Preliminary Strategic Analysis of Next Generation Fare Payment Systems for Public Transportation

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TCRP REPORT 177

Preliminary Strategic Analysis of Next Generation Fare Payment Systems for Public Transportation

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TRANSPORTATION RESEARCH BOARD

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TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213—Research for Public Transit: New Directions,* published in 1987 and based on a study sponsored by the Urban Mass Transportation Administration—now the Federal Transit Administration (FTA). A report by the American Public Transportation Association (APTA), Transportation 2000, also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA, the National Academies, acting through the Transportation Research Board (TRB); and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at any time. It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products.

Once selected, each project is assigned to an expert panel, appointed by the Transportation Research Board. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended end users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

The TCRP provides a forum where transit agencies can cooperatively address common operational problems. The TCRP results support and complement other ongoing transit research and training programs.

NOTICE

The project that is the subject of this report was a part of the Transit Cooperative Research Program, conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council.

The members of the technical panel selected to monitor this project and to review this report were chosen for their special competencies and with regard for appropriate balance. The report was reviewed by the technical panel and accepted for publication according to procedures established and overseen by the Transportation Research Board and approved by the Governing Board of the National Research Council.

The opinions and conclusions expressed or implied in this report are those of the researchers who performed the research and are not necessarily those of the Transportation Research Board, the National Research Council, or the program sponsors.

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F O R E W O R D

By Dianne S. Schwager
Staff Officer
Transportation Research Board

TCRP Report 177: Preliminary Strategic Analysis of Next Generation Fare Payment Systems for Public Transportation addresses how next generation transit fare payment (NGFP) systems can be designed to improve the customer experience, streamline transit system operation, and integrate transit more effectively within the broader context of mobility management. With their legacy fare collection systems approaching the end of their useful life and emerging technologies expanding fare payment options, many transit agencies are seeking information and solutions for NGFP systems. The report will assist transit agencies and other practitioners involved in decision-making related to NGFP systems.

Fare payment technologies for public transit have evolved from paper tickets and tokens to magnetic stripe cards, smart cards, and mobile devices. These NGFP systems can include payment media issued by both the transit agency as well as organizations outside the transit agency. A major innovation is the movement toward non-proprietary payment systems, meaning systems that use open interfaces and standardized devices.

TCRP Project J-06/Task 83 was conducted by the Volpe National Transportation Systems Center, U.S. Department of Transportation to provide a targeted, state of the practice review of emerging fare payments options for public transportation; develop a typology of available and anticipated options for NGFP that can serve a broad range of transit agencies and stakeholders in the United States; and evaluate the pros and cons (opportunities and barriers) of the options presented in the typology. This report was developed through a targeted literature review and interviews with professionals involved in the public transit fare payment industry, including public transit agencies, private sector vendors, consultants, and experts from the transportation, financial, and mobile payments industries.

This research presents four sets of design attributes in transit fare payment system design: (1) single versus multiagency operating environments; (2) proprietary fare payment systems versus standards-based systems that comply with the data and technology specifications used by the financial payments industry for contactless bankcards; (3) card versus account-based fare payment systems; and (4) closed fare payment systems versus open loop systems. The report then evaluates the relative capabilities of different NGFP system design and technology approaches, and concludes with a discussion of implementation strategies and best practices.

The report concludes with an evaluation of the relative capabilities of NGFP systems and a discussion of implementation strategies and best practices.

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Introduction and Research Approach

Background

The design and operation of transit fare payment systems continually evolve, as new technologies and practices emerge and gain widespread acceptance by riders and operators. Recent advances in the payments industry, as well as emerging technologies such as smart bankcards and mobile devices, are creating opportunities for the development of the next generation of public transit fare payment systems.

Next generation transit fare payment systems promise to yield a number of valuable benefits to riders and transit agencies, which can improve the customer experience, streamline transit system operation, and integrate transit more effectively within the broader context of mobility management.

This report is intended to assist transit agencies and other practitioners with decision-making related to next generation transit fare payment systems. It provides an overview of transit fare payment system design and technology, and delineates a typology of design approaches in use and under development. The report describes the attributes of next generation transit fare payment systems, and how those attributes can be configured to provide varying levels of functionality and flexibility. The report also identifies how changes in technology and practice can be leveraged to create transit fare payment systems that are more capable and adaptable to future changes and developments.

Finally, the report describes different strategies and approaches for next generation transit fare payment for public transportation to account for the variety of transit agencies and circumstances within the transit community. This will address accounting for legacy fare systems, managing capital costs, and other strategic and practical considerations.[1]

Research Approach

This report is developed through a targeted literature review and interviews with professionals involved in the public transit fare payment industry, including public transit agencies, private sector vendors, consultants and experts from the transportation, financial, and mobile payments industries.

The literature review provides a background into the history of public transit fare payment systems and emerging trends and issues. The evolution of transit fare payment media is examined using resources that provide benchmark information such as the following TCRP Reports:

- *TCRP Report 10: Fare Policies, Structures, and Technologies*;
- *TCRP Report 32: Multipurpose Transit Payment Media*;

- *TCRP Report 94: Fare Policies, Structures, and Technologies: Update*; and,
- *TCRP Report 115: Smartcard Interoperability Issues for the Transit Industry.*

Information on transit payment system research initiatives is captured through peer-review publications such as TRB and academic papers and studies. Emerging trends and current transit industry issues are established through reports and white papers produced by professional associations, such as the Smart Card Alliance, as well as by professionals in the field. Finally, the self-defined needs of transit agencies large and small are identified using Requests for Proposals (RFPs) recently published by transit agencies such as the Washington Metropolitan Area Transportation Authority (WMATA) in Washington, DC and the Whatcom Transportation Authority (WTA) in Bellingham, Washington. This literature review provides a technical background, identifying how transit payment has changed, what new technologies are being incorporated, and the needs of transit agencies and their approaches to the next generation of transit fare payment systems.

Targeted industry interviews are used to determine the technologies, business models, governance approaches, and fare media in deployment, under consideration, or currently being studied. Industries include Public Transit, Financial Payments, Smart Card, and Mobile Payments. Interviewees are selected to provide insight into transit payment systems from various perspectives, identifying the unique challenges and needs that distinguish transit agencies:

- Public Sector:
  - Larger transit agencies (regional/multi-region, single transit agency and multi-transit agency, multimodal)
  - Smaller transit agencies (single transit agency local authorities, mostly single-modal)
- Private Sector:
  - Transit fare payment equipment suppliers and system integrators
  - Financial payment institutions
  - Mobile payments and mobile ticketing suppliers
  - Consultants

This report focuses primarily on transit fare payment systems that employ contactless smart card technology, as well as emerging and forward leaning transit fare payment systems that have been implemented or are in implementation. Consequently, examination and study of conventional transit fare payment solutions such as cash and coin, tokens, and magnetic stripe technologies are not analyzed in the study. Subjects uncovered in literature study and in interviews with subject matter experts are examined in more depth. The primary focus of this project is the U.S. marketplace; due to resource constraints the information related to foreign transit agencies is limited.

Report Overview

The report is structured as follows:

- **Chapter 2: Planning for a Next Generation Transit Fare Payment System.** This chapter provides a broad overview of the planning and policy issues that a transit agency must consider when designing and implementing a new transit fare payment system.
- **Chapter 3: Design Attributes of Transit Fare Payment Systems.** This section describes the key features or approaches used in the design of current and forward leaning fare payment systems.
- **Chapter 4: Transit Fare Payment System Typologies.** This chapter presents a proposed framework or typology that configures fare payment system design attributes in different ways to create four functional fare payment systems.

- **Chapter 5: Transit Fare Payment System Technology.** This section provides an overview of the key technology elements found in fare payment systems.
- **Chapter 6: Emerging Payment Technologies and Payment Convergence.** This chapter presents an overview of new and inventive technologies used in fare payment systems, and describes how existing technology can be used in innovative ways for transit fare payments. It also introduces the concept of payment convergence, where multiple payment systems (e.g., transit and toll, or transit and parking) are integrated to create a unified travel payment process.
- **Chapter 7: Next Generation Transit Fare Payment System Case Studies.** This chapter presents case studies for three recent new transit fare payment system implementation projects. The first two studies discuss implementation of fare payment systems that accept open payments, while the third discusses a more conventional upgrade of magnetic stripe technology to a smartcard-based, proprietary closed fare payment system.
- **Chapter 8: Evaluating Public Transit Fare Payment System Typologies and Implementation Strategies.** The final chapter discusses the relative advantages of each transit fare payment system typology, and presents strategies and best practices for transit agencies to use in the acquisition and implementation of a new fare payment system.
- **Appendix A: Definition of Terms.** This appendix defines key terms used in this report; readers unfamiliar with recent developments in transit fare payment systems should familiarize themselves with the terms in the section.
- **Appendix B: Examples of Transit Agency Fare Payment System Goals.** This appendix offers examples of the goals and objectives established by five transit agencies in the design and implementation process for their new fare payment systems.

CHAPTER 2

Planning for a Next Generation Transit Fare Payment System

Chapter Overview

This chapter provides an overview of the policy and planning considerations involved in implementing a new transit fare payment system. It begins by offering a working definition of a "next generation transit fare payment system," that establishes a common starting point for the discussion of new and evolving transit fare payment systems described in this report. The chapter also identifies other elements of transit agency policy and practice that can influence the design and operation of a new transit fare payment system. These include: planning considerations; alignment of goals between the transit agency and its fare payment system; and the impact of fare media and fare policy.

Defining a Next Generation Transit Fare Payment System

The term "next generation public transit fare payment system" has not been universally defined by the transit community. It is an aspirational, self-defining phrase that might best be described as, *something better than what we have now.* The next generation transit fare payment system will take advantage of innovative technologies and new business and partnership opportunities. The choice of options, however, will be determined by the requirements of individual transit agencies, which may vary significantly.

In that context, a transit agency that accepts cash and tokens might consider a magnetic stripe card system as its "next generation." However, that approach ignores the advances in technology that have taken place since mag stripe cards were introduced 50 years ago; as technology continues to advance, today's "state-of-the-art" could be obsolete within ten years. As new technologies such as smart phones and mobile applications are introduced, new opportunities emerge to apply those technologies to public transit fare payment systems.

A next generation transit fare payment system must be able to accommodate today's technology while also looking beyond it. Such a transit fare payment system would have a high degree of flexibility and adaptability, so that it is better able to accommodate evolutions in technology. A next generation fare payment system must also be capable of supporting changes to the transit agency's operational or business processes.

In a transit fare payment system, what are those processes? In its simplest form, a rider boards a bus, pays the operator cash, and takes a journey. It involves a single transaction between the rider (the customer) and the transit operator (the merchant or service provider) to **pay for a fare** and to **collect the fare**. Cash serves as both payment medium and fare medium.

Over time, both riders and transit operators sought to move away from cash for cost reasons and customer convenience. So, an intermediate step was added to the process. The rider would

use a payment medium (e.g., cash, credit or debit card) to purchase a fare medium (i.e., a fare card). The passenger then used that fare medium to gain access to transit services.

Why not merge those two processes back into a single transaction, in which **the payment medium becomes the medium for fare collection**? This is the basis for the open payment system, in which payment media issued by other organizations (e.g., credit or debit cards or mobile applications, prepaid cards) are used to pay for or grant access to transit services.

Transit fare payment systems can be designed to ensure interoperability across modes, among components from different suppliers, and for compatibility with future technologies. Standards-based fare payment systems and account-based architectures can facilitate open payment systems, which expand opportunities for partnering and leveraging the investments of other industries. It is from these concepts that we derive a working definition of next generation transit fare payment system.

> Next generation transit fare payment system: A transit fare payment system that leverages technology to improve transit agency operations across the business enterprise, while increasing customer convenience and enhancing the customer experience.

Planning Considerations for New Transit Fare Payment Systems

The process of implementing a new transit fare payment system for public transit can range from the very simple to the most complex. At one end of the spectrum may be a small rural transit agency operating fewer than 50 buses, which seeks to replace its aging cash only farebox with modern technology. At the other end of the spectrum might be a regional transit authority that seeks to acquire a transit fare payment system that will provide seamless travel across several local transit systems using a variety of buses, subways, light rail vehicles, paratransit vans, and commuter trains.

While these two scenarios may be quite different in project scope and impact, each transit agency would follow a similar planning and evaluation process to design, select and implement their new transit fare payment systems. There are several transit-specific tools and planning models available through TCRP that describe the detailed planning necessary to ensure success. The planning steps vary, but typically include:

1. Comprehensive assessment of the current fare collection system. This should consider:
   a. The condition and remaining service life of existing fare collection components
   b. The costs of operating and maintaining current fare collection equipment
   c. The ability of existing fare collection systems to meet regional goals
   d. Funding availability for a new transit fare payment system
2. Establishing transit agency goals and objectives for a new transit fare payment system;
3. Understanding transit fare payment system design and technology;
4. Weighing those options against their transit agency goals and objectives;
5. Determining the most viable approach;
6. Acquiring and implementing the new transit fare payment system.

Each step itself can be quite involved, and require significant study and review. That review may involve riders and other stakeholders, such as regional transit authorities or funding transit agencies. There are also complex relationships between each step, which may require periodic reevaluation of system goals, changes in technology, or consideration of innovative funding

approaches. This report focuses on the third step, by describing the transit fare payment systems or typologies currently in use and identifying technologies available that support different typologies. However, since this report is intended as a guidebook for transit agency leaders, we will identify where decision points may influence each other, thereby impacting functionality or flexibility. These relationships will be explored in depth in subsequent chapters.

Align Fare Payment System Goals with Transit Agency Objectives

It is important that a transit agency have the fullest knowledge about their current transit fare payment system and a clear vision for the future in order to inform the decision-making process and guide transit fare payment system design. Transit fare payment system technologies vary in their ability to support operational requirements. Consequently, a transit agency must achieve consensus across its operating departments to align policy, operating and technology strategies.

Any transit agency considering a new transit fare payment system should include a review of their overall transit system, and identify the connections between strategic goals and transit fare payment system objectives, since there can be significant connections between transit fare payment system choices and the transit agency's strategic goals.[2] For example, while transit agencies may want to adopt the latest transit fare payment technologies and establish partnerships with outside organizations such as financial institutions, they must ensure their transit system is able to equitably serve all their riders, particularly riders with limited access to traditional financial services (see discussion box).

Discussion: Considering the Needs of Unbanked and Underbanked Riders

Title VI of the Civil Rights Act of 1964 (42 U.S.C. § 2000d) requires that a transit agency receiving federal funds cannot discriminate directly or indirectly against any subset of ridership. From a practical standpoint, a transit agency must be able to provide equivalent levels of mobility for equivalent fares, often to those riders most in need of the service—and with the least ability to pay. In the transit community, these riders are typically considered to come from "unbanked" or "underbanked" households.

In the 2011 National Survey of Unbanked and Underbanked Households, the Federal Deposit Insurance Corporation reported that "The highest unbanked and underbanked rates are found among non-Asian minorities, lower-income households, younger households, and unemployed households." From a transit fare payment system perspective, Title VI considerations come into play when considering the types of fare media and payment options available to unbanked or underbanked populations.

Since riders from unbanked or underbanked households are less likely to have their own credit or debit card, a transit agency can meet the needs of this ridership community by offering prepaid fare options, such as prepaid, reloadable fare cards; by accepting EBT (Electronic Benefit Transfer) cards; or other fare payment options that are compatible with their fare payment system's technology.

Source: Federal Deposit Insurance Corporation, "2011 National Survey of Unbanked and Underbanked Households," Sep 2012, p. 5.

As transit fare payment systems have become more capable, they have become an effective tool in helping a transit agency achieve its overall system goals. Four broad transit fare payment system goals can be identified which apply to transit agencies of all sizes and scopes.

- Improve customer experience
- Improve technical operations
- Improve financial processes
- Improve overall system operation

The goals for transit fare payment systems are listed in Table 2-1, along with associated characteristics and objectives often cited by transit agencies as reasons for implementing a new transit fare payment system. These four goals can serve as helpful metrics against which to assess different elements of transit fare payment system design. Appendix B provides four examples of transit fare payment system goals established by transit agencies currently involved in fare system upgrades.[3]

A transit agency should have a thorough knowledge of the recent trends within transit fare payment systems, including technology; best practices for system acquisition, implementation and operation. An informed understanding of their ridership base and customer preferences is also essential to design a system that meets the needs and expectations of riders.

Once the decision is made to develop a new transit fare payment system, transit operators need to consider three broad areas of system design, and assess the impact of their respective

Table 2-1. Transit fare payment system goals.

GOALS				Characteristics or Objectives For Transit Fare Payment Systems
Improve Customer Experience	Improve Technical Operations	Improve Financial Operations	Improve Overall System Operation	
✔			✔	Increased customer convenience: Ease of use
✔				Increased customer convenience: More fare media options
✔			✔	Achieve seamless travel across all modes of own system
✔			✔	Achieve seamless travel with partner transit agencies / regional travel
✔		✔		Increase fare options and pricing flexibility
✔	✔	✔	✔	Ensure smooth implementation of new fare payment system
✔	✔			Improve reliability of fare equipment
		✔	✔	Reduce fare collection costs
		✔	✔	Reduce fare abuse and evasion
		✔	✔	Reduce use of cash
		✔	✔	Increase prepayment
		✔		Improve revenue control / accountability
		✔	✔	Improve fare revenue allocation in a multi-operator system
			✔	Improve data collection and reporting capabilities
	✔	✔		Upgrade existing system with forward-capable technology
	✔		✔	Flexibility in hardware replacement and lifecycle renewal
✔	✔	✔	✔	Reduce system complexity
		✔		Get out of the payments and settlements business
			✔	Increase ridership
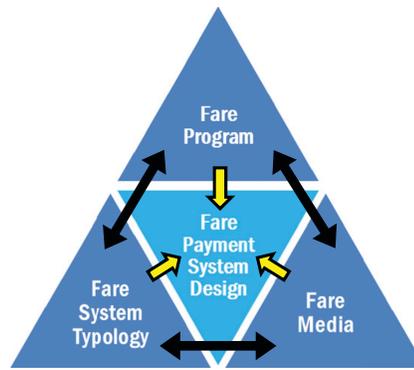
Figure 2-1.   Relationships of transit fare payment system design elements.

elements and attributes upon the new fare payment system's ability to meet the transit agency's goals. The three areas are:

- **Fare program:** This represents all aspects of fare structure, transfer policy, transit fare payment, fare control and fare collection.
- **Fare media:** The type or types of "ticket" that a transit agency will accept from its riders.
- **Fare system typology:** The classification of attributes that describes the technical design approach to the transit fare payment system. (These will be discussed in detail in Chapter 3 and Chapter 4.)

The relationships between fare program, fare media, and fare system typology are represented in Figure 2-1. As the diagram shows, a transit agency's action or decision—such as setting a particular objective for a fare program—can be driven by, or have an impact upon the other two elements. This report will identify those linkages, and describe where the most significant flexibilities or limitations exist.

Fare Program: Pricing, Payment, Control, and Collection

The first set of parameters in designing a transit fare payment system for public transit is the combination of policy and operational decisions that determine the cost of a particular fare, how the rider will pay that fare, and how that fare will be collected.

Fare Pricing Structure

Transit agencies operate under a wide, often complex variety of fare pricing structures. There can be flat fares or differential fares, reduced fares, and even free fares (see Table 2-2). This report does not address the merits of one fare structure over another. However, as will be discussed, certain transit fare payment system design choices can support a greater variety of fare structures or facilitate changes to an existing fare structure.

In practice, some transit agencies may have well over a dozen published fares. Transit agencies that use a zone or distance-based fare structure may have hundreds of individual fares that are based upon a complex station-to-station or zone-to-zone fare matrix. Some transit agencies may also offer discounts or impose a convenience fee or other surcharge upon a base fare according to the type of fare medium used.

Table 2-2.   Typical transit fare structures and fare programs.

Fare Type	Sample Fares
Flat Fare	Single trip Round-trip Multi-trip
Differential Fare	Distance-based (zone) Time based (peak, off-peak) Tap-On-Tap-Off
Period Pass	Weekly Monthly
Reduced fares	Seniors Students Special Needs / Disabled
Discounts, Surcharges or Penalties	On-board purchases Different fares for users of fare cards, tickets, tokens, or cash
Transfers	Transfer charge
Service premium	Express bus Commuter Rail
Bonuses	Bonus value added to fare card when reloading with more than a prescribed amount in new value (e.g., a $5.00 payment gets $5.25 in value)
Free fare	Designated zone Designated times
Subsidies	Employers, schools or universities cover full or partial cost of transit fare or pass.
Tax benefits	Transit subsidy programs that provide pretax benefits to employers or employees

Some choices in transit fare payment system design are better able to support certain aspects of fare policy. For example, some transit agencies and designers of transit fare payment systems report that changes in fare structure, such as implementing distance-based fares, will be easier to do with an account-based system than with a card-based system because the software modifications can be done relatively easily on the "back end" rather than with cards and card reading devices.[4]

Transfer Policy

Transit agencies operating more than one type or mode of service (e.g., bus and subway, subway and commuter rail, etc.) will also evaluate whether or not to include transfers between modes. Considerations include the number of transfers to allow a rider, the time frame for the transfers, and the fare allocation structure between modes. There is also a need to consider the compatibility of fare media and fare collection practices used by different modes of service.

On larger, regional transit networks that seek to provide seamless travel across multiple transit agencies, the transfer policy and fare medium compatibility are even more critical. Some transit agencies have noted that simplified fare structures should be an integral element of regional fare integration and new technology implementation efforts. This could reduce confusion among riders, simplify the software needed to manage fare computations, and potentially reduce the time to develop the system.[5]

> **Discussion: Stored-Value Fare Cards Explained**
>
> A stored-value card originally referred to a prepaid fare card that was programed or "loaded" with a specific dollar value that was then decremented with each use. As fare systems developed, the term took on a broader meaning to include prepaid fare options in which the "value" loaded onto the fare card may not be monetary.
>
> There are three forms of stored-value card in general use:
>
> - 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., daily, weekly, or monthly passes).
>
> Stored-value systems can be card based or account-based, and are able to support a variety of fare structures and payment options. They are also capable of simultaneously carrying both stored-value and pass options.
>
> Source: TCRP Report 10: Fare Policies, Structures, and Technologies, p.88

Transit Fare Payment Options

In addition to basic fare pricing structures, transit agencies must select the transit fare payment options that riders can use to access the transit system.[6] These options include:

- Prepayment: Rider purchases fare before boarding.
  - Single-ride
  - Multi-ride
  - Period pass
  - Stored value
- Post payment: Rider purchases fare upon alighting, or is billed on a regular cycle, e.g., through an employer program.

Fare Control and Collection

Fare control and collection also influence transit fare payment system design decisions. Some fare control and collection methodologies are more prevalent in some transit modes, so changes in transit fare payment or fare media must be considered across the transit system.

Fare control approaches include open (barrier-free), closed (barrier), and mixed systems, where fare control varies by mode or station. Within fare collection, there are generally four options:

- **Pay on Board:** the rider presents his/her fare medium when boarding the transit vehicle.
- **Barrier:** the rider pays at a turnstile, fare gate or other physical control point that allows the rider access onto a transit vehicle or into a transit station. (This also includes transit systems that collect fares upon exit, e.g., WMATA).
- **Conductor Validated:** the rider presents a ticket that is then punched, stamped, or otherwise marked as "used." (This also includes mobile electronic tickets that automatically "expire" in a set period of time, after being "activated" and presented to the conductor.)
- **Proof-of-Payment (POP):** a rider presents a physical ticket or other fare medium to indicate that a fare has been paid.

Table 2-3.   Fare collection approaches and prevalence by mode.

Approaches to Fare Collection				Prevalence by Mode			
Basis of Approach	**Collection Method**	**Time of Payment**	**Equipment**	**Bus**	**Heavy Rail**	**Light Rail**	**Commuter Rail**
Physical	Pay on Boarding	Entry	Agents, Farebox, Turnstiles	✕		✕	
	Barrier	Entry or Exit	Farebox or Ticket Processing Unit		✕	✕	
Inspection	Conductor Validated	Before Entry or On-Board by Conductor	Conductor, Hand-held Readers				✕
	Proof-of-Payment	Before Entry or On-Board	Automatic Validator, Conductor, Hand-held Readers	✕		✕	✕

Source: Adapted from Joel D. Anders, "Future Paths for Regional Fare Collection in Atlanta," Atlanta: Georgia Institute of Technology, December 2012.

Historically, certain fare collection approaches have been associated with specific transit modes (see Table 2-3). Consequently, transit systems operating two or more modes will need to address fare media compatibility and interoperability. There are also customer service considerations, particularly when introducing barriers or entry gates to a once barrier-free environment.

