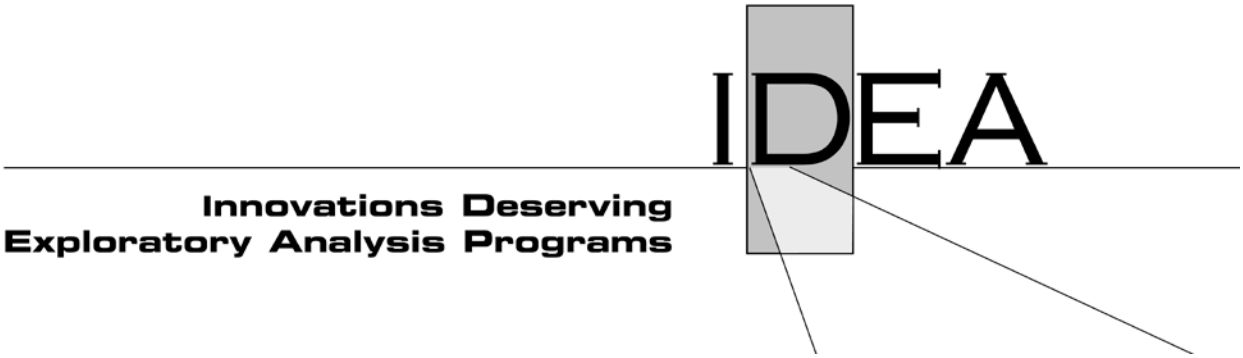

Transit IDEA Program

Implementation of Smart Card Automatic Fare Collection (AFC) Technology in Small Transit Agencies for Standards Development

Final Report for
Transit IDEA Project 79

Prepared by:
Walter E. Allen and
Robert D. Murray
Acumen Building Enterprise, Inc.

September 2016

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Transportation Research Board
National Academy of Sciences

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TABLE OF CONTENTS

EXECUTIVE SUMMARY 1

1 INDUSTRY ENVIRONMENT 3

2 THE IDEA 4

3 APPROACH 5

GENERAL 5

UNDERSTANDING THE APTA CONTACTLESS FARE MEDIA STANDARD 5

YCIPTA SMART CARD SYSTEM 5

ACUMEN CFMS ARCHITECTURE FOR YCIPTA 6

REFORMAT EXISTING YCAT SMART CARD 8

ACUFARE 200 CARD READER 8

YCAT CARD MANAGEMENT 8

ACUMEN HOST PROCESSING CENTER 8

Communications Interface Modifications 9

Add APTA CFMS Regional Central System and Agency Central System 9

Add Purchasing Product with Payment Card 9

Smart Card Loading Terminology 10

Acumen Smart Card Loading Implementation 11

Add Website to Access Payment Processor 11

Add Link from YCAT Website to Acumen Website 12

PILOT OPERATION 12

Completion of Pilot Operation 12

LESSONS LEARNED 133

IMPLEMENTATION LESSONS 13

Cost Containment, Debit Card Implementation 13

Original Design Used Data Cables 13

Banking Gateway—eBay Card Format Transition 13

Coexistence of Different Data Structures 13

PROCEDURAL LESSONS 144

Pilot Duration Limitations 14

Agency Understanding of Functionality 14

Maintenance 14

Passenger Training and Awareness 14

Limited Agency Staff 14

TECHNOLOGY LESSONS 15

APTA Contactless Fare Media Standard 15

APTA CFMS Data Communication Structures 15

Business Rules 15

CFMS Consistency Among Parts 16

Large Data Structure 16

Software and Data Version Reporting 16

APTA CFMS—Agency Central System 17

APTA CFMS—Regional Central System 17

APTA Standard—Card Data Structure 17

Card Reader to Subsystem Controller 17

DEMOGRAPHIC LESSONS 17

Passenger Acceptance of Technology 188

Language Issues **18**
Passenger Biases **18**
Passenger Monetary Capability **18**
CONCLUSIONS **19**
GLOSSARY **20**
REFERENCES **21**
APPENDIX A EVALUATION REPORT SAMPLE **20**
APPENDIX B PROJECT PLAN SAMPLE **244**
APPENDIX C APTA CFMS SPECIFIC ANOMALY REFERENCE **256**
INVESTIGATOR PROFILE **27**

TABLE OF FIGURES

Figure 1 YCAT bus **1**
Figure 2 APTA CFMS architecture overview **5**
Figure 3 APTA CFMS system architecture for YCIPTA **7**
Figure 4 AcuFare reader **8**
Figure 5 Website screen for YCAT product selection **11**
Figure 6 Website screen for value selection **12**
Figure 7 Pilot operation evaluation criteria **23**
Figure 8 Project plan **244**

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EXECUTIVE SUMMARY

While many of the nation's large transit agencies have adopted electronic automatic fare collection (AFC) and smart card systems, small and rural agencies remain tied to obsolete manual, cash-based fare collection. Implementation of smart card AFC technology in small and rural transit agencies offers the promise of increased passenger convenience, added passenger satisfaction, improved agency efficiency, and seamless transfers among other modes of transportation and other transit providers in their area. Smart card AFC technology provides improved and more frequent passenger data flow and bus stop data. However, small agencies cannot afford the cost of expensive proprietary smart card solutions typically offered by the major suppliers of fare collection systems. Deployment of the American Public Transportation Association (APTA) Contactless Fare Media System (CFMS) Standard eliminates the proprietary solution, thereby driving down the cost of implementation. A standards-based solution also offers inter-agency compatibility of fare payment systems.

The Acumen Building Enterprise, Inc. plan was to implement the APTA CFMS on a small rural agency system. Design and implementation of a total operational smart card system from the ground up is beyond the funding limits of the IDEA Program. Acumen chose the existing proprietary Yuma County Intergovernmental Public Transportation Authority (YCIPTA) system for standards implementation (Figure 1). In addition, Acumen offered YCIPTA the added benefit for Yuma County Area Transit (YCAT) passengers to purchase and load fare products from an Internet credit card payment processor. Depending on the particular transit agency, fare products include the following prepaid transit fares:

- Cash fares
- Rides
- Daily passes
- Monthly passes
- Multi-day passes
- Discounted fares and passes.

Figure 1 YCAT bus.

The Acumen Transit IDEA 79 Project plan culminated in a 90-day pilot operation successfully demonstrating the feasibility and operability of the APTA CFMS on a small agency.

Acumen modified the existing proprietary smart card data format. The new smart card format is the APTA CFMS format installed at YCIPTA. All existing YCIPTA fare policy features and functions are retained in the new smart card data format. The smart card readers, AcuFare 200 readers, were modified to read the old proprietary card format and the new APTA CFMS format interchangeably. Acumen ensured that both card formats could coexist in the revised system. Acumen also implemented an APTA CFMS-compliant back office computer system. The back office software was set up on Acumen computer servers in Acumen offices. Acumen designed and implemented a connection to PayPal® for credit card purchases. A connection was implemented with the YCIPTA existing passenger information website. Thus, a YCIPTA passenger is able to connect to YCIPTA website and purchase YCIPTA fare products for the fare payment smart card (YCAT card) by connecting to PayPal® through Acumen servers.

The revised and extended software was successfully placed into operation in April 2016 and continued in operation through September 2016.

With the successful operation of the APTA CFMS at YCIPTA, Acumen is evaluating other small and rural agencies who may be candidates for the smart card fare collection system. An operational credit card payment-processing feature will be included as an agency-selected optional feature. Since the APTA CFMS data communications protocol was implemented by Acumen, any CFMS-compatible devices and systems can be included in other systems regardless of the manufacturer. Acumen is in progress to placing the Acumen manufactured hardware components into the General Services Administration (GSA) pricing schedule to provide small agencies with the opportunity to purchase devices at the lowest market prices. The devices may then be incorporated into a CFMS-compliant smart card system.

Acumen believed that the small and rural agencies represented a large untapped market for contactless fare media smart cards. Further, with the utilization of standards, the implementation costs may be driven down within the range of affordability

of these small agencies. The combination of the above factors, the unserved need and market combined with the flexibility of Acumen's small size and cost structure, leads Acumen to believe that it can serve the small and rural agencies. On this basis, Acumen applied for a grant under the Transit IDEA 79 Project to implement a demonstration smart card system with a 90-day proof-of-concept Pilot Operation in conjunction with YCIPTA. This program is named Implementation of Smart Card Automatic Fare Collection (AFC) Technology in Small Transit Agencies for Standards Development. Throughout this report, it is referenced as Transit IDEA 79 Project.

As described in this report, Acumen implemented the APTA CFMS card format and back office computer structure for the YCAT system. It also implemented the ability for passengers to load or add cash value or fare products on to the smart card by accessing an online website and purchasing the value or fare products with a credit card. This system was successfully piloted on the YCAT system for 90 days to prove its viability and operability.

Acumen chose YCIPTA to participate in the Transit IDEA 79 Project because it had a contactless smart card system installed and in operation using a proprietary smart card data structure. Their geographical location is remote from any major metropolitan area and thus they are not under the umbrella of a potential regional smart card system. They are also geographically closer to the Acumen offices than most of the other small or rural agencies in the United States.

The implementation and placing into operation of the APTA CFMS card format and back office computer structure for the YCAT system was successful. In addition, the Transit IDEA 79 Project demonstrated the viability of a cost-effective implementation of the ability to load fare product purchased through the Internet and have the fare product autoloaded onto the smart card. The initial schedule was not met as a result of several unforeseen technical hurdles during the conversion of the proprietary contactless card data structure to the APTA CFMS data structure. Additional hurdles were experienced after the system was placed into operation. However, the system was viable and was implemented at a reasonable cost. The hurdles are described in the Lessons Learned section later in this report.

In summary, Acumen successfully implemented the APTA Contactless Fare Media Standard on the YCIPTA bus system as follows:

- Modified existing smart card readers
- Enabled passengers to select upgrading their smart card data structure
- Implemented an Agency Central Computer System
- Implemented a Regional Computer System
- Implemented an online Internet connection to a credit card payment processor
- Successfully operated a 90-day pilot of all implementations on the YCAT bus system.

