Study on electronic ticketing in public transport

FINAL REPORT

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Objectives and scope of the study

EMTA has established a working group[1] to work on the issue of electronic ticketing. This group is mandated to generate knowledge, exchange/compile information and learn from the experience of its members in the field of electronic ticketing. In this framework, EMTA has launched a study on electronic ticketing in public transport under the supervision of the working group and with the assistance of Mohamed Mezghani, public transport consultant.

The study has the following objectives:

- To collect and analyse the relevant information related to the **state-of-the-art** of e-ticketing (in particular related to the group member's networks)
- To discuss the different **components** related to the development and implementation of e-ticketing systems
- To understand the key aspects supporting the **decision-making** process when developing and implementing e-ticketing systems at all levels: political, organisational and operational.
- To analyse the **business model** of e-ticketing

The study is being carried out according to the following steps and time schedule:

- Inception phase: refine objectives and scope and discuss basic notions related to pricing and ticketing
  1st WG meeting (Inception report): 11 October 2007

- Collection phase: compilation of information dealing with the main issues of the study in WG networks and others
  2nd WG meeting (Progress report): 21 January 2008

- Analysis phase: Discuss the general context and each of the e-ticketing issues in order to highlight benefits, constraints of implementation, obstacles, role of actors, etc and draw recommendations
  3rd WG meeting (Draft final report): 31 March 2008

- Presentation of the study results
  EMTA General Assembly: 18 April 2008

- Final report and
  summary leaflet for decision-makers May 2008

[1] *The working group is composed of representatives from STIF (Paris), YTV (Helsinki), ATM (Barcelona), CTB (Bilbao), TfL (London), MESP (Vilnius), CTM (Madrid), CENTRO (Birmingham), SL (Stockholm), ATM (Montreal) and RMV (Francfort) and EMTA Secretariat.*

Public transport pricing and (e)-ticketing concepts

1. Public transport pricing

The price of product or a service is its exchange value. In public transport, it is the exchange value of a journey (one or more trips). 'Price' and 'fare' are equivalent.

A price policy includes all actions to influence and set prices, while a tariff is an overview of all the different prices that one network offers.

Price elasticity is the quotient of the demand change in percentage and the price modification in percentage.

In principle, the level of fares should be such that the total revenue earned by a public transport service is sufficient to cover the total cost of providing it plus a reasonable profit. This principle would be fine if public transport was operated as a fully commercial service. But this is not the case in the majority of cities/regions where public transport is at the authority's initiative and is implemented pursuing social objectives. Consequently, public transport price policy should find the right balance between several sometimes contradictory objectives:

For the authority
- Increasing the number of citizens using public transport
- Setting low prices and simple tariffs
- Balancing prices and encouraging social inclusion
- Minimising public subsidies or financial compensation

For the operator
- Covering costs and maximising profit
- Building an attractive public transport system (image, loyalty)

For the passenger
- Minimising transport cost
- Travelling in 'good' conditions

Thus, the greatest challenge for a pricing policy is to determine a tariff structure that reconciles the user's need for an affordable public service with the commercial interests of the operators, while at the same time pursuing the authority's social objectives.

Decision-making about fare levels varies from one city to another. There are generally three situations:

1. Authority's decision: the authority decides, and the operator has no formal role or only has the right to be consulted.
2. Operator's proposal: fares are decided on the operator's proposal, and this proposal requires the approval of the authority.
3. Operator's decision: the operator decides, and the authority has no formal role. This situation is particularly observed in open market regimes.

Even if the user is not involved in the decision-making process, he/she influences it indirectly because fare levels take into account affordability for the user. A high fare level will be perceived as anti-social and will reduce public transport use, unless it is part of a voluntary marketing policy targeting high-income people.

The term "price discrimination" can be used to refer to all types of deviation from the practice of charging an identical fare for all passengers and trips. In this respect, price discrimination can be divided into two categories:

- Journey-based price discrimination
- Passenger-based price discrimination

Journey-based price discrimination reflects a situation where the price depends on characteristics of the journey (such as time of travel; distance travelled; or mode). Journey-based price discrimination can be seen as cost-reflective pricing: some modes cost less to operate than others; off-peak services are cheaper to provide than peak services; it costs less to cater for short trips than for long ones.

Journey-based fare structures can be split into the following categories:

- *Flat fare*: This is the simplest system in which all passengers are charged identical fares regardless of route, distance travelled, or type of passenger. This system fits well in a situation where a majority of passengers travel approximately the same distance. Flat fares are more equitable in a city in which the richer passengers live nearer the city centre and poorer people farther out, since the former would pay a higher rate per kilometre than the latter.

- *Route fare*: each route has its own fare. This system is often applied in cities where franchises are granted per route. The challenge is to ensure equity between city areas and according to the length of routes.

- *Zonal fare* (network based or route based): the network is divided into zones - with a flat fare within each zone - and the price is determined according to the number of zones crossed by the passenger. It is not equitable for passengers travelling short distances across two zones as they have to pay for two zones.

- *Distance-based fare*: a price per km is applied. Usually, each route is divided into fare stages, with a clearly identifiable boundary point for each stage. The spacing of the fare stages may be varied to reflect differences in operating costs or different demand characteristics, on different sections of a route. Such system may be considered to be reasonably equitable, since the fare for each journey is related to the distance travelled. The

finer the fare scale, the more equitable it becomes, provided that the distances between fare stages are consistent. In this respect smartcard technologies offer interesting possibilities for fares based on actual distance travelled.
However, a distance-based fare system is less equitable than a flat fare system, for example where low-income residential areas are located on the outskirts of a city, meaning that the poorest users pay more to travel to the city centre.

Passenger-based price discrimination reflects the situation where the price depends on characteristics of the passenger (such as their age or social status). Passenger-based price discrimination is often used by commercial companies as another means to segment the market and maximise revenue. In the case of public transport operators, however, it may be appropriate to consider this form of price discrimination as being socially (concessionary fares) rather than commercially motivated – at least in the case of discounts for captive passengers such as children and elderly people.

Concessionary fares include fares for:

- Children
- Pupils and students
- Elderly people and pensioners
- Disabled
- Unemployed people
- Police and army

Offering concessionary fares is often a legal requirement in many countries. In some cases, there are restrictions on the times when concessionary fares are available. For example pensioners may not be eligible for the concessionary fare at peak time.
Responsibility for funding concessionary fares often lies with the central or local government who must compensate the operator. However, the most equitable, transparent and effective means of providing such compensation is to subsidise the beneficiaries directly.

Based on all these considerations, fare structures will be more or less complex to implement and to follow-up. When defining a fare structure it is important to carefully consider the following issues:

- Ease-of-use for passengers
- Equity (types of users, types of trips)
- Simplicity of revenue collection
- Ease-of-control for operators
- Attractiveness to passengers
- Intermodality (transfer tickets)
- Simplicity of clearing and sharing revenues between operators
- Maximising farebox revenues
- Reducing fraud

2. Public transport ticketing

Ticketing is a tool for the implementation of a pricing policy with the consideration of operational, commercial and social objectives. The ticketing system is the translation of fares into concrete means of payment (for the passenger) and fare collection (for the operator).

Several types of tickets are used in public transport systems (ticket-based price discrimination). In other words, the price depends on the ticket type used. Ticket-based price discrimination is price discrimination in its purest form. It makes virtually no difference to an operator's production costs whether a passenger makes a trip using a single ticket, a carnet or a season ticket. Indeed, it costs the same for the operator to transport a student, an elderly or a passenger paying full fare. The use of differential pricing for such tickets is a way to segment the market and maximise revenue – 'airline-style pricing'.

Generally speaking, the following types of tickets are in use in public transport network:

- Single ticket: one journey (no time limit)
  - Zonal single ticket
  - Origin-Destination single ticket
- Single ticket: several journeys within a limited duration (ex: 1 h.)
- Single-mode / Single-operator ticket
- Multi-mode / Multi-operator ticket
- Return ticket
- Multi-journey ticket (5, 10, 20)
- Season ticket (day, week, month, year)
- Value ticket (Pay-as-you-go)
- Off-peak ticket / Night ticket
- Combined ticket (ex: Park & Ride)
- Group ticket / Family ticket
- Special event ticket

Ticketing media include:

- Cash
- Tokens
- Paper tickets
- Magnetic strip ticket
- Contact-based smartcards
- Contactless cards
- Mobile ticketing

Sales channels include on-board vehicles (usually only for single tickets), at vending machines, counters, retail shops, on internet, by phone or via affiliates.

Whatever are the fare structure and the payment scheme, for the passenger it is often the user-friendliness of the system that will be most important. In this respect, harmonising and integrating fares and ticketing will facilitate the use of

public transport. An integrated ticketing system is defined as one in which it makes no difference, in terms of price, if a passenger has to board more than one public transport vehicle to complete their journey. Fare integration provides an incentive to travel, because public transport is much easier to use and more accessible for travellers. New technologies (e-ticketing) can be a great help in implementing complex fare structure and fare integration while keeping the system easy to use.

3. Electronic ticketing in public transport

Four subsequent generations of ticketing systems co-exist in the world today and sometimes even in the same city:

- The oldest system of tokens or paper tickets is still widely used worldwide.
- The magnetic ticketing system that was introduced in the 70s, can be classified into two categories:
  - Ticketing with automatic belt drive (the most common format)
  - Ticketing with manual a sweeping motion of the ticket by the passenger.
- Contactless ticketing appeared in the 90s. The technology has many advantages and it is fast replacing the other two types of ticketing. Some public transport networks are replacing their first ticketing generation system directly by a contactless one, omitting the magnetic ticket generation stage. Contactless ticketing uses Radio Frequency Identification (RFID) or Near Field Communication (NFC) technology to establish a communication between the card and the validation device.
- Mobile ticketing systems based on the use of the passenger's mobile phone for the payment of travel cost. Mobile tickets are being issued using SMS (short text message) or mobile barcodes. The ticket selection is performed by sending an SMS to the background system, either accompanied by a specifying text or by sending it to a specific phone number for each possible ticket. An electronic ticket is then returned via SMS to the user. Users can also use mobile phones to purchase tickets in the same way as they do with contactless smartcards by placing the RFID technology into the battery casing of the device.

In public transport, e-ticketing systems are not only means of payment but process huge amount of information which offer a large range of possibilities to make public transport easier to use, to manage and to control. They offer as well opportunities to introduce integrated pricing structure that are not easy to implement with traditional payment tools. The table below lists these different possibilities.

Electronic ticketing technologies are classified according to the way they are used for payment. The closer the card is to the payment system, the more reliable the transaction is, but the more constraining it is for the user. Therefore, the long-term objective is for the customer to be able to pay for public transport without having to show or validate any card, relying on fully automatic fare payment

systems. In this context we can distinguish the following 'distance range' possibilities:

- *Contact-based* technologies are mainly based on a standardised communication between user devices (only memory or smart cards) and access systems according to the ISO 7816 standard.
- *Proximity* technologies are often based on contactless communications according to the different sub-standards of ISO 14443, which results in theoretical transmission distances of about 10 cm.
- *Vicinity* technologies are related to ISO 15693 and usually cover transmission distances of up to 1m.
- *Long-range* (or wide-range) technology requires a battery in the user device (card) and combines inductive coupling with radio frequency data transmission. While the first communication method is used to activate the user device when entering a transport vehicle, the second one allows contactless data transmission between all places within the vehicle and, for instance, electronic access components at its ceiling. The technology provides anti-collision mechanisms to prevent the collision of electronic transactions, as they may occur otherwise.

Scope of applications of e-ticketing systems	
O*pen payment schemes*	E-ticketing could be potentially integrated in existing bank or credit cards
Intermodality	E-ticketing makes payment for multi-modal trips easier to implement and generated revenues easier to re-distribute across the different modes after clearing.
Interoperability	E-ticketing makes payment for multi-operators trips easier to implement and generated revenues easier to re-distribute across the different operators after clearing.
Interservices (e-purse)	E-ticketing enables the use of public transport smartcards for paying for additional services offered in conjunction with public transport (eg parking space payment or retail purchase).
Parking and road pricing	The integration of electronic toll collection for road usage or parking with electronic fare management allows travellers to pay for public transport and private car use with the same card.
Customer relationship management (CRM)	E-ticketing is a strong marketing tool since it enables detailed data collection on the mobility behaviour of customers, which helps to develop targeted products.
Network monitoring and planning	Data collected from ticketing will improve knowledge on boardings and therefore allow for bus capacity and timetables to be adapted to the actual use of the route.
Secured access and Individual safety	Smartcards could be also used as an access card to designated buildings. They can be equipped with an individual alarm function, which either informs the driver or automatically transfers the passenger's location to an emergency response centre.

Applying the above “distance range” possibilities offer the following advanced potentialities for payment:

- *Check-in/check-out* (CICO) requires an intentional user action. In other words the customer has to present his user device at an in-vehicle validation device while entering and/or leaving a vehicle or alternatively at a platform.
- *Walk-in/walk-out* (WIWO) is based on antennas which are for instance placed at vehicle doors. They perform an entrance and exit registration by detecting the user device carried by a passenger without a required user action.
- *Be-in/be-out* (BIBO) systems detect the user devices carried by passengers while the vehicle is moving from one station to the next, thus allowing to register all passengers that are actually on board at that time.

Mining on the public transport data collected through the e-ticketing system provides valuable information on network usage and travel patterns which could be used for planning, operation and marketing purposes, e.g.:

- Monitor capacity utilisation and loading on different routes
- Monitor bus headways and punctuality
- Monitor boarding and alighting at stops and estimate passenger volumes at stops
- Estimate ridership per operator and ticket types
- Analyse travel patterns for different groups of passengers, introduce incentives
- Estimate O-D, time, cost, modes, transfer information, related to any journey.