Fare Media

The choice of fare media is the second factor in public transit fare payment system design. Fare media can include cash, tokens, paper tickets, magnetic stripe cards, smart cards, bank cards, mobile phones, and other electronic devices. This report focuses on the benefits of contactless smart cards, mobile phones and other electronic devices over other fare media, and does not discuss in detail the relative advantages or disadvantages between other fare media such as cash/coin, tokens or tickets.

Each fare medium and the associated devices and infrastructure used to "collect" a fare using that particular medium have their own capabilities and limitations, such as durability, reliability, interoperability, maintenance, and automation. Transit agencies may accept several different fare media across its entire transit system, though each individual mode may not accept the same variety of fare media.

Allowing the use of different fare media permits riders to select the type or types of fare media that are most convenient and cost-effective to them. The use of reusable, reloadable media such as smart cards or personal mobile devices can reduce or eliminate fare media issuance costs for transit agencies. Electronic fare media provide an opportunity for integration with trip planning applications and other transit information; and an opportunity to link transit payment to non-transit events, transit benefit programs and other offers. The use of electronic fare media can also simplify the transfer process between modes, by eliminating the need for different fare media and the use of paper "transfers."

There may be added costs associated with accepting multiple fare media, such as: initial capital investment in fare media readers; additional programming and audit requirements at the transit agency central computer. Ultimately, however, these costs should be offset through increased ridership; reduced costs associated with fare media issuance; and reduction of fraud (e.g., counterfeit fare cards, misuse of transit benefits).

Discussion: Payment Media vs. Fare Media: Sometimes One-In-The-Same

Payment media are the means by which riders purchase their transit fare. Payment media can include cash, credit cards, debit cards, pre-paid cards, benefits cards, or mobile payment applications on smartphones or other devices.

Fare media describes the various types of "tickets" that a transit agency allows a rider to use for access to the transit system. Fare media can include cash, tokens, paper tickets, magnetic stripe cards, contactless smart cards, "virtual tickets" displayed on a mobile phone, or mobile ticketing applications (on smartphones or other devices) specifically designed for that system.

Payment media become fare media when a single instrument is used to both pay for a fare and access transit services. The most common example is the use of cash: a bus passenger deposits cash into a farebox and begins a journey. A contactless credit card used in an open payments transit fare payment system is another example: the rider's card is read at the fare barrier, the rider is allowed access into the transit system, and the fare payment transaction is initiated between the rider's credit card company and the transit agency.

Fare media will be discussed in detail in Chapter 5.

Chapter 2 Review

- A "Next Generation Transit Fare Payment System" is a transit fare payment system that leverages technology to improve transit agency operations across the business enterprise, while enhancing the customer experience.
- The design and implementation of a new fare public transit payment system is a major undertaking, and should be done in concert with a thorough strategic and operational review across the business enterprise to establish fare payment system goals that support agency objectives.
- Any transit fare payment system should achieve four broad objectives:
  - Improve customer experience, such as greater choice, faster boarding, or seamless travel across different modes or multiple systems;
  - Improve technical operations, such as improved equipment reliability and reduced maintenance;
  - Improve financial processes, such as lower operating costs or increased revenue; and,
  - Improve overall transit system operations, such as acquiring data to optimize schedules and routes.
- Major influences of fare system design include:
  - Fare program: fare structure, transfer policy, transit fare payment, fare control and fare collection.
  - Fare media: what "tickets" or other devices that a transit agency will accept from its riders. A wide variety of transit fare media exist, with varying capabilities and limitations.
  - Fare system typology: the fare system design attributes (discussed in detail in in the next chapter).

CHAPTER 3

Design Attributes of Transit Fare Payment Systems

Chapter Overview

This chapter describes the four primary characteristics or design attributes that, when aligned together in different combinations, comprise the range of transit fare payment system typologies. These four sets of attributes are:

1. **Transit system scope:** single agency or multiagency (e.g., lead transit agency with partners, or regional authority);
2. **Design and technology:** proprietary or standards-based technology;
3. **Fare system architecture:** card-based or account-based; and
4. **Payment architecture:** closed payments or open payments.

Typology: the Architecture of Transit Fare Payment Systems

The system elements and the functional flows of information by which a transit agency collects fares or funds from payment media relate to a transit agency's fare payment system architecture. This has been described as: ". . . the basic fare collection and distribution approach, as well as the specific equipment and payment media. . . ."[7]

The transit fare payment system architecture is a key component in establishing the operational, business, and financial relationships between the transit agency and the rider, and between any third parties involved in the financial transaction. It is the overall roadmap that describes the technical design approach to the transit fare payment system.

Transit fare payment system architectures are governed according to the processing, storage, or communication capabilities of individual elements within the system, or specific system connectivity requirements.[8] Regardless of specific factors, the operational methodology by which a transit agency collects fares and the physical elements used for fare collection comprise a transit agency's transit fare payment system architecture. This report describes different types of transit fare payment system architectures in terms of "typologies."

Each of the four sets of attributes has inherent strengths and operational requirements. In some combinations of attributes, different choices may be compatible or scalable, so decisions are not necessarily "either A or B." This lets a transit agency combine multiple approaches in order to leverage strengths of individual attributes in order to meet current or future fare system objectives.

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Transit System Scope: Single Agency or Multiagency

Understanding the existing, planned, or potential relationships between regional transit agencies is critical when evaluating payment system designs options. This is due to inherent flexibility that certain attributes provide in a multiagency application. In a single agency structure, the transit fare payment system is intended for use by a single transit agency. In a multiagency system, three design approaches can be considered.

- **Lead transit agency with regional partners.** In this scenario, a single transit agency (often a large urban transit system) has primary responsibility for transit fare payment system design and implementation, but shares the transit fare payment system design and specifications with participating transit agencies in the region. Transit agencies in this scheme use the lead transit agency fare card and send transaction data to the lead transit agency central computer system to settle revenues among the partner transit agencies. The lead transit agency applies the business rules and manages transactions. Participating transit agencies typically adopt the same system technology and vendor for their transit fare payment system as the lead transit agency. In planning for regional systems, the participating transit agencies can even piggyback on the procurements of the lead transit agency. This is by far the most common approach to achieving seamless regional transit fare payment systems.
- **Regional transit authority.** In this arrangement, a regional transit authority or metropolitan planning organization (i.e., a central transit agency that does not operate its own transit vehicles) replaces the lead transit agency in the scenario above. The regional transit authority issues and manages the regional fare media, promulgates the institutional rules of the system and clears and settles the transactions that are processed by the individual transit agencies. An example of this approach is the Metropolitan Transportation Commission's role in the San Francisco Bay Area Clipper Card System.
- **Peer-to-peer.** In this arrangement, usually found in an open payments environment, two or more transit agencies share the same transit fare payment system. A joint coordinating inter-agency committee develops the transit fare payment system design, as well as business rules for managing travel between multiple transit systems.

Design and Technology: Proprietary or Standards-Based

When designing a new transit fare payment system, it is important to determine whether the system will use proprietary designs and technology or be designed to the standards of the financial payments industry. This may appear to be an acquisition decision, but choosing a proprietary approach can restrict future system development and interoperability.

Proprietary Fare Payment System

In a proprietary transit fare payment system, the system is developed and owned by a commercial entity and typically licensed to a transit agency. Proprietary transit fare payment systems can be highly customized to meet specific customer requirements, and can be robust and reliable. A proprietary fare payment system may also include design features that meet common industry standards. For example, contactless fare cards and fare card readers share the same communications technology used by contactless bankcards.

However, in a proprietary environment, there is no requirement for inherent compatibility or interoperability with other devices or transit fare payment systems from other suppliers. In proprietary fare payment systems, the system designer or manufacturer maintains control over their intellectual property and their products. The use of proprietary hardware (cards, readers, etc.) often precludes the transit agency from procuring new or replacement equipment from other manufacturers. Similarly, changes to fare rules or other adjustments at the back-end's

central agency computers also involve device updates, both of which require the involvement of the original system vendor, and usually include an additional cost to the transit agency.

Standards-Based Fare Payment System

Standards-based transit fare payment systems adhere to data and technology specifications for the financial payments industries, as well as other technical standards regarding communications, data security and physical characteristics. In the case of transit fare payment systems, these standards typically include:

- **Financial transaction standards**, such as exchange of merchant and cardholder information, transaction amount and transaction type;
- **Communications protocols**, such as the transmission frequency for contactless fare cards, (e.g., ISO standard 14443, Part 2) or the communications modes for Near Field Communications (ISO 18092:2013);
- **Physical characteristics of devices**, such as the length, width and thickness of a contactless bankcard (e.g., ISO standard 14443/Part 1 or ISO 7810);
- **Security of information**, such as how data is stored or transmitted to prevent tampering or theft; and,
- **Data requirements**, such as the sequence and format of a data exchange between a contactless fare card and the card reader.

> For the purpose of this report, a "standards-based transit fare payment system" is designed to meet the ISO standards and specifications used by the financial payments industry for contactless bank cards, which can support open or closed payments architectures.

Financial payments standards are established by groups such as EMVCo or the Payment Card Industry (PCI) Security Standards Council. EVMCo—a global consortium representing American Express, Discover, JCB, MasterCard, UnionPay, and Visa—manages the global Europay MasterCard and Visa (EMV) Specifications used for contact chip, contactless chip, common payment application (CPA), card personalization, and tokenization used by the financial payments industry. Other technical specifications used in standards-based fare payment systems include those established by national and international standards associations such as the International Standards Organization (ISO) and the National Institute of Standards and Technology (NIST), or by transit industry organizations such as the American Public Transportation Association (APTA).

One common set of standards used to define the communications technology used for contactless smart card fare media is ISO 14443 "Identification cards—Contactless integrated circuit cards—Proximity cards." Both the transit industry and the financial payments community currently use this standard for their contactless fare media and contactless bank cards. In order to ensure interoperability between fare payment systems and devices, national transit initiatives and consortia have established common electronic ticketing standards, including APTA's Contactless Fare Media System,[9] Germany's VDV,[10] and France's Calypso.[11]

The global financial payments industry is in the final phases of implementing payment card specifications that will provide greater security and global interoperability. The "EMV specification" will apply to virtually all payments cards, including contactless cards.[12] The U.S. is scheduled to implement the EMV standards for nearly all merchants by October 2015, so transit agencies implementing a contactless fare card solution must ensure that card readers and other devices comply with the EMV standards if they want to be able to accept cards issued by financial institutions in the future.

Standards-based transit fare payment systems tend to provide greater flexibility in system design, acquisition and operation, which can be seen in such areas as:

- **System-wide interoperability and compatibility** between devices from different manufacturers, or from other transit partners.
- **Integration** across multiple agencies, through acceptance of common payment media.
- **Front-end technology:** the cost or availability of new or replacement equipment such as fare cards, card readers, fare boxes, TVMs, etc.
- **Back end technology:** the ability to perform updates and changes to system software (e.g., changes in fare rules; adding transit agency partners).

Fare System Architecture: Card-Based or Account-Based Systems

Card-Based Fare System Architecture

A card-based fare system is the traditional transit fare collection system architecture, in which the transit card serves solely as the fare medium. Value is carried on the transit fare card, and decremented as the rider as granted access to the transit system.

Value is added by the rider using a separate payment medium such cash or a personal bank card or by a third party (e.g., through an employer transit benefit program). Fare value may be added in the form of a dollar amount (to pay single fares) or in the form of a period pass (e.g., a monthly pass). Once a fare card has been loaded, the card "carries" that value or pass. Since the fare card itself holds fare value, the rider will lose any value remaining on the card if it is lost or stolen, unless the fare card has been registered (see discussion box).

In a card-based system, all fare transactions take place at the front-end of the system, at the card reader located at the farebox, barrier, or other transit system point-of-entry (POE). At the card-to-reader interface, the transit fare payment medium (i.e., the payment card) and the card reader interact and two transactions take place to:

- **Authenticate the card**, to ensure that the card is "valid," and
- **Transit fare payment/grant transit system access.** In the case of a stored value card, the card and reader interact to calculate the fare; decrement the card (transit fare payment transaction); and permit entry into the transit system. In the case of a period pass, the card and reader interact, business rules are applied, and entry permitted.

Discussion: Registering a Fare Card in a Card-Based Transit Fare Payment System

Many card-based systems allow riders to register their cards through an online portal and create an "account"; the WMATA SmarTrip card and MBTA Boston's CharlieCard are two examples.* Through that account, riders can use their own credit or debit cards to add value or schedule automatic reloads to their fare card. Value added through an online transaction may take up to two days before it "appears" on a rider's fare card, since the data must be downloaded from the transit agency's central computers to individual card readers or bus/station computers. Registering a fare card can also protect a rider in the event of card loss, allowing a lost card to be canceled and the rider issued a new card loaded with the pre-loss balance. While a rider may create such an account, these fare systems still operate under a card-based architecture.

*See www.wmata.com/fares/smartrip/index.cfm or https://charliecard.mbta.com/

Account-Based Fare System Architecture

In an account-based fare system, the fare medium functions as a single credential to identify the rider to the transit system (for access) *and* to associate that rider with an account (for transit fare payment). All transit fare payment transactions take place at the back end, within the rider's account, rather than on the fare medium itself.

For ease of understanding, the reader should think of the automated toll collection (ATC) systems used throughout the toll industry (e.g., *E-ZPass*). No value or products are stored on the toll "tag" itself. Rather, it functions as a "token" or credential that identifies the tag-holder to his or her account within the central computer of the toll system. All toll calculations and charges take place at that central computer.

An account-based transit fare payment system operates in a similar manner. When a fare card or other fare medium is presented at the card reader, the medium and reader communicate in order to:

- **Authenticate the card/grant transit system access**, to ensure that the card is "valid" and then grant access to the transit system, and
- **Authorize the fare transaction.** The reader communicates with the transit agency's central payments system, provides necessary information to associate the card with a payment account, calculate the fare, and charge the rider's account.

The account-based approach de-couples the access and payment function, and makes a number of other design alternatives available. Advantages of an account-based approach include:

- Permits the simultaneous use of a number of fare media options (transit agency smart cards, contactless credit and debit cards, mobile devices, ID cards, mobile applications, etc.);
- Eases partnering across transit agencies, other transportation operators, and non-transportation organizations;
- Increases the modularity of the front-end (i.e., decouples sales transactions from fare/business logic from card reader);
- Simplifies administrations of government transportation benefits, by moving payment functions to a centralized computer; and,
- Enhances ability to provide incentives and promotions across transit operators, and with other modes of transportation and non-transit organizations.

Payment Architecture: Closed Payments or Open Payments

Closed Payment Architecture

A closed payment (or "closed loop") architecture utilizes a fare card that can only be used within that transit system or on other transit systems that accept the same fare card. Transit fare payment has traditionally operated in a closed payment system, similar to a university campus card.[13] Closed loop payment systems were pioneered in cities such as Ventura, CA, Washington, DC, and in the San Francisco Bay Area, and remain the most common form of payment system currently in use by transit agencies. In a closed payment, account-based system, a rider's account is within the transit agency's control. The *Chicago Card Plus* was an example of this type of payment system.

Open-Payment Architecture

An open payment (or "open loop") architecture is a payment system in which an outside entity's card or other form of payment (e.g., bank cards) is accepted for use by a transit agency. Open payments do not necessarily preclude the use of a transit agency's own, account-based

Table 3-1.   Benefits and capabilities of open payment fare system.

Open Payment Benefits	Open Payments Capabilities

• Ubiquitous nature of the payment medium
• Card issued and managed by banks and other issuers, not by the transit agency
• Standards for cards, points of sale, business rules, and security
• Transit agency can "outsource" fare collection and become a merchant
• Achieving cross transit agency interoperability
• Addressing occasional riders in a contactless system
	• Can equitably serve all customer markets through the use of account-based agency fare cards, including:
	  o Unbanked and underbanked
	  o Seniors, students, and disabled
	• Can accommodate financial payments industry requirements through
	  o Use of off-line transactions
	  o Authentication vs. authorization
	  o Aggregation of payments
	  o Use of micropayment practices

transit fare card, but the underlying premise is that all fare media must utilize the same non-proprietary communications and data exchange protocols used by the financial payments industry, as well as standardized technology platforms and devices.[14] In the case of an open payment system, a rider's account could be held by the transit agency (in the case of transit agency-issued fare media), by a bank (using a bank-issued contactless credit or debit card or mobile application), or by another entity that uses open payment compatible fare media, such as a prepaid card. This allows the use of contactless bankcards, mobile payment applications, and other compatible technologies for transit fare payment, reducing or eliminating the need for a separate transit agency-issued fare card.

> For the purpose of this report, an "open payments" transit fare payment system is designed to accept any form of compatible payment media. This could include payment media issued directly by the transit agency, by a financial institution, or by any third party.

Acceptance of open payments has been an area of intense research and development, study, and field piloting, with successful implementations in Salt Lake City, Chicago, and London. The major benefits seen by transit industry professionals and the capabilities these systems offer appear in Table 3-1.

Approaches that address these challenges, such as targeted prepaid or general purpose reloadable transit fare payment cards for unbanked and underbanked riders which limit transaction fees, have been successfully implemented at the Utah Transit Authority and other transit agencies.

Additionally, there have been a number of significant developments within the financial payments industry that address the increasing number of low-value, electronic payment transactions (known as "micro-payments"). These include altering the signature rules for micro-payments (see discussion box); implementing new approaches to authorize transactions in off-line environments; and aggregating or batching multiple small purchases together in a single financial transaction.

Discussion: Serving Up Electronic Payment Cards in America's Quick Service Restaurants

The first general purpose credit cards were introduced in 1966, and saw widespread acceptance amongst many types of merchants. Retailers, restaurants, and other higher-value vendors found that accepting credit cards increased both transaction volume and average sales.

Merchants with smaller average transaction values, such as quick service restaurants, were much slower to adopt electronic payments. They were concerned with the higher cost of accepting credit cards (as a percentage of sales), and the impact on slowing service speed, while cashiers waited for credit card authorization and patrons signed receipts.

To overcome these hurdles, the payments industry developed two solutions. First, they developed lower pricing structures for merchants with small-dollar-value transactions, to lower the relative cost of accepting credit or debit cards. Second, the payment associations such as Visa, American Express and MasterCard adjusted their business rules to dispense with signature requirements for these smaller transactions.

Before these measures were implemented in 2001, payment cards were accepted at only 10 percent of quick service restaurants. By 2006, that figure had risen to 67 percent. Today, virtually every quick service restaurant accepts electronic payment cards.

Adapted from James C. McGrath, "Micropayments: The Final Frontier for Electronic Consumer Payments," Payment Cards Center, Federal Reserve Bank of Philadelphia, June 2006

Chapter 3 Review

- The typology of a transit fare payment system is comprised of four attributes:
  - Transit system scope: single transit agency or multiagency?
  - Design and technology: will the system be of a proprietary design or use proprietary technology? Or will fare media, readers, and other devices and software systems be compatible with the financial payments industry standards?
  - Fare system architecture: will the system be card-based or account based?
  - Payment architecture: whether the system accepts only transit agency-issued fare media (closed) or will it accept open payments?
- Some design approaches are compatible with each other, while others are not.

CHAPTER 4

Transit Fare Payment System Typologies

Chapter Overview

This chapter identifies the typologies found in modern transit fare payment systems, and compares them with one another based upon the four attributes (transit system scope, design and technology, system architecture, and payment architecture) discussed in Chapter 3. It will identify instances where certain systems are more capable of adapting in the future, such as development of new technology or an expansion of the transit system framework from a single agency to a multiagency.

Typology Framework

The four transit fare payment system design attributes can be presented schematically as shown in Figure 4-1.

Descriptions of Fare Payment System Typologies

The selection and configuration of each of these four attributes plays a role in determining the operation, capabilities and limitations of the transit fare payment system. While selecting from each pair of attributes is generally an "either-or" choice, some possible combinations of design attributes are not compatible with one another (e.g., card-based systems cannot be open payment systems, while standards-based systems cannot be card-based), which limits the total number of system configurations. In addition, some combinations of design attributes are capable of future development (e.g., for single agencies to join together under a multiagency fare payment system), without requiring significant change or expense to an existing system or infrastructure.

Single Agency, Proprietary, Card-Based, Closed Payments System
Multiagency, Proprietary, Card-Based, Closed Payments System

The single transit agency, proprietary, card-based, closed payment system (Figure 4-2) is the architecture first developed to support magnetic stripe payment fare cards in the 1970s, and is the approach used by the Whatcom Transportation Authority (see Chapter 7, Case Study 3). This same architecture was adopted in the late 1990s as fare collection systems began to accept contactless smart cards. In a multiagency transit fare payment system, the same proprietary technology (fare medium, card readers, TVMs) is used by multiple transit agencies, allowing seamless travel throughout a region and improving customer convenience.
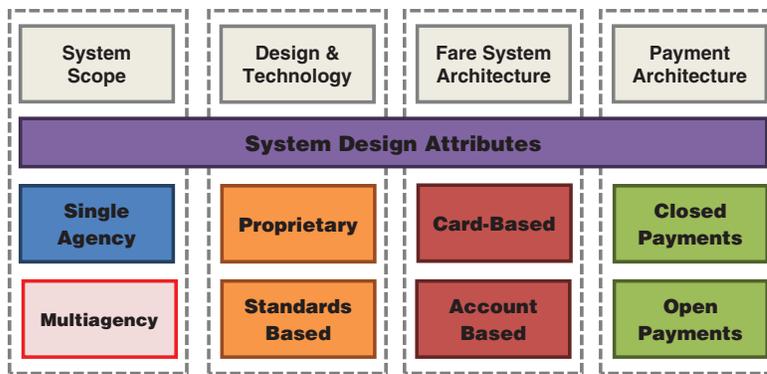
*Figure 4-1.   Typology framework for transit fare payment
system design attributes.*

The proprietary, card-based closed payment typology is the prevalent fare payment system in use today in large transit systems. Fully fielded systems are in operation in single and multiagency environments serving urban, regional, and rural transit markets. Some examples include:

- *CharlieCard*, serving the Boston, Massachusetts, metropolitan area, operating across heavy rail, bus, and express bus systems;
- *Clipper*, serving the San Francisco, California, metropolitan area, operating across multiple bus, heavy rail, commuter rail, and ferry systems;
- *ORCA* card, serving the Seattle, Washington, and Puget Sound area, operating across multiple bus, heavy rail, light rail, commuter rail, water taxi, and ferry systems;
- *Tap* card, serving Los Angeles County, California, operating across multiple bus, express bus, bus rapid transit, light rail, and heavy rail systems.

However, since this typology uses proprietary, card-based technology, these systems cannot support an open payments architecture that accepts contactless payment media issued by other organizations (e.g., contactless bank cards).

Single Agency, Proprietary, Account-Based, Closed Payments System
Multiagency, Proprietary, Account-Based, Closed Payments System

These fare payment systems (Figure 4-3) use account-based architecture, which can increase customer convenience and improve business operations. The multiagency fare payment system also allows regional travel. The use of proprietary technology, however, does not allow future

Design Attributes for Single Transit Agency ——— or Multiagency Application ▬ ▬ ▬
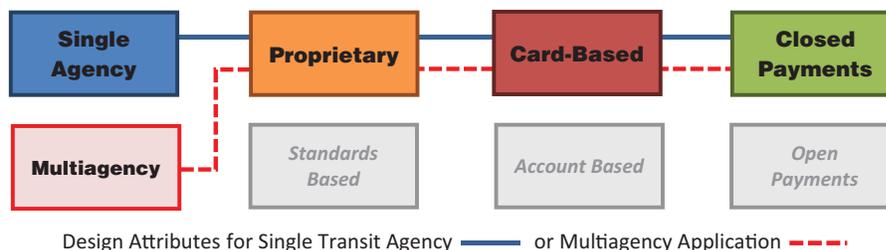
*Figure 4-2.   Single or multiagency, proprietary, card-based, closed
payment system design.*
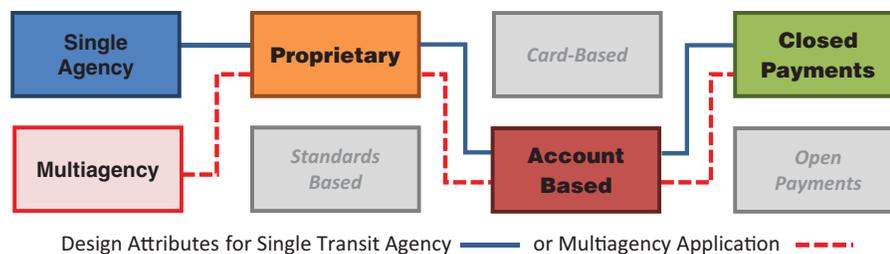
Figure 4-3.   Single or multiagency, proprietary, card-based, closed payment system design.

development into an open payments system, and prevents the use of other fare or payment media. This is an uncommon typology, and was used in the *Chicago Card Plus* system.

