Feature

State-of-the-Art Automated Ticketing

Jorge M. Rebelo

Electronic Fare Payment

Advancements in card technology have created new capabilities and opportunities for transit fare systems. The technological advancements include: radio-frequency proximity cards; contact chip/stored-value bank cards; combined contact/radio-frequency cards (combi-cards); improved microprocessors; and development of multi-application software. The opportunities this type of technology can provide are: security, multi-function capability, open software solutions, data capacity and portability, and non-contact card usage. The added value of smart cards versus existing card solutions is the security of the transaction. Smart cards offer secure data banks, requiring on-board, rewriteable, flexible memory solutions. The development of new software environments provide open programming solutions for multi-applications.

A considerable benefit of the non-contact smart card for a transit application is the quicker transaction time through the turnstile. This article examines the spectrum of current and planned fare systems including the technology that makes them possible and the current challenges transit managers are confronting. Transit managers across the country are exploring and adopting coordinated fare payment systems that promise greater flexibility in fare structures, less expense at collection, and greater convenience for riders. Transit, like other service areas, has the desire to reduce use of cash payments while improving customer convenience. New card technology offers transit managers the opportunity to integrate a new generation of electronic fare media and equipment that will provide a more cost-effective distribution and a more secure fare collection process.

Automated Fare Payment Systems

The system or environment in which a card will be issued or used is a fundamental issue. Generally, cards will either be used in what is commonly referred to as an 'open' (multiple card issuers and multiple service providers) or 'closed' (a single card issuing organization) system. It is important to note that a system can and may evolve from a closed system to an open system. There are two primary distinctions relevant to transit: 1. Is the transit agency issuing and accepting it's own card? 2. Is the transit authority accepting cards issued by other organizations? Historically, many transit agency fare programs have operated a closed system. Currently, transit authorities in the USA are using three types of fare payment media: magnetic stripe cards, credit cards, and smart cards. There are three types of smart cards: contact, non-contact, and combi-cards. Extensive technological developments in many forms of payment media have recently occurred. The trend towards 'electronic cashless commerce' is a growing business practice worldwide. Interest from the finance, postal and telecommunications industries is contributing to the rapid pace of technological advancement. Advancement in card technology will facilitate acceptance of electronic payment media programs as a viable payment option for transit operators. Currently, stored-value (stored-fare) and multi-use programs are in limited trials in US cities. Multi-use transit projects are already in operation in other parts of the world. Ultimately, the success of electronic payment programs will depend on the degree of acceptance of the media by issuers, merchants and, most importantly, consumers. System definitions and overviews are detailed below.

Closed systems

A closed system is one in which the card is issued by a single organization and can be used for that organization's services and other agreed service providers. Historically, a closed system is how transit agency fare programs have operated. Today, closed systems are also

Octopus system train gates in Hong Kong (B. Chalmers)

emerging at many large universities, such as the University of Michigan and Florida State University[1].

Closed transportation-only system overview

Within a closed, transportation-only system, a transit agency or group of regional transit agencies issue fare media that can be used on any of the agencies' services. This system can be used to achieve an upgrade in the agencies' fare collection processes and/or generate additional ridership and revenue. Individual agency functions such as card production, distribution, revenue settlement, equipment acquisition and maintenance can be provided by one or more of the member agencies, a system integrator (contractor), or by a new organization created by the agencies. To achieve maximum benefits and efficiencies, re-engineering of operational procedures will have to be achieved. Coordinating the purchase of equipment, installation and subsequent maintenance procedures will make multi-agency fare collection settlements more complex, but potentially more cost-effective[1].

Open systems

The term open system can be interpreted differently. A truly open system can consist of multiple card issuers and multiple service providers. However, within the transit industry, an open system describes a fare payment system in which an outside organization's card (a bank's card) is accepted for use within the transit agency. There are three types of models that can be implemented in an open system[1]. These models are discussed later.