Some of the above-mentioned possibilities will be only feasible with a check-in check-out system. On the other hand, restrictions imposed by individual freedom related regulations will limit the potentialities of exploiting passenger related data.

Generally speaking, e-ticketing offers a large number of benefits compared to traditional ways of payment as listed in the table below.

For Authorities	For Operators	For Passengers
▪ Creation of seamless journeys in PT networks ▪ Unification of ticketing ▪ Source of new marketing data ▪ Better control of revenues & subsidies ▪ Extend the scheme to other players (eg. taxis) ▪ Projects with political connection value ▪ Improve PT image ▪ Reduce cost of selling tickets	▪ Gain new customers with modern approach ▪ Increase medium term operating profit and reduce fraud ▪ Reduce the use of cash ▪ Reduce cost of selling tickets ▪ Reduce maintenance costs ▪ Improving cash flow ▪ Increase speed at boarding (buses) ▪ Valuable opportunities to add “new services” ▪ Source of marketing data for PT management	▪ Convenience & speed, no cash ▪ Seamless journeys in multimodal, multi PT schemes ▪ Easier ways to reload value or renew passes ▪ New card when it has been lost or stolen ▪ Additional appreciated services when available

Analysis of (e)-ticketing schemes in selected networks

The present section summarise the information collected from the working group members and other selected networks on the state of the art of (electronic) ticketing. It briefly describes the situation and synthesises the main findings according to the main themes and issues of the study.

1. Collected information and references

Information was collected from the working group members representing the following cities/regions: Paris, Barcelona, Madrid, Helsinki, Bilbao, West Midlands, London, Vilnius, Stockholm and Frankfurt region. It comprises brief notes, slide show presentations and leaflets covering the organisation of public transport in the city/region, fare and ticket structure, e-ticketing system (when relevant) and clearing procedure, and web pages.

Moreover, Helsinki's YTV provided a study report entitled "Fare and ticketing systems in Europe" describing the situation in a number of cities including Amsterdam, Barcelona, Zürich, Stuttgart, Vienna, Manchester, London, Stockholm, Malmö, Gothenburg, Copenhagen, Oslo and Singapore.

The consultant referred as well to information related to e-ticketing schemes implemented in Seoul, Taipeh, Tokyo, Hong Kong and Singapore.

2. Description of pricing and ticketing in selected cities

The present section describes for each city represented in the working group the following aspects:

a) The main public transport actors (organising authority and operators)
b) The pricing and ticketing structure
c) The clearing mechanisms
d) The progress of introducing e-ticketing
e) Comments and results related to the ticketing system

BARCELONA	
Public transport actors	ATM (1997) is an inter-administrations consortium open voluntary to all authorities responsible for collective transport services in the metropolitan region of Barcelona. There are 4 main operators: TMB operating metro and buses FGC operating metro and suburban trains, Renfe Cercanias is the local train section operated by the state railways, and Tramvia Metropolità operating tramway. There are additional private companies running suburban lines and more than 25 municipalities have their own bus network.
Fare system	Implemented in 2001. Zonal fare system (concentric crowns divided each into sectors): The fare zone is the area resulting from the intersection of crowns and sectors. In total 6 crowns and 33 sectors. Zone 1 includes the city of Barcelona and 17 other municipalities. The price is set according to the number of zones crossed with a maximum of 6 zones Integrated fares with transfer rights between modes and operators (75 minutes for the one-zone journey to 150 minutes of the six-zone journey) Concessionary fares exist for students and young under 21. Children under 4 travel for free
Single tickets	Mode-exclusive tickets
Multi-journey tickets	All are integrated tickets (transfer rights) within the validity area 10 journeys (T-10): valid for one year 50 journeys within 30 days: personal ticket 70 journeys within 30 days: family ticket, with which the passenger can pay for the journeys of several persons.
Season tickets	All are integrated tickets for unlimited amount of journeys within the validity area One-day pass 30-day pass (T-Mes): personal ticket 90-day pass: Personal ticket and can be personified by attaching a personal pass including the personal data of the ticket holder in it.
Value-stored tickets	Not available
Other types of tickets	There are some operator-specific tickets as, for example, the TC ticket offered by the TMB for motorists. It is valid for one day and entitles to unlimited number of public transport journeys operated by the TMB. The ticket can be purchased when parking in specific connection car parks.
E-ticketing	Not available
Clearing	Revenue from integrated tickets collected by ATM and paid monthly to all operators as established in the contracts Private operators are paid according to concession contracts Renfe is paid by ATM as a result of the increase in passengers following fare integration (limited in time)
Comments/results	T-10 represents more than 70% of all the sold tickets Single tickets only 10%. 75% of tickets are for used in zone 1. Free tickets represent 10%

MADRID	
Public transport actors	CRTM (1985) is the public transport authority for Madrid region. It depends functionally on the regional government. CRTM takes all decisions concerning the fare system –prices, tickets, etc.-, with the exception of suburban railways, which depend on the Central Government. Metro operators: MetroMadrid (in Madrid city), MetroSur (in South metropolitan ring), TFM (suburban metro) Bus operators: EMT (Madrid urban buses) and 33 private companies in suburban areas grouped in two associations (Fenebus, Asintra) Train operator: RENFE Cercanias for suburban rail
Fare system	Zonal structure. Prices depending on the number of zones crossed. There are 8 zones: the central zone (A), which is practically the same than Madrid municipality; three metropolitan zones (B1, B2, B3), covering an area about 30 km from the centre of the city; two regional zones (C1 and C2), which complete the region, and two exterior zones (E1 and E2), which have been created to facilitate movements between Madrid and the bordering region of Castilla -La Mancha. Each zone includes the previous one.
Single tickets	Mode-exclusive tickets. Sold on-board buses and at metro stations.
Multi-journey tickets	10 journeys: in the central zone (A), this ticket is multimodal but without transfer rights between modes. In other zones it is operator exclusive.
Season tickets	All are integrated multimodal tickets for unlimited amount of journeys within the validity area. All are personal tickets Visitor pass: unlimited travel for 1,2,3,5 or 7 consecutive days in zone A or in all zones. Monthly pass: Regular (21 to 64), Youth (under 21), Senior (over 64) Annual pass: for Regular and Seniors.
Value-stored tickets	Not available
Other types of tickets	
E-ticketing	Started in 2006. The first phase, associated to the installation of the integrated AFC system in all transport operators of zone A, has already been completed. There are 35.000 regular smart card users since 1/1/2006 using the Annual Travel Pass for zone A. The smart card used with the Mifare DesFire chip embedded, is called Sube-T, and coexists alongside the current Edmonson (magnetic zone) system. The next phase (planned for years 2007 and 2008), will be to establish a broad card and ticket sales network. At the same time, the installation of the system in the public transport operators in the rest of the zones will continue.
Clearing	Incomes from sales of multimodal tickets –Travel Cards and 10-trip tickets for zone A- are collected by CRTM, which has different agreements with operators in order to refund their loss by the use of multimodal passes. Metro and EMT –public operators with a flat fare in their networks- receive a monthly amount calculated as a product of the number of stages and the technical fare, which balances their budgets. Private operators, as well as suburban railway operator –Renfe-, receive a monthly amount, in this case only based on the trips or stages carried out through Travel Cards, owing to the fact that the incomes from the rest of the tickets are perceived by themselves.
Comments/results	Abono Transportes (season ticket) is used in almost 70% of trips

BILBAO	
Public transport actors	CTB (1975) was created as an organisation independent from its members (Basque government, Bizkaia county government, municipality of Bilbao and other municipalities). CTB operates the metropolitan railways through Metro Bilbao. Other modes are controlled/operated as follows: - Bilbobus controlled by Bilbao city council and operated by TCSA - Bizkaibus controlled by Bizkaia county government and operated by various bus companies - Euskotren and tramway (Euskotran) controlled by Basque Gvt. - FEVE and RENFE controlled by the Spanish Gvt.
Fare system	Zonal structure: common zoning scheme approved in 2001 by all operators but each operator has its own fare structure applied to the zoning scheme. No tariff integration. New fares for certain group of people (young people, eldery, big families) are under development.
Single tickets	Mode-exclusive tickets. Fares vary according to mode.
Multi-journey tickets	10 journeys: Available only for rail service: EuskoTren, RENFE and FEVE but valid different passes for each operator. No integration.
Season tickets	Monthly pass: personal ticket, validity starts at first day of use, unlimited number of journeys in chosen zone and modes. Available for Metro Bilbao, EuskoTren and RENFE, FEVE.
Value-stored tickets	Creditrans Uniform ticket: Non-personalised value ticket, multimodal, multijourney, allows transfer between modes, long period of validity. Different values: 5, 10 or 15 €. Each operator/mode deducts its fare for the journey. The amount charged is that set out in each mode for season tickets (bonos). When passenger transfers to a second mode, 20% of the total price of the combined journey is deducted by the second operator. Gaztetrans (same as Creditrans but for young people) is under development.
Other types of tickets	
E-ticketing	Barik contactless smartcard pilot project started in 2004. The idea is to implement one common card valid for all modes to be fully owned and produced by CTB (Mifare Desfire). Card valid for 4 years, reusable, with transfer rights, (anonymous) possibility for multiperson uses or personalised. One Stored value and 2 active season ticket could be jointly incorporated in the card as well as a reserve season ticket. Season ticket will cover a combination of modes and zones. Validation will differ according to the mode: check-in/check-out, on board, on tram platform. Different fare structure will be defined combining flat fare and variable fare. Implementation is expected for end of 2009.
Clearing	No issue for single, season and multi-journey tickets: they are sold by operators for their own network. For Creditrans CTB manages sales revenues. Clearing is executed monthly: each operator receives money according to the real number of validations.
Comments/results	

PARIS	
Public transport actors	STIF (1959) coordinates the provision of public transport services and determines the fare policy in the Ile-de-France region. Public transport system is operated by 95 companies: - RATP operating metro, tramway and bus service in the central area and 2 regional rail lines. It carries 75% of passengers. - SNCF, the national railways company operating regional and suburban trains. It carries 17% of passengers. - Optile, an association bringing together 93 private bus companies operating mainly in the periphery of Paris and represents 8% of passengers.
Fare system	STIF is responsible for the fare policy. The region is divided into 6 concentrical fare zones with full integration between modes and operators. In practical terms, it is a flat fare within Paris city and zonal fare system elsewhere with some variations (see below). Concessionary fares cover those on income support (free travel), elderly, disabled, low income (CST card) and those following back-to-work plans.
Single tickets	Ticket t+: valid for rail services within Paris city and for bus services in the whole region. Transfer rights between buses and between bus and tramway (90 minutes). Valid on night buses. Origin-Destination ticket: Fare according to distance. Valid for rail services between the region's towns. Transfer rights to other rail mode within Paris city only. Both tickets are available in carnets of 10 tickets (cheaper than unit ticket)
Multi-journey tickets	Not available
Season tickets	All are integrated multimodal tickets for unlimited amount of journeys within the validity area. All are personal tickets. Day pass (Mobilis) Week pass (carte orange): from Monday to Sunday. Month pass (carte orange): from 1st to last day of calendar month Yearly pass (Carte Intégrale) Imagin'R card: for pupils and students (under 26). One year validity. Valid on the whole Ile-de-France region during weekends and school holidays. Special one-day ticket for young people valid during weekends.
Value-stored tickets	Not available
Other types of tickets	Visitor pass: unlimited travel for 1,2,3 or 5 consecutive days within the validity area. Combined tickets: public transport + touristic sites
E-ticketing	Navigo contactless smartcard (Calypso type) is being disseminated in order to replace magnetic type passes. To date, week, month and annual passes (including Imagin'R) are issued on Navigo card. Solidarity card will follow. Navigo is media for season passes and does not offer value stored possibilities. Navigo is reserved for those leaving or working in the region. Navigo Découverte is offered for non-residents in the region, the card is paying and could be issued immediately. Circa 2.200.000 users hold a Navigo card. Operators have set up an economic interest group (GIE Comutitres) to manage and follow-up ticketing: personalises and distributes Navigo passes, supervise sales and after-sales services of Imagin'R, manages and information of Navigo passes,

Clearing	For RATP and SNCF, each ticket sold is associated with a mobility rate which enables the ticket's reference price to be calculated. The reference prices are then used to calculate the total income from passengers. Operators have also incentives according to contractual objectives. Private enterprises are remunerated according to statistical counts for passes and to actual ticket validations (for ticket t+). With the development of Navigo, STIF plans to use electronic data.
Comments/results	Travel passes represent 80% of trips and 67% of ticketing income (single ticket: 20% vs. 32%). 50% of pupils and students use Imagin'R 35% of employees uses Carte Orange The most popular passes are those which offer Zone 1 travel.

