Field Communication

Source: World Bank.

Transport Standards Development

52. The UK, Germany, France and the Netherlands have led the way in Europe in the development of national standards for smart ticketing. Figure 6 below summarizes the scope and usage of these systems. At the European level, the Interoperable Fare Management (IFM) project has been looking to bring all of these national standards together. The aim of the project is to ensure cross-border interoperability of transport Smartcards across Europe. One of the key objectives is to develop a road map towards a EU-wide concept where: (a) customers use their local transport smartcards outside their home network; (b) transport authorities have the tool-set to build new systems using standardized specifications; (c) deliver the associated Security Environment; and (d) charter a way through privacy issues.

Figure 6: Summary of European National Standards for AFC

	ITSO (UK)	Calypso (F)	VDV (D)	OV-Chipkaart (NL)
Scope	Developed a common specification to enable the use of interoperable smart cards and other media in transport	Calypso is a set of technical specifications describing a fast and secure contactless transaction between a terminal and a portable device.	Verband Deutscher Verkehrsunternehmen (VDV) is responsible for the development of the standard for eTicketing in Germany	TransLink Systems operates and maintains a national standard for end to end smart ticketing in the Netherlands
Users	9% of all public transport journeys in Great Britain are made using ITSO-compliant smartcards	>52 million Calypso cards and 260 000 readers at the beginning of 2010,	10 billion trips/year € 11 billion revenues 75% of all trips made by season ticket holders	4-5 million transactions per day when in full operation. NS gates will be closed in 2014
Website	http://www.itso.org.uk/	http://www.calypsonet-asso.org/	http://www.vdv.de/en/index.html	https://www.translink.nl/en-GB/Home

Source: World Bank.

53. Financial Service Providers (FSPs) have increased their role in the smart-ticketing market in recent years and have established positive working relationships with many scheme providers this period. The realization of contactless EMV payments in smart-ticketing pilot schemes shows that these working relationships are successful and have demonstrated that EMV technologies are now feasible for public transport ticketing.

54. Europe has adopted the International Standard ISO EN 24014-1:2015 as the global model to define the systems and processes required to manage the distribution and use of fare products in an interoperable public transport environment.[11] The standard provides the basis for the development of multi-operator/multi-service interoperable public surface (including subways) transport fare management (IFM) systems on a national and international level. ISO 24014-1:2015 is applicable to bodies in public transport and related services which agree that their systems need to interoperate. While ISO 24014-1:2015 does not imply that existing interoperable fare management systems need to be changed, it applies so far as it is practically possible to extensions of these. At the system level, it is the aim of the EU-IFM to build on this standard developing a model that defines the generic components and interfaces as well as generic low level processes. The approach adopted and the proposed strategy appear to be the most cohesive available, considering media interoperation, organizational roles, privacy, trust and security, together with the back office systems that will allow schemes to network and interoperate.

55. ISO is helping to bring the worlds of transit and payments together with a Technical Report paper on the use of transit data area or TDA.[12] TDA is an innovation by the payments industry to introduce a space on payment cards that can be written to by transit operators. Bank issued cards may also have an extended payment application that permits the public transport industry to store data within the payment application in what are called TDAs. By definition, the available data storage space will be quite limited. It thus allows the

[11] http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=61545

[12] ISO/TR 14806:2013 Intelligent transport systems -- Public transport requirements for the use of payment applications for fare media. Available at: http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=55067 ISO TR14806 is a technical report that defines the state of the art in respect of using bank-issue payment applications/cards for transport ticketing. The report provides a set of use cases and requirements for payment applications, most of which can be met by the current offerings from MasterCard and Visa.

storage of limited information only and will not be able to host national, interoperable fare management application standards. The TDA will only be approx. 140 bytes, so will hold just enough information to indicate that the user has performed a transaction to enable an inspector to see, but not to carry a ticket product, which was never its intended use. The ISO Technical Report describes the ways that bank issued payment cards can be used by the public transport industry to serve customer needs, independent of specific payment card scheme specifications.

56. As AFC systems have opened up with the introduction of new payment technologies and mobile phones, there are significant opportunities to develop new approaches to fare collection. Some of this can be seen in London where TfL is accepting contactless payment cards and in Washington DC where the new system will accept PIV identity cards on the Metro. These approaches signal a shift from the 1990s technology. Some trends that are becoming apparent in the industry that will influence the way in which AFC is delivered in the coming years are:

- Development of national standards, particularly in Germany, UK, and France;
- Introduction of new form factors, particularly mobile, which is opening up a wide range of opportunities;
- A realization that multiple standards will exist, due to the complex nature of public transport in different countries across the EU;
- The development of further standards will not add any further value, or identify any further functionality and will cost a great deal; and
- It cannot be said that one standard is better than another, as each system has been developed according to a particular vision, and the best solution developed to implement that vision.

Summing Up

57. Existing AFC schemes have already installed some components that conform to international norms, and have adopted operating models that comply with best practice. However, these are generally insufficient to support interoperability between schemes or across national or international boundaries. This conformity across schemes could form a general basis for the development of a European organization model that is capable of incorporating the existing national organizations that can fit, for example, the ISO EN 24014-1 standard. Leading IFM organizations have built a shared vision to (a) create an EU-IFM network to provide direction, coordination, networking of best practices and implementation planning of pan- European IFM initiatives; (b) promote further European standards for transport smartcards including security and certification equipment; and (c) develop a multi-application solution to interoperable ticketing that can be implemented in stages.

58. Ultimately, the leading IFM organizations expect a common smart media application to be the best way of ensuring interoperability. However, the use of multi-application media provides a first step toward this goal, allowing customers to hold their transport applications and means of payment on one single convenient media. Local schemes may then implement the common application at their own pace with reasonable modification costs and minimum disruption to their operation.

Interoperability across Regions

Introduction

59. Standardization of AFC systems and components does not guarantee that a system will be able to operate across a region or country. In order for that to happen there must be interoperability of systems. The Transport Research Board (TRB) in the US has defined interoperability as the ability of different agencies to coordinate and share information so that passengers can travel in a seamless fashion. The Transport Card Forum in the UK defines interoperability as the " The ability of systems to provide services to, and accept services from, other systems, and to use the services so exchanged to enable them to operate effectively together. When used in relation to ticketing systems in public transport, interoperability means the provision for the passenger of a seamless journey using the same smartcard and/or terminals, on all contractually participating operators' routes. Fare payment interoperability is only one factor that affects seamless travel.

Elements of Fare Payment Interoperability

60. Fare payment interoperability does not necessarily require the use of a smartcard. Figure 7 illustrates the high-level components to achieving interoperability. This can occur with a manual or automated system. A manual system relies on human interaction such as visual inspection, and business rules are agreed between participants so passengers can travel across different operators and/or modes. An automated system relies on technology—usually using fare media such as a contactless smartcard to validate interoperability. The information and data flows required to achieve smartcard interoperability also applies to other media such as magnetic stripe tickets or radio frequency identification (RFID) tags.

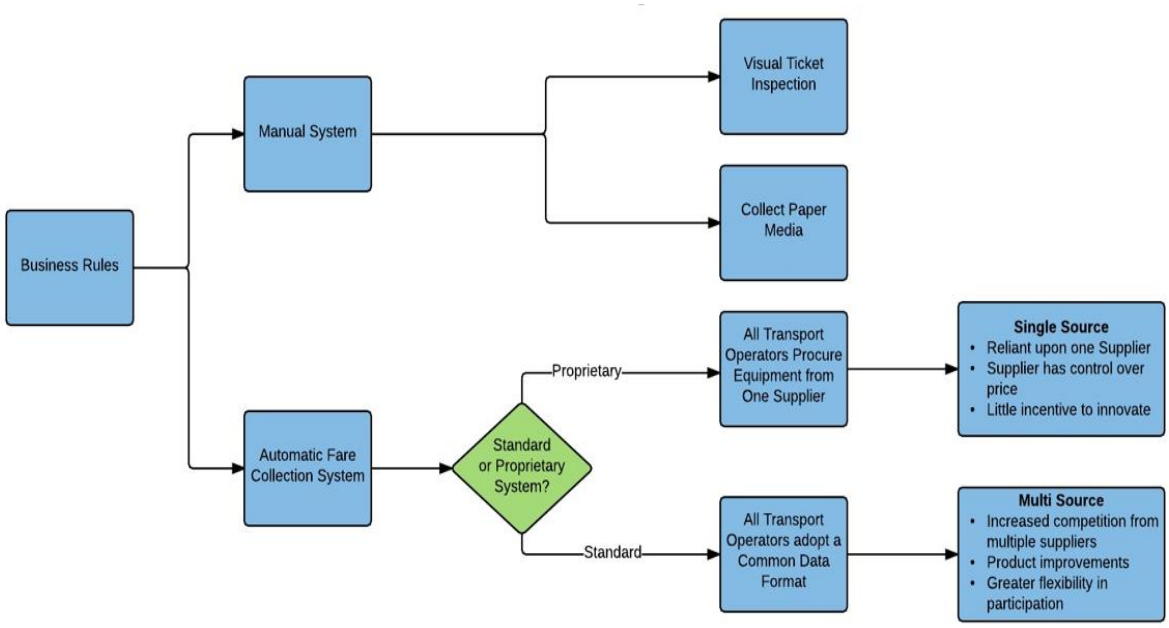
61. A clear set of business rules are necessary to outline how each of the participants needs to work together. At a minimum, the rules must provide the technology requirements that include systems and fare media and transaction processing that defines the data to be transferred for processing and when (how often) that occurs. These rules may also define other business-related aspects such as branding (how the product is to be identified in the market), customer service processes and procedures, sharing of expenses and payment for services; items controlled by participants; dispute resolution; and legal framework.

62. The next step is to define the technical information required to achieve interoperability. The business rules define the information to be exchanged by the interoperable smartcard system. At a minimum, the card-to-reader data format and the data format for transferring the transaction records to a central clearinghouse need to be defined. The minimum requirements for implementing an interoperable smartcard system can be accomplished by using one of the following approaches:

- Procuring the technology from a single supplier, similar to TfL in London, with the Oyster scheme from Cubic

- Developing an interface specification that defines the requirements with which each participant's supplier has to comply, similar to what is done in the financial services or telecommunications industries and with ITSO (UK), VdV (Germany), Calypso (France) and the *OV-chipkaart* (Netherlands)

Figure 7: Interoperability Model



Source: World Bank.

Evolution of Interoperability with Open Payment Systems

63. Now that financial institutions are implementing contactless payment products throughout Europe, a baseline architecture may be used to begin developing an interoperability strategy for public transport with open payment systems. There is a strong take up of such products in Poland with over 80 percent of the population users making contactless payments. As a consequence, the following scenarios for interoperability begin to emerge:

- Acceptance of contactless bank cards on buses and at fare gates;
- Two or more public transport operators arrange to accept each other's closed stored-value payment products,; and
- Acceptance of multiple-payment-enabled devices.

To determine the interoperability requirements with an open payment system, the characteristics of the existing transit payment architecture need to be identified.