Open system overview

Within an open system, a transit agency accepts the fare payment media from one or more outside issuers. Open systems contain three principal models or scenarios in which a transit agency can participate:

- A transit agency can become a 'merchant' in a participating program. Within this model, the agency will have to pay a transaction fee for their customer's usage. The principal benefit to this model is the agency reduces the risks associated with investing in rapidly changing technology and leverages infrastructure and card distribution costs with their partners. The card issuer absorbs this risk.
- The transit agency can become a formal partner, sharing the benefits and risks associated with such a venture. Partnering as a co-issuer of the card can result in additional revenues and maximum market penetration.
- The agency can administer its own payment program. This model allows outside-issuer cards to be used as long as the cards comply with the program's requirements. A primary benefit to any type of open system model is broader market penetration. In addition, successful partnerships will offer greater opportunity to generate additional revenue. However, with an open system, partnership agreements, issues and conflicts become more prevalent and complex. A major disadvantage of an open system is the transit agency will have less control over fare collection and less flexibility with pricing[1].

Multi-use systems

The emergence of a multi-use smart card system is gaining interest with members of the transit community. The advent of integrated circuit (IC) smart cards and the use of stored fares has created new opportunities to integrate more than one market with a single payment option. A multi-use application card can be established in various institutional environments including: transit-only, a more general public environment, or in an open system.

Transit Multi-use Overview

Transit operators implement a multi-use program for different reasons. The transit agency's goals and objectives are critical elements in determining the type of multi-use program that is pursued. Additional factors such as availability of funding resources and availability of technology will also influence the program type. The nature of the institutional setting and partnership agreements will depend on the program initiator's goals and the capabilities and constraints of the organization. Adopting a multi-use payment system will require a fundamental change in the way an organization has previously operated. These changes will impact the consumer, participating merchants, banks, clearing houses, and transit agencies. Many of the legal, regulatory, and policy issues concern the integration of multiple service providers and card issuers, as well as future technology development and the deployment environment[2].

There is growing commercial acceptance and availability of multi-use payment options, particularly in the banking and financial industry. Banks and financial institutions are very interested in seeing what the transit industry will do with multi-use cards because of the broad, geographically focused market that transit provides access to. Banks hope that they can establish valuable partnership agreements with regional transit agencies, which in turn may provide opportunities to share card distribution, infrastructure and costs. More pilot tests are needed to see if a multi-use smart card can accommodate integrated electronic payment in a diverse, environment.

While there are many obstacles, there are benefits to a transit authority in implementing a multi-use system, including:

- Integrated, seamless regional transit using universal ticket
- Increased market base
- Additional revenues
- Improved data collection and ridership information
- Reduced fare collection costs
- Improved customer convenience[3]

Closed multi-use systems

In a closed multi-use system the transit-agency-issued fare media can be used for other purposes, such as telephones or retail. The institutional support to carry out production and distribution of cards, and the purchase and maintenance of equipment can be provided by the agency, private contractor, or through a partnership with a separate company. The potential benefits of this system can include creation of an innovative, integrated fare system and increased market penetration. However, the transit agency's expanded role in a complex collection process with multiple merchants will be a disadvantage. This system will involve complex legal, regulatory, and political hurdles that may be difficult to overcome[1].

Types of Payment Media

The use of cash in transit fare collection has long been seen as a problem. Many transit operators have sought to minimize the associated risks in favor of some sort of prepaid option. Currently, transit authorities in the USA use three types of fare payment media.

Magnetic stripe cards

The San Francisco Bay Area Rapid Transit (BART) system was among the first operators to introduce magnetic stripe cards into the fare collection system. Now, nearly 30 years later, the magnetic stripe card continues to be implemented in various transit systems across the country. The stripe card is read by read-write units in computerized ticket machines and turnstiles. Ticket vending machines in transit stations accept regular currency and the ticket value is then recorded on the magnetic stripe. When the rider enters the system, the turnstile read-write unit records the place and time of entry. For systems with a flat fare, the reader deducts the fare from the value on the card and writes the remaining value. For systems with a distance-based fare, the exit turnstile computes and subtracts the price of the trip and sometimes records the time of day[1].

