TRANSIT STRATEGIES
FARE PAYMENT AND COLLECTION TECHNOLOGIES

The fare collection system used by Nashville MTA is currently based on magnetic technology, which is still common throughout the transit industry and is generally considered to be a reliable and low-cost method of fare collection. However, magnetic systems become more unreliable over time due to the wear and tear caused by the required contact between the fare media and fare equipment. This can result in delays, as an operator stops to help a passenger deal with a card that is not reading, and loss of revenue when it is not possible to collect a fare due to malfunction.

MAGNETIC TECHNOLOGY USED BY NASHVILLE MTA FOR FARE CARDS AND FAREBOXES

There are now a growing number of options for transit fare collection that have emerged over the past decade. Today, advancements in mobile phone technology, banking, and payment systems have made methods for paying a fare more numerous than they have ever been before.

Allowing more choices for purchasing and paying fares can attract riders (especially younger people who are more accustomed to innovative payment options for other goods and services) and can reduce dwell times and, therefore, speed up service. Adding new payment options can be appropriate when fare equipment needs to be replaced or when an opportunity is presented for new partnerships with retail establishments, institutions, other transit agencies, or vendors like mobile payment providers.

TECHNOLOGY'S ROLE IN FARE ALTERNATIVES

While technology has changed rapidly, new approaches to fare payment should follow and support the fare policies and products of a transit agency. The technology options described in this strategy paper introduce options for collecting fares. Implementation of new approaches must have the following considerations:

- **Operations:** How will the new technology impact dwell time, driver enforcement, and fare evasion?
- **Planning:** Are there new opportunities for ridership and revenue data as a result of the technology?
- **Distribution:** How will the fare media be distributed? What are the options for fare card outlets, ticket vending machines, online portals, etc?
- **Maintenance:** What is the cost to maintain fareboxes and supportive networks?
- **Costs/Revenues:** What is the cost of fare collection? Are there opportunities to increase revenue?
- **Customer Experience:** What's the quality of the customer experience in terms of ease of payment, convenience, and customer support?

FARE COLLECTION TECHNOLOGY

The following section surveys fare collection technologies that are in use at select transit agencies along with the trade-0ffs associated with each technology.

MAGNETIC STRIPE MEDIA

Nashville MTA uses fareboxes that read and dispense magnetic stripe media (in addition to accepting cash) and has several magnetic fare products including time-period passes (good for unlimited rides within the period), 20-ride products, and change cards. Some of these products require the farebox only to read the media, while others require the farebox to both read and encode media. Based on recent discussions with operators, fareboxes are more prone to malfunction when accepting any fare product that requires reading and encoding, such as 20-Ride products.

Experience from LA Metro indicated that magnetic stripes have a much higher failure rate than "contactless" smartcards—200 times per day compared to 6.7 for smartcards. The publicly known failure rate of magnetic stripe cards has opened the door for fare evasion for passengers who claim that a card is malfunctioning when it is actually out of value. In addition, magnetic stripes on farecards are susceptible to demagnetization or damage if exposed to the elements.

Despite these drawbacks, magnetic media also carry many advantages. Since they are printed on paper, they are easy to manufacture and can be pre-printed and distributed to vendors or partner agencies without requiring special card-encoding equipment at the vendor sites. Magnetic stripe media can also be dispensed easily at the farebox.

BENEFITS AND DRAWBACKS OF MAGNETIC STRIPE TECHNOLOGY

Benefits	Drawbacks
- Collection of basic fare data - Reduces operator interactions/fare enforcement - Reduces cash in system - Accommodates cash (stored value), passes, and transfers (cannot necessarily do all at once on the same card) - Can be purchased pre-loaded (encoded)	- Fare media can be damaged/deactivated - Limited uses of fare media (cannot combine passes and stored value on same card) - Reloading can only occur at designated locations (cannot be done automatically)

SMARTCARDS

Electronic contactless smartcards—a more durable, hard plastic card—have become common at many transit agencies. For customers, smartcards have advantages over magnetic cards, but successful implementation can be challenging. The most significant customer advantage of smartcards compared to magnetic cards is their durability; they can last for several years without replacement. Smartcards can be reloaded with stored cash value or passes and offer the opportunity to provide balance protection,[1] increasing security. In addition, the use of smartcards allows more flexible pricing options since transfer costs can be automatically calculated.