HELSINKI	
Public transport actors	The principal duties of YTV (1970) comprise transport system planning, regional public transport provision, waste management and air quality monitoring for its four member municipalities (Helsinki, Espoo, Kauniainen and Vantaa). YTV regulates and operates regional bus services and trains, Espoo internal bus services and Vantaa internal bus services. Public transport in Helsinki City is operated by HKL which covers buses, trams, metro and ferry.
Fare system	The metropolitan area (Helsinki, Espoo, Kauniainen, Vantaa plus Kerava and Kirkkonummi) has a unified fare system. The region is divided into three tariff zones. Each of the towns comprises its own zone. Kauniainen is a part of the Espoo zone. Journeys made within a single town area are charged as one zone. Regional journeys which cross city boundaries are counted as two and three zone journeys, irrespective of how many town areas have been driven through. When allowed, transfer between modes must take place within 60 to 80 minutes after the first validation. Concessionary fares exist for the elderly, pupils and students.
Single tickets	Fares vary according to mode, area of validity and transfer possibilities. They exist as paper tickets or integrated in the travel card as stored value. Price is the same for both payment media.
Multi-journey tickets	Not available as such but integrated into the Travel card (see value-stored tickets)
Season tickets	Season tickets are valid for durations varying from 14 days to one year on the contactless travel card. For the same period, tariffs vary according to mode, area of validity and transfer possibilities. Season tickets are not valid for night trips between 2:00 and 4:30 am.
Value-stored tickets	The travel card may be loaded with value i.e. from 5 to 400 euros worth of money.
Other types of tickets	Tourist passes for 3 days Group passes valid for 24 hours
E-ticketing	The electronic Travel Card system (Matkakortti) has been in use in the Helsinki Metropolitan Area since 2002. Presently, the Travel Card is used on the public transport of five municipalities. The same card is in use in all transport modes – buses, commuter trains, trams, metro and Suomenlinna ferry. Over a million cards have been issued. Every day around one million passengers travel on public transport. YTV has launched a project to transform the Travel Card system into a future generation system by 2014. The project will be implemented in two stages. In the first stage during 2009-2011, the Travel Cards will be exchanged to cards conforming to the ISO standard and the whole system will be up-dated so that it can read both the current and the new generation cards. In the second stage, other parts of the system will be reformed and a real-time information system will be linked to it.
Clearing	
Comments/results	According to YTV surveys, fraud has increased after the introduction of the Travel card (from 1.7% to 3% in open systems, and from 0.35% to 0.5% in closed systems).

LONDON	
Public transport actors	TfL is the body responsible for the majority of London's transport systems. It manages London Buses, the Underground, the Docklands Light Rail (DLR) and Croydon Tramlink, London's road network and traffic lights, traffic management and the congestion charging scheme. TfL runs London River Services and regulates taxis and the private hire trade. National rail services are not TfL's direct responsibility except some services in London.
Fare system	TfL proposes a fare structure for Transport for London's services, which is then agreed and signed off by the Mayor of London. There are a variety of tickets for both single rides and for periods of time. Bus and tram travel is based on a flat fare. The Tube and National Rail fares are generally based on zones. The Travelcard is a joint TfL /National Rail product for the London area and is administered through a formal Travelcard Agreement between the two undertakings. As such, Travelcard pricing is agreed between TfL and the Train Operating Companies (TOCs), which are regulated by the Department for Transport. Tickets are issued on Oyster (Smartcard ticketing system for season tickets and Pay-and-Go PAYG), magnetic tickets (primarily for Tube cash singles and one day Travelcards), Bus Savers (a book of six paper tickets), and paper tickets issued on-bus or through roadside ticket machines Oyster single fares are cheaper than cash single fares. A 'capping' system guarantees that an Oyster card user will be charged no more than the cheapest combinations of single tickets, travelcards and/or bus pass that cover all journeys made that day. The cap is based on modal choice, maximum zonal journey made on the Tube and time of day. A 50p discount is given where the price is capped at the travelcard or bus pass rate. Unlike paper daily travelcards, Oyster cards capped at travelcard rates are not valid on National Rail services other than those routes which accept Oyster Pay as you go. Concessionary fares exist for children, students, elderly and physically impaired people, as well as adults on some types of benefits.
Single tickets	Single paper tickets are mode exclusive. Using Oyster, single tickets amounts will be deducted from the stored value. Oyster single fares are cheaper than cash single fares. Bus savers are a book of six single paper tickets.
Multi-journey tickets	Not available as such but multi journeys are made available through capping season tickets.
Season tickets	There are peak and off-peak prices for one-day and three day Travelcards (valid on all TfL modes and National Rail). There is also a one day Bus Pass. Travelcards and Bus Passes are also available as season tickets for periods of 7 days, one month and longer periods up to one year. Travel cards may be used without limitations in the area of validity. A season ticket can be loaded onto the Oyster card for a period of 7 days or any period between 30 days to one year. The transport zones where the ticket is valid are loaded into the card.
Value-stored tickets	An amount up to 90£ can be stored into Oyster.
Other types of tickets	Tourist travel card, Visitor Oyster Group tickets (at least 10 passengers)

E-ticketing	(Additional information to the above) TfL's contactless ticketing system is run by a consortium called TranSys, comprised of Cubic Transportation Systems and EDS. The Oyster card uses the Philips MIFARE 1k ISO 14443 (RFID) Type A 13.56 MHz contactless smart card standard. The system is a proprietary closed system, run by TranSys. TfL uses anonymised information from the Oyster data to understand journey patterns, and has been investigating the possibility of using Oyster journey data to measure system reliability and crowding levels. TfL has also begun to analyse full journey patterns, e.g., how people make end-to-end trips from Tube to bus, using Oyster data. TfL encourages customer to register their Oyster card to protect it if lost or stolen (a registered card can be cancelled with a replacement product issued). TfL mandates registration for high-value ticket products (monthly or longer period season tickets). An Oystercard can hold up to three "products" at the same time. These may be Travelcards or bus passes, and PAYG. Four main factors affect the price of the ticket when paying with the Oyster card: - In how many zones the ticket is valid - When (time of day and weekday) does the journey take place - Which transport mode is used - Season ticket validity
Clearing	TfL manages the accounting and revenue allocation between modes within TfL (e.g., bus, Tube, DLR, etc.) and between TfL and the TOCs on TfL products. The allocation is done based on both actual travel (as measured by Pay-as-you-go journeys) and surveys of Travelcard users to capture journey behaviours of customers.
Comments/results	By October 2007 more than sixteen million Oyster cards had been distributed In September 2007, Oyster card journeys represented around 73% of bus and Tube journeys Increase of passenger flows at gates (up to 25 passenger per gate per minute vs. 20 with magnetic tickets) Reduction of fraud in London Underground

VILNIUS	
Public transport actors	There are several bodies participating in PT system. • The head is Vilnius city municipality, which sets all regulations concerning PT operation, tariffs, types of tickets, PT financing etc. • Municipal company „Susisiekimo paslaugos“ (MESP) which performs as public transport agency. It produces, sells tickets, collects revenues from it, distributes it to municipal operators, makes control of passengers and operators. • Municipal PT operators, there are only 2: bus company and trolleybus company. They have the same ticket system and get subsidies from city municipality. • Private operators: they have their separate ticket system, they do not get any subsidies from municipality.
Fare system	Prices are set by city municipality council. MESP gives only suggestions and acts as consultant body in this process. Flat fare system applied in the whole area. Buses and trolleybuses apply the same fares. There are group of people who benefit from concessionary fares: 50% or 80% discount.
Single tickets	Single ticket costs more if bought onboard vehicles. No transfer rights between modes.
Multi-journey tickets	Not available
Season tickets	Monthly tickets are available for one mode (bus or trolleybus) or for both. Possibility to buy a monthly ticket valid on working days only. Other season tickets: 1, 3 or 10 days covering both modes.
Value-stored tickets	See E-ticketing below.
Other types of tickets	
E-ticketing	Vilnius is implementing e-ticketing system. The system should start operating since December 2007. At first only monthly tickets will be available in electronic form (also it is still possible to purchase monthly paper tickets). Electronic ticket types are the same as paper tickets (see above). Transitional period is 8 months. After that, monthly tickets will be only electronic. It is planned to introduce electronic single and period tickets in the second part of year 2008. E-ticket – is a contactless RFID plastic card (ISO 14443). Monthly tickets are based on ID. There is an ID number in a card and all information is in data base. Single tickets will work as e-purse and will be recorded in a card.
Clearing	For paper tickets the clearing scheme is as follows: ticket distributers collect revenues from passengers, then money is transferred to MESP and, according to contractual agreements with operators, money is split between them (bus and trolleybus company). For e-tickets the scheme is very similar. However, the difference with paper tickets is, that it is based on information work up centre that collects data about tickets sells from ticket distributer and transfers it to MESP. So MESP knows how many e-tickets were sold, but money goes straight from distributor to MESP.
Comments/results	

WEST MIDLANDS	
Public transport actors	The West Midlands is made up of 7 local authority areas. WMPTE (CENTRO) and WMPTA work in partnership to develop public transport in the region. Bus services are deregulated. Over 90% of bus services in the WM county are operated on a commercial basis by over 40 private operators. Travel West Midlands operates over 80% of the bus mileage. London Midlands Railways operates the majority of local rail services under a franchise agreement. Altram consortium operates metro Line One under a 23 year concession let by CENTRO
Fare system	There is virtually no overall pricing policy for public transport in the region. Bus companies charge whatever fare they choose. There is an overall integrated ticket for all modes available and this has the effectively caps prices of other tickets as there would be no point in buying a less flexible ticket which was more expensive. It should be noted that travel on all modes is free for those aged 60 and over after 09:30 on weekdays and all day Saturday and Sunday (concessionary fares) Around 33% of bus fares are paid cash, 33% free concessions and the rest are pre-paid passes
Single tickets	Bus single tickets are operator exclusive. Single ticket costs more if bought cash onboard vehicles. No transfer rights between operators. Rail single tickets are valid on any local train.
Multi-journey tickets	Not available
Season tickets	Season tickets are available for one operator or multi-operator/mode (managed by CENTRO). Available for one day, week, month, year.
Value-stored tickets	Not available
Other types of tickets	
E-ticketing	An electronic ticketing system is planned which will operate on all modes. The system is being funded by Centro who are buying the on bus hardware for all operators in the West Midlands including the light rail line. Equipment for the heavy rail services is being funded through the franchise. Centro is funding the back office operation. Because there are so many different types of tickets and bus operators are free to set their own fares the ticket will at first be restricted concessionary fares only. Smartcards are being sent to everyone entitled to free travel and these will be used from April 2008 initially as flash passes. As the reading equipment is rolled out by April 2009 these will be used as Smartcards on buses, trams and trains. Trains may start after April 2009. The cards have the potential for operators to put their own tickets on the system if they chose to do so. The scheme will be ITSO compliant. When implemented only 2 types of tickets will be available on the card: free concession fares, and n-bus network

Clearing	Revenue from single operator tickets are 100% kept by the operator. Revenue from multi modal tickets is split between operators on the basis of surveys undertaken by the transport authority on all modes. The key reason for these surveys is to allocate the very large concessionary fares budget but multi operator tickets are included. Some local journeys which are sold as single or return rail tickets are cleared through the national rail clearing system run by the Association of Train Operating Companies (ATOC).
Comments/results	

STOCKHOLM	
Public transport actors	Public transportation in the Stockholm region serves 25% of the Swedish population and stands for 50% of all public transportation in Sweden. Some 80% of the population in Stockholm regularly use public transportation (on a weekly basis). Public transportation is handled by Storstockholms Lokaltrafik, SL, as is financed 50/50 by sales and taxes. SL tasks include the planning and the purchasing of transport services by competitive tendering
Fare system	All prices are decided by the County Council. The region of Stockholm is divided into three zones, A, B and C, where A is the central part of Stockholm including the whole metro system.
Single tickets	"One hour zone ticket – single trip tickets based on coupons. First zone two coupons and then one coupon for additional zone, max 4 coupons. Single trips are also sold in vending machines (not as coupons) and via mobile telephones, sms-tickets.
Multi-journey tickets	
Season tickets	Periodkort/period card" – tickets valid over a period of time, starting at 24 hours, 72 hours, 7 days, 30 days, 4 months and annual validity. These cards are valid in all three zones The most popular and common ticket is the 30-day pass, and stands for 50% of SLs annual revenue. The price is 690 SEK (approx. 74€).
Value-stored tickets	Not available
Other types of tickets	There are also various special student cards – some with limited validity (school days etc.)
E-ticketing	SL is in the process of implementing a new system delivered by ERG. The new system is called SL Access and is based on contact less Mifare classic chip (4k). Implementation was planned for October/November 2007 but is now postponed until late 2008. When SL introduces SL Access (contactless electronic ticketing) price structure will be the same but with more flexible periods and single trips based on fares for travelling in certain zones (not necessary priced as for coupons).
Clearing	For the moment SLs tickets are only valid in the Stockholm region (with some exceptions). However the new contactless electronic ticketing system will have the same standard (RKF standard) for Sweden (and Denmark) so in the future there will be a clearing function between the various transportation operators in Sweden
Comments/results	

3. Main issues to be addressed when developing e-ticketing

When developing an e-ticketing system, a number of issues must be discussed and will influence the scope and possibilities offered by the system. They cover mainly the following aspects:

- The fare levels and structure
- The ticketing spectrum
- The possibilities for integration
- The smartcard technology
- The interoperability issue
- The business case
- The business model
- The clearing mechanisms
- The exploitation of data

They above-listed are discussed in the present section illustrated with examples from selected public transport networks.

3.1 Fares

3.1.1 The responsibility for setting fares

Studied networks can be distributed on the following categories as far as the responsibility for setting fares is concerned:

- Fares are under the responsibility of a unique public transport authority for all modes and operators in the region or metropolitan area (Paris, Madrid, London except national rail services, Vilnius, Barcelona)
- The responsibility for setting fares is shared amongst several bodies: the regional authority and/or the central city authority and/or national authority (Helsinki, Bilbao)
- The responsibility for setting fares is mainly with public transport operators (West-Midlands)

Having an umbrella authority in charge of setting fares does not necessarily mean that the fare structure is simple and easy to understand. As an example, in London, the fare structure combines flat fares and zonal fares. In Paris, there are additional distance-based fares. In both cities, pricing combines mode exclusive fares and integrated fares, and transfer rights differs according to modes.
In West Midlands, in a deregulated framework, there is virtually no fare policy but the fare structure is very simple (each operator has its own fare system) but not attractive for the passengers because of the lack of integration.