The principal benefit of the magnetic stripe card is the read-write magnetic stripe stored value. This stored value is a convenience for the transit rider and a benefit to the transit agency.

A stripe card can hold a large number of fares, greatly reducing the number of separate fare purchase transactions. The transit agency benefits from automated fare collection through lower labor costs and greater security in the handling of money. Although the concept of stored value is a principal benefit of the stripe card, there are some shortcomings with this technology. The mechanical systems that carry fare cards inside the read-write units are prone to wear and require frequent and costly maintenance. More importantly, the passage of riders through the turnstile is substantially slower with stripe cards than with cash or tokens. The slow transaction time is due in large part to the process of putting the card into the turnstile slot and retrieving it. To reduce transaction time and increase card life, some transit agencies tried plastic stripe cards designed for hand swiping through the read-write unit but found that this process is subject to various problems, including unreliable write operations[4].

Credit cards

A major benefit of credit cards is that they offer riders the convenience of a cashless fare payment. The major disadvantage is that the transit authority incurs a risk of invalid credit cards and must pay the card issuer a transaction fee.

Smart cards

Technically, smart card refers to a card with an embedded, pre-programmed IC or chip. However, many use the term to describe a variety of chipless automated cards. There are three types of smart cards: contact, non-contact, and combi-cards. Contact cards require physical contact between the card and reader, typically requiring the user to insert the card into a slot. The transaction time for these cards is relatively long and may not meet some unique needs of transit. Reliability of contact readers in the transit environment is also a concern. Additionally, finance cards require different security checks than a transit card. These issues make contact cards less preferable among transit managers. Because of these issues, separate electronic 'purses' may be required for retail, banking and transportation applications. An electronic purse is an application in a card where value is stored for low-value transactions.

Non-contact cards do not require insertion into a unit slot or reader. Instead, these cards are read by passing the card close to the reader unit. Non-contact cards speed up the passage of the rider through the turnstile, providing greater convenience. While the fast transaction time is a benefit of non-contact cards, customers and operators have expressed concern about the security of non-contact cards. Systems must be designed to assure customers that their card cannot be read from a card reader inappropriately. Customers must also be assured that the value of their cards cannot be stolen. Encryption and

verification software needs to be developed to provide adequate security[1]. The combi-card is a recent innovation in smart card technology that combines the characteristics of both contact and non-contact cards. Combi-cards can use either two separate purses for the interface or a single purse capable of being accessed in either manner. A card may be dedicated to the purse function or contain memory and programs for other applications. Cards with separate memory and processing for the contact and non-contact interfaces are called hybrid cards[2]. Most developers are trying to integrate the microprocessor and memory into one card. This would reduce manufacturing costs and enable the user to access a single electronic purse in either contact or non-contact mode if desired. Operational tests will assist in assessing the different card configurations and market acceptance[1].

State-of-the-Art Summary

There have been extensive technological developments in many forms of payment media. The trend towards electronic cashless commerce is growing worldwide. Interest from the finance, postal and telecommunications industries is contributing to the rapid pace of technological advancement. Transit, like other service areas, wants to reduce the use of cash payments while improving customer convenience. Advancement in card technology will facilitate acceptance of electronic payment media programs as a viable payment option for transit operators. Currently, stored-value and multi-use programs are in limited trials in US cities. Multi-use transit projects are already in operation in the UK, Germany, France, Australia, the Netherlands, South Korea, Hong Kong, and Japan.

While there is considerable interest in multi-use programs, prospective participants will have to overcome many barriers. To successfully achieve the benefits of a regional fare payment system, many of the institutional aspects of the revenue collection process must be integrated or at least coordinated. Combining card production, distribution, and marketing of several agencies can be complex but it can produce significant cost savings. A clearing house or payment settlement process can be developed to manage these processes. Participating agencies and merchants will have to agree on revenue management policies and procedures. Complex partnership agreements will need to be developed specifying each party's position with regard to responsibilities, ownership, costs, and revenues.