SMARTCARD IN ATLANTA

From an operational perspective, payment with smartcards is faster than both magnetic stripe payment and cash payment. In addition, since the validation and encoding of a smartcard do not require any mechanical action at the farebox, smartcard systems are frequently more reliable (fewer breakdowns) compared with magnetic stripe fare collection systems.

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[1] If a smartcard is lost, a customer's cash balance or pass is not lost. That value or pass can be migrated to a new replacement smartcard.

Despite these benefits, smartcards also present challenges. One significant challenge is the need for elaborate back-end systems to manage accounts and balances. For example, smartcards typically do not come "pre-loaded" and must have value added to them. As a result, smartcards require a network of opportunities to load smartcards including in-person, online, and telephone options. In-person reloading could occur at a fixed-location (such as Music City Central), an automatic fare reloading station (ticket vending machine), or even at the farebox. Each location requires special hardware to read the smartcard and real-time communications to ensure that the customer's account can be updated with new balance information. The use of smartcards also necessitates capabilities for potential retail vendors to be able to add value or new fare products to cards.

Although there are challenges, there may be opportunities for limited rollout of smartcards for specific markets such as universities or major employers. In these scenarios, university students, staff, or faculty may be able to use their existing university identification cards as a fare payment device. Similarly, if an employer pass program is created, special cards could be developed that can be administered through employer staff.

FIGURE BENEFITS AND DRAWBACKS OF SMARTCARDS

Benefits	Drawbacks
▪ Enhanced data collection capabilities ▪ User features like "autoload" and "balance protection" ▪ Loading value online or over the telephone ▪ Lower on-board transaction times (reduced dwell times) ▪ Permanence of cards (single card can be used for months)	▪ Higher cost of implementation (back-end systems, value-loading terminals, new equipment, need for on-board vehicle communications equipment) ▪ Greater range of fare options may lead to greater levels of confusion for customers and complexity for agency staff

SMARTPHONE PAYMENT

Smartphone payment offers an increase in customer convenience over paper or smartcard payment as well as potential operational savings. Smartphone payments eliminate the need for customers to buy and carry a separate card, may reduce delay in fare payment by reducing the use of cash, and may lower maintenance costs by reducing the volume of passes that must be processed. Unlike other fare technology options, smartphone payments require a person to have a linked credit card or banking account, which means that smartphone payment is not an option for customers who rely on cash. Smartphone payment options can serve as a supplement to an existing fare collection system until smartphone ownership is standard. In bus environments, smartphone payments can be accepted in one of three ways, described below.

**SMARTPHONE FARE PAYMENT ON DC METRO**

Flash Pass

The simplest implementation of smartphone payment is to allow riders to use their phone as a "flash pass" that is validated by the bus operator when they board the bus. This strategy does not require any additional hardware to be installed and can be implemented with few hurdles. The primary drawback is that this method requires additional attention of the operator to visually validate fare media. TriMet in Portland has launched a mobile payment app that uses this system (similar to the flashing of paper passes/tickets). As part of their fare products, transfer media have been eliminated and all cash one-way payments ($2.50) provide a "2.5 hour" ticket upon fare payment, which can be used for transfers during that time window.

Barcode/Optical Scanners

A smartphone's large screen provides an opportunity to use barcodes or QR codes to validate fare payment. This approach requires the farebox to use a barcode scanning device (similar to a grocery store checkout counter or an airport scanner reading a boarding pass) to read a smartphone's screen. Barcode readers can read barcodes beyond

those on smartphones, including those issued by ticket machines or barcodes printed at home. A fare system using 2-D barcodes can allow both print and mobile payment validation. Optical barcodes also can be scanned by mobile devices for enforcement, and systems can be put in place to update valid barcodes regularly. Currently, Nassau Inter-County Express (NICE) is using in-vehicle optical scanners to validate payments via mobile phone.

TRIMET FLASH PASS (PORTLAND, OR)
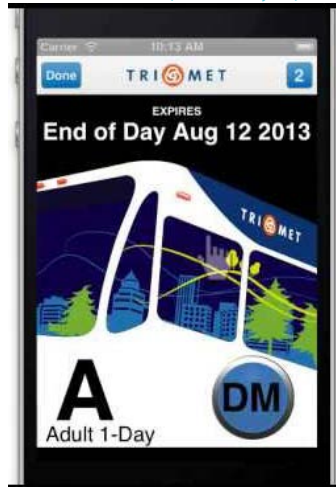
NICE IN-VEHICLE BARCODE SCANNER (LONG ISLAND, NY)

Proximity Validation

Using a smartphone as a farecard in the U.S. is very rare due to a variety of factors. The Utah Transportation Authority in Salt Lake City is one of the country's leaders in fare technology and just began to accept Apple Pay and Google Wallet in late 2014. Chicago Transit Authority also accepts Apple Pay as of 2015. For many years, different technologies created by smartphone manufacturers have not produced a clear solution that could be included as part of universal fare collection equipment. As a result, many agencies have opted to use simpler ways of validating mobile phone-based fare payment in the interim. Future technologies that support proximity validation include Near-Field Communication (NFC) and Bluetooth Low Energy (BLE).

BENEFITS AND DRAWBACKS OF SMARTPHONE-ENABLED FARE PAYMENT

Benefits	Drawbacks
▪ Fare products can be accessed through one's smartphone; there is no need for separate fare distribution outlets ▪ Various means to validate media (visual, scan, proximity) ▪ Customers can purchase fare products at any time and at any location	▪ Visual validation of fare products could add dwell time; however, some studies suggest that flash passes may be faster than processing individual magnetic cards or smartcards ▪ Access issue for those who do not have a smartphone with data plan or a linked credit card/bank account ▪ Need to supplement existing fare payment options (smartcard or magnetic stripe)

OFF-BOARD FARE PAYMENT

In addition to the specific technology used for fare collection, another important consideration is whether to move payment off of the vehicle and have fare payment take place at machines in bus stops or stations. Off-board payment can significantly reduce dwell times and speed service. Typically, riders are allowed to board through all doors of the vehicle, which also helps to better distribute passengers within the vehicle. Fare enforcement is conducted either at stations or on board the vehicle. Fare enforcers ask for "proof-of-payment" from customers, which can be inspected visually or by use of equipment that reads smartcards, barcodes, etc. Fare enforcement officials are increasingly using smartphone-based equipment for their work.

OFF-BOARD FARE PAYMENT IN MANHATTAN

CONNECTED VEHICLES

Another capability that can be very powerful is to have vehicles that are online all the time. In combination with account-based fare systems (discussed below), this real-time communication allows customers to purchase and pay fares through various channels with instantaneous updating of their account balance. Having connected vehicles can facilitate more partnerships with retail vendors and better online account management, since customer payments are immediately available for use on the vehicle. These improved options can speed up transit service by reducing onboard cash transactions and/or card refills.

Connected vehicles can also be used for real-time communications by other onboard systems, including video surveillance, passenger counting, and maintenance sensors. Typically, the vehicles communicate through the cellular network. There are both upfront capital costs and ongoing charges for access to the cell network, but the benefits can make these costs worthwhile. Besides the customer service advantages, the collection and transmission of real-time data can improve transit planning and operations.

FARE PURCHASE FEATURES AND OPTIONS

Technology has also allowed many new alternatives for purchasing fares, which can be much more convenient for transit customers. Much of this is related to the choice of fare payment technologies, but purchasing of fares also has its own features and options.

ACCOUNT-BASED SYSTEM

In an account-based system, the customer's account balance is not stored on the fare media itself but in a back-office account. This is a prerequisite for some other features listed below, including regional fare payment processing, full online account management, auto-loading, open payments, and many innovative fare options.

OPEN PAYMENT ACCEPTANCE

Most U.S. transit systems still require payment through fare media issued by the transit agency (usually tickets or cards).

VENTRA READERS IN CHICAGO ACCEPT CONTACTLESS CREDIT CARDS

However, in addition to the rise in smartphone payments, there has been interest in allowing direct payment by credit card. Some pilot programs have been conducted, and the Chicago Transit Authority (CTA) now allows credit card payment for contactless cards only. The main advantage is that customers do not have to carry a separate form of transit payment and can simply use a card or phone that they already carry. These "open payment" systems can also facilitate partnership programs between transit agencies and other merchants.

TICKET VENDING MACHINES

Vending machines are commonly used to provide another means of purchasing fares. They are most often placed on the transit agency's property, such as at transfer centers. However, many agencies have agreements to place ticket vending machines on other public property, including sidewalks. Some vending machines are found in private institutions, especially stadiums, museums, or other places with many visitors. The machines require power and communications as well as some weather protection, but nevertheless can be installed in diverse environments.