3.1.2 Fare structure

Almost all regions have designed fare zones around the central city. However, fare systems vary according to the area considered for travel. In most cases, a flat fare system is applied in the central city and a zone system is used in the

broader city region. Vilnius is an exception where a flat fare is applied on the entire public transport perimeter.

The fare structure is often different for regional and suburban train networks compared to urban rail and buses. In most cases they apply distance-based pricing against zonal or flat fare for urban modes. This is mainly due to the longer distances they serve. However, this difference often disappears when an integrated multimodal travel pass is implemented.

There is a general move towards enlarging zones and simplifying the zonal fare system (ex: Paris: 6 zones instead of 8 but on the same area). In many cases these zones have become so large that for entire regions a flat-fare system applies. As an example: Flanders, Belgium, may well have several zones, but for a passenger this is expressed in just two tariff rates: one for a trip of one or two zones and one for a trip of three or more zones. In the German regions around Cologne and Mannheim the zones correspond with the administrative boundaries. In many cases the user thus effectively pays a flat fare. Throughout the very large area of the Stockholm region there are three zones. The Vienna region, the VOR area, has many zones, but travellers in the city of Vienna, which is quite a bit bigger than Amsterdam, pay a flat fare.
In United States, between 1994 and 2000, the proportion of bus and heavy rail operators with zonal or distance-based fares declined by 7% and 13% respectively in favour of flat fare structure.
Many smaller Australia/New Zealand cities have either maintained or migrated to flat fare structure and Melbourne has recently moved from 3 to 2 zones.

The introduction of what is called ‘convenience tickets’ also falls under the trend of simplification. In the Netherlands the ‘euro tickets’ are reasonably popular. Travellers pay one euro in the bus and do not have to buy a national bus and tram ticket (‘strippenkaart’) beforehand. One euro sounds cheap and in advertising the carrier also presents it as such, but travelling on a ‘strippenkaart’ bought in advance is generally cheaper. Another example is the day return tickets which offer unlimited travel in a large area, as it is the case in Germany.

Fare levels may depend on the payment media or the time of payment. Pre-paid tickets are cheaper than tickets bought on board (ex: Vilnius). Fares paid with smartcard are cheaper than those paid cash (ex: Oyster).

Distance-based fare system is implemented mainly in Asian cities (Hong Kong, Seoul, Singapore, Guangzhou) or for designated origin-destination tickets. Seoul Metro provides an example where a new smartcard dare system supported the re-introduction of distance based pricing. Until mid-1980s, a distance-based structure (i.e. fixed fare for first 8 km plus a distance component for each additional kilometre) was used and supported by a paper ticket. From mid-1980s to 2004, the development of the network and technical limitations with the fare collection system in place at the time necessitated that the Metro employs a zonal-based structure that divided Seoul into seven districts. A magnetic stripe ticket was used. From 2004, the functionality provided by the new contactless smartcard ticketing system (called T-money) was employed to reintroduce an integrated multimodal distance-based fare structure.

3.1.3 Passenger-based discrimination

Passenger-based fare discrimination exists in all networks either using a market segmentation approach or for social reasons (concessionary fares). Main categories eligible for concessionary fares are:

- Children
- Senior citizens (over 60 or 65 according to the network)
- Large family members (at least 3 children)
- Disabled
- Army officers
- No/Low income people and unemployed

Some characteristics of concessionary fares (in most cases):

- Discounts are different on single tickets compared to season tickets
- Concessionary fares have limited validity (only during off-peak hours and weekends in some cases)
- Reduction compared to regular fares varies from 50 to 100% (free transport for targeted passengers)

Passenger-based fare discrimination is increasingly applied for young people (15-25). Indeed, this segment of the market is very important for public transport companies since they are about to obtain their driving license and to start a professional career which will make them independent in modal choice. Consequently public transport networks are developing specific tickets and services to attract them and increase their loyalty (ex: Imagin'R in Paris, Gaztetrans in Bilbao, free travel in London for under 16 on buses).

By working with target groups, the transport companies sell more season tickets. The marketing is targeted towards these specific groups with a view to increase public transport usage.

3.2 Ticketing

3.2.1 Ticketing spectrum

The studied networks offer all a large spectrum of traditional tickets: single tickets for one or more mode/operator, origin-destination tickets (for regional trips mainly), season tickets (from 1 day to 1 year), multi-journey tickets and tickets corresponding to the concessionary fares.

Season tickets obey to different rules according to the network: in some cases they are valid based on calendar periods (week from Monday to Sunday, month from 1st day to last day); in others validity period starts the first day of validation (7 days or 30 days from the first day of validation); a third category of networks offer more flexibility by allowing the use of a 30-day card within a long period of time (ex: 3 months). Season tickets are generally nominative and not transferable.

Multi-journey cards or multi-tickets books are in some cases limited in duration and in others without time limit which makes their use very flexible.

Value-stored tickets are generally offered with smartcard ticketing (London's Oyster, Helsinki's Travel card). This is not the case with Paris' Navigo which can only host season passes. In Bilbao, Creditrans is a magnetic type stored-value ticket.

Visitor tickets are offered to tourists and valid for1 to 7 consecutive days. They are usually more expensive than season tickets of the same duration. The latter are generally reserved for citizens leaving or working in the region. London is an exception where there is no price-discrimination between local residents/workers and visitors.

Mode-based fare discrimination makes bus fares different from rail fares for single tickets. In some cities, users can choose a bus-only travel card or a multi-modal pass. When there is more than one bus operator, different single fares may be applied for bus routes according to the operator.

3.2.2 Integration

In the context of fare collection, it is important to distinguish between tariff integration and ticket integration. Fare or tariff integration is the possibility offered to passengers to travel form origin to destination by applying the same fare whatever is the mode or the operator used and with full transfer rights between modes and operators. Helsinki public transport pricing is an integrated fare system.
Ticket integration is the possibility to use the same ticket (with possible limitation in time) to travel from origin to destination whatever is the mode or operator used and with full transfer rights. It does not prevent to apply different fares according to modes or operators. Bilbao's Creditrans is an integrated ticket. Brussels's STIB offers integrated pricing and ticketing.

It is important to note that integrated (multi-mode, multi-operator) fare schemes are initiatives taken or at least endorsed by transport authorities to make travel by public transport easy.

Fare integration is treated differently on single tickets compared to season tickets. Single tickets tend to be mode-exclusive (or surface transport vs. heavy rail) while season tickets are in most cases multi-modal. Besides, the more fare-setting is controlled by the authority, the highest fare integration is.

E-ticketing makes ticketing integration easier to implement because it can manage a more complex fare system without necessarily harmonising amongst fares of different operators or modes. Each operator or mode keeps its own single fares and the smartcard acts as a unique means of payment. In addition, the system can include rules for transfer rights in order to be more attractive. Fares integration is no longer a pre-requisite to achieving seamless travel This is the case with London's Oyster, Hong Kong's Octopus and Seoul's T-Money.

3.3. E-ticketing schemes

Previous research revealed that the installation of new ticketing technology was typically the 'trigger' event for a fare structure review in only around 30% of cases. Around half of fare structure reviews were triggered by way of either a regular review process and/or an unexpected revenue shortfall.

Generally speaking, the following reasons were identified as the main reasons for the introduction of e-ticketing in public transport network:

- Limitation of the existing traditional/magnetic system
- Technology obsolescence of existing equipment
- Sociopolitical context and translation of social commitments into a new fare policy
- Implementation of new (innovative) fare policy
- Reduction of fraud
- Increase of passenger loyalty
- Reduction of operating and maintenance costs
- Increase of boarding speeds by reducing transaction times
- Need for integration between modes, regions, operators
- Need to improve the image of public transport

Amongst the public transport networks represented in the working group, Helsinki (Matkakortti), London (Oyster) and Paris (Navigo) have already widely implemented electronic ticketing. In Madrid (Sube-T) e-ticketing is reserved for those who have an annual pass covering the central zone. In Vilnius, e-ticketing is being implemented for monthly passes. Bilbao (Barik) is at the pilot project stage. Barcelona and West Midlands do not have e-ticketing at the time of preparing the report.

E-ticketing schemes differ from one city to another according to the pursued objectives:

- In Paris, Navigo is primarily a media for season passes: it is mainly developed for loyal passengers (yearly, monthly and now weekly subscribers) to speed boarding to train and buses and loading of their passes. There was not any change in the fare structure directly linked to the introduction of Navigo.

- In London, Oyster is used for season passes and as a stored-value card as well. Therefore, it is used to pay for single tickets equally. Fare levels have been changed with the introduction of Oyster to encourage electronic transactions against cash payment: Oyster tickets are cheaper than cash tickets. Bilbao and Vilnius will have e-purse (stored-value) on their smartcard.

- In Seoul, the implementation of the T-Money e-ticketing has been an opportunity to redesign the fare system by introducing distance-based pricing for all modes. The consequence has been to implement compulsory check-in/check-out procedure in all vehicles (including buses).

Developing electronic ticketing is an opportunity to introduce innovations in the fare structure which would have not been possible (or hardly) to implement with a traditional ticketing system, such as:

- **Fare capping**: Rewards the user by ensuring that they pay no more than the fare associated with traditional periodical product concepts via the establishment of daily, weekly or monthly fare caps. A capping system is available with Oyster. It guarantees that an Oyster card user will be charged no more than the cheapest combinations of single tickets, travelcards and/or bus pass that cover all journeys made that day. The cap is based on modal choice, maximum zonal journey made on the Tube and time of day.

- **Frequency-based discounts**: The smartcard user is rewarded through receipt of free or discounted journeys once they have made the necessary number of threshold journeys in a specified period. In Brisbane, the "Go Card" scheme offers a 50% discount on fares after the 6th journey within a one week period.

- **Mileage service**: It is similar to the principle of airline mileage. Mileage points can be accumulated by the smartcard user each time they use their smartcard for transport or to purchase other services. Collected miles are then converted into value stored on the smartcard. In Seoul, mileage can be earned by using T-money. Initially, 0.1% of the public transport fare will be credited to the account. Then, both the credited mileage from the fare and the converted mileage can be used as T-money credit. Moreover, through a partnership with selected business organisations, passengers can accumulate mileage points when purchasing their services. Mileage can be transferred and be used as T-money for public transport.

- **Sales channels incentives**: The smartcard user is rewarded with a discount for adding value to their smartcard via the most cost effective channels (e.g. direct debit, internet) as opposed to third party sales outlets and on board. All users of Perth's SmartRider receive discount on their travel compared to cash fares. The level of discounts depends on the recharge channels (from 15% at add-value machines to 25% for self-load)

- **Time-of-day pricing**: Not a new concept but significantly greater flexibility for innovative pricing schemes compared to traditional fare media where discounts needed to be hard wired to specific time periods. Peak pricing is being used in London as a way to solve some of the capacity problems. Stated preference research says that a 25% peak premium could reduce peak hour demand by 4% for short distance rail commuting.

- **Minus ride system**: In Seoul, the smartcard user is allowed a one time ride in case the balance of their T-money smartcard is not sufficient for a ride. The difference will be reimbursed when they recharge the smartcard.

All above-listed options are likely to attract new customers and increase their loyalty.

3.4 Smartcard technology

Often the terms “chip card,” “integrated circuit card” and “smart card” are used interchangeably, but they can mean different things. Cards are distinguished both by the type of chip that they contain and by the type of interface that they use to communicate with the reader.

3.4.1 Smartcard types

There are three different types of chips that can be associated with these cards: memory only, wired logic and microcontroller. The terms “memory only,” “wired logic” and “microcontroller” refer to the functionality that the chip provides:

- **Memory-Only integrated circuit chip cards:** Memory-only cards are “electronic magnetic stripes,” and provide little more security than a magnetic stripe card. The two advantages they have over magnetic stripe cards are: a) they have a higher data capacity (up to 16 kilobits (Kbits) compared with 80 bytes per track), and b) the read/write device is much less expensive. The memory-only chip cards do not contain logic or perform calculations; they simply store data. Serial-protected memory chip cards have a security feature not found in the memory-only chip card; they can contain a hardwired memory that cannot be overwritten. Early versions of memory-only cards were read-only, low capacity (maximum of 160 units of value), prepaid disposable cards with little security. New versions include prepaid disposable cards that use read/write memory and binary counting schemes that allow the cards to carry more than 20,000 units of value. Many of these cards also have advanced logic-based authentication schemes built into the chip. Other memory-only cards have been developed for re-loadable stored value applications. The cards contain a purse, which can be protected through the use of a personal identification number (PIN) and counters, which limit the number of times the purse can be reloaded.

- **Wired logic integrated circuit chip cards**. A wired logic chip card contains a logic-based state machine that provides encryption and authenticated access to the memory and its contents. Wired logic cards provide a static file system supporting multiple applications, with optional encrypted access to memory contents. Their file systems and command set can only be changed by redesigning the logic of the integrated circuits. Wired logic-integrated chip cards include contactless variations such as I-Class or MIFARE.

- **Secure microcontroller integrated circuit chip cards**. Microcontroller cards contain a microcontroller, an operating system, and read/write memory that can be updated many times. The secure microcontroller chip card contains and executes logic and calculations and stores data in accordance with its operating system. The microcontroller card is like a miniature PC one can carry in a wallet. All it needs to operate is power and a communication terminal. Contact, contactless and dual-interface microcontroller integrated circuits are available. Unlike memory-only products, these microcontroller integrated circuits have been designed

(and can be verified) to meet security targets. The secure microcontroller chip card is normally the version referred to as the "smart card."

