CHAPTER 6

ELECTRONIC FARE PAYMENT OPTIONS

INTRODUCTION

In line with the notion of a National Transportation System in the United States, the vision for transit is that of a "seamless" network, in which one can conveniently travel via a multitude of independent transit partners, using a single universal fare card. Historically, the U.S. transit environment has been anything but seamless—each transit agency has maintained its own fare structure and its own combination of fare media (e.g., cash, tokens, multiple-ride tickets, unlimited ride passes, and transfers). The situation is beginning to change, however, as increasing numbers of transit agencies are considering and implementing electronic fare payment methods that will facilitate convenience of travel both within and between transit agencies. These emerging technologies permit progress toward the vision of seamless travel.

A major focus of this study has been to review these emerging technologies and their implications for transit fare payment. The basic elements of this part of the study effort included the following:

- Identification of the key fare technologies and related developments,
- Review of financial implications of the emerging technologies,
- Examination of opportunities and barriers related to the emerging technologies and associated developments,
- Identification of key trends related to the emerging technologies, and
- Review of applications of the emerging technologies and developments.

The results of these tasks are presented in the remainder of this report. This chapter discusses the characteristics of existing and emerging electronic payment methods, particularly magnetic and smart card technologies. The advantages and disadvantages of these technologies are reviewed, and examples of each are discussed.*

Emerging Technology Research Approach

The research approach in this phase of the project entailed the following:

- Reviewing existing and planned tests and applications of emerging technologies throughout the world: information on a broad range of transit applications was compiled;
- Reviewing related research and development efforts: other researchers in the field were contacted and their studies were reviewed; and
- Reviewing trends and developments in non-transit sectors that could have potential for transit: applications and developments related to emerging payment technologies and methods were studied.

These efforts and the key issues addressed are summarized below.

Applications of Emerging Technologies

The focus of the research was on current and planned transit applications of electronic fare payment methods. Through the Phase I state-of-the-art research and the ongoing literature review, attendance at relevant conferences, and discussions with researchers and practitioners, the research team identified a broad and, presumably, comprehensive listing of such applications in the United States and abroad. Many of these agencies, as well as a range of equipment suppliers, were contacted to 1) make them aware of Project A-1 and to 2) solicit their input on their experiences and plans in this area. Information on the various tests, ongoing programs, and new technological developments was compiled and served as the basis for much of the analysis presented in this report. The types of projects reviewed included smart card tests, both transit-initiated and initiated by other entities, and new developments involving magnetic stripe technology; the latter includes regional fare integration projects, multiple use systems, and post payment/employer billing programs. Many of these applications are discussed in this chapter and Chapter 7, and several are described in more detail in Appendix A.

Related Research and Development Efforts

A number of research and development efforts were being conducted simultaneous to this study in areas of direct relevance to the research. Much of this work falls within the realm of Intelligent Transportation Systems (ITS)—formerly known as Intelligent Vehicle Highway Systems (IVHS)—research, and Advanced Public Transportation Systems (APTS) in particular. There are several ITS committees and working groups concerned with various issues associated with smart card technologies; for instance, the APTS Electronic Transportation

*This discussion represents information available to the researchers at the time the report was written. Other suppliers may exist, and omissions were inadvertent. This discussion is not intended to endorse specific products or manufacturers.

Card Systems (formerly known as Smart Card/Tag Systems) Working Group has been working toward defining transportation-related user and technical requirements for this technology. Meanwhile, several ITS/APTS demonstration projects will be testing the operational feasibility and impacts of smart cards on buses (and other applications). Another demonstration was sponsored by the California Department of Transportation, with tests on buses in three agencies in Southern California; this represented Phase II of the FTA-sponsored *Advanced Fare Payment Media Study*, which assessed the potential for various fare technologies. Another research and development effort has been the Ridetracking project being developed by IMMI; this project has focused on an electronic fare payment and trip monitoring system for use in human-service-agency-sponsored transportation programs. Finally, the research team reviewed a recently completed study, sponsored by the Volpe National Transportation Systems Center, that considered the development of a common card-based transit and toll payment system. Information on other efforts dealing with the development and potential application of smart cards in transit was also sought and reviewed. A summary of the key efforts in this area is included in Appendix C.

Trends and Developments in Non-Transit Sectors

This research focused on activities and developments in the banking and payments (e.g., credit card companies) industries, as well as in government activities related to the distribution of benefits. There has been increasing interest in the banking and payments sectors in the use of smart cards in general, as well as in the development of "electronic purse" applications involving multiple uses; transit has become one of these uses in several projects, and this appears to be a key area of development affecting future transit fare payment methods. Several key groups are involved in the establishment of standards and regulations governing smart card use. Review of activity in the banking and payments industries was also important in the consideration of electronic funds transfer forms of fare media purchase and the associated "back-end" settlement and processing requirements and regulations. The Federal and several state governments have become involved in smart card use in the electronic benefits transfer area; food stamp and other social service benefits are distributed to recipients via smart cards.

ELECTRONIC PAYMENT METHODS

Overview

The two basic parameters of fare payment methods are as follows:

- Payment options (e.g., single-ride, multi-ride, period pass, stored value, and post payment) and
- Payment media (e.g., cash, token, paper ticket, magnetic ticket, smart card, credit card, debit/ATM card, and transit voucher).

There has been a general trend in the transit industry toward greater prepayment, so as to reduce the use of cash and the purchase of one trip at a time. Although non-electronic media allow prepayment—e.g., through multi-ride tickets or tokens or monthly flash passes—these media have various shortcomings, including lack of flexibility for the agency (in terms of modifying fare structures and levels and intermodal integration) and problems with security (theft and counterfeiting). Electronic payment media (i.e., primarily those based on magnetic stripe or smart card technologies) have been designed to overcome these deficiencies while offering other types of benefits—to both agencies and riders. This chapter discusses electronic payment options (i.e., stored value and other prepayment options) and the advantages and disadvantages of electronic payment methods in general—as well as those of the specific types of media.

With regard to the media technologies, the research team has focused on those media that offer the most promise as transit fare payment mechanisms: magnetic stripe and smart cards. Although other card technologies (e.g., laser cards and long distance radio frequency [RF] tags) exist, past evaluations (i.e., other fare technology studies and agency reviews) have deemed these generally inappropriate for use in transit applications. RF tags are, however, an important element in highwaytoll fare collection and are discussed briefly in Appendix B. One technology that has seen limited use in public transportation is the use of bar codes. Although this technology is not seen as a major development or trend in fare collection, an application of this technology is reviewed in Appendix B.

Stored-Value and Prepayment Options

The Basic Concept

The basic electronic payment options involve stored value (and the full range of prepayment and post payment options). "Stored value" formally refers to a specific option in which a dollar value is held on the card and the amount of each transit trip (or other purchase) is decremented on each use. The term is often used in a broader sense—as it is in the remainder of this report—to describe any prepaid option that is then decremented. A prepaid card can also include period pass options. Thus, the stored-value or prepaid card can take one of the following forms:

- Value-based—contains a dollar value,
- Trip-based—contains a predetermined number of trips, or
- Time-based—can be used for a specific period (i.e., an unlimited-ride pass).

Electronic fare collection equipment can be programmed to accommodate a wide variety of fare structures. This offers the transit agency tremendous flexibility in setting fare structures that can be differentiated by type of payment option, time of day (e.g., peak/off-peak), mode (or level of service), and the nature of minimum purchase price and discount offered. The farecard can include transfers between vehicles or modes.

The array of options is further complicated by the fact that a farecard can accommodate more than one type of fare structure on the same card (e.g., a period pass for use on one operator's service or a particular mode, plus a stored dollar value amount for use on another operator or mode). Examples of such combined time-and value-based media are found in the Washington, DC, and San Francisco areas. For instance, WMATA offers six different types of 2-week passes that can be used on bus (unlimited rides) and rail (each type of pass carries a different amount of stored value).

Purchase and Pricing Parameters

With regard to purchase parameters for a stored-value card, the basic alternatives are as follows:

- User-encoded (one-trip minimum)—This is the approach at BART and WMATA. Fare cards can be purchased for any amount equal to or greater than the single-ride adult base fare, and value can subsequently be added (in "addfare" machines). The advantage of this method over one that has a higher minimum initial payment is that it addresses issues related to equity (i.e., ability to produce the minimum payment) and the need for a fare medium for the one-time user (e.g., a visitor to the city).
- User-encoded (higher minimum initial purchase price)—In addition to the fixed $15.00 cards, NYMTA MetroCards can be purchased in $5.00 increments (from $5.00 up to a maximum of $80.00); value is added in the same increments. An alternative is to allow adding value in any increment once the initial minimum payment is made. CTA plans to require a $5.00 minimum payment in its system—and the AVMs will not provide change; however, CTA has not yet formally established its payment parameters. The advantages of this approach over the above option are 1) that it will reduce both the number of cards that must be supplied and, presumably, the number of AVM transactions; and 2) it should increase revenue to the agency through the float associated with greater prepayment. This option, however, has key drawbacks—the equity and one-time user issues mentioned above. It means that the agency probably always will have to permit use of cash, tokens, or both.
- Pre-encoded (fixed amount)—The third option is a card that is pre-encoded with a certain value (e.g., $5.00, $10.00, $15.00, or higher) and thus can be sold manually (i.e., without an AVM) at off-site locations. NYMTA sells a $15.00 card at outside vendors (as well as in rail stations). CTA may sell pre-encoded cards at off-site locations, although the details have not been finalized; one option under consideration is for cards to be sold through ATMs—both on and off CTA property. Prepaid telephone cards are extremely popular in Europe and are beginning to see more widespread use in the United States. The U.S. version of the prepaid telephone card actually represents a variation on the stored value concept. Unlike the transit cards and the European telephone cards, the value is not actually carried on the card; rather, each card has a central account that is accessed by dialing a special code number. When the cardholder calls, he or she is told the remaining value.

The options for a stored-value pass include the following:

- Unlimited trips—at all times—during a calendar month: This is equivalent to a regular monthly pass. Its advantages are that it maximizes rider convenience and system ridership; on the other hand, it generates less revenue than other options. CTA may introduce such a pass on its stored-value card eventually.
- Unlimited trips—at all times—during a specified period (e.g., 28-, 14-, 7-, or 1-day periods): This is similar to the above, except that the period of availability typically begins with the first use of the card. For instance, WMATA has rail-only passes (priced at $50.00 and $100.00) valid for 14 or 28 days, respectively, beginning with the first use; WMATA also has a 1-day pass (costing $5.00) that can be used only after 9:30 a.m. (or all day on Saturday or Sunday). Delaware Authority for Regional Transportation in Wilmington, Delaware, has a "rolling" 7-day pass and also issues 1-day passes on board its buses through TPUs.
- Unlimited trips—peak or off-peak only, or weekday-only: Similar to the former CTA weekday-only pass, this option limits the use of the pass to specific periods, which minimizes usage—and concomitant revenue loss—of passes.
- Capped number of trips: The programming capabilities of electronic fare systems actually create the opportunity to offer passes that are "capped" at a certain number of rides per month (or per week or 2-week period), thereby limiting the revenue that is "lost" through very high usage of a pass as well as limiting the extent of pass "sharing"—but also limiting the benefit to the pass user. NYMTA, very concerned about the potential for lost revenue but committed to introducing passes, considered a capped pass (e.g., 60 rides per month) on its MetroCard, although this option was ultimately rejected.

The basic stored-value farecard options are summarized in Table 44. The options for discounts and/or bonuses related to buying and using the cards are described below.

Discount and Bonus Options

One of the key parameters of a stored value fare structure is the nature of the discount or bonus—if any—offered as an incentive to purchase and/or use the card. Stored-value farecards can be configured to include a range of discount and bonus options related to time-of-day or modal differentials, in addition to volume purchase or frequent use. The basic types of discount or bonus that might be considered are presented in Table 45 and can be summarized as follows:

- Initial purchase bonus: A certain additional value is offered for purchase of a certain amount. The percentage

TABLE 44 Stored-value farecard options

Fare Option	Basis	Purchase/Use Alternatives	Example	Advantages
value-based	dollars	1-trip minimum payment (user-encoded) minimum initial payment (user-encoded) fixed amount (pre-encoded)	$1.50 for 1 trip $5 minimum $5, $10, etc.	addresses equity, occasional user issues reduces no. of cards needed, reduces no. AVM transactions no need for change in AVM, facilitates off-site sale
trip-based	trips	no minimum no. trips (user-encoded) minimum initial no. trips (user-encoded) fixed no. trips (pre-encoded)	1 trip (e.g., $1 50) 10 trips (e.g., $15) 10, 20 trips (e.g , $15, $30)	(same as for value-based)
time-based	no. days, 1 week, 1 month	unlimited trips, all times capped no. trips unlimited trips, off-peak unlimited trips, peak	$75/mo. (based on 50 trips x $1.50) $60/mo. (capped at 40 trips) $30/mo. (based on 20 off-pk trips) $60/mo. (based on 40 pk trips)	maximizes convenience & ridership minimize rev. loss due to high usage reduce rev. loss, encourage off-pk use reduce rev. loss
combined value & time-based	dollars/time	unlimited trip (e.g., pk only or commuter rail), + value (e.g., off-pk or bus/rail)	$80 ($60 for pk pass, $20 in value)	facilitates integration with other properties (i.e., with different fare structures)

TABLE 45 Stored-value bonus and discount options

Option	Basis/When Received	Example*	Comments
none	equivalent to multiple single rides	$30 for 20 rides	only incentive to buy card is convenience for riders
initial purchase bonus (fixed %, regardless of $)	fixed % bonus, at time of purchase	$11 value for $10 payment (10%)	encourages prepayment
initial purchase bonus (sliding %, based on $)	% bonus higher with higher $	$11 value for $10 payment (10%); $23 for $20 payment (15%)	encourages greater prepayment
add-value bonus	% bonus when value added (i.e., not on initial purchase)	$5 value for initial $5; $11 value for additional $10	encourages retention of cards
per trip discount (above threshold)	reduced price per trip above minimum no. of trips	$1.50/ride for first 10 rides; $1.35/ride for rest of rides	encourages higher transit use
guaranteed last ride	last ride provided, regardless of amount left on card	ride provided even if $0.05 left on card	encourages use of card (especially where no add-fare machines)
off-peak discount	lower cost for mid-day, evening, and/or weekend use	$1.50/ride peak, $1.25 off-pk	encourages off-peak use
farecard discount (i.e., cash premium)	higher fare if using cash than if using farecard	$1.60 with cash, $1.50 with farecard	encourages use of farecard
transfer discount	free bus-rail transfer (or lower cost than without farecard)	$0.30 transfer with cash or token, $0.15 with farecard	encourages use of farecard
bus discount/rail premium	lower cost per ride for bus than rail	$1.50 rail, $1.30 bus; or $1.70 rail, $1.50 bus	generate higher ridership or revenue (depending on prices)

* assumes cash (or single ride) fare=$1.50

can either be fixed, regardless of the amount of value, or can increase with higher initial purchases. The former approach is like a bulk token or ticket discount. WMATA uses the latter approach, offering a 10 percent bonus if a rider buys a card for $20.00 or more; WMATA formerly used the latter approach, offering a 5 percent bonus if a rider bought a card for more than $10.00, or 10 percent for more than $20.00, but recently eliminated the lower level discount. Both options encourage prepayment, although the latter encourages greater prepayment.

- Add-value bonus: To encourage long-term use of individual cards (i.e., rather than disposing of them after using up the initial purchase value), users of farecards receive a certain percentage bonus each time they add a certain minimum amount to the card—but not with the initial minimum purchase. This approach is being tried in the Harrow area of London and has been considered in New York.
- Per-ride discount (above a threshold number of rides): This option offers a reduced price per ride for each ride above a certain minimum number; this is similar in theory to the bonus for adding value, except that it is designed to maximize transit usage rather than prepayment.
- Fare differentials: An electronic fare system can accept a peak/off-peak or bus-rail differential without requiring action by a ticket agent or bus operator—in contrast to the existing off-peak bus discount. The fare collection equipment can be programmed to deduct the appropriate amount automatically.
- Farecard discount and cash premium: Another option is a per-ride discount for use of a farecard as opposed to using cash (or, conversely, a premium for use of cash). This can be offered in addition to one of the other options.
- Guaranteed last ride: In this option, a last ride is guaranteed, regardless of the amount of value remaining on a person's card. In other words, if someone attempts to board a bus or use a turnstile with insufficient funds left on his or her farecard, the equipment will "zero out" the amount of value remaining and allow the rider to complete the trip. This is designed to overcome people's resistance to using farecards because of fear that they will run out of stored value where it is inconvenient to add value (i.e., on many bus routes). On the other hand, this can result in substantial revenue loss, i.e., if riders take advantage of the option; it also discourages extensive prepayment and retention and reuse of the cards.
- Transfer discount: The equipment can be programmed so as to deduct the appropriate transfer price automatically. One option to encourage card use is to charge a lower transfer fee with the card than if using cash.

There is also a discount inherent in any time-based pass, but, unlike the value- or trip-based options, the extent of the discount is controlled by the rider rather than by the agency. As explained above, it is possible to limit the discount on a pass by restricting the period of available usage (by time of day or day of week) or by capping the number of rides that can be taken.

Thus, the type—and size—of the discount or bonus offered is an important element of the stored value fare structure. A discount and bonus in general provide an incentive to purchase and/or use a farecard (as opposed to cash or token), and the exact nature of the discount affects the extent of the incentive and, thus, the impact on ridership, fare revenue, and fare collection costs. The alternative is to not offer any discount or bonus with purchase or use of the farecard; in such a case, the only incentive for riders is the convenience of prepayment and not having to carry exact change or tokens.

The Multiple Use Card and Electronic Purse

A transit prepaid farecard can be configured in many different ways—this flexibility can be further expanded if the card is a "multiple-use" card. This is a stored-value card that can be used for various small purchases or payments (e.g., for telephone calls, use in vending machines, and use in parking lots), in addition to transit trips. Various multiple use card projects—also called expanded utility or universal card—are underway around the world; issues associated with this development, along with several examples (including those in Great Britain, Denmark, and Switzerland), are described in Chapter 7.

All of the existing and planned applications identified through this study are using smart cards; the smart multiple use card is known generically as an "electronic purse." The first major U.S. application—planned for the New York area, as part of the NYMTA's MetroCard project—was designed to use the magnetic stripe MetroCard; however, NYMTA has revised its plans and now envisions a smart-card-based program, with magnetic cards probably still available to accommodate occasional transit riders. NYMTA is negotiating with a private company interested in forming a joint venture with the MTA Card Company (a subsidiary of NYMTA) to develop arrangements with businesses willing to accept the MetroCard for small purchases; the MetroCard project is discussed further in Chapter 7.

Stored value and prepayment options are the key elements of electronic payment. Post payment, i.e., in which the rider—or his or her employer—is billed for trips taken after the fact, is a newer use for electronic media. This concept is discussed in Chapter 7. The basic options and issues mentioned above apply to either magnetic or smart card technologies; technology-specific issues are discussed below.

ADVANTAGES AND DISADVANTAGES OF ELECTRONIC PAYMENT METHODS

Electronic payment methods offer transit agencies and riders a range of benefits unmatched by traditional payment methods and present new opportunities to expand the integration of transit fare payment with payment for other transit services, other travel modes, and other types of expenditures. Barriers to these new developments and disadvantages associated with these media in general do exist. These general opportunities and barriers are reviewed below; relative advantages and disadvantages of the individual types of electronic media are discussed in the remainder of the chapter.

Advantages and Opportunities

The primary advantages of electronic payment methods over more traditional methods can be summarized as follows:

- Improved flexibility, in terms of the range of fare options that can be offered and the ability to modify the fare structure; this can produce increased ridership, because of the ability to better target different fare options to specific markets;
- Improved revenue accountability and security, in terms of improved ability to track transactions and discourage employee theft or mishandling of fare revenue; this in turn should result in increased revenues;
- Reduced fare abuse, including counterfeiting of media and short payment or illegal reuse of media;
- Improved ridership data, i.e., generated from fare payment; these data can be collected without the additional expense of special surveys, and the data stream is continuous rather than discrete "snapshots" of the system as provided by surveys;
- Reduced transit operator and rider interaction and administrative and operational requirements, i.e., related to the need for operators to sell and verify the validity of media (flash passes and transfers, in particular);
- Improved convenience for riders, for both purchasing and using the media; in a fare system with many options, for example, the rider does not have to carry exact change or know the specific fare for every trip; and
- Ancillary revenue from unused value on stored value cards; the agency benefits from the "float" associated with prepayment in general, as well as the remaining value on cards never actually used for purchasing trips (e.g., out-of-town visitors buy cards with greater value than they end up using, or, if there is an expiration date for a card, riders may end up with some unused value); this can be a significant source of revenue, although an agency must address possible concerns regarding rules (local and possibly federal) for refunds for unused value (at this point federal regulations regarding prepaid cards in general are being formulated, and they ultimately could have implications for transit; these issues are discussed in Chapter 7).

