



W E L C O M E



U.S. Department of Transportation  
Office of the Assistant Secretary for  
Research and Technology

# Mac Lister

A screenshot of the website for the ITS Professional Capacity Building Program. The header includes the United States Department of Transportation logo and navigation links. The main content area features a navigation menu, a 'WHAT'S NEW' section with several news items, and a 'FREE TRAINING' section with a list of courses. A blue banner at the top of the main content area reads 'Welcome to ITS Professional Capacity Building' and provides a brief description of the program.

United States Department of Transportation  
OFFICE OF THE ASSISTANT SECRETARY FOR RESEARCH AND TECHNOLOGY  
Intelligent Transportation Systems  
Joint Program Office

ITS Professional Capacity Building Program / Advancing ITS Education

About | ITS Training | Knowledge Exchange | Technology Transfer | ITS in Academics | Media Library

**WHAT'S NEW**

**New Web-Based Training from ITS Joint Program Office**

- Connected Vehicle Reference Implementation Architecture Training now available

**New NHI Course**

- Systems Engineering for Signal Systems Including Adaptive Control (NHI-133123)

**New ITS Case Study Available**

- National ITS Architecture

**Added to T3 Archive**

- Learn from the Experts: Open Data Policy Guidelines for Transit - Maximizing Real Time and Schedule Data-Legalities, Evolutions, Customer Perspectives, Challenges, and Economic Opportunities - Part II Presented on August 7, 2014
- Saving Lives and Keeping Traffic Moving: Quantifying the Outcomes of Traffic Incident Management (TIM) Programs Presented on July 31, 2014

**FREE TRAINING**

The ITS PCB Program and partners offer many free ITS training courses.

- Web and Blended Courses from CITE
- ITS Standards Training
- Upcoming T3 Webinars

Welcome to ITS Professional Capacity Building  
The ITS PCB Program is the U.S. Department of Transportation's leading program for delivering ITS training and learning resources to the nation's ITS workforce.

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U.S. Department of Transportation  
Office of the Assistant Secretary for  
Research and Technology

# Jeffrey Spencer



The screenshot shows the website for the ITS Professional Capacity Building Program. At the top, it identifies the United States Department of Transportation, Office of the Assistant Secretary for Research and Technology, and the Intelligent Transportation Systems Joint Program Office. A navigation menu includes 'About', 'ITS Training', 'Knowledge Exchange', 'Technology Transfer', 'ITS in Academics', and 'Media Library'. A central banner features a photo of people in a classroom and the text: 'Welcome to ITS Professional Capacity Building. The ITS PCB Program is the U.S. Department of Transportation's leading program for delivering ITS training and learning resources to the nation's ITS workforce.' Below this is a 'FREE TRAINING' section with a list of courses: 'Web and Blended Courses from CITE', 'ITS Standards Training', and 'Upcoming T3 Webinars'. On the right, a 'WHAT'S NEW' section lists recent updates, including 'New Web-Based Training from ITS Joint Program Office' (Connected Vehicle Reference Implementation Architecture Training), 'New NHI Course' (Systems Engineering for Signal Systems), and 'New ITS Case Study Available' (National ITS Architecture).

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U.S. Department of Transportation  
Office of the Assistant Secretary for  
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# ITS Transit Standards Professional Capacity Building Program

## Module 10: Electronic Fare Payment Systems



# ACTIVITY



U.S. Department of Transportation  
Office of the Assistant Secretary for  
Research and Technology

## Instructor



**Gary B. Yamamura**  
**Principal Consultant**  
**Three Point Consulting, Inc.**  
**Oceanside, CA USA**

# Target Audience

- Staff considering the purchase of a new EFP or making an upgrade to an existing electronic fare payment system:
  - Transit management staff;
  - Transit planning, operations, and maintenance staff;
  - Transit finance and revenue management staff;
  - Metropolitan Planning Organizations (MPO) staff;
  - Transit procurement staff;
  - Transit grants staff; and
  - Project managers.

## Target Audience (cont.)

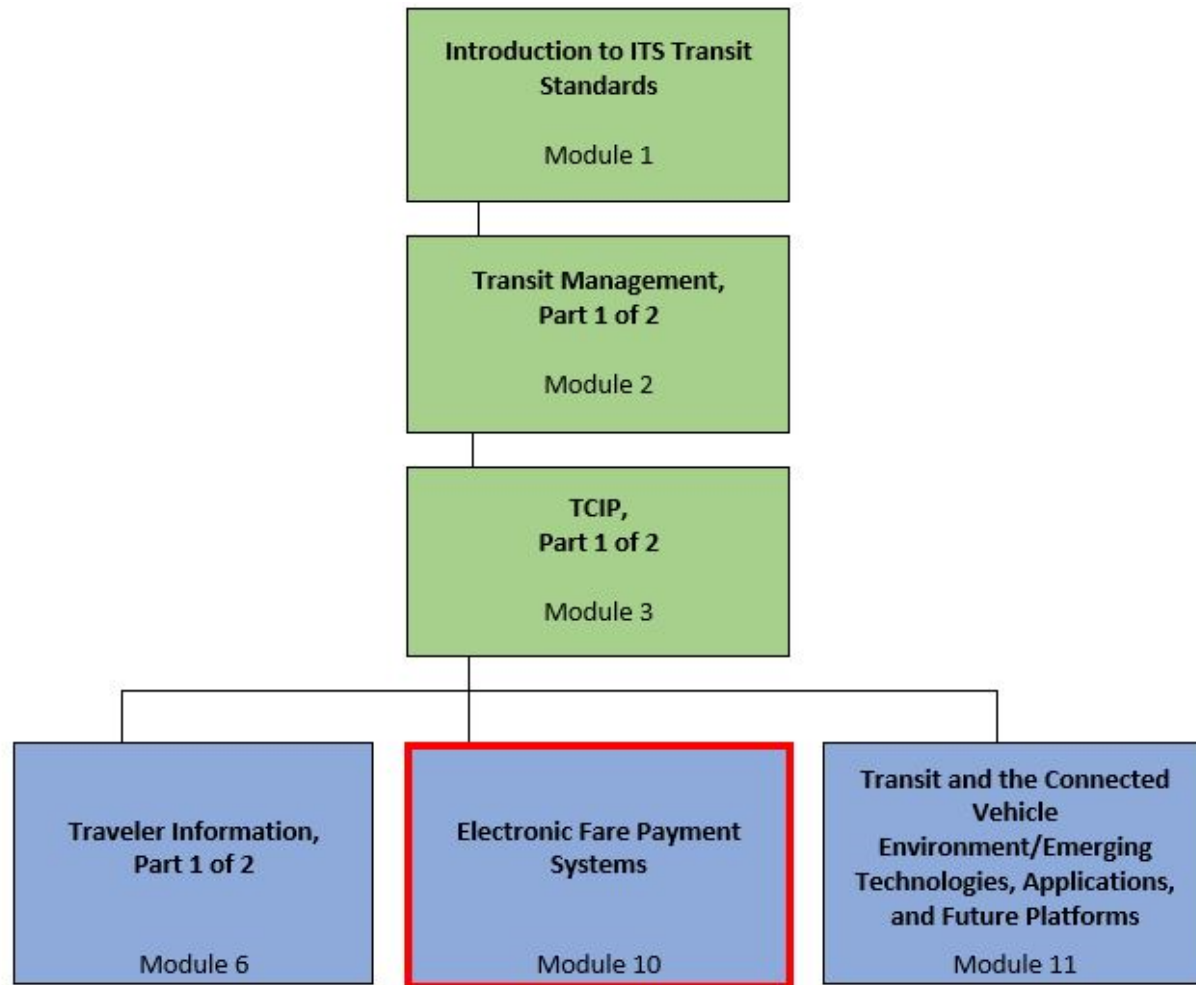
- Staff that need a foundational understanding of electronic fare payment systems and methodologies:
  - Department of Transportation (DOT) / Intelligent Transportation Systems (ITS) staff;
  - Transit budgeting and accounting staff;
  - Transit technology vendors; and
  - Transit ITS consultants and contractors.





# Recommended Prerequisite(s)

	Decision-Maker	Project Manager	Project Engineer
<b>Module 1:</b> Introduction to ITS Transit Standards	✓	✓	✓
<b>Module 2:</b> Transit Management Standards, Part 1 of 2	✓	✓	✓
<b>Module 3:</b> Transit Communications Interface Profiles (TCIP), Part 1 of 2	✓	✓	✓
<b>Module 4:</b> Transit Communications Interface Profiles (TCIP), Part 2 of 2	N/A	✓	✓
<b>Module 5:</b> Transit Management Standards, Part 2 of 2	N/A	✓	✓

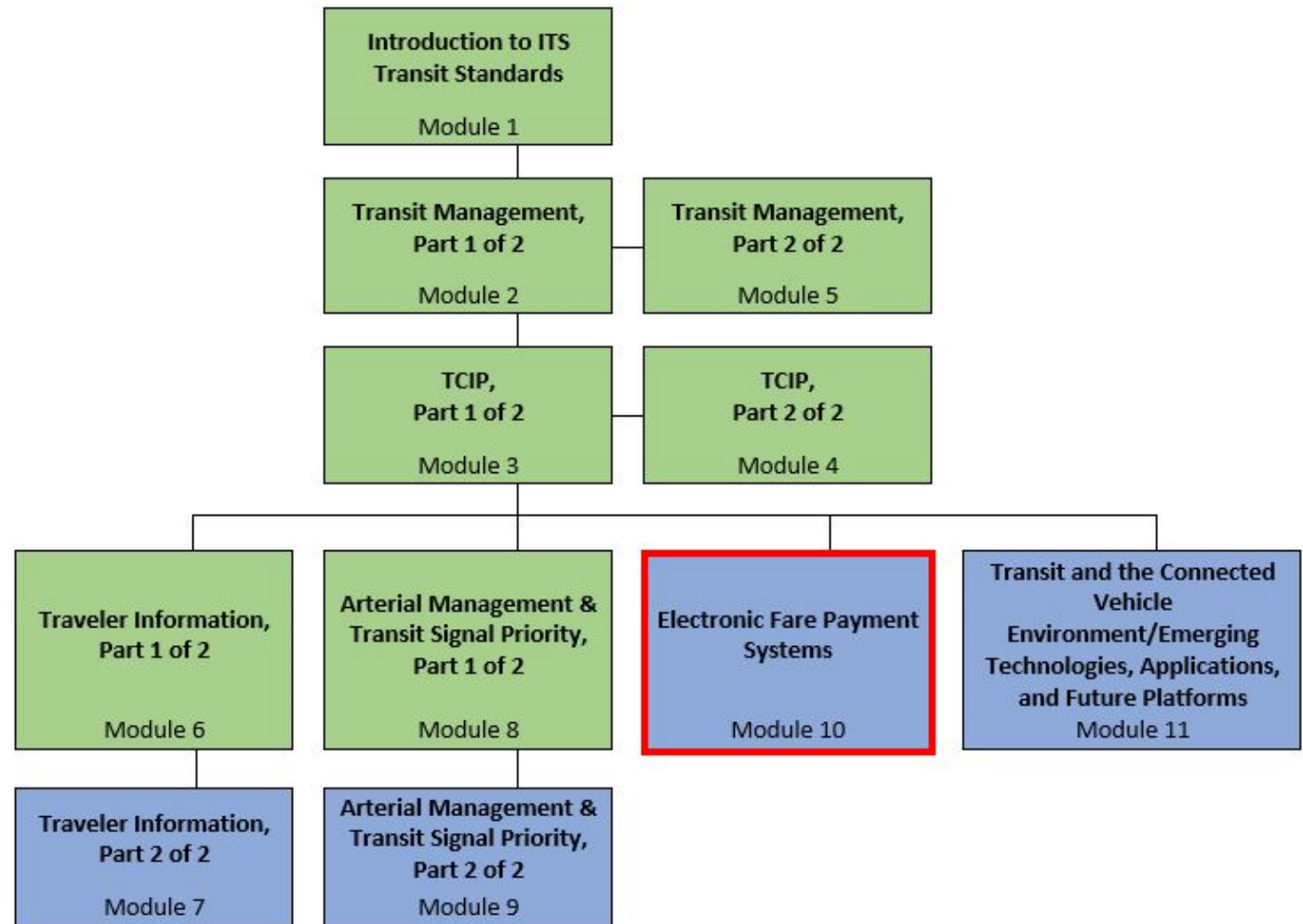
# Curriculum Path (Decision-Maker)