Today's chip card market offers a range of memory-only and microcontroller chip cards. Because of their limited storage capacity and low level of security, memory-only chip cards are not suitable as multi-application or multi-purpose cards.

3.4.2 Interface

There are two primary types of chip card interfaces—contact and contactless. The terms "contact" and "contactless" describe the means by which electrical power is supplied to the ICC and by which data is transferred from the ICC to an interface (or card acceptance) device (reader). Cards may offer both contact and contactless interfaces by using two separate chips (sometimes called hybrid cards) or by using a dual-interface chip (sometimes called "combi" cards).

- **Contact Smart Cards.** A contact smart card requires insertion into a smart card reader with a direct connection to a conductive micromodule on the surface of the card.

- **Contactless Smart Cards.** Contactless smart cards must only be in near proximity to the reader (generally within 10 centimeters) for data exchange to take place. The contactless data exchange takes place over radio frequency (RF) waves. The device that facilitates communication between the card and the reader are RF antennae internal to both the card and the reader.

Smart cards with contacts must comply to the ISO standard 7816 whereas those without contacts are yet to be fully standardised (partially, through ISO 14443).

As far as technology approaches and industrial products are concerned, there are two types of products used in the networks represented in the working group:

- Type A cards such as the Philips mifare card (ex: London, Madrid, Helsinki)
- Type B cards such as Innovatron Calypso (ex: Paris, Lisbon, Brussels)

A third standard represented by Sony Felica card is mainly used in Asian countries (ex: Hong Kong, Singapore).

Cards	ISO 14443 Type A	ISO 14443 Type B	Sony FeliCa
Memory logic	Mifare 1 Mifare 4k Mifare Token Mifare Ultralight	C.Ticket PicoPass	RC-S890 Token
Microprocessor	Mifare DESFire CT3004 Smart MX	Calypso GTML/GTML2 GTML+ CD97 / CD97BX CD21 / CD4002	RC-S833 Card

Most used references of contactless smartcards in public transport

Type A and Type B corresponds both to specifications defined in the ISO 14443 standard. Most of the contactless smartcards implemented in public transport comply with ISO 14443 standard. Cards that comply with this standard are intelligent, read/write devices capable of storing different kinds of data and operating at different ranges. Standards-based contactless smart cards can securely authenticate a person's identity, determine the appropriate level of access, and admit the cardholder to a facility, all from data stored on the card. ISO 14443 has been designed specifically to function poorly beyond the 10 centimeter specified range. It is not possible to "listen to" the card from a distance that is far enough away that the extremely large antenna needed to energize the card would go undetected.

3.4.3 Memory

The size of the dynamic memory on a smart card into which data can be written or changed is limited, at present, both by the cost of this kind of memory (EEPROM – Electrically erasable programmable read only memory) and by the physical size of the memory chip within the card's processor. Many of the first generation of 'read–write' cards offer only a few hundred bytes of EEPROM; however, commercial cards with 4, 8 and reliably up to 64K bytes are now available—albeit at a cost. Cards with 100K bytes are also emerging. 2–4K bytes of memory is sufficient to store the financial balance and contract information, plus an auditable register of around 100 of the most recent transactions (containing information such as time, location, service, charge and final balance). However, the memory is really a function of what and how many applications the card is expected to support and this largely determines the unit cost of the card

3.4.4 Security

The security of, e.g., public transport systems against fraud relies on many components, of which the smartcard is just one. Typically, to minimize costs, system integrators will chose a relatively cheap card and concentrate the security efforts in the back office. Additional encryption on the card, transaction counters, and other methods known in cryptography are then required to make cloned cards useless, or at least to enable the back office to detect fraud should a card be compromised, and put it on a blacklist. Systems that work with online readers only (i.e., readers with a permanent link to the back office) are easier to protect

than systems that have offline readers as well, for which real-time checks are not possible and blacklists cannot be updated as frequently

A presentation by Henryk Plötz and Karsten Nohl at the 24th Chaos Communication Congress in December 2007 described a partial reverse-engineering of the algorithm used in the Mifare Classic chip, and potentially revealed some insecurities in the Mifare Classic security model, with a full paper detailing the cipher used and its weaknesses being promised during 2008. Cards other than Mifare Classic are not affected.

3.4.5 Near Field Communication

Evolving from a combination of contactless identification and networking technologies, Near Field Communication (NFC) is a wireless connectivity technology that enables convenient short-range communication between electronic devices. NFC enables rapid and easy communications. Simply by bringing two NFC-enabled devices close together, they automatically initiate network communications without requiring the user to configure the setup. Its intuitive operation makes it particularly easy for consumers to use, while its built-in security makes it appropriate for payment and financial applications.

NFC technology was developed by Philips and Sony. NFC is based on the combination of electronic transmission standards familiar from the chip card industry. The technology allows electronic transmission of data across distances of up to 10 cm. The NFC standard incorporates important security features required for the transmission of sensitive data for identification, ticketing and payment. Data are transmitted at a frequency of 13.56 MHz. NFC is standardised in the following norms: ISO 18092, ISO 21481, ECMA (340, 352 and 356) and ETSI TS 102 190. The technology is compatible with the international chip card standard ISO 14443 A/B.

The RMV transport network teamed up with Nokia and T-Systems to develop the system which is now being piloted in the city of Frankfurt am Main. Those taking part in the trial need only to touch one of the passive radio chips at any given stop with an NFC-capable mobile phone in order to buy a ticket or to ask about bus and train departure times and their request will be processed in a matter of seconds. Initially 59 selected stops in Frankfurt will be fitted with some 600 passive radio chips or so-called “ConTags”. These are 2 installed on the masts and ticket machines at the relevant stops. By touching the “ConTag” with an NFC-capable mobile telephone it is possible to buy a ticket in just three clicks. In contrast to the original RMV HandyTicket users no longer need to manually open the mobile ticket program installed on their mobile phone beforehand. The simple act of touching the “ConTag” at the stop automatically opens the RMV HandyTicket program for ticket purchase. One particularly convenient feature for passengers is that the start of journey location is entered automatically, leaving only the destination tariff zone to be selected. Another advantage is the ease with which users can download the current timetable for the stop in a matter of seconds, also by touching the “ConTag”. If there is no “ConTag”, the start and end stop can be entered manually as before.
(Source: RMV)

According to a survey carried out by UITP[2], technologies most likely to be used in next generation fare collection system are the following (expressed in % of respondents, with possibility for multiple choices):

- Public transport only smartcards: 71%
- Smartcards without need for Check-in/Check-out: 47%
- Public transport applications on smartcards: 29%
- Public transport smartcards across regions (interoperability): 24%
- NFC: 65%
- RFID: 24%

3.5 Interoperability

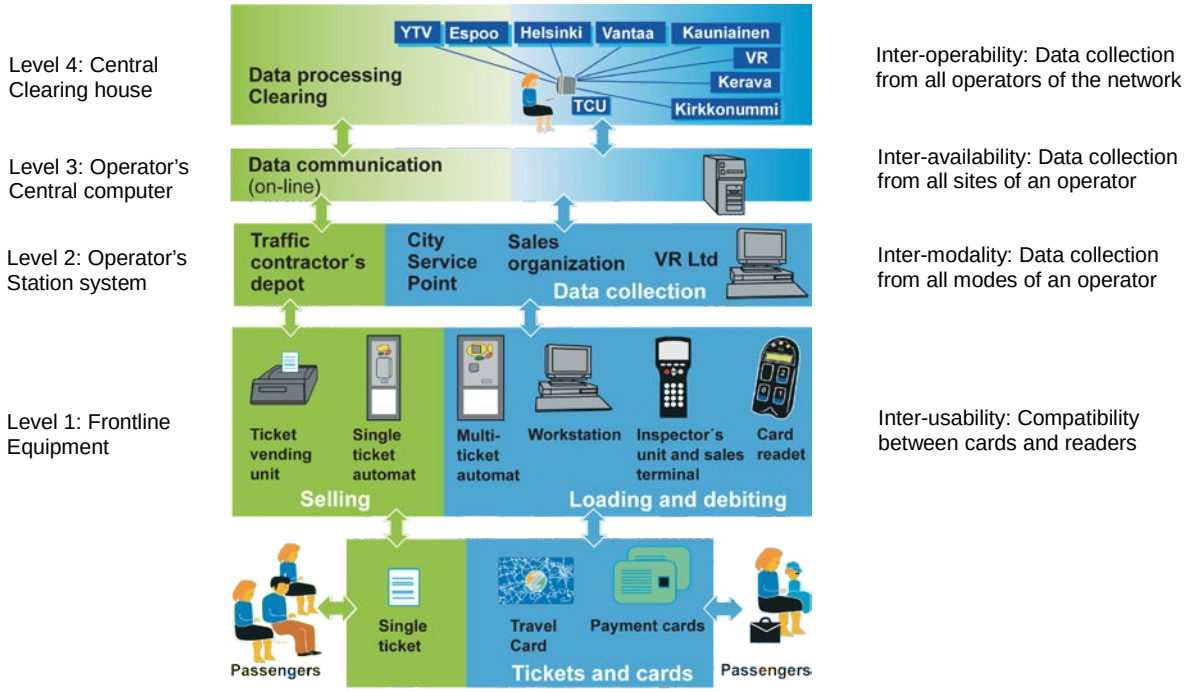
The term "interoperability" can create confusion, since it can be defined in more than one way. Standardisation is an important concern in particular when it deals with interoperability. In this respect, several initiatives have been developed at national level in order to define interoperable standard specifications, e.g. ITSO standard in the UK and VDV Kernapplikations in Germany, Intercode and Interbob in France, SDOA in the Netherlands. They have jointly developed some basic concepts for European e-ticketing. A suite of three standards which serve as a generic framework has been published: a standard for data elements (EN 1545), a standard for a framework for interoperable ticketing (EN 15320, also known as “IOPTA” Interoperable Public Transport Application), and a basic standard for the functional interoperable fare management system architecture (ISO 24014-1, also known as “IFM SA”) which was additionally jointly developed with US and Japanese experts. According to IFM system architecture, there are four different levels of the interoperability concept.

Level 1

On its lowest level (level 1), where the contactless smartcard is only used on one means of transportation operated by one transport operator in one location, it is essential that the ticketing media (supplied by various suppliers) is accepted by all front end equipment (supplied by various suppliers). It is **inter-usability**, i.e. the usage of ticketing media supplied by various suppliers on infrastructure deployed by various suppliers. To guarantee such inter-usability, transport operators should consider the following:

- Contactless interface compatibility (ref. ISO 14443)
- Functional testing & certifications by independent test houses
- Test methods for proximity cards (ref. ISO 10373-6:2001)

[2] *Survey on fares carried out by UITP Transport Economics Commission in 2007 which covered 22 European public transport organisations.*



The 4-level approach of interoperability applied to the case of Helsinki

Level 2

On level 2, where the contactless smartcard is used on several means of transport (such as buses, trains, trams, metro, and ferry boats) operated by one transport operator in one location, it is required to make sure that interusable ticketing media and front end equipment is used and that the data from all stationary computers (e.g.: subway stations, bus depots, etc.) is collected at a central computer system and updated in an appropriate and secure way. Hence, **intermodality** implicates an increased need for more advanced:

- Security by the usage of secure application modules (SAMs)
- Sophisticated backend systems and application software

Level 3

On level 3, where the contactless smartcard is used on several means of transportation operated by one transport operator in several locations (such as districts, regions, counties, states, etc.), there are the same needs for inter-usability and intermodality, but as the contactless smart card scheme has to be available for the transport of users in different and maybe remote geographical areas, transport operators must consider solutions for the following:

- **Inter-availability** of services and information
- Reloading of ticketing media (e.g.: e-purse)
- Downloading of contracts and applications
- Key management: distribution of keys to make the network accessible to the card holder

Level 4

On the highest level (level 4) of an automatic fare collection (AFC) system, where the contactless smartcard is used on several means of transportation

operated by several independent transport operators in several locations, there are additional tasks to be performed

It is the only level, definition or configuration of an automatic fare collection system, where the term "**interoperability**" is appropriate, because it is the first time that several transport operators cooperate in one and the same contactless smartcard scheme. Hence, interoperability can be described as the extent to which a travel card issued by one public transport operator can be used by other public transport operators.

Whereas the usage and availability of system and application objects should be analyzed and discussed on level 1 (inter-usability), level 2 (intermodality), and level 3 (inter-availability), level 4 (interoperability) focuses more on commercial issues rather than on the card technology itself. On levels 1, 2 and 3, commercial agreements are normally only necessary if tickets are distributed and sold through sales agents.