Beyond these advantages, however, electronic payment methods offer benefits and opportunities related to expanding the existing capabilities of the fare media themselves; these include the following areas:

- Regional fare integration—electronic media and the appropriate equipment can allow the use of a single farecard on multiple transit operators in a region; each participating agency can still function independently and set its own fares.
- Multiple use or electronic purse—as indicated above, an electronic farecard can function as an electronic purse to allow small purchases for various goods or services, including transit.
- Post payment and employer billing—as mentioned above, electronic payment methods can provide a means to capture transaction data for billing of actual trips; this also offers a means of monitoring demand management and Clean Air Act requirements.

These functions are discussed later in this chapter and in Chapter 7.

Disadvantages and Barriers

The disadvantages of electronic payment methods are related primarily to the very complexities that produce the above benefits. Because these methods depend on complex technologies in equipment—and perhaps the media themselves—there are greater costs involved in many aspects of introducing and maintaining these options. The general disadvantages of electronic methods versus non-electronic methods can be summarized as follows:

- High cost of equipment and production of media, although the cost of the media depends on the specific media technology used (discussed in Chapter 8);
- Higher maintenance cost of fare collection equipment, including higher number of maintenance personnel and possibly greater skill level—and higher training costs—required for maintenance personnel;
- Greater lead time for implementation, because of an often lengthy procurement process, followed by the need to test equipment, modify and/or prepare stations or vehicles, and phase in introduction of system (depending on size and complexity);
- Possibly long "break-in" period, because of limited in-service testing of equipment and possible reliability problems with very new designs;
- Greater planning required for developing new fare structures, in light of the broad array of possibilities; new planning and modeling techniques are needed to understand riders' potential reactions to and usage of new fare options—and new media; for instance, NYMTA recently completed a more than 2-year-long process of developing a new structure for use with its MetroCard, and this effort required extensive surveys of riders and non-riders, analysis of potential use of different pricing options, and evaluation of alternatives; CTA has recently completed a similar study in conjunction with procurement of its new fare system;
- Possible union resistance, given that a key benefit is reduced operating and maintenance costs — primarily through personnel reductions; and
- Privacy concerns on the part of riders; card users may not want the transit agency to be able to track their ridership patterns; this is discussed further later in this chapter.

The specific cost impacts are discussed in Chapter 8.

Although the potentially high costs are perhaps the most important barrier, the concerns associated with reliability of new equipment and the long implementation period also represent serious barriers to the pursuit of electronic methods for many transit agencies. Some agencies generally are more inclined to try out new developments and like to be on the "cutting edge" of technological advancements. For instance, WMATA had one of the first stored-value systems in the world and is now testing contactless smart cards in a portion of its system; meanwhile, the Ann Arbor Transportation Authority (AATA) is planning to test a full "intelligent vehicle" system, which will include smart cards for fare payment. In fact, it may be a single individual in a transit agency who drives innovation and pushes to acquire the latest technology. Much more common, however, is a reluctance to try out a new technology; given the funding pressures facing most transit agencies, they much prefer to wait until a technology has been proven to be reliable and cost-effective before considering it. Most agencies are unwilling to risk potentially long "down time" periods for their fare collection equipment; this can mean significant lost or improperly accounted for revenue, as well as the negative public relations resulting from equipment problems.

A less obvious, but related, concern is what can be termed the fear of immediate obsolescence. With the rapid advancements taking place in electronic fare technologies and equipment, an agency may be reluctant to acquire a particular piece of equipment or a new media technology, for fear that it will soon be replaced in the marketplace by something new and improved. In light of the long implementation lead time that often occurs, an agency may end up finally installing a new fare collection system or piece of equipment after an improved version—or improved technology altogether—has already been introduced. As is discussed below, the rapid pace of development in the smart card arena falls into this category.

The prospect of a long research and development period before an agency can get the type of system or equipment that meets its particular needs can be a barrier. NYMTA is the extreme example, with its 10-year process leading to the installation of the first phase of its new fare collection equipment. Other projects, however, such as the integrated ticketing effort in the San Francisco (TransLink) area, are also in the midst of what will end up being long development and implementation periods.

There are also several barriers related specifically to efforts to take advantage of the expanded opportunities identified above. In regional fare integration, as well as multiple use card projects, extensive coordination among participating parties is required. This often involves development of complicated revenue and cost-sharing agreements and can be extremely time-consuming. Typically, a single agency initiates the project (as with NYMTA, LACMTA, and the Metropolitan Transportation Commission in the San Francisco Bay area), but if not, one must be designated. Once the program is operational, there is a need for additional administration—on the part of the lead agency, as well as at the other participating agencies. NYMTA has established a separate subsidiary, the MTA Card Company, to implement and administer the MetroCard expanded utility program. Another key element of a multi-entity payment effort is some type of "back-end" clearinghouse system for distributing revenues to the appropriate parties; these systems are discussed in Chapter 7.

Electronic payment methods offer a range of benefits to transit agencies and their riders, although there are also several important costs and other disadvantages. The specific costs and benefits are linked closely to the particular media and equipment technology selected; these, along with descriptions of current and planned applications of these methods, are discussed in the following sections.

MAGNETIC STRIPE TECHNOLOGY

Overview

Magnetic stripe technology has represented the state of the art in fare technology in the U.S. transit industry for many years. Magnetic tickets have been in use in the transit industry for 30 years, beginning in London and the LIRR in 1964. The first stored value application was in Chicago (Metra Electric ICGRR Line) in 1966, followed by PATCO (1968). Although development has continued and the equipment has been improved considerably, the technological advancements in the basic rail electronic fare collection system have been relatively minor, especially when compared to advancements in other areas (e.g., computers). Even judged by today's standards, the distance-based read-write-print BART (1972) and WMATA (1976) systems are quite sophisticated. Of course, the pace of development is related largely to the slow acceptance of the technology. Despite the fact that magnetic stored value systems have been "proven" at BART, WMATA, Baltimore MTA, and several other agencies around the world, relatively few agencies have introduced stored-value magnetic media to date. Although 12 of the North American heavy rail systems have some type of magnetic media, only 4 have an electronic fare system (i.e., rather than just magnetic pass readers). On the other hand, application of the technology has been expanding considerably over the last couple of years, with NYMTA, CTA, MBTA, and GCRTA (Cleveland) all introducing (or in the procurement process for) electronic fare collection. (See Table 46 for examples of current and planned applications.)

The use of magnetic technologies in the bus arena has been even slower to take hold. Approximately 20 North American bus agencies have magnetic media (predominantly swipe pass readers), with another 12 or so systems in test phases—thus, less than 10 percent of bus systems have incorporated any type of magnetic technology; however, magnetic technology is a much more recent development for bus than for rail. Electronic registering fareboxes were not introduced until the early 1980s, and magnetic swipe readers (for passes) were first installed in the mid-1980s. Bus TPUs—also known as bus ticket validators (BTVs)—have been in existence for several years but are just beginning to see significant usage. A number of agencies are installing and testing—or have initiated the procurement of—TPUs (see Table 47). Some agencies are apparently delaying

TABLE 46 Magnetic tickets for North American heavy rail systems

PROPERTY		TICKET PROCESSING METHOD				
		Ticket Transport - Rail		Swipe Reader - Rail		Bus
		Entry Control	Exit Control	Entry Control	Exit Control	
Atlanta	MARTA	X				Swipe Reader
Baltimore	MTA [(a)]	X	X			
Bay Area	BART	X	X			[(b)]
Boston	MBTA	[(c)]		X		TPU [(c)]
Camden	PATCO	X	X			
Chicago	Metra Electric	X	X			
	CTA	X		X		TPU [(c)]
Cleveland	GCRTA	X				TPU
Miami	MDTA	X				
Montreal	STCUM [(a)]	X		X		
New York area	PATH	X				
	NYCTA			X [(d)]		TPU
Philadelphia	SEPTA			X		Swipe Reader
Toronto	TTC			X		
Washington, DC	WMATA	X	X			

Notes

(a) - Baltimore and Montreal have Edmondson size tickets in ticket transports. Montreal has swipe readers for reading passes which are credit card size. All other systems have credit card size tickets.

(b) - TPU's tested on connecting bus services: CCCTA, BART Express

(c) - planned

(d) - read/write swipe reader

decisions to move to this technology pending further in-service testing of the equipment because of continuing concerns about the reliability of TPUs. Nevertheless, there has been considerable advancement in bus fare collection technology over the past few years, and the reliability of the equipment should improve with further usage and refinement by the manufacturers.

Examples of Magnetic Ticket Applications

The following represent examples of the types of emerging developments and trends using magnetic stripe technology:

- Multiple Use Card: MetroCard (New York City)—MetroCard is a stored-value card that is being introduced by MTA-NYCT. A key aspect of the project is to have a multiple use card available for transit as well as other uses; it appears likely that the multiple use card will be a smart card, rather than the current magnetic card (which will be retained for low-frequency transit users). The MTA Card Company has been established for the purpose of implementing this program, in which the card will be used for non-transit uses such as telephones and other small point of sale purchases.
- Post Payment: Bus Card Plus and Credit Card Acceptance (Phoenix)—The Phoenix Transit System has installed a magnetic card system called Bus Card Plus. It provides for billing of employers on the basis of number of uses of the card per month (for each employee), although the bill is capped at the cost of a monthly pass. PTS also

TABLE 47 Magnetic bus ticket processing units

Location	Agency	TPU Status
Large Systems (>500 buses)		
Columbus	COTA	planned
Houston	Metro	in test
Minneapolis	Metro Council - Transit	in test
San Antonio	VIA	planned
Medium/Small Systems (<500 buses)		
C. Contra Costa Co., CA	CCCTA	in test (TransLink)
Charleston, WV	KVRTA	planned
Clearwater, FL	PSCTA	planned
Culver City, CA	Culver City Transit	in use (Metrocard)
Detroit	Det.DOT	planned
Hartford, CT	Conn. Transit	in test
Montebello, CA	Montebello Transit	in use (Metrocard)
Monterey, CA	Monterey-Salinas Tran.	in use
San Diego	N.San Diego TD	in use
San Francisco	BART Express	in test (TransLink)
Savannah, GA	CATA	in use
Stockton, CA	San Joaquin RTD	in use
Tallahassee, FL	TALTRAN	in use
W.Covina, CA	Foothill Transit	in use (Metrocard)
Wilmington, DE	DART	in use

accepts credit cards (e.g., MasterCard, VISA, American Express, and Discover) directly in its bus swipe readers.

- Electronic Fare Collection on Buses: Delaware Authority for Regional Transportation (Wilmington, Delaware)—This system in Wilmington uses TPUs on its buses for several innovative fare functions: stored-ride tickets (10 rides; a ride is automatically decremented on each boarding), "rolling" passes (good for 7 days once they have been activated on the first use), automated issuance of 1-day passes, and automated issuance and handling of transfers. This system is also to participate in a smart card demonstration, as discussed below.
- Bus TPUs/Vehicle Area Network (VAN) (Houston)—Houston Metro has installed TPUs and plans to offer stored-value tickets; the agency also plans to expand the SAEJ 1708 standard to include a VAN for transit vehicles by specifying an on-board data controller that will provide a central control for all devices, i.e., radios, passenger counters, and fare collection functions.

These developments are discussed in greater detail in this and the next chapter.

Characteristics of Magnetic Tickets

There are two basic types of magnetic tickets available:

- Low coercivity tickets (approx. 300 oersteds), called "soft magnetics" and
- High coercivity tickets (approx. 3000 oersteds), called "hard magnetics."

Encoded data on low coercivity tickets, such as those used at Metra, BART, and WMATA, can be destroyed by a refrigerator magnet. High coercivity tickets, such as those used by CTA and PATH, cannot be altered by refrigerator and other soft magnets. The CTA "QuickPass" uses high coercivity magnetics and a hologram, which is employed for visual inspection. Magnetic verification is done by reading the encoded bit pattern and cancellation is achieved by altering the magnetic codes associated with items such as rides left or value remaining. Some systems (e.g., WMATA and BART) require the rider to insert his or her ticket on both entering and departing a station; the proper fare amount is deducted according to the specific origin-destination station combination.

Both printed and magnetic types of tickets are predominantly made of paper, with the thickness varying between 7 and 12 thousandths of an inch depending on the system requirements. WMATA and BART tickets are examples of 7 thousandths of an inch. However, "tickets" can be made of plastic. For example, MBTA uses a 10-mm-thick plastic card with a "hard magnetics" stripe for read-only operation by swipe readers. Plastic tickets can be recirculated for use in a "closed" magnetic ticket system, such as at PATCO, where entry and exit control are used. In such a system, single- or multi-ride tickets can be captured, re-encoded, and reused. There is no printing by the AVM or turnstiles. The life cycle has proven to be at least 100 uses. Similar tickets are employed in the Hong Kong and Singapore systems. Use of plastic tickets is an attraction, especially for systems that experience high humidity and that have machine-readable ticket devices. However, if printing is to be done by the turnstile or bus validator, the plastic material must be thermally coated to retain a smudge-proof printed image.

Counterfeiting of magnetic tickets—and all types of tickets—has been raised as an issue by some transit operators. Although this has plagued the commercial banking industry (i.e., in terms of counterfeit credit cards), there is little evidence that counterfeiting has been a problem in the transit industry to date. Nevertheless, efforts continue to develop improved anti-counterfeiting techniques. With increased density of magnetic encoding and use of hard magnetics, the degree of difficulty of duplication is increased. Other improvements in encoding technology include Thorn EMI's patented "Watermark" magnetic encoding technology. The magnetic elements are fixed in a particular pattern when the stripes are formed and cannot be altered later. Watermark magnetics offer protection against the two most common forms of fraud used on magnetically encoded tickets — skimming and buffering. Another method to thwart the potential counterfeiter is to include means in the system to track the use of the tickets. Tickets in the Southern California Metrocard project are serialized and these serial numbers can be tracked by the computers. Value remaining patterns of abnormal ticket use can be flagged and fraud prevented. A new technology called XSec Security System offers installing a "chip" set in existing reader devices. It uses the fuzzy logic technique to establish a digital signature unique to that ticket.

Capabilities of Magnetic Stripe Technology

A magnetic stripe ticket can be used for any type of payment option—i.e., single-ride, multi-ride, or period pass—and can allow for differentiation of fares by time, type of service, and distance (depending on overall system configuration). It can also be used in a post payment format. The technology offers a transit agency extensive flexibility in pricing and payment options. This flexibility has expanded to include the aforementioned regional integration and multiple use applications.

Magnetic stripe technology offers the basic advantages, opportunities, and disadvantages ascribed to electronic payment methods in general. Its specific advantages over smart cards can be summarized as follows:

- The media are considerably less costly to produce; whereas the unit price of a magnetic ticket is between $0.10 and $0.60 (depending on the specific characteristics of the card and the volume purchased), a smart card costs anywhere from $3.00 to $10.00 (again, depending on the specific characteristics of the card and the volume purchased); the cost issues are discussed in Chapter 8.
- It is a proven technology, in both transit and other applications (particularly credit and ATM cards); there has been considerable development and testing of magnetic-based fare collection equipment, as well as advancements in the medium itself.

Another advantage lies in the fact that there are industry standards for the technology and an extremely extensive usage base—i.e., in the form of credit and ATM cards. Because transit systems tend to be closed systems, their media do not have to conform to standards for other systems, and many transit applications do not necessarily follow International Standardization for Organization (ISO) standards. The move toward more "open" applications, such as regional fare integration and multiple-use cards, however, suggests an advantage in being able to use a standardized technology. Thus, this will become a greater advantage as the trend toward integration of uses expands.

The disadvantages of magnetic stripe technology as compared to smart card technology are as follows:

- Magnetic tickets are not as secure as smart cards (i.e., in terms of being counterfeited), although there have been continuing developments in improving the anti-counterfeiting characteristics of the technology.
- Magnetic tickets have considerably less data storage than—and lack the logical capability of—smart cards; this issue is discussed later in this chapter.

The benefits and costs of the two technologies have to be considered in determining the best approach for a particular transit application. To this point, the transit industry has generally accepted magnetic ticket technology as a proven, cost-effective technology, although there is increasing consideration of the use of various types of smart cards. Some agencies are considering smart cards as complementary media, for special uses; others are planning to test the feasibility of using smart cards as their basic fare media. The characteristics and advantages and disadvantages of smart cards for use in transit applications are addressed in the following section.

SMART CARD TECHNOLOGY

Overview: Definition of Smart Card

The term smart card has been used to describe a range of automated card technologies. The various types of cards are defined and categorized in many different ways and the characteristics of individual types of cards are changing as development continues. The different definitions reflect evolving features and that smart cards can be — and have been — categorized according to several different characteristics, including the following:

- The form and quantity of memory and the logic capabilities and
- The technique by which the card and the reader communicate (i.e., transfer data).

When defined according to the first approach, automated cards (other than magnetic stripe, bar code, and optical/laser cards, which are discussed in separate sections) can be categorized as follows:

- Memory cards—These are credit-card-size integrated circuit cards that store information but do not contain on-board microprocessors.
- Microprocessor cards—These are credit-card-size integrated circuit cards that have internal logic capabilities because of the presence of a microprocessor; in other words, they are essentially tiny computers. An advanced version is the "super smart card," which includes a miniature keypad and display.

When defined on the basis of communication technique, smart cards can be categorized as follows:

- Contact cards—These cards (memory or microprocessor) require a physical contact between the card and the reader-writer unit. Examples are cards made by Schlumberger, Gemplus, MicroCard, Bull, and Solaic.
- Contactless cards—These "remote coupling" or "close coupling" cards use a contactless interface to provide power to the card and transfer data using inductive and capacitive techniques. Examples are close coupling cards developed by AT&T and remote coupling cards developed by GEC, Racom, and Mikron; the card does not have to be inserted into a slot but is simply placed close to the reader.
- RF identification (RFID) cards or tags — RFID cards transfer data between the card and the reader-writer unit using RF techniques. The card can be held 1 or more in. (up to 100 ft in some toll applications) away from the reader. Power is supplied either with a battery (as in cards produced by Sony and Cubic) or by means of received magnetic energy. Close-distance RFID cards are often known as contactless cards,

There is significant overlap between contactless and close-distance RFID cards—all of these cards are increasingly being referred to as contactless cards. The key distinction for transit users—and for the agencies for most issues—is whether or not the card has to be inserted physically into a reader slot. For purposes of evaluating potential transit applications, the research team adopted the following categorization of smart cards:

- Contact cards are any cards that require insertion into a slot.
- Contactless cards are any cards that do not require insertion but must only be held close to (i.e., within a few inches of) the reader-writer; this includes remote coupling, close coupling, and RFID cards.

A hybrid card configuration, born of practical necessity, is a smart card with a magnetic stripe. This allows both technologies to be used during the transition stage—or permanently, if there is a need for both. This has been done in France and other places that have used contact cards. AT&T, in alliance with Chemical Bank, is testing its card with a magnetic stripe in a smart banking and stored-value card trial in New York City. Another type of hybrid card would include both contact and contactless functions; this would allow a single card to best meet the needs associated with transit and other types of applications (e.g., banking). Such cards are now being developed by several manufacturers and are expected to be available commercially by 1997. An alternative means of integrating the two card types—inserting a contact card in a contactless "sleeve,"—has been developed (by Innovatron of France) for use in Paris.

Background: Smart Cards in the United States

Although smart cards have existed in Europe for more than a decade, the United States has been slow to use the technology. Table 48 gives a historical perspective. Contact smart cards, originally developed in France in the early 1970s, are used by millions of cardholders worldwide. More than 36 countries, primarily in Europe and the Far East, are using or testing the cards in a variety of applications, particularly prepaid telephone cards. In France alone, more than 70 million Telecom cards were sold in 1992. These cards are discarded when exhausted.