Acceptance of Contactless Bank Cards

64. As contactless credit cards proliferate, public transport operators become increasingly attractive customers for financial institutions. The most likely relationship that will emerge between financial institutions and public transport operators is similar to a merchant in the retail space. Under this type of relationship, PTOs

accept a bankcard for transit fare payment and pay a transaction processing fee to the financial institutions. The key issue is that the bankcard data structure is not designed for conducting fare calculations. Therefore, two baseline system architecture configurations emerge for using a bankcard to pay a fare: (a) transit and credit card applications both reside on the same chip or (b) the credit card application only resides on a contactless chip.

65. Though technically feasible to combine transport and payment applications on a single card, the institutional barriers still make this configuration economically infeasible. However, using a contactless credit card product for fare payment is technically feasible in a cost-effective manner if some of the institutional constraints can be modified. This has been proven to work in Salt Lake City, Utah and across the TfL network in London. In conjunction with the major card schemes, Visa, MasterCard and American Express, TfL developed a set of rules for the use of contactless payment cards in public transport fare collection. These are summarized in Table 3.

Table 3: Transport Requirements for Contactless Payment Cards

General rules	Challenges implicit in transport PAYG	Agreed new rules for transport PAYG
Price is known	Price not known until rail journey is completed	Tap = £0, Price calculated at end of day
Card counters to manage risk - Chip & PIN	• Max transaction time of 500ms • No PIN pads	Operator manages risks: • Offline data authentication of card • 'Deny Lists' in terminals • Online authorisations from the back-office
Terminal field activated	No time to activate field for customer	Always active - maximise throughput

Source: World Bank.

Multiple Closed Stored-Value Payment Products

66. Closed stored-value products are becoming an increasingly attractive means to create loyal customer relationships. In the retail environment, coffee shops, such as Starbucks issue closed-account-based stored-value cards. Sports venues are also beginning to recognize the benefits of a contactless stored-value payment media. Two parts are required to create interoperability between disparate closed stored-value systems:

- The need to read participants' cards or payment media and
- Agreement on how settlement will occur.

67. This type of arrangement is referred to as a trust model, as it requires participants to trust the integrity of the transaction data. An example of where this has been implemented is between TfL and the train operating companies (TOCs) who feed the London terminals. The TOCs have agreed to accept TfL's Oyster card in several stations close to London. These TOCs need to purchase Cubic's Tri-Reader and integrate them with their own gates. This is not dissimilar to the regional interoperability approach where it is necessary to purchase equipment from one supplier. However, the TOCs do not issue the Oyster Card, they just collect transactions and feed them to TfL. They then receive an invoice at the end of the month for a lump sum, there is no detailed breakdown of transactions, the TOC has to trust that TfL has collected the correct journey information.

Multiple Payment-Enabled Devices

68. There are two configurations of payment-enabled devices: (a) transit-enabled contactless chips embedded into devices; and (b) devices with transit application (software) that communicates with the reader in a non-ISO-14443-compliant mode (e.g., Bluetooth, 802.11, or infra-red).[13] The most common payment-enabled device is a key fob with the same contactless chip as a smartcard (e.g., the ExxonMobil Speedpass device). Contactless smartcard chips have also been embedded in mobile phone covers or even into a designated slot in the mobile phone. The primary difference between a contactless smartcard and a key fob or mobile phone cover is the form. Therefore, when a transit-enabled contactless chip is embedded in, for example, a mobile phone cover, interoperability is the same as for transit-issued contactless smartcards, as long as the same contactless chips are used.

69. In recent years, there has been development of Near Field Communications (NFC) with mobile phones able to emulate payment cards. A prime example of this is Apple Pay, which uses a tokenized form of a payment card stored on an iPhone, which can make contactless payments through the NFC interface. This migration towards a mobile platform is a long-term trend that will become more prevalent in coming years. At the moment, Apple Pay is the first with major traction. The idea is that people will be able to leave their wallets at home and just take their phones, so it becomes more convenient and secure for users.

Implications for Poland

70. In Poland some areas have expanded their systems to include neighboring cities, and this is a good example of interoperability based on a single supplier as described above. However, there is no coordinated plan for a nation wide interoperable smart ticketing system. It could be argued that this lack of a plan is limiting usage of public transport, as buying a ticket to travel becomes a barrier to usage. With the high penetration of contactless payment cards in Poland, over 80 percent, there must be a strong case for bank issued payment cards to be part of any national interoperable AFC scheme. There is still work to be done in this area, particularly in relation to long distance rail journeys, but the problems are not insurmountable. There is the potential for Poland to take a lead in this area, with the support of the leading card schemes, Visa, MasterCard and Amex, to demonstrate how this can be implemented, and create the basis of a standard for the use of bank cards in this scenario, similar to what TfL achieved with regards to urban transport and bank issued payment cards.

[13] 802.11is the standard for WiFi and infra-red refers to the communication channel used.

International Case Studies

Introduction

71. This chapter focuses on examples of standardization and interoperability of AFC systems for public transport. The first two case studies are from the European Union--the first is the *OV-chipkaart* of the Netherlands, the second is the evolution of public transport ticketing in London, while the third surveys Korea's experience. It also presents an innovative pilot multi-modal booking and payment system mobile app developed in Vienna, which provides an individual mobility payment system that integrates across all modes, without the need for smartcard interoperability. There are interesting lessons to learn from all approaches taken by both countries.

Netherlands – OV Chipkaart

72. The *OV-chipkaart* (*Openbaar Vervoer Chipkaart*) is a contactless smartcard system used for all public transport in the Netherlands. First introduced in the Rotterdam metro in April 2005, it has subsequently been rolled out to other areas and travel modes. It fully replaced the national paper based ticket system *strippenkaart* for buses, trams and metros in 2011 and the paper ticket system for rail travel in July 2014. The *OV-chipkaart* works in two ways: either as a stored-value card which is used to travel on pre-loaded credit or as a means of storing so-called travel products such as single or return rail tickets, day passes, seasonal tickets and discount plans.

73. This product was developed by Trans Link Systems (TLS), which was an entity established in 2002 by Connexxion, GVB (Amsterdam), HTM (Den Haag), NS-R (Dutch Railway Company) and RET (Rotterdam). Together these five companies provide 80 percent of public transport services in the Netherlands and cooperate with all other public transport organizations. Trans Link Systems (TLS) works in partnership with the carriers involved to ensure the *OV-chipkaart* is made available to the people using public transport in the Netherlands. The *OV-chipkaart* can be used on the bus, metro, tram and train. A tender process was started in 2002 to select a supplier that can build the central system and this was awarded to the East-West e-Ticketing B.V. consortium in 2003.[14] The solution that East-West has designed is based on the existing "Octopus" smartcard system for public transport used in Hong Kong. Connexxion is the largest public transport bus company in the Netherlands, operating in the west, middle, east and far northern part of the country since 1999. TLS is now owned by the four largest operators: GVB, RET, HTM, and NS-R. Connexxion withdrew for reasons related to its French parent, Transdev, which is a subsidiary of France's state- owned Caisse des Dépôts, and which acquired Connexxion in 2007.

74. TLS has developed a nationwide smartcard system for transport, covering various products – t-purse and passes, and allowing different price mechanisms and concession areas—this is the Dutch term for bus

[14] This consortium consists of: Accenture, Thales and Vialis with the following Thales subcontractors: MTR Corporation and Octopus Cards Ltd (both companies established in Hong Kong).

franchise—and all modes. Cards are either personalized or anonymous; there are also limited use tickets for incidental users, with a typical life of two days, in Amsterdam (using a lower cost Mifare Ultralight ticket). Several million cards have been issued to date, and 60,000 "front end devices" (validators, rail, metro gate readers, and vending machines) have been deployed. Across the country, few cities are not now using the scheme; Rotterdam and Amsterdam have gone fully smart, and Rotterdam has phased out legacy means of payment. [15]The cards only have a public transport journey functionality – they do not currently handle taxis, parking, or parking, but cover bike rentals in railway stations.

75. TLS has the role of card issuer and central processor. Cards are procured by individual operators and issued to customers, but transactions are processed by TLS's central processing facility. Operators benefit from having their own brands on the card. The scheme is known as *OV-chipkaart*, and the interoperability is achieved through a three part set of definitions: 1) technical specification; 2) rules and regulations; and 3) registrar documentation containing the global parameters.

76. Implementation delays were due to stakeholder management, especially related to NS-R changing its mind on how it wanted to see smartcards used. Originally, the rest of the network wanted to have a touch in/touch out system, but NS-R did not, and wanted to allow travel as long as there is a valid product on the card. However, in 2007 NS-R decided to accept Touch In/Touch Out and changed the operating model. Another reason for delay was that system integration capability was insufficient within the operators, and TLS had to source this from the East-West consortium. Also, TLS decided on a procurement model where the selected implementer also wrote the specification (unlike ITSO which has been defined by Government). This has made it difficult for other suppliers to enter the market quickly as they have not had the skills and facilities to deliver the integrator defined solution.

77. For non-rail journeys, typically 89 eurocents are deducted at the start and a kilometer-based price calculated on exit (like Oyster on underground). The concern in the UK about rail fares being of a potentially high transaction value is not as applicable; the maximum Dutch rail fare is currently Euro 26.30 (single trip, 2nd class). As a result, the collection risk is lower and NS-R is willing to take a risk by deducting only Euro 20 at the start of a journey, because 50 percent of travel either starts or ends in a closed station.

78. TLS prefers to see all tickets operate with Touch In/Touch Out be either t-purse with auto reload linked to a payment account or season tickets. It would also like to see a "National Action List" – an internet site where tickets can be purchased on-line then "picked up" electronically at a device located at a place of the passenger's choice (similar to Oyster)[16]. This is expected to speed up journey times. Buying on the internet is considered to be more secure than in public where payment card PINs can be observed. Internet kiosks are located in convenient places. These payment channels related efficiencies are expected to reduce staff costs. The Netherlands has already moved away from manned ticket offices to electronic ticket vending machines.

79. National regulations require that there be one national ticketing system in the country. Public transport authorities require operators to accept the use of *OV-chipkaart* and the scheme has been developed with much seeking of input from interested parties. Its strength is derived from the power of the participating operators and their collective dominance of transport ticketing. Within cities such as Amsterdam and Rotterdam, operators are subsidiaries of the transport authorities, such as RET and GVB. They are not independent commercial entities and have no discretion on whether to accept *OV- chipkaart* or not.

[15] All areas have nowadays, but some paper tickets (created by local bus operators) continue to exist on top of *OV-chipkaart* acceptance.
[16] This works for top-up, though not yet for specific seasonal passes from the operators themselves.

80. Connexxion, one of the major bus operators, is fully committed to OV-*chipkaart*, despite there being many challenges and considerable effort for it. It likes the performance level of smart ticketing, reduced transaction times, and there have been numerous design considerations over type and placement of validators on board bus. There are no financial incentives to take part; to date Connexxion has been a net contributor. The notion of providing an incentive to operators to adopt *OV-chipkaart* was not considered during the project, but there are still discussions about who should pay for what element of the service.