Single Agency, Standards-Based, Account-Based, Closed Payments System
Multiagency, Standards-Based, Account-Based, Closed Payments System

This transit fare payment option (Figure 4-4) builds on the proprietary design approach of the earlier example by combining both standards and account-based attributes.

The combination of both standards- and account-based architectures provides for a number of future system development opportunities.

- **Flexibility in replacing or upgrading transit fare payment system hardware and devices.** Because the transit fare payment system is standards-based, hardware is more commoditized, allowing the transit agency to purchase new devices (e.g., card readers, fare boxes, validators, and ticket vending machines) from any vendor that sells devices based upon that standard.
- **Potential for a single transit agency system to expand to a multiagency system at low cost.** Since the transit fare payment system is standards-based, it would be able to accept fare media from other transit agencies using the same standards-based elements. Changes would be made at the back end of each transit agency's central system computer, to permit adjustments to fare rules or transfer policies or accommodate changes to business rules which account for distribution of fare revenue from multiple transit agencies.
- **Future ability to evolve to an open payments system.** Since the system is account based, it is capable of accepting open payments, by making adjustments to business rules at the back-end of the transit agency's central system computer, without any requirement to change front-end hardware.
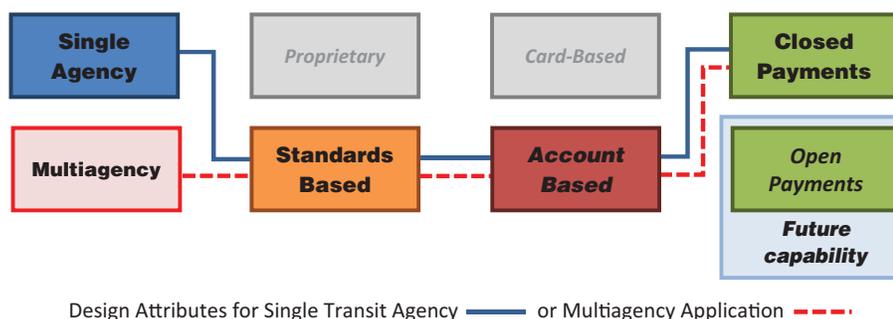
Figure 4-4.   Single or multiagency, standards-based, account-based, closed payment system design.

Design Attributes for Single Transit Agency ——— or Multiagency Application ‑‑‑‑
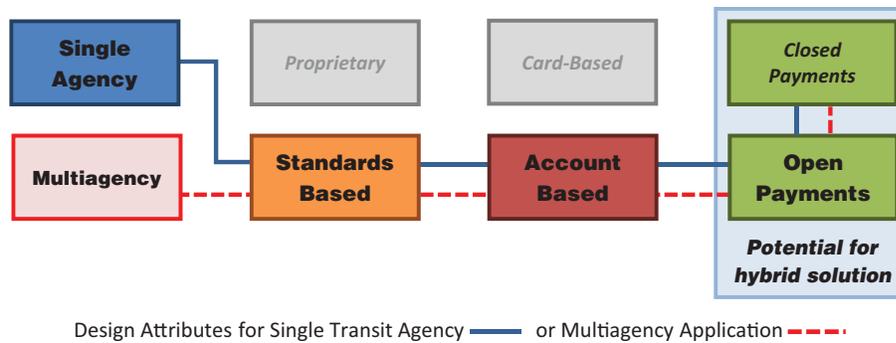
Figure 4-5.   Single or multiagency, standards-based, account-based, open payment system design.

Single Agency, Standards-Based, Account-Based, Open Payments System
Multiagency, Standards-Based, Account-Based, Open Payments System

These transit fare payment systems (Figure 4-5) offer the greatest potential flexibility for transit agencies and riders. Since the system is standards- and account-based, it would allow transit agencies to issue their own system-compatible fare medium (the "hybrid solution"), which would allow the transit agency to meet its accessibility goals. This is the approach adopted by the Utah Transit Authority (Chapter 7, Case Study 1) and by the Southeastern Pennsylvania Transportation Authority (Chapter 7, Case Study 2). This is also the approach used by the Chicago Transit Authority and Pace (the suburban bus line serving the greater Chicago metropolitan area) in developing the Ventra transit fare payments card, as well as by the Washington Metro system (WMATA).

Chapter 4 Review

- The four principal attributes of transit fare payment system design (transit system scope, design and technology approach, fare system architecture and payment system architecture) can be combined in a number of different typologies.
- Proprietary fare payment systems can accommodate both card-based and account-based architectures. However, proprietary fare payment systems cannot support open payments architecture.
- Standards-based, account-based transit fare payment systems are capable of expansion from closed payments to open payments.
- An account-based approach must be used in any open payments system.
- A transit fare payment system that accepts open payments appears to be the most versatile since it provides its riders and transit agency the greatest choice, flexibility, and adaptability.

CHAPTER 5

Transit Fare Payment System Technology

Chapter Overview

This chapter explores the technology of transit fare payment and collection, including the relationships between system components, fare media, and other devices, and the roles devices play in the fare collection process itself. It also discusses different types of fare media, focusing on "smart" media such as smartcards, mobile phones and other contactless devices.

System Components

Modern transit fare payment systems are networks of front-end devices (ticket vending machines, readers at fare gates and fare boxes, platform validators, electronic registering fare boxes) and back-end devices (computers at bus depots and train stations, and the central transit agency computer) that are interconnected over a network of wired and wireless communications (see Figure 5-1). Data flows up and down the system, to support fare transactions and system operations. (Data will also flow in and out between the transit agency and the financial payment system; those relationships will be discussed separately.)

Key data flows involved in transit fare system and system operation include:

- **Fare information**, sufficient to complete the transit fare payment transaction (in card-based systems) or to authorize the transit fare payment transaction (in account-based systems).
- **Fare system rules**, such as transfers, fare allocation, etc.
- **Lists of good and bad cards**, which are used by fare boxes and barriers to allow or prevent access to the transit system. (Industry terms vary, but "hot lists" and "cold lists" are often used to identify lists of bad and good cards, respectively.)
- **System operational data** such as dispatch information, automated vehicle location (AVL) information, and automated passenger counting (APC) systems.
- **System diagnostics**, indicating "health and welfare" of card readers, computers and other devices.

Whether fare value is stored directly on the fare medium (card-based) or the medium is used to initiate a transaction with a rider's payment account (account-based), transit agencies need a protocol that automatically transfers money to the operator. For this to occur, automated transit fare payment systems must:

1. Create a secure interface with transit fare payment medium; and
2. Provide sufficient information to complete or initiate a transfer of funds to the transit operator.
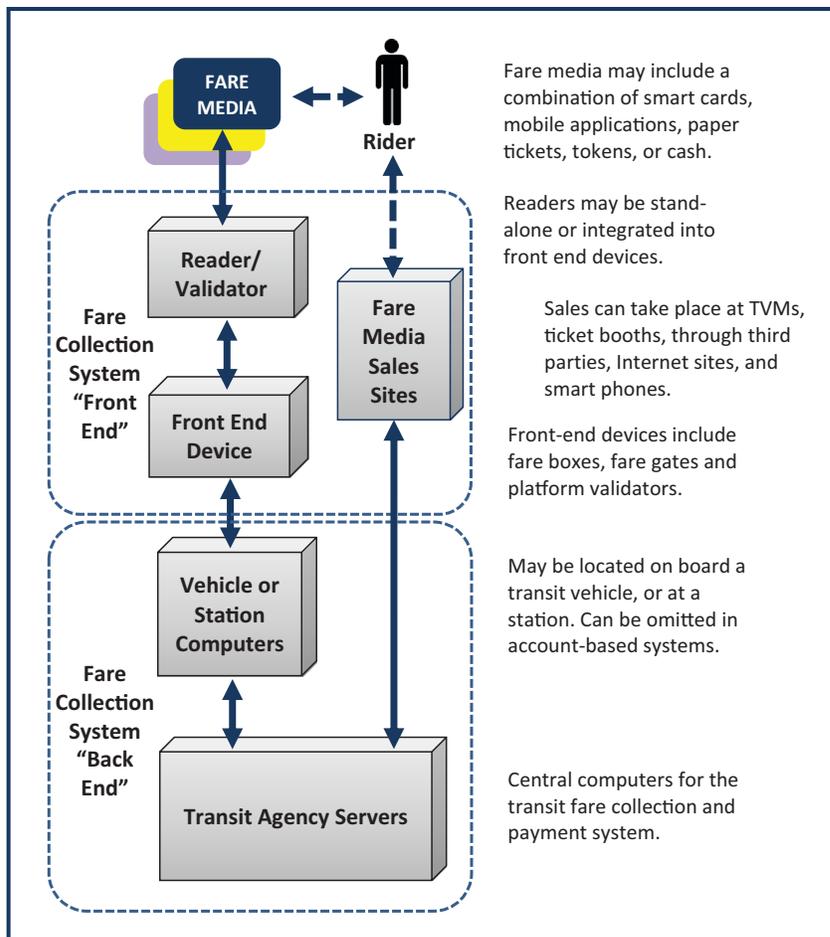
Figure 5-1.   Transit fare payment system devices.

Fare Media and Readers

Fare media are the physical instruments that a rider uses to access the transit system.[15] Transit agencies may decide to accept several different fare media, to accommodate legacy systems, multiple transit modes, or to meet certain fare policy objectives. Although this report focuses on the benefits of contactless smart cards, mobile phones and other electronic devices over other fare media, it also discusses magnetic stripe technology due to its current widespread use in public transit.

Magnetic Stripe Cards and Card Readers

Magnetic stripe ("mag stripe") transit fare cards are, second perhaps to cash, the most prevalent form of fare medium in use today. The technology was introduced on the London Underground and the Long Island Railroad (LIRR) in 1964, and consists of a paper or plastic card with a magnetic stripe that can be read by a card reader mounted on a fare box, fare gate or ticket validator (see Figure 5-2).[16]

Mag stripe cards can only carry a limited number of fare options, due to their limited storage capacity. Security features for mag stripe cards are limited, allowing them to be copied or altered.

Mag stripe card readers require physical contact with the transit fare payment card in order to collect the fare. Some card readers are surface mounted and consist of a guide slot through which the rider swipes the card. Other readers require that the rider insert or "dip" the card into a mechanical device, where the card is moved across a reader, and then ejected back to the rider.[17] Some farebox systems may also validate or time-stamp the card before ejecting the card, adding

Source: Gold Coast Transit

Figure 5-2.   Typical magnetic stripe fare cards.

further mechanical steps to the process. These electro-mechanical ticket processing units (TPU) or bus ticket validators (BTV) involve sensitive motor-driven equipment, and require routine maintenance and repair. They are also susceptible to vandalism.

Contactless Smart Cards and Card Readers

Contactless smart cards have become the fare medium of choice with transit agencies during the last decade. Contactless smart cards are pocket-sized cards (usually the size of a bank card) which incorporate a tiny computer chip and antenna, sandwiched between layers of plastic or paper (see Figure 5-3).[18] Contactless smart cards are "read" by passing them near a card reader ("tapped" near a "target"), where the card and reader communicate over a radio frequency. Smart cards have no battery, but derive power through the electromagnetic radio signal.[19] Over 25 smart card systems have been implemented or are under development at public transit agencies in North America (see Table 5-1).

Contactless smart cards can also be classified as "full feature" or "limited use" cards. Full feature cards comply with more stringent technical and manufacturing requirements, provide higher security, include greater data capacity, and provide more physical durability. Limited use cards, which may be made of thin plastic or even paper, carry less data, and are best suited for short-term applications, such as a one-trip ticket or daily pass.[20]

Contactless smart card readers are fitted with antennas connected to other circuitry at the farebox or fare gate. The reader or target is often equipped with colored LEDs to indicate that the card has been accepted or rejected, and display screens that provide fare information or card status (see Figure 5-4). Smart card readers have no openings or moving parts, significantly reducing maintenance costs and susceptibility to vandalism.
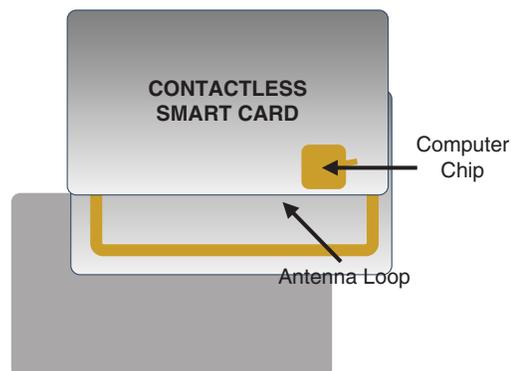
Figure 5-3.   Elements of a contactless smart card.

Table 5-1.   Smart card transit fare payment systems in use in 2014.

Smart Card System	Service Area	Description	Open Payments
Breeze Card	Greater Atlanta, Georgia (MARTA)	Multiagency	No
CharlieCard	Boston Metro Area, Massachusetts (MBTA)	Multiagency	No
Charm Card	Baltimore, MD-Washington, DC Metro Area	Regional Agency	No
Clipper	San Francisco Metro Area, California (MTC)	Multiagency	No
COMPASS	Greater Vancouver, Canada (TransLink)	Multiagency	No
Compass Card	San Diego Metro Area, California (SANDAG)	Multiagency	No
ConnectCard	Pittsburgh / Allegheny County, Pennsylvania	Multiagency	No
EASY Card	Greater Miami/Dade County, Florida	Multiagency	No
FarePay	Greater Salt Lake City region (UTA)	Regional agency	**Yes**
Freedom	Philadelphia, PA to Camden County, NJ (PATCO)	Single Agency	No
GO Smartcard	Greater Spokane, Washington (STA)	Regional agency	No
Go Ventura	Ventura County, California (GCT)	Multiagency	No
Go-To Card	Minneapolis-St. Paul Metro Area, Wisconsin	Regional agency	No
METRO Q Card	Houston Metro Area, Texas (METRO)	Regional agency	No
OPUS	Greater Montréal, Canada	Regional Agency	No
ORCA	Greater Seattle Metro Area, Washington	Multiagency	No
Platinum Pass	Phoenix Metro Area, Arizona	Multiagency	No
PRESTO	Greater Ontario, Canada	Multiagency	No
SmartLink	Newark/Northern New Jersey to New York City	Single Agency	No
SmarTrip	Greater Washington, D.C. (WMATA)	Multiagency	No
STAR Card	Greater Jacksonville, Florida	Multiagency	No
SunGo	Tucson Metro Area, Arizona	Multiagency	No
TAP	Los Angeles County Region, Cali. (LA Metro)	Multiagency	No
Ventra	Chicago Region, Illinois (CTA)	Multiagency	**Yes**
Smart Card Systems Under Development or In Deployment (partial list, December 2014)			
Connect	Greater Sacramento, California (SACRT)	Multiagency	No
eFare	Portland Metro Area, Oregon (TriMet)	Regional Agency	Yes
Key Card	Southeastern Pennsylvania (SEPTA)	Regional Agency	Yes
Metro Pass	St. Louis Metro Area, Missouri (Metro Transit)	Regional Agency	Yes
NEPP	Greater Washington, D.C. (WMATA)	Multiagency	Yes
NFPS	New York City (MTA)	Regional Agency	Yes
SmarTrip	Greater Washington, D.C. (WMATA)	Multiagency	Yes

Note: The brand name for each smart card system is trademarked by its respective transit authority.

Contactless Bank Cards, Benefits Cards and Identification Cards

Contactless smart card technology is also used in bank cards and credentialing applications (i.e., employee identification badges) that need to protect personal information and/or deliver fast, secure transactions. These cards use open standards established by the financial payments industry or other standards bodies, and are currently in use as government and corporate identification cards, electronic passports and visas, as well as financial payment system cards (credit, debit, prepaid, ATM, and benefits cards).[21] These cards share the same communications technology

Source: King County, Washington

Figure 5-4.   Typical transit smart card reader.

(ISO 14443) as contactless transit smart cards, although additional protocols for data units, encryption and global IDs are needed to implement an interoperable system. These elements are specified in bank card standards that are implemented worldwide.

Smartphone Applications

The smartphone has revolutionized the personal computing landscape, giving users unprecedented access to data and real-time information. In 2013, 74 percent of Americans aged 12–64 used a smartphone; that figure is projected to reach 80 percent by 2014.[22] By comparison, the number of credit card owners in the United States is estimated at 71 percent of the population.[23]

This explosive growth of the smartphone industry presents an opportunity for transit agencies to leverage the technology capabilities of a device already in the hands of nearly three quarters of the U.S. population. Many transit agencies have already implemented mobile ticketing applications, with further studies and proofs-of-concept projects underway as both mobile phone and mobile payments technology evolves (see Figure 5-5). (Mobile applications technologies and approaches will be discussed in depth in Chapter 6.)

Other Contactless Devices

The embedded computer chip and antenna technology used in contactless smart cards can also be used in other devices such as key fobs, wrist watches, wristbands, and mobile phones.[24] These devices use contactless technology that is compatible with smart card readers. These devices have been used to manage access at events, amusement parks, hotels, clubs and hospitals.[25] Wearable devices could have particular advantages in transit environments for school children or riders with limited dexterity. For example, the Capital Metro system in Austin, Texas, makes key fobs and wristbands available to seniors and disabled riders (see Figure 5-6).[26] In Europe, a developer

Source: TriMet

Figure 5-5.   Smartphone with mobile ticketing application.
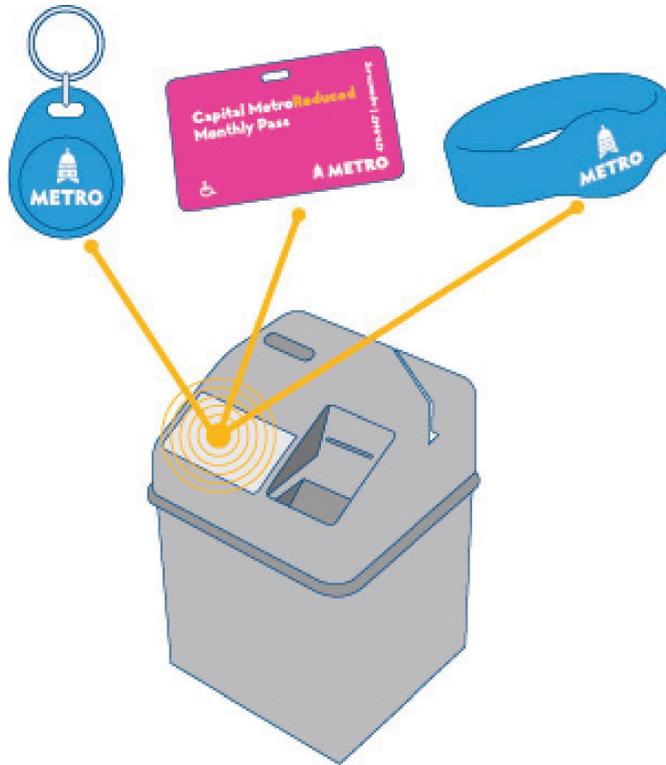
Source: CapMetro

Figure 5-6.   Contactless devices used on the Capital Metro System, Austin, Texas.

is combining Google Glass technology with a mobile payment application using a novel, "nod-to-pay" approach.[27]

Chapter 5 Review

- Transit fare payment technology comprises the devices used to process electronic transit fare payments. There are generally three elements:
  - The fare medium carried by the rider
  - Front-end devices that communicate and interact with the fare medium.
    - Card readers
    - Fare boxes, barriers, validators, vending machines
  - Back-end devices that communicate and interact with front-end devices
    - Vehicle or station computers
    - Central transit agency computers
- Different transit fare payment media offer a range of capabilities, when assessing customer convenience, data collection, fare structure flexibility, and security.
- Contactless smart cards have emerged as the fare medium of choice among transit agencies, due to their versatility and durability, and the reduced maintenance requirements of associated readers.
- Many other devices, such as contactless identification cards and smartphones, comply with the same standards as contactless smartcards, which could allow their use as transit fare media and/or payment media.

CHAPTER 6

Emerging Payment Technologies and Payment Convergence

Chapter Overview

This chapter highlights several emerging technologies and practices that can provide public transit agencies with a variety of options to improve and enhance their own operations, while offering riders increased convenience. These include:

- Availability and security of contactless bankcards, which increase the potential ridership base for public transit agencies;
- Availability of prepaid and reloadable payment cards, which offer options for unbanked or underbanked transit customers;
- Advances in mobile payments and mobile technology, which can be incorporated into next generation transit fare payment systems;
- Acceptance of smart card ID credentials on transit, which can improve customer convenience through integration with transit benefit programs; and,
- Convergence of mobile payments, travel and planning information across multiple modes of transportation.

Availability and Security of Contactless Bankcards

Each of the leading credit card associations has deployed branded contactless bankcards, and are working to encourage their member financial institutions to make them available to their customers. They have also worked together to develop international standards that improve card security in order to reduce the risk of fraud associated with magnetic stripe technology.

Availability of Contactless Bankcards

Many banks and other financial institutions now issue credit and debit cards incorporating contactless smart card technology. Examples of the branded contactless cards available include:

- MasterCard *PayPass*
- Visa *PayWave*
- American Express *ExpressPay*
- Discover *Zip*

Transit fare payment systems that include both standards-based and account-based attributes are capable of accepting these financial payment cards as fare media, thereby becoming open payment systems. Utah Transit Authority was the first transit agency in the United States to accept contactless transit fare payment cards issued by financial institutions when they implemented

an open loop transit fare payments system. While the percentage of riders using these cards has been relatively small, they provide an additional payment option for riders who do not have a transit payment card or pass.[28]

Higher Security: The EMV Card

To reduce the risks of fraud with magnetic credit and debit cards, financial institutions are introducing smart cards with a secure microprocessor chip in them which provides strong security for payment transactions and the data stored on the cards. A consortium of financial institutions developed open standard specifications for these cards and card acceptance devices called "EMV," named after the initiators of the approach. The specification is managed by EMVCo, which is owned by a consortium of organizations from the payments industry. EMV cards have been implemented in at least 80 countries throughout the world; retailers in these countries have reported significant reductions in fraud.[29]

The EMV card typically has a contact chip which is read when the card is inserted into a card reader (see Figure 6-1). A personal identification number (PIN) or signature may be required as an additional form of identity authentication. In Europe, for example, most merchants require a "chip and PIN" for retail purchases. In the United States a chip and signature approach is likely to be used initially. The credit card associations are providing incentives to merchants to implement EMV-compliant cards and devices by offering them protection from liability for fraudulent transactions. Many of these incentives require adoption of EMV technology by October 1, 2015.

Source: www.ingenico.us

Figure 6-1. EMV card and reader.

Dual Interface Cards: Security and Speed

The new transit payment programs being implemented in Chicago; Portland; Philadelphia; Washington, DC; and other regions are requiring that the new payment system be open loop and accept EMV-compliant cards issued by financial institutions. To maintain the rapid transaction times required in transit (up to 0.5 seconds), these cards must have a contactless interface.

Because the contact interface will be required for banking and retail uses, cards issued by financial institutions will have to have both contact and contactless interfaces if they are to be used on transit. These cards are called "dual interface" cards (see Figure 6-2). Although dual interface cards are widely available in Europe, they have not seen widespread distribution in the United States due to the higher cost (approximately $1.00 more per card). Greater use of dual interface cards will also be influenced by the increased use of smartphones that allow mobile payments using near field communication technology (discussed later in this chapter).

Prepaid and Reloadable Payment Cards

Another form of payment that could be accepted using the open loop payment approach is a prepaid or reloadable payment card. In the retail sector, prepaid cards have replaced paper gift certificates. They provide people with an electronic payment medium that functions like a debit card. These cards are issued by companies or financial institutions, and are popular among people who do not have bank accounts, or who prefer not to use a personal credit or debit card.