The United States has lagged behind in smart card applications, although serious efforts are underway by the banking, telecommunications, and government sectors to use the card in a range of applications, including financial, social benefit delivery, and prepayment applications. For instance, the AT&T smart card was designed for use in its AT&T 2000 telephones, and, as indicated above, the card is being tested in collaboration with Chemical Bank in New York. This and other U.S. applications and developments are as follows:

- AT&T and Chemical Bank Project—This banking application is using a hybrid magnetic stripe and smart card technology. In November 1993, Chemical Bank announced it planned to test the AT&T contactless card as a debit card, first with its employees as a cafeteria card, then (by 1995) with its customers in New York City.
- Peanut Commodity Card—This is a program initiated by the Department of Agriculture in 1987 to reduce the amount of paperwork, increase the accuracy of the transactions, and reduce the manual effort in administering the peanut price support program by providing a smart card. The smart card records the producer's peanut sales and tracks sales against a quota. Approximately 200,000 cards are used. By 1990, the $12 million implementation cost was recovered, and, in 1996, the U.S. government anticipates a net savings of $14 million.
- Women, Infants, and Children (WIC) Electronic Benefits Program—A test was initiated in one county in Wyoming using smart cards in place of paper checks for disbursing WIC benefits. The card was encoded with the cardholder's personal identification, clinic, and food package benefit data. The cardholder was able to spread food purchases throughout a month and the support system automatically tracked allowed purchases.
- State of Ohio Food Stamp Program—This is similar to the WIC program in that smart cards are used to carry food stamp benefits for redemption at food retailers. Approximately 11,000 food stamp recipients received cards to use at 93 food retailers in one county near Dayton. A request for proposal has been issued to expand the demonstration project statewide and to add other benefit programs to the card.

Of broader significance regarding the potential for smart cards in this country and around the world is that MasterCard International, VISA International, and Europay International (of Belgium) are developing international specifications for smart card payment systems. These companies ultimately plan to replace the current magnetic stripe technology on their payment cards with contact smart card technology. The joint "EMV" specifications are evolving in three parts: 1) definition of the mechanical and electrical characteristics along with card and terminal transmission protocols; 2) definition of the terminal commands, applications, and data elements; and 3) definition of how the smart card, terminal, and back-end transaction processing network will work together. The initial plan was to complete the specifications and establish rules regarding the acceptance and issuance of smart cards by the end of 1995 and make terminals available to merchants within the next few years.

MasterCard and VISA, along with AT&T, Chemical Bank, and a number of other key entities (including the U.S. Treasury Department; American Express; and various banks, vendors, and consultants) are also involved in the Smart Card Forum, founded to discuss smart card infrastructure standards in the United States. With regard to specific smart card trials, VISA will be rolling out its VISACash prepaid card in Atlanta in conjunction with the 1996 Summer Olympics. This roll-out will actually involve a transit element, as MARTA will accept the cards (to be issued by three banks) for fare payment in its rail stations. Meanwhile, MAC/CoreStates—the largest northeast ATM network services company—is running a prepaid card pilot program among its employees; MAC has announced plans to offer a prepaid smart card to its ATM customers. Bank

TABLE 48 Time line for smart card developments

1970	The first and only patent on smart card concept was filed in Japan.
1974	Frenchman Ronald Moreno filed the original patent for Integrated Chip (IC) card; later dubbed the "smart card".
1979	Motorola developed the first secure single chip microcontroller for use in French banking.
1982	Field testing of phone cards took place in France - the world's first major smart card application.
1984	Field trials of bank (ATM) cards with chips were conducted successfully and French Post, Telephone and Telegraph (PTT) moved into higher volume usage of prepaid phone cards (smart cards).
1991	London Underground successfully applied contactless smart cards as yearly passes in revenue service.
1992	Autostrada in Italy selected AT&T's contactless card for toll collections.
	Germany introduced smart cards for health care.
	DANMONT, a nationwide prepaid card project started in Denmark.
	London Bus completed their "212 Demonstration Project" to assess the suitability of using smart cards.
1993	Singapore announced its CashCard program - first trial in 1995 The program may be extended to the transit system later.
1994	London Transport began its 18 month Harrow Trial in February.
	Dublin Bus and its partners began a pilot test in February for bus, phone, parking, and toll applications.
	Manchester launched its contactless smart card system pilot test in March on selected bus routes.
	Hong Kong selected a contractor for its common transportation electronic purse card
1995	Washington Metro began its 12-month field tests for the Go-Card project for bus, rail and parking payment.

of America is also conducting a smart card test at its campus in Concord, California. Finally, there are smart card initiatives underway at several universities, including a demonstration of five campuses in the University of Michigan system. Thus, there is considerable interest in the technology in the United States in several sectors. These developments ultimately may have a significant effect on the use of smart cards in transit, as is discussed below.

There are also several research and development efforts underway related to the usage of smart cards for transit. For instance, ITS America has a smart card working group whose purpose is to define technical and user requirements and system standards for smart cards and tags to be used in transit applications; this group is made up of representatives of research firms, manufacturers, and government agencies. The Volpe National Transportation Systems Center is also sponsoring an effort that is developing a plan for a common standard card-based toll and fare payment system for all modes of transportation. Finally, the FTA has sponsored the Advanced Fare Payment Media projects, aimed at developing cost-effective advanced fare media. A key concern of all of these efforts is the issue of standardization. Currently, there are probably as many standards as there are suppliers of the product. This is another barrier to the widespread adoption of smart card technology by the transit industry; issues related to standardization are discussed later in this chapter.

U.S. Transit Applications

The potential for transit smart card applications has received increasing consideration during the past few years. There have been several studies and development efforts related to potential use in transit. A number of pilot projects and tests are in progress—or planned—around the world, including several in the United States. The emergence of contactless cards has sparked interest within the U.S. transit industry, and the development of multiple use smart card systems that include transit has expanded the use of smart cards by transit agencies abroad. The use of smart cards was first tested at the Port Authority of Allegheny County (Pittsburgh) in 1990; Schlumberger, manufacturer of the cards, sponsored this test, which applied only to monthly passes. Example of smart card projects in test phases or under development are as follows:

- WMATA Contactless Card Demonstration—In December 1995, WMATA completed a 1-year test of the feasibility of a contactless card (using Cubic's Go-Card) for use on rail and bus, as well as at park and ride lots. The project includes installation of reader-writer units in 24 rail mezzanines, 21 buses (on 3 routes), 1 bus depot, and 5 park and ride facilities and is testing the ability to use the Go-Card as a common payment instrument. The basic Go-Card technology was extensively tested by London

Underground in 1990 and 1991 in its "Touch and Pass" Program. The card uses a battery-operated contactless, low power, RF data link to communicate and receive fareand fee- related data to and from a "target reader," which is integrated with the fare collection and parking equipment. AVMs can read and display the value remaining on a Go-Card and add value to the card when payment is made in the AVM. The Go-Cards are used in the faregates to enter and exit the Metro system. On the bus, the maximum fare is deducted on entry by the "target reader" (three-zone fare, for example). The passenger must check out on leaving, using either the front or rear door; if a one- or two-zone ride is taken, the appropriate value is restored. The same concept is used to pay for parking fee collection. Data from rail, bus, and parking subsystems is transmitted via modem to WMATA's Central Computer System to apportion revenue. The test began with 5,000 Go-Cards given to Metro employees and 1,000 to selected Metro riders.

- Southern California Advanced Fare Payment Media Test—As part of Phase II of the Advanced Fare Payment Media Study (funded by FTA and the California Department of Transportation), the contractor, Echelon Industries, developed bus card read-write units and installed them on buses at three transit agencies in Southern California (Gardena, Torrance, and LA DOT). Echelon tested these units with contact cards on some buses and contactless cards on others, in order to evaluate the user acceptance and performance of the two types of cards. In Phase III, the read-write units are being used by seven transit operators in Ventura County, California.
- AATA Smart Intermodal Project—As part of a multifaceted FTA-funded Advanced Public Transportation System (APTS) project, AATA plans to introduce smart cards for use on its system—as well as in designated parking lots. The plan is to use contact cards, at least initially, to accommodate the University of Michigan campus card now offered on the Ann Arbor campus. The demonstration is being designed to test, among other issues, the feasibility of the cards on buses and the potential for integrating the cards with an automated vehicle location system.
- Wilmington (Delaware) Smart Card Project—As part of a Federally funded ITS Operational Test, the Delaware Authority for Regional Transportation will be testing the use of contact smart cards on its bus system. The cards themselves will be provided by a local bank and will eventually be usable in ATMs and for other services at designated locations; the project is discussed further in Chapter 7.
- Central Puget Sound Integrated Fare Project—Transit agencies (and the ferry operator) in the Seattle/Central Puget Sound area are planning to conduct a trial of contactless smart cards as a common fare medium that will be used throughout the region. A comprehensive feasibility study has been conducted, and the plan is to develop an integrated system, including a regional clearinghouse, over the next 2 years.
- San Francisco Bay Area TransLink Project—This project involves development of a regional integrated stored-value card system for transit operators in the Bay Area. It was initially intended that the project would use magnetic tickets, similar to the existing BART ticket, and the original TransLink ticket was tested at BART and two bus systems (BART Express and Central Contra Costa County) in 1994 and 1995. However, following a trial period, it was decided not to proceed with the original plan. The Metropolitan Transportation Commission (MTC), the lead agency, commissioned a study to determine the most appropriate technology. This study, completed in late 1995, recommended a contactless card system, and MTC planned to commence development of the regional system in mid-1996.
- MARTA Smart Card Project—As part of the introduction of a stored-value smart card (VISACash) in Atlanta, the Metropolitan Atlanta Rapid Transit Authority will be accepting the contact smart cards for the payment of fares on the rail system. The cards and the card read/write units will be provided by VISA and the three participating banks; the project is discussed further in Chapter 7.

Various other U.S. transit agencies are considering smart cards either for use by specific market segments (e.g., the disabled) and/or for use by maintenance personnel. For instance, CTA plans to install contactless card readers on all turnstiles in its new fare collection system. Maintenance personnel will use the cards to gain access to the equipment. It is possible that disabled riders could receive the cards for use instead of the magnetic stripe fare card to be used by other riders. CTA tested the use of contactless cards in one station in mid-1995. NYMTA is planning to introduce smart cards along with its current magnetic stripe cards. The extent to which smart cards ultimately become used on a broad scale by U.S. agencies will depend on various factors, including the cost of the technology, the results of the above and other tests (e.g., related to the reliability of the technology), and the extent of the cards' adoption in banking and other industries. These issues are addressed later in this chapter and in Chapter 7.

Transit Applications Abroad

The use of smart cards in general is considerably advanced outside of the United States. This applies to transit usage as well. A number of transit agencies and government agencies overseas, as well as in Canada, have developed smart card projects over the past several years; several of these have been implemented; others are in the planning stage. Many of the current projects and those nearing implementation (both in the United States and abroad) are summarized in Table 49. Several of these efforts (i.e., those in Manchester, England; Dublin, Ireland; Hong Kong; Toronto, Canada; Copenhagen, Denmark; and Biel, Switzerland) were designed as regional integration and/or multiple use and electronic purse programs; these are described in Chapter 7. Other representative projects and tests are summarized below; these represent examples of the two

TABLE 49 Current and planned transit smart card applications

Location	Mode/ Uses	Type of Card	Supplier	Status (Start Date)	Size of Trial (or Plan)
Melbourne, Australia	R, B	CL/ M	AES, Fujitsu, Mayne Nickless	contract awarded (1994)	150 buses, 2 rail lines
Newcastle, Australia	MU	NA	AES, Fujitsu	in use (1995)	160 buses, phones, vending, retail
Sydney, Australia	MU	CL*	CTA/Mikron	in use (1995)	1M + cards
Ajax, ON	B	O**	GEC, Precursor Ltd	in use (1991)	20 buses, 1300 (student) cards
Burlington, ON	B	CL	GEC	trial planned	1100 cards
Toronto/Mississauga, ON	CR, B	CL	AES/Racom	trial completed (late 1995)	45 buses, 2 stations, 1000 cards
Frydek-Mistek, Czech Rep.	NA	CL	EMTEST/Mikron	trial (1995)	20000 cards, 100 readers
Copenhagen, Denmark	MU	C/CL	(various)	in use (1993)	NA
Helsinki, Finland	B	CL	BusCom, GEC	in use (1992)	20,000 cards
Oulu, Finland	B	CL	BusCom	in use (1992)	90 buses, 11000 cards, plus
Pori, Finland	B	CL	Inter Marketing Oy/Mikron	in use (1995)	60 buses, 5000 cards
Seinäjoki, Finland	B	CL	AES	in use (1992)	1800 cards
Turku, Finland	B	CL	BusCom	in use (1992)	NA
Besançon, France	B	CL	AES	trial (1993)	30 cards
Brest, France	B	M	NA	in use (1987)	bank cards for bus ticket prepurchase
Chambéry, France	MU	CL	NA	1 year trail (early 1995)	2000 student cards
Côte d'Or, France	B	C	Eurekar, Logicam	in use (1988)	28000 students
Dijon, France	B	CL/ M	AES	in use (1993)	8 buses, 1 route, 128 students
Marseille, France	MU	CL	AES (E C. GAUDI program)	trial (late 1994)	citywide tests, various cards
Montpellier, France	B	CL/ I	NA	trial (spring 1991)	two late-night services
Paris, France	B, R	C/ CL	Innovatron	trial (late 1993)	200 readers, 40000 employee cards
Valence, France	B	CL	Monétel/Mikron	implementation (early 1996)	95 buses, 10000 cards
Oldenburg & Luneburg, Ger.	B	CL	Siemens/G&D/ Mikron	trial (late 95)	20 buses, 3000 cards
Pusan, Korea	B	CL	Intec Ltd./Mikron	possible trial (1996)	100 buses
Seoul, Korea	B	CL	Intec Ltd./Mikron	trial (late 1995)	500/8700 buses, 100000 cards
Hong Kong	B, R, F	CL	AES/SONY/ Mitsubishi	planned (mid 1996)	3M cards, 5000 readers
Dublin, Ireland	MU	C	Schlumberger	3 month trial (Feb 1994)	25 buses, 2000 cards
Tokyo, Japan	R	CL	SONY (Felica)	trial (April 1995)	13 stations
Macau	B	CL	Racom	NA	800 cards
Netherlands	R	TBD	TBD	trial planned	NA
Oslo, Norway	B, R, F, L	CL	Scanpoint/Mikron	implementation (1995-97)	1200 bus, 108 LRT, 69 rail
Trondhelm, Norway	B	CL	AES	NA	180 buses
Szczecin, Poland	B, R	CL	ADE	trial	NA
Valencia, Spain	B	NA	IBM	in development (1996)	part of 500 bus "total control" system
Göteborg, Sweden	B, R, F	CL	AES, BusCom	trial planned	750 buses, 200 trams, 30 rail, 25 ferries
Lulea, Sweden	B	CL	BusCom	in use (1995)	100 buses (+Ostersund & Uppsala)
Ostersund, Sweden	B	CL	BusCom	in use (1995)	100 buses (+Luela & Uppsala)
Tempere, Sweden	NA	CL	NA	trial planned	NA
Uppsala, Sweden	B	CL	BusCom	in use (1995)	100 buses (+Ostersund & Luela)
Singapore	B, R	TBD	TBD	trial planned	NA
Biel, Switzerland	MU	C	Bull (w/ Swiss Post Office)	in use (1991)	30,000 cards
Liverpool, UK	B, R	CL	Wayfarer/Mikron	trial (June 1995)	10000 cards, 80 readers
London, UK	R	CL	Western-Cubic	trial (1991)	460 cards
London, UK	B	CL	GEC, Buscom	18 month trial (Mar 1995)	235 buses, 16000 cards, 19 routes
Manchester, UK	MU	CL	AES/GEC, SONY	in full use by 1997	32 operators, 2700 buses
Milton Keynes, UK	B	C	AES	in use (1990)	100 buses, 22000 cards
Los Angeles/Torrance, CA	B	CL	Echelon, Racom	trial (late 1994)	11 buses, 300 cards
Gardena, CA	B	C	Echelon, Gemplus	trial (late 1994)	10 buses, 500 cards
San Francisco, CA	B,R,L	CL	TBD	trial planned (1996)	plan for integrated regional card
Ventura Co , CA	B, P	CL	various	trial (early 1996)	7 agencies, 3500 cards
Washington, DC	B, R, P	CL	Cubic	1 year trial (Feb. 1995)	19 sta , 22 buses, 5 pkg lots, 1000 users
Wilmington, DE	MU	C	Gemplus, EPS	trial planned	150 buses (plus bank uses)
Atlanta, GA	MU	C	TBD	trial planned (Mar. 1996)	33 rail sta. (to use VISA Cash® card)
Chicago, IL	B***	C	ASI, Gemplus	on-hold	260 paratransit vehicles, 17000 cards
Chicago, IL	B, R	CL	Cubic, Racom	trial (1995)	CTA employees only, 250 cards
Ann Arbor, MI	B, P	C	TBD	trial planned	75 buses, 5000 cards
New York, NY	MU	TBD	TBD	TBD	all buses and stations
Winston-Salem, NC	B	CL	Racom	trial planned	1500 cards
Seattle, WA	B, F	CL	TBD	trial planned (1996)	plan for integrated regional card

* system designed to accommodate both contact smart cards and magnetic cards
**system used contactless cards initially
*** paratransit service only

NA = data not available	TBD = to be determined	C = contact card
MU = multi-use	B = bus	CL = contactless card
R = heavy rail	L = light rail	M = magstripe card
CR = commuter rail	SB = tourist shuttle bus	O = optical card
F = ferry	P = parking	'I = infrared card

basic smart card technologies, although most are using contactless cards.

- London Underground—London Underground conducted an extensive test of a contactless card system ("Touch and Pass") in 1990 and 1991. London Underground tested 458 cards and the trial had over 190,000 uses. On the basis of technical evaluation and surveys, the Touch and Pass program showed great promise in terms of ease of use, throughput, and passenger acceptability. Plans for systemwide expansion, however, are on hold for budgetary reasons. (Additional details are presented in Appendix A.)
- London Bus—A Stored Value Ticketing project, using contactless cards, has been initiated on London's buses. The trial is being conducted in two phases—the 212 Demonstration Project and the Harrow Trial. The 212 Demonstration was completed in 1992. The Harrow Trial began in February 1994 with over 200 buses (on a total of 21 routes) operated by 5 different operators for London Transport's Tendered Buses (contracted services). Phase II of the trial began in February 1995; the overall trial is scheduled to last 18 months. (Additional details are presented in Appendix A.)
- Milton Keynes, England—The town of Milton Keynes has used contact smart cards for riders for over 3 years. Approximately 40,000 passengers use smart cards on fixed-route service, and smart cards are also used on demand-responsive service. Passengers can pre-purchase a fixed number of rides at a slight discount; the system also supports unlimited-ride passes that begin on first use. The plan is that, eventually, passengers will be able to sign up to have their bank accounts debited, with value transferred to the smart card. A list of rides taken will appear on their monthly bank statements.
- Japan Railway East (JRE)—In February 1994, JRE started field tests in the Tokyo area with Sony's Remote Card System (called the Felica Touch-and-Go system). JRE has been researching the application of contactless cards for its automated (gated) fare collection system since 1987. The test involved 8 stations and 18 magnetic ticket-accepting faregates modified to include contactless card read-write operations. Preliminary results discovered some minor flaws that JRE believes can be fixed before the next trial.
- Singapore—A nationwide smart card system (CashCard) is being developed and will be introduced within the next 5 years. Although this is primarily a banking system, serious consideration will be given to using the CashCards for trains and buses.
- Ajax and Burlington, Ontario—A contactless card system is being developed for the towns of Ajax and Burlington. The original card vendor had to be replaced because the company decided not to develop the product.
- Oulu, Finland—Oulu has had a contactless card (supplied by Buscom of Finland) for use on its bus system since 1992. The card can be read and written to when it is held within about an inch of the reader-writer unit.
- Helsinki, Finland — The Helsinki Metropolitan Area Council and Helsinki City Transport tested contact, contactless (insertion-type), and contactless cards on its buses in 1991 and 1992. On the basis of the results of these tests, contactless cards were selected as being the most appropriate medium; plans call for the distribution of 20,000 cards.
- Oslo, Norway—The Oslo region is served by three transport authorities. The companies planned to introduce smart cards for an initial trial at the end of 1994. Prior to that, 100 smart cards were used by bus drivers for initializing 40 ticket issuing machines. These cards enable the drivers to log-on their paddle and sign-off and off-load data for manual transfer at the depot. Systemwide implementation was scheduled for 1995. The system employs contactless cards, which are validated before each ride. The system will include period passes and stored value cards that can be used throughout the region. Single trips (without transfers) will be made using paper tickets.
- Szczecin, Poland—In partnership with the AutoKomp Company, ADE is testing its contactless card as a fare medium on buses and has plans to expand the functionality of the card to payment for parking and taxi service.
- Melbourne, Australia — Melbourne's Public Transport Corporation (PTC) has awarded a contract to a consortium called "Onelink" to develop, implement, operate, and manage a smart-card- and magnetic-ticket-based system for the region's network of trams and light rail vehicles, buses, metropolitan trains, and over 1,000 private buses. A major decision by the government was to outsource the entire ticket and revenue handling system and associated services. Fares will continue to be set by PTC. All smart cards will be contactless and have a magnetic stripe. It is expected that ultimately the fare media for low-value rides (under 10 rides) will be one-shot, magnetic tickets. The availability of smart cards for the full range of ticket types, i.e., monthly, weekly, multi-ride, will be progressively introduced over an extended period, the rate of introduction being related to customer demand. The new fare system will be introduced in two stages; the first stage began in late 1994. Riders who will be provided with smart cards will include disabled persons, long-term riders who normally buy yearly passes and school children.
- Netherlands Railways—In 1992, the Netherlands Railways (NS) conducted a feasibility study for use of smart cards. The aim of the study was to establish whether paper tickets used for NS could be replaced by a smart card that would 1) combine tickets for bicycle sheds, parking facilities, buses, and trains; 2) would offer more suitable tariffs; and 3) provide better statistics for allocation of revenue. The specifications were finalized in 1994. (Additional details are provided in Appendix A.)