81. From an operator perspective the key benefits are time savings when compared to paper tickets, and fraud reduction, in conjunction with a closed network. Fraud reduction is the next most important expected benefit, especially for smartcards in conjunction with a closed network. A third benefit is related to getting better data on transport usage is a key driver, which supports optimizing lines, routes and frequencies.

82. National interoperability is key; this is multi-layer, the front end is offline and transactions are sent to a central processor for each operator, then data is forwarded to the single TLS clearing and settlement system. TLS has been established to secure this national interoperability; it is a private company, funded by its shareholders. It is still losing money, but this is getting better and breakeven is being approached.[17]

83. The Dutch specification is open; there is no lack of vendors given the country size; there are currently 20 vendors. The specification is owned and edited by TLS, and is freely available upon registration. It, or something with a very similar technology specification, is currently implemented in Toronto, Oslo, and Denmark. TLS likes the idea of a common European specification, but does not see it as a high priority since not many travelers use public transport internationally.

The Evolution of Ticketing in the UK – Inside and Outside London

84. Launched in 2003, the Oyster card scheme is a form of electronic ticketing used on public transport in Greater London. It is promoted by Transport for London (TfL) and is valid on travel modes across London including London Underground, London Buses, the Docklands Light Railway (DLR), London Overground, trams, some river boat services, and most National Rail services within the London fare zones. Usage of Oyster cards in the train system took several years to negotiate (2006-2009) but was introduced in January 2010 on all nine London train operating companies (TOCs). This has resulted in increased TOC revenues of 6 percent in London (GBP 100 million per annum).

85. An Oyster card is a stored-value contactless smartcard that can hold single tickets, period tickets and travel permits, which must be added to the card before travel. Passengers touch it on an electronic reader when entering and leaving the transport system in order to validate it or deduct funds. Cards may be topped-up by recurring payment authority, by online purchase, at credit card terminals or by cash, the last two methods at stations or ticket offices. The card is designed to reduce the number of transactions at ticket offices and the number of paper tickets. Usage is encouraged by offering substantially cheaper fares than with cash though the acceptance of cash is being phased out. On London buses, cash is no longer accepted.

[17] TLS likes the fact that ITSO supports multiple media types – this is helpful given the security concerns over Mifare Classic cards. However, they feel that the ITSO requirements for all readers to read all media is costly. The ITSO clearing and settlement process (not being provided centrally) is also perceived to be onerous, with 'on us/not on us'[17] transactions being a big task. TfL's Oyster on the other hand is regarded as quite similar to the Dutch system—multi tickets (changing products during a journey, e.g. part on t-purse, part on a fixed product) is not supported by ITSO, but required in the Netherlands.

86. The Oyster card increased capacity at gates by allowing 40 customers to pass per minute compared to 15-20 for mag-stripe credit card sized tickets (CCST). PAYG and capping were subsequently introduced and a price differential with cash fares was used to drive the adoption of Oyster. Now 87 percent of TfL's services use Oyster (12.7 m taps per day). Since 1998 it has reduced the cost of revenue collection by one third. Key benefits of Oyster benefits include the following:

- Interoperable ticketing across all public transport in London;
- Removing the need for ticket purchase before journeys resulting in significant reductions in ticket office use;
- Easier for customers to self-serve, purchasing choices simplified;
- Increased throughput at gate-lines;
- Reduction of ticket fraud.

Future Ticketing Programme

87. As part of TfL's Future Ticketing Programme (FTP) the Oyster card platform is due to be replaced by a contactless payment card system, the first stage of which was completed by June 2015. A study in 2006 identified the alternatives that might become available to TfL, of which Contactless Payment Cards (CPCs or cEMV) and mobile phones enabled with near field communication technology were the most promising. The cost of revenue collection shone a light on the cost of ticket selling, a process that can be radically changed with the acceptance of a payment product issued by the wider payments industry. The introduction of CPCs was seen as a significant opportunity to find new ways for customers to pay for their travel without the need to get a ticket from TfL first. This enables TfL to reduce ticketing costs while also improving the customer experience (compared to Oyster) because information is held in an intelligent back office system rather than on the card itself. The development of FTP was driven by the desire to reduce the cost of ticket sales which could not be reduced further using Oyster. This has been achieved by using CPC which are issued by banks and not by TfL and by moving intelligence from cards and readers to a more flexible and responsive back office. The program is in five phases:

- CPC on buses launched in December 2012 using a retail payment model for the flat fare charge;
- Extending CPC acceptance to the rest of the Oyster reader estate (as well as new places such as riverboats) and also introducing weekly capping. This required the design of a transit payment model in conjunction with payment schemes to allow CPC transactions to take place where the cost was not known until the end of the journey;
- A new card platform for Oyster which uses the FTP back office for all ticketing products; and
- The decommissioning of the legacy Oyster system.

88. The UK Department for Transportation (DfT) has paid GBP 66 million to have the Oyster readers also accept ITSO customer media[18]. The program currently has delivered the capability to allow National Rail singles, returns and season tickets—as well as English National Concessionary Travel Scheme (ENCTS) concessions on buses—but has struggled due to the immaturity of ITSO. The first phase is live:

- TOCs can accept their own products at their own gated stations.
- Tube and Overground readers have been upgraded to accept Travelcard seasons if a TOC issues them on ITSO.
- ITSO cards can be accepted at un-gated stations and on buses.

[18] Customer media refers to the media which holds the ITSO product, i.e. the smartcard.

TfL is working with several TOCs, including Southern, to enable ITSO compliant smartcards to be used by their customers when travelling into London from outlying areas.

89. The technology split which has evolved between London and the rest of the UK needs to be fixed. TfL currently has TravelCard and Through-London agreements with the TOCs, based on CCST. These might need to be renegotiated to work with smart tickets. Once FTP Phase 4 is completed, TfL would like to be able to offer their back office to all UK operators who are interested in making use of it. TfL is also considering integrating their back office with cycle hire in London and even accepting Tesco Clubcard points in exchange for travel value. If ITSO and South East Flexible Ticketing (SEFT) are a success, then TfL will continue to accept ITSO product entities for cross and through-London travel. The TOCs are not motivated to agree SLAs between each other and the franchises are not motivating them to work together. We would likely have to wait until 2021 before the last of the TOC franchises are renewed and mandate ITSO.

90. If ITSO and SEFT are not a success, there seem to be complimentary solutions that could co-exist side by side:

- *PAYG*: Whatever the TfL solution is that replaces the current Oyster system for TfL-issued tokens and pre-paid accounts in the back office. This could apply to London rail like Oyster currently does.
- *Tap & Go*: CPC solution based on FTP Phase 2, but for rail outside of London. This will aim to offer a price match guarantee (pay the lowest price that was available that day for the journey made). How this works will depend upon the results of the Chiltern trial.
- *Ticket in the Cloud:* A token is associated with an advance purchase rail ticket. There is no fulfilment of the ticket to the customer. The reader authenticates the token and uses the token ID to access the ticket stored in the cloud. The token could be the CPC card used to purchase the ticket or it could be a barcode on a mobile device (though London gates do not accept barcodes and have no plans to).

Transit Model 2

91. TfL is considering with Visa and Barclaycard whether a new transit mode is possible that is more appropriate to rail. It is based on the 'hotel model' where a card is pre-authorised for a certain amount in order to limit the risk of not being paid at the end of the spend. It is thought that a CPC card could be held for two seconds at a rail reader which would cause the reader to perform an online authentication of the card and to pre-authorize an amount (e.g. GBP 50) and the payment schemes might be prepared to accept the risk of not receiving payment for the full costs of the actual rail travel after the journey has taken place.

Ticketing Technology Outside of London

92. Outside of London there is less interoperability of ticketing across all modes of operation due to the fragmented approach adopted by the major operators and lack of leadership in the deregulated environment. It should be noted that outside of London there is little interoperability of e-ticket and m-ticket schemes making journeys between operating regions problematic and ensuring that CCST magnetic stripe tickets remain dominant.

93. ITSO-compliant smart ticketing has been adopted by all five main bus operating companies in Britain (Arriva, First, Go-Ahead, National Express and Stagecoach) and is used for concessionary smart ticketing on around 14,000 buses outside London. ITSO has already been adopted by six train companies – East Midlands, Abellio ScotRail, London Midland, Merseyrail, Southern Railway, and South West Trains and will be adopted in all new rail franchises. Large parts of the UK are moving towards commercial ITSO-compliant schemes. In many cases local authorities and passenger transport executives are taking the lead and working with transport operators in their regions. For instance:

- NESTI (North East Smart Ticketing Initiative) in the North East covering 12 local authority areas including Nexus Tyne & Wear (so far partly covered by the Pop card).
- The NoWcard in Cumbria and Lancashire.
- Yorcard is looking to cover the region of Yorkshire and Humber, including Sheffield, York and Leeds.
- South West Smart Applications Limited (SWSAL), a smart ticketing project involving 15 local authorities and 17 transport operators in the South West of England.
- Merseyside, Greater Manchester and the West Midlands all have existing or planned ITSO-compliant smart ticketing systems.
- The whole of Cheshire is covered by the first ITSO-compliant commercial travelcard on its buses.
- In Scotland, buses have been equipped nationally to take ITSO smartcards for its concessionary travel scheme. An ITSO scheme is also being operated by Abellio ScotRail. (seasons only) Strathclyde Partnership for Transport (centred in Glasgow) has introduced ITSO-smart ticketing on the Subway.

South East Flexible Ticketing (SEFT)

94. The South East Flexible Ticketing (SEFT) program's objective is to deliver 'smart' ticketing infrastructure and products to the rail network surrounding London. The program will complement the existing Oyster infrastructure deployed in London by TfL. The DfT and TfL are currently implementing the ITSO on Prestige (IoP) program which will upgrade all existing London Oyster readers to support ITSO media and products. Four years since inception, SEFT seems to have stalled. Rail Settlement Plan (RSP) provides and manages, on behalf of TOCs, a number of shared services, ranging from the provision of ticket stock to the allocation of industry revenue. RSP and the TOCs are working together to provide the infrastructure (both at station equipment and back office based systems) required to operate an ITSO compliant smart ticketing solution at various stations operated by TOCs, all initially based in the South East of England with the potential to be expanded beyond this region.

CPC Outside of London

95. Outside of London several transport operators are investigating the use of CPC. Notable trials have been undertaken by Stagecoach who used CPC as a cash replacement on buses in the North West. Transport for Greater Manchester (TfGM) have appointed ATOS to provide a system (similar to TfL's FTP but different since there are no back office standards) for the Manchester Tram network that will accept ITSO and CPC. This is currently being rolled out and ATOS is licensing to TfGM so that they retain the intellectual property rights and can sell to other operators. The other major transport operating groups are looking at what is happening in London before deciding if they will follow suit and roll out CPC across their bus networks. Some are in negotiation with TfL about using the FTP back office. In the rail sector there is a well documented pilot being proposed by Chiltern with TfL which will demonstrate if the model being used by TfL will be extendable to the rail network beyond the London area and the GBP 6 fare risk limit. Currently there appear to be no other operators who are looking at implementing CPC in the rail network.