 Recommended Prerequisite Modules

 Optional Modules

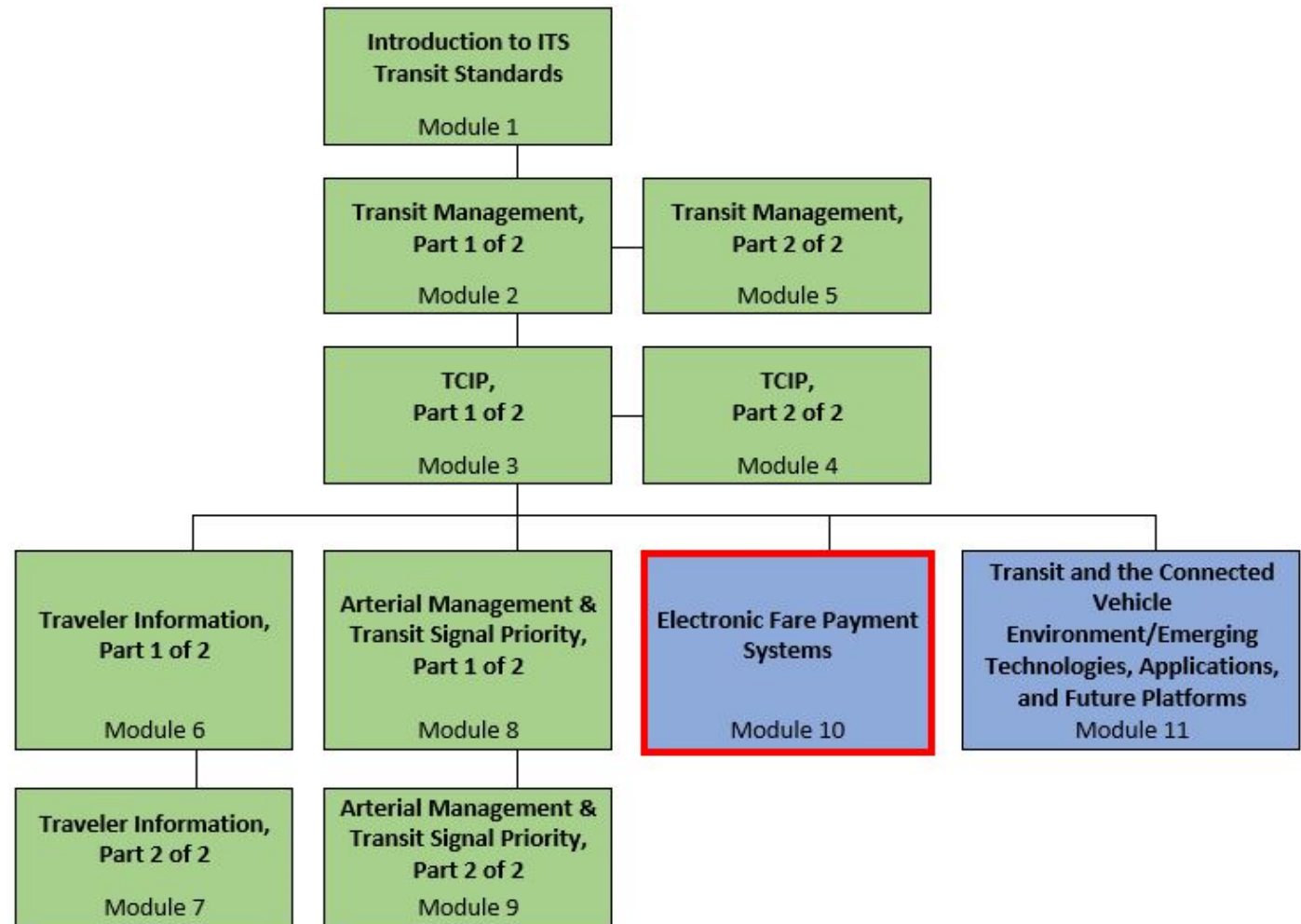
# Curriculum Path (Project Manager)





 Recommended Prerequisite Modules

 Optional Modules

# Curriculum Path (Project Engineer)



 Recommended Prerequisite Modules

 Optional Modules

# Learning Objective #1

- Recognize and identify:
  - Commonly used terms in electronic fare payment
  - The characteristics (e.g. architecture, features, costs, media, benefits, and challenges) of the leading electronic fare payment methodologies



## Learning Objective #2

- Recognize and identify:
  - The applicable national and international standards, rules, and regulations for electronic fare payment systems and the benefits of applying those standards, rules, and regulations
  - Where the lack of applicable standards create logical gaps in fare payment architectures that must be addressed by the agency

## Learning Objective #3

- Evaluate the options for electronic fare payment by:
  - Assessing the unique implementation issues of the transit industry
  - Applying case studies of leading-edge electronic fare payment technologies and methodologies

## Learning Objective #4

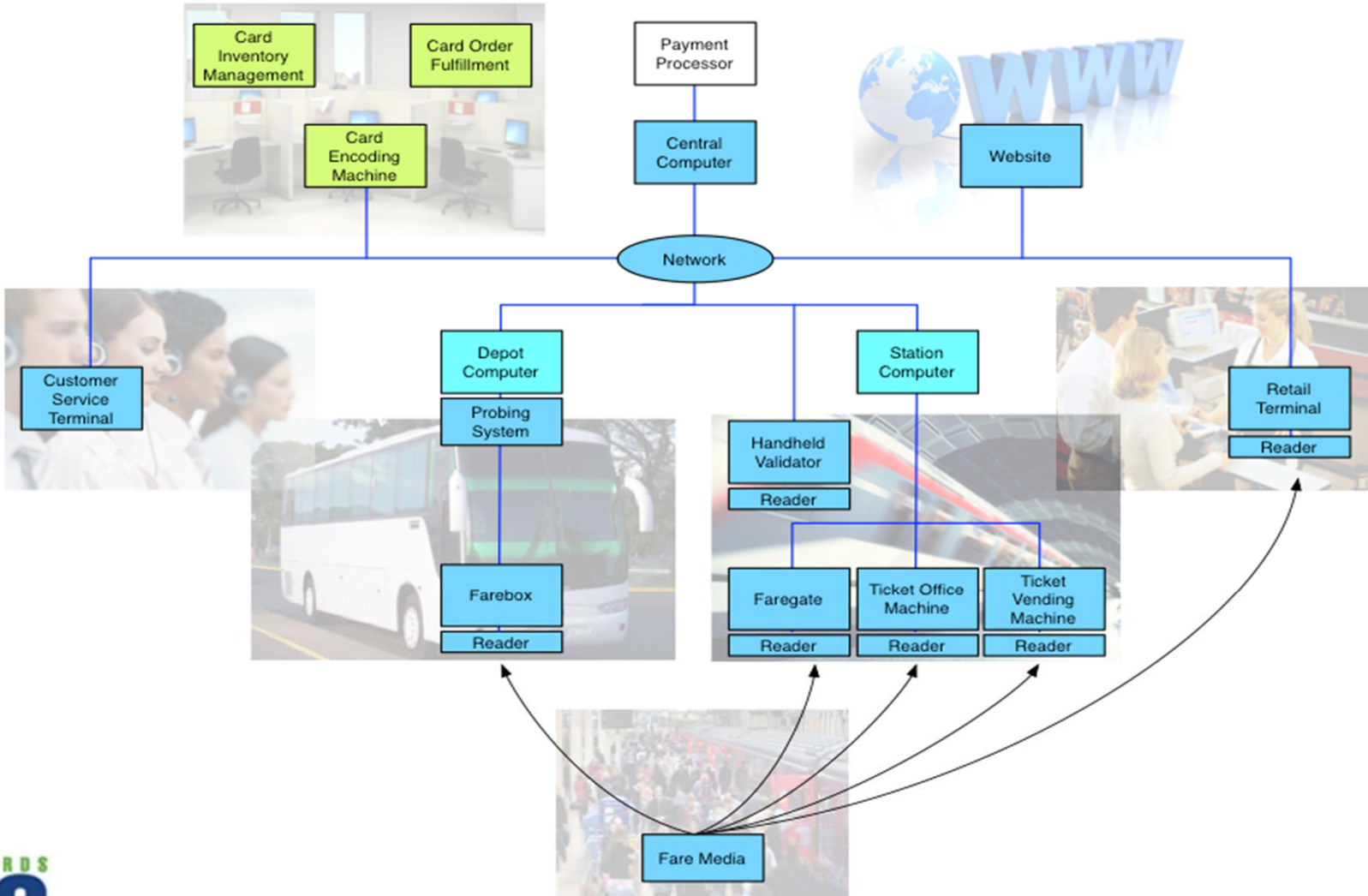
- Apply newly developed skills to:
  - Assess agency requirements in order to facilitate selection of a methodology and architecture for electronic fare payment
  - Support the procurement and implementation of a new electronic fare payment system or existing system enhancement

# Learning Objective #1

## Recognize and Identify:

- Commonly used terms in electronic fare payment
- The characteristics (e.g. architecture, features, costs, media, benefits, and challenges) of the leading electronic fare payment methodologies

# Typical Electronic Fare Payment System (EFPS) Architecture and Components





# Commonly Used Terms

## Electronic Fare Payment System (EFPS)

- System that performs automated calculation, collection, recording, and reporting of fare payment transactions for rides on a public transit system
- Uses some form of electronic validation and, in most instances, electronic media (e.g. contactless smart card, magnetic stripe card, card emulated through mobile phone)

# Commonly Used Terms

## EFPS Types

- Account-based System
  - Comparable to credit card systems – payment media is only a token to access centrally stored/managed account record
- Card-based System
  - Most common form of EFPS
  - Fare product data is stored in card memory and read/updated by readers
- Open Payment System
  - System where contactless bankcards are the primary fare media
  - Often combined with either card- or account-based systems to support prepaid fare products

