ITS ePrimer
Module 8: Electronic Toll Collection, Electronic Payment Systems, and Pricing

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ITS Professional Capacity Building Program
ITS Joint Program Office
U.S. Department of Transportation
Instructor

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Learning Objectives

- Understand the basic terminology of electronic payment systems applications and pricing strategies
- Describe electronic payment technologies, applications, and strategies
- Understand the application of electronic payment systems applications to transportation and Intelligent Transportation Systems and describe some challenges
- Understand the approximate costs and benefits associated with electronic payment systems applications and pricing
- Define the role of the private sector in electronic payment systems applications
- Describe some implementation examples and lessons learned
Electronic Payment Systems Introduction

- **Technologies** – the technologies and products that can be applied to our needs, issues, problems and objectives. For example, contactless payment technologies

- **Applications** – specific technology implementations designed to address a set of needs, for example, an electronic toll collection system

- **Strategies** – ways in which the technologies can be applied to achieve specific policy objectives, for example, congestion pricing
SF Park San Francisco

- The following link points to a video that provides an example of a smart car parking system being implemented in San Francisco

- This shows how electronic payment systems can be applied to fee collection for parking within a wider congestion management context

http://sfpark.org/resources/sfpark-overview-video/
Non-cash Transactions Worldwide

- 260 billion on-cash transactions worldwide

- Electronic payment techniques are growing in importance every year

- The USA accounts for more than 40% of the total, with 104 billion transactions

- Transportation electronic payment systems fit within this larger context and benefit from innovation and development from the wider market
Contactless Payment Systems

- Short-range wireless technologies are used to enable payment without contact between the payment device and the reader.
- This example shows a contactless smart card being used to pay for a transit fare in Finland.

Near Field Communications

- The use of cell phones and smart phones to support contactless payment is known as Near Field Communications (NFC).
- This differentiates between this use and the use of the phone as a wide area wireless device for voice and data communications.
- It also covers communications between one phone and another one.
- Applications include Android Pay and Apple Pay.

Android Pay and Apple Pay

- Use Near Field Communications technology
- Enables you to use your credit cards, store credit cards, and rewards cards with your smartphone or smart watch
- Apple Pay works with the cards you already have on the devices you use every day.
- Card details are never shared and aren’t stored on your device at all
- Both let you use smartphones or smart watches to pay in over a million stores accepting contactless payments. You can also make purchases within participating apps.

Apple Pay being used to purchase a cup of coffee retrieved from Wikipedia on April 18 2016
https://commons.wikimedia.org/wiki/File:Apple-payment-square.jpg
Android Pay and Apple Pay Operation

- Android Pay was introduced in 2015 and Apple Pay was introduced in 2014. Both make use of Near Field Communications combined with Host Card Emulation (HCE).
- As the name suggests, Host Card Emulation enables a smart phone to emulate a credit card and communicate with an appropriate Near Field Communication reader.
- The user enters credit card data into the smart phone where it is stored securely. When the user pays for an item, the credit card data is encrypted or “tokenized”.
- This generates a one-time use temporary credit card number that is used to pay, thus protecting the user’s real credit card number.
- The Android Pay approach makes use of a cloud-based store to retain these tokens, with a few tokens held securely on the smart phone to enable payment when there is no cell phone signal. The Apple Pay approach makes use of a special chip on board the phone to store the tokens.
- Similar electronic payment approaches are being introduced by a number of banks and also by Samsung, one of the major cell phone manufacturers.
Smart Phones and Bar Codes

- Several major airlines are now using two-dimensional bar codes as a boarding pass.
- You can download the bar code from the airline Web site and have it scanned by a special optical reader at TSA airport security.
- The bar code is used as proof of payment.

Samsung Focus Smartphone, retrieved from http://upload.wikimedia.org/wikipedia/commons/5/5f/Mobile_boarding_pass_KLM.JPG on January 31, 2013
Bar Code Billboards

- Large bar codes can be used to transmit a lot of information to passersby.
- Scan the bar code with your smartphone loaded with a special app and you can be taken to an appropriate Web site for more information.