These features can be implemented at other small and rural agencies.

1 INDUSTRY ENVIRONMENT

While there are many major metropolitan areas with large populations with transit agencies having hundreds of vehicles, there are more than 1,300 small and rural agencies throughout the United States (Mattson 2015). Most major metropolitan areas, if not all, have or will shortly invest millions of dollars in regional contactless fare media systems. The overwhelming majority of contactless fare media systems have been proprietary smart card and communications data structures implemented by large suppliers.

Having an online system with automatic data gathering is increasingly important for small/rural operators as Federal Transit Administration (FTA) and Moving Ahead for Progress in the 21st Century Act (MAP-21) reporting requirements become more stringent. Small transit agencies have avoided smart card automatic fare collection (AFC) technology due to the high cost of proprietary solutions. Proprietary solutions typically are not responsive to Intelligent Transit System (ITS) protocols and the challenges of integrating mismatched equipment without defined standards. Furthermore, many of the high-end proprietary AFC applications fail to meet the modest needs of small agencies.

Twenty years ago, Hong Kong recognized that smart cards could provide increased value to the passenger travel experience. They became among the first major transit systems to implement a contactless smart card-based AFC system. (Octopus card 2005) Since then, most major transit systems have implemented contactless smart card AFC systems. Hong Kong Transit (MTR) carries 5.2 million passengers daily [Mass Transit Railway (MTR) 2016)]. Unfortunately, small and rural agencies outside the umbrella of a major metropolitan area lack the monetary and technical resources to implement expensive and complex smart card systems provided by major suppliers.

Use of contactless smart cards for electronic fare payment is increasing over time. The trend began with contactless smart cards having the physical shape of payment cards and is now expanding to mobile devices such as mobile telephones, watches, fobs, and other forms. As the usage has increased, the cost of deployment has been driven lower. International standardization of the smart card has been a key driver of the expanded use. ISO/IEC 14443 is an international standard that covers the physical and electronic characteristics for contactless smart cards. However, this standard does not define how the data are represented on the card. In 2002–2003, American Public Transportation Association (APTA) realized that standardization of AFC systems data would be a key to driving down the cost and increasing the interoperability of transit fare collection systems.

APTA formed the Universal Transit Fare System (UTFS) task force to develop standards. The task force examined a number of standardization efforts evolving worldwide including the Port Authority Trans–Hudson (PATH) Regional Interface Specification (RIS) (Trends in Electronic Fare Media Technology 2004). The task force also examined the following emerging standards efforts.

- ITSO—is unique in transport (England) smart card specifications in that it covers all components—card, point of service, and back office systems (ITSO Ltd n.d.)
- CALYPSO—is the international electronic ticketing standard for contactless smart cards, originally designed by a group of European transit operators [Calypso (electronic ticketing system) n.d.].

More recently, other standards have emerged that impact the transit AFC systems. These standards are:

- Near-field communication (NFC) is a set of communication protocols that enable two electronic devices, one of which is usually a portable device such as a smartphone, to establish communication by bringing them within about 4 cm (2 in.) of each other (Near field communication n.d.).
- CiPurse/OSPT—security standard is a highly flexible set of specifications that can be adapted for both card-based and account-based AFC systems (ospt Alliance 2011).

The documents resulting from the APTA UTFS task force were the Contactless Fare Media System (CFMS), Volumes 1 through 4, Trends in Fare Media and Major Business Issues, as well as several other documents related the implementation of the smart card fare collection systems.

ITSO and CALYPSO are standards developed and used in Europe. CiPurse was developed to standardize on smart card data security and evolved after the CFMS. NFC standards relate to mobile devices that have different ISO/IEC standards. This Transit IDEA 79 Project focused on the CFMS applicability in small and rural agencies and, therefore other standards not required by CFMS were not considered.

2 THE IDEA

Acumen is a professional consulting firm established in 1994. It is a small, flexible organization that is focused on transit systems engineering, construction management, and operations and maintenance of systems for bus and rail. Acumen and Yuma County Intergovernmental Public Transportation Authority (YCIPTA), under a contract from the National Academy of Sciences, Transportation Research Board, IDEA Program, agreed to implement and conduct a pilot transit smart card fare payment system. This Transit IDEA 79 Project implements the APTA CFMS Standard. The APTA Standard specifies an interface between a smart card and a smart card reader, and the interface between the local equipment and the back-office fare collection data system. It was believed by Acumen and YCIPTA that no other small or rural agency in the United States had implemented the APTA CFMS other than a large agency such as Miami–Dade Transit.

YCIPTA provides fixed-route service throughout southwestern Yuma County including the cities of Yuma, San Luis, Somerton, Town of Wellton, Cocopah Indian Reservations, and the unincorporated communities of Yuma County, including Gadsden, Ligurta, and Fortuna. They also have routes to Imperial County, El Centro, and Andrade, California. YCIPTA operates 18 buses on 11 routes, Monday through Saturday. The YCIPTA buses operate under the name of YCAT and the existing contactless smart cards are called YCAT smart cards [Kreger, Comprehensive Annual Financial Report, Fiscal Year Ending June 30, 2015 (2015)].

Based on the premise explained in the Executive Summary, Acumen formed the idea from the following:

- Small and rural agencies can benefit from a contactless fare media smart card system.
- Implementation costs will be driven down by the use of standards for smart card system implementation.
- Small system integrators such as Acumen have lower cost structures and possess the organizational nimbleness to implement small systems in transit agencies.
- The APTA CFMS has been demonstrated to be a viable AFC schema in several U.S. transit agency implementations including Miami–Dade Transit with the EASY Card. (Cubic Wins $45+ Million Contract Award from Miami-Dade Transit, Building on 25-Year Relationship as Fare Collection System Supplier 2008) (Miami-Dade-Transit Automated Fare Collection System Contract 8481- 2008).
- The implementation of the APTA CFMS in small and rural agencies will provide the potential for greater interoperability among agencies.
- Directed loading of smart card fare product (value, rides) will be achieved through a low-cost credit card payment processor and therefore be affordable by small and rural agencies.

YCIPTA was an ideal candidate for the Transit IDEA 79 Project because of the following factors:

- It already has a smart card fare collection system in operation.
- It is small and isolated from large regional transit systems.
- It is believed that a bank payment card website connection will encourage expanded use of its existing smart card system.
- It will receive additional smart card fare payment system features if the program is successful for a minimal investment.

From these beliefs, Acumen submitted the Transit IDEA 79 Project request that was subsequently approved by TRB/NAS.

3 APPROACH

GENERAL

The approach to demonstrate the viability of the APTA CFMS on a small agency involves first, recognition of the elements covered by the standard, and second, the prerequisites required by the standard. Figure 2 shows the main elements of the CFMS. Details of this diagram are discussed here.

The APTA CFMS requires the use of the International Standards Organization (ISO)/International Electrotechnical Commission (IEC) Standard 14443 Identification Cards—Contactless Integrated Circuit Cards, as the underlying smart card characteristics (Contactless Fare Media System Standard 2006). The operational YCIPTA smart card fare collection uses an ISO/IEC standard compliant card and thus is adaptable to the APTA standard data structure.

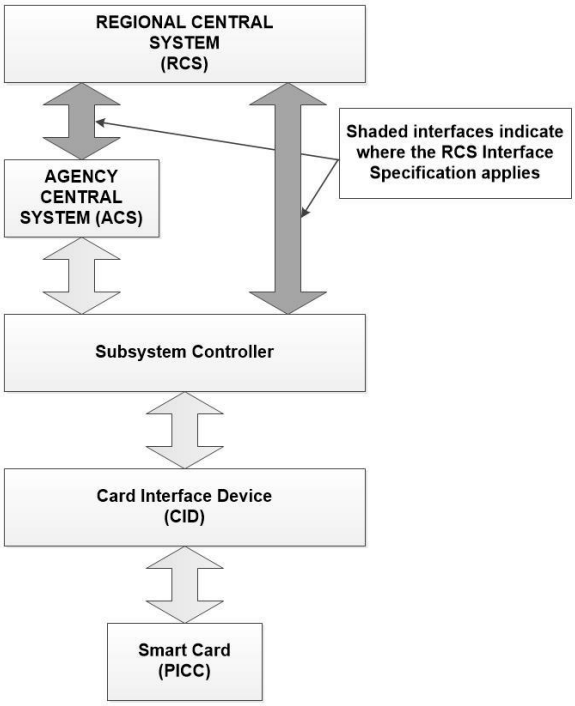

Figure 2 APTA CFMS architecture overview.

UNDERSTANDING THE APTA CONTACTLESS FARE MEDIA STANDARD

In 2003 (Contactless Fare Media System Standard 2006), APTA realized that the lack of interoperability of fare media, in particular smart cards, was a deterrent to regional operability of fare media among transit agencies. Therefore, under the sponsorship of APTA, a central coordinating committee was formed with several major subgroups with specific tasks. The subgroups were staffed with volunteer transit agency professionals and transit industry supplier professionals. These subgroups developed the Contactless Fare Media Standards for use by U.S. and Canadian transit agencies. The primary goal was to promote interoperability of fare media among transit agencies. Two of the subgroups developed the standards implemented in YCIPTA as described in this report. One subgroup developed the data standards for the Proximity Integrated Circuit Card (PICC). The other group developed the communications, data, and data structures for the Regional Central System (RCS) and the Agency Central System (ACS) (Contactless Fare Media System Standard 2007). Figure 2 shows the parts and the particular interfaces. The dark gray arrows in Figure 2 show the data communications developed and specified in the standard for the RCS and FCS. The communications data structures shown by the light gray arrows to the subsystem controller, the CID and the PICC, are not defined in any of the CFMS parts. They have been left undefined and at the discretion of the system designer and implementer.