Since transit agencies must provide service for all customers, prepaid cards provide an option to customers who do not qualify for a credit or debit card, or who prefer not to have a relationship with a financial institution or use a financial institution card for transit. Prepaid cards can be loaded and reloaded with value at retail outlets, ticket booths, and automated kiosks.
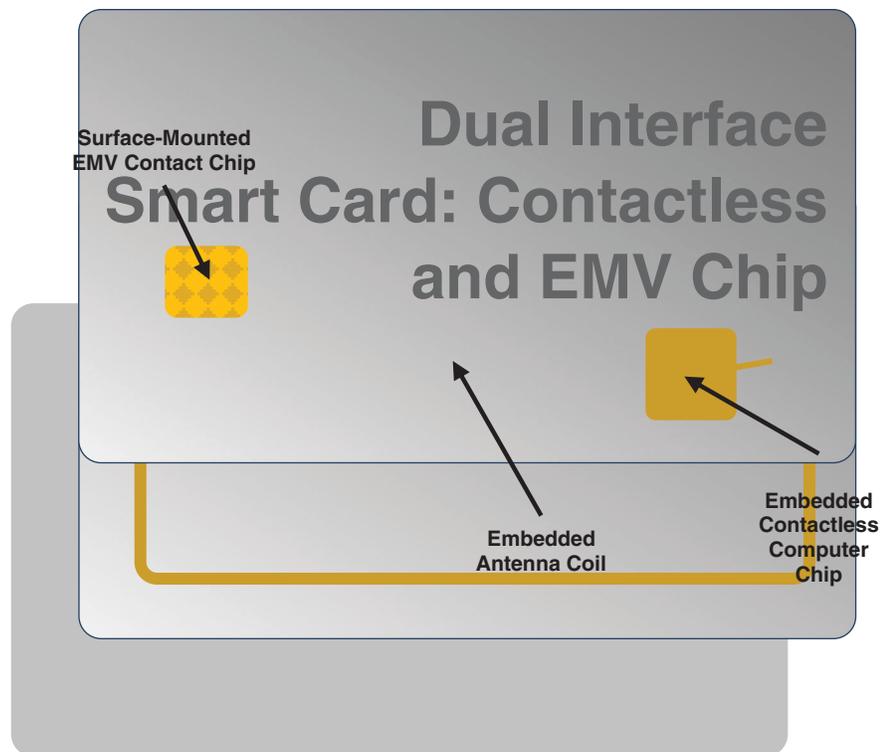
Figure 6-2.   Dual-Interface Card (Contactless & EMV Chip).

Source: UTA

Figure 6-3.   Utah Transit Authority prepaid card.

Banks are the legal issuer of any "branded" prepaid card (e.g., MasterCard, Visa). However, a financial institution may license the use of its Bank Identification Number (BIN) to a transit agency or other third party; the licensee then takes responsibility for marking and operating the prepaid card program. These "transit agency prepaid cards" can be used for transit fare payment and sometimes for other retail payments. The Utah Transit Authority (see Figure 6-3), the Los Angeles Metro and the Chicago Transit Authority were among the first U.S. transit agencies to accept prepaid payment cards.

Mobile Technology

The widespread use of smartphones has revolutionized the transit landscape, as an increasing percentage of riders carry these devices. According to the Federal Reserve, over 61 percent of Americans owned a smartphone as of 2013, with significant smartphone ownership among unbanked and underbanked populations (49 percent and 64 percent, respectively).[30] With 192 million Americans carrying these devices, public transit agencies have developed a number of solutions to deliver ticketing and payment services to riders equipped with smartphone technologies.

Use of mobile phones and devices for transit payment can eliminate the need to issue separate fare media to these customers, lowering operational costs to the transit agency. The use of a mobile transit application can also facilitate delivery of other information to help riders plan and take their transit trips (e.g., schedule information, system maps, and service updates).

The most common uses of mobile technology include visual or flash passes for mobile ticketing and the use of a near field communication (NFC) enabled smartphone or other contactless device for mobile payments. There are also a number of other mobile technology approaches

Figure 6-4.   Animated flash pass.

under development which eliminate the need for a rider to activate a mobile ticket or initiate a mobile payment.

Flash Pass

The most common form of mobile payment which has been adopted in the United States for transit payments is when the mobile device hosts a ticketing application which emulates a paper ticket or pass. The "virtual ticket" appears on the device screen, and is used as a flash pass in a proof-of-payment or conductor validated environment.[31]

This approach has a low barrier to entry to deploy a mobile ticketing solution, particularly in a proof-of-payment environment where no ticket-reader infrastructure is required. In this scenario, a rider activates the ticket, and displays it to the conductor. Some transit authorities, such as MBTA in Boston and TriMet in Portland, OR, have included color and animation in the mobile ticket image which deters counterfeiting (see Figure 6-4: when the ticket is activated, the activation date and time appear, while the tri-colored bar slowly shifts colors).

In a conductor validated environment, the ticketing application typically displays a two dimensional bar code, or "QR code," which fare inspectors can validate with a mobile reader (see Figure 6-5). An added security feature in both proof-of-payment and conductor validated environments, the virtual ticket "expires" after a fixed period of time, and is no longer available for display by the rider.

Figure 6-5.   Conductor scanning mobile ticket.

Several transit agencies and contract transit providers are using this flash pass approach to augment their existing fare systems, including:

- Capital Metropolitan Transportation Authority (Austin, Texas), *CapMetro.*[32]
- Dallas Area Rapid Transit (DART), *GoPass.*[33]
- Massachusetts Bay Transportation Authority (MBTA), *mTicket.*[34]
- Nassau Inter-County Express (NICE), *goMobile.*[35]
- New Jersey Transit (NJT), *MyTix.*[36]
- New York Waterways, Mobile Ticket.[37]
- Tri-County Metropolitan Transportation District of Oregon (TriMet), Mobile Ticket.[38]

Near Field Communications

Near Field Communication (NFC) is a mobile payment technology that utilizes radio frequency (RF) communication technology to exchange data securely.[39] Devices with NFC technology are designed to the contactless smart card standards, and operate with the same card readers and infrastructure. When presented to a card reader, they function similar to a contactless credit, debit or prepaid transit card to initiate a fare payment transaction.[40] Recently released smart phones by a number of manufacturers are equipped with NFC technology including Apple, Blackberry, HTC, LG, Motorola, Nokia, and Samsung.

Mobile payments that use NFC technology require a third-party "trusted service manager" (TSM) to bring the service providers together and manage the secure payment credentials. Several wireless communications companies have formed partnerships with TSMs to provide NFC payment services, while third parties have developed mobile wallet or "ePurse" applications for devices incorporating NFC technology (see Figure 6-6).

Each mobile wallet can contain data for multiple payment cards, including credit cards, debit cards, prepaid cards, and compatible transit agency fare payment cards. This feature allows the user to select the payment card they wish to use for a specific transaction. Many NFC compatible mobile phones include an Integrated Secure Element, a separate computer chip that ensures that transactions stored on the device and payment transactions are secure. Other NFC technology approaches include Host Card Emulation (HCE) and moving the secure element to the Cloud, both of which seek to emulate a smart card, but which avoid the cost of incorporating a secure element in the device.[41]

Source: Google

Figure 6-6.   Mobile wallet and NFC reader.

NFC payments have been successfully demonstrated in several transit agencies. Recent developments in mobile payment technology are likely to accelerate the adoption of NFC technology among transit riders and transit agencies. Another development was the creation of an industry consortium (Open Mobile Ticketing Alliance or OMTA) that seeks to develop open standards for mobile ticketing.

SMS Ticketing (Text Messaging)

Several public transit agencies in Scandinavia and elsewhere in Europe have developed transit fare payment systems that utilize the short message service (SMS) texting capability of a cell phone. This approach is similar to the flash pass, since the ticket information is displayed on the rider's mobile device. Unlike the flash pass, which can only be used on a smart phone, an SMS ticket can be delivered to any cell phone that can send and receive text messages.

To purchase an SMS ticket, a rider sends a text message to the transit agency, and receives a text message back from the transit agency. The message sent by the rider varies from transit agency to transit agency, but is typically a pre-determined code that represents the fare for a particular type of ticket, such as a period pass (e.g., 30 minutes or 24 hours) or a distance pass (e.g., for travel between designated fare zones). The message received from the transit agency provides information on the fare, including any expiration details. The SMS "ticket" is then presented upon boarding or when requested by a conductor or operator.

A transit agency considering an SMS-based fare collection program must coordinate closely with one or more telephone service providers, in order to develop business rules for payment or billing. In some SMS ticketing programs, the cost of the fare is deducted from a prepaid phone card account; in others, the cost of the fare is billed to the rider's cell phone account, and collected as part of a monthly bill. On Uppsala County's transit system in Sweden, riders intending to use the SMS ticketing program must register their cell phone or smartphone in advance and set up an account linking their phone number to a separate credit or debit card.

Passive Mobile Payment Approaches

There are a number of mobile technologies under development that have potential application in transit fare payment systems. These technologies utilize passive interaction between the rider's smartphone and readers located at the transit system point-of-entry, such as a fare gate or at the boarding and exit doors of buses or trams. In a passive environment, the rider does not have to physically interact with his/her mobile device to display a flash pass, activate a ticket or authorize a fare payment transaction. Instead, the readers at the point-of-entry are able to automatically detect the time and/or location that a rider enters and departs the transit system. That information is passed to the central transit agency computer and used to calculate the correct fare according to the fare system rules, and then authorize the fare payment transaction.

In these passive mobile payment systems, a customer sets up an account with a transit agency, provides payment information (e.g., a bankcard), and registers a mobile device; the mobile device must be compatible with the device reading/detection technology used in the transit system (e.g., Bluetooth or NFC). The rider may also need to configure their mobile device to permit automatic communication with the transit agency's readers.

Two such systems under evaluation are Bluetooth Smart and Be-In-Be-Out.

Bluetooth Smart

Bluetooth Smart (also known as Bluetooth Low Energy, or Bluetooth LE) technology requires less energy than the original Bluetooth communications. Bluetooth Smart technology uses

Source: www.bluetooth.com
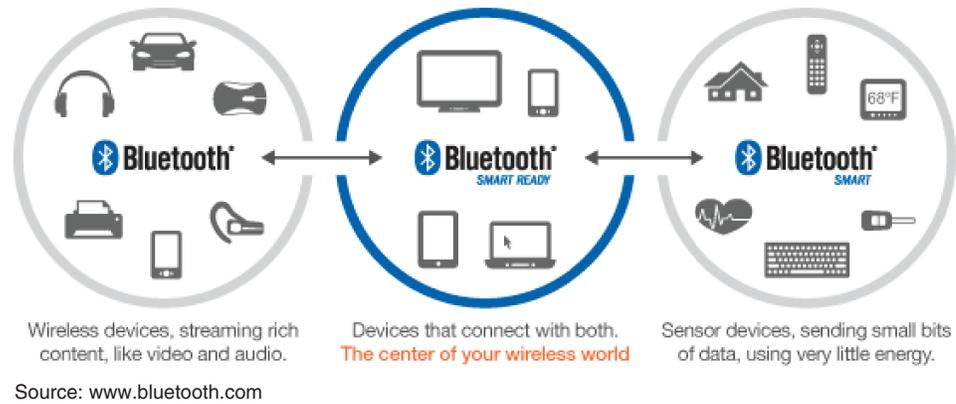
Figure 6-7.   Bluetooth and Bluetooth smart devices.

Bluetooth beacons that detect nearby mobile phones or devices (see Figure 6-7). Many smartphones and tablets currently include Bluetooth Smart technology, including devices from Apple, Google, Microsoft, and Samsung. As Bluetooth Smart technology becomes widespread in consumer mobile devices it could be an alternative to NFC communications. The sensors could be used for hands free payment transactions or could be used to send traveler information, rider rewards, or other offers and incentives. Several demonstration projects are underway in the U.S. and Europe, as software developers and service providers seek ways to apply this technology.[42]

Be-In-Be-Out (BIBO)

The Be-In-Be-Out payment scheme involves a device on-board the transit bus which would detect contactless fare media or mobile devices. When a customer boards the bus, the on-board transceiver detects the payment device, and the payment transaction is automatically initiated. A processor on board the vehicle then transmits the transaction information to the fare processor at the transit system or payment system provider. A proof of concept demonstration of the BIBO payment concept was demonstrated in Germany in 2012 (see Figure 6-8). The demonstration lasted 6 months, and involved 30 buses and 150 passengers with contactless key fob devices.[43]

Table 6-1 compares the various approaches to mobile payment technologies.

Source: Dresdner Verkehrsbetriebe AG

Figure 6-8.   BIBO demonstration project in Dresden, Germany.

Table 6-1.   Comparison of mobile payment technologies.

Scope	Efficiency	Penetration	Technical Maturity
Flash Pass and Bar Code			
Flash pass cannot be used at fare gates or barriers, which prevents integration in a fully gated system. Bar code allows use at fare gates or barriers, but requires installation of bar code readers.	Allows customers to buy tickets online, or to print tickets at home. No productivity improvements in systems with 100 percent visual inspection (i.e., most commuter rail systems), since it requires same staffing level as paper ticket system.	Can be used by any passenger with a smartphone.	Technically mature, with many operational systems throughout the U.S. and internationally.
Near Field Communications (NFC) Enabled Devices			
Can be used in gated and non-gated systems. Allows integration across transit modes and between transit agencies. Can support visual inspection when paired with mobile ticketing app. Can support customers using compatible ID cards issued by employers, colleges, or gov't agencies.	Supports validators and self-service devices at un-gated stations. May increase efficiency of ticketing by reducing inspection labor.	Market penetration not yet sufficient to be the primary mobile payment technology, but the number of NFC-enabled devices is increasing. Not all carriers may offer NFC-enabled phones.	Secure element technology (device, cloud and host card emulation) is mature.
SMS / Text Message (Visual)			
Cannot be used at fare gates or barriers, which limits regional integration in a gated system.	Same as for Flash Pass (see above).	Can be used by any passenger with a cell phone, including non-smartphones.	Technically mature, primarily internationally, with several operational systems.
Passive Ticketing (Bluetooth Smart, BIBO)			
Can be used in gated and non-gated systems. Allows integration across transit modes and between transit agencies. Can support visual inspection as needed.	Supports validators and self-service devices at un-gated stations. May increase efficiency of ticketing by reducing inspection labor. Requires prior set up and configuration by rider to allow passive interaction.	Not sufficient to be the primary mobile payment technology. Only some riders may elect to allow passive interaction.	Not technically mature, with limited number of systems under development.

Acceptance of Smart Card ID Credentials on Transit

Many of the contactless identification badges issued by private employers, colleges and universities, and federal, state and local governments comply with the ISO 14443 communications standards. This feature could be leveraged to grant cardholders access to a transit system. As discussed in Chapter 3 and Chapter 4, the transit agency's transit fare payment system must be designed to accept open payments in order to accept smart card IDs as fare media since accepting smart card ID credentials require both a standards-based design and an account-based architecture.

The ability to use a contactless identification card for transit services is beneficial in a number of ways. Employers can link their employees' ID cards to a transit payment account, which itself could be linked to a transit benefits account. This would eliminate the need for separate transit benefit vouchers or transit benefit debit cards, and would virtually eliminate the possibility of employees fraudulently selling their transit benefits.

The contactless smart card technology used for federal government ID credentials is compatible with the contactless technology used in transit. As a result of Homeland Security Presidential

Directive 12 in 2004, all federal government employees have been issued smart card identification cards, with identifying information about the employee encrypted on the chip on the card. The cards have both contact and contactless interfaces, and are used for access to computer networks and government facilities.

Specifications for several types of smart card ID's have been developed and are being implemented by public and private organizations. Civilian federal agencies have issued over five million Personal Identity Verification (PIV) cards to federal employees and contractors (see Figure 6-9). Department of Defense employees have been issued a similar card called the Common Access Card (CAC).

Specifications have been developed for credentials of state and local government transit agency employees and employees of companies that do business with government transit agencies called PIV-I (PIV Interoperable) or CIV (Commercial Identity Verification) card. PIV, CAC, PIV-I and CIV cards are all technically interoperable, but are issued using different security policies which vary with the needs of the issuing organizations. A similar smart card credential called the Transportation Worker Identification Credential, or TWIC, is required for anyone needing unescorted access to maritime and port facilities.

In 2012, the Utah Transit Authority (UTA) demonstrated acceptance on transit of ID credentials used by several federal agencies in the Salt Lake City area. The demonstration was very well received by transit users, and the transit authority would like to implement the program throughout the region.[44] The new fare payment systems being implemented by both Washington Metro/WMATA and SEPTA will accept PIV cards as fare media.

In UTA's proof of concept demonstrations, the user ID number on the card was transmitted without any encryption presenting potential risks of the ID number being intercepted by someone trying to "skim" (steal) the number on the card. This risk can be mitigated by using a new communications protocol (OPACITY) that has been developed to provide security for

Figure 6-9.   U.S. federal government PIV card.

contactless payments using government ID's. OPACITY (<u>O</u>pen <u>P</u>rotocol for <u>A</u>ccess <u>C</u>ontrol, <u>I</u>dentification and <u>T</u>icketing with <u>P</u>rivac<u>y</u>) is a series of authentication and security protocols developed to provide secure and high-speed transactions for transit fare payment and physical access to facilities. Contactless smart cards, or mobile devices with secure element chips, can use the OPACITY protocol to prevent the interception or alteration of data during a contactless transaction. The OPACITY protocol will be tested in pilot applications in different use cases for physical access and transit payments.[45]

Payment Convergence for Public Transit and Travel

One of the emerging strategies in public transit is "convergence." Convergence is the combination or integration of payments systems from different transportation modes, payment systems and traveler information systems. One of the objectives of convergence is to integrate route planning, ticketing, payment and travel across all modes of transportation.

Convergence seeks to merge all aspects of travel and transportation, including multimodal public transit, parking, and tolls, by linking together two or more aspects of a traveler's journey. The availability of planning information and real-time data allows travelers to make smarter travel decisions. Some of the goals of a convergence strategy include:

- Integration of travel planning and ticketing across multiple modes, through a single mobile application;
- Demand management, by incentivizing travel through pricing, rewards or credits, social nudges and competition;
- Increasing agency revenue through increased ridership;
- Improving customer service and enhancing the customer experience.

This section explores convergence from the perspective of public transit fare payment systems. It provides examples of convergence programs that have been implemented by transit agencies, as well as other approaches under development or evaluation.

Changing Trends in Travel and Transit

Market research has noted that urban residents like to have choices in how they travel, and the way they make choices is now relatively situational, and not necessarily based on long-standing habits.[46] Transit travelers can easily get information to help them plan a trip, tell them exactly when the next bus or train will arrive, and pay for their trip with mobile ticketing or a mobile device or wallet.

Taking a convergence approach can address changing transportation habits of key demographic sectors of transit ridership. A 2012 study on transportation habits of younger Americans (16 to 34 years of age) found that they are moving away from car ownership towards the use of public transportation and alternative transportation methods.[47] This same population group, which represents an estimated 86.8 million people (28 percent of the U.S. population in 2013) is also the largest group of smartphone users, with over 80 percent reporting smartphone ownership.[48] Among the report's findings were:

From 2001 to 2009, young people (16 to 34-years-old) who lived in households with annual incomes of over $70,000 increased their use of public transit by 100 percent, biking by 122 percent, and walking by 37 percent.

According to a survey by the National Association for Realtors, conducted in March 2011, 62 percent of people ages 18–29 said they would prefer to live in an area with smart growth (defined as a place with a mix of single family houses, apartments, and condominiums, with stores, restaurants, libraries, schools and access to public transportation nearby) as opposed to sprawl.

Improvements in technology make transportation alternatives more convenient. Websites and smart phone apps that provide real-time transit data make public transportation easier to use, particularly for infrequent users. Meanwhile, technology has opened the door for new transportation alternatives, such as the car-sharing and bike-sharing services that have taken root in numerous American cities.

Public transportation is more compatible with a lifestyle based on mobility and peer-to-peer connectivity than driving. Bus and train riders can often talk on the phone, text or work safely while riding, while many state governments are outlawing using mobile devices while driving.

This information suggests that public transit efforts that address convergence between transportation and technology could yield benefits for public transit agencies and customers. The following section offers examples where public transit agencies have partnered with other transportation service providers to offer customers more efficient travel options.

Transit Facility Parking Payment Using Transit Fare Cards

Several transit agencies accept the payment card used on their rail system for parking at rail transit stations. In some cases, like Washington Metro, transit contactless payment cards are sold and accepted for payment at all parking facilities near rail stations (see Figure 6-10).[49] These arrangements are convenient for transit customers, and can help ensure that parking is available at the facilities for transit riders. Some transit agencies give discounts to transit riders to encourage park-and-ride use.

Transit Facility Parking Payment Using Mobile Payment Applications

Some transit agencies, like the MBTA in Boston, have implemented mobile payment systems for park-and-ride lots. Riders can download an application to their mobile device and register with a commercial payment processor. When they park their car, the driver enters the location number into the parking application. Customers can register to receive reminders that tell them when the time covered by their parking payment is ending, and they can add value without having to return to the parking location. The mobile parking application is not integrated with mobile transit payment applications, but commuter rail tickets and passes can be purchased using a different mobile application.

Source: WMATA

Figure 6-10.   Use of SmarTrip fare card at Washington Metro lot.

Reducing Downtown Congestion by Sharing Parking Data

Los Angeles is home to an innovative parking demonstration called ExpressPark. The goals of this program are to make it easier for drivers to find parking spaces, and reduce congestion downtown. In Los Angeles, as much as 30 percent of the traffic downtown at some times of day is people looking for a place to park.

ExpressPark varies parking fees according to demand, and provides information on prices and the locations of available parking via mobile phone applications (see Figure 6-11), or dynamic message signs. Drivers can pay with credit or debit cards or with mobile payment systems. ExpressPark is not integrated with ExpressLanes, which is probably an indication of the challenges of linking programs where the technology investments and revenues are controlled by different transit agencies.

Transit and Toll Payment Convergence: Metro ExpressLanes

In many regions, transportation managers are attempting to better manage transportation demand to reduce congestion. In Los Angeles, a demonstration called Metro ExpressLanes was initiated in 2013 to evaluate different types of travel alternatives. The goal of the demonstration was to "move more people, not more cars."[50]

The LA Metro, in cooperation with Caltrans, implemented a toll system in two highly congested freeways (the I-110 and the I-10), with variable toll charges based upon congestion levels and the number of passengers in the vehicle. The program also provided travelers with other travel choices such as express buses, and made improvements to bike and rail facilities.

Travelers were given the option of linking their toll and transit accounts, and were given incentives to help reduce congestion. For example, if a traveler took 32 transit rides at peak

Source: ParkMe.com

Figure 6-11.   Mobile parking app.

times, they received a $5 toll credit, and the more often they used car pools or took transit, the more chances they had to win gift cards.[51] LA Metro also offered rewards to travelers who referred others to the program, and announced the rewards given on social media.

After one year, the demonstration resulted in increased transit ridership by 14 percent, and 110 new van pools were created. Over $10,000 in toll credits were awarded, and 480 commuters received gift cards. This outcome suggests that incentives, social nudges, and "competition" can motivate travelers to change their behavior. The ExpressLanes program was made permanent in April 2014.

Universal or Linked Transportation Accounts

Account-based payment systems can facilitate convergence of transit and toll payment systems. Different payment media can be used (e.g., transit smart card, toll radio frequency tag), but the travelers' payment accounts are linked. In some regions, transportation planners have envisioned a Universal Transportation Account, which would integrate travelers' payments for any mode of transportation. Agencies could also reduce costs and increase customer convenience by consolidating common functions such as customer service call centers from multiple agencies into a single one-stop-shop provider. An alternative, and perhaps more easily implemented, approach would be to link the travelers' accounts for various modes. This will provide convenience to customers, and the ability to give cross-modal incentives.

The International Organization for Standardization (ISO) Technical Committee 204 for Intelligent Transport Systems currently has a joint study group examining convergence of payment systems across public transit and toll roads through linkage of payment accounts. The group is led by representatives from South Africa and includes key participation from the United States, Norway, Korea, and Japan. The study group's goal is to identify an international standard work item to facilitate convergence, such as development of critical application programming interfaces, business rules, and roles and responsibilities for actors within a multimodal convergence program.

Integration of Transit Mobile Payment Services with Traveler Information and Third-Party Events

Software applications on mobile phones and devices can be used for door-to-door trip planning, enabling the traveler to use a single application to plan, travel and pay for the trip. For example, a traveler could use the planning function of the application to identify which route to take; find out the scheduled departure and arrival times; and get information on the fare or ticket types available. Using the mobile payment and ticketing function application, the traveler would be able to purchase a mobile ticket, and in some instances, might even be able to reserve a specific seat on a particular train. When the traveler arrives at the station, he or she simply displays the mobile ticket and begins the journey.

In some instances, transit agencies have partnered with event organizers, concert venues, and sporting arenas, to deliver mobile ticketing packages that include both a transit flash pass and a virtual event ticket creating a convenient, "one-stop" service for passengers and patrons. In 2014, for example, Dallas Area Rapid Transit (DART) partnered with the organizers of the Texas State Fair to encourage fair goers to use public transit to travel to the fairgrounds. Fairgoers were eligible for a discounted general admission tickets when purchased through DART's *GoPass* mobile transit ticketing application (see Figure 6-12); the *GoPass* application was also used to display the fairground admission ticket.