Smart cards can produce a record of where the traveler has been. Many believe that it is important that this information is used only for providing ridership information and that riders' privacy is ensured. Since multi-use cards are in the early stages of development, there are few current resolutions to these issues. Ultimately, the success of any of these electronic fare payment programs will depend on the degree of acceptance of the media by issuers, merchants, and most importantly, consumers.

Application Examples

Seattle/Central Puget Sound, Washington State

Six regional transit agencies and the Washington State Ferry in the Seattle/Central Puget Sound area have recently completed a smart card prototype trial. Implementation of a regional fare coordination program will enable customers to use one fare card on multiple systems throughout the four-county area. Non-contact smart card fare collection technology will allow linked trips between buses, railroads, and ferries and will significantly expand each agency's strategic fare policy capabilities[5]. Non-contact smart cards were distributed to riders participating in the revenue service trial. Cards were configured as a fixed period pass with unlimited rides, stored rides, or stored value. Revenue service testing included installation and operation of the prototype demonstration equipment on four King County Metro coaches serving Boeing custom bus routes, and four Pierce Transit coaches serving a Seattle Express route. Non-revenue service testing consisted of portable versions of the equipment in a variety of environments, demonstrating the equipment to agency and stakeholders groups. Overall reactions from both the customer survey and focus groups were positive. The final business requirements[6,7] received regional approval in 1998[8].

Bus contact card reader in Salvador, Brazil
(B. Chalmers)

San Francisco Bay Area, California

The TransLink system is being developed and implemented by more than 20 regional transit agencies in the Bay Area. The lead agency in this effort, The Metropolitan Transportation Commission (MTC), determined that the most appropriate form of technology would be a regional integrated system using non-contact smart cards. An initial demonstration of magnetic stripe cards revealed that this technology was not flexible enough to meet regional needs. Partnerships with private companies have been encouraged. Private-sector participation in system management, integration and operational processes, including clearing-house functions, is anticipated[1,7]. An Industry Review Draft of the TransLink Contract Book was distributed in early October 1997. The Contract Book serves as an introduction to MTC's planned regional fare payment systems. These documents have been distributed to firms, organizations, and agencies that have expressed interest in MTC's program[9].

New York City, New York

In 1990, the New York Metropolitan Transportation Authority (MTA) began implementing an automated fare collection system using the MetroCard magnetic stripe stored-value card. Read-write ticket units are installed on all buses and in all rail stations. Cards in specific denominations can be purchased at stations and nearby retail units. The initial project was designed with the intent of expanding usage of the card to other regional transit operators as well as for tolls and other uses. The MTA established the MTA Card Company to implement this broader plan by entering into a joint venture with a private company. The MTA entered into negotiations with a bank over the agreement terms but the two sides could not agree and negotiations ended in May 1996. The MTA is still hoping to proceed with integration of a multi-use program but the mechanism for administering these functions has yet to be decided[1].

Ventura County, California

Seven transit agencies are currently participating in a non-contact smart card program in Ventura County. The Passport program, initiated in March 1996, is a monthly pass, stored-value card that can be used on any bus in Ventura County. The smart card can be recharged onboard buses of all program participants except one. In addition to the card payment system, the Ventura County Transportation Commission has implemented other advanced public transportation systems (APTS) technologies, including automatic vehicle location and automated passenger-counting systems. Linking smart cards with these systems will provide the agency with valuable ridership information[1].

Ann Arbor, Michigan

The Ann Arbor Transportation Authority has over 80 buses with card readers that accept the University of Michigan 'M' smart card and more than 35,000 trips were made using the M cards during a trial period. However, the transaction time was found to be too long for the bus environment and the Transportation Authority is now studying potential equipment changes that could accept both the M card and a transit-issued non-contact card[1,7].