Acumen developed and placed into operation a combined RCS and ACS in Acumen's data center and extended the data communications (e.g., dark gray arrows in Figure 2 from the RCS to the CID). The APTA CFMS does not cover the light gray arrows or the Subsystem Controller shown in this figure. Acumen encountered issues when the communications were extended to the CID. These issues are discussed later in this report in the Lessons Learned section.

YCIPTA SMART CARD SYSTEM

The YCIPTA smart card fare collection system was an ideal system upon which to pilot the APTA CFMS. Several years ago, Acumen implemented the original smart card system with a proprietary smart card data format and placed the system into full operation for bus passengers. The business rules originally implemented by Acumen cover many of the options used in AFC systems. The YCIPTA system has a proprietary back office computer data system that compiles, analyzes, and updates the smart cards and smart card readers on the system. The YCIPTA bus system is remote to any major metropolitan system and therefore any changes to the fare collection system do not affect other transit agencies. The smart card readers comply with International Standards as required by the APTA CFMS.

For YCIPTA to participate in the Transit IDEA 79 Project, they would expend internal resources to conduct the pilot. To encourage YCIPTA participation in the project, Acumen added smart card system enhancements beyond conformance to the CFMS. The extended functionality enables the purchase of YCIPTA fare products, value, and passes by using a credit card online over the Internet. This, of course, gives passengers who use the smart cards a substantial benefit by being able to load smart cards remotely and without cash.

Based on this, Acumen established an investigation and implementation plan. The main tasks in the plan were (see Appendix B

Project Plan Sample):

- Defined the division of work between Acumen and YCIPTA.
- Defined the business rules implemented into the smart card and reader that use the newly adopted APTA CFMS.
- Defined the software, using the APTA CFMS data communication interfaces among the smart card reader, back-office collection system, and web-based auto-load system.
- Defined additional back-office business reports on system utilization resulting from use of the new functionality.
- Implemented the system on YCIPTA's fleet of fixed-route vehicles and in YCIPTA's administrative office.
- Made CFMS-compliant smart cards available to patrons.
- Provided system training to transit operators and management.
- Placed the system into use for a 90-day proof-of-concept Pilot Operation.
- Document all standards used.
- Document the business rules implemented.
- Develop a joint report with YCIPTA on the success of the pilot implementation.

ACUMEN CFMS ARCHITECTURE FOR YCIPTA

The Acumen system architecture to implement the APTA CFMS is shown in Figure 3. The diagram shows the following four major processing systems linked by the Internet:

- Passenger and Bus Center
- YCIPTA local AcuFare Management Center
- Acumen Host Processing Center
- PayPal® Payment Gateway Processing Center.

The Passenger and Bus Center shows the YCIPTA passenger environment. Passengers use the YCAT smart card for fare payment on the bus. The passengers' YCAT smart card maintains the most recent use of the fare products. A synchronized copy of the fare product use and full history of the smart card use is maintained on the Acumen Host Processing Center computers. However, unless the passenger's smart card is damaged, lost, or stolen, the "official account" is stored electronically on the smart card.

When a passenger desires to purchase fare products online, he/she must register the YCAT smart card in the Agency's database. This is accomplished by one of two methods. The passenger may use a new feature to register the card using the Internet connected through the YCAT website or visit the YCAT service center. Once the YCAT smart card is registered in the agency database with proper passenger identifying information, the passenger is able to request the purchase of YCAT fare products, which can be done on the same Internet site as the registration of the YCAT card. The features of the YCAT card-based system versus an account-based system are discussed later in the section titled Smart Card Loading Technology. Passengers purchase YCAT smart card fare products through the Internet, which are subsequently loaded onto the YCAT smart card. The passenger must own or have access to an Internet-capable device and own a credit card.

YCIPTA operations manage the AcuFare Readers mounted on the buses through the local AcuFare Management Center provided by Acumen. YCIPTA gathers daily YCAT card usage and fare payment data onto a USB thumb drive. This is accomplished by connecting the USB thumb drive to the AcuFare 200 Reader. The thumb drive downloads prior smart card transaction data from the reader to the thumb drive. Next, the thumb drive uploads card reader information to the reader. The uploaded information to the reader may include data such as directives to load value or products to the smart cards or revised business rules.

When the USB thumb drive is returned to the YCIPTA, the local AcuFare Management Center, the thumb drive is inserted into the local computer, all of the transaction data are sent to the Acumen Host Processing Center. At the same time, the Acumen Host Processing Center downloads negative card list updates, YCAT smart card action lists, and YCAT smart card fare product purchases to the thumb drive. The thumb drive is then ready for the next daily update cycle.

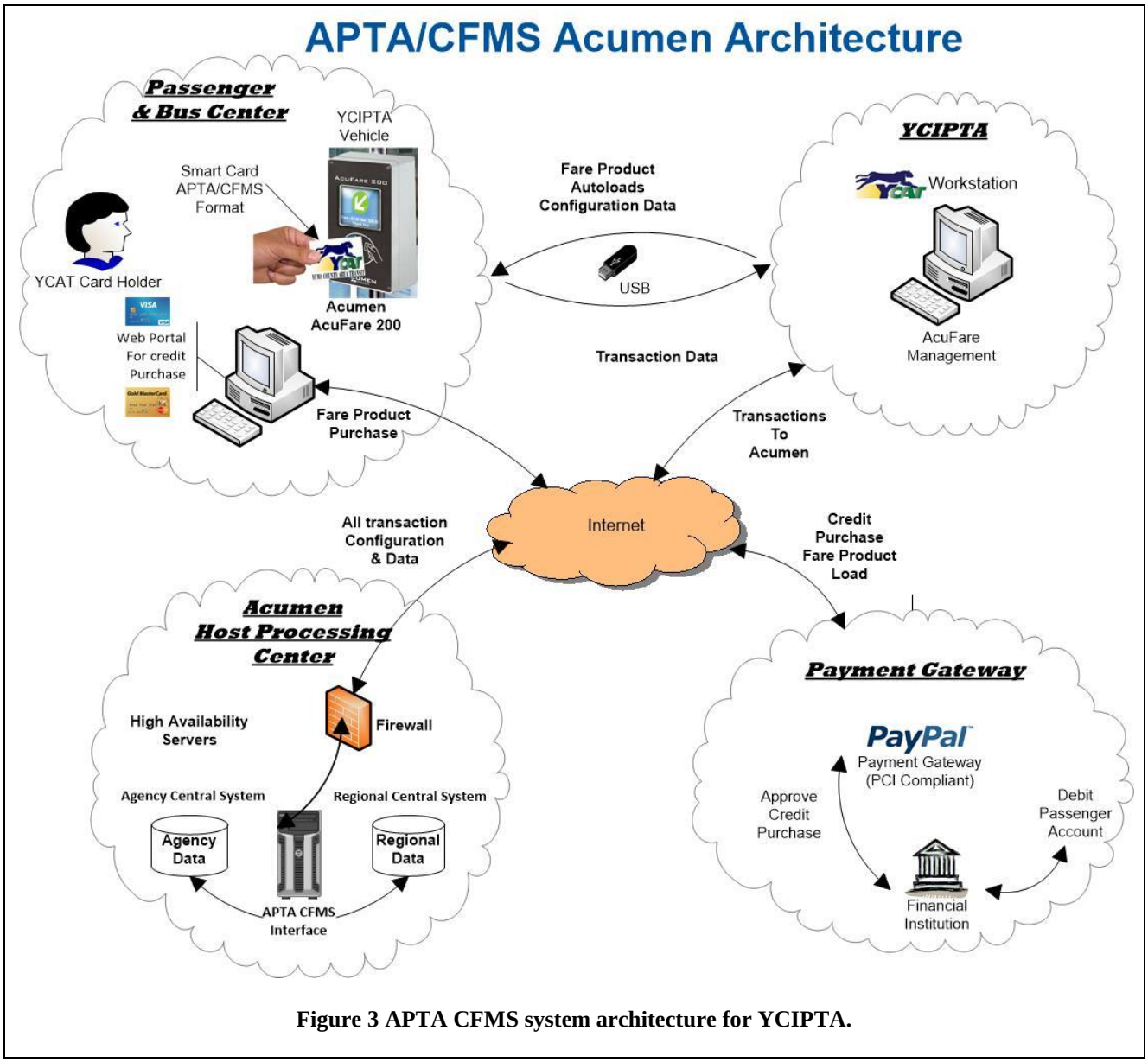

Figure 3 APTA CFMS system architecture for YCIPTA.

The Acumen Host Processing Center maintains all of the YCIPTA YCAT smart card transaction data in a history file. The Acumen Host Processing Center is the gateway for the YCAT smart card holder to access a secure payment-processing gateway. Although the Acumen Host Processing Center is secure, it does not conform to the Payment Card Industry (PCI) standards because it does not store or process credit or debit card information on the Acumen Processor. The Acumen Processor only provides the connection to the payment card gateway. The Acumen Processor is robust in its reliability and fully backed-up on a continuing basis.

Acumen selected the Payment Gateway Processing Center to handle the processing of credit or debit card transactions with the payment card industry; e.g., Visa, MasterCard, and Discover. The payment card processor chosen was PayPal®. When a YCAT card passenger makes a payment with a credit card, the passenger connects directly to PayPal® for all security

messaging by the Acumen Host Computer. Thus, as cited earlier, neither Acumen nor YCIPTA need conform to the very rigorous PCI standards. Absence of the PCI requirements substantially reduces the implementation and operating costs of a payment card gateway. Owing to project budget constraints, Acumen chose not to implement debit card processing at this time.