In technology heavy transit communities such as Boston and San Francisco, transit authorities make operational data available to application developers and sponsor "hackathons" to identify convergence opportunities and stimulate development of new applications.[52]

Source: Dallas Area Rapid Transit

Figure 6-12.   Screenshot of DART GoPass *mobile ticketing app.*

Integrating Transit with Shared-Use Mobility Options

As urban populations grow, a more diverse set of transportation choices is emerging, including bike, car, scooter, electric vehicle and ride-share programs. These transportation choices are being built into our cities using a "complete streets" approach. Many of these services are complimentary to public transit, and provide ways for customers to travel the "last mile" to and from transit stations. More accurate and accessible information on transportation choices is becoming available and delivered to travelers through mobile devices, the internet, and dynamic message signs.

In the last decade, there has been a significant increase in the number of public and private shared-use mobility programs. Programs such as car-share, ride-share and bike-share emphasize transportation access rather than ownership. Studies have shown that transit riders are the predominant users of shared-use transportation programs, which points towards potential for greater integration of transit and shared-use programs payment systems.[53]

One of the fastest growing transportation trends is bicycling.[54] Bike-share programs have started in cities across the country and help solve the "last mile" problem for many travelers by providing a way to get from a transit station to a final destination (see Figure 6-13). Smartphone and mobile applications developed for bike-share programs provide users with real-time information on the availability of bikes and docking stations, as well as route planning advice and payment accounts information. Transit and bike-share payment systems could be linked together, allowing use of either system's payment card on the other's system, or by linking accounts across both systems.

Transit agencies have also established partnerships with car-sharing services, in an effort to address the travel needs of non-car owners. Several demonstration programs have been established, including:

- TriMet, at three park-and-ride locations in greater Portland, Oregon[55]
- Metrolinx, at three GO Transit stations in greater Toronto, Canada[56]
- NJ Transit, at five stations in suburban Northern New Jersey[57]
- Chicago Transit Authority, at five locations in Greater Chicago, Illinois[58]

Source: BCycle

Figure 6-13.   Bicycle docking station and bicycles.

"This is where the idea of having a unified system really starts to make sense," Telles said. "Take the idea of the card with the bike share program the [mobility authority] is developing and you could use the card at a parking meter and also at a bike share station. So with it, you can get a bike, pay for parking, take toll roads and cross the bridges. We are now talking about a unified system where you could pay into one account to use for all these mobility uses."

Raymond Telles, Executive Director
Camino Real Regional Mobility Authority
Las Cruces *Sun-News*, May 24, 2014

Enhanced Data Analytics

"Smart city" infrastructure is expected to grow significantly over the next decade, as communities expand the installation and use of networked information and communications technology. Much of this growth will be in transportation.[59] Both the vast amount and greater variety of data being generated by various transit sources is extremely valuable to transportation planners and managers for service planning and operations management. Use of traditional sources of transit data such as automated passenger counters can be merged with statistical or census data to better understand existing and potential ridership demand in specific service areas (see Figure 6-14).

These sources can be augmented by data generated by transit fare payment systems which use smartcard technology since each smartcard has a unique identifier that allows the agency to track the travel patterns of individual cards. In a zone or distance-based fare system, origin and destination data can be used to describe travelers' entire journey. When flat fares are used, planners typically have been able to see only where trips originate.

Recent research by the Massachusetts Institute of Technology for the MBTA in Boston linked origin data for sequential passenger trips, enabling the transit agency to infer origin-destination trip pairs. This data enables the transit authority to identify the ridership and revenue generated on each part of the transit system by time of day.[60] Account-based fare payment systems may

Figure 6-14.   Transit passenger data, City of Austin, Texas.

also be able to access specific demographic data (e.g., residence address, age, etc.) associated with the transit rider's account.

Chapter 6 Review

- The four major credit card associations are issuing contactless bankcards that can be used as fare media in open payment transit fare payment systems.
- The security of contactless bankcards will increase with the adoption of new EMV security standards in 2015.
- Contactless smartcard technology can be used for prepaid and reloadable payment cards, which are attractive to unbanked and underbanked riders.
- Advances in mobile payments technology, as well as the increased number of smartphones in use, present an opportunity for transit agencies to include smart devices in their fare payment system strategy.
- Identification cards that use smartcard technology can be used at fare media on transit fare payment systems that incorporate an open payments design.
- By incorporating a convergence approach to its fare payment system, a transit agency can integrate route planning, mobile ticketing, and mobile payments across multiple modes of travel, creating a more seamless travel experience.
- Changing travel habits, particularly among residents of urban areas, offers opportunities to integrate transit travel and mobile payment accounts with shared-use programs such as bike-share and car-share.
- The granularity of system-wide traveler data can be improved through the use of smart technology and mobile payments applications.

CHAPTER 7

Next Generation Transit Fare Payment System Case Studies

Introduction

This chapter contains case studies that describe recent next generation transit fare payment system projects from three U.S. transit agencies. Each of the case studies is described in terms of transit fare payment system design and typology, with conclusions and lessons learned with respect to design and implementation.

Case Study 1: Utah Transit Authority (UTA)[61]

Introduction

The Utah Transit Authority (UTA) began operation on August 10, 1970 in Salt Lake County with 67 buses. Today, UTA serves approximately 1.8 million people in a 1,600 square mile service area that stretches over six counties from Payson to Brigham City. It operates a fleet of 520 buses out of four garages, 80 paratransit vehicles, 46 light rail vehicles on four light rail lines over 35 miles, and 63 commuter rail cars and 18 locomotives on a 44-mile commuter rail line. UTA is the regional transit provider for the primary urbanized areas of Utah. Two additional light rail lines and a doubling of commuter rail mileage will be added by 2015.[62,63]

UTA uses a flat fare structure on "local" services—Local Bus, TRAX, and Streetcar. Other pricing exists for "premium" services; express buses are priced at a higher rate and FrontRunner commuter rail uses a distance-based fare structure.

Legacy Transit Fare Payment System and History of Development

UTA started its payment system effort with virtually no legacy in automated fare collection systems, and was therefore free to explore the latest advances and opportunities in fare collection technology. At that time, the payments industry had just announced its launch of contactless media under the brands of *ExpressPay* (American Express), *Zip* (Discover), *PayPass* (MasterCard), and *PayWave* (Visa).[64]

When UTA began its investigation of electronic fare collection systems in 2005, its three primary goals were:

1. Customer convenience/ease of use;
2. Revenue collection efficiency/effectiveness; and,
3. Data capture to inform operations and planning.[65]

> UTA established business goals which drove the payment system design and acquisition.

The ability to accept contactless credit and debit cards for direct payment of transit fares was a decision factor for UTA. They saw several benefits for UTA with this approach:

- Provide convenience to riders who already have contactless financial industry payment smart cards;
- Achieve automatic interoperability with other transit agencies who would accept financial payment smart cards;
- Leverage investments and programs of the payments industry;
- Commoditization of devices;
- Established standards for business rules and security; and,
- Potential for co-promotion with financial sector issuers.

On the system side, UTA technical staff saw that use of an open payments, account-based payment system would give them enhanced architecture flexibility that could simplify system development and modification, with potential cost savings.[66] UTA also felt that an open, account-based payment system would provide advantages to the transit agency and its customers.

Throughout their investigation of fare payment system options, UTA developed additional objectives it felt a new system might attain.[67] These included:

- The potential to move to a distance-based fare (in beta-testing as of late 2014);[68]
- Ease the operators' burden for fare collection;
- Simplify the fare system for both customers and operators; and,
- Reduce the cost of fare collection.

Pilot Project

UTA management decided to pursue an evolutionary approach to their development and implementation of an automated system. In 2006, UTA began an electronic fare collection pilot on 41 ski service buses. The purpose of the pilot was to learn about the development and deployment of such a system by operating it on a relatively small number of buses. Partners included four ski resorts that issued picture passes to their employees on contactless smart cards. The pilot also included acceptance of contactless smart cards issued by the payment brands MasterCard, Visa, and American Express.[69] The pilot objectives were to:

1. Solve an immediate problem—accounting for the use of employee passes issued by and paid for by ski resorts;
2. Learn whether transit fares could be collected using the new contactless credit and debit cards; and,[70]
3. Test the account-based architecture approach.

The pilot was deemed a success. UTA was able to learn about many of the processes that it would need to manage in a full open payment system deployment. The internal and external stakeholders for the system were able to get real-world exposure to the technology. The pilot was continued for another year and UTA decided to develop and deploy an open payments fare collection system on all of its fixed route bus and rail service. UTA's experience with the pilot informed their development requirements for their full-deployment system.[71] These requirements included:

- An account-based architecture, which they felt would ease implementation of fare changes and creation and launch of new fare products.
- Tap-On/Tap-Off to allow UTA to capture origin/destination data, as well as position them to modify the fare structure to a distance-based fare.
- Ability to support its well established third-party paid pass programs associated with employers (Co-op Transit Pass and Eco Pass) (see Figure 7-1), universities (Ed Pass) and, ski resorts (Ski Pass).

UTA used a pilot implementation test to gain experience with open payments.

Source: UTA

Figure 7-1.   UTA Eco Pass card and reader.

- A hosted back office requiring compliance to accept and process financial payments.
- Card validators and readers certified to accept and process contactless financial payment cards.
- Ability to maintain cold and hot lists of card numbers for third-party issued employer and student credentials and financial payment cards.

UTA Transit Fare Payment System Deployment

On January 1, 2009, UTA launched the new system. The UTA system was the first open payments system to be implemented on a U.S. transit system. It included readers at the entrances of 520 fixed route buses and 170 validators installed on 35 TRAX light rail and FrontRunner commuter rail platforms. These readers and validators are connected to UTA-owned and developed wireless communications gateways on buses with both 3G connectivity and Wi-Fi connections at garages and optical fiber to all platforms. Internet links take the transaction data from each device to a back office payment management system hosted by the payment system vendor, VIX Technology.[72]

The initial fare products offered were contactless financial payment cards for single adult fares and third-party paid passes. The system also supported transfers between transit services. Third-party paid passes support UTA's institutional transit programs with local employers, colleges and universities. The Eco Pass is a contactless card that employers issue to their participating employees, the Ed Pass is issued by colleges and universities to their students, and the Ski Pass accepts employee credentials from participating employees of five ski resorts within the UTA service area.[73,74] These contactless smart card products were augmented by the acceptance of cash and coin, tokens, and various flash passes (monthly passes and day passes).

UTA has implemented an open payments, account-based approach that requires only real-time authentication of the contactless medium at their validators. This authentication determines if the payment medium being used is valid. Because of communications delays in some situations, they accept authorization of the transactions several seconds later.[75]

The price of each trip is calculated as the tap-on/tap-off actions are received and then submitted for full authorization and settlement. This authorization determines if the account

holder has sufficient funds or authority to make the payment. If the card is declined, it is hot listed and will not be accepted by the system going forward until the customer arranges for payment for the unpaid trip and card acceptance is restored.[76] UTA was comfortable assuming the "risk of the first tap" because if a transaction is not authorized they immediately hotlist the invalid fare medium and transmit it out to system end-points to prevent further unauthorized transactions.[77]

The system's account-based architecture accepts payment from ISO 14443/NFC-compliant contactless devices to authenticate valid transit riders and access their centrally managed accounts to authorize transit fare payment. Due to the system's centralized nature, a wide variety of NFC-enabled devices can be integrated into the existing system and used to access rider accounts to make a transit payment. Thus, this system is flexible to expand to new NFC-enabled fare media and to link a UTA customer account to an account in another transportation system, such as a toll system. Therefore, if UTA and the Utah Department of Transportation come to an agreement, it is feasible to link a customer's transit payments and toll fees through their central accounts.[78,79]

> Account-based architectures facilitate convergence of transit and toll accounts, enabling a multi-modal approach to regional travel demand.

An account-based architecture requires constant (or near-constant) communication between the on-board reader units and the centralized account to authorize payment transactions as quickly as possible. UTA readers on buses communicate with the central system using secure 3G communications. When operating on a bus, there is concern of the bus "dropping" out of contact with the account, adversely affecting the system.

To facilitate payment validation for off-line operation, each bus reader stores a "hotlist" and a "coldlist" of contactless media that is updated every 2–3 minutes when the reader is connected to the centralized system. Hot lists are lists of cards that are known to be *unauthorized* for use at the UTA system (due to non-payment of the last transaction). Cold lists are lists of Eco Pass, Ed Pass and Ski Pass credentials that are known to be *authorized* for use on UTA's system (essentially active employees or students of the businesses, universities, or ski resorts that are part of the these UTA institutional pass programs).[80,81]

UTA leaders believe they have a system that uses a "flexible, agile architecture" that allows them to continually evaluate and implement their fare policy and structure as well as new fare medium technologies without excessive integration.[82]

UTA Transit Fare Payment System Developments

Continual Experimentation

Today, UTA operates their account-based, contractor-hosted system and accepts a variety of transit fare payment media. They accept passes for employees, students and resort customers under their Eco Pass, Ed Pass, and Ski Pass programs. They also accept contactless credit and debit cards and the Google Wallet mobile applications. The system is still augmented by payment by flash passes and cash.

Since the launch of their system, UTA has continued to evaluate and introduce new transit fare payment options. Among those studied and developed to various stages include:

- Special fares for seniors and disabled individuals;
- Open loop prepaid partnerships;
- Contactless co-branded cards;
- Acceptance of government benefits distribution cards;
- System-wide pay-per-trip distance-based fares;
- Acceptance of federal government Personal Identity Verification (PIV) cards for administering employee transportation benefits; and
- Use of third-party access and identity media for prepaid or post-paid payment per trip.[83]

A proof of concept demonstration of accepting government-issued PIV identification credentials was conducted in 2012. This demonstration involved six federal agency partners and 36 employees. The technical approach was to simply read the unique Identification Number (UID) of the employees' PIV and CAC cards and compare to a cold list of the 36 trial PIV cards. There was no secure data exchange between the PIV and CAC cards and UTA readers.[84] UTA would like to accept federal credentials in the future, as it would reduce the number of fare media issued, simplify administration of transit benefit programs and reduce the potential for fraud in benefit programs.

UTA also has been involved in a mobile payments demonstration since October 2012 with Softcard (formerly known as "Isis Wallet"). Softcard is a mobile wallet developed and managed by AT&T, T-Mobile and Verizon. As part of the launch to raise awareness with customers, Softcard offered free rides on bus, TRAX and FrontRunner services for anyone using mobile payments through Jan. 31, 2013. Customers tap the mobile payment device to the contactless logo on a reader. The system automatically recognizes the type of card/device and responds accordingly.[85] Softcard used the Salt Lake City, UT pilot and a second pilot in Austin, TX to move to a nation-wide rollout in November 2013.[86]

Limited Penetration of Open Loop Media

UTA's system cannot distinguish between transactions using contactless credit/debit cards, Google Wallet or Softcard applications. Therefore transaction volumes of the mobile wallet applications fall within the contactless financial card transactions that UTA observes. To date, these various open loop financial media transactions are only 1 to 2 percent of their total transaction volume. This has been constant throughout the life of the system. Some reasons they see for this lack of penetration are:

1. UTA did not pursue a major marketing campaign targeting acceptance of contactless bank cards; and,
2. There has not been extensive issuance of contactless cards by financial payments industry in the region.

Development of FarePay

Since acceptance of contactless credit and debit cards mobile wallet payment applications has accounted for only 1 to 2 percent of UTA's transactions, UTA explored its options for closed loop transit smart cards.[87]

UTA investigated gift cards and closed loop prepaid cards (i.e., a transit agency smart card), and had vendors demonstrate the technology at the transit authority. This information informed their decision to pursue a third-party contactless payment card solution; essentially, they believed that a transit card could be sold like a gift card. They evaluated general purpose reloadable cards which could be used for any type of purchase, as well as a closed loop transit card approach which could only be used on transit.

They chose to develop a closed loop prepaid card program in order to minimize any costs for their customers, such as fees for card reload and carrying balances often associated with third-party prepaid reloadable cards. UTA wanted to leverage the capabilities of the prepaid card industry, however. They decided to engage in a contract for the card issuance and management as well as development of a third-party sales network.[88]

In October of 2013, UTA launched the UTA FarePay card. It is a transit-only prepaid contactless smart card that interfaces with existing contactless readers in their system. The UTA's account-based architecture facilitated introduction of the prepaid card. The UTA FarePay card

utilizes contactless technology to interface with NFC readers installed on transit vehicles that link riders to their account when making transit payments. Transit riders must pre-load their UTA FarePay accounts.

UTA's initial contact was with InComm, a company that manufactures, issues, and manages the FarePay cards. They arrange for sale of the cards in a merchant network of locations in the Salt Lake City area. At rollout, there were 30 locations, and that network has grown to approximately 250 locations in 6 months. The FarePay card is sold for $3.00 to cover the costs of card manufacturing, distribution, and management. Customers can load value at retail locations in the distribution network or on the FarePay website with no fees. They are not charged a fee for carrying a balance; all customer funds are available for paying UTA fares. The cards are initially anonymous. UTA has no interest in collecting personal information about riders. However, customers can register the card to be eligible for balance protection if their card is lost or stolen, and FarePay's auto-reload feature.

UTA gave incentives to its customers to use FarePay by offering a 20 percent fare discount ($2.00 versus $2.50). UTA has seen a very strong penetration of FarePay among their customers that use contactless media. In the first 6 months, FarePay has become 5 percent of all "taps" on the UTA system. UTA sees this as a significant penetration, given that the Eco, Ed, and Ski Pass options are approximately 50 percent of all taps. UTA sees that FarePay has quickly surpassed all other open loop media use. UTA is now evaluating its strategy for moving customers to contactless media, and FarePay is a key element of their future plans.

Working Towards Real-Time Transaction Authorization

The FarePay program has highlighted the need for UTA to attain real-time authorization of all transactions in their system. Prior to the rollout of FarePay, the vast majority of their contactless media (50 percent of all system transactions) are third-party passes under their Eco Pass, Ed Pass, and Ski Pass programs, so their risk exposure was seen as quite limited. However, since the rollout of FarePay, UTA is now actively driving their customers from flash passes to contactless media. Since FarePay is a prepaid instrument, UTA feels they must reduce risk by trying to do real-time authorization within 0.5 seconds. UTA now observes that virtually 100 percent of rail transactions and greater than 75 percent of bus transactions achieve authorizations within 0.5 seconds.[89]

Conclusions and Lessons Learned

The initial motivation for UTA to accept open loop contactless credit and debit cards led them to implement an account-based, open payment architecture (see Figure 7-2). UTA
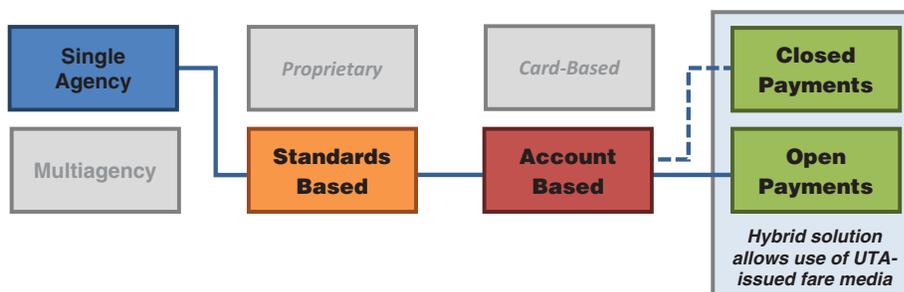
Figure 7-2.   Utah Transit Authority payment system design typology.

feels this system architecture gives them the flexibility to enhance and expand their customer offerings to provide more choices and enrich their customers' experience on UTA. UTA managers feel that the account-based architecture enables them to make fare policy changes more simply than a card-based architecture, and with minimal cost. They feel that they are better positioned to be able to implement strategies such as a distance-based fare structure. They feel that distance-based fares may benefit riders who take shorter trips by actually lowering their fares.

UTA took a very deliberate approach in the development and implementation of its payment system, opting to do pilot tests and demonstrations that they evaluated prior to full system deployment. UTA also developed a relationship with their payment system vendor which included co-ownership of any intellectual property for the payment system software. UTA feels that this allows them opportunities to partner with new organizations and to develop their system as they see fit.

UTA managers report that these two elements give UTA the flexibility to achieve their payment system goals and enhance their customers' experience. They feel that their system is future proofed, meaning that new approaches, such as mobile applications, acceptance of credentials, and other new technologies can be leveraged as long as a compatible communications interface is used.

UTA management has taken a deliberate and strategic approach to leveraging their payment system to achieve policy goals. They structured the payment system evolution to:

- Train their customers who use contactless media to tap-on and tap-off, which has positioned them to both capture boarding and alighting data for operational use, and position the transit agency to potentially move to a distance-based fare.
- Continually evaluate payment technologies and approaches, such as acceptance of PIV credentials and demonstration of Google Wallet and Softcard mobile NFC-based payment applications.
- Continually evaluate payment options for unbanked and underbanked customers. This approach led to the development of the FarePay closed loop transit card, which UTA feels fits customer needs and will be a mainstay of their future system.

Source: UTA

Figure 7-3.   UTA light rail station and commuter train.

Case Study 2: Southeastern Pennsylvania Transportation Authority (SEPTA)[90]

Introduction

The Southeastern Pennsylvania Transportation Authority (SEPTA) is a transit agency of the Commonwealth of Pennsylvania, created by the state legislature in 1964. SEPTA is the nation's sixth-largest public transportation system. SEPTA took the assets of multiple bankrupt private companies and shaped them into a vital public transportation network managed by a single transit authority focused on meeting the travel needs of the region. SEPTA is a vital regional asset, with a service area that includes the heavily populated southeastern Pennsylvania.[91]

Today SEPTA serves the city and county of Philadelphia, as well as Bucks, Chester, Delaware, and Montgomery counties, a total area of over 2,200 square miles and a population of 4 million.[92] SEPTA service also extends to Trenton and West Trenton, New Jersey, and Newark, Delaware. Systemwide, SEPTA recorded 337.3 million trips during Fiscal Year 2013 and approximately 1.4 million unlinked passenger trips were generated each weekday. SEPTA has an average weekday ridership of over 1.0 million trips.[93]

SEPTA is a multimodal transit system as it provides a vast network of fixed route services including 118 bus routes, a subway and subway-elevated line, 13 regional rail lines, 8 trolley lines, 3 trackless trolley routes, an inter-urban high-speed rail line, and customized community service (see Figure 7-4).

SEPTA Railroad Operations serves all five counties with approximately 126,000 unlinked passenger trips on commuter rail per weekday in Fiscal Year 2013. This service also operates in Newark, Delaware and to Trenton and West Trenton, New Jersey. SEPTA set a new Regional Rail ridership record, with 36,023,000 trips taken by customers during Fiscal Year 2013. Regional rail ridership has increased by 50 percent over the last 15 years. Approximately 30 percent of Regional Rail passengers utilize other SEPTA services, driving the vision for a comprehensive payment system with common fare media.

Suburban Operations (Victory and Frontier Divisions) provide service in the suburbs, north and west of the City of Philadelphia, with a network of 46 bus, trolley, and heavy rail routes providing approximately 74,000 unlinked passenger trips per weekday in Fiscal Year 2013. Customized Community Transportation (CCT) serves Philadelphia and the surrounding counties and schedules approximately 7,300 customized weekday trips for seniors and persons with disabilities.

SEPTA's four small bus circulator routes and shuttle services connect fixed route operations to business, retail, health and educational centers, as well as to park-and-ride facilities. In Fiscal Year 2013, these services provided transportation for approximately 4,400 passengers per weekday.[94]

Source: SEPTA

Figure 7-4.   SEPTA rail systems map.

SEPTA Fare Payment System Evolution

The legacy SEPTA fare payment system has been in existence for decades. For all modes except commuter rail (Regional Rail), a flat fare system is used with paper transfers available for purchase. Regional Rail uses a zonal fare structure and passenger fares are paid to or validated by conductors on-board trains.

The transit system accepts read-only magnetic stripe fixed-calendar daily, weekly, and monthly passes for both transit (*Transpass*) and railroad (*Trailpass*). Cash, coins, and metal tokens as well as paper transfers are also accepted. Regional Rail passengers can pay with cash and coin, a single trip or 10-trip tickets, or weekly and monthly passes that the conductor verifies by sight.