Atlanta, Georgia

The Metropolitan Atlanta Rapid Transit Authority (MARTA) partnered with Visa and three banks to rollout the VisaCash stored value contact card at the Atlanta 1996 Summer Olympic Games. Visa covered the cost of installing two card read-write units in 33 MARTA stations. Card vending machines were also installed in key transit stations around Atlanta. During the Games, MARTA represented the single largest use of VisaCash cards, accounting for 25% of all transactions. MARTA extended the pilot rollout through an agreement with one of the three banks[1,7].

Cleveland, Ohio

The Greater Cleveland Regional Transit Authority (GCRTA) has hired an evaluation firm to assist them in assessing the possibilities of integrating some form of electronic fare payment media into their system. GCRTA has been exploring possible multi-use arrangements with multiple partners including the Ohio Department of Human Services[10].

Standards and Interoperability

The question of standards and interoperability is a key concern being raised by transit managers considering an electronic payment system. Regional fare coordination can only occur if there is compatibility with payment systems of other transportation operations within the region. Although there are standards for certain aspects of smart cards, there is no specification to ensure complete interoperability between different card types and operating systems. Card standards are being developed by several international organizations, including the International Standards Organization (ISO), the American National Standards Institute (ANSI), and the European Committee for Normalization (CEN). Card standards are being developed under ISO Standard Committee 17 (Identification Cards and Related Devices) and the key working groups are WG1 (Magnetic Stripe Cards and Test Methods), WG4 (Contact Chip Cards) and WG8 (Non-contact Chip Cards)[1].

Contact cards

The basic set of standards for contact cards is known as ISO 7816. Additional standards ISO 9992 and ISO 10202 (Security) pertain specifically to financial-transaction cards. Moreover, a set of specifications is being developed to address interoperability of card acceptance, security, and payment functions. The jointly developed Europa/ MasterCard/Visa (EMV) Specifications govern financial (debit and credit) transactions using contact smart cards but only pertain to debit and credit transactions. Other organizations are working to produce standards for prepaid and e-purse cards. This gap in standards and specifications leaves the issue of interoperability between prepaid and stored-value cards unresolved. Stored-value programs in operation or on trial utilize ISO-compatible contact smart cards[1].

Non-contact cards

The development of relevant standards for non-contact cards for the transit industry is covered by ISO 14443 (Remote Coupling Cards) which addresses physical characteristics, radio-frequency interface, transmission protocols, and transmission security features. The smart-card industry is moving steadily towards adopting the standards for non-contact cards and combi-cards required for a successful move towards interoperability[2].

Functional standards

Functional standards and requirements also need to be developed and implemented. There are several initiatives underway at present. ITS America (http://www.itsa.org) has established an ITS Payment Systems Task Force to identify issues that may be involved in electronic payment programs in all modes. In addition, the US DOT/ Volpe Center has established a working group[11] under FTA sponsorship tasked with defining functional requirements and developing design guidelines for multi-use transit smart card applications. The APTA Fare Collection Committee also plans to consider the issue through a subcommittee. Finally, the Transportation and Multi-Application Working Groups of the Smart Card Forum are also reviewing multi-use card issues.

Octopus system city bus in Hong Kong (B. Chalmers)

Non-contact Smart Card as Key to Personal Mobility

Planning a smart-card non-contact system raises 10 technical and marketing issues:

1. **Should non-contact smart cards be only (or mainly) for public transport?**

User convenience issues in Tokyo (JR Suica), Hong Kong (Octopus), London (Travelcard) , and Seoul (Bus Card System) suggest that the answer is yes. Others push the case for multi-applications. Although there is still no full-scale multi-application, projects include several E-Purse providers (Proton, VisaCash). At first, financial institutions were reluctant to be involved with transport and were worried about the stricter security protocols needed for banking. Nowadays, they realize that transport smart cards have millions of transactions per day and they want to exploit this market opportunity.

2. **Should the card be non-contact or partial contact?**

A completely non-contact system permits a smaller-capacity reader for chip cards and decreases the number of electromechanical parts which cuts maintenance costs.