# Commonly Used Terms

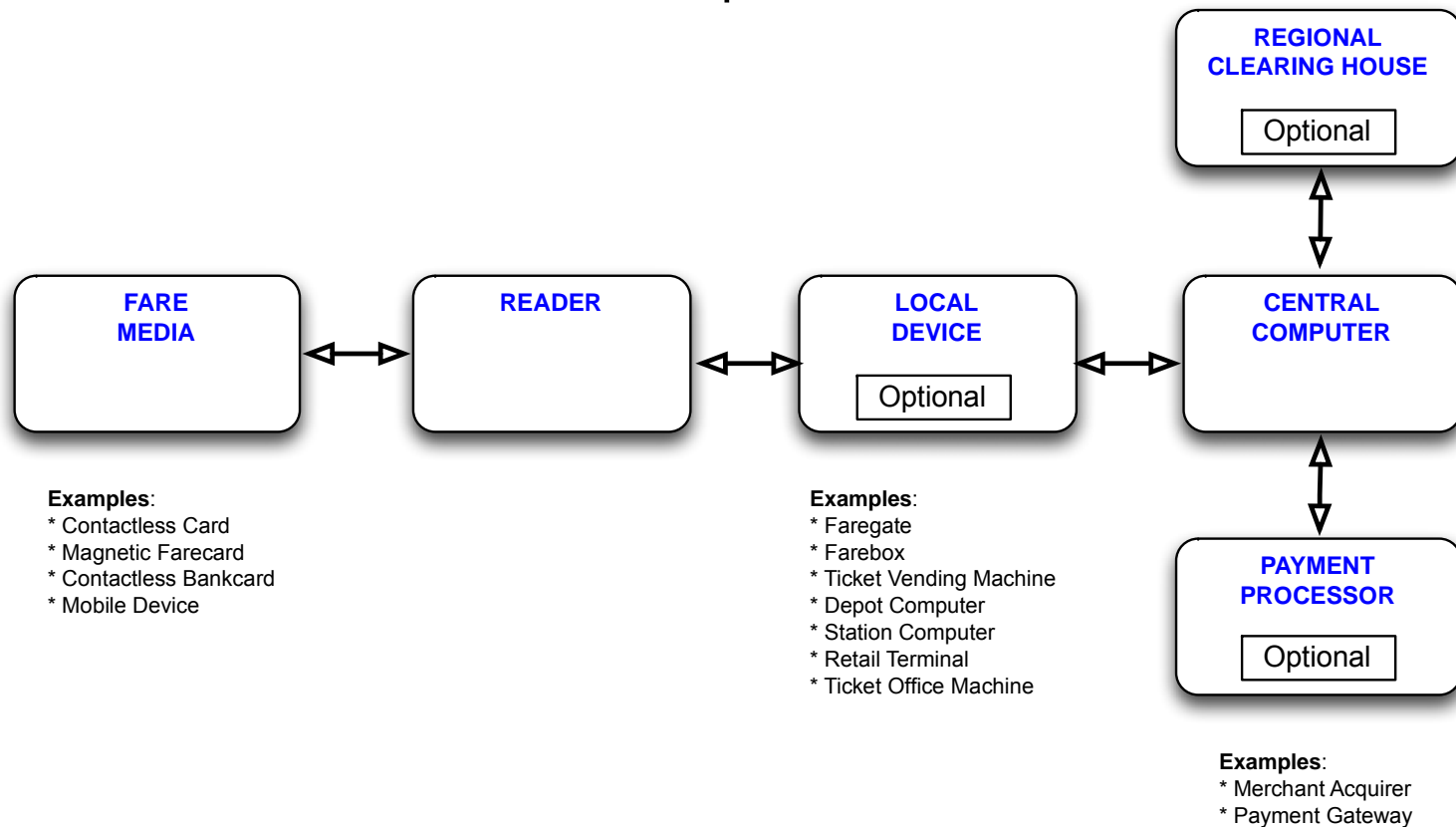
## Fare Policy

- The set of rules for a transit agency that define how, when, and by what methods passengers pay fares including:
  - The base price of fares paid using cash or stored value
  - The available types and retail price of passes
  - The discounts on fares and passes offered to individuals and groups that qualify for participation in special (discounted) fare programs
  - The rules and cost for making transfers from one transit agency vehicle to another as part of a single journey

# Commonly Used Terms

## System Architecture

The set of all components of an EFPS and the methods used to send information between those components.



# Commonly Used Terms

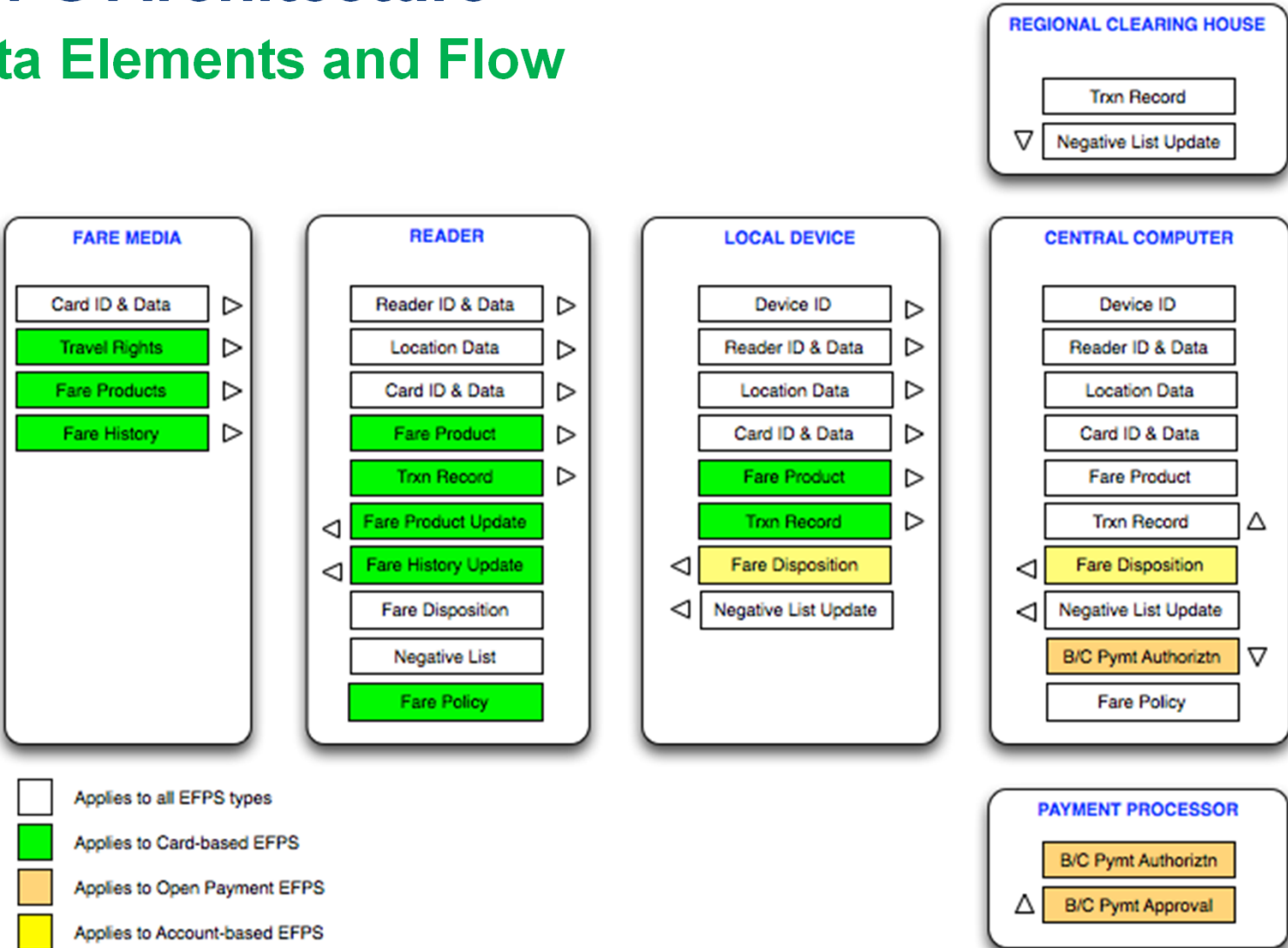
## Fare Value Options

- Closed Loop (Value)
  - Prepaid stored funds that can be used only for payment of fares
- Open Loop (Value)
  - Prepaid or postpaid funds that can be used to make fare payments as well as purchases at other retail merchants



# EFPS Architecture

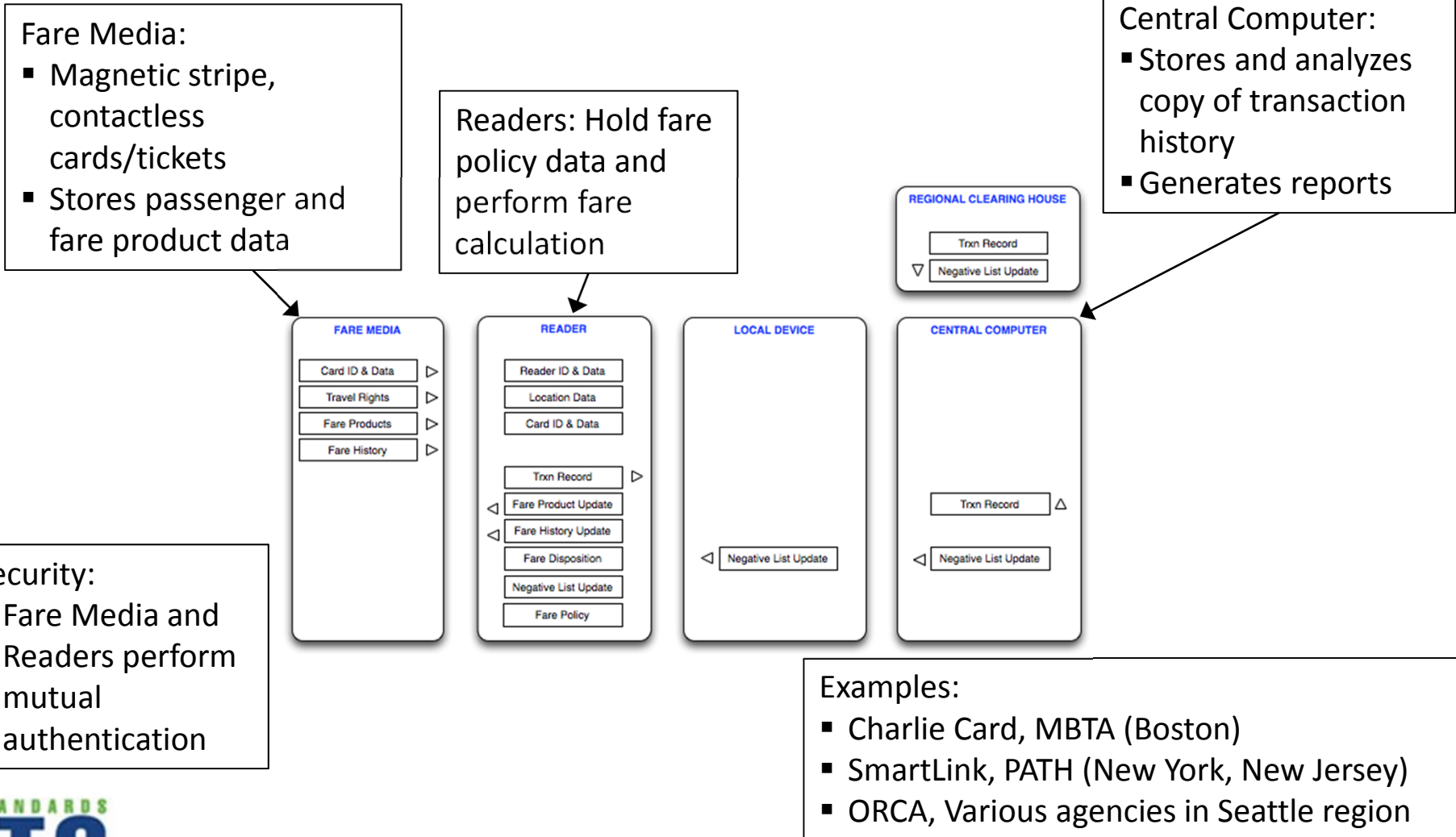
## Data Elements and Flow



# Card-Based Systems

## Feature Overview

Learning Objective #1



# Card-Based Systems

## Benefits and Disadvantages

### Key Benefits

- For agencies:
  - Offered by all leading fare collection system integrators and suppliers
  - Well developed set of best practices
  - Access points can operate despite loss of communications to central system
  - Secure transactions with fast transaction time
- For passengers:
  - Variety of prepaid fare products available for purchase and use

# Card-Based Systems

## Benefits and Disadvantages

### Disadvantages

- For agencies:
  - Adding (purchasing) fare products requires special devices to write data to fare media
  - Requires broad network for physical distribution of fare media and fare products
  - Central system not updated in real-time – can't be used as reliable source of passenger account data
  - Access points require substantial intelligence and processing power – more expensive to buy and maintain