The following sections discuss the characteristics and advantages and disadvantages of the different types of smart card. A general comparison and assessment of the different card technologies is presented at the end of the chapter.

Contact Cards

A contact card consists of an integrated circuit chip (ICC) in a credit-card-size plastic transport media. The card has five to eight metallic contacts that connect directly to a read-write terminal when the card is inserted into the terminal slot. Data (and programs, if a microprocessor is contained) are stored on the chip itself. Contact cards are configured as either electronically programmable, read-only memory (EPROM) or electronically erasable, programmable, read-only memory (EEPROM). In other words, once data have been encoded on an EPROM card, they cannot be erased; these cards are updated by adding data to unused sectors of the card. When capacity is reached, the card must be discarded. Data on EEPROM cards, on the other hand, are erasable and modifiable. Hence, an EEPROM card can be reused until the card itself malfunctions or wears out. Industry vendors guarantee a minimum of 10,000 read and writes to an EEPROM contact card. Most contact cards on the market today are of the EEPROM variety. A typical contact card is a microprocessor EEPROM card carrying 16 KBit of data. Using various bit-mapping techniques, it is possible to extend the amount of data stored beyond the 2,048 bytes (8 bits per byte) of a 16-KBit card.

The smart card with its on-board microprocessor, user memory, and chip operating system provides extensive data security. The security capabilities include maintenance of a log of transactions in the card itself for audit purposes. In addition, each smart card has a unique internal serial number, encoded by the manufacturer, which cannot be altered or erased. So, even if a card record is duplicated, the new card retains its original serial number. This makes it possible to list stolen cards, issue replacements, and have the system distinguish between the two.

Like the magnetic stripe card, the contact card follows an established international standard (ISO 7816 Series); thus, it is not the proprietary product of one vendor. There are multiple, competitive sources for the card. Hence, there is no risk to an agency of becoming dependent on a sole source. Next to magnetic stripe cards, contact cards have, among advanced card technologies, the broadest acceptability and use worldwide. Furthermore, the international "EMV specifications" now being developed for payment cards will lead to a tremendous increase in contact card usage in the United States and throughout the world. Although Europe and the Far East have used contact card technology primarily in financial applications (such as prepaid phone cards and other financial transaction cards), contact card activity in the United States has been prompted largely by government programs (e.g., the WIC example presented earlier).

Several transit applications of contact cards exist. The aforementioned Ann Arbor project plans to use contact cards, and a project in Dublin, Ireland—the Dublin Dash Card, which was a multiple use card—used contact cards; the Dublin project is discussed in Chapter 7. Other contact card applications include Milton Keynes (England), Biel (Switzerland), and Copenhagen (Denmark). Finally, contact cards have been tested in the Echelon AFPM study in Southern California and will be used in the Atlanta and Wilmington projects.

Contact cards are, by and large, employed in multiple use applications. In other words, they are used for various combinations of goods and services in addition to transit. There are international standards for these cards, which makes them more readily usable in multiple applications. As discussed later in this chapter, this represents a potentially major factor in the expansion of smart card use. Contact cards are widely viewed as being less attractive for transit usage than are contactless cards, because of concerns regarding rider throughput. The need for the contact cardholder to insert the card into a slot is often seen by transit agencies as being too time-consuming to meet throughput requirements; the cards are also considered less convenient than contactless cards for riders to use.

The relative rate of speed for using the different types of cards was demonstrated in a test on buses in Helsinki (Finland). The following results were reported on the basis of stop delay measurements carried out on the buses. The average boarding speed of the card options as compared to the conventional monthly flash pass (with a boarding time of 1.7 sec per person) was:

Contact cards—1.6 sec slower per person (total of 3.3 sec per person) and
Contactless cards—0.2 sec faster per person (total of 1.5 sec per person).

Thus, only the contactless card improved on the speed of a flash pass. Contact smart cards were also considered awkward to use by passengers. On the basis of these results, Helsinki decided that the most suitable technology for transit fare payment was contactless cards.

Contactless Cards

Transit agencies in the United States and abroad are increasingly looking at contactless card technologies for fare payment. "Contactless" is a generic term describing a group of proprietary devices that do not require insertion into a reader slot or any direct physical contact to interface with a reader-writer terminal. There is also a longer-distance RFID technology—typically in the form of a tag—that is used in toll applications; this is reviewed briefly below. These tags can interface with a reader or reader-writer terminal containing an antenna at a distance up to several feet.

Within this general category, the existing cards include a range of physical and operating characteristics. The parameters in which they can differ include the following:

- Farthest distance possible from the reader-writer to effectuate an interface;
- Internal logic and memory capacity (e.g., microprocessor or not);
- Active (has a battery) or passive (no battery), which affects the size of the card; and
- Data transfer rate.

The interface distance is determined by the presence—and size and signal strength—of an antenna used to collect and send data from and to the card. The distance is also affected by the power consumption of the card; the higher the consumption, the smaller the interface distance. This inverse relationship is mitigated if the card has an on-board battery, but this adds to the cost—and thickness—of the card.

Because of its convenience to the rider, its potential impact on throughput, and its expected lower equipment maintenance costs, the contactless card has been the smart card of choice in most of the recent smart card transit-based projects; Most multiple use card projects have (thus far) used contact cards. The lack of standards for contactless cards significantly complicates the ability to use them in multiple applications (i.e., beyond perhaps other transportation functions, such as parking lots or toll roads). NYMTA has expressed concerns over this issue and may well select contact cards for its MetroCard program, so as to ensure compatibility with bank and other standardized smart cards. In at least one other project, that in Burlington (Ontario), the transit agency approached local banks regarding possible interest in participating in its contactless smart card test. The banks were unable to take part, because of the requirement that they use only standardized technologies. As discussed later in this chapter, no standards for contactless card technology existed as of late 1995; however, work is now being done toward developing such standards.

On the other hand, several recent developments indicate that there is potential for contactless cards in multiple use arrangements. For instance, in the current Manchester (England) project, contactless cards are to be used for non-transportation (e.g., retailers and vending machines) as well as transit applications. In this case, the system vendor is helping to finance the equipment and media as part of a public-private partnership. Thus, this represents an important test of both the acceptance of contactless cards in multiple use arrangements and the potential for joint public-private financing of advanced fare collection systems. The Manchester project is discussed further in Chapter 7. Finally, the concept of a combined contact-contactless card offers considerable appeal to both transit agencies and financial institutions contemplating multiple use arrangements. As indicated earlier, these "combi-cards" are now in development by several manufacturers. The major drawback to these cards is likely to be their high cost, as they will clearly be more expensive than cards that are contact or contactless-only. The extent to which issuing agencies feel that their benefits outweigh their costs will dictate their ultimate popularity as a payment medium.

The key existing card technologies (magnetic stripe, contact, and contactless) are further compared in the following section.

COMPARISON OF CARD TECHNOLOGIES

Issues and Criteria

In comparing contact and contactless smart cards with each other—and with magnetic stripe cards—there are a number of key issues and criteria that must be considered. These are as follows:

- Convenience in using the card;
- Operational impact of the technology, in terms of how it affects throughput or boarding time;
- Data capacity of the card (i.e., how much information can it store);
- Privacy concerns related to the use of the data generated by use of the card;
- Security issues related to the prevention of counterfeiting, duplication, or modification of the card;
- Standardization of the technology;
- Operational experience with the technology or specific product;
- Costs of implementing and applying the technology; and
- Cost savings and additional revenues associated with the technologies.

These issues are discussed below and summarized in Table 50.

Convenience

Generally, convenience for the rider is improved with any electronic payment medium, just as it is with any prepayment option. The extent of convenience in this respect is thus unrelated to the card technology. Where the technologies differ is 1) the size of the card and 2) the manner in which it is used in the fare collection equipment. Regarding size, most cards have roughly credit card dimensions, although the thickness can vary. Paper-based magnetic media (e.g., those at WMATA and BART) are thinner than plastic cards—either magnetic or smart cards. The thickest cards are the contactless cards that have batteries (e.g., the Cubic Go-Card); however, newer contactless cards (e.g., those produced by Racom and Mikron) are being developed without batteries, and the thickness is thus decreasing.

The extra thickness of even the battery-powered contactless cards is compensated for to a large extent by the contactless nature of the card. Because it only has to be held within a short distance of the reader "target," the card does not necessarily have to be removed from a wallet or purse; for most cards, though, it is necessary to place the wallet or purse very near the target, and, at this point, the non-battery cards seem to work best when they actually touch the target. Although this feature adds to the convenience of paying fares in general, it is particularly appealing to riders who are older or have disabilities for whom using a conventional fare system may be difficult; it may also be advantageous for riders carrying bags (e.g., travelers or shoppers). Thus, the contactless card can be considered to be more convenient than the other card technologies, although all are more convenient than having to carry exact change or tokens.

Operational Impact

The impact of card use on boarding time (on buses) or throughput (through faregates) is related to the above discussion. As indicated earlier, contactless cards allow significantly

TABLE 50 Characteristics of card technologies

Criterion	Magnetic Stripe	Contactless	Contact
convenience	must be inserted or swiped	very convenient; hold near target	must be inserted
privacy	less of a concern than with smart cards	concern*	concern*
security	moderate	high*	high*
throughput	depends on format, lower than contactless	highest	lower than contactless
data capacity	up to 0.2KB	up to 8 KB	up to 8 KB
standardization	stds. exist (for stripes)	stds. being developed	standards exist
operating experience	considerable, but bus TPU's still in tests	tests in number of sites, but no long-term exper.	limited transit, extensive non-transit experience
unit cost of media (transit application)	$0.10-$0.60	$5-$15 **	$2-$10 **
operating & maintenance cost impact	highest equipment maintenance cost	lowest equipment maintenance cost; longer life for cards	longer life for cards than magnetic stripe cards

* assumes card has microprocessor; if not, roughly equivalent to magnetic stripe card
**with microprocessor

faster boarding of buses than do insertion-type cards (either smart or magnetic stripe). This is because inserting or swiping a card is simply more time-consuming than passing a card near—or even touching—a reader target. A related reason is the nature of the acknowledgment (by the card reader) of proper fare payment. The swiped or inserted card is typically acknowledged, if at all, by the amount of the fare being displayed on the reader—and/or the turnstile opening. In some cases, it is not immediately clear if the payment has been accepted, and the rider may swipe or insert a second time. The contactless card reader, on the other hand, typically "beeps" to indicate that the card is valid and the fare has been deducted (if appropriate). Thus, the average fare payment occurs faster with a contactless card. On rail, the need to proceed through a turnstile means that the entry time will not differ much with different media.

Use of a flash pass is also "contactless," but the boarding is slowed, at least in theory, by the process of the operator inspecting the pass; the operator has the option to not inspect passes (e.g., during a heavy boarding period), but this can result in lost revenue from the use of invalid passes. Ultimately, of course, it is necessary to compare speed of boarding using electronic media to that using cash, because on most bus systems, cash is the most common payment medium. The boarding time with cash depends largely on the fare (i.e., a convenient amount such as $0.50 or $1.00 versus a multi-coin fare such as $0.85) and whether the farebox accepts dollar bills. there is also substantial variation in the speed of boarding, because some people already have their exact change ready, while others fish for change as they reach the farebox. Although it is thus difficult to compare boarding times accurately using cash and prepaid media, the use of electronic media should, on average, be somewhat quicker. Finally, in comparing electronic media to tokens or tickets, the boarding times are roughly similar for the insert-type cards, although, again, contactless cards are typically faster. Under cost savings, the ability to translate faster boarding times into reduced operating costs depends on the extent of the time savings and the nature of the route schedules.

Data Capacity

One of the major differences between smart cards and magnetic stripe cards is the amount of information they can hold. A magnetic stripe can hold up to 200 bytes of information. In contrast, a smart card with a microprocessor can hold between 1,000 and 8,000 bytes. The issue here, though, is the capacity needed for transit applications. The relatively complicated (distance-based with peak/off-peak differential) WMATA and BART fare systems use magnetic stripe tickets. On the other hand, many people in the transit and card technology industries question whether magnetic tickets can adequately accommodate the data and processing needs of integrated fare or multiple use projects. NYMTA had intended to use magnetic stripe technology for its multiple use program but has become convinced of the need to move to a smart card in order to implement the multiple use element of its MetroCard program effectively. Similarly, the TransLink project in the San Francisco Bay Area has switched from a magnetic stripe ticket to a smart card for its regional fare integration medium.

In general, the extent of the functions and capacity required (or desired) for multiple use or regional fare integration efforts have made smart cards the technology of choice in such projects. The greater capacity of smart cards has also been recommended for use in paratransit systems, which often involve multiple accounts (representing different funding sources for which an individual is eligible). On the basis of the experience to date, however, magnetic stripe technology has sufficient capacity for at least individual agencies' fare requirements, even if relatively complicated.

Privacy

This is a potential concern with the use of electronic media in general, although it is somewhat greater with smart cards—given the extensive processing and data-generation capabilities of the cards. Many people would not want the transit agency—and possibly banks or merchants who accept the card—to be able to track their every move. The magnetic stripe card generally does not permit the same level of accounting of individuals' travel behavior, although there too the serial number can be tracked. One possible approach to addressing this concern is to authorize "anonymous" transactions (i.e., the serial number is not tracked) up to a certain value. In general, security of data extracted from the cards is paramount. Questions that must be addressed include who protects the information, who has access to what portion—and when and where—and how does one avoid abuse and misuse of these data? A related concern is how the transit agency keeps track of data and maintains reasonable checks and balances without violating privacy.

Security (Prevention of Fraud)

The circulation of "electronic money" and its fraudulent manipulation by software or telecommunications is a major security concern, although less in transit than in the broader electronic payment environment (e.g., general use of credit cards). It is generally felt that smart cards are more difficult to alter for misuse than magnetic cards, although improvements continue to be made in magnetic stripe security. Smart cards have built-in "fuse circuits." If an unauthorized entry is attempted, it blows the "fuse" and the card is permanently destroyed. As suggested earlier, there have been a variety of improvements related to magnetic anti-counterfeiting; specific developments include Rand McNally's ValuGard technology, Control Module's Holomagnetics, which places "optical mirrors" on a magnetic stripe, and Thorn EMI's Watermark encoding technology, which offers protection against the two most common forms of magnetic ticket fraud—skimming and buffering. The "XSec" Security System marketed by XTec, Inc., involves a "chip" set in existing reader devices and establishes a digital "signature" that is unique to a particular card.

Standardization

Although current international standards for magnetic stripe technology exist, the cards themselves tend to differ from one transit agency to the next. Some are paper, while others are sturdier plastic. They also come in different sizes and have different levels of resistance to damage (i.e., either "high" or "low" coercivity). There are also standards for contact card technology, and the level of standardization is increasing, through the efforts of MasterCard, VISA, and Europay.

Regarding contactless cards, there are probably as many "standards" as there are suppliers of the products. Because no international standard yet exists, each product has a proprietary architecture. Hence, the purchase of one vendor's cards and terminals can lock the agency into a single source and the prospect of monopoly pricing for subsequent procurements. Because the market for proprietary contactless products is limited, there is also the risk that an otherwise sound company could fold its product line for lack of sales; as indicated earlier, Burlington (Ontario) had to find a replacement card supplier when its original vendor decided to abandon development of its card. To allay these concerns, some vendors of contactless cards have raised the prospect of licensing their card technology to other manufacturers. This could bring additional sources as well as competition to the marketplace. Furthermore, standards are now being developed for contactless cards (both remote and close coupling). (Issues related to the development of standards are discussed later in this chapter.)

Operational Experience

A major issue in considering a new product is the extent of operational (i.e., in-service) testing of the technology (i.e., has it been proven to be reliable and cost-effective in a similar operational setting?). Magnetic stripe technology has been used in transit settings for three decades. It is felt to be reliable and cost-effective for use in swipe passes on buses and stored-value applications on rail. On the other hand, the use of stored-value media for buses is essentially still in the testing phase, because only a handful of bus systems have actually installed TPUs. A number of agencies are testing such units, but in-service operating experience is scarce at this point.

With regard to smart cards, experience is also relatively limited, particularly in the United States. Contact cards have been used in a few locations for 3 years or more; one U.S. test has been completed, and another is under development. Contactless cards are being tested in a number of locations around the world; several U.S. trials have begun, and others will probably follow. All of these projects, however, are relatively recent. Thus, the reliability and cost-effectiveness of smart card technology has yet to be proven over a multi-year period.

To a certain extent, the rapid pace of development and improvements in card technology is delaying the initiation of some projects, as agencies wait for the latest version of a particular type of card to begin implementation. In other cases, particular products or technologies are not completed as promised, or equipment fails in operational tests. In general, the complex nature of the technology and equipment and the extent of the change in fare collection and payment mechanisms can result in very long lead times in implementing smart card projects; thus, some efforts that have been described in the literature for several years have actually only recently been started—and some have yet to start. Many U.S. transit agencies are understandably reluctant to purchase "unproven" new equipment or technologies, given the budget pressures most face.

Costs and Cost Savings and Additional Revenues

Cost—and potential cost savings or additional revenue—are important factors to be considered in assessing the different card technologies. The financial implications associated with implementing an electronic fare payment system are discussed in Chapter 8. As described there, the unit cost of smart cards is much higher than that of magnetic stripe cards. The cost of the card read-write units, as used in transit applications, has been comparable for the two types of media, although basic smart card readers tend to be somewhat less expensive than magnetic TPUs. The full cost, however, depends on the specific capabilities and configuration of the unit, rather than on the media technology per se. In assessing the overall costs, there are considerations (i.e., related to retention and reuse of the media) that can minimize the number of cards that must be purchased, thereby bringing down the "effective" cost of smart cards. Furthermore, contactless cards offer potential benefits, including improved read-write unit reliability and maintenance cost reductions, as well as the possibility of bus operating cost savings.