Electronic Toll Collection

- Vehicle enters the toll zone and breaks the first laser beam (1), triggers transceiver (2)
- Transceiver signals vehicle’s transponder/tag requesting time, date, and transponder, or tag identity
- Camera (3) photographs the vehicle’s front license plate
- Vehicle breaks second laser beam (4) triggering the second camera (5)
- Second camera photographs the rear license plate

Audience Interaction

- What is your opinion regarding open road tolling compared to all electronic toll collection?
  - Should drivers be forced to use electronic means only, or should we always leave the opportunity to pay for cash at the roadside?
  - Do the customer service benefits of accepting cash out weigh the cost of the cash collection?
Electronic Toll Process

Account management
- Establish account
- Set up transponder
- Transfer funds from credit card
- Deposit funds using cash

Transaction processing
- Detect and classify vehicle
- Calculate appropriate fee
- Deduct fee from account

Enforcement
- Check for zero or negative balance
- Check for transponder fault
- Check for no transponder

Billing
- Calculate bill
- Distribute statements

Customer service
- Respond to customer questions
- Accept cash and add to account
- Install transponders
- Replace transponder batteries
- Handle transponder issues
Pricing Strategies

Now that we have electronic toll collection technologies at our disposal, there are a number of smart strategies that can be applied.

In ITS generally, there seems to be a change in emphasis from installing devices to discovering what management solutions we can apply.
Basic Economic Principles of Pricing

### Pricing Economics Simulator (1/3)

**Table:**

<table>
<thead>
<tr>
<th>Scenario Description</th>
<th>Parameter</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 base case</td>
<td>elasticity (veh/hour/$)</td>
<td>300</td>
<td></td>
<td>initial traffic volume (veh/hour)</td>
<td>5000</td>
<td>2000</td>
</tr>
<tr>
<td>2 change in elasticity</td>
<td>initial toll ($)</td>
<td>1</td>
<td></td>
<td>target traffic volume (veh/hour)</td>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>3 change in target traffic</td>
<td></td>
<td>300</td>
<td>1</td>
<td>target traffic volume (veh/hour)</td>
<td>3801</td>
<td></td>
</tr>
</tbody>
</table>

**Diagram:**

- **Trip Costs:**
  - Elasticity (veh/hour/$)
  - Initial toll ($)
- **Objective:**
  - Demand
  - Marginal Cost
  - Average Cost
- **Traffic Volume:**
  - Initial traffic volume (veh/hour)
  - Target traffic volume (veh/hour)
- **Target toll ($):**
  - Change in elasticity
  - Change in target traffic
# Pricing Economics Simulator (2/3)

<table>
<thead>
<tr>
<th>Scenario Description</th>
<th>Parameter 1</th>
<th>Parameter 2</th>
<th>Parameter 3</th>
<th>Parameter 4</th>
<th>Parameter 5</th>
</tr>
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<tr>
<td></td>
<td>300</td>
<td>1</td>
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<td>2000</td>
<td>$11.00</td>
</tr>
<tr>
<td>change in elasticity</td>
<td>601</td>
<td>1</td>
<td>5000</td>
<td>2000</td>
<td>$5.99</td>
</tr>
<tr>
<td>change in target traffic</td>
<td>300</td>
<td>1</td>
<td>5000</td>
<td>3801</td>
<td>$3.00</td>
</tr>
</tbody>
</table>
### Pricing Economics Simulator (3/3)

<table>
<thead>
<tr>
<th>Scenario Description</th>
<th>Parameter 1 (veh/hour/$)</th>
<th>Parameter 2 ($)</th>
<th>Parameter 3 (veh/hour)</th>
<th>Parameter 4 (veh/hour)</th>
<th>Parameter 5 ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>base case</td>
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<td>1</td>
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<tr>
<td>change in target</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>traffic</td>
<td>601</td>
<td>1</td>
<td>5000</td>
<td>3801</td>
<td>3.00</td>
</tr>
</tbody>
</table>
There are almost 50 projects worldwide involving some form of pricing strategy.