Conversely, a partial non-contact system requires an increased-capacity reader for handling non-contact smart cards, magnetic cards (single trip), paper tickets or even cash.

In developing countries , non-contact smart cards will co-exist with partially non-contact cards for some time but the consensus is that the non-contact smart card is better and faster.

3. **Will the public embrace non-contact smart cards?**

The answer depends on how convenient they are to use. The very rapid acceptance of the JR Suica in Tokyo and the Octopus card in Hong Kong suggest that the answer is yes.

Obtaining the full benefit of non-contact smart cards requires:

- High-quality customer information and training
- Educating staff to answer passenger

Suica system train ticket gate in Japan (EJRCF)

questions and assist with problems
- Educating the public about the user-friendliness (no need to think about fare) of smart cards
- Overcoming resistance when customers are accustomed to flat rates or unlimited travel passes
- Offering incentives to intermodal travel (discounts when using several modes/fidelity schemes/seamless travel)
- High-level anti-fraud/hacking/cracking measures

4. What are the advantages for the operators?

The business case for non-contact smart cards requires consideration of the life-cycle cost of investment in cards, equipment, and clearing houses plus the cost of operation and maintenance. Side benefits include reduced fraud, better market information based on accurate travel patterns, and more sophisticated ticket products such as the ability to adjust fares according to time of day.

5. Should the system operator be kept in-house or outsourced?

Each type has advantages and disadvantages; the Paris Transport Authority (RATP) and the Washington Metropolitan Area Transit Authority (WMATA) both operate in-house systems while Seoul (INTEC), Hong Kong (Creative Star) and London and Melbourne (Supplier Consortium) are outsourced.

6. How should revenues be divided?

This thorny issue has been resolved in a number of ways by division between operators in one mode (Seoul until now); between all operators in one system (Hong Kong, London); and between all operators and other service providers linked to the E-purse. London uses sampling in the case of non-smart-card revenues (for length of bus ride).

7. What is the best method for timely implementation?

Timely implementation requires a clear champion on either the contractor's side (TransSys consortium for London, ERG for Hong Kong) or the buyer's side (operator or service provider).

8. Should fares be debited at the start or end of the journey?

There are various schools of thought about this. Either the maximum fare may be debited from the stored value when entering the system (Kowloon Canton Railway Corporation in Hong Kong, London Underground, SMRT in Singapore) and then the unused part refunded when leaving the system. This reduces fraud and obviates the need for travelers to read fare tables, zones, etc. In the case of the Passport stored-fare card used on private railways in Tokyo, the minimum fare is debited on entering the system and the extra is debited at exit. If the card has insufficient stored fare, a ticket for the balance must be purchased from a fare adjustment machine at the ticket wicket. Another solution is to debit the stored value for an amount indicated by the traveler when entering the system (bus trial in Harrow, UK).

9. Should the card be supplied with a sleeve case?

RATP provides cards with a sleeve for easy reading of the card value and other information but it is bulky. The advantage of providing only a card is that it fits easily in a wallet.

10. How much information should be centrally collected?

This is a very difficult subject that raises important social questions about data privacy, etc. In some cases, all data is centrally tracked (Hong Kong) while in others, only limited data is collected by a decentralized system (RATP).

Conclusions

Most operators agree that introduction of smart cards will decrease maintenance costs if the electromechanical-based fare collection is replaced completely by optical/wireless readers. Most existing systems still have both collection systems, resulting in much lower benefits.

Operators also agree that a smart-card non-contact system allows faster passage

thereby saving time. There is also agreement that the non-contact smart card will decrease fraud, particularly when used for monthly passes and integrated fares.