REFORMAT EXISTING YCAT SMART CARD

Implementation of the APTA CFMS required a restructuring of the YCAT smart card data to the CFM Standard data structure. Since the YCIPTA system is in operation and is intended to remain in operation after the Transit IDEA 79 Project, the smart cards with the CFMS must co-exist with the existing cards during and after the project. The transition from the existing proprietary smart card data format to the new CFMS smart card data format had to be transparent to the YCAT cardholders. On passenger use, the card data structure must be seamless to the passenger and to YCIPTA. The new data structure includes all data fields necessary for the YCAT existing operation and business rules. The new data structure also includes all data structures required by the APTA CFMS even though similar fields may not have been implemented in the previous proprietary data format implemented by Acumen.

ACUFARE 200 CARD READER

Implementation of the APTA CFMS requires revision of the smart card reader in two areas. The software that communicates with the smart card must be modified to add the new data fields for the APTA CFMS. The software must also be augmented to recognize both the Acumen proprietary smart card data structure and the CFMS smart card data structure and handle each correctly. Further, as described late in Lessons Learned, the software was modified to enable the smart card data to be changed dynamically on the YCAT bus. The AcuFare 200 Card Reader is shown in Figure 4.

The communications protocol software to the back office data system was modified. The APTA CFMS specifies the data and its structures required to communicate between the reader and the back office data system. The quantity and the style of the data communicated using the APTA CFMS format is very different from the efficient proprietary format originally developed by Acumen.

Figure 4 AcuFare reader.

YCAT CARD MANAGEMENT

Acumen provided a back-office application to allow YCIPTA to manage and electronically repair the YCAT smart card. An existing management feature is the ability to restore fare products for lost or stolen cards that had been previously registered by the cardholder. Since the revised YCIPTA system must manage both the existing proprietary smart card format and the new CFMS card format, the back office application was modified by Acumen. The revised back office application adds a new option for YCIPTA use. When a YCAT smart card is detected by the back office application, the card type, whether the proprietary data format or the CFMS data format, the format is detected. If the proprietary data format is detected, the application offers YCIPTA the new option to modify the card data format to the CFMS data format. If the YCAT passenger instructs YCIPTA to modify (upgrade) the YCAT smart card, the Card Management Software inventories all fare products currently existing on the smart card, reformats the smart card and places the existing fare products into the new CFMS-compliant data structures. At this point, the passenger's YCAT smart card has the capability of receiving new fare products or adding fare products using the PayPal® payment processing through the Internet.

ACUMEN HOST PROCESSING CENTER

The original host processing system did *not* have the following software functions implemented:

- Communications from the Acumen Host Processing Center to a Payment Gateway Processing Center
- The data structures required APTA CFMS
- The APTA CFMS communications structure with the AcuFare 200 smart card reader
- A website user interface for YCAT cardholders to purchase YCAT smart card fare products

- A website interface from the Acumen Host Processing Center to the existing YCIPTA website making the YCAT smart cardholder experience seamless
- A website interface to PayPal® for processing payment (credit) cards used by YCAT smart cardholders.

Acumen developed the software to host the APTA CFMS back-office data system for YCIPTA on an Acumen server at Acumen offices. The Acumen Host Processing Center ensures that smart card transactions to add value to the YCAT card occurs smoothly in a stable, secure environment. The Acumen server(s) used for hosting the smart card load system are fault tolerant computers with high availability and utilize Redundant Array of Independent Disks (RAID) configured disk drives for maintaining high availability. Acumen also regularly stores a backup copy of its data disks off-site for additional protection against a catastrophic failure and disaster recovery.

Communications Interface Modifications

Acumen revised the software originally provided to YCIPTA that communicates between the Acumen Host Processing Center and the on-bus AcuFare 200 smart card readers using the APTA CFMS communications protocol. The revised software includes all APTA CFMS required data structures and a revision of the existing data structures. These revisions implemented substantially increased the required computer data storage because the APTA CFMS is substantially less compact. The APTA CFMS data structures use Extensible Markup Language (XML) a common international standard communications language (XML 2016) for the underlying data communications protocol between the smart card reader and the back-end systems.

Add APTA CFMS Regional Central System and Agency Central System

Implementation of the APTA CFMS on the YCIPTA system required Acumen to implement an APTA CFMS Regional Central System and Agency Central System to be fully compliant to the standard. Since a "region" does not really exist for YCIPTA, Acumen combined the Agency Central System functions and the Regional Central System functions into the single Acumen Host Processing Center. Both the RCS and the ACS functionality exist, but both systems are in one Acumen Host Processing Center. The data communications between the two functions occur internally within the Acumen Host Processing Center processor.

Add Purchasing Product with Payment Card

To reward YCIPTA participation in the TRANSIT IDEA 79 Project, Acumen provided an addition to the original functionality of the YCAT system. The revised system enables the purchase of YCAT fare product online with credit cards. This new feature required the development of software and an interface between the Acumen Host Processing Center and a Payment Gateway Processor. The Payment Gateway Processor chosen by Acumen was PayPal®. PayPal® is currently being used by YCIPTA for other purposes so that actual payments for the YCAT card purchases are easily deposited directly into YCIPTA's bank account. Using PayPal® also permitted Acumen to avoid the implementation of the PCI Data Security Standards (DSS).

The PCI DSS Quick Reference Guide (Payment Card Industry Data Security Standard 2016) states as follows:

> The PCI Data Security Standard (DSS)…applies to all entities that store, process, and/or transmit cardholder data. It covers technical and operational system components included in or connected to cardholder data. If you are a merchant who accepts or processes payment cards, you must comply with the PCI DSS.

The system Acumen provided to YCIPTA in the TRANSIT IDEA 79 Project does not perform any of the actions stated in the quoted paragraph above; therefore, the Acumen system need not conform to PCI-DSS. All such requirements are handled by PayPal®

The Payment Card Industry Data Security Standard (PCI DSS) is a proprietary information security standard for organizations that handle branded credit cards from the major card schemes including Visa, MasterCard, American Express, Discover, and JCB. Private label cards—those that are not part of a major card scheme—are not included in the scope of the PCI DSS.

The PCI Standard is mandated by the card brands and administered by the Payment Card Industry Security Standards Council. The standard was created to increase controls around cardholder data to reduce credit card fraud. Validation of compliance is performed annually, either by an external Qualified Security Assessor (QSA) that creates a Report on

Compliance (ROC) for organizations handling large volumes of transactions or by Self-Assessment Questionnaire (SAQ) for companies handling smaller volumes.

Implementation of a system employing PCI/DSS is expensive to develop and costly to operate on a continuing basis. Only very large transit agencies have the technical staff to develop and operate a system employing these standards. Typically, small and rural agencies do not have the staff either to develop or to operate a system requiring the PCI/DSS standards.

Smart Card Loading Terminology

To understand the purchase of YCAT fare products and to load the products onto the smart cards, it helps by understanding the industry terminology. Acumen's implementation of the Transit IDEA 79 Project with regard to prepaid purchases for the smart cards relies on the APTA loading terminology definitions. Per the APTA CFMS Part 1 (Contactless Fare Media System Standard 2007), the following is the definition of Autoload:

- Autoload: A method that automatically loads a PICC electronically with a transit fare product using a process that is usually transparent to the cardholder. Autoload may be implemented in three different ways: Directed, Threshold, or Recurring.

A Directed Autoload is a smart card fare product load (value, rider, or passes) that occurs whenever a cardholder purchases the fare product online and without presenting the smart card to the transit agency payment system at the time of purchase. For the system Acumen implemented at YCIPTA, the passenger first registers (or previously has registered) the smart card by providing unique identifying smart card and passenger information. Next, the passenger selects the products and values desired for loading. Upon validation of the passenger and smart card information, the passenger is connected to the PayPal® site where the purchase is consummated using a valid bank credit card. When approved, the Acumen-provided back office system records the purchase and marks the smart card account record for remote loading by the bus-mounted AcuFare 200 readers. This purchase and subsequent load process is a "Directed Autoload."

A Threshold Autoload occurs whenever a cardholder instructs the system to purchase additional fare product whenever a particular smart card threshold is reached. For example, a Threshold Autoload may occur when a designated low monetary value is reached or a low quantity of rides is reached. When the Threshold is reached, the system initiates a purchase and, if successful, instructs the system card reader to load the target smart card when next read by the card reader. This feature, Threshold Autoload, was *not* implemented by Acumen on the YCIPTA system.

A Recurring Autoload occurs when a cardholder instructs the system to purchase additional fare product whenever a particular period expires. For example, a Recurring Autoload may occur when 30 days or one month has expired since the last product load action. When the expired time is reached, the system initiates a purchase and, if successful, instructs the system card reader upon the next card reader update to load the target smart card when next read by the card reader. This feature, Recurring Autoload, was *not* implemented by Acumen on the YCIPTA system.

Implementation of Threshold Autoload and Recurring Autoload requires a means to retain identifying payment card information on the agency Central Computer System. A Central Computer System design that incorporates Threshold and Recurring Autoloads has account-based card records. While card payment processors such as Authorize.net and PayPal® offer these services, substantial additional design and implementation for the YCIPTA system would have been required by Acumen. Acumen will offer these features as options on future implementations.

Acumen Smart Card Loading Implementation

Due to the substantial additional complexities of implementation and the variety of options presented to the YCAT cardholder, Acumen chose to implement only the Directed Autoload.