# Card-Based Systems

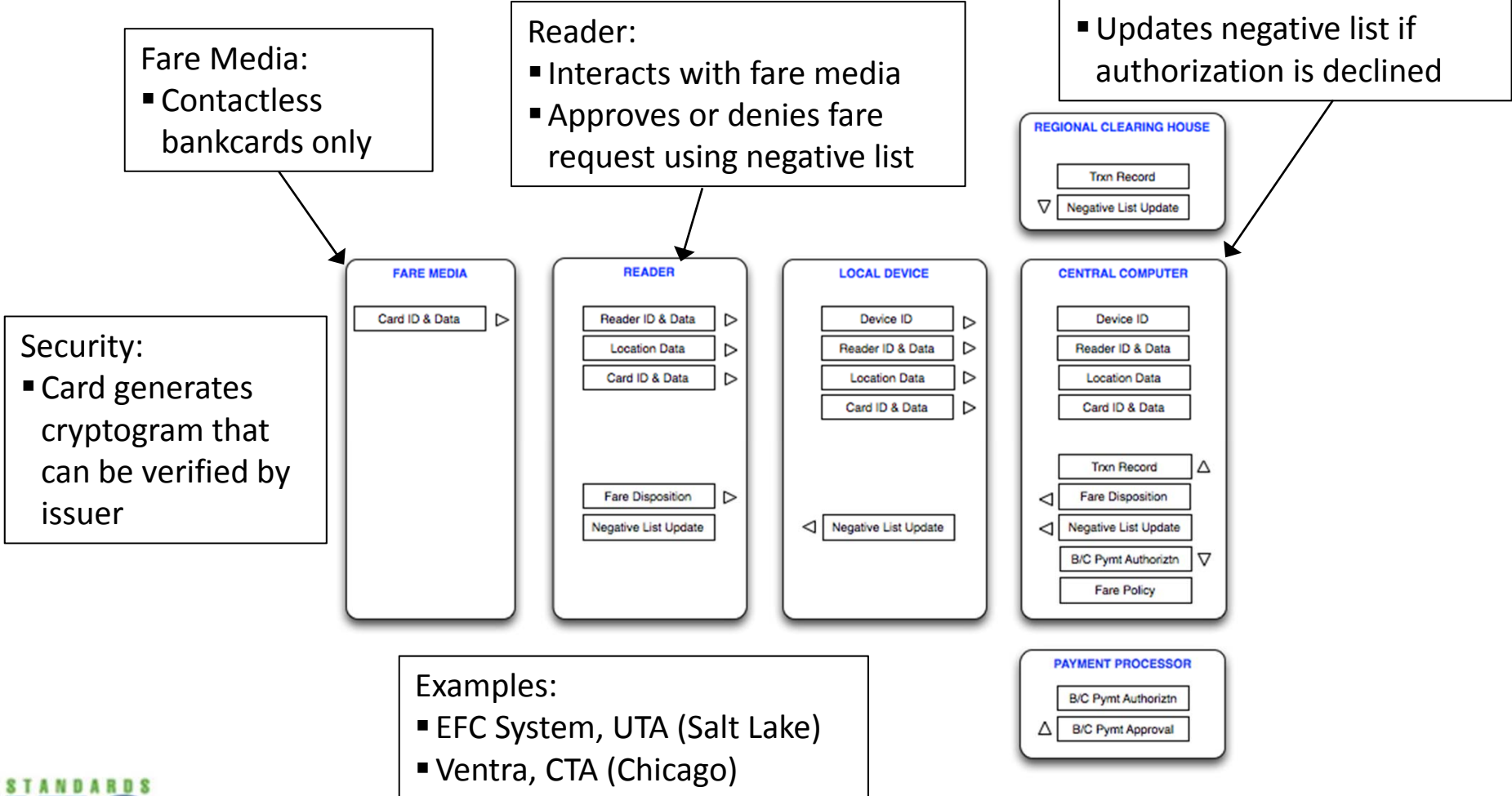
## Technical Challenges

- Automatic replenishment (e.g. autoload) of fare products is a complex process that may require several days to complete
- Fare policy changes require delivery of software changes to every field device
- Card data security is paramount – breach of security scheme can compromise system’s financial accuracy/reliability



# Open Payment Systems

## Feature Overview



# Open Payment Systems

## Feature Overview

*EFPS type which relies on bank-issued cards as the fare media. Initial fare processing is performed by the field devices and final authorization and settlement are performed later by the central computer.*

### Central System

- Receives and processes batches of fare payment transactions
- Generates bankcard payment authorization requests and transmits to acquirer
- May aggregate two or more payments from the same card to reduce processing cost

# Open Payment Systems

## Feature Overview (cont.)

### Access Points

- Approve or deny fare payments based on negative list of “bad” bankcards
- Provide approval/decline to passenger

### Fare Media

- Contactless bankcards
- Mobile devices emulating a contactless bankcard using an near field communication-compliant (NFC) communications protocol

# Open Payment Systems

## Benefits and Disadvantages

### Key Benefits

- For agencies:
  - Reduces or eliminates need for agency-issued fare media
  - May transfer portion of passenger servicing to bankcard issuers
  - Reduced complexity of software in field devices and central system
  - Reduced need for ticket vending machines and/or retail network
- For passengers:
  - No advanced knowledge of fare structure required
  - No special fare media required

# Open Payment Systems

## Benefits and Disadvantages

### Disadvantages

- For agencies:
  - No support for prepaid fare products
  - Little or no capability to perform real-time card authentication
  - Use of negative lists in Open Payment System is the subject of patent disputes
  - Only small percentage of passengers have contactless bankcard
- For passengers:
  - Passengers may be approved or denied incorrectly due to lag time for updates to negative list in field devices

# Open Payment Systems

## Technical Challenges

- Frequent and quick updates to negative list in field devices is critical
- Card/reader interface defined by networks – may not support the fast transaction times typically required within the transit industry

# Account-Based Systems

## Feature Overview

### Central System:

- Maintains passenger accounts
- Stores fare products
- Calculates fares

Fare Media:

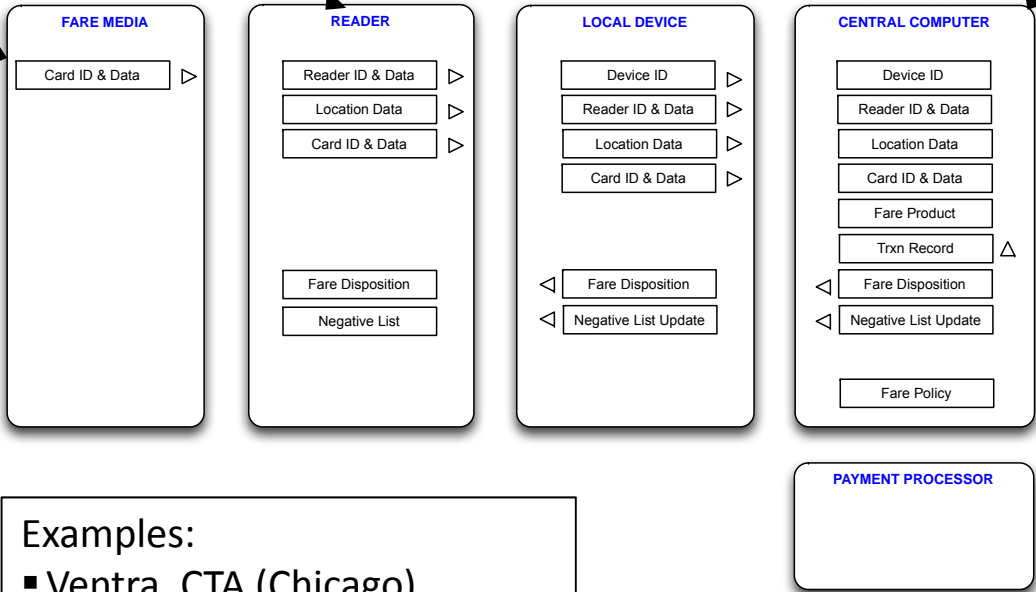
- Contactless cards / tickets, mobile devices, bar/QR codes
- Acts solely as token to access account

Reader:

- Interacts with fare media
- Send fare requests to Central Computer

Security:

- Varies. At a minimum, fare media should be authenticated by central computer or reader



Examples:

- Ventra, CTA (Chicago)
- NPT, SEPTA (Philadelphia)



# Account-Based Systems

## Benefits and Disadvantages

### Key Benefits

- For agencies:
  - Fare policy changes only need to be made at the central computer
  - Software in readers is less complex and easier to maintain
  - Any networked device can be used to sell fare products
- For passengers:
  - Wider sales network for fare products
  - Fare products and payments history accessible via any networked device

# Account-Based Systems

## Benefits and Disadvantages

### Disadvantages

- For agencies:
  - Offline readers must process fare requests using local negative or positive list
  - Online, real-time fare processing is infeasible without fast, reliable communications
  - New method with comparatively few systems in revenue service

# Account-Based Systems

## Technical Challenges

- High speed, reliable communications from stations and vehicles
- Complex logic to process offline transactions once uploaded

# EFPS Methodologies

Learning Objective #1

## Comparative Analysis

Methodology	Primary Security Scheme	Fare Processing Logic	Fare Products & Passenger Rights	Fare Media
<b>Account-based</b>	<ul style="list-style-type: none"> <li>Card authentication</li> </ul>	<ul style="list-style-type: none"> <li>Performed by central computer</li> <li>Fare policy changes made to central computer only</li> </ul>	<ul style="list-style-type: none"> <li>Stored in central account records</li> <li>Fare product sold via any networked device</li> </ul>	<ul style="list-style-type: none"> <li>Contactless card</li> <li>Limited use ticket</li> <li>Bar/QR code</li> <li>Mobile device</li> </ul>
<b>Card-based</b>	<ul style="list-style-type: none"> <li>Card/Reader mutual authentication</li> </ul>	<ul style="list-style-type: none"> <li>Performed by reader</li> <li>Fare policy changes downloaded to all field devices</li> </ul>	<ul style="list-style-type: none"> <li>Stored on card</li> <li>Fare product sold via agency-specific devices</li> </ul>	<ul style="list-style-type: none"> <li>Contactless card</li> <li>Magnetic farecard</li> <li>Limited use ticket</li> </ul>
<b>Open Payment</b>	<ul style="list-style-type: none"> <li>N/A</li> </ul>	<ul style="list-style-type: none"> <li>Yes/No decision performed by reader</li> </ul>	<ul style="list-style-type: none"> <li>N/A: Supports only value-based fares</li> </ul>	<ul style="list-style-type: none"> <li>Contactless bankcards</li> <li>Mobile device emulating contactless bankcard</li> </ul>

# ACTIVITY



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# Which of the following is a feature of only an account-based EFPS?