The success of a non-contact card system depends on how the general public embraces the system. In developing countries, there are cost constraints that might make introduction very challenging. For example, in Washington and Hong Kong, an initial investment of $10 and $6, respectively, is required. It is doubtful that a deposit of this amount could be afforded by many people in India for example. The deposit is important to operators because it represents a reserve revenue. However, a mechanism must be found to charge either a much lower deposit or to provide cards for free, although the latter may cause card wastage. Other issues concern the card recharge function. How much money will users in developing countries be able to afford? If the amount is too small they will have to constantly go back to recharge machines, creating delays. In many industrialized countries, the recharge machine accepts bills/coins, credit cards or direct debit from a bank account. This feature will require careful study for developing countries where most people do not have credit cards or even bank accounts. Somewhat unexpectedly, Hong Kong's sophisticated population still prefers to add value to their cards at station offices perhaps because they feel uncomfortable with the recharge machines.

When used in buses, especially when the bus does not have a flat fare, location features must be added to determine where passengers get on and off. A Global Positioning System (GPS) is being tested on Singapore's buses.

Staffing levels might not be cut easily in countries where vandalism is common. In Hong Kong and Singapore, there are very severe penalties for vandals and the presence of a single attendant is sufficient to prevent the already low levels of vandalism. However, vandalism and theft increased in Argentina when station attendants were removed during an attempt to introduce the magnetic strip cards. Total removal of station attendants could have severe consequences.

The open system seems likely to be more difficult to introduce in developing countries, because it assumes that users will have an electronic purse and most will not.

Before introduction of a smart-card system in any country, it is essential that the regional transport commission or equivalent is represented, and the business rules covering tickets, passes, discounts, concessions, etc., are carefully defined.

Systems that have mastered use of magnetic strip cards in several modes such as the TransLink system in Singapore will switch more easily to non-contact smart cards. Their business rules are clear and there is a regional transport coordination commission.

While selecting the appropriate technology is crucial, education campaigns to prepare users are important for succes. Consequently, any schedule for introduction of smart-card systems must take education campaigns into account. ■

Acknowledgement

The author acknowledges the assistance from Messrs. Dreibend (WMATA), the Secretari de Transportes de la Republica Argentina, Wildermuth (consultant for the Buenos Aires System), the Secretariat of Metropolitan Transport of the State of Sao Paulo, Bichara (Salvador, Bahia), Chambers (Octopus, Creative Star, Hong Kong), Bourgeois and Portier (Systra, RATP), Prakasam (LTA, Singapore), Tan and Wen (Singapore SMRT).

This article draws heavily on 'Advanced Public Transportation Systems: The State of the Art—Update '98' (January 1998, US Department of Transportation, Research and Special Programs Administration, Volpe National Transport System Center) and the original version is available at World Bank website (http://www.worldbank.org).

Notes

1. Potential of Multipurpose Fare Media, *Draft Final Report*, TCRP, Multisystems, Inc., Dove Associates, Inc., Mundle & Associates, Inc., June 1997.
2. *Smart Cards Seizing Strategic Business Opportunities*, The Smart Card Forum, The McGraw-Hill Companies, Inc., 1997.
3. Smart Cards: Promoting Partnerships and Profits, briefing by Michael G. Dinning, Volpe National Transportation Systems Center, May 1997.
4. F. R. Holmstrom, Smart Fare Payment Systems for Public Transit, *Technical Brief*, Volpe National Transportation Systems Center, January 10, 1996.
5. Smart Facts: Central Puget Sound Regional Fare Coordination Project, October 1997.
6. Smart Card Prototype Demonstration Project, *Final Report*, IBI Group, June 1997.
7. M. G. Dinning, Volpe National Transportation Systems Center, Cambridge, Massachusetts.
8. C. Carlson, King County Metro, Seattle, Washington.
9. R. Driver, Metropolitan Transportation Commission, Oakland, California.
10. J. Frielich, Greater Cleveland Regional Transit Authority, Cleveland, Ohio.
11. ITS America Web Site (http://www.itsa.org)

Jorge M. Rebelo

Mr Rebelo is Lead Transport Specialist of Latin America and the Caribbean Region at the World Bank. He obtained Masters degree from MIT and MBAI from Mc Gill University. He joined World Bank in 1987 and worked on urban transport projects.