The fact that several transport operators work together has a significant impact on the backend system, data model and security framework. To guarantee interoperability, all involved transport operators must agree on the following:

- Business rules
- Rights and duties
- Roles and responsibilities
- Clearing to apportion revenues
- Security & key management

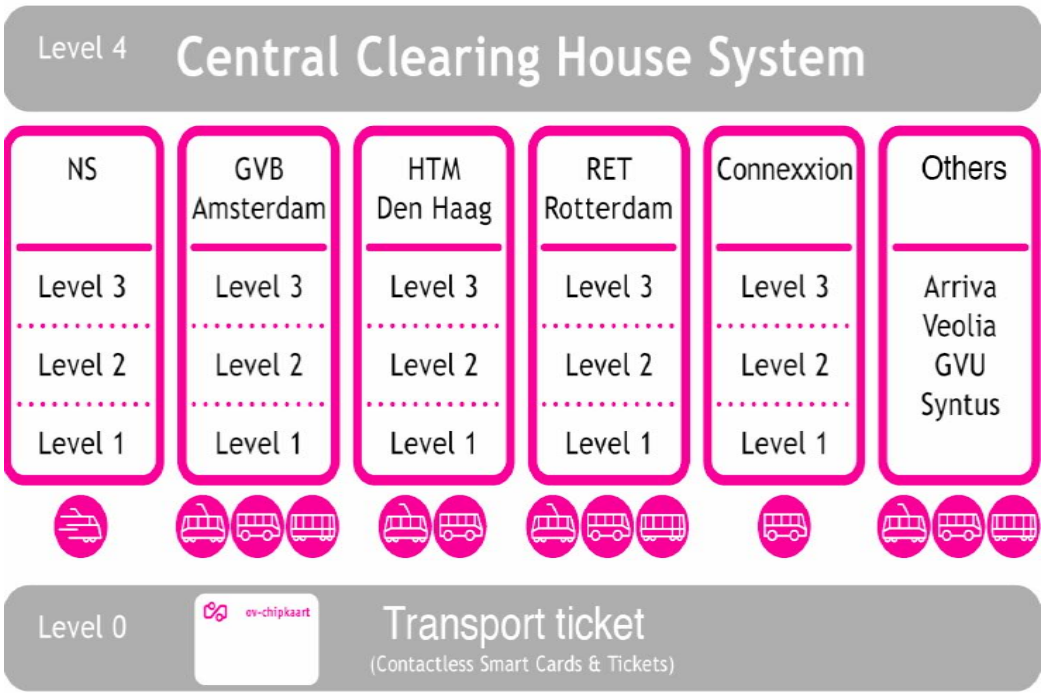
Other topics that have to be taken into consideration with respect to system-wide interoperability are: card formats and system interfaces.

If a transport operator is not sure about which level he is confronted with or which level he needs a solution for, he might end up with a completely over-qualified or under-qualified automatic fare collection system. This can create exceedingly high costs at the beginning of an e-ticketing project or extraordinary expenses at a later stage of a project for updates and modifications. Or can lead to continuous discussions over what solution on what level to use creating an incredibly long time to market for the contactless smartcard. As a consequence, users do not benefit from this simple, convenient and user-friendly solution, which could make their mobility and life much easier, safer and enjoyable and do not ride public transport more often than before.

Thus, it is highly recommended that transport operators use available standards and open specifications (incl. security, data model, transmission, etc.) as much as possible to avoid costly implementations of proprietary and non-compatible systems, which make interoperability impossible.

In this context, an **open platform** is composed of hardware and software components that adhere to common standards and are non-proprietary such that multiple vendors can supply these components interchangeably. In an open platform, components from multiple vendors using different technological approaches may be assembled and interoperability across products can be

ensured. The objective of an open platform is to achieve vendor independence and allow easy transition to emerging technologies.



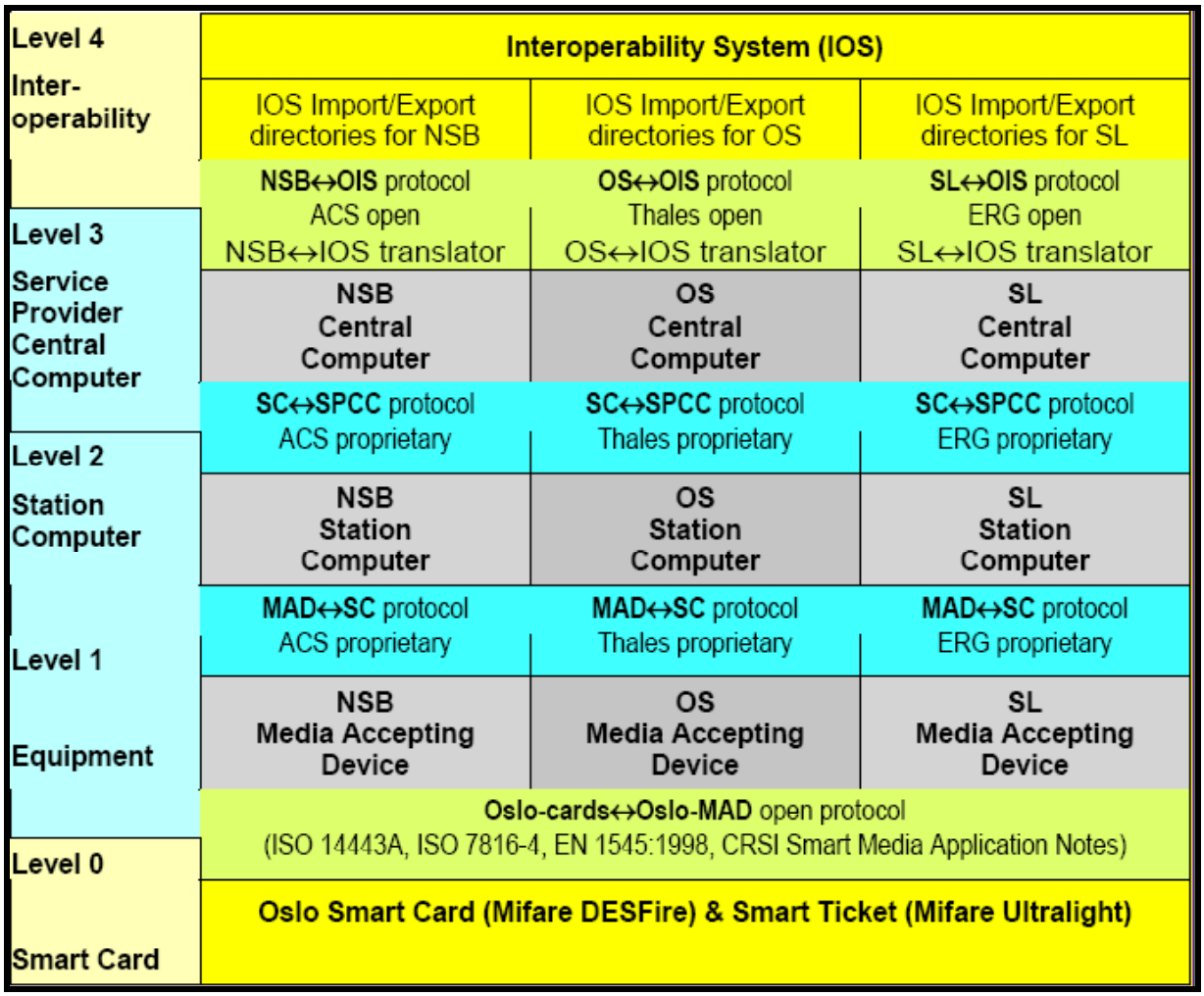
Architecture of the e-ticketing nation-wide system in the Netherlands

The implementation of the generic model as defined by the IFM system architecture differs from one situation to another. It depends on the levels of the system that are left open to suppliers and those that have their own proprietary solutions.

For example, in the Dutch implementation (see above figure), the objective is to provide an open architecture for vendors of all system components (at levels 1, 2 and 3), except the central and unique system components used for security management, card Production and management (Level 0) and clearing & settlement (Level 4).

In Oslo, the architecture is completely different. The Common Requirement Specifications for Interoperability (CRSI) have been developed in a way to find a conceptual model with a minimal impact on existing AFC system design. This has been achieved by applying normative interface specifications only:

- At the lowest level between the interoperable media, i.e. the smartcard (Level 0) and the media accepting devices (Level 1)
- At the highest level between each service provider (transport operator) central computer (Level 3) and the central Interoperability System (Level 4)



Conceptual model for interoperability in the Oslo region

As can be seen from the figure above, all internal interfaces in the interoperable AFC systems are kept out of the normative set of requirement specifications. They are proprietary to the selected suppliers. However, they have to ensure interoperability with the lowest and the highest levels.

In order to complete the chosen execution model, it was decided to acquire a centralized Interoperability System (IOS) covering the following set of capabilities:

- Clearing, apportionment and settlement; the IOS is providing the PT operators with clearing, apportionment and settlement of e-ticketing interoperable stored values and products, and transactions forwarding to their owner.

- Support to the execution model; the IOS shall support the execution model of the Interoperability Fare Management (IFM) in the area by providing services like collecting, storing and forwarding of transactions, black list entries, action list entries, etc.

- Security; the IOS shall act as the IFM Security Manager and provide the PT operators with the security features necessary to the

management of ticketing keys and of data exchanges between the PT operators systems and the IOS.

- Registration; the IOS shall provide the participating business entities with means to officially register and reference documents, with approved format and content, and aimed at uniquely identifying interoperable items.

As described in the figure above, the AFC systems of the three service providers (PT operators) also have to support the chosen execution model. One major part of this adaptation is the implementation of interfaces between each AFC system (at level 3) and the IOS (level 4). This is managed by implementation of translator services as pluggable extensions of each level 3 system, responsible for translation between the different level 3 system internal data format and the IOS data exchange common format.

3.5 Advantages / Disadvantages of using e-ticketing standardised products

Referring to standards when defining e-ticketing specifications offer several advantages in terms of sustainability of systems, modularity of its components, interoperability of systems, provision of information to travellers, cost saving, etc. However, these benefits will be lesser when technological evolution will imply to replace equipments or some part of them. The table below summarises the main benefits and disadvantages of opting for standardised systems, according to each type of stakeholder.

Stakeholders	Advantages vs. Disadvantages	
Public Transport Authorities	Advantages	▪ Nation-wide common technical specifications ▪ Better use of financial resources ▪ More potential bidders (choices) ▪ Compliance of bids ▪ Free from any industrial interest
	Disadvantages	▪ Standardised choice ▪ Specificities not taken into account
Public transport operators	Advantages	▪ Continuity and easy integration of existing equipment with new one ▪ Optimisation of acquisition and maintenance costs
	Disadvantages	▪ Possible over-costs related to standardisation of new equipment
Industry suppliers	Advantages	▪ Benefit from standardisation ▪ Ensure interoperability ▪ Market opening ▪ Less specific orders ▪ Return on initial investment
	Disadvantages	▪ Harmonisation of equipment (less added value) ▪ Certification

3.6 Business model

There are different business models which could be adopted for the development and implementation of e-ticketing systems in public transport networks. They depend on the organisation of public transport in the concerned area (single mode or multimodal network, one operator or more and the weight of each operator) and the degree of risk that the organising authority and the operators are willing to take in this field.

In Barcelona, ATM the organising authority will take the full responsibility to design, implement, run and maintain the future e-ticketing scheme.

In Hong Kong, Octopus Card is born from an initiative of local transport operators led by MTR (the metro operator) which owns 57% of the shares.

The trend observed in several countries, in particular in Asia, is that a third organisation composed of several stakeholders including the public authority, public transport operators, system suppliers, banks, etc. is responsible for the development and operation of the e-ticketing system. In Taipei, Taiwan Smart Card Corporation (TSCC) is a joint venture company of which shares belong to Taipei City Council, Mass Rapid Transit company, bus operators, parking department, Taipei Bank and the industrial consortium which supplies the smartcard equipment. TSCC has wide scope of responsibility covering:

- Project management and operation
- Card and equipment purchase
- Equipment maintenance
- Transaction collection

- Settlement processing
- Refund administration
- Personalized card administration
- Consumer complaint management

In Seoul, Korea Smart Card Corporation (KSCC) was established in 2003. Shareholders are Seoul City Government, industrial groups, financial investors, mobile operator and the solution provider. Public transport operators are not involved. The main business of KSCC is the fare collection service through smart card operation in public transport networks. KSCC's revenues come from:

- Card issuers (prepayment, post-payment, mobile phone): they pay a licence fee to be entitled to issue cards accepted for payment on the public transport network. Banks are in this category: credit cards represent half of the payments for public transport in Seoul. License fee represents around 27% of KSCC's revenues.
- Public transport operators: they pay a service fee as a remuneration of the service provided by KSCC for equipping their network with automatic fare collection system. Service fee represents 56% of KSCC's revenues.
- Card sales: KSCC is also one of the prepaid transport card issuers and generates 13% of its revenue from the sales of smart cards to passengers.
- Sale of various non-plate cards is another revenue source (4%).

In Paris, STIF, the organising authority, considers that transferring part of the ticket sales to a third organisation is risky for the operators because they will loose the exclusivity of the relationship with the customer. In this region, the operators (RATP, SNCF, OPTILE) have jointly established a consortium called COMUTITRES who acts as card issuer and information system manager for all Navigo passes. COMUTITRES collects the customer-related data when issuing cards and puts it at the disposal of the operators. COMUTITRES is not involved in sales and does not play any role in the clearing mechanism.

3.7 Business case of e-ticketing schemes

It is commonly assumed that the implementation of contactless smartcard system will reduce operation and maintenance costs related to ticketing compared to a traditional system. The data collected does not allow estimating the cost of each component of a smartcard system. However, it is possible to discuss the cost advantage and disadvantage related to the main elements of a contactless system, as in the table below.