## Answer Choices

- A) The central computer sends a negative list to each reader
- B) Data stored on card is read and updated by the reader
- C) Contactless bankcards are the primary fare media
- D) The central computer is responsible for fare calculation

Incorrect - Click anywhere or

Your answer:

The correct answer is:

Control Y to c

You did not answer this  
You must answer the question  
before continuing

Submit

Clear

## Review of Answers



a) The central computer sends a negative list to each reader

*Incorrect. This feature is applicable to all three types of EFPS.*



b) Data stored on card is read and updated by the reader

*Incorrect. This feature is unique to a card-based EFPS.*



c) Contactless bankcards are the primary fare media

*Incorrect. This feature applies primarily to an open payment EFPS.*



d) The central computer is responsible for fare calculation

***Correct! In an account-based EFPS, the central computer holds all of the passenger, fare product and history data and fare processing rules and uses this information to calculate the fare due for each fare payment.***



## Summary of Learning Objective #1

**After completing this section of the module, the reviewer should be able to recognize and identify:**

- Commonly used terms in electronic fare payment
- The characteristics (e.g. architecture, features, costs, media, benefits, and challenges) of the leading electronic fare payment methodologies

## Learning Objective #2

### Recognize and Identify:

- The applicable national and international standards, rules, and regulations for electronic fare payment systems and the benefits of applying them
- Where the lack of applicable standards create logical gaps in fare payment architectures that must be addressed by the agency

# Standards, Rules, and Regulations

## Overview

- Certain national and international standards and specifications are applicable to an EFPS
- Applicability of these standards and specifications varies by EFPS types
- These standards and specifications do not prescribe an end-to-end EFPS architecture and may not ensure interoperability of systems or components

# Standards, Rules, and Regulations

## ISO/IEC 14443 Identification cards – Contactless integrated circuit cards – Proximity cards

- Widely adopted standard for short range communications between cards and readers
- Applies to physical and virtual cards and readers
- Applicable to:
  - All EFPS methodologies

# Standards, Rules, and Regulations

## ISO/IEC 7816 Identification cards, Integrated circuit cards

- Defines physical dimensions of smart cards and a common set of instructions that should be supported
- Combined with ISO/IEC 14443, helps to promote interoperability
- Applicable to:
  - All EFPS methodologies

# Standards, Rules, and Regulations

ISO/IEC 18092 Information technology, Telecommunications and information exchange between systems, Near Field Communication, Interface and Protocol (NFCIP-1)

- Better known as “NFC”
- Defines methods to enable short-range communications between mobile phones and readers
- Applicable to:
  - EFPS methodologies where mobile devices may be used

# Standards, Rules, and Regulations

## ISO/IEC 21481, Information technology, Telecommunications and information exchange between systems, Near Field Communication Interface and Protocol -2 (NFCIP-2)

- Additional standard under the “NFC” umbrella
- Defines short-range communications between “active” and “passive” devices
- Applicable to:
  - All EFPS methodologies where mobile devices may be used



# Standards, Rules, and Regulations

## ISO/IEC 8583, Financial transaction card originated messages, Interchange message specifications

- Defines the format and content of messages exchanged for bankcard transactions
- Applicable to:
  - All EFPS methodologies where bankcards are accepted for fare payments or for purchases of any kind

# Standards, Rules, and Regulations

## ISO/TR 14806 Intelligent transport systems, Public transport requirements for the use of payment applications for fare media

- Technical report (TR) that defines the requirements for payment applications on multi-application, contactless bankcard used for fare payments
- Describes the possibility of adding the capability of storing and updating fare-specific data in card memory
- Applicable to:
  - Open payment EFPS, including those that also support card-based fare payments

# Standards, Rules, and Regulations

## ISO 24014 Interoperable Fare Management Systems (IFMS)

- Defines standards and rules for development and operation of a regional) fare system
- Applicable to:
  - Primarily card-based EFPS

# Standards, Rules, and Regulations

## Europay, MasterCard, Visa (EMV) Specifications

- Provides specifications for chip-based bankcards and merchant payment terminals
- Widely adopted internationally
- U.S. adoption began in 2013
- Applicable to:
  - Open payment EFPS
  - Any EFPS that accepts bankcards for payment of any purchases

# Standards, Rules, and Regulations

## Bankcard Network Contactless Credit and Debit Card Specifications

- Card networks' contactless card products used in the U.S. include:
  - American Express ExpressPay
  - Discover ZIP
  - MasterCard PayPass
  - Visa payWave
- Separate applications are required in the reader (or Central Computer) to enable communications with these cards.
- Rules for card acceptance also vary by network

# Standards, Rules, and Regulations

## Payment Card Industry Data Security Standards (PCI DSS)

- Defines standards for securing bankcard data
- Applicable to:
  - All EFPS methodologies where bankcards are accepted in any form

# Standards, Rules, and Regulations

## American Public Transportation Association (APTA) Contactless Fare Media System (CFMS) Standard

- National standard for regional, card-based EFPS programs
- Developed by APTA
- Applicable to:
  - Card-based EFPS



# Standards, Rules, and Regulations

## Transit Communications Interface Profiles (TCIP)

- Developed to be the ITS standard for transit management communications
- Introduces a standard framework for exchanging data among various transit modules and systems
- Includes a library of data elements, data frames, messages, and dialogs using Extensible Markup Language (XML).

# Standards, Rules, and Regulations

## Integrated Transport Smartcard Organization (ITSO)

- UK specification/standard for cards and terminals used in a card-based EFPS

## Calypso

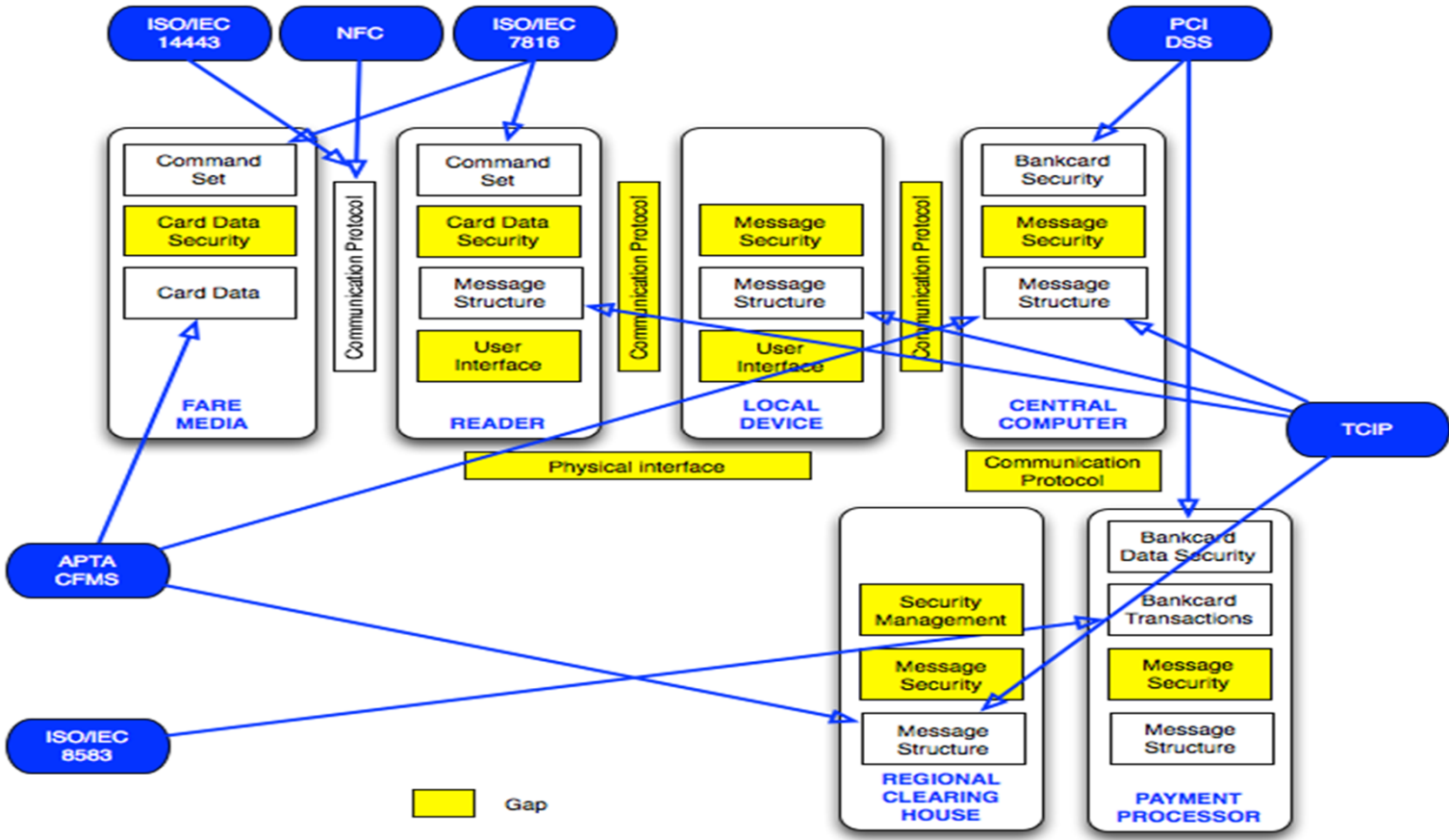
- European standard for card-based EFPS where the media uses a microprocessor-based chip to ensure exceptionally fast and secure transactions.
- One of the most widely adopted standards for EFPS with implementations in Europe, China, Canada, the United States, and Latin America

## CIPURSE

- An open standard for card-based fare collection systems focused primarily on the card data structure and card to reader security scheme.

# EFPS Architecture

## Gaps Created by the Lack of Applicable Standards



Yellow boxes indicate EFPS elements not covered by standards.

# Key Gaps in Existing Standards

Gap	Gap Description	Mitigation Tactics
Inter-system security	<ul style="list-style-type: none"> <li>Lack of comprehensive security standards inhibit system-to-system interoperability</li> </ul>	<ul style="list-style-type: none"> <li>Define regional security rules</li> <li>Require adherence to widely adopted security /encryption specifications (e.g. 3DES, AES)</li> </ul>
Component “plug-and-play”	<ul style="list-style-type: none"> <li>Lack of device-to-device messaging standards inhibit introduction of devices from new suppliers</li> </ul>	<ul style="list-style-type: none"> <li>Require open (e.g. documented, royalty-free) interface specifications</li> </ul>
New media integration	<ul style="list-style-type: none"> <li>Lack of card/reader security standards inhibit use of new payment media in card-based systems</li> </ul>	<ul style="list-style-type: none"> <li>Require comprehensive security protocols and management scheme</li> </ul>
User Interface	<ul style="list-style-type: none"> <li>Lack of interface standards promotes different experience at different devices/channels</li> </ul>	<ul style="list-style-type: none"> <li>Define regional or agency-specific rules for user interface look, feel, and flow</li> </ul>
Other	<ul style="list-style-type: none"> <li>System updates/changes</li> </ul>	<ul style="list-style-type: none"> <li>Require mechanism for secure, remote software updates</li> </ul>

# ACTIVITY



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# Which of the following EFPS features does the Transit Communications Interface Protocol (TCIP) cover?

## Answer Choices

- A) Local device to central computer message structure
- B) Card data structure
- C) Card to reader communication protocol
- D) Physical requirements for contactless farecard

Correct - Click your answer

The correct answer is:

You did not answer this

You must answer the question before continuing

Submit

Clear

## Review of Answers



- a) Local device to central computer message structure

**Correct! The content and structure of messages exchanged between a field (local) device and the central computer are included in the TCIP standards.**



- b) Card data structure

*Incorrect. This feature is defined in APTA CFMS.*



- c) Card to reader communications protocol

*Incorrect. This feature is defined in ISO/IEC 14443.*



- d) Physical requirements for a contactless farecard

*Incorrect. The feature is defined in ISO/IEC 7816.*



## Summary of Learning Objective #2

**After completing of this section of the module, the reviewer should be able to recognize and identify:**

- The applicable national and international standards, rules, and regulations for EFPS and the benefits of applying them
- Where the lack of applicable standards create logical gaps in fare payment architectures that must be addressed by the agency

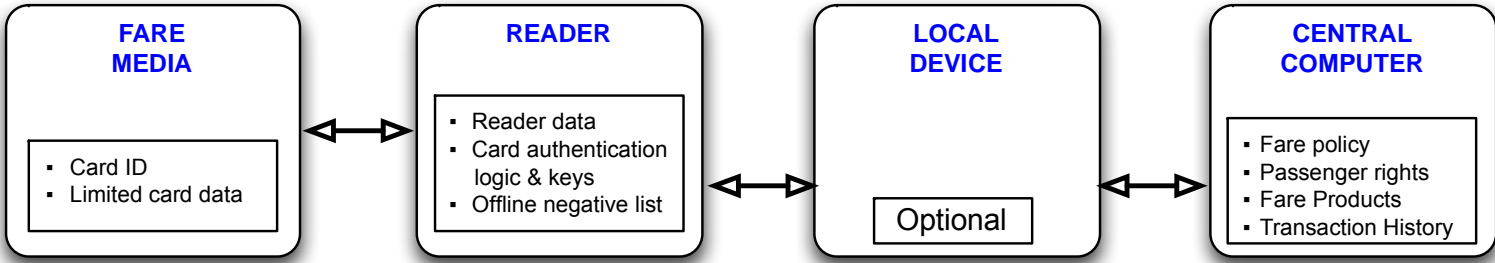


## **Learning Objective #3**

### **Evaluate the Options for Electronic Fare Payment by:**

- Assessing the unique implementation issues of the transit industry
- Applying case studies of leading-edge electronic fare payment technologies and methodologies

# Account-Based System Fare Payment Transaction Flow



**Step 1:** Fare media is presented to reader

**Step 2:** Reader & card perform card authentication

**Step 3:** Reader extracts card ID and data from card.

**Step 4:** Reader generates fare payment request using card and reader data.

**Step 5:** Reader transmits fare payment request to central computer (via local device, if applicable).

**Step 6:** Central computer receives fare payment request, retrieves account record from central database and calculates fare.