Smart in the North

96. In October 2013, DfT announced plans for a UK-wide future fares and ticketing strategy, central to which is the implementation of a nation-wide smart ticketing standard, with ITSO technology as the basis.[19] As part of this, the Smart in the North (STN) program will support DfT's commitment to ticketing transformation in the rail industry, and maintaining interoperability of rail tickets and products on smart media. STN offers the opportunity to create a new interoperable ticketing solution across the North of England that builds on the existing ITSO infrastructure, with new products and simplified fares structures, which will make ticket pricing more transparent, and allow transport passengers to make better-informed decisions about the most cost effective way to travel.

97. Currently, there are complex fare structures in place across the North that are confusing for passengers and make it difficult to make an informed decision as to the most cost effective means to travel. There is no single ticketing scheme in the North that compares with the Oyster card in London, which is accepted across multiple modes in all geographic areas of the region. There is no single source of information on fares, timetables or methods for purchasing journeys in the North; this is an additional barrier to passengers wishing to make simple and informed decisions about journeys. Without a single authority responsible for all transport modes, as in London, the need for local authorities, operators and regional authorities to work together in partnership is critical to the success of STN.

98. In a document outlining the Northern Powerhouse (HM Gov., Transport for the North, March 2015) the DfT outline their proposed approach to address the identified problems. This approach includes:

- Simplify rail fares across the North, reducing the number of regulated fares baskets;
- Draw up proposals for a fares structure for an integrated Northern Travel Area;
- Identify existing smart schemes across the North that need to be modified to meet the common objective;
- Align the different tickets and approaches in the different cities across the region;
- Trial contactless cards on transport schemes;
- Engage with public and private operators to agree ways of introducing new technology; and
- Develop proposals for simple and unified approach to journey planning, provision of customer information and retail strategies to make it easier for customers to make their journeys

Barcode Technology

99. Barcodes have been successfully implemented on the public transport network, both in rail and buses. Numerous bus operators, both large and small are providing mobile apps that can sell bus tickets and deliver them to a mobile device in the form of a bar code and visual ticket that can be used for visual and machine inspection. Several of these mobile apps have integrated new payment methods such as PayPal and Pingit to make the buying process more convenient for users. In the rail sector, TrainLine Ltd, a UK online rail ticket retailer, has been involved in providing bar code tickets for several of the TOCs, in addition Chiltern Rail has been an innovator in this field and has integrated bar code readers into its gate lines. There are problems that have been encountered with bar codes that are being addressed by the industry which include:

[19] Department for Transport (2015), The northern powerhouse: one agenda, one economy, one north – a report on the northern transport strategy. Available at:
https://www.gov.uk/government/publications/northern-transport-strategy

- No central database of bar code tickets to check against to determine if ticket has been used or not. This is important from a revenue-control point of view as refunds can be claimed if there is no record of the ticket being used. However, this is currently being rectified;
- Speed of transaction can be slow as the bar code needs to be presented to the reader at the correct angle to be read.

100. Within the last 12 months the rail industry finalized the development of a set of requirements to allow interoperable bar code tickets to be sold and used across multiple operators, and in so doing addresses the major issue above, of the need for a central database of tickets. Plans were announced earlier in 2016 for the rollout of this system on the UK rail network.

Overall British Landscape

101. As can be seen from the description above, the landscape in the UK is complex, with the ITSO standard mainly focusing outside London, in a deregulated multi-operator competitive environment, and Oyster and CPC the dominant approach in London, which is a regulated single operator environment. As a consequence, there is no overall national strategy for interoperable ticketing in the UK. Various cities have implemented ITSO based solutions, but not all of these are interoperable. Plans are underway to integrate these systems. There are plans to extend Oyster further outside London on the rail network, and as such this means that ITSO usage will decline. However, this would guarantee interoperability with the TfL network as the equipment has to be provided by the same supplier.

Korean Approach

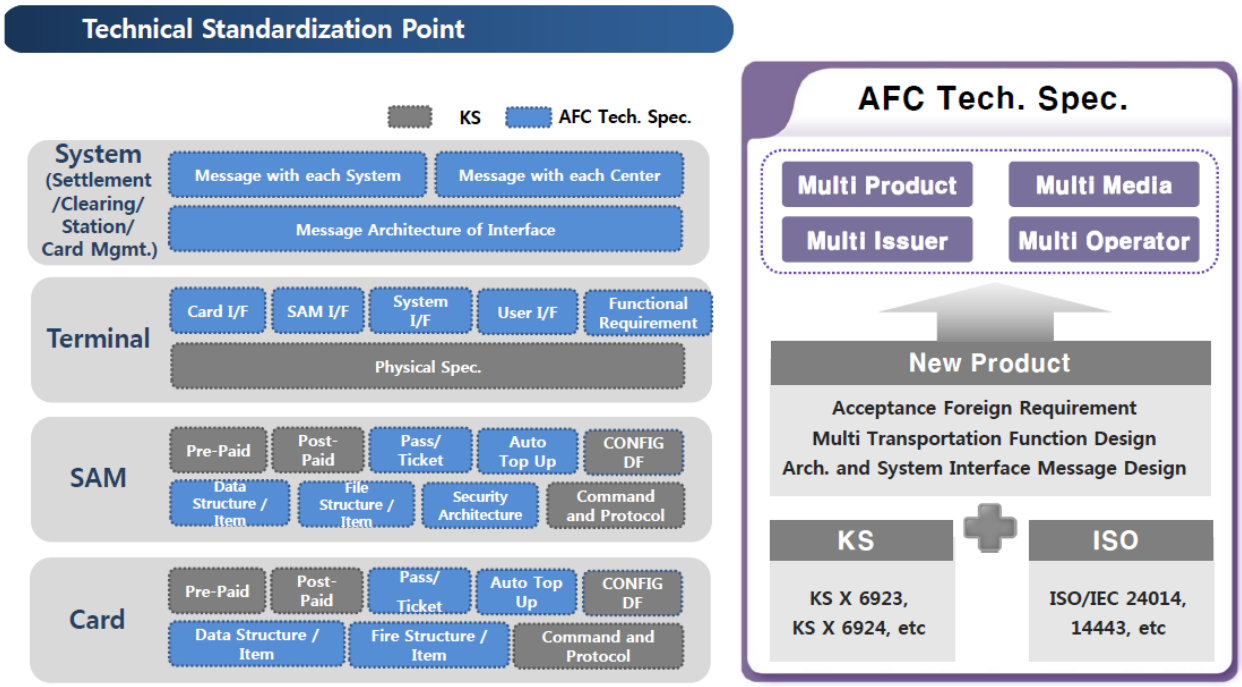
102. Korea's first smartcard ticketing system was introduced in Seoul in 1996 with the initial objective of ensuring transparent management of transport operators, allowing passengers to pay fares electronically, and address the problem of delays caused by manual fare payment. However, the system had a number of problems such as increasing costs due to technology monopoly by operators, lack of interoperability with other systems, and operators' refusal to disclose relevant technological information. Due to these problems, the city government faced difficulties in operating and maintaining the system as well as utilizing smartcard transaction data needed for developing transport policies.

103. In 2004, a new smartcard, named T-money, was introduced as part of public transport reform initiated in Seoul. The Ministry of Knowledge Economy supported the development of AFC (AFC) standard software solution (see Figure 1 for the illustration of standardization). Over time the transport related functionalities were also integrated into practically all credit cards issued in Korea. By 2009, smartcard usage has reached 96 percent in Seoul, while average usage in other cities of about 80 percent. A policy to ensure the compatible use of smartcard tickets among all public transport modes throughout the country was adopted. Smartcard ticketing services began to gradually cover taxi services in 2007, and by 2011, the rate of taxi passengers using smartcards rose to 40 percent.

104. T-money is managed by Korea Smart Card Co., Ltd, a joint venture between Seoul Metropolitan Government and LG Group. It is one of the world's largest settlement company, with more than 230 bus operators, 17,000 buses, 110,000 taxies, and 35 million data transition per day for US$14 million plus fare settlement per day.[20]

[20] http://www.asiaiccardforum.net/news/02-01-2012-01/data/AFC-KSCC-Korea.pdf

Figure 8: AFC Standardization[21]



Source: Asia Card Forum.

105. To make T-money work, the Korean government has put a significant effort to develop a national standard for automatic fare collection. This approach is based on existing international standards, while adapting them for the Korean national market and creating a national capability in AFC to develop an international market. It took them 1 year to develop technical specifications and 1 year to develop solution including smartcard, terminal, center systems and etc., and 6 months to build and operate the testing model. The standards referred to during their standardization listed in Table 4. This approach is not uncommon, and in fact has been adopted I the Netherlands, where the Hong Kong system was adapted to meet the Dutch banking requirements, and in Colombia, where the LG solution for Bogota has been adapted to meet the requirements for Colombia so it can become a national standard. This experience of creating an organization to oversee the development of a national vision for AFC in Korea and producing a standard has offered lessons that Poland can learn from.

106. With strong government backing there are plans to sell the specification and skills overseas, and a recent success has been achieved in Malaysia. In Europe this might be more difficult to achieve as there are several standards in existence from Germany, France, the UK and The Netherlands, which make the selection process more difficult, while there are no competing standards in South East Asia.

107. Meanwhile, the Korean standard is card based, as the vast majority of installed systems are based on smartcards. In the coming years there will be a significant shift to mobile based solutions, and so the standards will need to be adapted for mobile platforms. Korea has a strong track record in implementing mobile solutions and so this evolution should not pose too many problems to future upgrading.

[21] http://www.asiaiccardforum.net/news/02-01-2012-01/data/AFC-KSCC-Korea.pdf

Table 4: Reference Standards related to Korea AFC System[22]

Specification		Contents
International Standard	ISO/IEC 7816	IC Card with Contacts
	ISO/IEC 14443	Contactless proximity Card
	ISO/IEC 18092	Near Field Communication – Interface and protocol
	ISO/IEC 24014	Interoperable fare management system - Architecture
EU Standard	EN-1545	Surface transport applications. Elementary data types, general code lists and general data elements
	EN-15320	Surface transport applications. Interoperable public transport applications framework
Korea Standard	KS X 6923	Payment SAM specification
	KS X 6924	Transit Card specification
	KS X 6925	Payment terminal requirements
	KS X 6926	Reload terminal requirements
	KS X 6927	Reload SAM specification
De Facto	ITSO Standard	The Integrated Transport Smartcard Organization's standard(In United Kingdom)
	CFMS (APTA)	Contactless Fare Media Standard(In The United States of America)
	Calypso	Calypso Card and SAM specification

Source: Asia Card Forum.