These projects represent a combination of toll roads, urban congestion pricing, value pricing, managed lanes, and express lanes strategy implementations.
Dynamic Tolling Projects in the USA

- There are 11 projects that are conducting dynamic tolling currently in the U.S.
- Dynamic tolling can be viewed as a subset of managed lanes or express lanes as they are operated under variable tolling regimes in order to achieve a specific traffic conditions objectives.
## Is It Variable or Dynamic Tolling?

<table>
<thead>
<tr>
<th></th>
<th>Variable tolling</th>
<th>Dynamic tolling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-published schedules</td>
<td>For each segment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Level of service based</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Value of time saved based</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Combination of level of service</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and value of time</td>
</tr>
</tbody>
</table>
Typical Dynamic Tolling Algorithm

Toll Calculated at 4 Minutes Before Each 15-Minute Interval

Pop-Up Window with Calculated Toll

Accept

No, Close or Use Zero Toll

Adjust Operating Mode (Normal, Closed or Zero Toll)

Verify Toll on VMS with Closed Circuit Television (CCTV)

Pop-Up Window to Confirm

Notification Time Stamp

Acknowledgement Time Stamp

Confirmation Time Stamp

Audience Interaction

- What is your opinion regarding urban congestion pricing?
  - Would you be prepared to pay a mandatory fee for access to a downtown area in the U.S.?
  - Do you think that pricing is fair?
Defining Strategic Objectives

- Congestion Reduction
- Peak Spreading
- Modal Shift
- Revenue Generation

Multimodal Electronic Payment Systems

- Regional multimodal electronic payment system - all modes of transportation addressed by single payment system
- While there may be one single payment system there may be different payment devices
  - For example, vehicle-based payment can be achieved by transponder or tag while personal based payments such as ticketing for transit systems can be accomplished with a smartcard
  - The same account can be used for both even if different payment devices are used
- Regional multimodal approach offers more management solution possibilities
  - For example, conditional discounts could be offered where users of the transit system on one particular day may be offered free parking downtown for another day when they decide to take their car
Challenges

- Requirements definition
- Proprietary technologies
- Funding and financing
- Future proofing
- Privacy and anonymity
- Fairness and equity
- Fitting within the wider context
- Harnessing regional partners
- Finding the best business model
Electronic Payment, Transportation, ITS

- Electronic toll collection and pricing considered as a subset of ITS
- Many ITS applications complementary to electronic toll collection and pricing systems
- Electronic toll collection and pricing set within a wider context of performance management
- Electronic payment systems applications can be powerful collectors of data for performance management
- Electronic payment systems applications fit within ITS and transportation management through delivery of more efficient data collection and demand management
- The flexibility of electronic systems to adjust payment provides demand management possibilities
The Role of the Private Sector

- Providing technology products and services
  - The private sector may have already invested considerable sums in technologies, products and services that can be incorporated into a public agency project

- Providing expertise and experience
  - Many private sector companies have the ability to conduct business worldwide and may have gathered expertise and experience that is difficult to accumulate in a local context

- Providing financing
  - It may also be possible for the private sector to provide financing under a suitable public private partnership relationship
    - Defining a business model helps to define the private sector role in the implementation
Business Models

- More than technology, business models and business processes are very important.
- There are also new choices to acquire a service rather than technologies.
- The next few slides illustrate this with business process models from two transit agencies that acquired electronic ticketing capabilities recently:
  - Chicago Transit Authority (CTA), Chicago
  - Dallas Area Rapid Transit (DART), Dallas
CTA Chicago Business Model

Financing
Capex
Opex
Technology refresh

Implementation
Fare media
Readers
Fare machines
Back office
Telecommunications

Account Management
Establish account
Set up fare media
Transfer funds from credit
Deposit funds using cash

Transaction Processing
Tap on
Tap off
Advising fare management

Fraud Management
Check for zero or negative
Check for media fault
Anti passback

Fare Management
Determine fare policy
Advise transaction processing system

Customer Service
Respond to customer
Manage fare media issues
Accept cash and add to account

Marketing
Awareness
Interest
Desire
Action

Operations and maintenance
Fare media
Devices
Telecommunications
Back office
System administration

CTA
Service Provider
DART Dallas Business Model

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DART
Service Provider
# Illustrative Examples

<table>
<thead>
<tr>
<th>Name of Project</th>
<th>Description</th>
<th>Web Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ORCA Card</td>
<td>Implemented a single smart card for bus, rail, and ferry services in the Seattle Metro area. Single card, multiple modes, multiple service providers</td>
<td><a href="http://www.orcacard.com">www.orcacard.com</a></td>
</tr>
<tr>
<td>4 Houston Katy Freeway Express Lanes</td>
<td>Dynamic tolling on express lanes retrofitted in the median of major freeway</td>
<td><a href="https://www.hctra.org/katymanagedlanes/how_it_works.html">https://www.hctra.org/katymanagedlanes/how_it_works.html</a> on January 31 2013</td>
</tr>
<tr>
<td>5 WMATA Washington DC – SmarTrip</td>
<td>Smart card system for paying bus and Metro fares in Washington DC</td>
<td><a href="http://www.wmata.com/fares/smartrip/">http://www.wmata.com/fares/smartrip/</a></td>
</tr>
<tr>
<td>6 CTA Chicago Card</td>
<td>Smart card system for paying bus and Metro fares across multiple operators in the Chicago Metropolitan Area</td>
<td><a href="http://www.chicagocard.com/ccplus/firsttime.aspx">http://www.chicagocard.com/ccplus/firsttime.aspx</a></td>
</tr>
<tr>
<td>7 I15 FasTrak Tolls San Diego</td>
<td>First implementation of dynamic tolling on express lanes in the USA</td>
<td><a href="http://www.sandag.org/uploads/publicationid/publicationid_6_1065.pdf">http://www.sandag.org/uploads/publicationid/publicationid_6_1065.pdf</a></td>
</tr>
<tr>
<td>8 EZPass Group</td>
<td>Coalition of agencies in the northeast sharing interoperable electronic toll collection system and central clearing/settlement</td>
<td><a href="http://www.ezpassiag.com/aboutus/overview">http://www.ezpassiag.com/aboutus/overview</a></td>
</tr>
<tr>
<td>9 Oregon Mileage Based Road User Fees</td>
<td>Pilot projects and legislation development to replace fuel based taxation with distance based</td>
<td><a href="http://www.oregon.gov/ODOT/HWY/RUFPP/pages/rucpp.aspx">http://www.oregon.gov/ODOT/HWY/RUFPP/pages/rucpp.aspx</a></td>
</tr>
</tbody>
</table>
Lessons Learned

**Politics**
- The political will to address the problems
- Effective political leadership
- Clear briefings to political leaders
- Clearly defined and communicated value of good transport
- Tipping point reached

**Power**
- Effective enabling legislation
- Legislation lesson learned from others
- Consider separating legislation from program
- Suitable authority
- Strong consensus and institutional arrangements

**Problem**
- Needs, issues, problems, and objectives explored, identified, defined, and agreed
- Effective communication planning
- Value proposition defined
- Effective use of the "what/how/cycle"
- Excellent sketch planning for communication and understanding
- Early start to public involvement
- Proposed uses for the new revenue defined and explained clearly

**Program**
- Accurate technology review
- Thorough business model analysis
- Clear business process definition
- Effective institutional cooperation
- Thorough economic impact analysis
- Complete financial analysis
- Comprehensive effects analysis
- World-class use of simulation and visualization
- Effective public involvement
- Fairness and equity achieved
- Undesirable side effects recognized and managed

**Procurement**
- Framework for low costs, minimal risks
- Clearly defined requirements
- Simple well understood solutions
- Flexible, scalable solution based on open standards, tailored to supplier capabilities
- Interactive dialogue with potential providers
- Effective price negotiation based on understanding of needs and capabilities
- Effective use of private sector resources, innovative business models and public/private partnerships
- Plan for the possibility of delays

**Project Management**
- Effective project and program definition
- Practical deployment phasing
- Suitable project management arrangements
- Adequate project management resources
- Defined project objectives
- Match project management resources to procurement method selected
- Build performance lessons into next deployment phase

**Performance**
- Define key performance indicators
- Conduct formative evaluation
- Conduct summative evaluation
- Define achieved values and benefits
- Communicate value and benefits
- Demonstrate effective use of new revenue streams
- Build performance lessons into next deployment phase
The Cost of Change Lesson

- The lesson is simple – ambiguity costs money.
- Ambiguity appears in system requirements due to lack of formal agreement on what the system is designed to do and lack of definition on specific requirements.
- As a rule of thumb it will cost approximately $1,000 to correct problems during the deployment stage.
- While that same problem could have been dealt with during the requirements gathering stage for approximately $1.
- That is why it’s worthwhile investing heavily in initial requirements analysis and objectives agreement.
## Typical Cost Elements

<table>
<thead>
<tr>
<th>Application</th>
<th>Payment Device</th>
<th>Point of Sale Device</th>
<th>Telecommunications</th>
<th>Back Office</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electronic Toll Collection</strong></td>
<td>Transponder: $20 Or Sticker tag: $4 each</td>
<td>Toll zone readers, lane computer, enforcement system: $1 million per zone for 3 lanes</td>
<td>Design and Install Fiber Optic Cable: $40 per foot</td>
<td>Account management, transaction processing, enforcement, billing and customer service hardware, software: $400,000</td>
</tr>
<tr>
<td><strong>Electronic transit ticketing</strong></td>
<td>Contactless Smart Card: $5 each</td>
<td>Fare Box with Smart Card Reader: $15000</td>
<td>Wireless Communications between Vehicles and Back Office</td>
<td>Account management, transaction processing, enforcement, billing and customer service hardware, software: $400,000</td>
</tr>
<tr>
<td><strong>Electronic Fee Collection for Car Parking</strong></td>
<td>Transponder: $20 or Sticker tag: $4 or smart card $5 or smartphone $0 each</td>
<td>Access control system: $15,000 per lane, or Kiosk: $15,000 or Smart Meter: $10,000</td>
<td>Design and Install Fiber Optic Cable: $40 per foot</td>
<td>Account management, transaction processing, enforcement, billing and customer service hardware, software: $400,000</td>
</tr>
</tbody>
</table>
Summary

- Electronic payment systems for transportation fit within a wider context of payment systems
- Electronic payment systems are comprised of technologies
- Electronic payment systems solutions are applied to a number of application areas.
  - Electronic toll collection
  - Electronic transit ticketing
  - Electronic fee collection for parking
  - Multimodal electronic payment systems
- Electronic toll collection can be carried out in a number of ways.
  - Open road tolling
  - All electronic toll collection
  - Dynamic tolling
- There are a number of pricing strategies that can be applied
  - Bond financed toll roads.
  - Express lanes.
  - Managed lanes
  - Congestion pricing.
  - Value pricing
  - Dynamic tolling
- Pricing is based on a basic economic principles relating cost of travel to demand for travel
- There are multiple potential roles for the private sector in an electronic payment system
- Multiple lessons have been learned from prior implementations
- A significant body of knowledge has been developed for both benefits and costs
- Electronic payment systems have been proven to deliver value in terms of safety, efficiency, and customer service
References

The following additional resources can be used to gather more information and practical insight into electronic payment systems applications, electronic toll collection, and pricing:


- For electronic fee collection for car parking: The Smart Card Alliance. Web site at www.smartcardalliance.org
Questions

1. What is the difference between ORT and AETC?
2. Describe one electronic payment technology, one application, and one strategy.
3. What is the relationship between electronic payment systems and performance management?
4. Name two challenges that could be faced implementing electronic transportation payment systems.
5. Name one benefit of electronic payment systems applications and pricing.
6. Define one role that the private sector might play in electronic payment systems.
7. Describe two implementation examples and results achieved.