**Step 7:** Central computer determines if fare product or other right (e.g. transfer) in account is available to satisfy fare.

**Step 8:** Central computer approves or declines fare payment request.

**Step 9:** Central computer updates account record.

**Step 11:** Reader displays approval or decline to passenger

**Step 10:** Central computer sends response to reader (via local device, if applicable).

# Account-Based System

## Implementation Considerations

### Fare Payment Processing

- Option 1: Online/Real-time
  - ✓ Reader sends fare request to central computer
  - ✓ Central computer makes decision and responds
  - ✓ Need solution for offline conditions
- Option 2: Offline/Batch
  - ✓ Reader makes decision using negative list, etc.
  - ✓ Central computer calculates fare later

### Security

- Fare media authentication is essential

### Network

- High-speed, reliable communications required (Option 1)
- Buses probably use cellular

# Account-Based System Implementation Considerations (cont.)

## Fare Media Distribution

- N/A

## Fare Products

- With Option 2, negative or positive list in readers must be updated quickly or else passenger may be unable to pay fare

## Applicable Standards

- ISO/IEC 14443
- ISO/IEC 7816
- ISO/IEC 8583
- TCIP

# Account-Based System

## Operational Benefits

Various forms of fare media could be supported

- Contactless smartcard
- Limited use ticket
- Mobile phone displaying bar/QR code
- Printed bar/QR code
- Mobile phone using NFC

“Bring Your Own Device”

- Reduces cost of fare media distribution and replacement
- Mobile device is both fare media and virtual vending machine

# Account-based System

## Operational Benefits (cont.)

### Fare products are digital

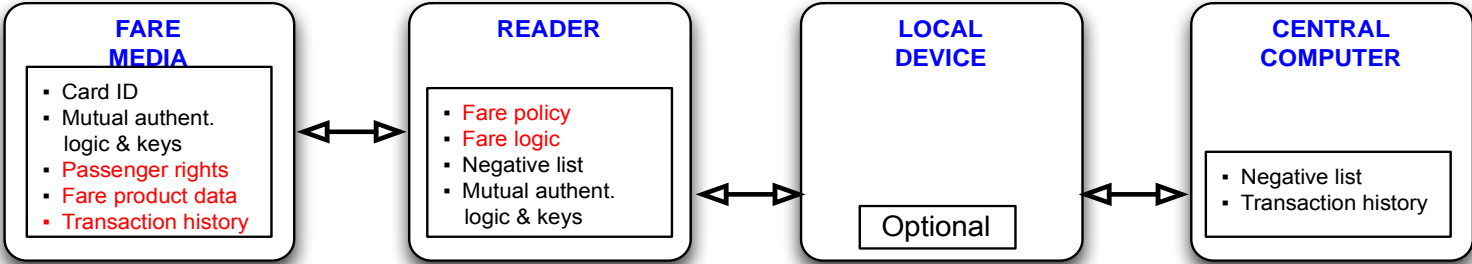
- Sale and “delivery” via any networked device
- Instantaneous “delivery” (buy now, use now)
- Autoloads easily accommodated
- Lost cards easily blocked and replaced

### Centralized fare policy and rules

- Changes required only in central system
- No need to send updates to every field device
- Greater processing power and storage at central system supports more complex fare policies

# Card-Based System

## Fare Payment Transaction Flow



- Step 1:** Fare media is presented to reader
- Step 2:** Fare media / reader perform mutual authentication
- Step 3:** Reader extracts fare product and payment history from card
- Step 4:** Reader calculates fare
- Step 5:** Reader determines if any fare product can satisfy fare.
- Step 6:** Reader updates fare product and payment history on card
- Step 7:** Reader displays approval or decline to passenger
- Step 8:** Reader records results.
- Step 9:** Reader uploads transaction records to central computer (via Local Device, if appropriate).
- Step 10:** Central computer analyzes and archives records

# Card-Based System

## Implementation Considerations

### Fare Payment Processing

- Robust application in readers to perform fare calculation
- Fare policy changes require software download to every field device
- Transaction time under 350ms to avoid “transaction tearing”

### Security

- Comprehensive security key management and distribution process
- Frequent updates required to negative list in field devices

### Network

- Minimal bandwidth required (to support batch uploading of transaction data)



# Card-Based System

## Implementation Considerations (cont.)

### Fare Media Distribution

- Special devices required to read/write data on fare media

### Fare Products

- Online purchases challenging to accommodate

### Applicable Standards

- ISO/IEC 14443
- ISO/IEC 7816
- APTA CFMS
- NFC
- ISO/IEC 8583
- TCIP

# Card-Based System

## Operational Benefits

### “Bring your own device”

- Mobile phone using NFC interface and custom-designed app
- Reduces cost of fare media distribution and replacement

### System works offline

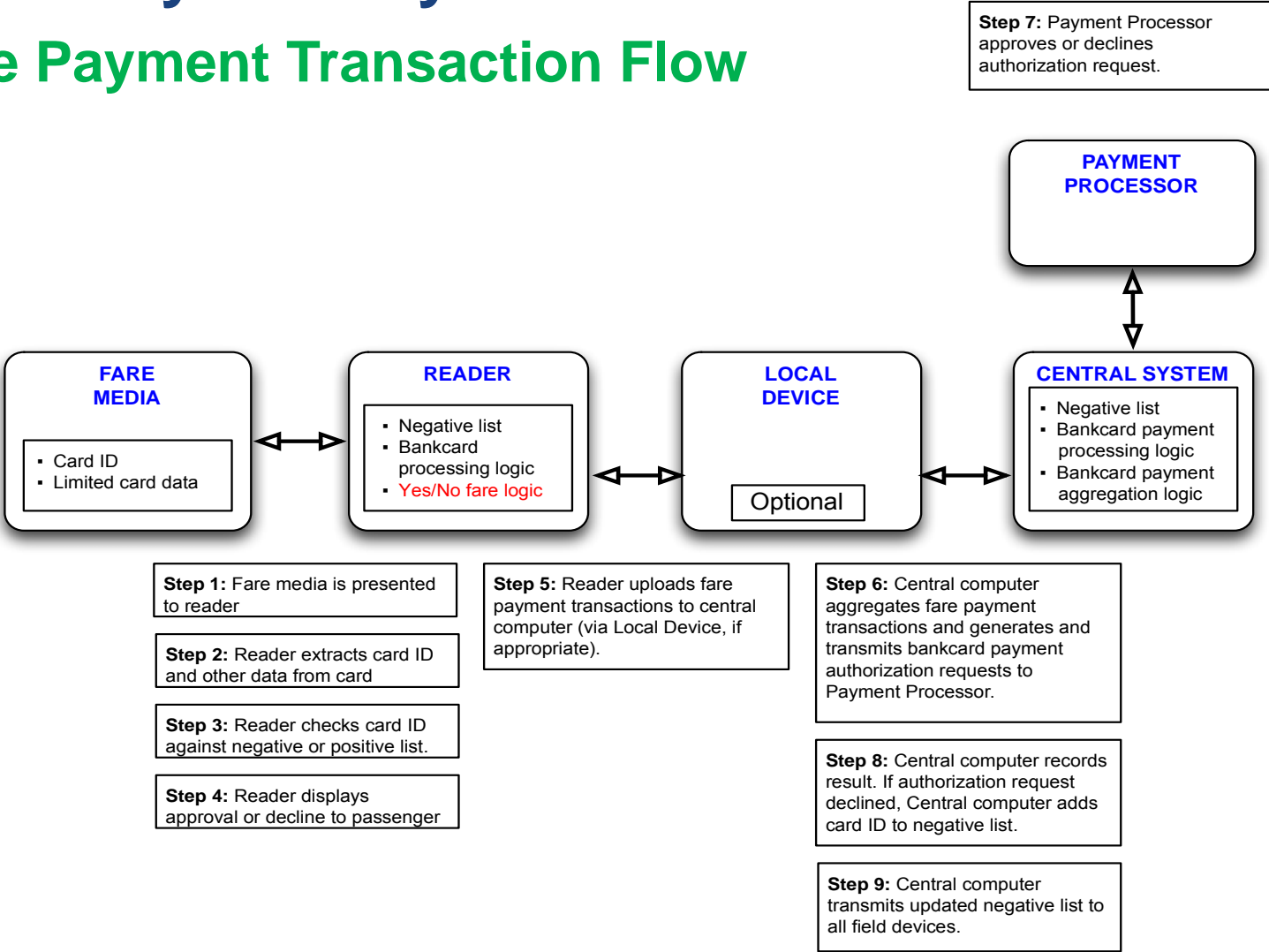
- Offline field devices can continue to process fare payments for long periods of time

### Extensive experience

- Method supported by every major EFPS supplier
- Many different cards and devices proven in revenue service

# Open Payment System

## Fare Payment Transaction Flow



# Open Payment System

## Implementation Considerations

### Fare Payment Processing

- Fare policy is restricted to value-based payments

### Security

- U.S.-issued contactless bankcards lack an offline card authentication solution
- Frequent updates to negative list stored in field devices is required

### Network

- Reliable communications required
  - Readers to central computer
  - Central computer to Payment Processor

# Open Payment System

## Implementation Considerations (cont.)

### Fare Media

- Program relies on continued bank and passenger use of contactless bankcards
- Solution needed for passengers without bankcards

### Fare Products

- Not applicable. Method only supports value-based fares.