	Cost advantage	Additional cost
Cards/Tickets	Various types of tickets on the same card Value-stored card → no need for disposable contactless single ticket Multiapplication cards and/or e-purse → shared cost Possibility to implement pricing based on operational cost (distance-based) or marketing approach	High costs of disposable contactless single ticket (0.6€)
Validation (check-in and/or check-out)	No mechanical parts → Less maintenance Shorter transaction time (0.2 to 0.4 s) → faster boarding → reduced idle time at stops → less fuel consumption → optimised operation → improved crowd management at metro stations	If magnetic single tickets → coexistence of both systems (contact and contactless) Need to gate metro systems to force passengers to validate Additional validators if check-in & check-out in buses
Sales	Automation of sales → Less staff needed	Printing of receipts and single tickets
Control	Reduced fraud due to compulsory validation	Portable control equipment needed to read smartcards
Customer information & marketing	Improved loyalty and customer relationship management	Provision of readers to allow passengers to check their smartcards
Back office & Clearing	Information system shared by all operators → data is easily accessible Exploitation of customer data Improved reliability of data and transparent clearing mechanisms	Necessity to build and maintain a network of information amongst operators and with the Authority/Clearing house On-board equipment for exchange of data between buses and central system
Standardisation & Interoperability	Makes use of public transport easy because of improved integration Open standards cost less than proprietary solutions	Costly and labour intensive process at development stage

It is not easy to estimate the overall cost of the implementation of smartcard system in a public transport network because such assessment must be carried out on the whole life cycle cost of the system in order to cover investment, operation and maintenance related costs. On the other hand, if it is commonly admitted that e-ticketing schemes have a positive impact on the image and the

use of public transport, quantifying the impact is not obvious in particular when the introduction of smartcards is accompanied by a change in the fare structure or is integrated in a wider project aiming at modernising the network. Nevertheless, it is possible at least to know the amounts invested directly linked to the e-ticketing system. For example, the Ez-Link smartcard system of Singapore had a total investment of S$300 million i.e. around €150 million which comprises the on-board equipment of 4,000 buses, 1,100 gates at metro stations and the installation of 400 ticket vending machines as well as the central clearing house. In Bilbao, the Barik project will include the installation of 592 validators and 274 vending machines at rail stations (metro and suburban) as well as the on-board validation equipment of 544 buses and 523 drivers consoles for a total cost of €18.7 Mio.

One very important element which has an impact on the cost is the solution adopted for single tickets. There are five ways of issuing single tickets in an electronic ticketing system:

- Traditional magnetic ticket: in this case, the network will need to keep both contact and contactless validators (ex: Paris)
- Disposable smartcard: the cost is approx. 0.2 € which is still very high compared to the cost of the single trip (ex: Lisbon), but it will avoid keeping in operation the traditional ticketing system together with the contactless system
- Value-stored card: The customer will have to pay a deposit which is generally higher than the cost of the single trip, but is reimbursable (ex: London, Hong Kong)
- Bank card: It needs agreements with the concerned card issuers (ex: Seoul)
- Mobile phone: It could be by sms or mobile barcode. In this case it implies a telecommunication cost. Contactless payment is possible with NFC mobile phones (to be used as any contactless card) but there number is still very limited (ex: Japan SUICA, test phase in Frankfurt region)

A cost/benefit assessment and feasibility study of each option is necessary in the decision-making process of an e-ticketing scheme.

One example of cost impact related to e-ticketing is the case of Paris Solidarity Card. In the Paris region, there are approx 1 million people who are entitled to social pricing. The cost of managing their rights (renewal of their status every 3 months) used to cost 8.5 million € per year to STIF, the transport authority. The introduction of Navigo led to a 2 Mio € saving thanks to a computerised processing of customer-related information.

3.8 Clearing mechanisms

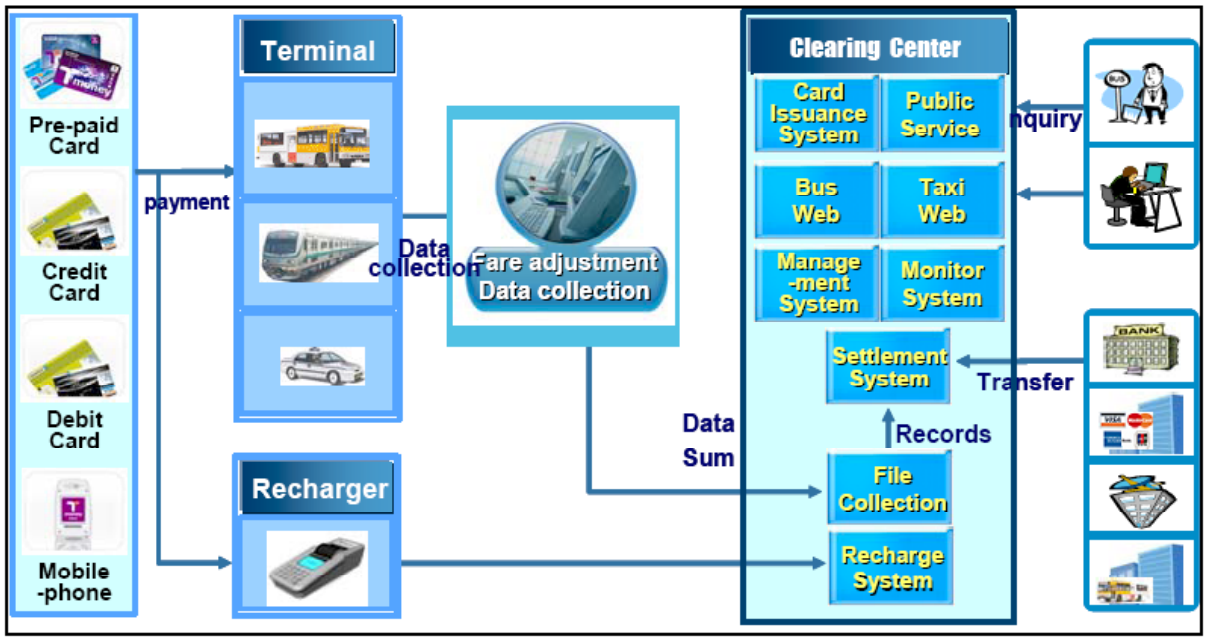
Clearing scheme depends on the type of contractual arrangements (if any) between the transport authority and the operator(s).

If the authority and the operator are linked by a gross cost contract, all revenues, even those collected by the operator, will go to the authority, and the operator is paid a fixed amount independently from the revenue generated from ticketing. In order to motivate the operator to increase patronage, the contract may include incentives. In this case, the operator could be entitled to receive a bonus (resp. to pay a penalty) if ridership or quality targets are reached (resp. if they are not reached). A compensation for concessionary fares is also paid by the authority.

If the operator has a net cost contract, or in a deregulated framework (no contract), the operator will collect all ticket revenues. In most situations, the pure net cost contract does not exist because fares are fixed by the authority and therefore the commercial risk is shared amongst both actors. In this case, the operator will receive compensation due to the fact that he is not free to set fares.

In most situations, there is more than one operator and a clearing scheme must be defined in order to remunerate each operator and reflect as much as possible the ridership of each. The issue is all the most important when passenger's transfer rights are full amongst operators and integrated ticketing is available.

The most common clearing method is based on counting and surveys carried out on the network to estimate how the different types of tickets are used amongst the various operators' systems. Each ticket type will be assigned a reference price reflecting its use. Based on the number of tickets sold and the related reference price, a total income is determined and then each operator is remunerated according to his share in this income.



Seoul T-money conceptual map of the system operation

Electronic ticketing can assist authority in improving clearing mechanisms by providing detailed information on customer's mobility behaviour. If a check-in/check-out procedure is implemented, it becomes easy to distribute revenues according to the actual travel pattern. (See Section "Exploitation of ticketing

data"). A direct impact is a saving on the cost of surveys which are periodically carried out to estimate how the different public transport networks are used.

In Paris, remuneration of RATP and SNCF is based on fixed distribution key according to the types of tickets sold. For OPTILE operators, the remuneration is based on periodic counting (every two years). In both cases, there is no direct link between the remuneration and the number of tickets sold by the operator. This is number is only used as an incentive to increase sales: if the target number of tickets (yearly) is reached, then the additional income is shared between RATP-SNCF (25% each) and STIF (50%).

3.9 Exploitation of e-ticketing data

Through mining the e-ticketing-related data, it becomes possible to get the operators' performance statistics: e.g. bus ridership by counting all bus boardings, service frequencies/headways by analysing the time interval between buses, and bus arrival time at bus stops by looking for the first person who taps the smartcard at a bus stop, etc. Mining on the public transport data collected provides valuable information on bus, rail, cards usage and travel patterns, which then could be utilized for policy, planning and marketing usages. This information will be more complete in a check-in/check-out system.

3.9.1 Operation-related information

In Singapore bus system, the e-ticketing system captures the necessary bus service information to compute bus fare when a commuter taps his card for boarding and alighting. A bus transaction record contents the information like service number, bus reference number, boarding stage, alighting stage, boarding time, alighting time, and fare paid. The data is used to analyze operators' service performance. Some popular reports are listed in the table below.

In addition, it is possible to get the bus capacity utilization by calculating number of passengers on each bus and bus stop usage by calculating number of passengers boarding and alighting at each bus stop. Such report could be used to monitor the bus utilisation and detect over-crowed buses.

In Singapore's rail system, the entry and exit information used for the fare calculation allows to compile statistics (e.g. daily ridership by lines and operators, number of entries and exits at each station) and analyse the travel within the rail system (e.g. transfers between operators, passenger-km for each line, time spent in the rail system).

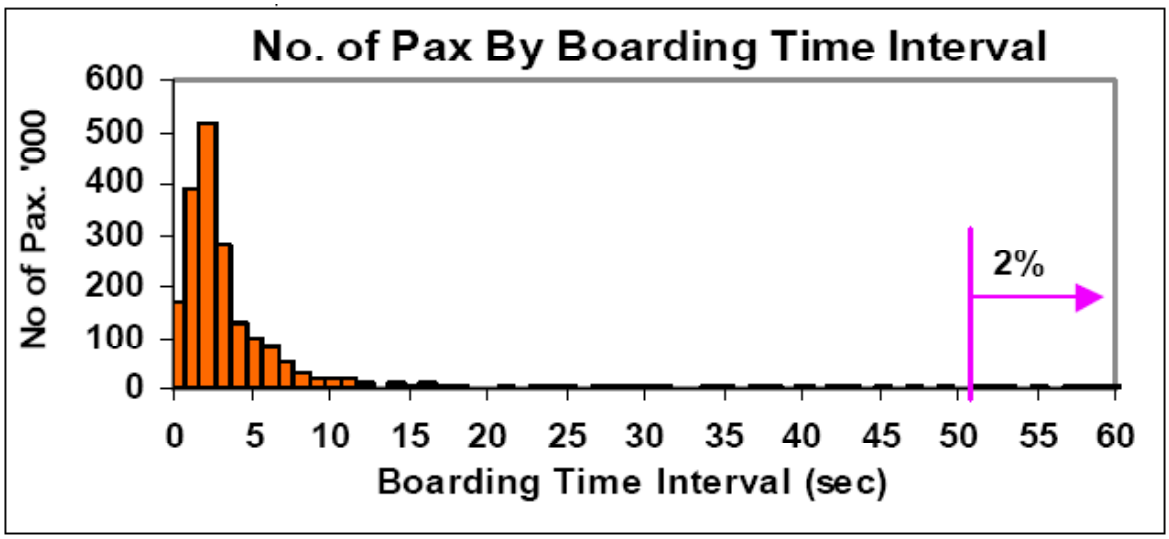
Category	Report	Description
Bus services related	Bus capacity utilisation	This report gives number of passengers boarding and alighting at each bus stop, and number of passengers on board of the bus along the selected bus route. It is used to monitor bus loading and investigate over-crowded buses.
	Bus arrival time	This report presents the actual bus arrival time at each bus stop along a selected bus route and time period and is used in monitoring and investigating bus headway and punctuality.
Bus stops	Board and alighting at bus stops	This report gives the number of boarding and alighting at the selected bus stops. This report helps to identify heavy boarding and alighting stops and estimate passenger volume at the selected stops.
Statistics	Bus ridership	This report covers daily ridership made by different operators and different ticket types.
	Bus rider travel distance and cost	This report provides average passenger-km and average bus fare per rider.

Example of reports on bus operation

3.9.2 Card-related information

Card-based information is collected each time a smartcard is used. When a commuter takes a bus or a metro, the system records the relevant details of the card, e.g. the card series number and type, and calculates the fare according to its card type. Therefore, when mining the transaction records according to the card type and series number, it is easy to get the travel pattern for the different groups of commuters. Furthermore, with the card series number on the transaction records, it is possible to trace commuters' travel pattern, such as whether a commuter takes bus only, or rail only, or both bus and rail. Consistency of commuter's travel pattern can be checked: for example some commuters make morning trips only and some take public transport in the afternoon only. They may select different routes (different services and modes) on different days when travelling between the same Origin-Destination. Adults, children, senior citizens and students may have different travel patterns.

One important issue is the number of incomplete transactions, i.e. the number of passengers who do not validate when alighting the bus. In Singapore, around 8% of all daily transactions are incomplete. It is mainly the case of students with monthly passes travelling by bus. A possible way to reconstruct the journey is, for a given card, to consider that the boarding stop of the a.m. ride corresponds to the alighting stop of p.m. ride and vice versa. Nevertheless, it is important to find ways to reduce the rate of incomplete transactions, for example by putting incentives: mileage service, frequency-based discounts.



Distribution of passengers boarding time interval in Singapore bus system

Exploitation of customer-related data raises the privacy issue. The way it is managed depends on the legislation of the country. It will not really have an impact on the type of date collected but on the duration of conservation of these data (only some days in France, eight weeks in London for travel service then anonymised, in some countries there is no legal limit), and on the legal possibility to merge databases making it possible to know actual itineraries of individual customers. In France for example, it is not allowed to merge the database of IDs with those of cards utilisation.

3.9.3 Journey-related information

A journey is a trip from the origin to the destination. A commuter may have to make a few consecutive entries and exits in the public transport system to reach his destination from his origin. A ride refers to a pair of entry and exit, and a journey consists of one or more rides on buses and rail. The journey-related information, like average journey time, average journey cost, and main modes of the journeys, is usually obtained through travel surveys or household surveys, which are costly, time-consuming and less frequent. Through processing the public transport data collected by e-ticketing, the data warehouse is able to provide reliable, detailed, and accurate journey-related information to the management, policy makers, and transport planners.