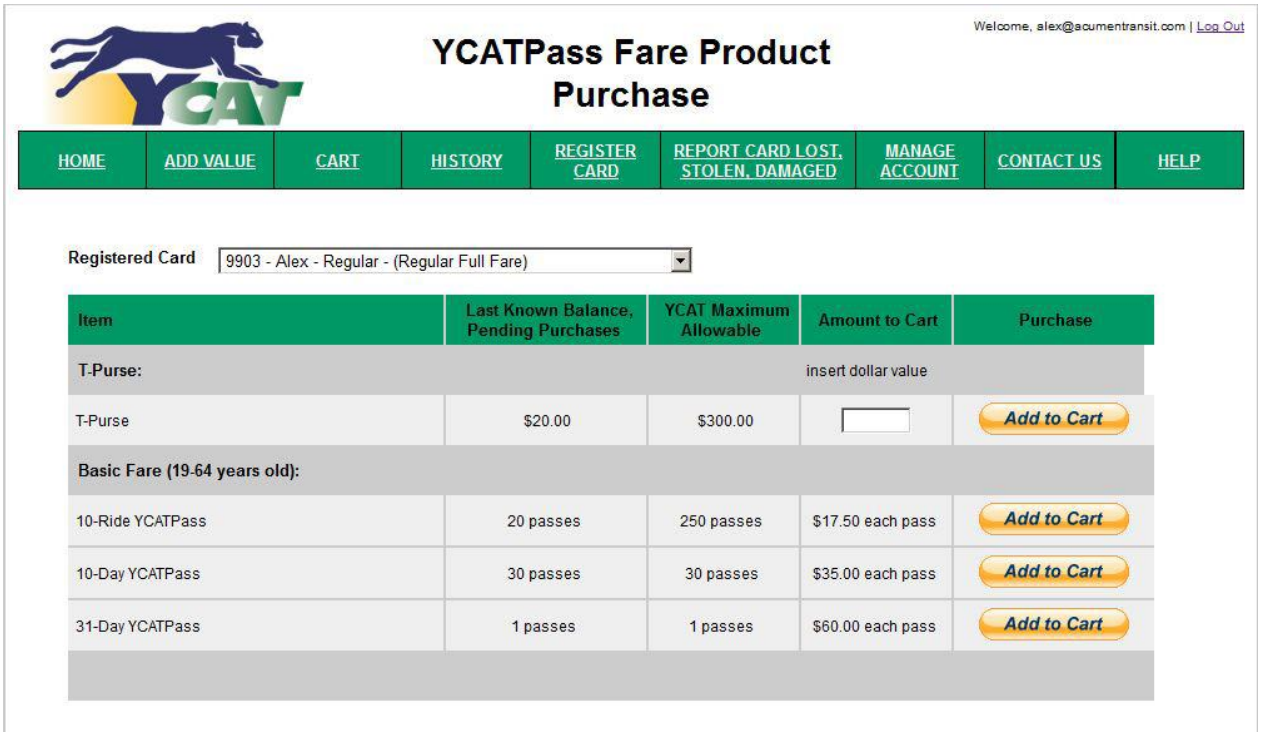

Figure 5 Website screen for YCAT product selection.

Add Website to Access Payment Processor

Acumen developed a multi-screen website to enable passengers to register their YCAT smart cards and to purchase fare products. Two of the screens developed are shown in Figures 5 and 6. Figure 5 shows the screen for the passenger to select one or more of the four products. Figure 6 shows the screen for the passenger to set the quantity or value of one or two products. Additional screens were developed by Acumen, but they are not illustrated here.

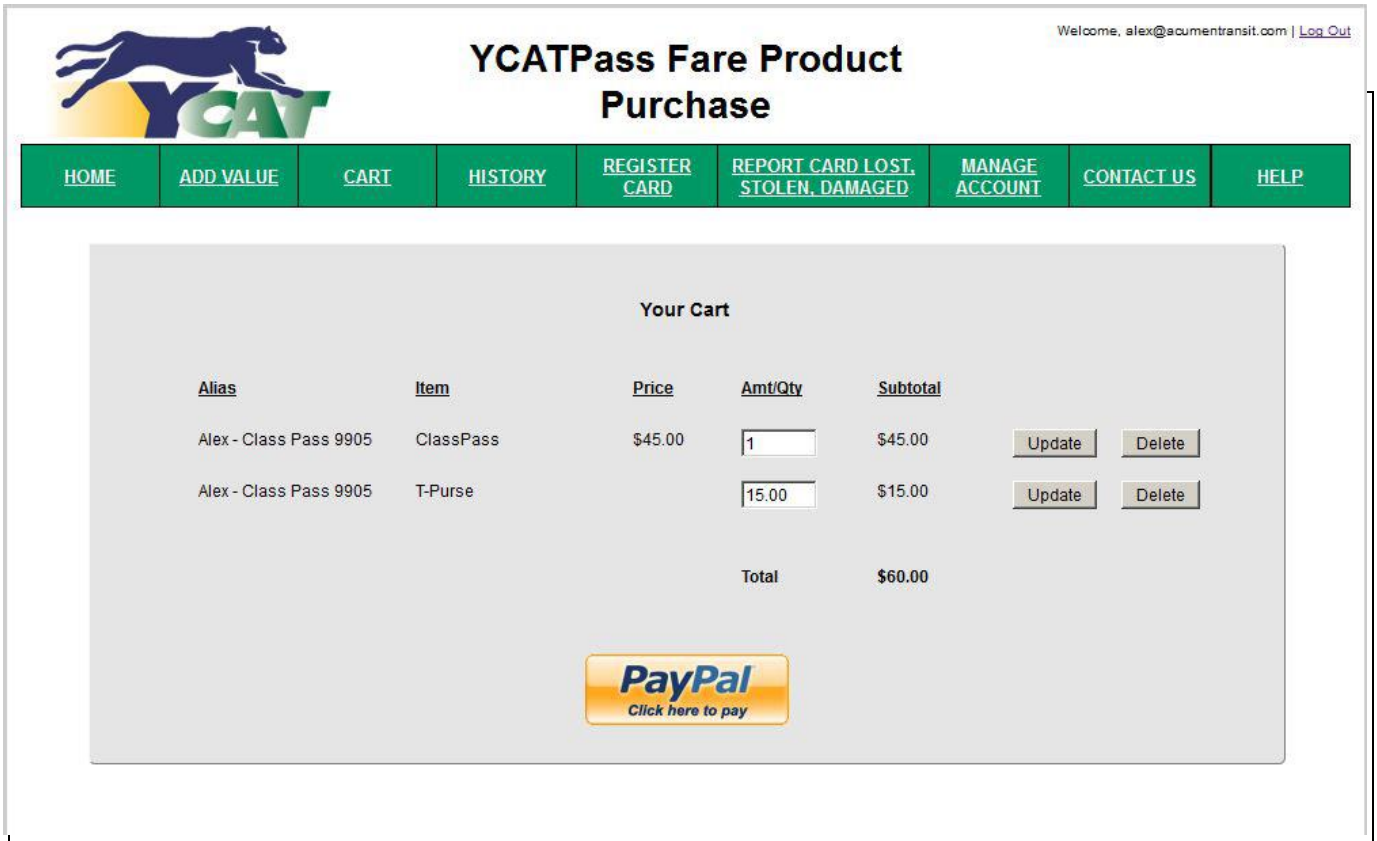

Figure 6 Website screen for value selection.

Add Link from YCAT Website to Acumen Website

Acumen linked the new screens to the existing YCAT website. This ensured that new the website screens were seamless and fully integrated with the YCAT website. Thus, a YCAT cardholder desiring to add fare products to the YCAT card makes a selection that seamlessly links to the Acumen website. When connected to the Acumen website, the cardholder selects the product or products to purchase. After selection, the cardholder is seamlessly linked to the PayPal® website for entry of the credit card information and completion of the purchase. A successfully completed purchase is communicated from the PayPal® website to the Acumen website for recording in the YCAT cardholder's account for proper processing as previously described. Acumen designed the YCAT product purchase pages with a "look and feel" the same as the YCAT website pages.

4 PILOT OPERATION

The Pilot Operation was conducted for 90 calendar days. Immediately before the Pilot Operation, Acumen and YCIPTA transferred the YCIPTA operating data from the YCIPTA computer to the Acumen Host Processing Center. During the 90-day proof-of-concept Pilot Operation, Acumen operated the systems gathering the YCIPTA transaction data and handling the websites to the Payment Gateway. YCIPTA has complete access to smart card and passenger travel data when YCIPTA accesses the Acumen Host Processing Center. YCIPTA views and prints any of the data by preformatted reports provided by Acumen. During the 90-day Pilot Operation YCIPTA gathers the data from the bus AcuFare 200 Card Reader, loads (copies) the data to a USB thumb drive and uploads the data to the Acumen Host Processing Center for consolidation of the data into the YCIPTA master data file.

Completion of Pilot Operation

Upon completion of the 90-day proof-of-concept Pilot Operation and the Transit IDEA 79 Project, Acumen will offer options to YCIPTA either to purchase the enhanced system features or to continue Acumen providing the Host Processing Center services for an annual fee. The enhanced features include the website services and the ability to purchase YCAT fare

products by means of the PayPal® Payment Gateway. Notwithstanding YCIPTA's decision on the enhanced functionality, the YCAT smart card data structure with the original proprietary data structure or the new APTA CFMS data structure are both recognized and interoperable on the AcuFare 200 smart card readers.

5 LESSONS LEARNED

As with any undertaking there are lessons learned, both positive and negative, that can be applied to improve the implementation efficiency and the results for a similar undertaking. The implementation of the APTA CFMS and the added functionality of purchasing fare product online for automatic fare product loading resulted in lessons learned. For the sake of discussion and consideration in this report, the lessons learned are grouped into the following paragraphs.

- Implementation Lessons—which include cost considerations, methods, conflicting requirements and proposal oversights.
- Procedural Lessons—which include operating problems and misunderstandings among the Transit IDEA 79 Project team.
- Technology Lessons—which include equipment capabilities, standards' requirements, and technological practicality.
- Demographic Lessons—which include affluence, low income, passenger values, and perceptions and special needs persons.

Another grouping that did not arise in the program is the means of conveyance such as buses, heavy rail, light rail, van, automobile, taxi, carpooling, etc.

IMPLEMENTATION LESSONS

Cost Containment, Debit Card Implementation

Acumen realized from the time of the initial proposal that the idea of demonstrating the APTA CFMS in a small agency was a major undertaking that would require careful management of everyone's expectations to fit the implementation effort within the time and budget allotted by the Transit IDEA 79 Project. Implementation of debit cards as a means of purchasing the fare products online was one item that had to be eliminated from the Transit IDEA 79 Project owing to the additional cost of the implementation. The elimination of this feature did not detract from the demonstration of the viability of the CFMS on YCAT. Implementation of purchase by a debit card is possible and can be offered as an option to other agencies. The purchase by debit card is already supported by the payment gateway, PayPal®.