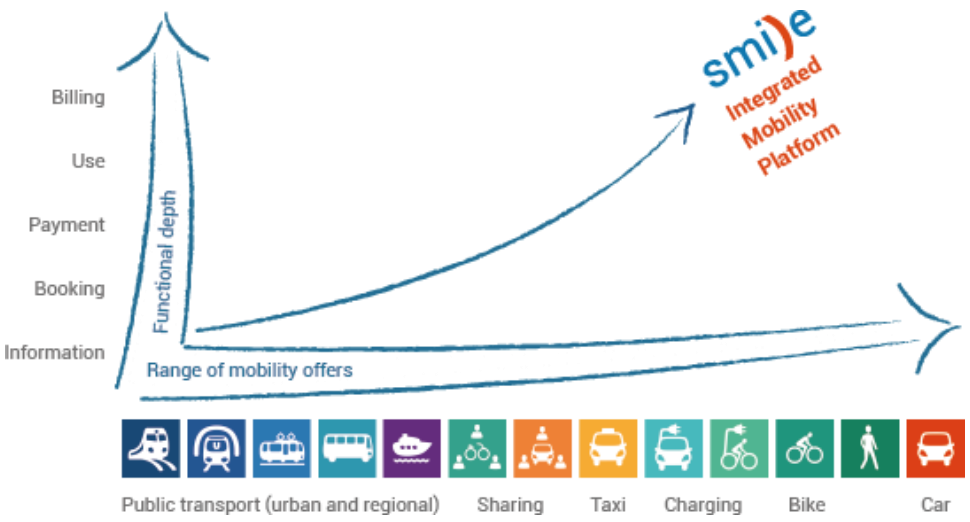
Vienna Project SMILE- Smartphone Integrated Mobility Platform

108. SMILE—Smart Mobility Info and Ticketing System Leading the Way for Effective E-Mobility Services—was a pilot multi-modal booking and payment system linking individual e-mobility services with public transport that ran from March 1st 2012 and ended on May 31st, 2015.[23] This smartphone-based platform was developed with public transport as a backbone.[24] It integrates diverse mobility offerings into multiple unified travel options taking into account unique customer needs. SMILE provides intelligent customer information, and enables electronic booking and payment. It is open to third-parties and is expected to develop into a nation-wide platform for Austria in the medium term, given the success of the pilot.

109. The SMILE concept was to offer a wide range of transportation information, booking, payment, usage, and billing functionality. A standardized interface (SMILE Connector) enables all mobility partners to link their technical systems via specific adaptors to provide all their data, including the ticketing. The mobility platform integrates various means of transport and combines them with routing information and user data to provide individual mobility offers. Within the application server of the mobility platform all data was consolidated. According to the specific user request the data will be selected and combined to provide the most suitable options for the requested trip (including the actual price). Additionally the users then had the chance to choose an option to book the entire trip – even with several mobility providers – without changing between different apps. The clearing with the payment provider was processed in the background.[25]

[22] http://www.asiaiccardforum.net/news/02-01-2012-01/data/AFC-KSCC-Korea.pdf
[23] SMILE was a research project funded by the Climate and Energy Fund of the Austrian Federal Government and is carried out as a part of the third call of the "Austrian Electric Mobility Flagship Projects" program. The Project costs Euro 6.7 million with another Euro 2.9 million on promotion.
[24] It integrates multiple mobility providers throughout Austria such as ÖBB (Austrian Railways), Wiener Linien (Public Transport Vienna), Taxi 31300 (Taxi Service), Car2Go (free-floating carsharing), Emil and Emorail (e-carsharing), Citybike (bikesharing), Tanke (Charging network for eCars).
[25] http://smile-einfachmobil.at/index_en.html

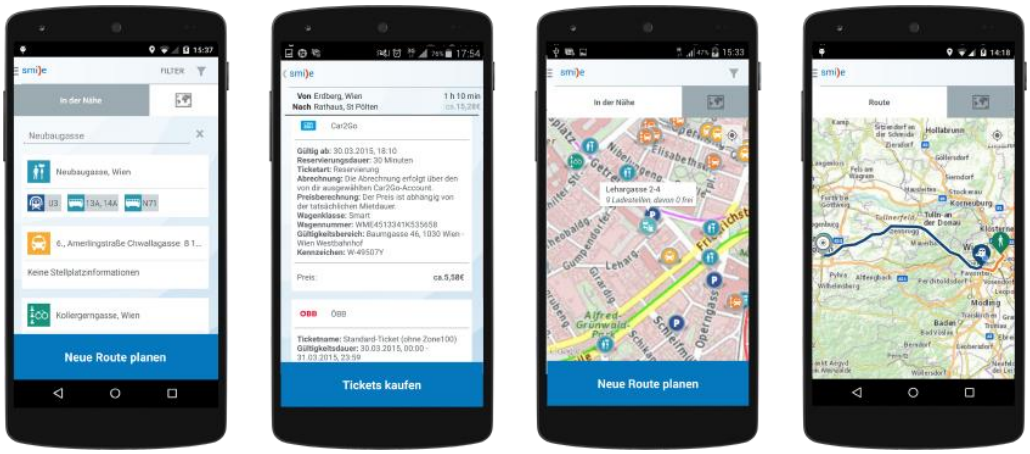
Figure 9: Illustration of SMILE Platform[26]



Source: New Urban Mobility Vienna Ltd.

110. From a transport user perspective, after opening the Smile App, users are informed about available means of transport around the current location or at any other chosen point in the map. Via tapping the icons further information can be accessed, such as departure times of public transport at a stop, available rental bikes, condition of a car-sharing vehicle or the available charging points in park houses. The mobility platform offers different individual options and combinations for trips. These can be sorted by mean of transport, time, price and CO2 emissions. With a filter certain means of transport can be filtered individually. Figure 11 shows prices for different travel options.

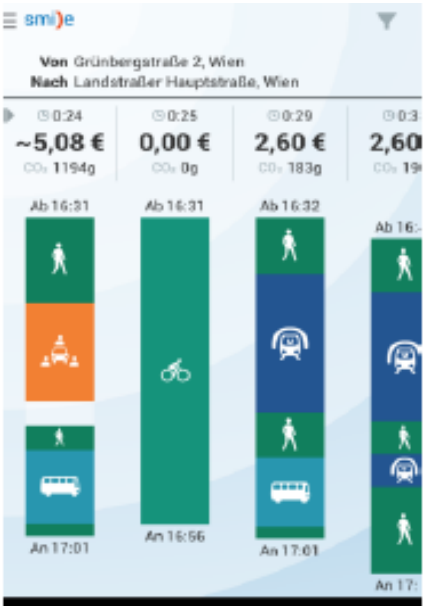
Figure 10: Interface of Smile App[27]



Source: New Urban Mobility Vienna Ltd.

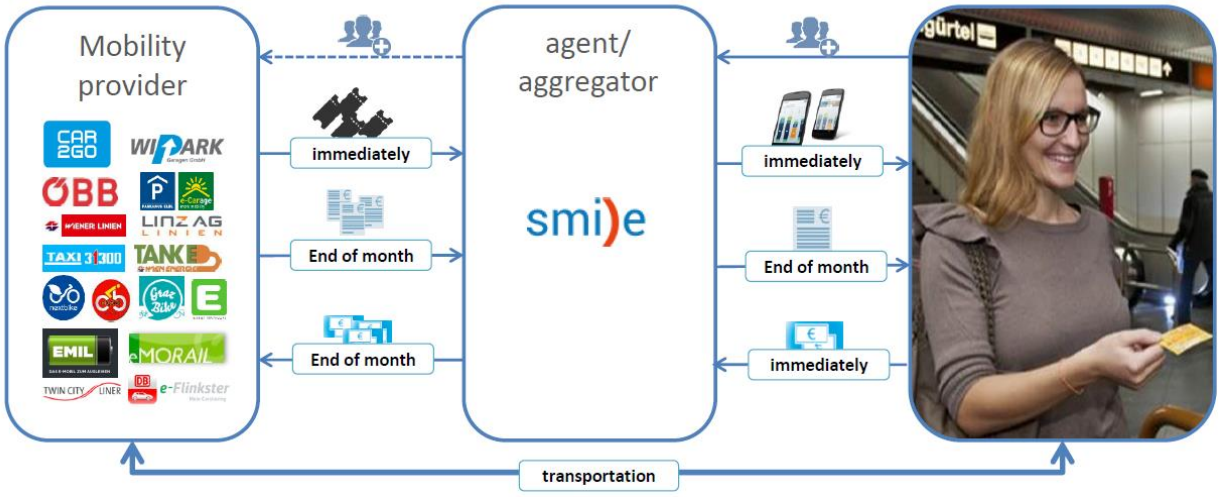
[26] http://smile-einfachmobil.at/index_en.html
[27] http://smile-einfachmobil.at/index_en.html

Figure 11: Screenshots of Smile



Source: New Urban Mobility Vienna Ltd.

Figure 12: Transaction process of Smile App[28]



Source: New Urban Mobility Vienna Ltd.

111. SMILE App also considers season tickets, discounts and memberships e.g. from sharing providers as well as private vehicles which can be saved in the Mobility Profile. The SMILE App shows the total price for the

[28] Adopted from a powerpoint by Dr. Ilse Stockinger and Mag. Reinhard Birke.

entire trip as well as for each segment. With the "book now" button the whole trip was booked, reserved and necessary tickets bought from the providers. The secure, cash-free payment process runs completely in the background. After the payment is authorized the tickets will be directly shown within the Smile App. The app was developed and tested for Android 4.1 or higher[29]. Smile separates the use of mobility offers from prompt payment which reduces experienced barriers of using intermodal or multimodal mobility offers. Central accounting does not only help the customer to get an overview of mobility activities but also helps companies gathering tickets for business trips. Furthermore it enables the usage of the entire range of public transportation. The transaction structure is further illustrated below.

Key Lessons for Poland

112. The Dutch example is relevant for Poland in a scenario where (a) multiple operators exist with their own desire to differentiate their services; (b) an existing set of paper tickets and non-interoperable smartcard tickets issued by operators; and (c) a desire to make smart ticketing interoperable on a national basis. Whether a national interoperable smart ticketing system for all forms of public transport is the approach that Poland wants to take is something that needs to be discussed and agreed with the various stakeholders. The Netherlands differs from Poland in the following key respects: the ticket supplier market is more mature and there are fewer operators involved. The latter is particularly important, as the more operators there are, the more complex the negotiations to agree on a common interoperable specification. Were such an approach to be considered the right way forward, there are many lessons to be learned from the Netherland's experience, but the key lessons include the following:

- **Central body**. There needs to be a central body willing to own and drive the specification and oversee the implementation of the ticketing solution including leveraging economies of scale, for example in back office; to achieve interoperability in Poland a central body is needed to take the lead in the specification;

- **Interoperable specification**. The specification needs to focus on the desired ticketing products and the enablement of efficient customer payments and fare collection not just re-producing the existing paper system. Delivering efficiencies in ticketing for both operators and the central body is important—there needs to be a clear specification for the ticketing products that would be paid for by an interoperable payment account. An open specification that is freely available is preferable. It is not advisable to allow the supplier of the system to overly influence the specification of the system;

- **Operators**. It is necessary to have strong operator support and adoption for the system, particularly on operational issues to ensure a common user experience across all modes; Placing integration risks on the operators should be minimized;

- **Procurement**. Procurement and implementation can take a long time, over 5 years. It is necessary to keep all stakeholders on board over this period. Where there is strong regulation and technical control, the project can proceed at a quicker pace.

113. The British approach holds a number of lessons for Poland and may be closer to the situation in Poland, where there is a fragmented public transport operator market for non-rail transport. The lessons that Poland can learn from the UK are: (a) identifying a clear vision for interoperable ticketing. ITSO has a remit to deliver this; (b) create an environment that is collaborative and encourages all operators to work together; currently in the

[29] http://smile-einfachmobil.at/index_en.html

UK deregulation does not encourage co-operation and makes the possibility of an interoperable smartcard solution unlikely; (c) incorporate technology changes into the specification to enable systems to evolve. The ITSO specification is reliant on technology developed in the 1990s. Work has been ongoing to extend the specification to incorporate HCE/NFC, but ITSO is still wedded to ticket sales, so a common PAYG solution is a long way off,[30] and set up a central certification process. ITSO acts as a central authority to approve all equipment connected to the ITSO system. This ensures interoperability.

114. The Korean smartcard standard was a result of central government involvement, the creation of an organization to oversee a national vision for AFC, and the key role of the metropolitan government of Seoul. This is a much more centralized approach than that of the Netherlands or London, and may be less relevant for Poland.

115. In contrast, Vienna's pilot of integrated mobility platforms using a smartphone app may be an important option for Poland to consider, given the high penetration rate of mobile telephony, and the fact that it does away with the need for an interoperable smartcard standard, as required by the London or Dutch approach. This is much quicker to implement than introducing a national smartcard standard, and would make multi-modal transport crossing local municipalities possible, an important objective to make public transport more attractive vis-à-vis passenger cars. The World Bank believes that though this is a less well-known example, it one worth studying and considering by Polish stakeholders, and could position Poland at the vanguard of urban mobility solutions.

on an Near Field Communication (NFC)-enabled device without relying on access to a secure element. NFC is a set of communication protocols that enable two electronic devices, one of which is usually a portable device such as a smartphone, to establish communication by bringing them within 4 cm (2 in) of each other.

Conclusion

116. Examples from other EU member states have been included in this Report to illustrate past experience that Poland can learn from. The introduction of an interoperable AFC system is more than a simple IT project, it is a large scale change project that will impact significantly across all aspects of a PTOs operations. Once this is understood, it is possible to develop a clear a vision as to what the system must deliver and with the agreement of all stakeholders, an implementation plan can be put in place.

117. Positive experiences of implementing smart-ticketing included:

- Higher than expected uptake rates, and a more modern, efficient public transport system, leading to improved business cases;
- Reduction in the level of fraud through direct fare evasion or misuse of the wrong ticket, leading to improved business cases and efficiencies;
- A chance to reassess existing fare structures, and more efficient management of concessionary fare schemes;
- Faster ticketing processes for the passenger, who favor the new technologies and find smart-ticketing easy to comprehend and use, particularly for those schemes which adopted auto-reload functionality (where the user's balance automatically tops-up when the credit level drops below a pre- specified limit);
- Seamless travel across modes (urban public transport and rail) and across regions and within or between functional urban areas; and
- Reduced cost of AFC system through economies of scale.

118. There are a number of challenges of implementing smart-ticketing interoperability including:

- Dealing with a vast network of PT operators, stakeholders, technology suppliers, funding bodies, legislative procedures etc., just to get the smart-ticketing scheme off the ground
- The timeframes required to deliver complex, technological products, particularly when third- party suppliers were involved and technological delays pushed back full implementation
- The financial investment and human resources required from the outset, plus identifying suitable funding sources to provide enough capital and ongoing revenue to make the scheme a success
- Dealing with expectations of the traveler when schemes became part of their everyday life, or when other schemes in a region offered different services not available to them
- Integration of a scheme across different modes or multiple PT operators, particularly where transport services are not under direct government control
- Initial marketing of smart-ticketing to establish its identity with the passengers, including those who would not be regular or familiar users of the system (especially tourists)
- The publicized security breach of the Mifare encryption meant that schemes using cards of this type had to mitigate against any possible security concerns in their own systems

119. To overcome potential barriers, a smart-ticketing scheme requires a strong network of stakeholders, all with common goals or aspirations to deliver an integrated product from the outset of the project. Good management is essential in keeping all partners round the discussion table, but quite often a large amount of time and resource is needed in order to resolve significant disagreements or other issues between partners.

120. Technology advances in recent years mean that there is a move from delivering automatic fare collection via card based form factors through bespoke transport solutions towards a more retail based focus on payments. This is particularly evident in urban environments, whereas in longer distance rail travel there is a move to use mobile devices with 2D barcode technology, similar to the airline industry.

121. These new technologies are moving the focus away from buying tickets, to paying for a service. Instead of a passenger carrying a ticket on a standardized smartcard, as with ITSO or the *OV-chipkaart*, it is now possible just to pay for the journey using a bank issued payment card which is used to identify the passenger to the system, so called Account Based Ticketing (ABT).

122. The standards as currently developed in places like the UK and the Netherlands need to evolve to cover this approach, and indeed there are projects underway in both the UK and the Netherlands to investigate the use of ABT. However, there is still a lot Poland can learn from countries such as the UK and the Netherlands in their approach to implementing national schemes and the setting up of organizations to create a vision for national interoperable ticketing, which is currently lacking in Poland. This does not mean that Poland needs to copy the approach taken by either of these countries, as their solutions were developed at a different point in time in terms of the existing technologies available.

123. The scope of these existing standards covered a wide spectrum. There was a need to define the data formats for the tickets and also the communications between each layer of the system amongst other things. Migration to mobile platforms has been evident in the finance sector, and through pilots on public transport over the last 10 years has changed this approach. Now an AFC system can be built up from existing standards from new technologies such as mobile devices and bank issued payment cards, the data requirements for the ticketing products can be extracted from current AFC specifications.

124. Development of interoperable solutions based on the existing systems may be difficult. The most frequent obstacles in this case include:

- binding contracts with suppliers of systems that make taking actions impossible until the end of validity period of the “old” contract,
- high new software development costs,
- limitations of the electronic card as the carrier of tickets,
- lack of knowledge on modern solutions applied in other cities and countries; difficult access to consultants and professional papers,
- obstacles of organizational or political nature.

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Migration Paths to Ticketing Interoperability

125. **Mobile ticket applications**. Mobile ticket applications seems to be the simplest path of migration to ticketing interoperability in Poland, in particular in the situation when public transport organizers issue their own electronic cards based on different electronic systems. Mobile ticket advantages: (a) redundancy of the sales network (like in case of the p-tickets) and loading (like in case of the e tickets); ease and speed of creating new common tickets as well as promotional tickets. Transmission of the m-ticket to mobile devices does not

require reconciliation of the electronic card map; and (c) ticket in the paper format – possibility of printing the ticket by the passenger.

126. The conditions for implementation of such a solution include the following: (a) assuring identification of the mobile ticket by controlling devices of all the entities participating in the integration. This means the necessity of equipping each controller device with the QR code scanner and NFC reader;[31] (b) processing data concerning the identified tickets in all the systems that are to be interoperable, e.g. the urban system and the railway system; (c) check-in or check-in & check-out required in case of all trips, in particular in case of changing the mode of transport, e.g. change from the regional railway to the urban bus. Control devices should be equipped with QR code scanners and NCF readers. If the control devices are positioned outside the public transport vehicle (e.g. on railway platforms) then it will be necessary to assure data transmission from those controllers to the control devices in vehicles (the conductors' team or ticket controllers in urban public transport).

127. The market in Poland in which local companies with established position and relatively high turnovers allowing development as well as new companies entering the market are present is supportive to building such solutions.

128. **Fare collection based on bank issued proximity pay cards**. Building the central transit transaction system represents a more difficult path. Such a system has recently been initiated in London by Transport for London. Works are in progress on the system in Budapest and many cities worldwide would like to follow the same path. The proliferation of proximity pay cards issued by banks as the method of payment for tickets and at the same time the carrier of the periodic ticket will decrease system operational costs and risks significantly. At least two companies operate in Poland that have suggested they are ready to develop such systems.

129. The following recommendations are proposed:

- **Establish a technical working group to develop a vision for AFC in Poland.** Such an organization should work with public transport organizers, operators, and industry to agree on a national vision or roadmap for the future with regard to interoperability.

- **Support EMV and Smartphone Apps developments for public transport and determine what is achievable over the medium-term years**. With the development of mobile and financial services technologies happening so rapidly, there is a need to ensure that the basic infrastructure is in place to benefit from this evolution. By WiFi enabling all stations, or ensuring 4G services are available across the country, the opportunities from mobile technologies can be more easily realized, and operational costs could be reduced. This is likely to be implementable much more quickly than a national interoperable AFC standard.

- **Work with major payment card issuers** to develop specifications for the use of payment cards using EMV based standards on the Polish rail network. Look at developing specifications for mobile devices, as well as card based form factors, and potentially incentivize the use of EMV cards in public transport.

- **Work with PTAs and PTOs to agree the vision nationally**. The organization identified in 1 above, will have to work with all stakeholders in Poland to clearly articulate the vision for interoperable Automatic Fare Collection and outline what interoperability is required from systems in Poland

[31] QR is the square, black and white matrix symbols which are 2 D barcodes that a mobile device can read.

- **Do not develop own standard, look to existing standards**. Current standards cover AFC technologies that have been developed since 1997. New systems make use of mobile and finance sector technologies. Poland should look to build on existing standards, but incorporate new technologies to capitalize on the benefits the new technologies will bring.

There is the potential to build on the new systems, such as those implemented in Świebodzice, and develop an interoperable standardized system for Poland that builds on the benefits of smart media for passengers and operators alike. With the development of new technologies there is the potential for Poland to be at the forefront of developing standards for the next generation of smart ticketing systems that will be implemented.

- **Develop migration plan to get to desired final system**. There are numerous legacy systems in existence that will be fast approaching their end-of-life. A plan would need to be in place to enable these systems to be included in any future specification development and migration to a new system.

- **Undertake a public transport fare review to maximize benefits from the new system, taking into account benefits for passengers**. It is often said in this industry that there is little value in taking the existing fare products and placing them on a new fare media. If this happens then it becomes very expensive, as the operator is not gaining the full benefit of the new technology. For example, in London PAYG has replaced all single tickets on the bus, and a significant number of travel cards, because the new technology enabled the service to be offered. The fare review would maximize the benefits from introducing a new system, both from the perspective of the passengers, and from public transport operators, as it could create enhanced opportunities for revenue generation.