A major data processing action in the data warehouse is to construct individual rides into journeys, i.e. identify the rides belonging to the same journey in sequence and the journeys made by the same card. By tracking the transfer information, the data warehouse identifies the rides belonging to the same journey and the journeys made by the same smart card holder. By examining the data on a journey basis, it is possible to obtain the information like number of journeys made within a month, average journey time, and main modes of the journeys, etc.

Through these data, it is possible to know when and where a commuter enters the public transport system and exit the system. It is therefore possible to estimate the journey time defined as the time difference between the entry time of the first ride and the exit time of the last ride of a journey, excluding the

walking and waiting time before the 1st boarding and the walking time after the last alighting. Journey time consists of in-vehicle time and waiting time for transfers. The waiting time for transfers is an indicator measuring seamless travelling in the transport network. The data warehouse could produce a report on the waiting time for transfers. For example, the waiting time for transfers between bus and rail, derived from that report, could tells how well the bus system and the rail system are integrated.

The journey-based O-D (Origin-Destination) analysis looks into travel time, cost, speed and main modes between any two predefined O-D zones. Based on the data collected through e-ticketing, the data warehouse identifies the origin and the destination zones of each journey. The journeys within the same O-D pair are grouped according to the modes taken, and the average journey time, in-vehicle time, cost and speed are calculated. The detail O-D analysis, which zooms into the O-D pairs with long-journey time, low speed, and long transfer waiting time, is an input to improving public transport system.

3.10 Impacts and results of e-ticketing schemes

A number of benefits are expected from the implementation of e-ticketing systems. However, only few public transport networks have carried out 'a posteriori' evaluation of their system which makes possible to compare with the situation before the implementation of e-ticketing. Hereafter, some results drawn from real life implementation:

Singapore (eZ-Link):

- The average time taken for a passenger to board a bus has been shortened from 4 seconds by using the magnetic card to 2 seconds by using the Contactless Smart Card (CSC). In the rail system, for every 25 persons using the magnetic cards enter the fare gates, 50 persons can do so using the CSCs.
- The implementation of Vehicle Location System (VLS) further ensures the fare stage on a bus is updated and the bus fares calculated correctly. The automatic bus fare deduction also reduces fare leakage significantly. Before the implementation of VLS, the bus fare stage had to be updated manually by bus drivers. Improper updating sometimes resulted in over or under-deduction of bus fares. The VLS uses GPS to identify bus location, provides it to the Bus Entry Processor and the Bus Exit Processor, and updates the fare stage automatically. This technique enables accurate fare deduction on alighting. It has reduced the over-deduction rate from 0.3% before the implementation of VLS to the current 0.006%.

London (Oyster)

- Operational peak capacity, with Oyster tickets is around 25 per minute; with magnetic stripe card only it is 20 per minute.
- Duration of transaction with Oyster is 0.2 seconds.

Hong Kong (Octopus)

Benefits of MTR Club (loyalty club) to the corporation:

- 21.1% (from research) took more rides because of the promotions
- Monthly spending of club member = 2x average spending of the passenger base
- Average ride per member per month =45

Conclusion

There are several reasons for transport authorities for introducing electronic ticketing systems. However, they do not have the same priorities to all of them. Hereafter a list of expectations compiled from a survey carried out by EMTA[3]:

- Prevention of fraud
- Fare flexibility
- Improved multi-modal and multi-operator integration especially where method of operation requires accurate allocation of fares to private operators.
- Reduction or elimination of survey costs
- Speed of passenger throughput – though this varies by mode
- Improved passenger convenience and ease of use
- Efficiency savings
- Ability to pay for other services with the same card
- Improved information for transport planning
- Improved image for public transport

Although it is a very topical subject, contactless ticketing is still in an early stage of development. If we except few projects (mainly in Asia, in Finland) which have been implemented in the 1990's, the most significant and large scale development are taking place presently such as in London and Paris or are at trial or feasibility stage such as in Barcelona, Bilbao, Vilnius, the Netherlands, Denmark, etc. Thus, it is still early for a global assessment of the cost-benefit implication or the business case of e-ticketing. Nevertheless, it is possible to draw some conclusions on specific issues from these various projects Only some aspects:

- The effective closure of the fare collection system (i.e. 'check in – check out') afforded by new fare collection systems has increased the practicality of distance-based pricing. While a number of economic arguments can be made to support a distance-based fare structure, the equity argument is probably the strongest.
- Although some examples can be identified where new fare collection equipment has facilitated a migration to distance-based fares (e.g. Seoul Metro), there is no dominant trend from a fare structure perspective.
- More generally, a number of cities have either retained or simplified their fare structures rather than embrace the full capabilities offered by contactless smart card fare collection systems.
- The expected termination of the traditional fare product concept with the introduction of contactless smart cards has not been matched by the reality. While e-cash is now extremely important in some systems, it often sits alongside traditional product concepts. In some cases this has required the on-going parallel operation of existing fare media and fare collection systems. There are a number of drivers of this outcome:
  – Desire to retain products that are popular and well understood

[3] *Report prepared by Paul Cobain, Transport Planning Team Leader, CENTRO, UK*

– Regions served by multiple operators and fare collection systems(i.e. lowest common denominator)
– Requirement to support visitors and infrequent users
– Political imperative not to impose fare increases on the market via fare system reform

- Most transport authorities that have chosen to introduce electronic ticketing have done so cautiously. Generally the launch of a system follows an extensive trial period, during which the system is only partly operational and available only to a small proportion of its eventual users, such as staff or those eligible for concessionary passes. Despite the understandable caution of all transport authorities that have chosen to introduce electronic ticketing, no major problems have occurred to date. Later schemes should be able to benefit from lessons learned in areas where electronic ticketing has already been introduced and from improvements to equipment made in hindsight of this experience.
- Referring to standards when defining e-ticketing specifications offer several advantages in terms of sustainability of systems, modularity of its components, interoperability of systems, provision of information to travellers, cost saving, etc. However, these benefits will be lesser when technological evolution will imply to replace equipments or some part of them.
- With e-ticketing, it becomes much more straightforward to provide multi-modal and multi-operator tickets that can be used for travel on any element of a public transport network. However, it is in places where public transport is less well integrated that this aspect of electronic ticketing could offer the greatest benefit.
- Electronic ticketing can assist authority in improving clearing mechanisms by providing detailed information on customer's mobility behaviour. If a check-in/check-out procedure is implemented, it becomes easy to distribute revenues according to the actual travel pattern. A direct impact is a saving on the cost of surveys which are periodically carried out to estimate how the different public transport networks are used.
- Through mining the e-ticketing-related data, it becomes possible to get the network performance statistics. Mining on the public transport data collected provides valuable information on bus, rail, cards usage and travel patterns, which then could be utilized for policy, planning and marketing usages. This information will be more complete in a check-in/check-out system.
- New possibilities offered by NFC and bank-issued smart cards opens up new horizons (mobile-ticketing, bank card ticketing)

ANNEX

GLOSSARY OF PUBLIC TRANSPORT TICKETING TERMS

Automatic fare collection (AFC): Transport payment systems based on the use of information and communications technologies. They are also referred to as electronic ticketing. These systems, compared to mechanical systems, are not only means of payment but also offer a large range of possibilities and data collection that make public transport easier to use, manage and control.

Be-in/Be-out: A type of innovative electronic ticketing system which detects the passenger's payment device while the vehicle is moving from one station to the next, thus registering all passengers that are actually on board at that time. Such systems are not yet in commercial revenue.

Check-in/Check-out: Electronic ticketing system where the customer has to present his payment device (smartcard) at an in-vehicle validation device while entering and leaving a vehicle or, alternatively, at a platform. Such installation is needed when the tariff system is based on zonal or distance fares.

Commercial risk: The risk taken by an operator or an authority on the revenue generated by the service.

Concessionary fare: A variation on the basic types of fare structure, and is used in conjunction with the conventional basic fare system to attract targeted passengers for social or economic reasons. Concessionary fares can include fares for children, pupils and students, the elderly, the disabled and unemployed people.

- **Contact Smart Cards.** A contact smart card requires insertion into a smart card reader with a direct connection to a conductive micromodule on the surface of the card.
- **Contactless Smart Cards.** Contactless smart cards must only be in near proximity to the reader (generally within 10 centimeters) for data exchange to take place. The contactless data exchange takes place over radio frequency (RF) waves. The device that facilitates communication between the card and the reader are RF antennae internal to both the card and the reader.

Contract: An agreement between two or more parties for the provision of services which creates obligations enforceable by law. Contracts clarify the rights and duties of each parties. The term agreement, although frequently used as synonymous with the word contract, is a term with a broader meaning. All contracts are agreements; but not every agreement is a contract.

Deregulation: An authority (assuming one exists) may allow free entry to the public transport market, subject only to a requirement that the vehicles or the operator meet a specific set of standards, without any prequalification or tendering process. It is the open entry regime.

- **Electronic Purse**: A chip-based application where cash or value is recorded on a chip and is available for use in vending machines and at participating merchants, typically for small transactions.

Electronic ticketing: See *automatic fare collection*.

Fare: The price to be paid by a passenger to be allowed to use the public transport system. There are different fare systems:

- **Flat fare**: The simplest system in which all passengers are charged identical fares regardless of route, distance travelled, or type of passenger.
- **Route fare**: Each route has its own fare.
- **Zonal fare**: The network is divided in zones - with a flat fare within each zone - and the price is determined according to the number of zones crossed by the passenger.
- **Distance-based fare**: a price per km is applied.

Fare-box revenue: See *Recovery rate*.

Fare evasion (fraud): The unlawful use of public transport facilities by riding without paying the applicable fare.

Gross-cost contract: Under a gross-cost system the operator is paid a specified sum to provide the specified service for a specified period. All revenue is collected and remitted to the authority. The industrial risk is borne by the operator while the commercial risk is taken by the authority. The remuneration of the operator can be modulated by a bonus/penalty scheme according to the evolution of quality, patronage and satisfaction, which enables the authority to modify the level of commercial risk.

- **Hybrid Smart Cards.** A hybrid card contains two chips on the card, one supporting a contact interface and one supporting a contactless interface. The chips contained on the card are generally not connected to each other.

Industrial risk: The risk taken by an operator or an authority on the production costs of the service.

Integration: The process aiming at the provision of a coordinated and unified public transport system over a given area in terms of travel information, ticketing, timetables, marketing, etc. Intermodality is one aspect of integration: it is the provision and operation of an integrated multi-modal public transport system.

Intermodal (**multimodal**): Issues or activities which involve or affect more than one mode of transport, including transport connections, choices, cooperation and coordination of various modes.

ISO 14443 standard for contactless smartcard: Cards that comply with this standard are intelligent, read/write devices capable of storing different kinds of data and operating at different ranges. Standards-based contactless smart cards can securely authenticate a person's identity, determine the appropriate level of access, and admit the cardholder to a facility, all from data stored on the card. ISO 14443 has been designed specifically to function poorly beyond the 10 centimeter specified range. It is not possible to "listen to" the card from a distance that is far enough away that the extremely large antenna needed to energize the card would go undetected.

Mobile ticketing: A ticketing system based on the use of the passenger's mobile phone for the payment of the travel cost.

Multi-applications smart cards: Smart card technology provides an opportunity to include multiple applications on one card. A multi-application card may serve as an identity authentication token and may also provide the cardholder with additional capabilities, such as payment using an electronic purse, physical access to controlled buildings, logical access to computer systems, and data storage for medical information for use by authorized personnel. Both contact and contactless smart cards can support multiple applications. When using a multiple application card, each application may be managed by a different group within an organization or even by an external application provider (for example, a third-party electronic purse for cafeteria use). While requiring more complex organizational coordination, implementation of multiple applications can enhance the business case supporting the adoption of smart cards.

Net-cost contract: Under this contract, all revenue is kept by the operator. Therefore, the operator has to forecast both costs and revenues. The industrial risk is borne by the operator, as well as the commercial risk which is mainly taken by the operator. The operator is remunerated by the revenues and by a complementary compensation payment fixed by the authority with or without adjustment, for social fares or other public service requirements. The sharing of the commercial risk depends on the existence of this adjustment system between the fixed amount and the real revenues.

Operator: An individual or an entity, such as a corporation or a partnership, in the business of providing public transport services against payment by the passengers and/or the authority.

Organising authority (regulator or regulatory body)**:** A government or public agency created to perform a single function or restricted group of related activities. The authority pertains to the government entity that is responsible for the organisation of the public transport market. It is responsible for transport fare level, route designations and other public transport operating system policies, supervision, regulation and award of operating contracts and franchises. In some cases, the transport operating company and the authority are within the same government unit and perform policy, regulatory, planning, and operating functions. In other cases the authority is a separate public agency that does not have any operating responsibilities, but establishes public transport system policies and acts as the system's regulator.

Radio Frequency Identification (RFID) – Refers to an access control system that features a tag embedded with both a circuit and an antenna. As the antenna enters the electronic field of the reader, it generates energy for the circuit, and transmits the identification number in the tag to the reader.

Recovery rate of public transport operating expenditure: The ratio between the total public transport fare box revenue – including reimbursements for concessionary fares - and the operating expenditure of public transport – excluding depreciation.

Ticketing: A tool for the implementation of a pricing policy with the consideration of operational, commercial and social objectives. The ticketing system is the translation of tariffs into concrete means of payment (for the passenger) and fare collection (for the operator).

Through-ticketing: Some operators or transport authorities offer transfer tickets, enabling passengers to transfer from one route to another to complete

their journeys. There is usually a time limit, typically one hour or 90 minutes after the initial purchase or validation, within which the second journey must start.