Smart cards—contactless cards in particular—present certain benefits to transit agencies. Whether the potential cost savings and additional revenues can offset the high cost of the cards is unclear at this time. Although some vendors and operators have concluded, on the basis of limited trials, that smart cards are considerably more cost-effective than magnetic stripe cards, larger applications—coupled with independent evaluations—are needed in order to determine the true costs and benefits of the different technologies. The economic considerations change substantially, however, if the transit agency does not directly provide the cards. As suggested above, one option is for the cards to be furnished by a bank, telephone company, or other entity and accepted for use on transit. If a bank credit or ATM card or a prepaid telephone card is accepted by the local transit agency, there is no card production cost for the agency. An alternative approach, beginning to see applications abroad, is joint public-private financing ventures. Given the current economics of smart card provision, these approaches would appear to represent the most likely scenario under which smart card usage would be adopted for transit on a widespread basis. These options are discussed further in Chapters 7 and 8. The advantages and disadvantages of the specific card technologies are summarized below.

Summary: Advantages and Disadvantages of Different Cards

Contact Smart Cards

The primary advantages of contact smart cards are as follows:

- International standards, ensuring multiple-vendor sources and competitive prices;
- The capabilities provided for secured off-line processing by the on-board microprocessor and extensive data capacity; and
- Established track record in various payment-based applications in Europe and the Far East, and their growing support among U.S. banks and the government sector as an alternative to the magnetic stripe card.

The primary disadvantages of the contact smart card are as follows:

- The high cost of smart cards in general, as compared to magnetic stripe cards and
- Lower rider throughput using smart cards that require insertion into a terminal.

Contactless Cards

The primary advantages of contactless cards are as follows:

- Only has to be near the reader "target" to be processed—very convenient; thus, better suited for the elderly and persons with disabilities than magnetic or contact cards; and
- Offers better throughput than a contact or magnetic card.

The primary disadvantages of contactless cards are as follows:

- High cost of cards,
- Proprietary nature of the product and no international standards, and
- Lack of long-term transit applications.

Magnetic Stripe Cards

The primary advantages of magnetic stripe cards are as follows:

- Proven technology with extensive transit operational experience and
- Inexpensive with much lower cost per card than smart cards.

The primary disadvantages of magnetic stripe cards are as follows:

- Not as secure (in terms of preventing fraud) as smart cards,
- Not as much data capacity as smart cards,
- Lower throughput than contactless cards, and
- Not as convenient (e.g., for the elderly and those with disabilities) as contactless cards.

Issues associated with the development of smart card standards are discussed below.

DEVELOPMENT OF CARD STANDARDS

As with any developing technology or new applications, there are invariably a number of different proprietary techniques. If the technique is sound and useful and a marketable product can be developed, it becomes a leading contender for what can evolve into a de facto "standard." The IBM PC with Microsoft's DOS in the early 1980s is a good example. This section briefly reviews issues related to fare technology standards and the various efforts and initiatives that have been taken in this area. The ISO standardization process defines the basic technology, methods, and framework for contact smart cards. Other standards are evolving.

In some respects standards are a double-edged sword. They are important for consistency but can thwart creative applications. An example of the benefits that can be produced by product standardization is found in the cellular telephone market. The potential market for cellular technology in the United States is estimated at 15 million subscribers, in contrast to the 8 million in Europe. Despite this difference, Europe experienced much faster initial growth in cellular telephone use than did the United States. In the mid-1980s the European nations agreed on a single cellular standard, called Group Speciale Mobile (GSM); in the United States, on the other hand, cellular operators are still backing different standards, leaving customers confused. As a technology matures, some common ground generally appears where standardization can be both possible and useful. In magnetic card technology, for example, four key organizations (ISO, the American National Standards Institute [ANSI], AIM, and CEN) are involved in magnetic stripe standards. Each organization has its own focus; naturally, there is some overlapping of efforts, but each committee concentrates on its own distinct primary purpose.

There is no existing standard in the United States (or abroad) for either prepaid cards operating in a closed system or electronic purse smart cards operating in an open system. Three forums are at work to produce standards for the electronic purse, addressing such areas as security protocols, data definitions, and technical card specifications. These are:

- Smart Card Forum (in the United States),
- European Committee for Banking Standards (ECBS), and
- European Commission IC Card Standards.

In addition, the aforementioned EMV specifications process is developing standardized card payment systems on the basis of contact smart cards. International standards for contactless cards are still in flux. Participating countries have agreed on some of the standards to define the physical characteristics of the card but have been unable to agree on the details of the card layout for transmission. The U.S. delegation recently voted against the first draft of the second set of standards because they believed it would result in an excessively expensive reader-writer. (The draft requires the reader-writer to accept both capacitance and inductive transmission interfaces, as well as to accept the card in any direction of insertion.) According to an AT&T Report presented to the ANSI Committee in January 1993, the company experienced up to 50 percent failures on tests using the proposed Part 2 layout.

The benefits of standards are generally perceived to be that they remove the threat of customer confusion and incompatible system proliferation. There are significant difficulties in setting standards early in the development process—the R&D process must not be curtailed before the optimum design has been discovered nor must the consumer receive an inadequate product. Another major drawback to standard setting is the possibility of creating a monopoly, i.e., a vendor who would be able to control the market for the product and offer goods at high prices only. When carefully developed, however, standards do allow easier entry into the market for new firms, because competitors can develop applications in the same field, competing on detailed specifications rather than broad functional requirements. In effect, the consumer should benefit from increased utility of the product (e.g., a new fare system) and the equipment purchaser (the transit agency in this case) should benefit from greater choice among equipment options without compatibility complications—and at lower costs. Standards are also important for allowing future upward compatibility and inter-changeability. One important role for standards is to ensure that the responsibilities of the supplier of each portion of a system are defined. This helps to sort out the causes of different problems and to allow the relevant suppliers to be identified and then take prompt action.

The next chapter discusses key emerging developments associated with electronic fare payment methods, as well as methods related to electronic fare media purchase and processing.

CHAPTER 7

EMERGING FARE PAYMENT AND MEDIA PURCHASE DEVELOPMENTS

INTRODUCTION

Several developments in fare payment and collection associated with electronic payment methods are emerging. The stored value and information storage features of magnetic and smart cards, coupled with the processing capabilities of card readers and processors, have allowed the use of the fare payment mechanisms to be expanded beyond the single operator fare payment mode. This chapter discusses applications of the following emerging developments:

- Regional fare integration,
- Prepaid and multiple use cards, and
- Post payment and employer billing.

The chapter also discusses emerging fare media purchase and processing methods. The focus is on the issues associated with the move toward more open payment systems. In some transit agencies, the use of debit and credit cards—or the use of ATMs—has meant that the movement to a more open system has already begun. The current state of developments in this area and the issue of regulations governing these payment and purchase mechanisms are reviewed.

FARE PAYMENT DEVELOPMENTS

Regional Fare Integration

The Concept

Historically, a person who needed to travel on more than one transit vehicle to complete a journey had to pay a full fare at each boarding. Although some agencies continue to follow this procedure, most offer paper transfers—at a price lower than the full fare and often free. Use of an unlimited-ride pass allows seamless travel between vehicles and—depending on the level of pricing—between modes within a single transit system. There are even interoperator agreements permitting transferring between operators with a joint pass or perhaps payment of a transfer or upgrade fee; one of the more comprehensive examples of non-electronic regional integration is in San Diego; this is discussed in this chapter. In most multi-operator regions, however, transit travel is anything but seamless, because each operator has its own fare structure and fare payment mechanisms—a handful of agencies do not even provide for transfers within their own systems.

In recent years, however, federal and state air quality regulations and the concomitant regional transportation demand management efforts (including employee trip reduction mandates in some locations) have provided additional impetus to long-established efforts to promote and facilitate transit use. These efforts have increasingly focused on regional fare integration as potentially important. Electronic media and sophisticated fare collection equipment (i.e., with ticket issuing and processing capabilities) have made it feasible to consider the development of universal ticketing agreements that would allow seamless travel throughout a multi-operator region. One of the key benefits of such a technology-based arrangement is that it allows each participating agency to retain its own fare structure (i.e., fare levels and differentials, as well as discounts). Besides simply allowing the different operators to accept a common medium, the technologies facilitate the interagency revenue accounting arrangements that are essential to such integration.

Regional fare integration discussions have taken place for years in all of the large multi-operator regions in the United States (e.g., New York, Chicago, Washington, Seattle). These regions have had varying degrees of success in achieving integration. The first extensive universal ticket (i.e., technology-based) programs have been initiated in California. Air quality and TDM requirements are more stringent there than in other states, and the major metropolitan areas (Los Angeles, San Francisco, and San Diego) each have different transit operators. In Los Angeles, MTA Metrobus (formerly SCRTD) is the predominant bus service, but there are 14 other local bus systems. In addition, Metro Rail includes the Blue Line and Green Line (light rail) and Red Line (subway); finally, Metrolink is the commuter rail operation. BART and Muni predominate in the San Francisco-Oakland area, but there are 26 other transit operators in the region as well. San Diego has eight transit services; as indicated above, this region has developed regional fare integration without using electronic fare payment methods. Other universal ticket projects are being developed or implemented outside the United States, in Hong Kong and in the Toronto area, for example. Each of these regions has a multitude of fare structures and fare levels and serves both bus and rail passengers. These integration efforts are discussed later in this chapter.

Technological and Institutional Requirements

Implementing a universal ticket program for a region carries with it extensive requirements, from both a technological and institutional point of view. The planning and development must address a range of complex issues and can, therefore, take many years. The notion of regional ticketing in the San

Francisco area, for instance, was first proposed (by the Metropolitan Transportation Commission) in the late 1970s as a way to improve transit access and usage among the many transit operators in the region. The key issues and requirements that must be addressed in instituting a universal ticket program include the following:

- Identifying a mutually acceptable fare medium and fare collection technology,
- Integrating different types of fare collection systems (e.g., POP) into a universal ticket program, and
- Establishing an interagency revenue allocation and distribution methodology and agreement.

These issues are discussed further in the following paragraphs.

Identifying Appropriate Technology. A universal ticket requires each participating operator to have an on-board (or in-station) ticket processor to read the ticket, deduct the fare according to the particular agency's fare table, store the data for later processing, and rewrite the ticket. The existing fare collection equipment at agencies in a region typically varies from a simple drop box to electronic registering fareboxes (for buses) and magnetic ticket-reading equipment (for heavy rail services). To include buses in a universal ticket system, a TPU integrated with the farebox or a stand-alone validator must be installed on each vehicle. Computer software must be included to process the data collected, both for the agency and for transmission to a central clearinghouse. The central clearinghouse reconciles the data and prepares reimbursement checks for services provided. Finally, vending equipment must be provided (i.e., in stations, transfer centers, or other sales points). (Incorporating a POP system in a universal ticket scheme presents its own set of complications; these are discussed below.)

Because the various operators probably will have different types of existing equipment and differing levels of financial resources available to invest in new systems, the identification of a single type of equipment to be used in the region and a particular fare medium is unlikely to be straightforward. Furthermore, as discussed in Chapter 6, the pace of development and refinement of media technology can also complicate the decision-making and implementation process. For instance, agencies participating in the TransLink project have re-evaluated the technology options for the universal ticket, and have decided to switch from magnetic stripe tickets to smart cards. The availability of financial resources also represents a key barrier to this process and is discussed below.

As with all ticketing equipment, key considerations must be the passenger-equipment and operator-equipment interfaces. These issues are particularly important in the introduction of integrated ticketing systems because they mark a departure from the familiar fare payment procedure. Thus, educating both the rider and the operator about the new system will be crucial. It will also affect the degree to which the key passenger benefit, that of more convenient travel, is realized.

Integrating POP Systems into a Universal Ticket Program. Although TPUs and electronic faregates can directly accommodate a universal ticket, electronic fare payment cannot be directly used with a POP system, because POP requires the rider to display a validated ticket or a flash pass to an inspector. An electronic faregate or a TPU automatically identifies the validity of a farecard and deducts the proper fare value (if not a pass), but this is not feasible in POP. Thus, use of an electronic fare card on light rail or commuter rail requires either special vending or validating equipment in stations or portable ticket readers/validators carried by inspectors. With the former approach, depending on the equipment capabilities and the nature of the fare media, the rider must either insert the farecard into a special in-station TPU, so that the trip value can be deducted and the time, date, and value deducted be printed on the farecard; or, if the cards cannot be printed on, the card must be used to purchase a separate validated paper ticket for the trip.

Acknowledging the complexity of this issue, Santa Clara County Transportation Agency (SCCTA) has undertaken a study of technology options to determine the most appropriate approach for using a stored-value card in a POP system (i.e., on its LRT service and on the CalTrain commuter rail service). SCCTA sought to identify the best direction to take in improving its fare collection system in general, in addition to addressing how best to integrate its fare payment into the TransLink program. LACMTA is also considering the appropriate approach it should take in accepting a stored-value card on its rail services.

Establishing a Revenue Allocation Methodology. Prior to participating in a universal ticket program, each agency must negotiate and agree to a revenue allocation and distribution arrangement. This agreement defines the terms and conditions of revenue exchange among the agencies (i.e., on the basis of the origin and destination of the rider and the specific fare structures of the agencies used for each trip). Each participating agency records universal ticket transactions for transmittal to a central clearinghouse. The central clearinghouse verifies the incoming data, performs reasonableness checks, makes payments, prepares backup copies, and distributes reports to the agencies. Each agency will still be required to complete reports of its own system ridership and cost-effectiveness (e.g., Section 15 reports) and hence it will be critical that financial data are complete, accurate, and processed in a timely manner.

Given the complexity of the issues, gaining cooperation among the various operators in a region and then implementing the program is a time-consuming effort. A single lead agency must take the initiative for the program and must see it through. In San Francisco, this role has been taken by the regional planning agency, the MTC. In Los Angeles, the major operator, LACMTA, took the implementation and coordination lead in the Metrocard program.

Of course, unless the lead agency is going to be providing funding for program implementation and administration, it is still up to the individual agencies to purchase the equipment and cover their own operating costs related to the program. The availability of sufficient financial resources can be a major impediment to the successful implementation of an integrated program. Although it coordinated the procurement of TPUs capable of processing the card by three smaller operators in the region (see discussion below), LACMTA itself has not yet purchased the TPUs because of funding issues. In the TransLink program, most of the key operators in the region have agreed to participate in the program, although implementation will be phased in, usually one agency at a time.

Developing regional fare integration is an ambitious undertaking. Not only is it difficult to determine a mutually acceptable technology and revenue allocation and distribution system for technical and financial reasons, it is likely that there will be significant differences in managerial approaches between the agencies. The difficulty of developing agreements within these different institutional settings should not be underestimated. Another crucial element in the introduction of a regional fare system, if the full benefits are to be reaped, will be that the agencies understand how these changes in the transportation environment could affect the perceptions of their riders and that the services are then marketed in this light.

Examples of Regional Fare Integration

Several current and recent efforts toward regional integration are the San Francisco Bay Area, Los Angeles, Seattle, Hong Kong, Toronto, and San Diego. Each of the first five examples uses electronic fare technology. The sixth example, San Diego, illustrates a non-electronic approach. Each example is described briefly.

San Francisco Bay Area. TransLink represented the first implementation of a common-use stored-value ticket for multiple transit agencies in the United States. It allowed the passenger to use just one ticket for both bus and rail (BART). The program was initiated and has been developed by the MTC and its partner agencies. In the initial phase, the initial ticket was used on BART (on all faregates in all 34 stations), Central Contra Costa County Transit Authority's (CCCTA's) 112 buses, and 45 BART Express buses. The original TransLink ticket was a magnetic stripe stored-value ticket; each ticket had a unique serial number so that counterfeiting could be controlled and individual trips could eventually be tracked. The ticket could be used in BART's faregates and in BTVs on CCCTA and BART Express buses; the BTVs were provided by CGA of France. The key challenge here was that the ticket encoding and printing requirements for the BTVs had to "fit" with the BART system requirements.

A decision has now been made to expand the TransLink project and phase in other transit operators in the region. MTC and the operators have, however, taken a second look at the program's—as well as each individual agency's—needs and have decided that the existing BART ticket technology is not the most appropriate medium for the TransLink card. The recently completed evaluation of technology and clearinghouse options has led to a recommendation for a system based on contactless smart cards and potentially including private sector involvement in providing clearinghouse functions and equipment maintenance support. (Additional details are presented in Appendix A.)

Los Angeles. The Los Angeles Metrocard Stored Value Card Project was a demonstration project designed to show how a universal card could be implemented in the Los Angeles area. LACMTA served as the lead agency. The Metrocard is a common fare medium designed to allow bus and rail trip fare payment and transfer charges to be collected on buses and in rail stations by the agency providing the service. The Metrocard is magnetically encoded and the size of a credit card. A predetermined value is deducted for each trip segment, with fare credit given for continuing trips on connecting buses and services.

Buses at three agencies—Culver City Municipal Bus Lines (28 buses), Foothill Transit (198 buses), and Montebello Bus Lines (54)—have been equipped with TPUs made by GFI-Genfare. Metrocards are sold in $10.00, $20.00, and $30.00 denominations. The validator prints remaining value on the card only when the remaining value is $10.00 or less, at which time a gauge mark is printed inside a designated boxed print area. As the remaining value is used up, the box darkens to indicate visually the approximate amount left on the card. The validator on the bus displays the remaining value exactly.

The official test period for the equipment and cards at the three agencies ended in June 1995. The equipment has apparently been quite reliable, and the test has shown that the concept is acceptable to both riders and operators. The agencies began actively marketing the Metrocard for general use following the end of the test period. With the initial demonstration of the concept now complete, LACMTA is evaluating its own fare collection situation (including whether to introduce the TPUs and Metrocard on its own services); budgetary constraints have delayed this decision—the agency feels that it will likely need new fareboxes as well as new ticket validators. (Additional details are presented in Appendix A.)

Seattle/Central Puget Sound Area. The transportation agencies in the Central Puget Sound region recently completed a Regional Fare and Technology Integration Feasibility study; the participating agencies were Seattle/King County Metro, Kitsap Transit, Pierce Transit, Community Transit, Everett Transit, the Puget Sound Regional Council, the Washington State Ferry System, the Regional Transportation Authority, and the Cascadia Project (representing Amtrak). This study recommended development of a contactless smart-card-based system that would facilitate easy transfers among the different systems and modes. Other key goals are to improve the operating efficiency of each individual agency and to expand market opportunities within the region. Based on the results of the feasibility study (completed in mid-1995), a detailed smart-card analysis was undertaken, involving a business needs assessment and feasibility analysis for the recommended regionwide fare payment system.

Concomitant with this analysis, three related efforts have been initiated: 1) the Washington State Ferry System is developing a fare collection system that is intended to be compatible with the regionwide system; 2) the Transportation Operators Committee is identifying policy issues associated with regional fare integration; and 3) the participating agencies are undertaking an assessment of issues and opportunities related to establishment of a regional revenue clearinghouse. Based on the findings of these efforts, the agencies in the region plan to conduct an initial trial of contactless smart cards and then proceed with implementation throughout the region over the next 2 years.

Hong Kong. The Mass Transit Railway (MTR) and other transit operators in Hong Kong are establishing the institutional arrangements necessary to introduce a common transportation ticket encompassing all major forms of public transport in Hong Kong. The project will include the urban transit railways, as well as bus and ferry operators, accounting for up to 4 million passenger trips per day. MTR and Kowloon Canton Railway (KCR) already offer a Common Stored Value Ticket (CSVT) for commuters who use both systems. The CSVT is quite popular, accounting for roughly 80 percent of the trips on each system; it is estimated that at least 50 percent of the adult population of Hong Kong holds at least one CSVT.

The new universal ticket will be a contactless smart card. For MTR, existing faregates will be modified to accept the cards, while the current magnetic system will be retained for the single-journey patrons. A great deal of interest has also been shown by many non-transport organizations. The transportation application alone will require approximately 3 million cards to be introduced and 4,000 pieces of processing equipment to be installed. With regard to the revenue-sharing mechanism, an independent Central Clearinghouse (CCH) will be established. Requests for bid on the new system were issued to a number of international companies. Nine companies that have demonstrated experience with both electronic fare collection systems and utilization of smart cards were prequalified. Four proposals were received, and a contract was awarded (to AESProdata) in late 1994.