Annex 1: Introducing Public Transport AFC Standards

Introduction

In order to implement a standardized, interoperable AFC system in Poland there needs to be a clear vision as to what the system will achieve. A vision defines an organization's business and purpose, and communicates the desired future state of the organization. The vision provides focus for all the stakeholders on why we are doing what we are doing and keeps everyone on track toward the future state. The stakeholders could include all levels of government, public transport authorities (PTAs), public transport operators (urban and rail), equipment vendors, passengers, payment providers, communications providers, as well as bodies such as the Chamber of Urban Transport. The vision emerges from three sources: experience, knowledge, and inspiration, as detailed below:

1. **Experience**
   - **Organizational** – areas where the organization wants to improve, or can see opportunities to reduce costs, or increase customer service
   - **Staff** – staff understand the operations of fare collection systems best and are in a position to provide input to areas where improvements are necessary
   - **Global** – experience from other schemes where new technologies or processes have been introduced that can be replicated
2. **Knowledge**
   - **Market, business, and trends** – as AFC moves away from being transport specific as technologies in other sectors are becoming applicable there is a need to keep abreast of technology trends and assess their application to the AFC market. The transport business is also changing significantly and there is a challenge to deliver with fewer resources, so managing their use efficiently is paramount. There are trends appearing in the mobile and payments markets that are transitioning into transport, with NFC and contactless payments being most obvious. However, there is increasing use of apps for journey planning and delivery of 2-D barcode tickets in public transport, similar to the airline sector. These trends will have significant impact on public transport in the longer term. PTOs need to embrace some of these changes as it can reduce barriers to using public transport if payment for services is easier.
   - **Resources and skills** – AFC projects are major change projects for any organization. They can bring together several industries, mobile, payments, transport, IT, finance in order to deliver systems. Having access to resources to help co-ordinate these organizations to enable each party to understand what is required, and the needs and limitations of other sectors.
3. **Inspiration**—pulling current facts into the future. AFC systems are not cheap, so there is a need to understand the long term, 5-10 year, changes to technology that may impact on the AFC system. The vision should take these into account.

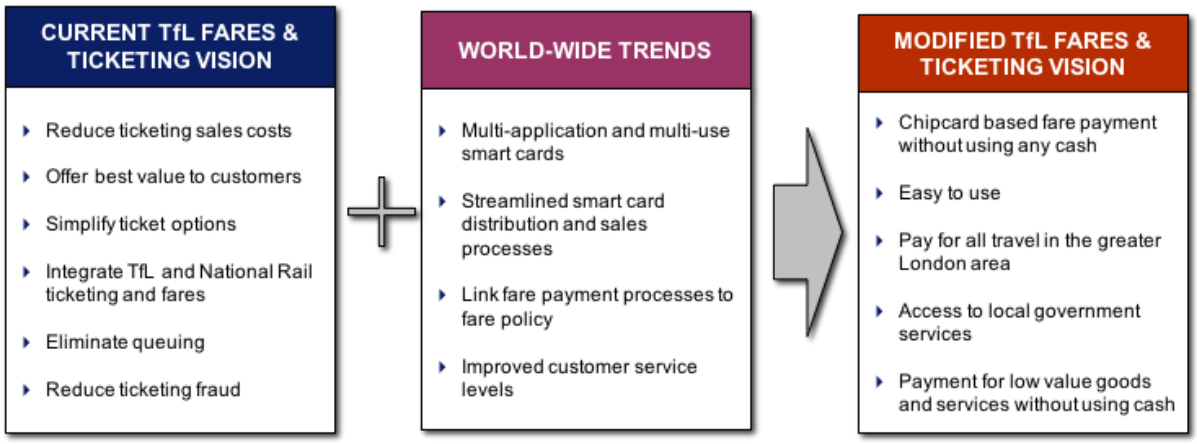
There are six key attributes that can contribute to the long term success of a vision:

- **Realistic**—can all stakeholders see the "end zone"?
- **Simple**—can the vision be easily understood and remembered?
- **Sustainable**—does it have a shelf life?
- **Straightforward / doable**—does it have credibility?
- **Organisationally linked**—does it fit with the organisation's mission and vision umbrellas?

- **Compelling**—does it cause all stakeholders to feel good about the future?

Using the above process, it should be possible to develop a clear vision for AFC in Poland. The figure below shows the output when the process was applied to TfL as they developed their vision for Oyster over 14 years ago.

Figure 13: Development of TfL Vision for Oyster



Sources: TfL, World Bank.

Specification Development

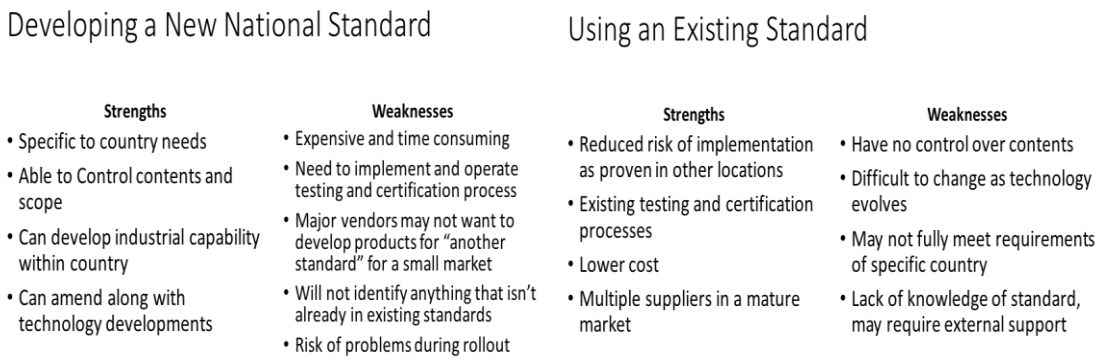
Several countries and cities have gone about this in different ways. Some have developed a specification and then implemented it, as in the UK, German, and Korea. Alternatively, a system can be implemented which then becomes the standard, as was the case in the Netherlands, and is being implemented in Colombia. Each approach has its strengths and weaknesses. However, there is no approach that suits all situations, so each country should determine what suits its vision and approach the best.

Regardless of the approach adopted there needs to be a level of interoperability incorporated in the specification to allow the benefits of cross region or countrywide coverage to be implemented as determined by the relevant authority. For example, in Germany and the UK there are stringent testing and certification processes necessary for each vendor who wants to sell equipment into the national AFC markets. These tests are undertaken with respect to a published specification produced by *Verband Deutscher Verkehrsunternehmen* (VDV; Association of German Transport Companies) and ITSO respectively.

In the Netherlands the approach is the same in that equipment is certified against a specification that was developed by the initial contractor, Thales. However, in the early stages it was noticed that when third party vendors attempted to build equipment based on the published specification it was found that they would not work in the field. This was because the published specification did not reflect the system in situ. This has since been resolved and the specification reflects exactly what has been implemented and so PTOs can be confident that equipment built against the specification will work as required.

An important question to ask is what specification should Poland use or should it develop its own specification. The answer to this is it depends. At first reading that might not seem a very helpful answer, so further explanation is necessary. Looking at the results from a SWOT analysis below will clarify this.

Figure 14: New National Standard versus Existing Standard



Source: World Bank.

The way public transport is provided in each country, region or city varies across Europe and the world. There are some countries where transport is controlled by central, regional and city governments. There are also different approaches to the regulation of PTOs, with private, public and franchising models all existing, in some cases, within the same country leading to regulated and deregulated environments.

Alongside this political environment there will be, as in Poland, multiple schemes that already exist which are incompatible. This rainbow of political and technical environments means that picking any one standard that can address all of the local issues or fully meet the defined vision will be, arguably impossible. However, each of the major standards has identified a range of functionality that is necessary for interoperability of AFC systems which can be said to be generic to all schemes. It would seem sensible to incorporate this functionality, but look to add additional, local functionality as necessary to meet national requirements and political environment.

The idea that Poland can develop its own specification should not be considered on grounds of cost, as it will be expensive, estimates are that the ITSO standard in the UK has cost several tens of millions pounds sterling over the last 15 years and there is no national interoperable system in place yet. There is also the need for a test and certification process that needs to be administered and delivered. Individual vendors will have to design completely new devices to meet the new standard, with only a limited market, unless other countries can be encouraged to adopt the Polish standard. Given that VDV has only recently managed to provide a system to Luxemburg, and ITSO has not managed to encourage any external countries to adopt its specification, means Poland is also likely to struggle. Calypso has been the most successful, as it was initiated via a European funded project comprising multiple cities from several EU countries, who adopted the system.[32] But the Calypso specification only relates to the card reader interface and not the complete system as the ITSO and VdV specifications do. For this reason, it is important that the vision is developed and is accepted by all stakeholders, then the appropriate specification can be developed.

With the trend towards account based ticketing there is a significant simplification of the requirements for contactless readers, as a token is presented that identifies the user as having travel rights. The details are worked out in the back office. In this case there is only a need for the system to recognize different ID tokens, which can range from proprietary cards such as Oyster, CPC or bank payment cards, or PIV cards as used in Washington DC. In this case standardization of data for AFC systems becomes unnecessary as only the token data is transferred.

[32] Calypso is an international electronic ticketing standard for microprocessor contactless smartcards, originally designed by a group of European transit operators from Belgium, Germany, France, Italy and Portugal. It ensures multi-sources of compatible products, and allows for interoperability between several transport operators in the same area.

Additionally, with improvements in the 3G/4G mobile network it is possible to locate passengers better and so mobile devices can be used to locate passengers, making passengers need to physically check in and out through a gate unnecessary. With the rollout of 5G in the next 5-10 years this becomes more of a reality. What this means is as technology advances the need for specific AFC standardization decreases to some extent. However, a debate rages within the industry over the difference between ticketing and payment systems. This Report is not the place to discuss the details of this, but as identification technologies start to take hold there becomes less need for physical ticketing with everything being held in the back office, and the future standardization landscape changes significantly.

Gap Analysis of Current and Existing Systems

As stated earlier in the Report, there are numerous systems in existence in Poland which are proprietary and have no interoperability. In order to unify these systems, it will be necessary to review their functionality. Where there is a decision, as in the Dutch and Colombian situations, to build upon an existing specification, it will be necessary to analyze the specification to remove any proprietary aspects so third parties can build equipment that meets the specification. More importantly, for reasons stated earlier, it is necessary to determine that the specification reflects the reality of the installed equipment. For the approach where a new specification is being developed there will be a need to analyze how the current installed system deviates from this specification. The output from either of these streams should be the same in that there will be a key list of issues that need to be addressed and system changes necessary to meet the new requirements.

Migration Plan

Based on the output of the gap analysis a migration plan can be drawn that highlights the key issues that need to be overcome in order to migrate the existing schemes to the new vision for AFC in Poland. As part of the migration plan there will be a rollout plan. Experience has shown that there are multiple ways to roll out AFC systems, but what is common with all of them is the clear need for leadership. In particular resolution of issues that cause delay will tax the leadership of AFC rollouts. There are four different models that can be considered when rolling out an AFC system, based on different institutions taking the lead. These are:

- **Public Transport Authorities led**. In Sweden the PTAs are working to implement an e-ticketing system, however, each PTA has its own system currently in operation and is claiming that the standard should be based on their system. This has led to deadlock for the last 8 years and will need legislation at a national level to break the deadlock.

- **Public Transport Operator led**. In the Netherland e-ticketing was started by the PTOs, but with the Dutch Passenger Transport Act of 2000 introducing PTAs the latter have had a significant influence in the development of e-ticketing.[33] This approach is to the advantage of the PTOs who developed the system to meet their needs. In situations like this it is usually the largest PTO who determines the requirements for the system. If there is no buy in from all parties then progress will be slow, as was the experience in Austria.