SEPTA examined a fare system upgrade in the 1990s and considered the card-based, proprietary read-write magnetic systems of the day. While the timing was never right for a procurement of a new fare payment system, SEPTA management and staff kept abreast of payment system developments and technical advances and continued to operate its legacy system.

Events changed beginning in 2008 when the SEPTA system was subject to spare parts shortages and the end of the system's useful life was at hand. The reliability and functionality of the existing fare collection system could not be improved due to the age of the electronics and limitations of the existing computer operating system. Also, a portion of the collection process relied heavily on manual procedures.[95]

Additionally, the legacy fare payment system was deemed to be a barrier to transit use. While frequent riders learned to navigate the current system, first time and infrequent riders often found the system confusing and challenging to use. Many expressed frustration about payment methods that vary by mode and the often cumbersome process of purchasing tokens and paper tickets and transfers.[96] Due to these issues, SEPTA staff began to actively plan for a new fare payment system.

SEPTA's Next Generation Fare Payment System: New Payment Technologies

SEPTA management and staff were very aware of transit payment systems technical and business developments through involvement in industry conferences such as the APTA and the Smart Card Alliance as well as peer-to-peer information sharing. This knowledge of the state-of-the-art of payment systems allowed SEPTA staff to focus their efforts quickly in the planning process that began in earnest in 2008. The business drivers for the move to the New Payment Technology (NPT) were:

1. Replace SEPTA's old fare system which was at the end of its useful life;
2. Use an account-based system to achieve more control for rider convenience and allow customers to get "maximum value for their riding dollar";[97]
3. Leverage advancements in fare payment technology and approaches that offer more options to customers and SEPTA; and
4. Build a state-of-the-art system with a limited availability of capital funding.

> Transit agency officials stayed abreast of payment system developments outside the transit industry through industry conferences and other avenues.

SEPTA staff concluded that there were two general approaches available in the 2008 timeframe: "a proprietary, card-based approach, and an open system approach using cards issued by financial institutions, as demonstrated in the New York MTA pilots that had taken place over in the late 2000s." SEPTA also had "a motivation to bring in tried and tested elements so riders know them from payments they use in their daily lives."[98]

Ultimately, SEPTA management selected the standards-based, account-based, open payments typology (see Figure 7-5). They have opted for a hybrid solution that will allow both closed transit media as well as open loop contactless financial payment cards, with potentially mobile payment applications, thus expanding payment options for passengers.

SEPTA management was very aware of technical and business developments in the financial payments industry. Since financial payment cards were a key fare payment option in the new
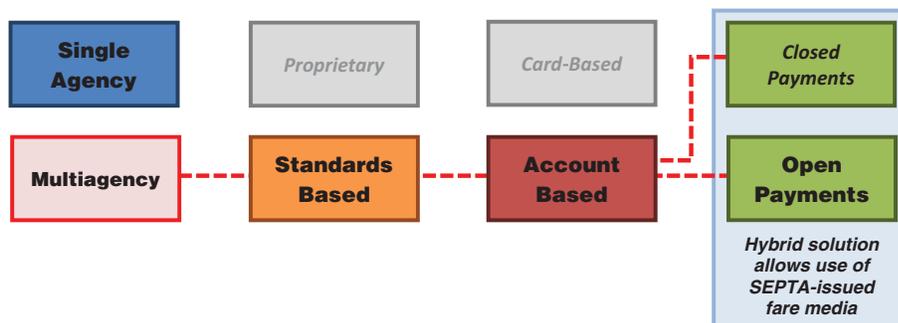

Figure 7-5.   *SEPTA fare payment system design typology.*

system, SEPTA required compliance with EMV standards. EMV is a technology that includes a smart card chip and requires a user PIN for purchases to help protect personal and transaction data. EMV chip technology is becoming the global standard for credit card and debit card payments. Named after its original developers (Europay, MasterCard and Visa), this smart chip technology features payment instruments (cards, mobile phones, etc.) with embedded microprocessor chips that store and protect cardholder data. This standard has many names worldwide and may also be referred to as: "chip and PIN" or "chip and signature."[99]

Procurement Approach

The payment system program was complicated by limited availability of capital funding, thus SEPTA officials sought to leverage public-private partnerships to build their new fare payment system. SEPTA determined that the procurement approach would be to do a Design, Build, Operate, and Maintain (DBOM) that would outsource all or selected fare payment functions. SEPTA eventually chose Xerox (specifically ACS, a Xerox Company) to deliver the new system in November 2011. Financing for the project was through a unique financing approach that accumulated international investment through individuals and businesses.

NPT Program Implementation Approach

SEPTA worked with their contractor Xerox to plan the design, build and rollout of the NPT program. Updating the fare collection system is a large undertaking that will span several years. The NPT installation project is divided into three phases, with completion expected by early 2016.[100]

Phase I.   Design, testing, and manufacturing
Phase II.   Transit installation (bus, trolley, subway)
Phase III. Regional rail installation

SEPTA and Xerox are completing the design, testing, and manufacturing stage of the project. There have been challenges merging legacy systems with the NPT program back-office functionality such as reports, accounting, and general ledger applications. The project is currently in the process of installation with new goals of beginning a pilot test of the system that includes SEPTA and Xerox employees and other stakeholders to test all payment options, interfaces, and the process of ordering, delivering, activating, personalizing, purchasing fare products and using fare media.

The next step after the pilot test is a "soft-launch"/beta test where installation will increase from 10 percent of the system to 50 percent. At this level, the system will officially launch and continue towards 100 percent installation. During this transition, SEPTA requires that the legacy payment system and new payment system are both available for customer use. At a point to be determined, SEPTA will cease issuance of legacy fare media. Bus passengers can still pay cash or use the new payment system media.

The final phase of the installation is to adopt the new fare payment system on its Regional Rail commuter system. This service mode operates 13 lines running to more than 150 active stations, using a zone or distance-based fare program. It also employs a conventional, open boarding and full conductor inspection approach for fare payment and collection. SEPTA has selected a hybrid model for this service mode, combining barrier and non-barrier approaches.

Five of SEPTA's Regional Rail stations are located in downtown Philadelphia and serve as the origin/terminating point for more than 90 percent of all trips. At these stations, SEPTA will install 375 gates and require a tap-in or a tap-out by Regional Rail passengers to collect fares. For non-downtown stations, validators will be installed at all Regional Rail platforms at which passengers will tap-in or tap-out. Conductors will focus their responsibilities on train operations,

> Pilot tests allow the transit agency, vendors, and riders to ensure functionality and identify issues prior to full system-wide implementation.

while performing limited on-board inspections, selling single fares and allowing passengers to replenish their accounts. For SEPTA, this hybrid barrier/barrier-free model for commuter rail was a cost-effective solution.

New Fare Media

The new system will accept both bank and non-bank-issued payment media that comply with the ISO 14443 contactless interface standard. The agency issued fare media will be a general purpose reloadable MasterCard-branded contactless smart card valid across all SEPTA services. Riders may choose to use the card only for transit fare payment purposes (pass purchase, stored value, etc.) as well as a general purpose reloadable card allowing regular debit card purchases. In addition to web-based and telephone center sales, channels for cards sales include vending devices at downtown rail stations, agency sales locations and over 1,000 retail locations throughout the service area. Customers can also add value or products to their accounts through vending machines, a website, or by enabling "subscriptions."

The SEPTA-branded, transit-only card is a key element in SEPTA's strategy as it gives them a greater level of control over the fare media and the ability to add customers. Agency issued cards can be linked to a customer's credit/debit card or bank account to provide automatic value add when needed. SEPTA officials have seen the success of E-ZPass at using this automated value-added approach in the toll industry and built it into their new payment system. In addition, SEPTA has outsourced the provision of its agency branded fare card to a prepaid card manager in a revenue sharing agreement that intends to provide a significant new revenue stream to the agency.

Future Payment Research

SEPTA is still in the midst of fielding their new fare system, thus their attention is fixed on its successful launch and operation. However, management and staff remain aware of advancement in the payment industry that can impact their system. SEPTA requires EMV compliance, so the design will welcome EMV chip cards as they become available in the United States.

SEPTA also sees mobile payments as a potentially beneficial option for their customers. They are aware of these developments and believe their system will be ready to accept mobile payment applications. Future pilot programs for mobile payment applications or EMV are not planned until the core system is fully functional. SEPTA feels that their decision to move forward with an account-based technical architecture that allows flexibility at the front-end devices (fare gates, validators, and fare boxes) will keep it nimble enough to examine and accept payment types as they become available in the industry.

Case Study 3: Whatcom Transportation Authority (WTA)[101]

Introduction

Whatcom Transportation Authority (WTA) provides public transportation services throughout Whatcom County in Northwest Washington State approximately 100 miles north of Seattle. WTA serves the city of Bellingham as well as the smaller towns and communities of Ferndale, Lynden, Blaine and Birch Bay, Lummi Nation, Sudden Valley, Kendall, Everson, Nooksack, and

Sumas. WTA also cooperates with Skagit Transit in neighboring Skagit County, to provide service between Bellingham and Mount Vernon. Service is offered seven days a week, with more limited service on Saturdays, Sundays and evenings. Services include:

- 60 fixed route buses (including eight hybrid electric buses) that provide 4.9 million fixed route boardings, or approximately 17,000 boardings per weekday;
- Specialized transportation: 37 minibuses providing 600 paratransit trips per weekday;
- Vanpool program: 39 vanpool vans; and
- Four transit centers: Bellingham Station, Cordata Station (in North Bellingham), Ferndale Station and Lynden Station.

WTA's fixed route service includes a network of four high-frequency corridors within Bellingham. WTA plays a major role transporting students to and from Western Washington University; students comprise 38 percent of fixed route ridership. Between 2002 and 2012, WTA ridership increased by 84 percent and in 2008, WTA was recognized by the Federal Transit Administration *for achieving the highest annual ridership increase in the nation.*

WTA's mission is to enhance its community by:

- Delivering safe, reliable, efficient, and friendly service.
- Offering environmentally sound transportation choices.
- Providing leadership in creating innovative transportation solutions.
- Partnering with our community to improve transportation systems.

Legacy Transit Fare Payment System and History of Development

WTA collects fares on its 60 fixed route buses at GFI fare boxes. WTA's cash fare is $1.00 per ride within Whatcom County and $2.00 when traveling between Whatcom and Skagit counties. Fare media accepted includes cash, tokens, and magnetic stripe monthly, quarterly and annual passes (as well as reduced and student monthly and quarterly passes). WTA has a network of retail sales locations as well as a web portal (note: web portal at http://www.ridewta.com/store only sells full fare passes and tokens).

Due to its proximity to Seattle, WTA has the ability to join with the Sound Transit ORCA program. They chose not to join due to a very small passenger crossover with ORCA, the fact that Skagit county is a buffer between Whatcom County and the ORCA program service area and Skagit is not joining ORCA, and finally anecdotal evidence that costs to join and participate in ORCA were higher than WTA was willing to pay. Kitsap County does belong to the ORCA program, but adjoins the ORCA service area.

WTA began to investigate a transit fare payment system upgrade. The driving element of their planning was the need to replace existing fare boxes reaching the end of their life. WTA had Urbanized Area Formula Funding program (49 U.S.C. 5307) funds[102] that they programmed for this capital improvement. They decided to piggyback their smart card solution on top of the farebox upgrade.

WTA had the following technical goals for their new fare system:

- Replace obsolete fare boxes,
- Develop new pass distribution processes,
- Offer new fare options, and
- Improve data management.

WTA established business goals which drove the payment system acquisition.

WTA also had business goals they wished to achieve. Among them was the desire to future-proof their system, so it could support fare policy adjustments such as distance-based fares as well as support the use of stored value cards and potentially bank cards. They wanted a system that used readily available commercial hardware (e.g., fareboxes), that could be provided by a single vendor.
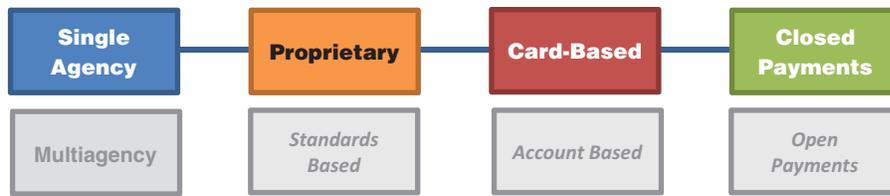
Figure 7-6.   Whatcom Transit Authority fare system typology.

WTA's main fare media objective was to migrate away from flash pass. This would address their goals for data capture as well as new fare options. They wanted to transition monthly or quarterly passes to "rolling" passes that are 31-day or other timeframes that begin when the customer first uses them. This will alleviate sales surges at the beginning of the month. Migrating from a flash pass also eliminates driver conflict issues by making the acceptance or rejection of the fare card the role of the reader.

Ultimately, WTA determined that a proprietary, card-based, closed system was the best solution to their needs (see Figure 7-6).

Request for Proposal (RFP) Process

WTA used RFPs from Sun Tran in Tucson, Arizona and the Spokane Transit Authority (STA) as templates. Their main requirement of a farebox upgrade steered their process and resulted in three proposals.

WTA selected the GFI proposal (see Figure 7-7). The new fare system features include new GFI Odyssey fare boxes and a card-based smart card solution. The total project cost for new fare

WTA obtained information from their peers on payment system acquisition and implementation experiences.

Source:www.ridewta.com

Figure 7-7.   Whatcom Transit Authority new farebox.

boxes with a smart card fare system is $2M of which the farebox upgrade was $1.5M. The fare media will be pass-based with no stored value product initially. The pass types include 1-day, 31-day, 90-day, annual, and an 11 ride ticket for $10.

The tentative project schedule included three key milestones:

- Mid-April 2014: replace fare boxes.
- Late summer 2014: new fare configuration and launch of smart card.
- Fall 2014: launch of web portal (www.ridewta.com).

Lessons Learned and Fare System Implications for Small Transit Agencies

Through their experience in their procurement, WTA officials identified several implications for small transit agencies that wish to upgrade their transit fare payment systems. WTA officials believe that once they implement their system, they may be a model for other small transit agencies in Washington State. They feel that their experience can inform other future fare system procurements. They stated that they gained valuable insights through peer-to-peer exchange with other smaller transit agencies. One point that they cited is that small, bus-only transit agencies must focus on the farebox as their primary need and let that drive their fare system procurement.

When a farebox replacement is placed at the forefront of fare system planning and implementation, the group of vendors and the approach to a contactless smart card solution is pared down considerably. WTA officials believe proposals for small transit agencies that lead their fare system procurements with a farebox replacement are limited due to two factors:

1. The limited number of farebox vendors; and,
2. The limited number of vendors with a combination of proven farebox technology and a deep smart card system integration ability (including back office, web portal, etc.).

Their perception was that larger system integrators who might be able to offer open, account-based payment systems do not have an offering for small transit agencies, and farebox vendors have limited system integration capabilities. Therefore, they feel that the closed, card-based architecture may be the only real option available for small transit agencies at this time. They feel that the single transit agency, closed payment system, card-based smart card solution using readily available commercial hardware equipment fits their needs well.

CHAPTER 8

Evaluating Public Transit Fare Payment System Typologies and Implementation Strategies

Chapter Overview

This chapter draws together the information provided throughout this report, in order to provide some comparisons and evaluations of different fare payment system design options. It will also identify some best practices and implementations strategies for transit agencies to consider when adopting a next generation fare payment system.

Evaluating Options

As identified in Chapter 4, there are four next generation transit fare payment system typologies, which can be used in both single- and multiagency transit environments:

- Proprietary, Card-based, Closed Payment Systems
- Proprietary, Account-based, Closed Payment Systems
- Standards, Account-based, Closed Payment Systems
- Standards, Account-based, Open Payment Systems

Each of these typologies will be evaluated according to goals and criteria discussed earlier in the report, including: how different fare payment system typologies can achieve fare payment system goals; compatibility of fare media with different fare payment systems; and the capacity of different typologies to adapt from a single transit agency to a multiagency environment

Capacity to Achieve Fare System Goals

As described in Chapter 2, the process of implementing a new transit fare payment system should involve a broader review of the transit agency's strategic goals. This allows the transit agency to identify the strengths and weaknesses of its current fare payment system, which in turn can guide the selection of features and capabilities in the new system. At a minimum, the new fare payment system must replicate all of the desired functionalities of the current system: the "same model car, only newer model year" approach.

Most transit agencies are likely to want to "upgrade to a better model" that incorporates new functionalities and capabilities in their next generation transit fare payment system, which meet defined customer needs and agency requirements. Will those additional capabilities come with a significant cost? If so, how will a transit agency official support and defend the decision to replace current technology with a next generation system? Table 8-1 provides a relative comparison of the four next generation fare payment system typologies and how each typology can be used to achieve the fare payment system goals identified in Chapter 2.

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Table 8-1.   Comparison of next generation fare payment system typologies to achieve fare payment system goals.

Fare Payment System Goals	Proprietary, Card-based Closed Payment	Proprietary, Account-based Closed Payment	Standards, Account-based Closed Payment	Standards, Account-based Open Payment
Increased customer convenience: Use of contactless smart cards	Faster entry/exit than traditional fare media such as mag stripe		More options through use of smart devices or contactless bankcards	
Increased customer convenience: More fare media options	Fare media options limited to agency fare card or mobile tickets		More fare media options such as rider owned smart devices and bankcards	
Achieve seamless travel across all transit modes of own system	Requires use of compatible fare media across all transit modes.			
Achieve seamless regional travel with partner agencies	Requires use of compatible fare media across all modes of multiple transit systems, or use of account-based fare system.			
Increase fare options and pricing flexibility	Less capable for changes to rules	Account-based systems allow easier changes to fare rules and pricing structure.		
Ensure smooth implementation of new fare payment system	Proprietary systems have a successful history of fielded use.		By thorough planning, testing and effective implementation	
Improve reliability of fare equipment	Use of contactless fare payment media reduces maintenance costs.			
Reduce fare collection costs	Proprietary systems rely upon transit agency-issued fare media		Reduces fare media issuance costs by allowing use of rider owned media	
Reduce fare abuse and evasion	Relies upon security of proprietary devise and systems		Through use of secure financial payment media as fare media	
Reduce use of cash	Fewer options for use of non-cash fare payment media		More options for use of non-cash fare payment media	
Increase prepayment	Through use of prepaid fare media			
Improve revenue control and accountability	Through use of automated fare collection and payment technology			
Improve fare revenue allocation in multi-operator system	Relies upon capability of proprietary systems		Through use of financial payments industry standards-based systems	
Improve data collection and reporting	Limited capability	Through use of rider-specific data made available through account-based systems		
Upgrade using forward-capable technology	Uses existing technology		Applies advancements in technology from other industries	
Flexibility in hardware replacement and lifecycle renewal	Relies upon proprietary hardware and software		Allows open source and commoditization of components	
Reduce system complexity	Relies upon proprietary hardware and software		By commoditizing front-end devices or use of COTS software	
Get out of payments and settlements business	Transit agency must process all payments			Through use of open payments
Increase ridership thru improved convenience and rider experience	Requires use of agency-issued fare media		Allows use of fare media already in possession of rider	

Compatibility of Fare Media

Another consideration is the compatibility of fare media with various fare payment system typologies. Table 8-2 lists five forms of fare media typically considered as part of a next genera-tion transit fare payment system, and indicates whether they are compatible with each of the four fare payment system typologies.

- Where fare media compatibility is shown as "Yes," the ability to use that form of fare media is inherent in the fare payment system typology.
- Where fare media compatibility is shown as "Possible," the use of that form of fare media for the given typology requires compatible front-end hardware, as well as software programming at the back end to adjust fare processing rules to ensure that the given fare media are accepted when presented to the front end.

Table 8-2.   Compatibility of fare media with next generation fare payment system typologies.

Transit Fare Payment System Typology	Contactless Transit Agency Fare Media	Contactless Bankcard	Contactless ID Card	Contactless Smart Device	Mobile Ticketing Application	Mobile Payment Application
Proprietary, Card-based, Closed Payment	Yes	No	No	Possible	Possible	No
Proprietary, Account-based Closed Payment	Yes	No	Possible	Possible	Possible	No
Standards-based, Account-based Closed Payment	Yes	No	Possible	Possible	Possible	Possible
Standards-based, Account-based Open Payment	Yes	Yes	Yes	Yes	Yes	Yes

Adaptability from Single Agency to Multiagency

A single transit agency seeking to replace its aging or obsolete fare payment system should consider the compatibility of its next generation fare payment system with the fare payment systems of neighboring transit authorities, in order to improve regional mobility through seamless travel across multiple systems. To accomplish this goal, there are two approaches: (1) use of a single fare payment system by all transit agencies within the region, or (2) use of multiple fare payment systems that are compatible with one another.

Consequently, the ability of a fare payment system typology to expand from a single agency system to a multiagency environment is an important consideration. As shown in Table 8-3, each of the four typologies described in Chapter 4 have different capacities to expand.

The most difficult transit fare payment system to adapt from a single to a multiagency environment is the proprietary, card-based, closed payment system, since it requires that each participating transit agency must purchase the same fare payment system. This can be problematic, whether due to budgetary constraints, or individual agency preferences. Further, there is no guarantee that equipment and software purchased today will be available in three or five years, or whether a system manufactured two years ago will be compatible with a system offered today, even if from the same system provider.

In contrast, a standards-based, account-based, open payments system is universally compatible with other standards-based, account-based, open payments systems. Individual agencies can continue to use their own hardware and agency-issued fare media. In order to accommodate additional agencies, changes are primarily made at the back end, in each agency's central computer, to ensure that fare revenue is properly allocated for travel between two or more transit systems.

Table 8-3.   Adaptability of next generation fare payment system typologies from single agency to multiagency.

Transit Fare Payment System Typology	Adaptable from Single Agency to Multiagency	Considerations and Challenges
Proprietary, Card-Based Closed Payment	Limited	• All participating transit agencies must acquire the same fare payment system (hardware and software). This requires that each participating transit agency follow the same fare policy and fare rules. • Fare revenue must be collected and managed by a lead agency or central transit authority and allocated among participating agencies based upon inter-agency business rules that account for travel entirely within a single transit system or between two or more transit systems.
Proprietary, Account-Based, Closed Payment	Limited	Same as for Proprietary, Card-Based, Closed Payment systems
Standards-Based, Account-Based Closed Payment	Yes	• Participating transit agencies may acquire any standards-based fare payment system, including any compatible hardware and software. • Fare revenue can be collected by a lead agency or central transit authority as described above (this is the most common). Alternatively, individual transit agencies could maintain accounts for those riders that primarily use that agency's transit system; in this case, fare revenue for travel across one or more transit systems would be distributed from the collecting transit agency to other agencies according to inter-agency business rules.
Standards-Based, Account-based Open Payment	Yes	• Participating transit agencies may acquire any standards-based fare payment system, including any compatible hardware and software. • Fare revenue can be collected by individual transit agencies, or by a lead agency or central transit authority. Fare revenue for travel between two or more transit systems would be allocated according to inter-agency business rules.

Compatibility of Transit Fare Payment System Designs with Convergence Strategies

Although convergence is still in its infancy, the approach is gaining interest among leaders within the transit, urban planning, and regional transportation communities. Consequently, a transit agency contemplating an upgrade to its fare payment system should consider whether their new fare payment system is able to support future implementation of a convergence strategy. Table 8-4 compares the fare payment system typologies identified in Chapter 4 with some common approaches of convergence. One can conclude that a next generation transit fare payment system that incorporates an account-based approach that supports smartcards and mobile payment applications provides two essential building blocks upon which a transit agency can build a seamless "plan-travel-pay" environment for the 21st century transit customer.

• Where compatibility is shown as "Yes," the transit fare payment system typology is capable of supporting the convergence strategy.

Table 8-4.   Compatibility of transit fare payment system typologies with typical convergence strategies.

Transit Fare Payment System Typology	Parking with Transit Smart Card	Linked Transit and Toll Program	Linked Transit and Bike-Share Program	Linked Smartphone Application for Transit, Travel, Events
Proprietary, Card-based, Closed Payment	Yes	No	No	Possible
Proprietary, Account-based, Closed Payment	Yes	Possible	Possible	Possible
Standards, Account-based, Closed Payment	Yes	Yes	Possible	Possible
Standards, Account-based, Open Payment	Yes	Yes	Yes	Yes

- Where compatibility is shown as "Possible," the transit fare payment system typology could support the stated convergence strategy, but it would require close coordination between each service provider, to establish the necessary back-end business rules such as access, authorization, revenue collection and allocation, etc.