Toronto. The Ministry of Transportation of Ontario has, for several years, been considering various approaches to introduce fare integration among the agencies serving the Greater Toronto Region. One of the first initiatives was to introduce the Twin Pass, which allowed GO Transit riders to use commuter rail to Union Station and then transfer to the Toronto Transportation Commission (TTC) subway. This is a magnetic pass, which is sold for $C20.00 less than the combined value of the TTC and GO Transit pass, if purchased separately. The combined discount ($C20.00) is shared according to an allocation formula. The second initiative is a regional 1-week pass ($C30.00), which can be used on local transit services in Metro Toronto, Mississauga, Brampton, Markham, Richmond Hill, Vaughan, and on selected GO Transit bus routes. A third effort is tests of integrated smart cards. In the first trial, 45 Mississauga Transit buses will be equipped with contactless smart card reader-writer units provided by AESProdata (the cards will be provided by Racom). About 1,000 passengers will be involved in the system test. Equipment will also be installed at two GO Transit commuter rail stations interfacing with these routes. This trial is part of the region's long-range development effort (i.e., to test different technologies and arrangements and determine the best regional integration approach).

San Diego. In contrast to the above technology-based examples, the San Diego region has achieved regional fare integration by establishing a uniform fare structure for the region's operators. Most of the region's fixed-route operating entities have banded together to form a "federation" of transit service providers called the Metropolitan Transit System (MTS); the purpose of MTS, and the related MTS symbol, is to identify this unified transit system to the public. MTS includes bus and light rail (San Diego Trolley) service.

The Metropolitan Transit Development Board (MTDB) serves as the policy setting and overall coordinating agency for public transportation in the metropolitan area. MTDB, as the state-designated regional transportation coordinating agency, took the lead in establishing fare integration and developed the Uniform Fare Structure Agreement. This Agreement applies to fixed-route operators only, although dial-a-ride operators participate in the Agreement. The basic elements of the Agreement, which is updated annually, are that it does the following:

- Establishes a uniform fare structure for the region, providing a coordinated transit system in a multi-operator environment;
- Establishes a regional transit pass valid for travel on all fixed-route services in the San Diego region, and establishes a formula for distribution of pass revenue; and
- Establishes a regional policy of free transfers between equal or lower levels of service and sets upgrade fares for transfers to higher levels of service. (Additional details are presented in Appendix A.)

Multiple Use Card and Electronic Purse

Prepaid Cards

There are essentially three types of financial transaction cards: a credit card can be thought of as an "electronic loan," a debit card as an "electronic check," and a prepaid card as "electronic cash." Credit cards have been used for several decades and debit cards have been used for several years in an open environment (i.e., cutting across a variety of service providers and applications). Prepaid (i.e., stored value) cards, on the other hand, have typically been used only in closed environments (i.e., they can be used for only a single activity, such as fare payment on a particular transit system). Prepaid cards have actually been in use in the transit industry for a number of years, with BART and WMATA the most prominent long-running U.S. examples. Except for the regional integration examples discussed earlier, transit represents a closed financial system. With the emergence of advanced card technologies, however, and with the growing interest on the part of the financial, banking, and retail sectors, in cash-based transactions, prepaid cards are increasingly being considered for open applications as well. In addition to transit, prepayment is in use in other types of closed systems. For example, the largest issuers of prepaid cards are the over 130 Public Telephone and Telecommunications (PTT) organizations around the world. These cards tend to be sold in fixed-value amounts, are used until fully decremented, and then thrown away. These systems do not display the remaining value on the card itself; rather this amount is only displayed on the telephone, after the card has been inserted—or, as is typical in the United States, the remaining amount is indicated orally over the telephone when the user enters the card's code number.

In recent years, the banking and finance industry has also taken an interest in the concept of prepayment. Each year 270 billion transactions with values of $2.00 or less, and 30 billion between $2.00 and $10.00 are made in the United States, and it is these types of transactions that have stimulated this interest. The prepaid card is well suited to low-value transactions, and market research suggests that consumers would entertain the idea as a means of reducing their need to handle cash, as well as increasing the security of their transactions and finances. For the banking and retail industries, prepaid mechanisms are thought to be most viable in multiple use applications, because consumers have indicated that a critical aspect of these systems is convenience. Convenience for consumers comes from being able to use a single card for a range of uses and at different locations—as they can with credit cards. As indicated earlier, the use of credit cards for fare payment has been introduced at a U.S. transit agency; this concept is discussed below, under Post Payment.

For the merchant, prepayment is particularly attractive for low value transactions, where referring to a central authorization network for each card usage is time consuming and costly under the current credit card system (i.e., with charges to the service providers). Whereas there will be charges for a merchant—or other entity (e.g., a transit agency)—participating in a multiple use arrangement, these should be lower than for accepting credit cards. A recent example of a multiple use prepaid card is the Mondex card, distributed by two major English banks, the National Westminster Bank and the Midland Bank. A trial of the Mondex card was initiated in the town of Swindon in July 1995; the card is accepted by over 600 stores, pubs, and other services. The two banks plan to expand the program throughout England if the trial proves successful; the card may also soon be distributed in the United States (through Marine Midland Bank and Wells Fargo & Co.)

Institutional and Technological Issues

For the transit industry, the major benefit of a prepaid card, that of reducing the amount of cash in the system and hence improving revenue control, does not require the card to be valid for a range of uses; however, an agency would experience reduced media purchase and production costs if the cards themselves were provided by an outside party (e.g., a bank or telephone company). Furthermore, the issuance by a bank or other entity of a multiple use card that can be used on transit could attract new riders to transit. If the transit agency were to administer a multiple use program itself, it could conceivably generate revenues through relationships with other vendors.

Thus, the two basic models for a transit agency's participation in a multiple use card program are as follows:

- In one approach, the transit agency establishes and administers the program (directly or through a contractor or joint venture partner); the farecard is made available for use in parking lots, pay telephones, vending machines, and/or other functions. Where a joint venture or consortium is involved, there is likely to be some private financing, and the consortium might receive a fee for each transaction (i.e., each fare or other payment). This basic model has been demonstrated in Dublin, Ireland, and Manchester, England, and represents the basic approach being pursued in the NYMTA MetroCard program, as well as Hong Kong and Sydney, Australia (several of these projects are described below).
- The alternative approach is for a bank or other private entity to initiate and administer the program; in other words, the bank ATM and credit card or telephone prepaid card can be used for fare payment, as well as other functions. This is the approach in several projects in Europe (e.g., Biel, Switzerland, and throughout Denmark), and in the United States where MARTA in Atlanta, Georgia, will accept bank-issued cards for fare payment. This approach is also being developed as part of a demonstration project in Wilmington, Delaware, involving the transit system and a local bank (these projects are described below). In Phoenix, Arizona, Valley Metro's acceptance of credit cards for fare payment represents a variation on this approach and is discussed in the next section.

The latter type of arrangement is more widespread than the first. The Biel (Switzerland) POSTCARD project, for instance, is administered by the Post, Telephone, and Telegraph Service (PTT), in whose offices the cards are sold and value can be added. The DANMONT A/S project was established by Danish banks and telephone companies. The MARTA project is associated with the introduction of the VISACash card in Atlanta by three banks. There are now several examples of the first approach, however, and they are receiving increasing consideration in other locations. The plan for the NYMTA MetroCard program is that it will be administered by a private entity, under contract to the MTA Card Company (a subsidiary of the NYMTA); the private partner (probably a major bank) is expected to help finance the system and will share in the multiple-use-generated revenues. Similar to the plan for New York, the Manchester program is being financed by a public-private consortium (the transit operator and the system integrator, AESProdata), which receives a transaction fee for certain types of uses. The Wilmington project is actually being funded by the U.S. Department of Transportation (an ITS Operational Test to evaluate smart cards), but the bank will own the cards.

None of the above U.S. projects has been implemented as of this writing; however, their ultimate experiences, in terms of both implementation issues and operational results, will be invaluable in assessing the potential for the multiple use concept in this country. Meanwhile, other projects include multiple transportation uses. For instance, the WMATA and Ventura County smart card tests include both transit and parking payments; the Seattle project will include ferries as well as transit. If successful, these and other efforts could conceivably be expanded to a broader multiple use focus.

With regard to technology, all of the existing and planned prepaid multiple use programs are based on smart card technology, although the NYMTA MetroCard program will likely retain magnetic stripe cards for use by occasional transit riders; of course, Valley Metro's post payment multiple use arrangement involves standard magnetic stripe credit cards. Most of the prepaid programs use contact cards, while Manchester, Sydney, WMATA, Ventura County, Seattle, and the Bay Area are—or will be—using contactless cards. The Hong Kong project now under development will also use a contactless card, as discussed above. The multiple use smart card is commonly referred to as an "electronic purse." The enhanced security attributes of smart cards are well suited to use in an open environment, and the data capacity and processing capabilities facilitate a broad array of uses. For instance, the card could conceivably be used for storage of health care records, electronic benefits, school records, and security access, as well as stored value for purchases. These multiple functions require a system that can ensure the security of data for each function within the card (i.e., the medical records would only be accessible to the authorized reader or terminal).

The unit cost of smart cards is high, as noted elsewhere in this report, and it is unclear at this point how many transit agencies would adopt an electronic purse system in isolation. Most of the smart card projects in the United States to date—and in development—represent relatively small-scale tests of the technology; thus, the costs have not been a major consideration. On the other hand, partnership arrangements, in which the system supplier is helping to finance the fare system improvements and media production in return for transaction fees, could be a model for the introduction of widespread multiple use programs. The development and success of all of the multiple use efforts will be carefully watched by both the transit and card technology industries.

Potential for Transit Participation

Although the choice of technology is an important concern, the more basic question is, to what extent will transit agencies initiate and administer—or participate in—broad-based multiple use programs at all? The most likely candidates would appear to be the very large agencies, that, like NYMTA, have a large enough ridership base to make a multiple use transit farecard appealing to other merchants, services, or other types of transportation service providers. The multiple use concept could conceivably be an extension of a regional fare integration program, because revenue distribution arrangements are already being established. Multiple use transportation applications also represent a natural extension of transit farecard use and will likely be initiated by a number of transit agencies.

Of course, a key issue affecting the potential for recruiting non-transportation participants to a transit-initiated program is the compatibility of payment technologies. For instance, NYMTA encountered resistance to acceptance of its magnetic MetroCard by other entities. In order to take advantage of the banking industry's move toward smart cards, MTA has decided to incorporate smart cards in its program. MTA's experience in developing a joint public-private venture—and in maintaining both smart and magnetic cards—will be observed closely. The Integrated Card System being developed in Sydney will enable use of multiple card technologies as well.

For most transit agencies, participation in a multiple use program—if it comes at all—will probably come in the form of an eligible use for a bank or other card, as in the Atlanta, Wilmington, Swiss, and Danish examples. Some agencies will not want to become part of an open payment system, because they will want to maintain full control over their fare media and fare collection systems; such agencies could pursue the New York approach and look for a private entity with which to form a business partnership. Other agencies will see a benefit in participating in a bank-administered program. As suggested above, an agency would reduce its fare collection costs by having another entity provide the fare media and would also expand its ridership base by adding cardholders who are not transit users. In considering smart card use in particular, widespread transit usage is likely to come—at least in the near term—only where the cost of the cards is either covered by another entity or shared among the different applications. The Atlanta and Wilmington projects will provide good tests of the potential for this type of arrangement. Similar to the manner in which the transit industry has gradually begun to allow the use of credit and debit cards for purchase of fare media—and even for direct fare payment, in the case of credit cards—developments in the financial sector relative to electronic purse systems and prepayment in general could begin to include transit.

Of course, discussion of the potential expansion of multiple use cards for transit must also consider two critical questions:

- How will the multiple use card concept be embraced by transit riders?
- To what extent are financial institutions pursuing multiple use prepayment applications?

Regarding the first point, the extent to which these cards can gain wider acceptance from the public will be critical to their success. It has often been found that a certain level of availability is required before the benefits of new technology really begin to make an impact. For example, the new technology for prepaid phone cards in the United Kingdom did not gain widespread acceptance until 10,000 public telephones that accept the cards became available. In an attempt to ensure that the MetroCard gains acceptance, NYMTA has undertaken considerable market research, and this has led to the conclusion that the most effective means of disseminating the card is to introduce it gradually—first in a few subway stations, then on the complete network, and finally, once customers are more familiar with the concept of stored value and the company has perfected the administrative systems, on an expanded basis for retail uses. Of course, this process has become more complicated with the recent decision to add a new technology to the mix.

Stored-value ticketing in general has been used in the transit world for several years, and use has recently begun to expand, as agencies of all sizes are implementing—or at least considering—automated fare collection systems. The convenience of stored-value media has been shown to appeal to riders, and it permits the transit agency to offer riders a broader range of fare options (e.g., different levels of stored value and features such as off-peak discounts). The use of a prepaid stored-value ticket means that the rider does not have to know the exact fare for a particular trip (i.e., if the fare structure is relatively complicated, as in WMATA and BART) and also obviates the need to carry exact change. Furthermore, as discussed in Chapter 6, various types of discounts can be provided with prepayment. The appeal of discounted fare options has been demonstrated in non-electronic forms—i.e., unlimited ride passes and bulk purchase of tokens or tickets—throughout the industry. Thus, there is every reason to believe that electronic options will also be popular. (Of course, offering discounts on farecards can present complications in a multiple use system; this is discussed below.)

With regard to the second issue, financial organizations, as indicated earlier, have demonstrated increasing interest in prepayment options in general. There are serious moves underway within the banking industry to develop a uniform, open, prepaid system. The primary focus of these systems is not the transit field but the elimination of low-value cash transactions, a large market still largely untapped by the banking system. For example, the Smart Card Forum established by the U.S. banking industry and other interested entities (including the U.S. Treasury), was founded to discuss interoperability standards for a smart card infrastructure. In addition, VISA has recently announced the formation of an international consortium to develop common specifications for an electronic purse based on the smart card. The aim is that this card will eventually replace bills and coins for purchases of less than $10.00.

Though the focus of these new systems is purely commercial, ultimately they could be expanded to fare payment at transit agencies (as in Atlanta). The control of the system would then be in the hands of those organizations now in control of the online credit and ATM financial card processes, with whom the transit operators are slowly beginning to develop relationships (as discussed in the next section of this chapter). The advantages for the transit industry in such a payment arrangement would be, as suggested earlier, that it would have a participatory rather than a management role in the payment system and, therefore, be relieved of the major costs, responsibilities, and liabilities connected with card issue and with the transaction processing business. The major disadvantage would be that the transit agency's long-term revenue collection goals will differ from those of the bank or financial institution responsible for the cards and that these may be difficult to reconcile.

Besides the aforementioned developments, another important program is taking place in Europe. Several nations are collaborating in the development of a fully integrated electronic payment system for all forms of transportation, called the Automatic Debiting and Electronic Payment for Transport (ADEPT). This system has been tested in various ways in five European cities and is envisioned as a way to increase the speed of fiscal transactions and to provide more secure and simple audit trails. The basic system includes the following:

- Smart cards for carrying electronic credit or information on service rights in a secure area—these may be read and written to with contact or contactless interfaces;
- Tags (automatic debiting transponders) that act as a communications and processing device for real-time charging transactions; and
- An integrated payment network that allows different service providers to use a single electronic payment mechanism for collection and charging of fees from different users.

Thus, there is a growing level of activity in the development of multiple use card systems, both in and outside of the transit industry.

Institutional and Regulatory Issues

While interest in multiple use programs has been increasing, there are legal and regulatory issues associated with multiple use cards and open system arrangements in general. For instance, such card systems introduce legal questions that must be resolved to the satisfaction of the user, the card issuers, and the service providers. Without formal conditions of use, for example, the following issues will need to be considered:

- Refunds and reimbursement of unused stored value,
- Theft or loss of the card, and
- Card or hardware failures.

Privacy and data protection are also important and are addressed later in this chapter.

Several institutional and operational issues are related to integration of transit and other uses. For instance, the provision of discounts and bonuses on purchase (or recharging) of stored value cards, as mentioned above, can significantly complicate a multiple use arrangement; this is because every expenditure—transit or other—will be subject to the same discount. Although the transit agency may well be interested in offering some type of purchase or add-value discount or bonus, other entities (e.g., retailers and vending machine operators) may have no interest in offering a similar discount. The nature of the prepaid stored value concept makes it very difficult to allocate the discount just to transit. Solving this problem requires either that no discount or bonus is provided or a discount is offered on rides taken, rather than a bonus on amount of purchase. In other words, if a farecard is sold for face value, but $1.15 is deducted for each boarding using a farecard—compared to the $1.25 cash fare—the discount can be restricted to transit use.

A similar issue relates to the use of transit vouchers to purchase multiple use cards—or direct employer provision of cards (i.e., in lieu of monthly flash passes). Because the card does not have to be used for transit, an employer providing vouchers or actual farecards could be effectively subsidizing retail purchases or telephone calls rather than transit use for some employees. Thus, it may be necessary to prevent the use of subsidized vouchers in purchasing multiple use farecards; in such a case, the vouchers would be restricted to buying transit-only fare media (e.g., passes, tokens, or tickets—or perhaps "restricted" stored-value cards). Similarly, subsidized fare media provided directly to employees would have to be restricted to transit use in some fashion. This could take the form of a post payment/employer billing option, for instance. Another possibility is to offer unlimited ride passes (on farecards) that can only be used for transit. The Wilmington demonstration, described below, will have to address this issue, because a key element of the project is employer provision of fare media; a post payment option, as well as a stored value debit option, is planned.

Thus, while the important transit fare concepts of bulk purchase discounting and employer subsidization are largely incompatible with multiple use of prepaid cards, electronic payment technologies can allow their coexistence with stored value options—i.e., through the discounting of trips (rather than initial purchase value) and the provision of fare media that cannot be used outside the transit setting. Nevertheless, these issues must be considered carefully in pursuing multiple use arrangements.

Examples of Multiple Use Programs

Table 51 presents a summary of electronic purse applications around the world. Several examples of multiple use programs, either already in use or in or near the testing stage, are described below.

Metropolitan Atlanta Rapid Transit Authority Smart Card Project—MARTA is working with VISA and three local banks (NationsBank, the First Union Bank, and Wachovia Bank) on a project involving the VISACash stored-values (contact) card. Card read/write units will be installed in two turnstiles in each MARTA station by mid-1996, and the VISACash card (initially to be used as a prepaid disposable card, later to be issued as a reloadable card) will be accepted for direct fare payment. This pilot project will test the institutional and operational feasibility of an arrangement in which the transit agency does not produce the payment media but rather particpates as a "merchant" in a multiple-use card/electronic purse program.

New York Metropolitan Transportation Authority Metro-Card—NYMTA is implementing an automated fare collection system. The fare medium for the new system, MetroCard, is a magnetic stripe stored-value card, although a smart card will likely be introduced also at some point. Read-write units have been installed on the buses and at many key stations thus far; eventually, all stations will be equipped with the new equipment. The cards can be purchased at stations and nearby retail units in specific denominations and can be recharged as value is used. One of the key aspects of the project is the plan for expanding the usage of the card to the other transit operators in the region as well as for other uses such as telephone and retail. NYMTA has established a subsidiary, the MTA Card Company, to carry out this plan; as of early 1996, the Card Company was in the process of negotiating an agreement to enter into a joint venture with a major New York-based bank for the purpose of implementing and administering the multiple use arrangements — and for distributing the MetroCard in general.

Wilmington (Delaware) SMART DART Project—This multiple use project is an ITS Operational Test involving the use of

TABLE 51 Electronic purse applications

Country	Scheme Operator	Sector	Status
Australia	NSW Government	Government	Tenders (bids) in
Australia	MasterCard	Banking	Trial (96)
Belgium	Banksys	Banking	Trial
Denmark	Danmont	Inter-Sector	Roll-out
Finland	Avant	Central Bank	Trial
France	La Poste	PTT	Planning trial
Germany	GAD	Banking	Specifications agreed
Latvia	Union Baltic Bank	Banking	Planning trial
Portugal	SIBS	Banking	Trial (to start 6/94)
Singapore	NETS	Banking	Trial (started 4/94)
South Africa	Inter-bank SCC	Banking	Agreeing on specs.
Spain	SEMP	Banking	Trial
Switzerland	Swiss PTT	PTT	Planning roll-out
Taiwan	FISC	Government	Roll-out
United Kingdom	Mondex UK	Banking	Trial (started 7/95)
USA	MAC	Banking	Trial (96)
USA	VISA	Banking	Roll-out (96)

bank-issued smart ATM cards on 135 Delaware Authority for Regional Transportation (DART) buses. The Wilmington Trust Bank will issue MAC ATM contact smart cards, and the 135 buses will be equipped with smart card readers (attached to the existing fareboxes). The stored-value cards will be provided to bank customers, but they will also be made available to non-customers (i.e., for use on the transit system), as well as for other services at specific locations. The project, currently in the development stage, will test the use of contact smart cards on buses, the bank/transit institutional arrangement, and the potential for employer involvement. Participating employers will provide cards to interested employees and will place funds (i.e., stored value) directly on the cards—probably through on-site add-value machines or ATMs. The initial plan is that the employer will be able to select either a debit or credit option for employee cards; in the debit option, the value of each trip would be deducted from the stored value, while in the credit option, trips would be paid for after the fact. Employer involvement (including a monthly subsidy) is viewed as one means of addressing participating employers' trip reduction requirements.

Manchester (England) Contactless Smart Card Project—This contactless smart card system, now in testing on buses, was developed with the intention of expansion to a wide variety of purchase applications ranging from transit, commuter rail and taxi fares, and parking charges to supermarket purchases and telephone calls. At least initially, the card is used to pay for the fare, rather than for direct fare payment; in other words, on buses, the rider tells the operator his or her destination (this is a zonal system) and the operator enters the appropriate fare, which is then deducted from the farecard. On light rail, the rider will purchase a ticket from a vending machine using the farecard. Unlimited ride passes will also be available on the cards.

The system is being tested by 5,000 people who are entitled to "concessionary" fares (i.e., reduced fare for seniors and those with disabilities). In the test phase, the card is not being used for fare payment—only to "authorize" the lower fare. The passenger places the card close to the reader, which displays the fare. Upon receiving payment of the fare, the driver presses the appropriate button to issue a receipt. This testing phase began in February 1994 in a single suburb of Manchester. The plan is to extend the test to more than 3,000 buses (operated by a number of different agencies), schools, and retail businesses throughout the greater Manchester area, although as of late 1995, plans for expansion were on hold, pending resolution of transit funding issues. As mentioned earlier, the system integrator (AESProdata) is helping to finance the system; the joint public-private consortium receives a fee for each transaction made with one of the cards.

Sydney, Australia Integrated Card System—Another joint public-private multiple use venture is being developed in Sydney, Australia. This program is being developed by Card Technologies Australia Limited in conjunction with local transit agencies, a major bank, retailers, and vending machine operators. The initial trial is being conducted in a major transit corridor. Perhaps the key aspect of the integrated card system (ICS) is that it is an open system designed to allow 1) the use of different card technologies (e.g., contactless, contact, and magnetic), as required, and 2) any terminal/reader manufacturer to integrate ICS into its own units. A range of terminals (i.e., read-write units) is being developed and will be tested in the system; these include bus ticket issue machines with integrated validators, rail validators, taxi terminals, retail agent terminals (with bank certification), retail purchase terminals, vending machine integrated readers, toll booth integrated readers, and fast food outlet driveway integrated readers. One of the features of the system will be the ability to use the existing banking systems for adding value to cards; clearing and settlements will also be done through the banking system.

Dublin DASH Card Pilot Test—In the DASH card pilot project, completed in 1994, a single card could be used to pay for bus fares, phone calls, parking, and tolls. The test was part of the European Community's Generalized and Advanced Urban Debiting Innovations (GAUDI) project and used a contact smart card (produced by Schlumberger.) The cards were used as electronic purses and were also pre-programmed with weekly or monthly pass privileges for transit, telephone units, token values (as free promotional offers), and value for a parking season pass. The pilot test included 25 buses, 24 public phones, a parking facility, and a toll road. The contact smart card technology was selected because this equipment is compatible with the telephone cards already in use in Ireland and because the equipment could be procured without delay or development costs.

Biel (Switzerland) POSTCARD—In Biel, a program called POSTCARD is entering its 5th year. This is the first of the applications discussed here for which the driving force was not the transportation industry; the POSTCARD was introduced by PTT. The POSTCARDs are contact smart cards, although they also have magnetic stripes so that both technologies can be used during the transition to a smart card only system. POSTCARDs can be used to purchase local bus tickets, long-distance bus tickets, telephone calls, goods and services, and stamps. Additional functions include payment of electric and phone bills. At present, there are 30,000 users of the POSTCARD.

DANMONT A/S—Another application of a multiple use card that has not been led by the transit industry is a national card that can be used throughout Denmark. In 1991, the Danish banks and telephone companies agreed to establish an independent company called DANMONT A/S as the "System Operator" of their central clearinghouse for a national payment card. The objective was to introduce a nationwide prepaid smart card that could be used for purchases from vending machines, telephones, trains, buses, and parking meters. The "Dancard," a national debit card system, had been in use since 1983, with more than 155 million transactions in 1992. This acceptance of card technology was important in allowing the new prepaid card to gain widespread approval and understanding. The prepaid card system was developed as a low-cost method of making low-value payments.

The average transaction with the new cards was expected to be between DKK 3 and 7. Cards are sold in denominations of DKK 100, 250, and 300 (the equivalent of between $20.00 and $50.00). After a 6-month field trial starting in September 1993, the card was introduced into 17 cities, with Copenhagen joining the system in December 1993. One-time cards (i.e., there is no capacity to add value) are used primarily to simplify the electronic money tracking logistics; the cost of the one-time cards will be borne largely by advertising revenue. It is, however, expected that, in Phase II, rechargeable cards and add-value machines will be introduced. The system is off line and the user remains anonymous. The system is managed by the system operator (i.e., DANMONT A/S), which provides the sole link between the card issuers, card and equipment suppliers, and service providers. This allows even small retailers to join the system as service providers, even if they do not have the requisite size to become independent card issuers. Seven different manufacturers have invested in and now operate different services. Eight banks and a telephone company issue cards, and other manufacturers and card issuers have begun to express interest in the system.

CoreStates (MAC) Stored Value Card/Electronic Purse Project. The CoreStates project began with an extensive 2-year consumer (employee) acceptance test using a stored-value high-coercivity magnetic stripe card called MoneyPass. The MAC Headquarters in downtown Philadelphia employs about 3,400 people. The headquarters building was turned cashless for food purchases at the counter in the cafeteria. Snack vending machines were also modified to accept only MoneyPass. MoneyPass and cash were accepted in the lobby shop, which is operated by an outside company. During the first 6 months, surveys indicated good acceptance by employees; at the suggestion of employees, MAC added one token dispenser (to vend SEPTA tokens), and newspaper boxes. In addition, on each floor two pay phones that only accepted MoneyPass were introduced. An employee buys the first MoneyPass from a vending machine that only accepts bills. It costs $0.60 for the first purchase to encourage re-use of the MoneyPass. An add-value function is included in the machines (called Cash Value Stations). In addition, two ATMs are available in the building to load value from one's bank account to the MoneyPass, using the MAC (ATM) card. Some of the benefits achieved in the program thus far are as follows:

- Cardholders have convenience, safety, and a budgeting tool.
- Merchants have reduced cash handling, lower operating costs, reduced vandalism, and better and more timely product usage data.
- MAC has increased customer service, increased transaction fee revenue, an increased card base, and a competitive edge.

With the success of the 2-year test, CoreStates has moved to the next stage of the project and has introduced contact smart cards for extended trial at another CoreStates facility in Wilmington. (It should also be noted that the MAC network will be involved in the Wilmington transit multiple use smart card project described above.)

These projects, as well as others in development, will allow the transit industry, as well as the financial and other industries, to observe the barriers faced in—and the results of—developing, implementing, and managing a multiple use card system. There are potential benefits to all parties involved; however, the institutional and operational issues are complex, and where a technological change—i.e., to smart cards—is involved, the challenges will be magnified significantly. Although a widespread move to multiple use cards in the transit environment is not a near-term trend, it does appear to represent a possible longer-term scenario for many transit agencies. (Issues associated with the "back-end" processing of multiple use transactions are addressed later in this chapter.)

Post Payment/Employer Billing

In contrast to prepayment using electronic media, post payment is well-established in the conduct of commercial transactions. However, whereas transit has employed electronic prepayment for years, the use of post payment in fare transactions is quite new. As explained earlier, it appears that only one transit agency, Valley Metro in Phoenix, is utilizing post payment methods for fare payment. Credit and/or debit cards are used by several agencies for purchasing fare media from automated vending machines, as explained below. Post payment for direct fare payment can take the following two basic forms:

- Using transit agency-issued fare cards and a transactional data base (in the card reader unit) that facilitates the billing of trips made and
- Using commercial credit cards in the farebox or turnstile; the rider is then billed for trips made along with his/her other credit transactions.

Valley Metro uses both of these approaches, as the swipe readers on the fareboxes have been programmed to accept both transit media and commercial credit cards (MasterCard, VISA, American Express, and Discover). The agency-issued cards are used in an employer billing program—i.e., individual riders are not billed directly for their trips. The two options are described below.

Employer Billing Program

The last several years have seen a significant increase in federal, state, and local regulations requiring the reduction of single-occupant auto usage in many areas. Spurred by the recent

Clean Air Act, virtually all urban areas have stepped up requirements that employers implement—and document—transportation demand management and trip reduction measures. In many regions, employee trip reduction mandates have required companies to reduce the number of their employees who drive to work alone. These efforts have obviously focused on the work trip and the measures have included the establishment of incentives for employees to increase transit use and car and van pooling, as well as disincentives to driving alone.

Employee transit subsidies are one of the most widely used strategies; these typically take the form of a monthly pass, fully or partially subsidized by the employer—or, where available, a fully subsidized transit voucher that can be used to purchase a pass or other prepaid fare media. Although the provision of subsidized passes and vouchers promote transit usage, they do not provide a means of documenting the actual use of transit. Valley Metro addressed this issue by developing an employer billing/post payment system. In this system, employers provide their employees with passes that allow the transit agency to track and report the level of usage to the employer; the employer is then billed each month for the number of trips each employee makes (up to a maximum value equivalent to the face value of the monthly pass). The reports of card usage, produced by the transit agency from the farebox records, are then used by the employers to document the level of transit use in their firm and, hopefully, to show compliance with government requirements.

Valley Metro installed electronic fareboxes in 1981, and, in 1990 decided to add a magnetic card swipe reader to the farebox to permit reading of credit-card-size (0.03-in.-thick) magnetic passes. Installation of this read-only technology permitted the agency to capture trip transaction data identifying the card number, employer number, date, and time of trip and to use this information in monthly billing. Hence, a new employer billing system was developed in-house (implemented in 1991), using available off-the-shelf components. It has become known as BusCard Plus (the standard monthly pass is known as BusCard.) BusCard Plus can be used in the same reader as the BusCards, though the latter are only 0.01 in. thick. Unlike BusCard, BusCard Plus does not have to be purchased every month; rather, each BusCard Plus is valid for 2 years, starting with the first month of issue.

The system is essentially a transactional database that identifies the date and time when each employee boards the bus, as well as bus number, card number, account number, fare type, and city of use. All data stored in the farebox are backed up with a secondary power source (battery), in case power to the farebox is lost. When the farebox is probed, all data stored in the farebox are downloaded to the network system at the bus facility. Billing is performed monthly. For each account, an invoice and report are generated that indicate the number of trips taken and the details of these trips; this enables the employer to identify all work-related trips, i.e., for purposes of documenting compliance with the Maricopa County trip reduction ordinance (affecting all employers with 100 or more employees).

Valley Metro has demonstrated that an employer billing system, including the ability to track individual trips, can be an important tool in the documentation of the extent of compliance with TDM and trip reduction programs. Although the agency imposes a cap on an individual's total monthly fare payment, post payment can allow an agency to bill an employer—or an individual—for all trips taken, even if the resulting bill exceeds the monthly pass price or some other monthly cap. An unlimited ride pass results in "lost" revenue to the agency whenever a pass user makes more than the pass breakeven rate. Post payment provides a means of providing riders the convenience of a monthly pass, while preventing the agency from having to forfeit the revenue associated with trips above the pass breakeven rate. Of course, this must be weighed against the need to generate and send out invoices; the agency also loses the "float" (interest) gained from selling pass and other prepaid fare instruments.

A potential concern regarding post payment systems regards riders' privacy—i.e., given that the systems are based on the ability to provide detailed tracking of each cardholder's usage. This has been a significant concern in the applications of smart technologies in private transportation (i.e., in toll collection systems) and has also been identified as a concern in tests of smart cards on transit. It has apparently not been a major issue in Phoenix; whether it will be a problem as the concept is adopted elsewhere remains to be seen.

Several agencies have recently included post payment/employer billing requirements in technical specifications for new fare collection equipment. For example, Seattle/King Co. Metro and Santa Cruz Transit are interested in instituting such a system. Pinellas Suncoast Transit Authority (Clearwater, Florida) has also announced that they are considering introducing an employer billing program in conjunction with installation of TPUs. The popularity of employer billing systems is likely to increase in the coming years, as growing numbers of agencies install electronic payment systems and have to document trip reduction efforts.

Credit Card Acceptance

Beginning in May 1995, Valley Metro has accepted commercial credit cards for fare payment on the roughly 400 buses in the Valley Metro system; Valley Metro service is provided by a total of four contractors in the region. On each boarding using a credit card, a single full fare ($1.25 for local service, $1.75 for express service, as of August 1995) is recorded in the data base under the credit card account number. The cards are swiped through the same card readers used for the passes, as described above; Valley Metro staff reprogrammed the transactional data base to handle the credit card accounting. At the end of each week, all trips for each card are "batched" and submitted to the credit card clearinghouse; the cardholders are then billed for their trips as part of their normal monthly bill. The clearinghouse reimburses the transit agency the next day for the trips submitted. Valley Metro negotiated the weekly billing arrangement with the local clearinghouse and also negotiated a lower fee per transaction—$0.05—than the normal transaction fee of $0.19. At that price, Valley Metro feels that this arrangement is considerably less expensive than issuing and processing the agency's own fare media. (The agency had not had the opportunity to evaluate the cost impacts as of this writing.)

The key to making the use of commercial cards viable was the decision to 1) not perform on-line verification of each account and 2) not issue a receipt with each boarding. Because these are absolute requirements for using debit cards, Valley Metro could not accept debit cards. However, a credit card can be accepted without verification if the payee is willing to accept the risk, and a receipt is not required at the time of use for credit cards; a credit card can be used to make a purchase over the telephone, for instance. Valley Metro accepts the risk of fraudulent cards, but only for a maximum of 1 week's worth of trips per card; the clearinghouse informs the transit agency if any of the cards used are stolen or otherwise invalid, and the agency then enters the fraudulent account numbers into the card reader data base. Thus, a subsequent attempt to use a bad card will be rejected.

Valley Metro claims that there have been no problems with the program, as of its 6th month. The agency also reports that the program has been well-received by users, although usage has been limited to date. There were approximately 1,100 uses during the initial month of the program (May 1995); this had rose to roughly 1,900 in the 2nd month. The agency has not yet actively marketed the program.

On the basis of this limited experience, the use of commercial credit cards would appear to be quite feasible for the transit industry in general. The barriers in any given location are primarily related to 1) technology (i.e., the need to adapt card readers to accept and process the cards) and 2) accounting (i.e., the need to negotiate a satisfactory arrangement with the local credit card clearinghouse and establish a procedure for billing for trips taken so as to minimize cash flow issues). A transit agency must also weigh the cost advantage of not having to provide all of its own fare media against the lost revenue from not receiving payment in advance of trip-making. In general, however, in the move toward integrating transit fare payment into a more open payment system, the acceptance of credit cards represents an important concept.

EMERGING FARE MEDIA PURCHASE AND PROCESSING METHODS

Whereas the previous section addressed fare payment methods, this section reviews fare media purchase and processing methods. The focus is on the issues associated with the move toward more open systems. In some transit agencies, the use of debit and credit cards—or the use of ATMs—has meant that the movement to a more open system has already begun. The current state of developments in this area is reviewed, as is the issue of regulations governing these payment/purchase mechanisms.

Emerging Developments in Fare Media Purchasing

As explained in earlier chapters, the possible means of purchase of prepaid fare media include the following:

- Cash,
- Credit card,
- Debit card,
- Transit voucher,
- Personal check,
- Deduction from a paycheck (i.e., in an employer pass program), and
- Stored-value card (i.e., to purchase a ticket in a POP system).

Although most of the media purchase developments and issues are related to prepayment, the emergence of post payment as an option raises new possibilities and issues. The employer billing method discussed above is the best known, though hardly widespread, approach to post payment. Another method, however, involves purchase of fare media from home, via telephone, mail, or personal computer (through an on-line service); the buyer is then billed for the price of the pass.

Transit agencies each have their own rules—and capabilities—as to which of these forms of payment they will accept, and this depends on several factors, including the types and prices of fare media available (e.g., monthly passes, weekly passes, book of tickets, 10-pack of tokens, or stored value card), and the form and location of purchases (i.e., from ticket agents or other sales personnel versus ticket or token vending machines and in-station versus remote outlet). Of course, if purchases are made from vending machines, the capabilities of the machines themselves limit the acceptable forms of payment.

The issues of concern here are primarily those dealing with technological developments; hence, this discussion focuses on trends related to automated transactions, rather than policy issues related to allowable forms of payment. The key technology-related trend in purchase of fare media is use of electronic funds transfer (EFT) methods, such as the following:

- The use of credit/debit cards in AVMs and
- The use of ATMs for fare media purchase.

The use of AVMs and token vending machines (and add-value machines, for that matter) has, in most locations, limited purchases to cash. Increasing numbers of AVMs, however, are being configured to accept credit and/or debit cards. The use of ATMs is also in place, although on a very limited basis.

There are also several other developments that could affect future fare purchase methods and technologies. These are described in the following sections.

Transit Vouchers/Electronic Benefits Transfer

The expansion of the use of transit vouchers as a form of employer subsidy suggests the merit of developing machine-readable vouchers for use in AVMs or perhaps even ATMs. There are design issues related to size and method of recognition.

The use of electronic means (akin to electronic benefits transfer methods being applied in social service areas) to provide subsidized transit benefits may also have potential (i.e., in lieu of providing a paper transit voucher or directly providing a monthly pass). For example, $60.00 (or whatever subsidy level is being provided by an employer) could be electronically banked each month to eligible account holders to buy fare media. Voucher benefits could also be loaded directly on employees' stored-value fare media.

Cash

The acceptance of high denominations of bills ($50.00) with new bill acceptance technology, especially for commuter rail applications can be expected to occur.

Proposed changes in currency design, beginning with high denomination ($100.00) bills and working toward the $1 bill by 1999, will require new bill registration techniques.

A new dollar coin has been proposed—and is strongly supported by a number of transit agencies; however, enthusiasm is also tempered by the failure of the Susan B. Anthony dollar coin to gain widespread acceptance.

Debit Cards for Off-Line AVM Sales

ATM/debit cards need an on-line authorization. VISA introduced a new prepaid debit card during the 1994 Winter Olympics. Value can be transferred from one's bank account to the prepaid part of the card and used as an off-line payment method, in addition to serving as a regular on-line ATM card.

Key issues and trends associated with the emerging fare purchase developments are discussed below, along with issues associated with the reconciliation and settlement of electronic payments (i.e., the back-end processing of credit and debit card transactions).

Use of Credit/Debit Cards

Most transit agencies operate a closed system for fare payment, and the same is true for purchase of fare media. Advancements in the technological capabilities of vending equipment, however, have now made the use of EFT methods that are common in banking and retail feasible in the transit environment as well. The two major developments related to EFT are the use of credit and debit cards in AVMs and the sale of fare media through ATMs.

Because the use of credit/debit card payment in AVMs prevents the purchaser's entering a signature, there were, for a long time, concerns over account security. The successful adoption of this approach at gasoline pumps, however, essentially cleared the path for transit applications. There are only a handful of examples of use of credit and/or debit cards for media purchase in the U.S. transit industry, and at this point, all are commuter rail services; the European agencies tend to be somewhat more advanced in this area, in part because of the differences in the banking systems there. The existing U.S. sites and the extent of use of these systems are shown in Table 52. (NJT also uses EFT applications, but no data were available.)

The first transit agency to adopt credit card fare media purchases was LIRR, in 1986. LIRR began with credit card sales only, through AVMs, and passenger acceptance was strong. For the next phase of implementation, the agency planned to use both credit and debit cards, but the parent (i.e., NYMTA) made a policy decision to place a moratorium on credit card sales. NYMTA saw no economic justification for the credit card system because of the transaction fee charged by the card companies; hence, only debit card options were made available. Metro North Commuter Railroad followed suit with a few AVMs for debit card and cash purchases.

With the exception of 8 LIRR AVMs that accept credit cards, both LIRR and Metro North now offer only 10-trip, weekly, and monthly tickets by debit card, while the more recent installations at SCRRA and VRE allow both credit and debit cards. In fact, VRE has AVMs that accept only credit and debit cards; they do not accept cash. In contrast, the NJT system does not allow the use of debit cards; the bus and rail ticket agent machines and the customer-operated rail AVMs (on two lines) accept both cash and credit cards. The NJT machines are electronically linked to the Revenue Transactions Authorization Collection System for credit card authorization, revenue accounting, and machine function monitoring.

Other agencies are acquiring or implementing the technology for EFT payment methods. For example, BART has purchased and is testing some AVMs that will accept credit and debit cards, and other agencies, including CTA, MBTA, and Portland TRI-MET are or will be procuring AVMs with these capabilities. Some of PATH's AVMs are equipped for credit/debit payment, but this feature has yet to be activated, and they accept only cash.

One of the primary benefits of introducing an EFT arrangement is reduction in cash handling costs. The extent of the net cost impact, however, will depend on the costs associated with the use of the central clearing mechanisms of the credit and debit card schemes. For example, SCRRA reports that the costs associated with EFT processing are between 1 percent and 2 percent of the credit card sales volume, and there are also costs associated with the lease of lines running between the central data computer system and the regular dial-up lines. As noted above, NYMTA did not feel that there was sufficient economic justification for accepting credit cards.

Another benefit of the new systems will be a reduction in the delay between deposit and availability of funds. For example, LIRR staff conduct and account for ticket window sales manually. Bank deposits are then delivered by the ticket agent at the end of the shift, and about 25 days later the LIRR has access to the money deposited. EFT mechanisms can reduce this revenue turnaround time by almost a factor of 10. Enhanced passenger convenience is the other chief potential benefit of the electronic systems.

In summary, agencies must weigh the benefits of EFT in terms of reduced cash handling costs and quicker deposit of revenues—as well as improved rider convenience—against the credit card transaction costs. Although some agencies have found this cost to be too high, the use of credit and/or debit

TABLE 52 EFT sales in transit

Agency (1)	# of TVM's	Type	Period		Cash Sales	Credit Sales	Debit Sales	Total
LIRR (2)	73	A	Oct-93	$	1,110,497	89,004	283,614	1,483,115
				#	118,094	674	2,363	121,131
	7	D	Oct-93	$		986,040		986,040
				#		7,785		7,785
MNCR	10	B	Apr-94	$	204,777		412,078	616,855
				#	36,891		3,428	40,319
SCRRA	70	A	May-94	$	636,369	465,077	32,050	1,133,496
				#	35,196	7,438	533	43,167
VRE (3)	48	C	May-94	$	1,159	314,663	107,271	423,093
				#	203	7,733	2,712	10,648

Machine Types
A - cash/credit/debit
B - cash / debit
C - credit / debit
D - credit only

(1) - NJT also uses EFT mechanisms for both commuter rail and bus tickets; however, data was not available.
(2) - Of 73 AVM's, only 8 accept credit cards
(3) - The AVM which accepts cash has been removed (1994)

cards for purchase of prepaid fare media from AVMs is growing. This trend should continue, particularly with the increase in POP fare systems (i.e., as agencies open new light rail and commuter rail lines).

Use of ATMs

Another method of using EFT for fare payment is the purchase of tickets through the banking system directly, using ATMs. This approach greatly expands the pass sales distribution network, without having to rely on recruitment of sales outlets. ATM sales is a newer development than credit card sales through AVMs and has presented greater challenges to transit agencies that have implemented it. Although at least three agencies (WMATA, TRI-MET, and Seattle/King Co. Metro) have implemented ATM sales programs at one time or another, we are aware of only one current program—that at Seattle/King Co. Metro.

Seattle/King Co. Metro has offered two different (one- and two-zone) monthly passes through a limited number of machines in the ATM network of Seafirst Bank since 1990. These machines are located at all stations of the downtown Seattle transit tunnel and near many major work, shopping, and transit centers. For passes purchased between the 10th and the 23rd day of the month, the cost is pro-rated, i.e., the purchaser pays only for the time left in the month. Pro-rated passes are available only from the cash machines. On the 25th day of the month, passes go on sale for the following month. Metro sells about 3,000 passes a month through ATMs. A survey of ATM pass purchasers in April 1992 produced the following findings:

- Most people who used an ATM to buy their bus pass were repeat purchasers.
- ATM pass buyers were quite satisfied with the service (88 percent were very satisfied.)

Metro and Seafirst are also working together to allow the purchase of magnetically encoded passes through the ATMs. In a separate initiative, Metro also now accepts pass requests through the Internet on-line computer network. This program was begun in late 1993 and works in a similar manner to pass sales by phone, fax, or mail, which have all been possible for more than 5 years now. The purchaser sends a message identifying the type of pass that he or she wishes to purchase and stating a name, address, and VISA or MasterCard number. Metro then mails the pass to the purchaser. Metro has provided very little publicity for this method of purchasing passes, and it is used to buy an average of fewer than 10 fare media items per month. Other agencies also operate a pass by mail service.

WMATA also introduced ATM sales with an operational test beginning in 1990. The program offered purchase of prepaid $10.00 and $20.00 stored-value farecards (for use in the rail system), with debit or credit cards, from six ATMs at several rail stations. The program was a joint venture with Sovran Bank, with the software development and the machines themselves paid for, installed, and maintained by the bank at no cost to WMATA. WMATA in return provided high-volume sites (with no space rental charge during the 1-year test phase) for conducting normal bank ATM business and supplied the electricity for operating the ATMs; WMATA instructed the station managers to report problems with the machines directly to Sovran. It was perceived that the stations offered a relatively safe environment for the cash machine users. A four-stage plan for the program was developed, as follows:

- One Year Operational Test—June 1990 to June 1991. In January 1991, the breakdown of transactions at these machines was 19 percent farecard transactions and 81 percent other ATM business.
- Stage 1—More modified ATMs would have been added and the initial units would have been retained on a permanent basis.
- Stage 2—Debit card acceptance capabilities would have been added to the farecard vending machines.
- Stage 3—Credit cards would be accepted in the entry/exit gates; the charges would be accumulated over the course of a month, and then billings would be handled by the credit card companies.

The operational test was deemed a success, because the three conditions set by the WMATA Board—1) that the use of ATMs should not be discriminatory to any minority or socioeconomic group, 2) that the program should provide a positive customer service, and 3) that the demonstration project should not cost taxpayers money—were met. The ATMs also appeared to be a reliable mechanism for purchasing farecards. Despite the success of the operational test, however, the program has since been canceled. Sovran has merged with C&S bank, and a review of management objectives by the new bank, coupled with the transaction fees that WMATA wished to charge in the second phase, caused the bank to terminate the agreement. Portland's TRI-MET is another agency that encountered difficulties in introducing ATM pass purchase. The system there had provided for pass purchase with credit cards through the ATMs of a savings and loan; however, when this institution was sold, the purchasing bank decided not to continue to offer the service.

Thus, the future direction for ATM sales of fare media is unclear. Although the arrangement has apparently worked satisfactorily in the limited cases in which it has been tested, the transit industry is obviously at the mercy of the banking industry in such efforts. It would appear that the potential is highly dependent on the policies of particular banks, and thus varies from one location to the next. For instance, CTA has been exploring potential sales of its forthcoming stored value card through the ATMs of the Cash Station network, which has expressed considerable interest in such an arrangement.

What is possible is that this type of arrangement will spread to some extent through the introduction of bank-initiated multiple use card arrangements, as described earlier. In the Atlanta and Wilmington (Delaware) smart card demonstrations now in development, for instance, smart cards that can be used for transit will be provided by local banks. This approach differs from that of selling the agency's fare media through ATMs (i.e., rather, the agency is using the bank's media). Nevertheless, it has a similar result in terms of expanding the sales locations for transit fare media.

Electronic Benefits Transfer (EBT) Approach

An as yet untried method for distribution of fare media—and provision of employer or other subsidies—is an approach along the lines of the Federal government's EBT system. EBT provides for the electronic payment of government benefits (e.g., food stamps). The system operates much like commercial debit card (ATM) networks: the recipient accesses and redeems benefits by using ATM's and point of sale terminals (e.g., in supermarkets), and settlement between the government and retailers is transacted using current electronic networks. An alternative to the on-line verification system is an off-line approach, i.e., using stored-value cards. Examples of off-line EBT applications are the Wyoming WIC and Ohio Food Stamp programs mentioned in Chapter 6 (and described in Appendix B); both of these use smart cards, as the issue of privacy and security of information is considered critical. The cards are designed such that each individual function is stored in separate "files" of memory on the card and can, therefore, not be accessed by other users.

An EBT-type approach could conceivably be used to provide subsidized transit benefits (i.e., in lieu of providing a paper transit voucher or directly providing a monthly pass). This system could operate in much the same manner as a transit voucher or subsidized pass program, the difference being that this would be an electronic stored-value mechanism rather than a check or a monthly pass. For example, each month, the employer subsidy (e.g., $60.00 or whatever subsidy level is being provided) could be electronically deposited in a special fare media account; the employee would then add value to his or her farecard from this account. Alternatively, the employer could directly load voucher benefits onto the employees' stored value farecards. An approach along these lines is planned for testing in the upcoming Wilmington smart card project.

The card would either be used as a direct fare payment medium (like a pass) or for purchase of fare media (as in the traditional transit voucher arrangement). In an integrated regional fare system, this arrangement would mean that the value of the voucher could be used by each recipient to purchase rides on services operated by different agencies and at different times. This would be a significant change from the present voucher system, in which the total value must be allocated to the purchase of a pass or multiple rides with a single operator, because all the funds must be used in one transaction.

Summary of Benefits and Limitations of Electronic Fare Purchase Mechanisms

The major reason for initiating the move toward more open fare purchase and payment mechanisms in general has been increased convenience for the customer. There are other potential benefits to both the transit rider and the agency. The potential benefits to the customer of EFT-type purchasing arrangements—as well as multiple use systems in general—include a reduction in the need to carry cash and increased access to the fare media (e.g., through ATMs). The key potential drawback for the rider is concern over privacy (i.e., because of the ability to track individual card uses).

The potential benefits to the transit agency include improved revenue security (through a reduction in cash in the system and improved audit trails); reductions in the cost of cash handling; and faster access to revenue. The present cash deposit systems are very slow in allowing access to revenue; automated systems allow much quicker access (reductions by a factor of 10 in some cases); however, the extent of reductions is in the hands of the banks and clearinghouses. The major drawback for the transit agency is the loss of direct control over the payment system. If payments are made through the banking system, the agency may have to pay transaction fees, as well as management assistance and auditing. The net benefit of EFT use for purchase of fare media will therefore depend on the procedures adopted by the banks themselves.

Settlement and Processing in an Open Payment System

A key element of an EFT-type arrangement—or any open fare payment system for that matter—is the back-end settlement and processing system. This system consists of the infrastructure and mechanics for tracking the sale and use of cards, along with the associated audit and security requirements. The settlement system used in financial industry payments, though similar in concept to the basic transit system, is more complex, tends to be more automated, and operates in an open environment in which there are interfaces with a wide range of machinery and institutions.

The financial infrastructure (i.e., users, equipment, standards, rules and regulations, and network facilities) is already in place in the United States. The core of this infrastructure is the Automated Clearing House (ACH) System linking U.S. banks. The ACH is essentially a facility that provides a set of processes, operations, and systems for the electronic exchange of financial transactions. Funds for payables and receivables between banks authorized to use the ACH system are transmitted through regional automated clearinghouses administered by the National Automated Clearing House Association (NACHA). Each clearinghouse, in turn, directs the funds to the appropriate regional Federal Reserve Bank for settlement. All banks belong the Federal Reserve; however, a bank must apply for participation in the ACH and to be able to initiate an ACH transaction. Those participating in the ACH must maintain an account with the clearinghouse either directly or indirectly through another financial institution (called a correspondent bank). Regulations applying to the ACH and the settlement process in general are discussed below.

In a closed system, setting the processing procedures generally involves several in-house departments (e.g., revenue accounting, management information systems, operations, and finance), and it is necessary to ensure that their needs and requirements are met. This can be more of an administrative than a technical challenge. On the other hand, in an open system with a number of decision-making bodies—and opportunities for system malfunctioning—establishing this network is a more significant concern, both administratively and technically.

The key participants in the network will be as follows:

- Card issuer—The issuer will manage the pool of cardholder prepaid funds and any certification keys for security. It will also authorize the transaction collection center to initiate a debit entry against its bank account as cards are used to pay for trips or other services. The card issuer may be the transit agency (as in current transit applications) or a bank, telephone company, or retailer, for example. The cards may be issued on demand at local service centers or retail outlets, through mail delivery (as is used for credit cards), or through interactive terminals (such as ATMs) at various convenient locations.
- Network manager—The manager will establish the controls and protocols for the electronic movement of financial transactions in the network and certify or supply the card terminal hardware and firmware programs (including security modules where necessary). In many cases the network manager will control the transaction collection center and may also undertake the functions of the card issuer. In most current financial transactions, the services of the network manager are charged back to the service provider on a per-fee transaction basis.
- Service provider—As the name implies, the service provider provides the trips, or other products, purchased by the consumer using the card. It will authorize the transaction collection center to initiate a credit entry to its bank account for goods or services paid for by a consumer using the card.
- Transaction collection center (TCC) or system—As well as collecting the credit and debit transactions from the authorized terminals or service provider systems, the center will initiate credits to the service providers, and debits to the card issuer, resulting from the card payment activities. The TCC will also serve as the originator for ACH transfers. A critical issue that will have to be resolved is whether or not each transaction will be cleared individually as well as at a more aggregate level. Individual clearing increases the cost of the system, but it allows the operators to determine the redemption value left on the cards in circulation, as well as helping to detect possible double transactions—as a result of equipment malfunction or fraud—and in general helps in the detection of all fraudulent card activity.

In setting up its procedures and structures for the new MetroCard, and for distribution through a network of Manhattan retailers, NYMTA identified a range of requirements for the remote terminals that the ticket agents will have; these include a minimal footprint, flexibility to handle all types of payment media, reliability, free availability to the agent (including the telecommunications requirements), user-friendly systems, security, and compatibility with existing terminals (e.g., PCs). These are requirements that transit agencies may not be aware of or sympathetic to, having in most cases been in charge of their own fare issuing equipment and decisions in the past. Transit agencies also, with a few exceptions, have not had to develop working relationships with private retail firms for ticket issue. Hence, the agencies will need to identify and introduce the necessary new internal structures to address these issues.

User confidence is a key aspect of all monetary transactions. The extremely high level of accuracy and financial control of the various payment services and banking systems available today has been a key feature in their acceptance and success. Hence, producing a secure settlement mechanism in a more widely used card system, one which includes transit services, will be a key ingredient to ensuring the reductions in service provision costs that are expected to result from these new services. It is also critical, of course, that the settlement system disburse revenue to the service providers (or retailers) in a timely fashion.

High levels of accountability are crucial to the acceptance of multiple use programs for a wide range of uses (e.g., retail, social services, government regulation, and transit). In the systems presently being considered, the source data for transaction processing will be held on the card, not in a central database; hence, security will require controls and protection being in place at each point of capture, processing, or transfer of transaction data. The security and privacy of an automated system is viewed as crucial by many consumers, and the banking system has been, in most cases, very sensitive to this issue.

Transit agencies, on the other hand, have had to pay little attention to the need for customer privacy to date. In part, this is because, with the exception of those who purchase period passes, the agency has not maintained any information about the user of a specific card. Depending on the technology adopted, however, the situation will be significantly altered. In fact, it is likely that the agency will want to make use of the newly available information on individual riders to improve its service—presumably to the benefit of the cardholder. For example, transit service could be extended in a particular geographic area if it is found that there is a large number of regular users in that area. However, because of the potential to use card-specific information as a revenue-generating source by the agency (e.g., through the sale of cardholder lists), privacy issues become important. It may well be that the extension of the open environment, in which the new payment mechanisms are used, will encourage the federal government to become involved in setting privacy standards.

Because most multiple use—and particularly smart card-based electronic purse—applications being developed or considered would require information to be passed between agencies and possibly financial institutions, it will be difficult to combine access to the system with the control of that access. A prepaid electronic purse application using smart cards will require the following types of elements to maximize security in these applications:

- A hardware/software security module, provided by the Network Manager and installed in card terminals, service provider systems (if transactions are passing through the systems), and the TCC or system and
- The Data Encryption Standard (DES) algorithm and public or private keys. These keys would probably be encoded on the card and downloaded by the card issuer to the security modules distributed by the Network Manager. These devices would be used to authorize network users and authenticate the card, card terminal, and host computer as card transactions move around the payment network. They would also ensure that the card transaction data are securely encrypted as the data move around the network, to prevent unauthorized modifications, deletions, or additions.

Regulations Governing Electronic Payment

Regulations Governing EFT

Certain banking standards and regulations must be met in establishing EFT as a method of payment. The standards on which ACH operates are based on Federal Reserve regulations and NACHA Operating Rules and Guidelines, published on a yearly basis. NACHA Operating Rules cover a full range of topics, including the following:

- Return, adjustment, and correction of entries and entry information;
- Settlement and accountability;
- Recall, stop payment, recredit, and adjustment;
- Compensation rules;
- Arbitration procedures;
- Obligations and functional responsibilities of all entities participating in the ACH system;
- Technical specifications of the ACH file exchange and record format; and
- Audit requirements.

The key Federal Reserve regulations affecting ACH (contained in the Consumer Credits Protection Act) are: Regulation E, which provides consumers protection in disputes arising from EFT transactions; and, to a lesser extent, Regulation J, which establishes procedures for the interbank system of collecting checks and wire transfers, settling balances, and transferring funds in the Federal Reserve System. Regulation E defines EFT as "... any transfer of funds, other than a transaction originated by check, draft, or similar paper instrument, which is initiated through an electronic terminal, telephonic instrument, or computer or magnetic tape so as to order, instruct or authorize a financial institution to debit or credit an account. Such term includes, but is not limited to, point of sale transfers, automated teller machine transactions, direct deposits or withdrawal of funds, and transfers initiated by telephone." Thus, transit EFT transactions through a AVM would fall under this regulation.

Regulations Governing Prepaid Cards

Unlike that concerning on-line credit and debit transactions, federal government legislation covering prepaid cards has not yet been formulated. This leaves a number of questions open, including the handling of card theft or loss, of refunds on unused stored value, and of card or terminal failures. Closely related to the question of establishing new effective regulations is defining the role of the Federal Reserve, particularly in protecting consumers and licensing card issuers. Japan, as the largest user of prepaid cards, may serve as a model in this area. For example, in 1990, the Japanese government established, in the Prepaid Application Legislation that, among other requirements, the following would be necessary:

- Prepaid card issuers must register with the Ministry of Finance when the accumulated unused value (of the pool) exceeds US$69,000. In practice, issuers have to lodge a guarantee or deposit of 50 percent of the unused value at the end of every March and September.
- Organizations issuing prepaid cards to their employees must advise the Ministry of Finance when the accumulated unused value exceeds US$48,000.
- Prepaid cards should be so marked to reflect that they comply with the legislation.

At the same time, a Prepaid Card Association was formed to review system integrity and to ensure adequate protection of consumers.

In the United States, there are already some financial directives, including the Financial Managers Financial Integrity Act, and Government Accounting Office audits that are relevant to this field. It may be that until there are significant losses in the industry or until consumer and manufacturing groups are expressing their displeasure strongly enough, strict regulations of the security and technical aspects of these systems will not be finalized. It is, however, crucial that, as a transit agency considers the adoption of new technology, it also seeks contractual provisions that reduce its exposure to losses if federal regulations on prepaid cards do change.