### Applicable Standards

- ISO/IEC 14443
- ISO/IEC 7816
- EMV-contactless
- NFC
- ISO/IEC 8583
- TCIP

# Open Payment System

## Operational Benefits

### “Bring your own device”

- Bank-issued credit, debit, or prepaid card
- Mobile phone using NFC interface and mobile app to emulate bank-issued card
- Reduces cost of fare media distribution and replacement

### System works offline

- Offline field devices can continue to process fare payments for short periods of time



# CASE STUDY



# Case Study

## Chicago Transit Authority (CTA) Ventra Program

EFPS type: Multi-agency, Account-based with Open Payment

- Standard features:
  - Extensive vending machine and retailer network for cards and fare products
- Unique requirements:
  - Outsourcing of 100% of system operations, maintenance, and risk
  - Aggressive (six-month) transition from old (card-based) system to new
  - Exclusive use of contactless bankcards as fare media
- Fare media:
  - Primary: Contactless prepaid MasterCard debit card
  - Secondary: Bank-issued, contactless credit and debit
- Implementation issues:
  - Negative public and media reaction to fees and early system glitches
  - Unreliable communications network prevents real-time fare calculation



# Case Study

## CTA Ventra Program Key Benefits

- \$5M+ annual savings in fare collection system operations
- Transfer of most financial and technology risks to vendor for life of contract
- Increased passenger convenience
  - Significant increase in card and fare product distribution network
  - Fare product purchases via website
  - All fare products available through every sales channel
  - Ability to use contactless bankcard in lieu of cash fares on buses

# Case Study

## Greater Toronto Area (GTA) Presto Program

EFPS type: Regional Card-based with Open Payment

- Standard features:
  - Contactless card readers
  - Extensive vending machine and retailer network for card and fare product sales
- Unique requirements:
  - Multi-agency, multi-mode regional program
  - Open interfaces allowing for variety of vendors to provide field equipment
  - Open payment included

## Case Study

### Greater Toronto Area (GTA) Presto Program (cont.)

- Fare media:
  - Primary: Clearinghouse-issued contactless farecard
  - Secondary: Bank-issued, contactless credit and debit
- Implementation issues:
  - Initial reluctance of largest agency in region (Toronto Transit Authority) to participate
  - Negative public and media reaction to delays, cost overruns and change orders
  - System glitches and delays with first medium-sized agency implementation

## Case Study

### GTA Presto Program Key Benefits

- Creation of regional fare payments program
- Reduced bus operator responsibilities for fare product validation
- Reduced cash fares
- Increased passenger convenience
  - Significant increase in card and fare product distribution network
  - Ability to use contactless bankcard in lieu of cash fares on buses and in stations

# Case Study

## Jacksonville Transit Authority (JTA) Star Card

EFPS type: Single agency, Card-based system

- Standard features:
  - Single agency program
  - Vending machines and equipment for retailer network
- Unique requirements:
  - Reduce bus operator responsibilities for fare collection
  - Eliminate paper transfer tickets and associated thefts
  - Simultaneous introduction of fare policy change from zone to flat fare
- Fare media:
  - Primary: Agency-issued contactless farecard
  - Limited use tickets
- Implementation issues:
  - Unanticipated operating costs (new staff, TVM servicing)
  - Lack of broad distribution network for cards and fare products
  - Lead time to purchase smart cards

## Case Study

### JTA Star Card Key Benefits

- Reduced transaction time (-63%)
- Reduced boarding time (-23.5%)
  - Average driving time reduction of 1 hour per route
  - 1% reduction in pollution
- Reduced operating costs
  - \$60,000 in annual fuel savings
  - Ticket printing costs: \$86,000+ annual savings
- Fare policy flexibility
  - Greater variety of fare media and fare products
  - Reduced fare evasion and transfer ticket theft
  - Increased passenger convenience
- Better data

# ACTIVITY



U.S. Department of Transportation  
Office of the Assistant Secretary for  
Research and Technology

# Which type of EFPS only supports value-based fares?

## Answer Choices

- A) Card-based EFPS
- B) Open Payment EFPS
- C) Account-based EFPS
- D) All of the above

Correct - Click The correct answer is:

Your answer:

You did not answer this

You must answer the question  
before continuing

Submit

Clear



# Review of Answers

Learning Objective #3



a) Card-based EFPS

*Incorrect. A card-based EFPS can support a wide variety of fare products including passes and various forms of prepaid stored value.*



b) Open Payment EFPS

***Correct! Open payment EFPS only accept contactless bankcards which hold only card-specific data that can't be changed. Since other forms of fare products would either need to be recorded in card memory or associated with an account in the central system an open payment EFPS can only support value-based fares.***



c) Account-based EFPS

*Incorrect. This type of EFPS can support a virtually unlimited variety of prepaid fare products, including passes.*



d) All of the above

*Incorrect. Card-based EFPS and account-based EFPS can each support a wide variety of prepaid fare products, including passes.*

## Summary of Learning Objective #3

**After completing this section of the module, the reviewer should be able to:**

- Evaluate the options for electronic fare payment by:
  - Assessing the unique implementation issues of the transit industry
  - Applying case studies of the leading EFPS methodologies

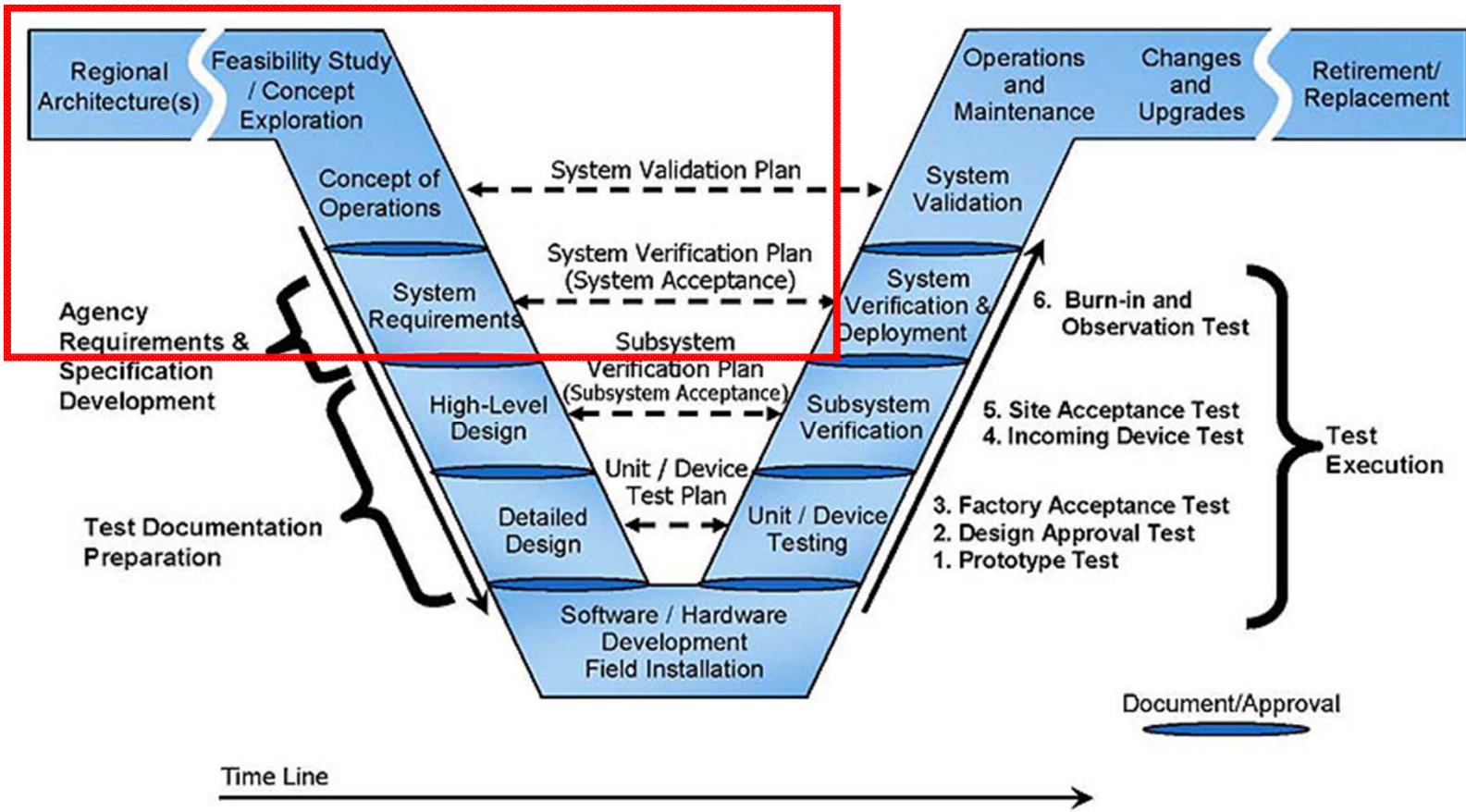
## Learning Objective #4

### Apply Newly Developed Skills to:

- Assess agency requirements in order to facilitate selection of a methodology and architecture for electronic fare payment
- Support the procurement and implementation of a new, electronic fare payment system or existing system enhancement

# Systems Engineering Process Vee Diagram

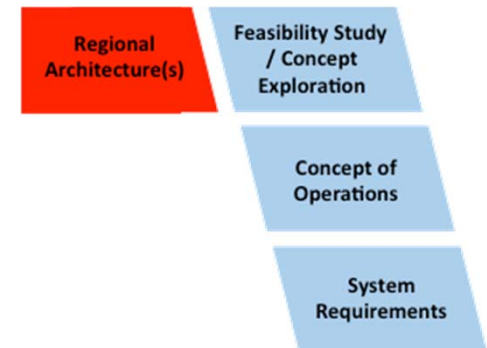
## Requirements Development and Analysis



# Applying the SEP

## Regional Architecture and Implications

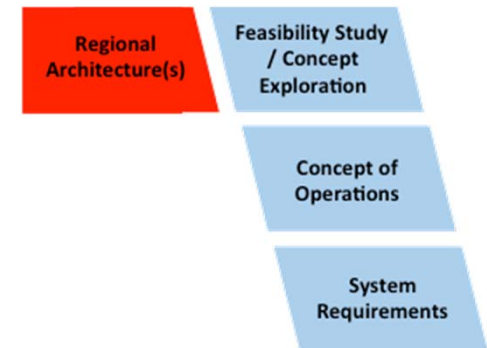
- Define the vision and objectives for the regional fare payments program
- Define the program scope
  - Infrastructure
  - Fare products and/or services
  - Procurement process and vendor contract(s)
- Define program governance
  - Stakeholders roles and responsibilities
  - System validation and certification
  - Revenues and expense sharing (if applicable)
  - Regional fare policy management
  - Vendor management



# Applying the SEP

## Regional Architecture and Implications (cont.)

- Define regional requirements
  - System architecture, interfaces and security
  - Financial settlement and clearing
  - Performance levels

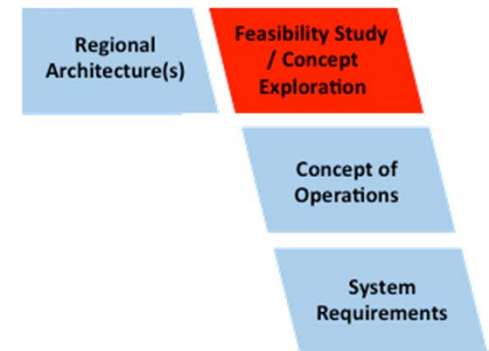


# Applying the SEP

## Feasibility Study / Concept Exploration

*During this phase, the agency should develop a high level concept for its EFPS.*

- Core Objectives
  - Identify and document business, technical and schedule constraints
  - Document key program objectives and desired implementation schedule
  - Make preliminary EFPS type selection
  - Verify project feasibility and identify key risks
  - Secure management buy-in and sponsorship
- Key Steps
  - Define evaluation criteria
  - Identify and evaluate alternative concepts
  - Evaluate alternatives



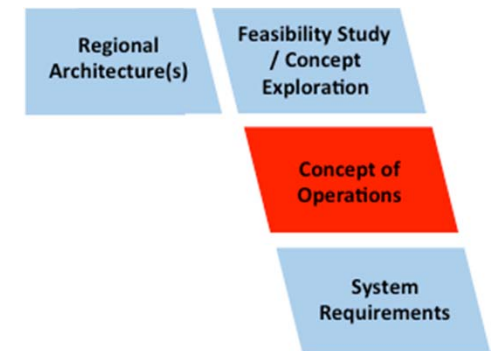


# Applying the SEP

## Concept of Operations

*During this phase, a preliminary decision on EFPS type is made.*

- Core Objectives
  - Define high level requirements for all stakeholders
  - Establish roles and responsibilities
  - Ensure common understanding of system concept and requirements
  - Establish system performance and program success metrics

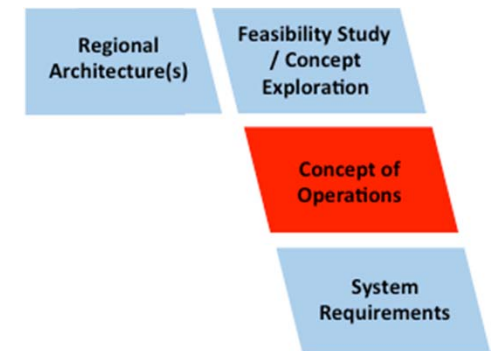




# Applying the SEP

## Concept of Operations (cont.)

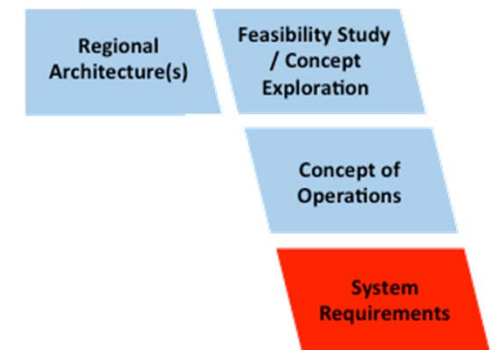
- Key Steps
  - Identify and document all stakeholders
  - Form the core program team
  - Develop an initial Concept of Operations
    - Identify business and operational issues of the existing system
    - Identify and analyze the cost components of the existing system
    - Review existing fare policy and define a strategy for future policy evolution



# Applying the SEP

## Requirements Definition

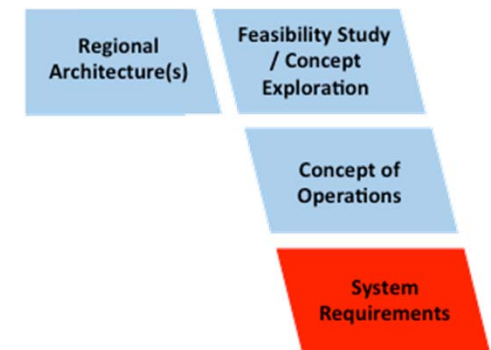
- Requirements should:
  - Clearly define a business or functional need
  - Identify business (e.g. budgetary, schedule) and technical constraints
  - Define performance service levels
  - Be consistent with program objectives
  - Encourage supplier innovation



# Applying the SEP

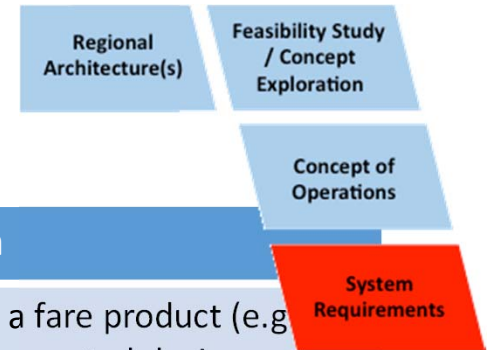
## Requirements Definition (cont.)

- Requirements should NOT:
  - Prescribe a particular technology or solution, except when required due to technical constraints
  - Use undefined terms, acronyms, or abbreviations
  - Be based on vague or undocumented assumptions

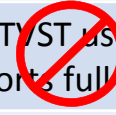


# Applying the SEP

## Requirements Definition (sample)



#	Category	Requirement	Description
1	Fare Product Distribution	Passenger purchases of fare products	Passengers must be able to purchase a fare product (e.g. pass, stored value) on any internet-connected device and immediately use that product to pay a fare.
2	Standards	Contactless Bankcard standards compliance	Applicable components shall be fully compliant with the bankcard standards
3	TVM – User Interface	Touchscreen with full color graphics	Users shall interact with TVM using a 10" x 12", touchscreen LCD monitor which supports full color graphics.
4	Security	End-to-end Encryption	All data exchanges between subsystems, subsystem to central computer, and central computer to external system shall be fully encrypted using an industry standard encryption algorithm and a key length of not less than 128 bits.
5	Service Levels	Fare Payment Transaction Time	Transaction times from recognition of the payment media by the reader to the display of the fare payment disposition shall be less than 500 ms.



# Selecting the Correct EFPS Type









## EFPS Characteristics

Methodology	Primary Security Scheme	Fare Processing Logic	Fare Products & Passenger Rights	Fare Media
<b>Account-based</b>	<ul style="list-style-type: none"> <li>Card authentication</li> </ul>	<ul style="list-style-type: none"> <li>Performed by central computer</li> <li>Fare policy changes made to central computer only</li> </ul>	<ul style="list-style-type: none"> <li>Stored in central account records</li> <li>Fare product sold via any networked device</li> </ul>	<ul style="list-style-type: none"> <li>Contactless card</li> <li>Limited use ticket</li> <li>Bar/QR code</li> <li>Mobile device</li> </ul>
<b>Card-based</b>	<ul style="list-style-type: none"> <li>Card/Reader mutual authentication</li> </ul>	<ul style="list-style-type: none"> <li>Performed by reader</li> <li>Fare policy changes downloaded to all field devices</li> </ul>	<ul style="list-style-type: none"> <li>Stored on card</li> <li>Fare product sold via agency-specific devices</li> </ul>	<ul style="list-style-type: none"> <li>Contactless card</li> <li>Magnetic farecard</li> <li>Limited use ticket</li> </ul>
<b>Open Payment</b>	<ul style="list-style-type: none"> <li>N/A</li> </ul>	<ul style="list-style-type: none"> <li>Yes/No decision performed by reader</li> </ul>	<ul style="list-style-type: none"> <li>N/A: Supports only value-based fares</li> </ul>	<ul style="list-style-type: none"> <li>Contactless bankcards</li> <li>Mobile device emulating contactless bankcard</li> </ul>

# Selecting the Correct EFPS Type

## Matching Requirements to EFPS Characteristics








*Sample Requirement: Passengers must be able to purchase a fare product (e.g. pass, stored value) on any internet-connected device and immediately use that product to pay a fare.*

EFPS Type	Fare Product Distribution
Account-based 	<ul style="list-style-type: none"> <li>▪ Stored in central account records</li> <li> Fare product sold via any networked device</li> <li> Buy now, use now</li> </ul>
Card-based 	<ul style="list-style-type: none"> <li>▪ Stored on card</li> <li> Fare product sold via agency-specific devices</li> <li> Buy now, use now</li> </ul>
Open Payment 	<ul style="list-style-type: none"> <li> N/A: Supports only value-based fares</li> </ul>

# Selecting the Correct EFPS Type

## Matching Requirements to EFPS Characteristics











*Sample Requirement: Devices at points of entry (e.g. faregates, fareboxes) shall use security mechanisms (e.g. authentication) that prevent the use of counterfeit payment media before allowing entry/boarding.*

EFPS Type	Payment Media Security
Account-based 	 Card authentication
Card-based 	 Card/Reader mutual authentication
Open Payment 	<ul style="list-style-type: none"> <li> Not applicable – Contactless bankcards do not support local authentication</li> <li> Card authentication may be performed by issuer later</li> </ul>

# Selecting the Correct EFPS Type

## Matching EFPS Features to Requirements

*Sample Requirement: The EFPS shall only accept for fare payments contactless bankcards that adhere to the ExpressPay, PayPass, payWave, or ZIP specifications.*







EFPS Type	Fare Media
Account-based 	<ul style="list-style-type: none"> <li> Contactless card</li> <li> Limited use ticket</li> <li> Bar Code/ QR Code</li> </ul>
Card-based 	<ul style="list-style-type: none"> <li> Contactless card</li> <li> Magnetic farecard</li> <li> Limited use ticket</li> </ul>
Open Payment 	<ul style="list-style-type: none"> <li> Contactless bankcards (only)</li> </ul>



# Selecting the Correct EFPS Type

## Matching EFPS Features to Requirements

*Sample Requirement: Fare payment processing shall support a variety of fare policies including, but not limited to, the use of pass products, transfer rights, and discounts to special fare program participants.*

EFPS Type	Fare Payment Processing
Account-based 	<ul style="list-style-type: none"> <li>▪ Performed by central computer</li> <li>▪ Fare policy changes made to central computer only</li> <li> Supports any policy</li> </ul>
Card-based 	<ul style="list-style-type: none"> <li>▪ Performed by reader</li> <li>▪ Fare policy changes downloaded to all field devices</li> <li> Supports any policy</li> </ul>
Open Payment 	<ul style="list-style-type: none"> <li>▪ Yes/No decision performed by reader</li> <li> Supports value-based fares only</li> </ul>

# Selecting the Correct EFPS Type

## Role of Security in an EFPS

- A comprehensive security program is essential and should include:
  - Fare media authentication
  - Message protection
  - Sensitive data storage and access rules
  - Encryption key management and distribution
  - System monitoring and testing
  - Procedures for handling security breaches
- Impacts of security breaches can be devastating
  - Loss of revenue
  - Loss of passenger confidence
  - Security system upgrade/replacement costs

# ACTIVITY



U.S. Department of Transportation  
Office of the Assistant Secretary for  
Research and Technology

# Which of the following is an important consideration when defining security requirements for an EFPS?

## Answer Choices

- A) Sensitive data protection
- B) Protection of cash while being transported to a bank
- C) On-board surveillance systems for bus vehicles
- D) Scheduling of daily fare payment reports

The correct answer is:

anywhere or

press Control

Your answer:

You did not answer this

You must answer the question  
before continuing

Submit

Clear

## Review of Answers



a) Sensitive data protection

***Correct! Protection of all sensitive, fare-related data is a critical concern for all transit agencies and must be carefully documented in the form of requirements when procuring an EFPS.***



b) Protection of cash while being transported to a bank

*Incorrect. Although important, protection of cash is not directly related to EFPS security.*



c) On-board surveillance system for bus vehicles

*Incorrect. Although important, such surveillance systems are not directly related to EFPS security.*



d) Scheduling of daily fare payment reports

*Incorrect. Although important, report printing and delivery is not directly related to EFPS security.*

## Summary of Learning Objective #4

**After completing this section of the module, the reviewer should be able to apply newly developed skills to:**

- Assess agency requirements in order to facilitate selection of a methodology and architecture for electronic fare payment
- Support the procurement and implementation of a new, electronic fare payment system or existing system enhancement

# What We Have Learned

1. Electronic fare payment is the automated calculation, validation, collection, recording, and reporting of transactions using some form of electronic validation system and, in many instances, electronic media for payment of rides on a public transit system
2. Electronic fare payment uses a variety of terms and acronyms that are unique to the transit fare collection industry
3. The three most common types of electronic fare payment systems are: card based, account-based, and open payment .



## What We Have Learned (cont.)

4. Various national and international standards can be applied, however, there are significant gaps between these standards which must be addressed by agencies that are procuring a new or upgrade to an existing electronic fare payment system.
5. Careful analysis of agency requirements is required in order to identify the correct EFPS type.
6. Data security plays a key role in every EFPS but the methods will vary depending on the type of EFPS selected.



# Resources

- Your Smart Phone is Getting Smarter:  
[http://www.pcb.its.dot.gov/t3/s110629\\_farecollection101.asp](http://www.pcb.its.dot.gov/t3/s110629_farecollection101.asp)
- Put it on my Card: The Trend Towards Account-based Systems in Transit Systems: [http://www.pcb.its.dot.gov/t3/s110118\\_openepay.asp](http://www.pcb.its.dot.gov/t3/s110118_openepay.asp)
- The Future of Fare Collection: Contactless Fare Payment Systems based on CFMS Standards: [http://www.pcb.its.dot.gov/t3/s071213\\_cfms.asp](http://www.pcb.its.dot.gov/t3/s071213_cfms.asp)
- Putting the Pieces in Place: Seamless Regional Fare Payment Puts the Super in Southern California's "Super Region":  
[http://www.pcb.its.dot.gov/t3/s120426\\_super\\_region.asp](http://www.pcb.its.dot.gov/t3/s120426_super_region.asp)
- TCRP BRD 57 Developing a Recommended Standard for Automated Fare Collection for Transit:  
[http://www.tcrponline.org/PDFDocuments/TCRP\\_RRD\\_57.pdf](http://www.tcrponline.org/PDFDocuments/TCRP_RRD_57.pdf)

*See Student Guide for a more comprehensive list of resource documents and materials.*

# Thank you for completing this module.

## Feedback

Please use the Feedback link below to provide us with your thoughts and comments about the value of the training

Thank you.