[33] The act introduced PTAs for the first time which altered the organization of public transport in the Netherlands and influenced the development of the e-ticketing solution.

- **Regional government led**. German approach, with all large transport related decisions made by the *Länder* (regional states) who adopted a regional implementation strategy of a specification agreed by the association of PTOs, the VdV. Public funding was not made available to cities that wanted to adopt non-standard e-ticketing systems. Economies of scale also enabled the cost of implementation to be reduced as procurement was centralized, so smaller cities benefited from the larger volumes purchased.

- **National government**. In the UK the Department for Transport (DfT) has been taking the lead for the last 15 years in the development of the ITSO specification. Outside of London the deregulated PTOs were encouraged to implement ITSO, but they could not make a positive business case and so to date progress has been slow. However, the major bus operators have implemented ITSO, thanks to financial support from the DfT, and the rail network is currently mandated to implement ITSO through the new Franchise Agreements that are currently out for tender. The expectation is that by 2025 the entire UK rail network will be ITSO enabled, 25 years after the specification was developed.

It is clear from the models and examples described above that regardless of who leads there is a need for the national government to break the deadlock in some cases to make sure that implementation occurs. In Poland it is not clear who could lead the implementation of an AFC system. For it to succeed this needs to be clear from the outset.

Organizational Issues

As the interoperability model shows, the first step toward creating an interoperable smartcard payment system is to identify the institutional requirements of the participants. Fare payment interoperability, regardless of technology used (e.g., smartcard, paper-based, or magnetic stripe) requires significant planning and cooperation among the participating agencies. In the public transport sector, PTAs have traditionally operated autonomously. Each agency's organizational cultures, policies, procedures, and fare-collection equipment are different. Transit agencies considering implementing an interoperable smartcard fare payment system must address numerous institutional and technological issues that may create barriers to implementation. The institutional issues can be categorized as follows:

- **Management and Organizational Issues**—Organizational cultures of the participating agencies and their effects on management decision-making processes;
- **Financial Management Issues**—The need to ensure that each participant does not lose revenue through participation;
- **Equipment Design Issues**—Ensuring equipment interoperability as an aspect of system design; and
- **Public Transport Industry Issues**—Dealing with the behavior of traditional system suppliers.

Management and Organizational Issues

One of the most significant challenges to interoperable smartcard fare payment systems implementation is how the existing organizational cultures affect the participating organizations. Creating an interoperable fare payment system requires participating organizations to work together. Organizations that may have had limited or no previous interaction must work closely with one another for program direction and control. Key management and organizational issues that need to be addressed on the road to interoperability include:

- Establishing a governing body or project sponsor;

- Identifying and mitigating operational differences;
- Establishing a framework for program funding;
- Creating a rollout schedule; and
- Developing a contracting strategy.

Establishing a governing body or project sponsor. One of the primary challenges of implementing an interoperable fare payment system in a multi-operator environment is encouraging organizations to work together for the overall good of the region and passengers. One of the first steps in implementing any regional fare payment system is to establish a governance structure, which will identify the institutional oversight structure and define the following:

- Items under regional control;
- Documentation of the governing structure; and
- Participant representation.

The governing body oversees the common elements of the interoperable fare payment system, which may include third-party services. Table 4 lists the different types of governing bodies. Participation in a governing body may require an organization to cede complete control over the common elements of the interoperable system. Even agencies that have an excellent working relationship may find adapting to a common governing body challenging.

Table 5: Overview of Different Types of Governance Bodies

Approach	How it Works	Where used
Corporation with Privately held Shares	Private Corporation • Shareholders include private and public PTOs • Shareholdings vary by organization • Not all members are shareholders	Hong Kong The Netherlands
Single Operator Owner	Owner makes decisions • Contract outlines specifications and obligations • Others free to join, but have no say in how scheme is run	TfL, London
Joint Powers Authority (JPA)	Independent legal entity • Created under powers of existing public entities • Composed of public entities	Singapore
Memorandum of Understanding (MoU)	No new organization • Specifies decision making and participation • Contractually created governance structure	Los Angeles Seattle San Francisco Washington DC

Source: World Bank.

The planning and implementation of a smartcard-based interoperable fare payment project is a long and often difficult process. Once the governing body is established, a project sponsor needs to emerge to direct the effort and provide leadership for the participants. It is critical that the full commitment and support of the member agencies are obtained and that a clear management structure is in place before starting planning and design.

Identifying and mitigating operational differences. Another challenge PTOs face during the implementation of an interoperable fare payment system is the differences in the way the participating PTOs conduct business. For example, many of the largest organizations have extensive internal capabilities, including technical and operational resources to support most, if not all of their design, operational, and maintenance needs. The trend to consider outsourcing to fulfill these same needs is increasing. Organizations that have extensive in-house

resources tend to prioritize more control over their operations; thus, those organizations tend to avoid outsourcing. The different organizational operations philosophies of the agencies must be examined, and compromises must be reached. There are two primary dimensions for implementing the system-related service functions of an interoperable system: (a) centralized, where one entity performs all the functions; and (b) decentralized, where each participating entity is responsible for performing its own functions according to established business rules. The project sponsor must decide between a centralized or decentralized approach and must also decide whether the services are delivered using in-house or outsourced resources. The operational philosophies of the participating organizations will determine the approach used for performing card-system-related functions.

Establishing a framework for program funding. Interoperable fare payment systems require a substantial capital investment for equipment and systems. Funding for a project of this magnitude will likely come from multiple sources because of multiple organizations' participation. The challenge with multi-jurisdictional funding is to arrive at an equitable formula that each of the participating agencies can endorse. Project funding requirements need to be determined early in the project life cycle to provide adequate time to meet the requirements for securing the funding. Member agencies also need to evaluate the benefits derived from the capital investment. The cost-benefit analysis helps to identify expensive features that do not create value. However, regional systems need to be sufficiently flexible to scale as the participating agencies needs change and grow more sophisticated.

Development of the business case is critical in defining the funding strategy. The business case identifies the estimated capital and operating costs for the project and possible future expansion of the system. At a minimum, the business case consists of the following parts:

- Estimated capital cost of the system;
- Existing operating costs;
- Operating and maintenance costs after system implementation;
- Schedule for implementation;
- Risk factors;
- Initial operational cost (start of revenue service); and
- Regional/management/lead agency oversight, administration, and management.

Identifying specific funding sources for the interoperable fare payment project starts when the preparation of a business case is completed. The completion of the business case provides the basis for determining the relationship of capital investment balanced against long-term operating costs. Once the specific sources of funding have been identified, funding agreements between the participating organizations need to be created. The inter-agency funding agreement establishes the level of capital investment and operating funding for which each participating organization is responsible. A commonly used strategy for allocating costs is to have each PTO responsible for the deployment of its respective interoperable system components and to share operating costs based on use of the shared system components.

Creating a rollout schedule. An overall project rollout schedule must be developed that details milestones for design, equipment production, testing, and implementation of the interoperable fare payment system across the participants. The rollout schedule is a critical component of operating cost. Because transaction processing and shared service, such as operating a call center, is a transaction-based business, the higher the volume, the lower the cost per transaction or call, respectively. The guiding principles to consider when developing the rollout schedule include:

- Realistic milestones reflective of actual experience,
- Ability to fit within contractors' capabilities,
- Ability to be supported by the participating agencies,
- Customer reaction and acceptance to change, and
- Schedule changes in response to changing customer needs.

System rollout can follow one of two approaches:

- *Phased*. Different PTOs and functionalities are brought online at different times. This approach is the most common because the disruption caused by passengers having to learn a new behavior is isolated to a specific area and thus is less resource-intensive to manage. This approach was adopted in the Netherlands where a single rail line near Rotterdam was implemented first and then other modes and areas brought online

- *Full rollout*. All PTOs and equipment are brought online at the same time. This approach requires extensive testing and careful preparation to successfully launch. In addition, significant resources are required to manage the first days of operation. There are limited examples of this approach, due to its high risk.

The phased approach is typically adopted when procurement is split among multiple supplier contracts. Risks associated with a phased approach include the possibility for passenger confusion when the system works for limited PTOs or has limited capabilities. Additionally, a phased approach needs to consider PTOs that share existing fare products such as a period pass. The rollout of these PTOs will need to occur simultaneously to avoid affecting passengers who use the common fare product. Although it is more passenger friendly, a full system rollout is more likely to disrupt operation for the PTOs. Project resources must be spread over a wider range and are less able to focus on those areas that may experience issues such as high degrees of confusion and lack of patron education. Additionally, unlike a phased approach, a full rollout does not afford the benefit of lessons learned from the earlier implementations.

Other issues that will affect the scheduling of the interoperable project include the (a) availability of staffing resources; (b) availability of financial resources; (c) PTO operations; and (d) passenger education and orientation.

Developing a contracting strategy. Participating PTOs need to determine and agree on how the equipment and services will be procured. The main contracting challenge is deciding whether to procure the equipment and services under a single contract or through multiple contracts. Each approach has challenges that must be overcome, and the selection of the approach will depend on factors such as an organizations appetite for integration risk, the availability of technical and project management resources, and the level of equipment and services to be procured. The most common contracting strategies are single procurement and contract, multiple procurements and contracts, and contract type selection.

Financial management issues. Financial integrity is the highest priority for any agency participating in an interoperable fare payment system. This section discusses the key financial management decisions and issues that must be addressed, including (a) transaction clearing and settlement; (b) funds pool management; and (c) financial exposure risk associated with advanced features. In a fare payment program where multiple operators are selling fare value accepted by more than one operator, transaction clearing and settlement allows each organization to be reimbursed for the services provided, regardless of where the fare product is

purchased. Again, the challenge is obtaining agreement from all participating organizations on an approach to transaction clearing and settlement.

130. The funds pool is created as a result of revenue collected (card loads) but not yet used in the system. The funds pool may be in a central account managed on behalf of the participants or it may be a "virtual" funds pool where each organization holds its own share of the total amount. Examples of how the money within the funds pool can be used are:

- Periodic movement of funds between member organizations to compensate for fare payments, purchases, or loads by one participant's cardholders on another participant's system;
- Periodic payment of transit services used by cardholders; and
- Coverage of charge-backs for transactions that should not have been posted.

Revenue is generated by investing the funds pool float—interest earned on unallocated funds—contained within the funds pool.

Industry impact. One of the primary challenges posed by existing equipment designs is to find a way to procure interoperable equipment from multiple vendors in a competitive manner. The goal is to build a fare payment system that conforms to open standards or specifications, uses existing infrastructure, offers flexibility to scale, and adds functionality as needs develop. Thus, open standards and specifications will enable the participating agencies to add equipment and functionality competitively and use the open platform to establish new opportunities for partnerships with non- transit applications. A secondary challenge for the member agencies is to determine the degree to which legacy systems are either upgraded and integrated into the new interoperable fare payment system or replaced with new equipment. The cost to replace may be less than the cost of upgrading and integrating legacy systems. The age of legacy systems and their incumbent technology are key factors in the cost of upgrades. Each organizations' legacy equipment will need to be reviewed to determine whether it can be upgraded to the new technology and industry standards of the interoperable system.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