Original Design Used Data Cables

When the original Acumen AcuFare system was implemented on the YCAT system, there was no low-cost, easy means to retrieve the data from the YCAT AcuFare reader on the buses at the end of the business day except by means of a USB cable connected to a thumb drive or a laptop computer by a bus garage person. During the very beginning of the 90-day pilot period, this limitation became an issue that was exacerbated by YCIPTA maintenance issues. In a typical systems integration project, the manufacturer, like Acumen, would have provided on-site representatives. In the Transit IDEA 79 Project, with only a 90-day proof-of-concept Pilot Operation and a tight budget, Acumen relied on the YCIPTA staff that had their goal of keeping the buses running with the on-site maintenance. The data transfer cables and connectors had not been sufficiently maintained and valuable project time was lost. Acumen has developed a conceptual solution to the issue to eliminate the USB thumb drive and connector. Acumen conceptualized a wireless option that will be offered on future systems.

Banking Gateway—eBay Card Format Transition

During implementation of the website to Payment Gateway provided by PayPal®, it became necessary for Acumen to access the PayPal® documents describing the means and methods for the interface. Possibly due to Acumen's unfamiliarity with this particular website, Acumen found the documents confusing, inaccurate, and incomplete. With some assistance from PayPal®, Acumen was able to decipher the requirements and implement the interface. This lack of familiarity and similar issues are to be expected in the systems integration business space.

Coexistence of Different Data Structures

Upgrading from a proprietary card format to the CFMS requires careful planning on the transition from the proprietary smart card data format to the CFMS smart card data format without disrupting the passenger use of the card. A possible resolution to this issue would be to replace the smart card originally provided to YCAT customers with new smart cards having the CFMS format. This would have resulted in additional cost of implementation.

PROCEDURAL LESSONS

Pilot Duration Limitations

Initially, YCIPTA and Acumen believed the 90-day proof-of-concept Pilot Operation duration would be sufficient for the full evaluation of the APTA CFMS implementation. Once the Pilot Period began, it became evident that it would be difficult to accomplish the evaluation within the period. Among the difficulties encountered were maintenance of smart card system equipment, passenger training and awareness, and the remoteness of the YCIPTA headquarters site. Nonetheless, all participants strived to achieve the goals within the allotted time. Acumen recommends a longer Pilot Period in complex projects.

Agency Understanding of Functionality

A small or rural transit agency understands the operation and maintenance of their transit system, but may not understand the complexities of a high technology project. For this reason, it is the supplier's responsibility, in this instance Acumen, to take the necessary extra steps to explain fully the workings of the technology being provided. This may require comprehensive training documents and on-site training. However, for a very limited budget, such as this Transit IDEA 79 Project budget, the cost of travel becomes prohibitive and the supplier generally must rely on training documents. Acumen was fortunate enough that manuals existed from the original implementation and that these manuals only needed to be supplemented with the updated information.

Maintenance

In a small agency with a limited staff, it is easy for staff attention to be redirected from making the Transit IDEA 79 Project successful and then possibly lose sight of keeping the system maintained. As mentioned in the previous section, during the early part of the 90-day proof-of-concept Pilot Operation, it seemed that the passengers were not using the existing smart card system at all. When the team investigated, we found that several AcuFare card reader connectors were broken and needed replacement. To exacerbate the situation, YCIPTA and Acumen did not have spare parts to repair the broken connectors. This maintenance issue resulted in a 7- to 10-day loss in the 90-day proof-of-concept Pilot Operation.

Passenger Training and Awareness

Passenger understanding of the system capabilities in relation to their needs is important in a highly technical undertaking. In large metropolitan areas, agencies have setup extensive and expensive passenger training sessions. For example, in New York when the Metro Card (i.e., a magnetic stripe fare card) was introduced to the public, the New York City Transit outfitted several buses with demonstration equipment and visited various sections of the city on a schedule. For the Washington Metropolitan Area Transit Authority (WMATA) SmarTrip Card (i.e., smart card fare card), the agency outfitted a bus that was driven around the city.

For a 90-day pilot on this Transit IDEA 79 Project, a formal passenger training and awareness campaign is impractical and cost prohibitive. However, this lack of training and awareness presented itself as an issue on the Transit IDEA 79 Project. It was difficult to create cardholder interest in the program, particularly since the project only included a 90-day proof-of-concept Pilot Operation. Both YCIPTA and Acumen attempted to bolster interest. For example, Acumen and YCIPTA developed a flyer (seat drop) to place on the bus seats to obtain more cardholder interest. In hindsight, a more aggressive customer outreach program was required and should have been planned.

Limited Agency Staff

A small or rural transit agency has limited and/or no engineering professionals to assign to the implementation of a high technology project. YCIPTA is typical of such an agency. Small and rural agencies do not have operating or capital labor

budgets to support such a staff on a continuing basis. Therefore, on the Transit IDEA 79 Project, where the Pilot operation is only 90 days, the agency must "time-share" its project activities with its normal day-to-day operating activities.

TECHNOLOGY LESSONS

APTA Contactless Fare Media Standard

At the time of development, the APTA CFMS was at the forefront of the smart card implementation in the United States and Canada. There were also various competing standards in existence or development in Europe and Asia vying for adoption in North America. Thus, the development of the CFMS was a major undertaking concurrent with the implementation of a few major successful smart card fare media implementations in North America. The CFMS teams were volunteers drawn from various North American agencies, major manufacturers, and several foreign manufacturers. The goal was to develop a set of standards that would be applicable to agencies, regions, and manufactures. From the perspective of the original goals, the CFMS Project was a success. It provided the framework and the details for implementation of a smart card-based automatic fare collection system. This was demonstrated in the successful implementation of the CFMS in the Miami–Dade Transit and the surrounding Miami region. However, because the CFMS was developed prior to the actual use in an implementation and because non-regional small and rural agencies were not represented in the CFMS development, a possible revision to the CFMS should be considered.

Several of the topics discussed below about the CFMS describe the issues encountered when implementing a standards approach on a small agency in a non-regional environment. In the future, the small agencies may be interconnected to larger regions. However, small agencies are isolated and operate alone with regard to a smart card AFC system.

APTA CFMS Data Communication Structures

During the Acumen implementation of the Contactless Fare Media Standard, Version 1.0, several areas for improvement became apparent to Acumen developers. To help improve the standard, Acumen has identified some Lessons Learned and has some recommendations to remedy some of these areas:

Extensible Markup Language (XML) is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable. XML is defined by several published specifications, all of which are free open standards. XML is a very flexible way to exchange information between computer systems. Unfortunately, it is extremely inefficient in terms of memory and storage space and communication bandwidth. For that reason, Acumen believes that the stipulation in CFMS Part 3 to require the use of XML to communicate between smart card system equipment in a CFMS system and the RCS and ACS are overbearing. The use of XML results in data files and intra-device communication messages many times larger than necessary as compared with a tighter binary format. Part 2 of the CFMS requires that the smart card data stored on the smart card use a specific binary data storage format. While there were many examples of the inefficiencies of XML in the Acumen implementation of the CFMS, Autoload Identification is one example. The Autoload Identification number on the smart card is a number between 0 and 63. This number is represented as 7 binary bits, whereas in XML format it requires at least 264 binary bits or 37 times more storage space and 37 times longer to transmit between devices. Therefore, the use of XML may require faster devices with more memory and greater communication bandwidth than may be required if a smaller data communications format is specified.

During the implementation of the Transit IDEA 79 Project, Acumen found that the XML data communications format was too inefficient to store the data in the XML data format on a bus smart card reader. Acumen decided to store card data on the reader in a compressed proprietary data format. When the data were sent unloaded from the card reader, the data were converted to the XML data format immediately prior to transmittal to the next level. Data conversion at this stage is a better strategy and guards against filling the bus-mounted smart card reader memory with unnecessary and useless information. During Acumen's implementation of the changes in the smart card reader storage and data communications, it took more design hours and schedule time without any increase in form or function. Since the entire premise of the Transit IDEA 79 Project was to implement and demonstrate the viability of CFMS on a small or rural agency, employment of XML communications was necessary.

Business Rules

A complex set of business rules is not easily implemented by the CFMS pass fare products definitions. The CFMS provides the means to define a custom data item that can store information to accommodate rules outside the simple pass fare products that are defined in the CFMS. Unfortunately, while this approach is very flexible, it defeats the purpose of a standard since it is a retreat to a proprietary implementation and away from a standard approach. Furthermore, since no one outside of a particular implementation will know how the customized data are used, this represents a return to a proprietary implementation. Unfortunately, Acumen had to use such a tactic to implement the CFMS at YCIPTA. Acumen made extensive use of the Extension Object feature in CFMS to allow Acumen to implement the existing YCIPTA business rules. Unfortunately, the Extension Object to a degree is a backward step to the uniformity of the standard; therefore, this was not an ideal workaround.

CFMS Consistency Among Parts

The APTA CFMS was developed by four separate teams. While there were several team members who participated in multiple teams, for the most part, the teams were autonomous. Since the effort was voluntary and the pace of standard development work was aggressive, a person could not easily cover more than two teams effectively. During the Acumen implementation of the CFMS on the YCAT system, Acumen identified a few areas of inconsistency. Since the Acumen implementation team was small and compact, the standard inconsistencies did not always present a problem. However, if the teams were large and each member assigned separate tasks, standard inconsistencies could lead to significant problems. Appendix C

PTA CFMS Specific Anomaly Reference, provides a list of some of the inconsistencies Acumen encountered during implementation of the Transit IDEA 79 Project. If the back-end system development and the front-end device firmware development are developed independently, the two systems may be incompatible. During implementation, Acumen made corrections in the inconsistencies where the intended meaning seemed obvious.