Implementation Strategies and Best Practices

Transit fare payment systems, as well as mobile payment technologies, are evolving rapidly, and transit agencies have many new technology options to enhance the ways that they collect fares and provide improved services to their customers. Each of the case studies presented in Chapter 7 provide good examples of innovative payment technology implementation and best practices. Other examples can be found in the United States, Canada, Europe, and elsewhere around the world, and transit managers can take advantage of these innovations and experiences. Other industries, such as the financial, retail and entertainment industries, are adopting innovative payment strategies and technologies, and new opportunities for collaboration with transit are emerging.

Regional Fare System Development

Several regional transit authorities across the U.S. are exploring various projects to more effectively integrate services across their individual local transit agencies. Each of these initiatives cites a number of reasons, including: seamless travel across the region, lower capital costs to individual transit agencies (achieved through purchasing power of a larger project), and the greater ability to access Federal funds that emphasize regional transportation projects.[103] Two initiatives underway in 2014 are listed below.

- TriMet (Portland, Oregon) has initiated acquisition of a regional, open payment system, which will allow seamless transfers between its existing bus service, MAX light rail, WES commuter rail, C-TRAN and Portland Streetcar.[104]
- The Tampa Bay Area Regional Transportation Authority has brought together several local transit agencies (Hillsborough Area Regional Transit Authority, Pinellas Suncoast Transit Authority, Polk County Transit Services, and Lakeland Area Mass Transit District) to

study the adoption of a smartcard-based, transit fare payment system that can be implemented across the region.[105]

- The Niagara Frontier Transportation Authority is seeking to implement a new fare payment system for travel in the Buffalo-Amherst corridor in upstate New York. "The new electronic fare system will include contactless smart cards, bar code tickets, mobile ticketing, customer and administrative web pages, as well as a retail media distribution and reload network. The successful Contractor will be responsible for the design, engineering, installation, and operation the new fare system for a minimum of five years."[106]

Integration with Transportation Demand and Mobility Management Programs

The development of corridor and regional travel demand programs is likely to become more widespread as real-time travel information for all modes becomes more readily available. Many regions are planning integrated corridor management programs and mobility management programs, which apply use of multimodal information, variable pricing and incentives to inform travelers and manage travel demand. Incentives related to transit payment systems may include measures such as discounted commuter rail fares and discounted parking.[107] The use of open, account-based payment systems may facilitate implementation of these types of incentive programs. Some examples of transportation demand management programs involving small and mid-sized transit markets are the following:

- Atlanta Regional Commission (Georgia): "Atlanta Regional Transportation Demand Management Plan"
- Puget Sound Regional Council (Washington): "TDM Action Plan"
- Triangle J Council of Governments (North Carolina), "Transportation Demand Management Program"
- Maricopa Association of Governments and Valley Metro (Arizona): "Transportation Demand Management Plan"

Payment as a Service—an Option for Smaller Transit Authorities

Payment as a Service (PAAS), or Ticketing as a Service, is a Cloud-based service delivery model that would involve a private sector organization providing transit fare payment services to one or more transit authorities. The target market for PAAS is smaller transit authorities which do not have the resources to acquire or operate payment processing software and other payment services. PAAS is modeled after Software as a Service, a software application delivery model. The organization providing the payment services would probably offer a subscription service based on transaction fees. The transit authority would implement fare collection equipment, such as contactless smart card readers, on their transit vehicles, and payment information would be sent to the PAAS provider that would operate the payment management software.[108] The PAAS provider might also handle other payment functions, such as customer service and marketing.

Evolutionary Implementation

The evolutionary approach to transit fare payment systems development and implementation has proven to have many advantages. The evolutionary approach involves developing relatively small portions of the new system very quickly, getting user feedback, and continuing development in an incremental fashion. It allows developers to provide users with functional capabilities faster, and expand these capabilities incrementally with each iteration of development. Developers benefit from user feedback at each phase of development.

A standards-based design architecture and open payments architecture facilitate use of an evolutionary approach to transit fare payment system implementation. New technology can be added as it becomes available as long as it is compliant with payment industry and contactless technology standards. Under open payments architecture, additional payment and identification media can be accepted as new marketing and partnering opportunities present themselves.

Utah Transit Authority has evolved their open payments system in an evolutionary manner. UTA implemented an open, account-based system, starting with transit and employer passes that built on established relationships. Financial payment cards, Federal ID cards, mobile payments and prepaid cards were then demonstrated or implemented. As each new payment product was introduced, the transit authority gained valuable insight into user and system requirements.

Demonstrations and Pilot Programs

Demonstrations and pilot programs have proven to be valuable ways to try new technologies and product in the transit environment. Both demonstrations and pilots allow developers to understand user and system requirements and to determine the feasibility of full scale implementation of the new capability. Demonstrations and pilot tests typically involve a relatively small number of customers and a limited set of transit vehicles or facilities.

Demonstrations and pilots give visibility of the proposed innovation, and often help generate support for the funding required for development and system-wide implementation. Demonstrations (sometimes called "proof of concept" tests) also give technology and product suppliers insight into the operational requirements of the transit environment and the preferences and behavior of transit customers.

Demonstrations are temporary trials of new technologies or methods, and enable the transit agency to gauge market acceptance of the new product, determine the system requirements more accurately and educate their staff about the technology being demonstrated. A pilot program typically follows a demonstration project, and serves as the initial or pre-implementation phase of a new system, in order to test a system's new operational capabilities prior to full scale implementation.

Several transit agencies have demonstrated innovative payment technologies through these mechanisms. Examples include demonstrations of financial institution contactless smart cards in New York, prepaid payment cards in Utah, mobile payment technology on the Long Island Railroad, and use of Google *Wallet* on select NJ Transit buses.

Washington Metro's Demonstration Project for Smart Devices

The Washington Metro has embarked upon a comprehensive demonstration project that will allow riders to pay for their transit fare using a wide range of smart devices and smartcards. This demonstration project is an integral step towards implementation of WMATA's New Electronic Payment Program, which is scheduled for full deployment by 2017 (see Specification document in Appendix 1).

The demonstration project will be implemented at ten Metrorail stations and along six Metrobus routes, including several stations and routes heavily used by U.S. government employees. WMATA will install designated fare lanes and fare gates at Metrorail stations, along with special card targets on board buses and at parking facilities. These front-end devices will be able to communicate with a variety of smartphones, wearable NFC devices, contactless credit and debit cards, and federal ID cards.

> WMATA sought 3,000 volunteers to participate in the project, and provided an on-line portal for riders to apply to participate (http://mpp.wmata.com/). In addition to eliminating the need to buy a separate SmarTrip fare card, participants will also be eligible for bonus incentives.
>
> Source: "Pay for Metro with your smartphone or watch? Testing starts soon." WMATA Press Release, September 9, 2014

Use of Commercial-Off-The-Shelf Software

In many industries, software developers have found that basing development on commercial-off-the-shelf (COTS) software or other readily available commercial products is an efficient and cost-effective strategy for system development.[109] Transit payment system developers and integrators report that this approach has benefits for the development of transit payment systems. Developers claim that the software required for managing payment accounts, customer service and other functions can be cost-effectively tailored from COTS software developed for other applications. Potential benefits include faster development times, reduced development and maintenance costs, and more flexibility in modification and expansion of the system.[110] Potential challenges to using COTS software include increased security risks and system integration challenges.[111]

> Commercially available software packages enable agencies to select best-in-class software for each component of the back-end system. Replacing legacy software can help to improve and automate existing processes such as financial management and reporting, customer relationship management, clearing and settlement, and order and inventory management. Leading software packages can also be used to introduce new capabilities such as analytics and real-time asset and system monitoring. Accenture, "Accelerating the Payback from Fare Collection Investment" [112]

> **Mobile Application Development: Driven by the Consumer Market**
>
> The power of the marketplace is a strong driving force in mobile application development. When Apple launched its App Store in 2008, there were 500 different software programs available for users to download. Within six months, the number of apps had increased 30-fold to 15,000. By October 2013, there were over 1,000,000 apps available. Similar growth took place amongst apps designed for Google's Android operating system since its launch in 2009, which also offers over 1,000,000 applications. Blackberry and Windows-based phones lag behind, but each operating system offers 250,000 downloadable products.
>
> There are thousands of transit applications available for download. The programs range in capability from static system maps, to more advanced travel planners that include current transit schedules, interactive system maps, and even layouts of individual stations to speed connections. Some of these applications were created by commercial developers under contract to transit agencies, while others were made by independent travel or mapping companies. Commercial developers have also created fully functional mobile ticketing applications for transit agencies throughout the U.S. and around the globe.
>
> Sources: Apple, Blackberry, Google, Microsoft

Multi-Vendor Integration

According to a 2014 survey of transit agencies, the use of multiple vendors for system components (e.g., card readers, barriers, and other front-end devices) can help to reduce fare management costs up to 50 percent with a 3- to 5-year payback on the capital investment.[113] Some of the issues identified by transit agencies in the 2014 survey that impact overall fare collection system cost savings were:

- *Size of agency: impacts scale of costs required in new system.*
- *Current cost of fare collection: determines the degree of savings opportunity.*
- *Speed of transition: dictates the cost and complexity of running both systems in parallel.*
- *Labor contracts: indicates whether labor savings can be realized.*
- *Condition of existing equipment: determines degree of capital costs avoided in pursuing a new system.*

Opportunities for Peer Exchange of Innovative Practices

Exchanging information among transit agency peers or with other industries involved in payment systems has proven to be extremely valuable to advancing payment innovation in transit. Exchange of information about payment demonstrations and implementation projects has several benefits:

- Increases awareness of and stimulates innovative approaches;
- Provides insight into the challenges involved in implementation;
- Provides models for design, acquisition and implementation of new payment systems;
- Informs potential suppliers about transit requirements; and
- Facilitates collaboration and partnerships among service providers.

Opportunities for information exchange occur at several periodic industry conferences, such as those sponsored by the American Public Transit Association (APTA), the Smart Card Alliance (SCA) and the Transportation Research Board. The SCA Transportation Council offers additional opportunities for member organizations to collaborate on the development of white papers about innovative approaches to transportation payment.

Many transit agencies have found that regional workshops and working groups have facilitated the introduction of new payment systems to their region. Workshops can increase the awareness of regional transit providers and their stakeholders of the new fare payment options available. They can also facilitate consensus building and regional collaboration. Peer exchange programs, such as those sponsored by the U.S. Department of Transportation, can provide valuable input from experienced professionals to their peers in regions considering innovation.

As innovative payment approaches expand more broadly throughout the transportation industry and opportunities for convergence with other modes and services emerge, additional industry organizations can be engaged to facilitate interaction with smaller transit organizations (Community Transportation Association of America, CTAA), toll authorities (International Bridge, Tunnel and Turnpike Association, IBTTA), parking providers (International Parking Institute, IPI), and providers of traveler and mobility information systems (Association for Commuter Transportation, ACT, and Shared-Use Mobility Center, SUMC) and other intelligent transportation systems (Intelligent Transportation Society of America, ITSA).

Observations and Conclusions

These comparisons suggest that a standards-based, open payment system appears to show the greatest potential for meeting a transit agency's fare payment system long-term goals. These systems can accept a wide variety of fare payment media, including mobile payments. Standards-based, open payment systems also have significant capabilities for growth and further development, including the capability of supporting convergence strategies to improve regional travel and mobility.

One area where there may be a higher level of risk associated with standards-based, open payment fare systems is in *implementation.* As of 2014, only a handful of account-based or open payments systems are in operation or under development, while proprietary, closed payment systems have been in operation for nearly two decades. These proprietary fare payment systems are proven, and shown to be highly capable and reliable. However, the potential risks associated with implementation of a standards-based, open fare payment system can be mitigated through comprehensive planning, thoughtful design, complete and thorough testing and well-executed implementation.

Chapter 8 Review

- Each of the four fare payment system typologies has varying capability to support a transit agency's fare payment system goals.
- Fare media options are linked to the choice of fare payment system typology.
- The potential of an individual transit agency's fare payment system to be compatible with other fare payment systems in a multiagency fare payment environment is an important consideration in selecting a fare payment system typology.
- Standards-based, open payments fare systems are the most capable of supporting a variety of transit convergence strategies.
- Transit agencies considering an upgrade to their fare payment system should avail themselves of the experience of other agencies that have implemented new fare payment systems, to identify successful implementation strategies and best practices for success.
- Standards-based, open payments fare systems appear to show the greatest promise in terms of current and future capability. Proprietary, card-based fare payment systems, although less capable of future development, have shown themselves to be reliable and robust. Consequently, a transit agency implementing their own "next generation fare payment system" will need to carefully weigh the benefits and risks associated with each approach to fare payment system design.
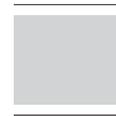
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Definition of Terms

The evolution of transit fare payment systems brings with it a lexicon of terms that may be unfamiliar to some transit agency professionals. The key terms and basic definitions used in this report are provided below; some of these terms and concepts are discussed in greater detail in the body of this report.

Account-based: a transit fare payment system in which the fare medium serves as to associate the rider with information held in a separate account. No fare value is carried on the fare medium itself. (See also "card-based.")

Back-end: the transit system devices that interact with front-end devices as part of any fare calculation, fare collection, and/or fare payment transactions. (See also "front-end.")

Card-based: a transit fare payment system in which fare value is carried on the fare medium itself. (See also "account-based.")

Central agency computers: the transit agency computer system that manages its fare payment system. The central computers collect and process data from front-end devices to manage all aspects of fare calculation, fare collection, and fare payment. They also exchange information with front-end devices about authorized and/or unauthorized fare media, system health and other aspects of system operation. The central agency computers may also collect ridership data from front-end devices.

Closed payment (closed loop) system: a transit fare payment system that uses fare media that can only be used within a single transit system or partnership of transit systems. All proprietary fare payment systems are closed loop systems. (See also "open payment" and "proprietary systems or design.")

Convergence: the combination or integration of payments systems from different transportation modes, such as transit and toll or transit and parking.

Fare media: The instruments (cash, token, ticket, fare card, mobile device, etc.) accepted by a transit system to grant riders access to transit services.

Front-end: the transit system devices (card readers, fare boxes, fare gates, validators, barriers) that interact with a transit rider and a rider's fare medium and/or payment medium at the point-of-entry into the transit system. Ticket vending machines and other ticket sales mechanisms such as internet websites are generally considered front-end devices. (See also "back-end.")

Interoperability: the capability of a transit fare payment system and its components (such as fare media, card readers, etc.) to work with or use the parts or equipment of another system. Interoperability includes the capacity to exchange information. (See also "standards-based" and "proprietary design.")

Mobile application: a software application developed specifically for use on small, wireless computing devices such as a smartphone, rather than desktop or laptop computers. Mobile applications typically require a wireless connection for full functionality.

Mobile payments: a point-of-sale payment transaction made through a mobile device (such as a smartphone, "smart watch," or other smart device), in which the mobile device functions as a contactless payment card. For the purpose of this report, a web-based or in-app purchase of a transit fare using a mobile device or smartphone is not considered a mobile payment. (See also "mobile ticketing.")

Mobile ticketing: a process whereby a transit rider can order, pay for, obtain and validate a transit ticket using a mobile device such as a smartphone, "smart watch", or other mobile device. Mobile ticketing is a separate function from mobile payment. (See also "mobile payments.")

Open payment (open loop) system: an account-based transit fare payment system that is able to accept third-party payment media such as bank cards and mobile device as its fare media. All open payment systems are both standards- and account-based systems. (See also "account based," "closed payment systems," and "standards-based systems or design.")

Point-of-entry: the point at which a rider gains access to the transit system to utilize transit services. A point-of-entry in a gated system uses a turnstile, barrier, platform reader or a farebox to control access. In an un-gated system, access may be entirely unrestricted (allowing passengers unimpeded access to board a transit vehicle), or require use of a ticket validator prior to boarding.

Payment media: any instrument, such as cash, credit cards, debit cards, benefit accounts, employer transit accounts, or mobile device that may be used to purchase transit services or fare media.

Proprietary system or design: a transit fare payment system in which the design and technology is developed and owned by a contracted manufacturer and sold or licensed for use by a transit agency. Proprietary designs based systems tend to have a low level of interoperability (See also "standards-based" and "interoperability.")

Smartcard (or smart card): a transit fare card, bankcard, or identification card or other credential that includes an embedded computer chip and antenna.

Smartphone: a mobile phone that can connect to the internet, and receive, download, and transmit data. Most smartphones allow users to download applications ("apps"), and many are equipped with near field communications technology.

Standards-based system or design: a transit fare payment system in which the design and technology follows public, non-proprietary standards and specifications established for the financial payments industry. Well-managed standards-based systems tend to have a high level of interoperability, and have been independently tested to confirm compliance. (See also "proprietary design" and "interoperability.")

Stored value fare card: a prepaid fare card that can be programed or "loaded" with a specific dollar value or other prepaid fare options that is then decremented with use.

System architecture: the organization of the components of a transit fare payment system, their relationship to each other, and the rules and processes governing their interaction.

Typology, Transit fare payment system: a configuration of design attributes or characteristics of a transit fare payment system into a functional framework. In this report, four characteristics are used to create transit fare payment system typologies:

1. Transit system scope: single agency or multiagency;
2. Design and technology: proprietary or standards-based technology;

3. Fare system architecture: card-based or account-based; and
4. Payment architecture: closed payments or open payments.

Unbanked household: a household that does not currently have a checking or savings account (as defined by the FDIC).

Underbanked household: a household that has a checking and/or a savings account and had used non-bank money orders, non-bank check cashing services, non-bank remittances, payday loans, rent-to-own services, pawn shops, or refund anticipation loans in the past 12 months (as defined by the FDIC).

APPENDIX B

Examples of Transit Agency Fare Payment System Goals

This Appendix contains sample transit fare payment system goals from the following transit agencies:

- Chicago Transit Authority (CTA), Chicago, Illinois
- Metropolitan Transit Authority (MTA), New York, New York
- City and Tri-County Metropolitan Transportation District of Oregon (TriMet), Portland, Oregon
- Southeastern Pennsylvania Transportation Authority (SEPTA), Philadelphia, Pennsylvania
- Washington Metropolitan Area Transit Authority (WMATA), Washington, D.C.

These goals were included as part of each transit agency's publically issued official documentation (e.g., a request for proposals or RFP) prepared as part of a study or acquisition process for a new transit fare payment system.

The excerpts are reprinted verbatim, with minor editing to remove any specific references to suggest endorsements of particular third parties, or to comply with editorial guidelines.

Source Document:	Open Transit Fare Payment Collection System Request for Proposals - Step One Chicago Transit Authority August 24, 2009
Link:	http://www.transitchicago.com/assets/1/solicitations/9OP03968.pdf

EXCERPTS

Section I. Overview

INTRODUCTION

The Chicago Transit Authority (the "CTA") has been a leading innovator in the area of transit fare collection technology, and was one of the first American public transit systems to implement a contactless payment option for its patrons. While individual transit payment transactions may be small, collectively these payments represent a significant market opportunity. Generally known as "micro-" or "low-value" payments, consumer transactions valued at less than $5 accounted for an estimated $1.7 trillion in consumer spending in 2005. The potential revenue opportunity from using technology to efficiently manage micro-payments, coupled with the desire of businesses and consumers to improve transaction speed and convenience, is driving the replacement of cash transactions in many venues with electronic payments, particularly using contactless payment options.

…

[The] CTA and other public transit systems are well positioned to drive the rapid and widespread adoption of innovative contactless payment systems. Contactless fare collection systems are being implemented across the world in order to achieve more efficient public transit operations. The CTA's vast physical infrastructure and extensive transit routes, like many other American public transit systems, are surrounded by thousands of retail and other service outlets that thrive on micropayment transactions. Accordingly, innovative contactless fare collection systems may profoundly influence more general consumer payment use for everyday retail purchases.

Public transit offers private sector businesses ("Prospective Partners") a huge opportunity for converting payments from cash to electronic payment methods. Currently, the CTA conducts an average of 1.6 million payment transactions per day, or nearly 500 million transactions annually. However, budgetary constraints and competition from other modes of transportation are prompting public transit systems like the CTA to find innovative ways to reduce expenses, fund needed capital costs and increase revenues by improving customer travel experiences. Contactless payment technologies offer a way to achieve these goals, but cost is still a major consideration in the decision to utilize this new payment technology. The challenge for the CTA

is determining how to best balance the long-term benefits against the considerable near-term capital investment required to introduce innovative transit fare payment options.

With this in mind, the CTA has engaged … [advisors]… to assist the CTA in connection with the solicitation and evaluation of proposals from prospective partners for an open transit fare payment and collection system (the "Open Fare System"). An Open Fare System is any automated fare collection system that accommodates several types of contactless media; some of which may also be used to purchase consumer goods from retail vendors other than the CTA. These include bank-issued contactless cards, cost-effective open and closed loop reloadable stored value contactless cards, and general purpose reloadable gift cards. The CTA's goals for an Open Fare System include:

- Enhancing the customer experience by making it more convenient to pay for fares by utilizing various forms of contactless payment media.

- Upgrading the existing fare collection system to provide for modern fare collection technology, including forward compatible contactless readers, kiosks, and the appropriate back-office systems necessary to accommodate a more cost-effective non-proprietary fare collection solution.

- Developing a new and unique relationship with the private sector to shift implementation expenditures, servicing functions, and associated costs involved with fare collection, so as to minimize the capital and operating costs directly incurred by the CTA.

- Providing flexibility for the future with regards to emerging technology, contactless and mobile payment options, and changing transit fare structures.

Section III. CTA Goals and Expectations for Prospective Open Fare System

The Prospective Partner chosen by the CTA to operate the Open Fare System will be charged with designing, installing, operating, and servicing an Open Fare System throughout the CTA's entire system of rail and bus services. This system must address the specific needs of the CTA's entire customer base: the banked, the underbanked, and the unbanked. Any successful project will include the following elements:

Fare collection terminal technology must:

1) Provide contactless media that adheres to Type A/Type B international standards of open collection, with the eventual goal of supplanting all other current media.

2) Be located alongside all 3,622 existing fare collection terminals, coexisting with CTA's existing magnetic stripe and contactless media technology.

3) Be installed at the rear doors of all 2,222 buses to accommodate for simultaneous fare collection and entrance from both front and back doors.

4) Provide for the potential use at a later date of other contactless media such as cell phones, Tags, or other types of open payment structures.

5) Possess real-time authorization communication on both bus and rail, to the extent possible.

6) Improve upon the CTA's current standards for transaction processing speed.

Card Technology must have the ability to be:

1) Purchased in a prepaid, reloadable format.

2) Accommodate existing fare offerings; i.e., Full fare, reduced fare, transit benefit, U-Pass, Monthly, and Seniors Ride Free pass formats.

3) Easily and cost-effectively accommodate future fare policy changes, including distance-based fares, peak and off-peak fares, etc.

4) Purchased at a greater number of points of sale than current fare media; e.g., self-service kiosks, retail outlets, and online.

Additionally, data on ridership, revenue, use trends, and other currently examined information must be available for use in real-time by the CTA.

Metropolitan Transportation Authority (MTA)
New York, New York

Source Document:	Concept of Operations for MTA New Transit Fare Payment System and NYCT Deployment Phase Metropolitan Transportation Authority (MTA) October 17, 2011 Release No. 1.2
Link:	http://www.smartcardalliance.org/resources/pdf/ MTA_NFPS_Concept_of_Operations_R1.2.pdf

EXCERPTS

[Note: in this particular excerpt, the underlining and italics reflect emphases or highlights used by the MTA in the original source document.]

7.1   Vision, goals, objectives and gaps

The vision, goals and objectives for NFPS are listed below. Limitations of current practice are in italics.

- NFPS will be a single, regional fare payment system capable of use across modes and agencies. It provides for seamless travel across agencies by taking advantage of the payment technology and communications infrastructure that customers already know and use in their daily lives.

  - *This vision encompasses the new fare payment system to be deployed on the MTA commuter railroads in the future. Significant differences exist in commuter railroad fare collection environment that will be addressed in a future phase.*

  - *The system must scale to accommodate future growth in NY/NJ regional travel via public transit.*

  - *The current MetroCard is not interoperable on MTA commuter rail services, or with several other regional agencies.*

- The system will reduce costs associated with fare collection, revenue processing, and reconciliation.

  - *The current cost of revenue collection is 15% of each $1 of revenue collected. The NFPS goal is to reduce this materially.*

  - *MetroCard card life is relatively short, which increases card production and distribution costs.*

  - *MetroCard is a proprietary system with increasing maintenance and operational costs.*

- NFPS will provide a customer experience that is superior to the MetroCard experience.

    – A customer will be able to choose his or her own contactless payment device. Most customers will not have to acquire and carry an additional card as is required with MetroCard.