RETAIL PARTNERS

Many cities have retailers that sell transit agency fare products. Sometimes the retailer receives a commission, although many merchants are willing to participate for reduced commissions since transit customers can bring new walk-up business. Typically, these retail partners already handle cash and have longer hours and can include check cashers, grocery stores, and pharmacies. In New Orleans, Walgreen's drug stores sell transit passes; in Seattle, Safeway grocery stores offer the opportunity for people to reload their smartcards. It may be appropriate to negotiate an agreement with a chain of stores, so that customers know they can always visit one of many locations with the same brand for their fare purchases. As mentioned above, having an account-based system and connected vehicles can enhance the value of retail partners, since payments will be instantaneously available for use on any vehicle.

ONLINE ACCOUNT MANAGEMENT

Allowing customers to make payments online, register their accounts for balance protection, review their account and usage history, and print their own transaction receipts are some of the features that transit riders appreciate. These features can attract new riders, since they alleviate the need for many transactions during the transit journey and also make reimbursement of business expenses easier. Many existing and potential transit riders are accustomed to managing their accounts online for other goods and services.

REGIONAL FARE PROCESSING

THE GOPASS CAN BE USED AT FOUR TRANSIT AGENCIES IN THE DALLAS-FORT WORTH AREA

With the growth of population and employment in Middle Tennessee, Nashville MTA and RTA should consider regional fare processing that allows people to seamlessly use the services of both agencies. The details could vary, but either stored value account balances or unlimited-ride passes could be shared with Nashville MTA, RTA, Clarksville Transit System, and others. Back-office processing would allow allocation of revenues and expenses as appropriate. The regional fare system is being used in many areas around the country—including the Dallas-Fort Worth Metroplex and the Puget Sound region—and can reduce barriers to transit ridership by making travel more integrated and seamless.

AUTO-LOADING

An account-based system also enables the possibility of auto-loading. Customers can automatically renew their time-based passes or automatically refill their stored-value account balance. This requires a person to link the transit account to a credit or debit card, but many people appreciate the convenience. Auto-loading often reduces onboard transactions, and therefore improves service as well.

INSTITUTIONAL PARTNERS

Institutional partnerships can take many forms. For groups of employees or students, an institution may be willing to purchase discounted transit access for everyone for any number of reasons, such as to reduce parking demand. Alternatively, an agreement could be based on actual usage, with time-based passes, stored value accounts, or some combination of both. User groups include:

- **Frequent users,** who are usually employees or students; they might use a card that they already carry for access to buildings and identification, or the transit agency might issue fare media through an administrator at the employer/university
- **Occasional users** include special events, visitors, and the like; prepaid disposable tickets can be issued through an event coordinator

Arrangements such as these can encourage transit use, provide advertising/branding opportunities, and reduce onboard transactions.

# EXAMPLES OF FARE PAYMENT AND COLLECTION TECHNOLOGIES

BOSTON, MA

In 2007, the Massachusetts Bay Transportation Authority (MBTA) converted the fare collection on subway and bus from a system based on tokens and magnetic-stripe passes to one where most payments are made via smartcard. The CharlieCard can simultaneously store both time-based passes and a stored-value account balance. However, it is not an account-based system; this information is encoded on the card itself. Many other regional transportation authorities in Massachusetts have also installed the infrastructure to accept CharlieCards, which allows customers to use their stored-value account balance (but not their time-based passes) on multiple transit providers in the region. For commuter rail services in Boston, smartphone payment is available as well. The MBTA also has a widespread network of ticket vending machines located at subway stations, some bus hubs, and within some large venues such as Fenway Park. There are dozens of retail outlets in the Boston area which sell MBTA fare products.

MBTA'S CHARLIECARD IS ACCEPTED BY REGIONAL PROVIDERS AS WELL

SMARTPHONE PAYMENT ON COMMUTER RAIL
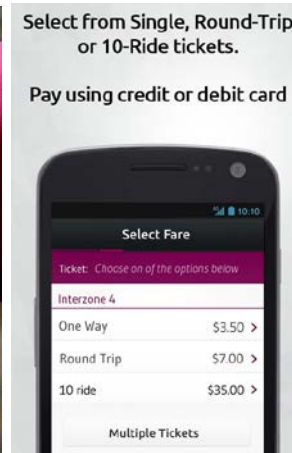
DALLAS AND FORT WORTH, TX

Three transit agencies in the Dallas/Fort Worth area accept the GoPass, which can only be purchased through smartphones. The GoPass can be used for most types of fares and passes in the region. Although fares and passes are also available on tickets—and some of each agency's passes are accepted at other agencies through visual inspection— the use of the smartphone platform for the GoPass eliminated the need to automate any coordination between the various providers' fare collection systems that had proprietary technologies. A vendor handles the back-office processing of transactions to enable appropriate cost and revenue sharing. The agencies include:

- Dallas Area Rapid Transit (DART), operates commuter rail, light rail, and bus
- Fort Worth Transportation Authority (The T), operates commuter rail and bus
- Denton County Transportation Authority (DCTA), operates bus and one rail line

GOPASS ADVERTISING BY DART

CHICAGO, IL

The Ventra fare payment system in Chicago is the first open payment system in the U.S. Transit riders can pay with the Ventra smartcard designed for transit use, or they can use their own credit or debit card if it is "contactless." While contactless cards are still relatively rare in the U.S., they are expected to become much more common. Smartphone payments are also allowed if the device is compatible (currently only Apple Pay). The Ventra system includes Chicago Transit Authority trains and buses as well as Pace Suburban Bus.

Not only can outside credit/debit cards be used for transit payment, but the Ventra card can be used as a credit/debit card at other merchants. This may lead to promotional opportunities for the transit agencies as well as partnerships with retailers. Although Ventra had significant glitches during its 2013-2014 rollout, it now appears to be working smoothly. Metra, the commuter rail provider in the area, is now planning for how it might accept Ventra.

VENTRA CARDS CAN ALSO WORK AS CREDIT/DEBIT CARDS AT RETAIL ESTABLISHMENTS
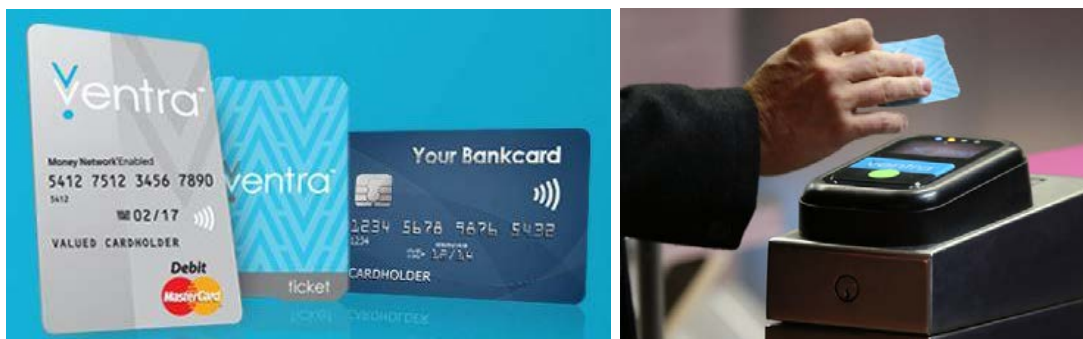
FARE TECHNOLOGY OPPORTUNITIES FOR NASHVILLE MTA AND RTA

Planning and designing new fare collection systems takes many years. While the current fareboxes used by Nashville MTA are generally in good repair, the time is right for thinking about the next generation of fare payment. Nashville MTA and RTA should consider the opportunity for smartphone payment options, as these can allow more regional cooperation, greater convenience in purchase and payment, and flexibility to adapt to change. Potential elements for Nashville MTA's and RTA's future fare technology include:

- Joint fares with Nashville MTA and RTA, since many people use both systems
- Much greater availability for purchasing fares and passes; even with smartphone payment as an option, there will be a need for other alternatives, including online payment, retail outlets, and vending machines
- An account-based system, which allows many of the other features and benefits since information is not stored on the fare media; this includes full online account management and auto-loading
- Connected vehicles, which allow many onboard systems to communicate in real time, including the fare system
- More off-board payment, especially for high-ridership and premium services, such as BRT lite; even if off-board payment is not used on all services, high-ridership services can become significantly faster and more reliable with payment moved off-board
- More institutional partnerships to encourage transit use and attract ridership, especially for larger groups of employees, students, and visitors

It is unclear at this time whether agency-issued smartcards will continue to be needed or whether smartphones and open payment will eventually allow these to be phased out. Initial planning should allow for a smartcard option, and a further assessment of the technology and payment marketplace can take place before final design and implementation.