Large Data Structure

Fare payment systems that have proprietary data structures complete a data transfer between the smart card and the smart card reader in 100 milliseconds or less. To a passenger, transaction times in this range appear instantaneous. Due to the large amount of data that needs to be exchanged between the smart card and the bus-mounted smart card reader using the APTA CFMS data structures, the transaction times are longer than ideal. Unless the card data structures and the read and write sequences are carefully designed, the transaction times can easily exceed 350 milliseconds. Transaction times of 350 milliseconds or more result in passenger frustration and frequent smart card reader requests to "tag again." For this reason, greater flexibility in the required quantity of data storage on the smart card may improve the transaction time.

From Acumen's perspective during implementation of the Transit IDEA 79 Project, the APTA CFMS appears biased toward the implementation and use of Recurring Autoloads. Recurring Autoloads are card loads of stored value or fare products that are added to a card at regular set time intervals without the cardholder intervention or action. Threshold Autoloads are card loads of stored value or fare products that are added to a card when the level of a card product reaches a minimum threshold as set by the cardholder. Directed Autoloads are a one-time smart card load that are made for stored value or fare products that are added to a card in response to a purchase made by a cardholder. Directed Autoloads using the APTA CFMS data structure are difficult to implement securely and could be improved to enhance the data and cardholder security. Threshold and Recurring Autoloads can be offered as options on future systems.

Software and Data Version Reporting

Although the APTA CFMS provides some options to attach a date to some of the data, Acumen found some inconsistencies and shortcomings in the process. All fare smart card systems require a Negative List (a list of cards to be blocked) or Action Event List (a list of actions to perform to the card). Acumen has found that all the smart card readers in a system should report to the central host data system the current version of their Negative and Action Event List as contained in the smart card reader memory. Acumen has designed its AcuFare system, where the interface between the two systems is a manual file exchange process by means of a USB drive. In the APTA CFMS, the Negative and Action Event List provide for a date to be passed in the using the XML data structure variables defined in the standard. Unfortunately, there are no data structure variables defined for the smart card reader that is communicated to the host data system that provides the data necessary for the host system to identify Negative List and Action Event List file dates. It is also our opinion that the data structures should have included the time as well as the date to allow for instances where a Negative List is created multiple times in one day. Acumen added a

proprietary message to convey this information in addition to the CFMS messaging. It would have been more desirable to have this included in the CFMS standard messages.

The APTA CFMS should contain a unique data structure identifier for every transaction performed by a system smart card reader. The host processing system would then know exactly which transactions have been performed, based on the messages sent from the card readers to the host processing system. Transactions that have been performed can be removed from future Action Event lists sent to the smart card reader. The APTA CFMS provides a data element that can be used for the transaction event; however, its range is very limited and likely will "wrap around." Even though the currently defined variable may work in most systems, a unique identifier would prevent the possible ambiguity inherent with a data field that can "wrap around" too quickly. Resolution of this issue will require careful study and planning in changes to the standard to not impact existing implementations.

APTA CFMS—Agency Central System

The CFMS explicitly states, "This Standard applies to contactless fare collection systems where two or more transit agencies share a common PICC and one or more common fare products for fare payment." This implies that a single agency, including small and rural agencies is discouraged from using the APTA CFMS. The CFMS is focused on "interoperability." Thus, by the explicit statement, the APTA CFMS is not intended for a single or small agency as currently structured. This focus of the APTA CFMS has resulted in some of the issues encountered by Acumen during the implementation of the Transit IDEA 79 Project for YCIPTA. To maintain conformance to the APTA CFMS, Acumen did implement both an Agency Central System and a Regional Central System (see earlier discussion.)

APTA CFMS—Regional Central System

The standard requires a "Regional" processing center that a small rural agency does not have or need. The Acumen implementation of the Acumen Host Processing Center placed the Agency Central System and Regional Central System functions into one processor. However, only one Central System was required. Therefore, Acumen's conformance to the CFMS required software functionality that was unnecessary.

APTA Standard—Card Data Structure

The APTA CFMS Part II—Contactless Fare Media Data Format and Interface Standard is oriented toward large and regional agencies. As such, the APTA CFMS does not describe a subset of data elements that could be used in a small rural agency and still be compatible with the standard.

Card Reader to Subsystem Controller

The communications protocol to the fare collection equipment (e.g., card readers) is not specified in the APTA CFMS. Thus, communications with the equipment level either can be a proprietary format or could be through a standard XML format as specified for the Regional Central System or the Agency Central System to and from the Agency devices; that is, card readers. However, the XML format has too much processing overhead for the functions performed. From Acumen's perspective, it appears the protocol is more focused on large agencies with powerful data centers and large Subsystem Controllers.

DEMOGRAPHIC LESSONS

The YCIPTA's service area centers in the city of Yuma, Arizona, the county seat of Yuma County. Yuma County's population as of the 2010 U.S. Census was 195,751 (Kreger, Comprehensive Annual Financial Report Fiscal Year Ending June 30, 2015 2015) (p. 6). The primary industries are agriculture, the military, and tourism. On Interstate 8, more than 6.5 million vehicles per year (18,000 per day) pass through Yuma. At San Luis, another 2.6 million autos and 46,000 commercial vehicles annually cross the Mexican/United States border.

Although Yuma County is mostly desert land surrounded by rugged mountains, the valley regions contain an abundance of arable land. These valley areas have some of the most fertile soils in the world. Yuma County is bordered by California on the West and Mexico on the South. Living close to the Mexican border offers a great opportunity to experience multicultural and international business opportunities (Kreger, Comprehensive Annual Financial Report For Fiscal Year Ending June 30, 2015 2015).

Passenger Acceptance of Technology

As stated immediately above, Yuma is a highly agricultural county. Thus, many of the residents may not be cognizant of the latest technology. The county is also relatively remote from major metropolitan areas. Therefore, YCAT passengers who have biases against using banks (see below) and who lack the monetary resources to prepay transit fares (see below) will also tend to reject high technology solutions to prepay a transit fare by the use of a smart card (a high technology solution). There is a variety of possible resolutions to this issue, each resolution having a cost impact. These resolutions may include:

- Install Point of Sale (POS) terminals in retail establishments such as Food City, Triple K, and others in the Yuma area.
- Introduce Limited Use YCAT cards.
- Offer larger fare discounts when paying fares with YCAT smart cards. (YCAT already offer discounts of 10% to 25% when using YCAT cards.)
- Change the existing YCAT fare policy on the use of cash

Language Issues

Yuma is highly multicultural. The YCAT buses serve several Native-American reservations and many Spanish-speaking Mexican riders. Conveying messages or instructions to non-English-speaking riders becomes a challenge. In a 90-day proof-of-concept Pilot Operation, the challenge becomes almost impossible. Acumen relied heavily on the multilingual capability of YCIPTA; however, getting the message of a new feature like loading fare products via the Internet in a short time period was very difficult.

Passenger Biases

Most agencies implementing smart care systems encounter issues on how to properly handle passengers and possibly cardholders who for multiple reasons are "unbanked." That is to say, the passengers prefer to use cash only and do not have bank accounts or credit cards. YCAT passengers appear to be even more unbanked and thus cannot use or will not use the feature to purchase fare products through the Internet.

YCIPTA reports that many of their passengers on YCAT fit into this category. Many of the YCAT passengers are Mexican residents who do not want to use banking and only ride the buses by paying with cash.

Passenger Monetary Capability

Many public transit riders use public transit because they cannot afford any other transportation mode. This is not unique to YCAT and even exists in affluent cities such as San Francisco. Purchasing transit products, value, or passes, particularly extended period passes, requires prepayment for the product in advance of use. Many public transit riders have insufficient monetary resources to prepay the transit fare. They lack the monetary resources to place transit value on a smart card for an extended period. As explained earlier in a summary of the Yuma area, Yuma County is primarily agriculture where worker income is low. Encouraging YCAT passengers to add value to their cards is a challenge and even encouraging the riders to obtain and use a smart card is a challenge.

CONCLUSIONS

There were many positive conclusions and lessons learned that could be derived from the implementation of Transit IDEA 79 Project. These conclusions are readily derived from the foregoing discussion of the many facets of the project.

The American Public Transportation Association (APTA) Contactless Fare Media Standards published by APTA (CFMS) can be implemented successfully at small, rural, and medium agencies. Demonstrating the successful integration at one agency using the APTA CFMS shows that multiple agencies in a rural setting can be successfully integrated into a common regional system. Acumen followed the requirements of the APTA CFMS as faithfully as possible and demonstrated a working system. Furthermore, the implementation was achieved within a reasonable cost, albeit on a system that already had a proprietary smart card system to start with as a basis for Transit IDEA 79 Project implementation.

Because of the many challenges regarding the Yuma County Intergovernmental Public Transportation Authority (YCIPTA) demographics, the demonstration of passenger use of the ability to load fare products online over the Internet was not demonstrated in a great volume. We are confident, however, that passengers can benefit from the ability to load fare products online at small and medium agencies.

Small and medium agencies, of which Yuma County Area Transit (YCAT) is one, are fully capable of operating simple smart card systems using the APTA standards. YCIPTA has successfully operated the existing proprietary smart card system for more than 4 years and the implementation of the APTA CFMS format has been transparent to their operation.

While Acumen experienced some minor issues with implementing the PayPal® interface, it found that using a readily available commercial bank card-processing system without the complexities of Payment Card Industry (PCI)/Data Security Standard (DSS) is highly recommended.

As was identified in the Lessons Learned and provided in Appendix C, the APTA CFMS needs to be examined and possibly modified to ensure that the various parts of the CFMS are coordinated and consistent.

The APTA standard should be augmented to include an Agency Level System that can be implemented for use by small- and medium-sized transit agencies.

The APTA standard should develop, evaluate, or adopt a viable data communications protocol for the equipment level. This equipment level communications standard should be non-proprietary and possibly have a proven record of accomplishment for implementation and functionality. One such communications protocol for automatic fare collections systems that is publicly available, royalty and license free, is the Vendor Equipment Interface (VEI) protocol (Agent Systems 2002). Acumen and others have successfully used the protocol in prior fare collection systems.

With the intent of driving down implementation costs of a contactless fare collection system, Acumen has developed a pricing schedule for system components, similar to those used on the YCIPTA system. Within the next 8 weeks, Acumen will apply to the U.S. Government, General Services Administration (GSA) to list the lowest price for the smart card fare collection systems components and services. This will allow small agencies to select those elements they require to implement a small system.

GLOSSARY

ACS — Area Computer System

AFC — Automatic fare collection

APTA — American Public Transportation Association

CFMS — Contactless Fare Media Standards published by APTA

CID — Card Interface Device (Contactless Fare Media System Standard 2007)

DSS — Data Security Standard

FTA — Federal Transit Administration

GSA — General Services Administration

IEC — International Electrotechnical Commission

ISO — International Organization for Standardization

ITS — Intelligent Transportation Systems

MAP-21 — Moving Ahead for Progress in the 21st Century Act

OSPT — Open Standard for Public Transportation

PATH — Port Authority Trans-Hudson

PCI — Payment Card Industry

PICC — Proximity Integrated Circuit Card (smart card) (Contactless Fare Media System Standard 2007)

POS — Point of Sale terminal

RAID — Redundant Array of Independent Disks

RCS — Regional Computer System

RIS — Regional Interface Specification

SSL — Secure Socket Layer

USB — Universal Serial Bus

UTFS — Universal Transit Fare System

VEI — Vendor Equipment Interface

WMATA — Washington Metropolitan Area Transit Authority

XML — Extensible Markup Language (XML 2016)

YCAT — Yuma County Area Transit

YCIPTA — Yuma County Intergovernmental Public Transportation Authority

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APPENDIX A

Evaluation Report Sample


ACUMEN building enterprise

National Academy of Sciences
IDEA Transit–79 Project
Evaluation Criteria

Version 1.0
March 11, 2016

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Table of Contents

1. Introduction 1
2. Purpose 2
3. Evaluated Features 3
3.1. YCAT Card 3
3.2. YCAT Reader 3
3.3. YCAT Web Site (for Smart Card Loading) 3
3.4. PayPal™ Web Site 3
3.5. Bank Card Operations 3
3.6. AcuFare™ 200 Management 3
4. Evaluation Responsibilities 4
4.1. Acumen 4
4.2. YCIPTA 4
4.3. Passenger or User 4
5. Recording and Summary Techniques 5
6. Evaluation Report Forms 6
APPENDIX A. Card Evaluation By YCIPTA 7
APPENDIX B. Reader Evaluation By YCIPTA 8
APPENDIX C. Web Site Evaluation BY YCIPTA 9
APPENDIX D. PayPal™ Evaluation BY YCIPTA 10
APPENDIX E. Bank Card Evaluation BY YCIPTA 11
APPENDIX F. New Card Format Evaluation By Riders 12

March 11, 2016 Page v of v Version 1.0

Figure 7 Pilot operation evaluation criteria.

APPENDIX B

Project Plan Sample

ACUMEN
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National Academy of Sciences &
Yuma County Intergovernmental Public
Transportation Authority

Project Plan

Implementation of Smart Card Automatic Fare
Collection (AFC) Technology in Small Transit
Agencies for Standards Development

IDEA Contract Number: TRANSIT-79
IDEA Project Account Number: 163613-0379
[DOT agreement number: DC-26-7355]

ABE-100-2
Version 0.85
February 4, 2015

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TABLE OF CONTENTS

1. PROJECT SCOPE OF WORK 6
2. EXISTING SYSTEM 7
3. STAGE 1 TASKS 8
4. STAGE 2 TASKS 10
5. EXCLUDED WORK 12
6. OVERSIGHT COMMITTEE 13
7. REFERENCE DOCUMENTS 14
   7.1.1. Documents 14
   7.1.2. Standards 14
8. OWNERSHIP AND DATA RIGHTS 15
APPENDIX A. SYSTEM OVERVIEW 16
APPENDIX B. OPERATION CONCEPTS 17
APPENDIX C. PROJECT SCHEDULE 26

February 4, 2015 Page 5 of 27 Version 0.85

Figure 8 Project plan.

APPENDIX C

PTA CFMS Specific Anomaly Reference

The following is a partial list of the anomalies identified during the implementation of the APTA CFMS on the YCIPTA system. This list is provided for future reference by those who may implement the CFMS on another system.

1. Examples in Part III of the XML messages did not include the root element, which is a requirement in the W3C standard definition.
2. Data element AuthenticationData was not defined anywhere in the four parts of the standard. This element is used in the 'Negative List' message on page 139 of Part III. Acumen entered the 'MACAlgorithmID' in this element.
3. In the definition of data element ActionEventDirectiveExpiry on page 36 of Part III, the datatype should have been DATETIME rather than ULONG.
4. Data element TransactionMessage was not defined anywhere in the four parts of the standard. This element is used in the 'Reject Transaction' message on page 126 of Part III.
5. In Table 2—Transit Application Profile Object (TAPO) RtsTransitExpirationDate is defined as having a size of 6 bits, but occupying bit positions 34 through 49 inclusive. The size should be 16 bits and not 6 bits as stated.
6. In Table 3—PICC Holder Profile Object (PHPO) RtsProfileCode is defined as having a size of 6 bits, but occupying bit positions 56–71 inclusive. The actual size of this object should be 16 bits rather than the 6 bits it is stated to have.
7. Part IV—Security Planning and Implementation Guidelines and Best Practices of Contactless Fare Media System Standard states: *This document is not intended to be a specification or to establish standards for security. Rather, it provides the reader with understanding of the terminology associated with security programs for fare collection systems and highlights the basic steps and considerations that should be employed in order to define, implement, and manage a security program for a regional smart card-based fare collection system.* From this perspective, Acumen continued to employ the security systems that it had previously developed for the YCIPTA system and that has proven to be effective to date. The transit industry may wish to revisit this portion of the specification.
8. Part II—Contactless Fare Media Data Format and Interface Standard, Business Rules in Table 11: Table 11—Pass and Transfer Product Objects, in data field RtsProductType, identifies the various Product Types. The product types identified in this table were insufficient to handle the pass types currently employed in YCIPTA. In particular, YCIPTA has a one-day pass, a 31-day pass (not monthly), and a single ride pass. None of these passes is listed in the product types. Thus, implementation of these passes on YCIPTA makes the implementation proprietary by definition. Acumen believes a standard needs to be inclusive of all variants to be a standard, otherwise it is not a standard. In particular, having selected one of the unassigned additional products may make YCIPTA a proprietary implementation.
9. Part II—Contactless Fare Media Data Format and Interface Standard specifies certain required data objects in Section 4.3, The Core Objects. Typically, a small transit agency will not require all of the objects listed as the "Core Objects." Furthermore, many of the CFMS core objects are 16 bytes in length. The compound effect of large required core data objects with an inefficient XML communication structure made it exceedingly difficult to implement CFMS on a small agency system. Most of the data structures are unnecessary on a small system. Acumen recommends that APTA examine reducing the quantity and size of the core objects for a small system implementation.
10. In a small system or a larger system but stand-alone it should not be necessary to include all of the required data objects. The quantity of required objects is unnecessary for a small system combined with the large size of the data structures making the implementation of CFMS on small systems very difficult. The CFMS should examine the required data objects and eliminate those that are unnecessary for small systems.
11. In prior implementations of fare collection equipment on other systems by Acumen and frequently within other standards there is a means to have remote version reporting. In the YCIPTA CFMS implementation, it became imperative that the card readers report their software version level. In this regard, Acumen implemented a version reporting system that automatically uploaded the software version level. This version level was then inserted into a preformatted report for operations personnel to use for system operation and maintenance. The APTA CFMS does not provide acceptable data fields to report system version levels. In Part II—Contactless Fare Media Data Format and Interface Standard under in Table 2: Transit Application Profile Object (TAPO), page 13, the RtsTAPOVersionID Field allows two bits (four values) to report the version of the data structure. This is not adequate to report the version of software on a subsystem in the overall fare collection system.

12. In Figure 2 APTA CFMS architecture overview, the communication structures are shown. As was previously indicated, no communication structure is provided for the Subsystem Controller to Card Interface Device. Without the communications structure provided in the standard, one possible interpretation is to use the XML communications protocol for this communications path. However, as discussed previously, the XML structure is too inefficient for this use. Acumen recommends that APTA evaluate the use of the Vendor Equipment Interface (VEI) protocol. Acumen and others have successfully used the protocol in prior fare collection systems. It is substantially more efficient than XML and the standard was intended for transit fare collection system. While the standard is licensed, there are no fees for using the standard.
13. In Part III—Regional Central System Interface Standard of the Contactless Fare Media System Standard, it states: *The specification does not define the system architecture of the fare collection system* and further *This Standard applies to regional contactless fare media systems for transit that use PICCs as the common contactless fare media*. Clearly, the APTA CFMS team did not intend for the standard to apply to an individual small transit agency. In fact, it does not appear to lay the basis for a fare collection system. Thus, small and rural agencies are at a substantial disadvantage with regard to implementation of a standards-based system as compared with well-funded large agencies. APTA should examine the possibility of defining a subset of functionality within the framework of the existing CFMS that can be applied to small and rural agencies.

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Mr. Allen has skills in systems planning, cost engineering, project planning, and smart card technology, and has worked in the transit industry for the past 21 years. He has been principal-in-charge on many industry projects at Alameda–Contra Costa County Transit District, California Department of Transportation (Caltrans), Metropolitan Transportation Commission, San Francisco Bay Area Rapid Transit District (BART), San Francisco Municipal Railway, Union Pacific Rail Road, and the California Air Resources Board.

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