    – A customer with a bank-issued contactless payment card will not be required to pay his/her fare in advance *as is required with MetroCard*. The MTA may allow MTA Card holders who link their card to a bank-issued payment card to pay as they go. [NFPS should be configurable to permit MTA Card holder to use PAYG if MTA decides the risk and operation of such policy is manageable.]

    – Customers will pay for MTA fare products in the same way they purchase other products; the same payment media, online account access, billing, dispute resolution, and rewards programs are used as for other merchants, *instead of an MTA-specific set of procedures that is likely to be less familiar.*

- A <u>customer</u> may register for an account with the MTA, either providing personal information or anonymously, and <u>will have online and telephone access to his or her own account</u>, including the ability to view payment transactions, and trips taken in near-real time.

    – This provides a high degree of account visibility and transparency. Users registered with personal information may have protection on products purchased if their card is lost or stolen.

    – MetroCard account information provided to riders is limited to balance, expiration date and insufficient funds information.

    – *MetroCard currently provides fare being charged, and balance and expiration date information at turnstile and farebox units*. NFPS does not envision providing this information at points of entry. NFPS will also not provide information on the fare product used at points of entry; a customer will not know from the turnstile or farebox indication if his or her pass covered the trip, or whether it was a PAYG trip. An example is a rider who purchases a subway/bus pass but boards an express bus where subway/bus passes are ineligible. Improved signage may be required on express buses and other situations where this may be an issue.

- For unbanked customers (those who do not have bankcards), banked customers without a contactless bankcard and banked customers with a contactless bankcard who prefer not to use their bankcard to directly pay their fare, MTA will make available the MTA Card. Customers with cash only can purchase fare products through a network of station kiosks, (which may include ATMs), and retail reload network. It gives the MTA Card holder the ability to use the same services the bankcard holder enjoys, with the exception of using PAYG fares.

    – Both MetroCard and MTA Card support unbanked riders with capabilities equal to banked customers.

- The NFPS will be a <u>server- and account-based system</u> that is more capable than a card- and reader-based system, in terms of software reconfiguration and transaction processing parameters. This architecture is more flexible to implement fare policy changes, to access system data, and to manage the system for the benefit of customers and MTA alike.

NFPS will have minimal customization to meet transit needs; it will be based on a mainstream merchant payment model.

- – MetroCard System has limited flexibility, is difficult to upgrade, and is not "future proofed."

7.2 Economic objectives

- Lower required capital investments in the long-term. Capital expenditures for the NFPS in the long-term should decrease relative to currently planned capital spending for MetroCard.

- Lower operating costs. The NFPS should have an operational model and cost structure at least as efficient as current payment systems of agencies covered by NFPS, and to show improvement over the long-term.

- Generate net integration savings across MTA agencies and modes. This applies when the NFPS is deployed at the commuter railroads, but the implementation for subways and buses should be done so that a future system operating across all agencies will reduce total operating costs at each agency by merging redundant functions and infrastructure and total costs when combined with NFPS costs at MTA.

- Minimize implementation costs.
  - – Manage NFPS implementation to use off-the-shelf components and existing processes as much as possible
  - – Use existing gate and other infrastructure as feasible
  - – Use existing payment processes where possible; MTA has substantial credit and debit card operations under current MetroCard and other fare payment systems
  - – Avoid interfaces between NFPS and MetroCard during NFPS implementation period
  - – Implement NFPS as rapidly as possible
  - – MetroCard is reaching the end of its useful life. NFPS should be implemented before significant MetroCard renewal costs would have to be incurred.

- Enable the MTA to negotiate business relationships that reduce reliance on single vendors, and ensure competition among potential partners for most needs.
  - – MetroCard is a proprietary system from single vendor

- Have an appropriate technological lifecycle so that MTA can take full advantage of future technologies, ensured by:
  - – Implementing technology that is at the appropriate stage in its life cycle,
  - – Using open standards-based hardware, software and processes to promote competitive procurement, and
  - – Managing systems integration to allow competitive, cost-effective migration and upgrades of components and vendors through time.

- MetroCard components cannot be upgraded independent from each other or from sources other than the single vendor. MetroCard is not standards-based.

7.3 Customer objectives

- Increase the <u>ease, speed, convenience and flexibility</u> with which customers may purchase fare products and use self-service to allow customers to directly manage accounts.

  - NFPS sales channels are more flexible and easier to use and operate than MetroCard channels

- Acceptance of <u>wide range of standard payment media</u>, such as pretax benefit cards, employer-issued ID cards, or non-traditional payment cards and other devices as they evolve.

  - MetroCard is sole payment medium currently (except on buses). Customers will choose their payment media with NFPS.

- Simplify how customers pay for fares

  - For contactless bankcard holders, there is no requirement to know, select and purchase fare products in advance to enter any of MTA bus and subway services.

  - MetroCard users must select and prepay fares and MetroCard required for entry on bus and subway, although coins accepted on bus.

- Ensure all customer groups, such as unbanked, reduced fare and others, have equitable access to fare payment options.

  - Users have no obligation to use a bankcard or third-party card to access public transit.

  - MTA Card supports all ==PIA== fare products. MetroCard at retail outlets supports only a subset of fare products.

  - MetroCard and MTA Card equally available to all groups.

- Have <u>no MTA-required customer fees</u> for use of bankcard or MTA Card for fare payment.

  - MTA Card will have one-time cost to obtain.

- Deliver a flexible access experience for families and groups.

  - The MTA may allow families/groups access from the same card by accepting multiple PAYG or PIA value taps on one card for the same ride.

  - MTA can increase the limit from today's four MetroCard swipes per group, but it still needs a cap to minimize fraud. This will require a tap for each person making a transfer in the group on same card.

  - NFPS can be more flexible than MetroCard for group travel.

7.4 Operational objectives

- NFPS must support the allow/deny decision at readers with transaction speeds that do not exceed 500 milliseconds for subway turnstiles/gates and 600 milliseconds on buses.

- Lower bus boarding times.
    - NFPS on-bus payment should result in no increase in SBS dwell time.
    - MetroCard bus fare payment times are slower than with a contactless card.
    - MetroCard mis-swipes are relatively high compared to most fare systems.

- Operation at high levels of reliability and availability, meeting transaction speed and quality standards for MTA passenger volumes and operational characteristics. The MTA will set values based on typical payments and transit industry practices.
    - NFPS must support real-time monitoring of readers, servers, communication networks and other key components. *MetroCard reader, turnstile and gate monitoring is based on aging equipment.*
    - NFPS new hardware will be more reliable than MetroCard, which is at end of life. NFPS components must be tested/verified for ruggedness/durability in bus use.
    - MetroCard MVM and MEM reliability is less than their goal levels as they near end of life. NFPS station kiosks will have newer hardware but must be designed to counter vandalism and fraud.

- Facilitate regional (MTA and outside MTA) transit interoperability through seamless transfers using the same fare media. Minimal or no fare coordination across agencies is required on ongoing basis: regional fares will be the sum of local fares unless agencies adopt joint fares.
    - MetroCard has limited ability to cover commuter rail, NJT, etc.
    - With NFPS based on open payments, it creates potential for interoperability.

- Compliance with ADA, egress standards, and other safety and service standards across all components.

7.5 Security and risk management objectives

- Robust risk management processes based on payment industry practices will be used for the administration of card acceptance, accounts, cash, audits and other safeguards.

- Measures to prevent fare evasion or uncollected fares will be implemented based on transit best practices from MetroCard and other agency experiences. NFPS will support more frequent updates of Deny Lists, better passback control with server authentication, and other improvements.

- Meet card security standards, including compliance with payment industry security standards (PCI-DSS and PA-DSS). [Payment Card Industry Data Security Standard and Payment Application Data Security Standard].
    - MetroCard vending machines must meet prevailing security standards.

- Provide <u>security measures to protect all components</u> from viruses, hacking (to steal credit card and personal account data), code-breaking, card replication, and others.
  - – Both MetroCard and NFPS must meet prevailing security standards.

7.6 Planning objectives

- <u>Capture</u> rich and valuable <u>insights into customer behavior through improved operational data</u>. NFPS will provide MTA with increased knowledge of customer behavior and habits through increased granularity of travel data and potential access to payments industry databases. Knowledge of travel and fare payment patterns and preferences will help management improve service planning, trafficking and service adjustments. As a result, services can be better targeted and marketed to customers to improve the travel experience and potentially increase ridership.
  - – MetroCard data is captured at six-minute intervals; NFPS data will be more flexible.
  - – Cash payment provides little data on the users of MTA services. NFPS will lower cash usage.
  - – NFPS data can more easily be used with other planned projects (such as Bus CIS and Bus Camera project) for even richer set of data.

7.7 System architecture objectives

The NFPS supports the following system elements:

- Use of commercial off-the-shelf components and existing payments industry processes.
  - – MetroCard uses proprietary, custom cards, readers and server software.
- Open architecture that defines interfaces between components that can be separately procured and upgraded.
  - – NFPS will allow MTA to procure readers, communications, server software, sales channels, MTA Card, and other components from different vendors. MTA can replace or change these components at different times, since they will meet standards to interface to other components.
  - – MetroCard is a single, proprietary system in which all components are delivered and integrated by a single vendor.
- Support of key standards for payments:
  - – North American contactless payment standards, implemented as *PayPass*, *PayWave*, *Blink*, *Express Pay* and others.
  - – North American magnetic stripe payment standards, at devices other than entry readers (turnstiles/gates, farebox units or validators).
  - – Standards for transactions between merchants, acquirers and bankcard associations: ISO/IEC 8583 Standard for Financial Transaction Card Originated Messages and others.

- – Best practices for Web and call center sales sites.

    - – EMV contactless standards, used globally but not widely implemented in the US. MTA may implement EMV (Europay MasterCard and Visa) in its readers and processing to support foreign cards, and it may adopt EMV for the MTA Card to provide a higher degree of security and risk management.

    - – MetroCard MVMs and MEMs support magnetic stripe payment cards. MetroCard readers support only MetroCards. No contactless or phone payment capabilities currently exist.

- Near Field Communications (NFC) for mobile phone payments:

    - – The NFC standard supports payment applications that have not gained wide acceptance. The MTA may implement NFC in its readers to be prepared for mobile phone payment, which is expected to become a mainstream technology in the next few years. NFC introduction has been slower than expected by many in the industry; the MTA will support NFC in anticipation of deployment of viable products and services in the mobile phone industry.

- Wireless telecommunication standards.

    - – NFPS will initially use 3G wireless, from either the CDMA or GSM family of standards. 4G services may be specified in the future.

    - – MetroCard uses older telecom services in subway environments, and does not use networks for communications with bus fare payment equipment. All fare payment is done off-line, and bus and subway collection are separate processes.

- Public transportation specific software.

    - – Open payment public transport software is being developed by Transport for London (TfL). TfL is developing end-to-end server software for authentication services, authorization services and a fare engine. MTA may be able to obtain the major elements of the open payment fare system from TfL through license, build or operating agreements. TfL is also developing readers for fare payment for its own system.

    - – Opportunities for sharing software and reducing costs will be higher in the open payment architecture than in a vendor architecture.

7.8 Other objectives

- Facilitate potential non-transit business development and revenue.

    - – NFPS allows card issuers and others to offer rewards programs for MTA travel as a marketing strategy.

    - – If a user has a contactless payment card, joint product offerings such as concert or event promotions with MTA travel, and others, are feasible.

    - – These options are difficult to implement with MetroCard.

- <u>Leverage</u>, don't duplicate, existing or <u>planned MTA or NYCT investments</u> to maximize scale and cost efficiency, where possible.

    – NFPS can share its on-board bus equipment with the bus CIS, as an example

- Support of staged implementation of the new system for customers, MTA and agency staff and MTA operations and management.

City & Tri-County Metropolitan Transportation District of Oregon (TriMet) Portland, OR

Source Document:	Fare System Migration A White Paper on Electronic Fare Collection November 17, 2011
Link:	http://portlandtransport.com/documents/Fare%20System%20Migration%20white%20paper_V10%20FNL_11%2017%202011.pdf

EXCERPT

New Fare System Objectives

The new fare payment system would have the following objectives for fare policy and fare payment:

1. Easy to understand, simple to use and convenient for customer

2. Easy to understand and convenient for operators and fare inspectors

3. Reduce the cost of fare collection and equipment maintenance

4. Work on all transit modes, including bus, MAX light rail, and WES commuter rail

5. Accommodate seamless transfers between vehicles, within the TriMet system, as well as with partner providers including C-TRAN and the Portland Streetcar

6. Bring TriMet into the mainstream of next generation payment technology

7. Reduce fraud

Southeastern Pennsylvania Transportation Authority (SEPTA)
Pennsylvania, PA

Source Document:	Request for Information RFI No. 133 SEPTA New Payment Technologies System March 27, 2008
Link:	http://floridaapts.lctr.org/RFPs/EFPS/ SEPTA%20REQUEST%20FOR%20INFORMATION.pdf

EXCERPT

6.   NEW PAYMENT TECHNOLOGIES SYSTEM

The New Payment Technologies (NPT) System is envisioned as an integrated, state-of-the-art electronic fare vending, payment, distribution, collection and processing system utilizing new payment technologies capable of interfacing with both bank and non-bank financial clearing systems for transaction settlement. SEPTA intends to deploy the NPT System across all modes of transportation operated as part of the SEPTA system, including buses, light rail vehicles (trolleys), rapid transit, commuter rail, paratransit services and parking.

SEPTA's strategic business interests for replacing its existing fare vending and collection system with one based on state-of-the-art technology are as follows:

- To provide SEPTA's customers with a modern system that enables convenient and secure fare payment options and improved customer services;
- To provide additional operating and cost efficiencies;
- To improve SEPTA's fiscal position and transit services with enhanced revenue security and accountability and readily available and accurate ridership and revenue data.

The successful implementation of the NPT System will provide SEPTA with the opportunity to not only update the present fare payment and collection systems, but also will enhance the level of customer service provided to its passengers. This will include the ability to offer fare plans tailored to changing customer needs and travel patterns. SEPTA wishes to leverage the new market opportunities available through emerging new payment technologies offered by the banking and wireless industries. By moving to a modern payment technology system, SEPTA intends to provide customers with new, more efficient, convenient and secure fare payment options.

6.1 Major System Goals and Constraints for NPT System

This section identifies major system goals and constraints that must be considered in the design of the NPT System.

Major System Goals

SEPTA's major system goal for customers is to provide an electronic fare payment system that:

- Is secure and reliable;
- Is easy to understand;
- Enables customer self-service;
- Is convenient and useable by all customers;
- Provides customers with modern and convenient payment options across all transit modes;
- Facilitates seamless customer transfer among adjoining transit agencies at intermodal connection points.

SEPTA's major system goal for internal stakeholders is to provide an electronic fare payment system that:

- Provides accurate revenue management and accountability;
- Provides accurate and timely ridership and revenue data;
- Reduces cash handling;
- Replaces tokens, paper transfers and printed paper tickets;
- Fosters fare policy innovation;
- Significantly decreases or eliminates SEPTA's role as transit-specific fare media issuer, transaction acquirer and processor.

Major System Constraints

The NPT System must be deployed in a manner that minimizes the impact on SEPTA's on-going operations and passenger handling capabilities.

The NPT System must interface with SEPTA's existing infrastructure, specifically the physical conditions at stations and their associated parking facilities; the existing communications and data network; and the equipment and facilities that support and maintain the existing fare system and data networks.

The NPT System will be designed and deployed within an ongoing program of improvement projects on the SEPTA rail and bus systems. Several projects currently underway or planned will affect the NPT System and must be considered in the design, including SEPTA's Customized Community Transportation Mobile Data Terminal upgrade program, the Smart Stations Initiative, and numerous upgrades to SEPTA's communications infrastructure, including the Fiber Optics Platform.

Washington Metropolitan Area Transit Authority (WMATA)
Washington, D.C.

Source Document:	**Technical Specification** New Electronic Payments Program Washington Metropolitan Area Transit Authority (WMATA) June 30, 2011 RFP Step-2, RFP FQ 11248-2
Link:	http://wmata.com/business/procurement_and_contracting/ solicitations/uploads/NEPP%20Tech%20Spec%20Step%202%20Rev%2 02%2006302011.pdf

EXCERPTS

1   SYSTEM DESCRIPTION

1.1   Overview

The Washington Metropolitan Area Transit Authority (WMATA) plans to modernize and replace its fare collection system and is currently preparing to procure a new electronic payments system in 2011. The New Electronic Payments Program (NEPP) shall be based on centralized accounts with fare calculations being performed by a Central Data System (CDS) rather than by field devices.

More than a decade has passed since WMATA, the first US transit agency to adopt contactless smart card technology, introduced SmarTrip®. The time has come to modernize WMATA's fare collection system and provide a broader array of payment alternatives to its customers. Expanded payment alternatives shall include providing functionality additional to that available today and the acceptance of multiple forms of smart media. This shall afford customers the opportunity to make fare and parking fee payments through various forms of contactless smart media, including credit and debit media.

While the NEPP represents a key opportunity for WMATA to modernize its legacy fare collection equipment and practices, the primary goal of this project is to significantly enhance customer convenience, experience, and service. However, the NEPP shall also be procured and implemented in a cost-effective manner.

The NEPP shall also provide WMATA a substantially greater degree of flexibility to introduce innovative concepts and features to its patrons. This includes, but is not limited to, the acceptance of new forms of payment, increased variety and types of media that can be processed, improved methods of communication and customer services, and more rapid integration of emerging technologies.

Through the NEPP, WMATA wishes to leverage new market-driven opportunities for fare payments and fare media by interfacing with the financial and wireless industries to accept a variety of contactless, open standard, fare payment media. The NEPP shall be

"form-factor agnostic," accepting all forms of ISO/IEC-14443 compliant media, including, but not limited to:

–   Credit card-sized media;
–   Key fobs;
–   Watches;
–   Mobile phones; and
–   Adhesive labels.

This NEPP shall accommodate and process Near Field Communications (NFC) based media (including mobile phones), which are based on an extension of the ISO/IEC-14443 standard. Further, the NEPP shall comply with contactless and EMV (Europay, MasterCard, Visa) standards.

The NEPP shall also accept a number of media already common within the WMATA service area, including government-issued contactless identification media compliant with the Personal Identification Verification (PIV) standard. PIV media includes the Common Access Card, as well as numerous other federal government, corporate and school/university-issued media.

For types of media where a payment mechanism is not directly associated with the media, including transit agency and partner-based media, the physical media shall act as the token for accessing an account maintained within a CDS. Within this account, customers shall be able to link their media with established payment mechanisms enabled by WMATA. This can include, but is not limited to:

–   Personal checking or savings accounts;
–   Bank-issued contactless credit and debit accounts;
–   PayPal accounts;
–   Electronic Benefit Transfer (EBT) accounts, including the Federal Transit Benefit Program;
–   Any account that is managed or administered in accordance with transit agency or partner arrangements; and,
–   Emerging financial and other account types.

The architecture for the NEPP will transition WMATA from a proprietary, single supplier architecture to an agency-controlled, multi-supplier open architecture, with well-defined interfaces that are controlled by WMATA.

When completed, WMATA envisions the NEPP as an integrated, electronic fare payment and collection system that incorporates new payment technologies capable of interfacing with both inter-bank and non-bank financial clearing systems for transaction settlement.

WMATA intends to deploy the NEPP across all modes of transportation operated as part of the WMATA system, including Metrorail, Metrobus, barrier-free environments for forthcoming light rail/streetcar service, MetroAccess (paratransit) and to WMATA Regional partners.

For this program, WMATA will employ a Systems Integrator with demonstrated expertise in implementing complex transaction-based systems and integrating the necessary hardware, software and ancillary components from a multitude of third-party suppliers. The Systems Integrator shall develop a system that utilizes an open architecture and WMATA-owned interfaces, allowing for equipment from a range of vendors to communicate with a single common CDS. The CDS shall monitor and control the functionality of all equipment; collect, store and report data; and clear/settle all customer transactions.

The CDS shall utilize a set of Application Programming Interfaces (APIs) that allow multiple vendors to integrate into the NEPP. This shall also include all necessary interfaces to integrate the new system with WMATA legacy systems, including Trapeze and Peoplesoft applications. The Systems Integrator shall develop the necessary APIs for the NEPP and provide them to WMATA. These APIs shall become the property of WMATA for their exclusive and unlimited use. WMATA envisions the use of independent third-party firms to certify the open architecture and completeness of the APIs.

The NEPP will be integrated with WMATA's other Mission Critical Business Systems (PeopleSoft, Trapeze, Maximo), and provide robust reporting and business analytics capabilities, including a "dashboard" capability for executive management. All data that is generated or stored by the CDS shall also become property of WMATA, enabling the Authority to perform comprehensive reporting and reconciliation.

The CDS shall feature a comprehensive risk management approach to identify fraudulent transactions, including possible areas of fare evasion, and other sources of fraud. This shall enable WMATA to make well-informed business decisions regarding transaction processing fees, settlement frequency, and loss mitigation.

New features shall be incorporated to enable enhanced customer service, convenience, and usability. Upgrades and improvements shall address automated customer service channels such as Fare Vending Devices (FVDs), Web Services, Interactive Voice Response (IVR) systems, and automatic account reloads. These features shall provide customers with more convenient ways to obtain and reload smart media. In addition, new system applications shall allow WMATA to offer registered customers desirable new services including expanded web-based account management and transaction tracking.

The NEPP shall be scalable, to allow for future adaptation and additions by WMATA. For example, the addition of the new Dulles airport extension and infill stations shall be easily incorporated into the system.

The NEPP shall remain adaptive and responsive to customers' changing needs. The system shall be capable of easily being configured to accept new forms of payment, and interacting with emerging new consumer electronics devices.

Prior to implementation, WMATA and the Systems Integrator will solicit program input from all internal and external stakeholders. This shall provide customers with an opportunity to express their concerns and gather valuable stakeholder input regarding the

project. It shall also serve to solicit input regarding equipment and applications. Pre-implementation customer input will be essential to a successful system deployment.

1.1.1   Fare Structure

The NEPP shall be capable of accommodating the existing and future WMATA fare structures and business rules, as well as the business rules and fare structures used by the WMATA Regional Partners. The NEPP shall also properly process Federal transit benefits. As a minimum, the system must accommodate fares which may vary by:

- Rail station entry/exit location
- Bus boarding location
- Time of day
- Day of week
- Distance traveled
- Zones traveled
- Individual user (affinity benefits)
- User category (seniors, employees)
- Mode transferred to/from
- Specially designated days (holidays)
- Variable parking fees by location and date
- Special services (express buses)

The NEPP shall accommodate all types of fare products available on current WMATA and Regional Partner systems. WMATA shall be able to modify the system to accept a different fare structure without Contractor assistance. This ability shall include the flexibility for WMATA to change fares for individual stations and routes, and through out the system, including parking on a scheduled or ad-hoc basis. Fare calculations shall be made by the CDS and when necessary, shall be completed before transmittal of payment information to the field device.

Additionally, the system shall accommodate all fare rules required to support MetroAccess.

The system shall support employer subsidies and pretax benefits for parking fee and fare payment. For these subsidies and benefits, payment shall not be deducted from the customer's personal store of funds until the pretax amount is depleted. Partial payment with pretax benefits shall also be permitted. The system shall comply with the Internal Revenue Service (IRS) revenue ruling 2006-57 regarding the separation of transit benefits and parking benefits, and all other regulations that may be put into effect during the implementation of the System. A variety of WMATA-issued and third-party issued media, including PIV credentials, shall be usable by customers accessing such accounts.

1.4.1   Major System Goals for the NEPP

WMATA's major goal for external stakeholders is to provide an electronic fare payment system that:

- Is convenient and usable by current and potential customers;
- Provides customers with modern and convenient fare payment options across all transit modes;
- Facilitates and promotes customer self-service;
- Is secure and reliable;
- Is easy to understand;
- Provides continued use of SmarTrip® media;
- Facilitates seamless customer transfer among adjoining transit agencies at connection points, regardless of whether the adjoining transit agency has migrated to NEPP.

WMATA's major system goal for internal stakeholders is to provide an electronic fare payment system that:

- Is secure and reliable;
- Introduces enhanced fraud and risk mitigation mechanisms;
- Provides accurate revenue reporting management and accountability;
- Provides accurate and timely ridership and revenue data;
- Reduces cash handling by WMATA staff;
- Fosters fare policy innovation and tailoring;
- Eliminates WMATA's dependency on a single supplier for compatible fare collection equipment;
- Eliminates WMATA's role as the sole transit-specific fare media issuer;
- Leverages market-driven capabilities to reduce WMATA's role as transaction acquirer and processor;
- Balances all other goals in the most cost-effective manner available.

Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation