Transition to Smart Card Technology: How Transit Operators Can Encourage the Take-Up of Smart Card Technology

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Abstract

This thesis explores and evaluates the essential strategies needed for transit agencies to switch from traditional fare collection systems to smart cards. More transit agencies today are investing in smart card technology as part of their new automated fare collection (AFC) systems. Although the benefits of switching to smart card systems have been well-researched and acknowledged by transit agencies, it is unclear how a transit agency should go about implementing a smart card system in order to achieve optimum customer acceptance and to reap maximum benefits from the system. Recent experience has shown that a range of implementation policy decisions can go a long way towards speeding or slowing down the adoption of the technology by customers.

A case study approach is used here to identify and evaluate the effectiveness and impacts of policies used by five transit agencies that currently employ smart cards. These policies fall into two categories: 1) distribution, operational and usage policies, and 2) fare policies. Distribution, operational and usage policies must be designed to facilitate and enhance customer adoption of smart cards, especially in the case where alternative fare media will co-exist. Fare policies are designed to differentiate smart cards from other fare media through differential pricing strategies, frequent-use bonuses and low price guarantees. The thesis also examines the use of fare models in assisting transit agencies to predict ridership and revenue, especially focusing on the features needed in these models to predict the usage rates of smart cards and their associated unique fare options.

Finally, the findings from the research are integrated and used to develop a set of guidelines for use by a transit agency that is switching to a smart card fare payment system. The main topics of these guidelines were identified as: 1) the use of fare policy incentives, 2) balance between restrictions and alternatives with respect to co-existing fare media, 3) accessibility to smart card support services, 4) capitalizing on the superiority of smart card technology, and 5) the use of a single card. To illustrate the usefulness of the guidelines, they were applied to a case study of the Massachusetts Bay Transportation Authority (MBTA)'s new AFC program, the CharlieCard.

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1 INTRODUCTION

The public transportation industry is evolving rapidly along with other industries, capitalizing on advances in technology. In public transportation, the impact of technology is growing as its associated benefits become more apparent. Transit agencies are investing large sums of money to enhance their systems in multiple dimensions. One important technology for transit operators is the introduction of smart cards as part of new automated fare collection (AFC) systems.

This thesis explores and evaluates strategies that a transit agency can take in switching from traditional fare collection systems to smart cards as a form of fare payment. It assesses what transit agencies that have already employed smart cards are doing and develops a set of guidelines that could be useful to a transit agency in determining how to make the transition to smart cards quickly and efficiently.

1.1 Background

During the past decade, transit agencies around the world have started moving from cash payments and magnetic stripe ticket technology towards a new form of technology – smart cards – as a form of fare collection. Transit agencies generally use "contactless" smart cards. While smart cards can operate in either the contact or contactless (or "proximity") mode, the latter is becoming more popular worldwide for transit applications and is replacing the magnetic stripe cards. Chapter 2 will define and explore smart cards in greater detail.

As a result of the numerous benefits that smart cards can bring to the public transportation arena, more transit agencies are interested in implementing smart card-based AFC systems to improve their market research and enhance operational performance. However, to date, there has been limited research into how such a transition to smart card technology can be accomplished most expeditiously so that transit operators can maximize their benefits from utilizing this new technology. Many transit agencies are reluctant to be the first in testing a new form of fare payment. There are few guidelines on how best to start up the smart card system. More specifically, there is often insufficient attention paid to the implementation plan in terms of how customers can be persuaded to take up smart cards quickly and in large numbers.

The implementation process is not simple and requires thoughtful consideration. According to Dreifus and Monk (192-202), the implementation process of a general smart card application consists of seven different aspects: control, deployment, synchronization, initial use, expiration and retirement of cards, development of a support team and the marketing of the smart card to consumers and merchants. Once formally launched, there are also operational considerations. Card replacement, system integrity, changing software in the field, expiration management, disaster recovery, management reports and operation in different kinds of environments are all operational issues that need to be continuously reviewed once implementation has occurred (203-214).

TCRP Report 32: Multipurpose Transit Payment Media (1998) was prepared to "provide a comprehensive study of the potential of multipurpose media programs and the implications of these programs for transit agencies, financial and other institutions and customers." While touching on smart card technology, the report focused on the perspectives of transit agencies and financial (and non-transportation) institutions. It identified institutional, operational, legal, technological, financial and customer acceptance issues for multi-purpose smart cards and proposed guidelines for developing a multi-purpose program.

An update to TCRP Report 32 is TCRP Report 94: Fare Policies, Structures and Technology (Update) (2003). In this report, various case studies are presented, some of which include transit agencies that already employ smart card technology. The impacts of the smart card programs on the transit agency and the customer are discussed in Chapter 3 of this report.

There are also many papers that report on the experience of individual transit agencies with smart cards. From the community's point of view, Cheung (2004) wrote about the two-year trial of the Tripperpas program in Netherlands and undertook a social cost-benefit analysis of smart card technology to understand the potential benefits and costs. From the perspective of a subway company, Chan (2002) described the experience with the implementation of Octopus, Hong Kong's smart card, on the subway system owned by MTR Corporation Limited.

1.2 Research Objectives and Motivation

This study aims to support transit operators in their transition to smart card technology as a form of fare collection by developing a set of guidelines that will assist them in increasing the take-up rate of smart cards. While many transit agencies have elected to make the transition from cash and/or magnetic stripe card technology to smart card technology, these agencies do not necessarily know what steps should be taken or which features of the technology should be implemented and/or promoted to encourage greater customer acceptance.

The objectives of this research are therefore to:

- Examine and evaluate the experiences and strategies of agencies currently employing smart card technology.
- Evaluate the use of fare models in evaluating fare policies with respect to the introduction of smart cards.
- Develop a set of guidelines for implementing smart card technology at transit agencies.

1.3 Research Approach

This thesis will focus on how the adoption (take-up) rate of smart card technology by transit users can be influenced through incentives and other agency strategies. The two main areas of emphasis are:

- Distribution, operational and usage policies and;
- Fare policies

Clearly, distribution, operational and usage policies can impact the pace of adoption in any system. They must be carefully designed to facilitate customer acceptance of the new media, especially when the traditional media are still available. Fare policies can distinguish smart cards from other fare media and take advantage of the flexibility of smart cards in offering new pricing initiatives. Here, a "fare medium" is defined as the physical form of the ticket such as paper tickets, tokens, cash, magnetic stripe cards and smart cards. Pricing initiatives alter the cost and/or value of the ticket. A "fare type" can be a single trip ticket, a stored value ticket, passes of various kinds or a combination of stored value tickets and passes, each incorporating various pricing initiatives.

1.3.1 Examination of Experiences of Transit Agencies with Smart Cards

Most of the prior research in this area has focused on the smart card's ability to implement substantial changes in fare structure and policy. The primary focus of this research is to examine the strategies and experience of transit agencies that have implemented smart cards in terms of the two areas of emphasis mentioned above.

In addition, case studies will be conducted on the implementation strategies for smart cards in selected transit agencies. The case studies will examine the distribution, operational, usage and fare policies that the various transit agencies have pursued. Where applicable, the impacts of these policies will also be described and evaluated. This will allow us to identify effective strategies for different types of transit systems.

1.3.2 Examination of Current Fare Models

In anticipation of new fare policies, most transit agencies make use of fare policy models to predict the new ridership and revenues. A good fare model allows them to analyze various innovative fare strategies. This is especially important with the advent of smart card technology because this new technology permits transit agencies to consider innovative policies that were previously limited by the features of prior fare payment technologies. Also, to implement a new smart card system successfully, it is essential for transit agencies to evaluate how well customers will accept the smart cards. The demand for existing fare media will interact with customer acceptance of the smart cards. Fare models allow transit agencies to analyze the changes in fare media share due to the introduction of a new fare medium.

Current fare models rely heavily on elasticity measures to predict the ridership demand and revenue. However, with respect to smart cards, these models may be insufficient to predict the change in demand accurately because there is either no initial demand from smart card users or no reliable elasticity measures for smart card users since little experience exists with the utilization of this fare medium.

Two fare models will be compared in this thesis, one of which is more sophisticated than the

other and could possibly be a solution to the above problem. The Central Transportation Planning Staff (CTPS) fare model (used by the Boston Metropolitan Planning Organization (MPO) and the Massachusetts Bay Transportation Authority (MBTA)) will be evaluated through a sensitivity analysis to understand the impacts of its assumptions. The Chicago Transit Authority (CTA) fare model will be used to predict the new ridership and compared against the actual ridership in the same period.

1.3.3 Development of Guidelines to Aid Transit Operators

Aggregating the results of the case studies, literature review, existing fare models and CTA customer surveys, a step-by-step framework will be developed. This framework will be based on the different kinds of policies that transit agencies can adopt with smart card technology and translated into six main ideas.

To exemplify how the guidelines will help a transit agency influence the take-up of smart card technology by transit customers, the steps in the guidelines will then be applied to the MBTA in the implementation of their new AFC system.

1.4 Thesis Organization

This thesis has seven chapters including this first introductory chapter.

In Chapter 2, a smart card will be defined. The benefits and drawbacks of the smart card technology are also explained. In addition, examples of transit agencies that currently employ smart card technology are given with emphasis on five transit agencies which will be the focus in Chapters 4 and 5. With the understanding of what a smart card is, Chapter 3 then lays the framework of the thesis by introducing factors that can influence the adoption of smart card technology.

Chapter 4 describes the distribution, operational and usage polices of transit agencies which currently employ smart card technology. Observations on some of these policies will be given and explained.

Chapter 5 discusses the fare policies that are in use presently and others that become feasible only with smart cards. Experiences of transit agencies other than the five transit agencies mentioned in Chapter 2 are also drawn upon where relevant. In this chapter, the implications of the various fare incentives are also assessed. In particular, the Chicago Transit Authority (CTA) and Transport for London (TfL) both recently introduced changes in their fare structures to encourage the take-up of smart cards. The focus of the analysis will be on these two transit agencies. Lastly, the CTA and CTPS fare models will also be examined with respect to their abilities to facilitate the transition from cash to smart cards. They will be described, evaluated and compared to each other.

In Chapter 6, guidelines to aid transit agencies in encouraging the take-up of smart cards are presented. In addition, the guidelines are also applied to the MBTA as an example of how they can help a transit agency transition to smart card technology. Finally, the research conclusions are summarized in Chapter 7. Topics that warrant further research are also identified.

2 UNDERSTANDING SMART CARDS

Developing an understanding of how current fare media compare to smart cards allows transit agencies to differentiate the methods with which smart cards should be marketed. The comparison will also allow transit agencies to identify more clearly the measures that could be taken to extend the benefits of smart card technology while coping with any potential costs of smart cards. In this chapter, the following questions will be answered:

1. What is a smart card? (see Section 2.1)
2. What are the advantages of using a smart card? (see Section 2.2)
3. What are the disadvantages of using a smart card? (see Section 2.3)
4. What are the differences between a smart card and a magnetic stripe card? (see Section 2.4)
5. Where have smart cards been used in transit? (see Section 2.5)

2.1 What is a Smart Card?

In a broad sense, a smart card is any pocket-sized card embedded with an integrated circuit which can be either a memory chip with no programmable capabilities, or a memory chip and a microprocessor chip.

The former has no processors within the card and stores only pre-programmed data. As such, it is used in large quantities as prepaid telephone cards where value is deducted whenever a phone call is made. When the value has been exhausted, the card is no longer useful and is discarded. On the other hand, cards with microprocessor chips can be used to add, delete or change data on the card using the processors. These cards can be reused even if the initial value within it has been used. Clearly, microprocessor cards are much more useful for transit applications.

There are two types of interfaces for smart cards: contact and contactless. Contact cards require insertion into a reader before information can be read. The contactless smart card, as the name suggests, transfers energy and data between the card and the reader without physical contact between them. Hence, the card does not have to be physically inserted into a reader and derives the energy needed to run the microprocessor from the electromagnetic field emitted by the reader.

Contact smart cards have been used in other industries for a long time. As mentioned above, contact smart cards are used in the telecommunications industry in prepaid phone cards, as well as in GSM cellular phones. Contactless smart cards, however, are a more recent development since the early 1990s. In the past decade, contactless smart cards have been used for building access, limited retail payment transactions, identification and of course, transit applications. ABI Research estimates that in 2005, 10 million contactless cards were issued in the U.S. In 2006, more than 40 million contactless payment cards, mini-cards, and fobs are expected to be shipped globally. Michielsen estimates that up to 90% of the current worldwide contactless card market is used for transit applications (qtd. in "Card Technology", 2006). In this thesis hereafter, the term 'smart card' will be used interchangeably with the contactless microprocessor smart card.

2.2 Benefits of Smart Cards

The smart card provides benefits to both customers and transit agencies not available before in existing fare media. Both transit agencies and their customers ultimately adopt smart card technology because they can see the benefits they will reap.

For customers, the benefits of using smart cards include:

- Ease of usage
- Faster boarding times
- No need for exact change
- Enhanced security and durability

For transit agencies, the benefits of using smart cards include:

- Lower dwell times and hence, higher service reliability
- Reduction in cash handling
- Reduction in fare evasion and fraud
- Better performance (than magnetic stripe cards)
- Enhanced capabilities

Benefits for Customers

Being contactless offers numerous benefits to transit operators and their customers. First, it is more convenient for the customers to pay their fares. In a recent CTA Survey conducted in Spring 2005, almost half of the 232 respondents who own a Chicago Card cited convenience as the main reason for using it (see Figure 2-1). When the card needs to be read, it is brought into close proximity with a reader which communicates with the smart cards over a radio frequency. For transit applications, this means that the customer does not have to remove the smart card from a wallet or leather case as the radio waves can penetrate through the wallet to read the smart card.

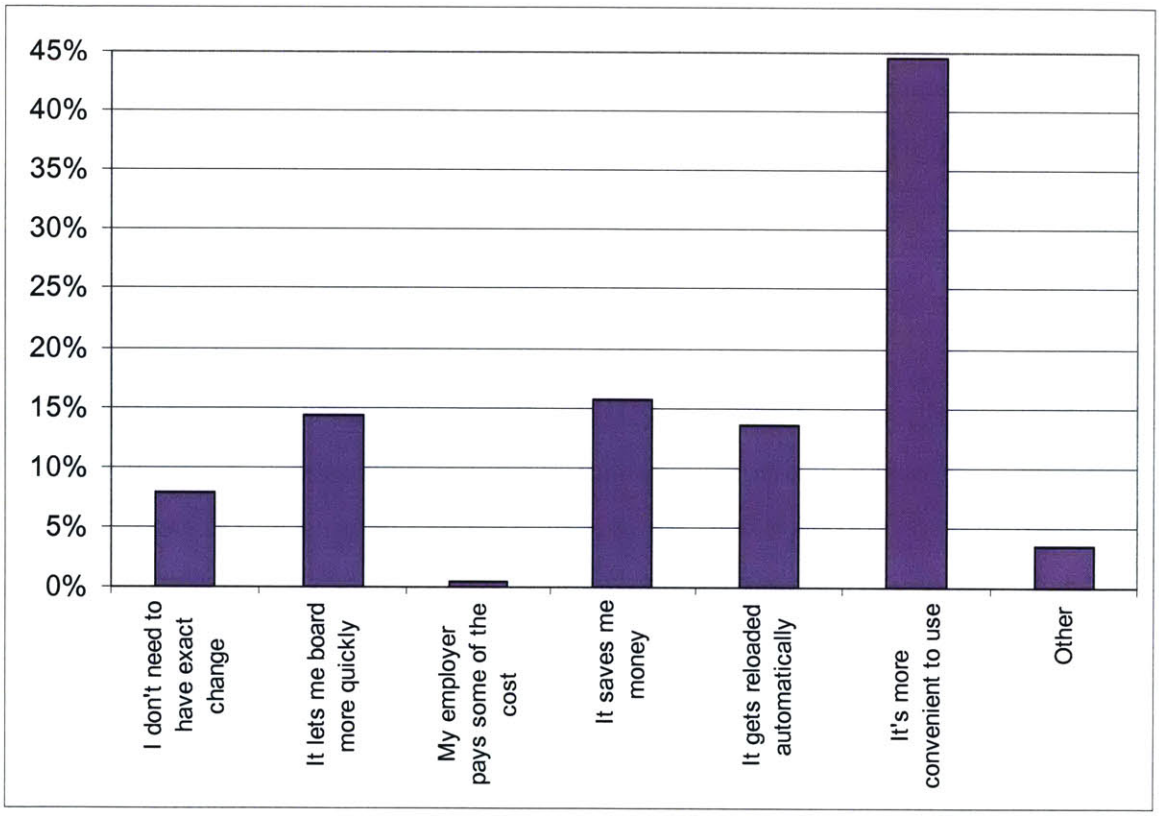

Figure 2-1: Reasons Why CTA Chicago Card Customers Use Chicago Cards *(CTA Spring 2005 Survey)*

Not only is the smart card more convenient for the transit customer, fare transaction times, especially on buses, are reduced, potentially decreasing dwell times. Customers only have to tap or even wave the smart card at the reader, eliminating the need to fumble with coins and tokens on buses. Hence, customers can board faster and do not have to wait for a long time in line.

Using smart cards also means reducing cash handling. Customers do not need to worry about bringing exact change to board a bus. For example, in Boston, the current bus fare is 90 cents. However, some customers do not have the exact change and end up paying with a dollar bill.

In addition, the enhanced security provided by smart cards ensures that customers do not lose everything in the event that the card is lost or stolen. The database stores information about the card and customers can expect to be refunded any value remaining on the card. The durability of the card, usually made from plastic, also reduces card turnover from failure as well as loss.

Benefits for Transit Agencies

Because customers can board more quickly with smart cards, the passenger throughput on buses will increase. This decreases dwell times and allow bus operators to adhere more strictly to bus schedules, potentially decreasing journey times and increasing ridership and productivity for the transit agency.

Just as smart cards remove the necessity of handling cash for customers, transit agencies are also glad to do away with the hassle of cash fare payment. In essence, the more automated the fare collection system, the less the likelihood of fare evasion or leakage because of the fewer times cash is handled. It is easier to identify non-payers who do not enter using smart cards as bus operators can concentrate on detecting fare evaders without having to also collect cash from or distribute paper transfers to boarding customers.

Experience in Singapore has also shown that the performance of the smart card system is superior to the magnetic stripe card system (Sim, Seow and Prakasam, 2003). It was found that while the use of magnetic stripe cards has an average throughput of 40 passengers per minute at fare gates and 35 passengers per minute at bus entry, the average throughput for smart cards was 50 passengers per minute at both fare gates and bus entry. In addition, the failure rate for smart cards was 1 in 200,000 versus 1 in 6000 for magnetic stripe cards.

Combining the durability and data-processing capability of smart cards, passenger behavior can be recorded and be used more effectively for planning. Smart cards communicate with

computing devices through readers, allowing information on customers' trips to be stored in a database. This provides transit agencies with an abundance of trip-making information which they previously had to rely on surveys to obtain. With higher quality and more ubiquitous information, transit agencies can plan and manage their operations more effectively. For example, by understanding the origin-destination matrix for a particular route, transit agencies will be better equipped to evaluate if express service would be a good option.

Likewise, the microprocessor within the smart card allows greater flexibility in fare policies as various fares can now be administered in parallel. This offers transit agencies more fare alternatives to attract customers and hence more revenue opportunities. For instance, daily price capping can potentially encourage customers to travel more and increase the transit agency's revenue. Chapter 5 will examine the various fare policies that smart cards can facilitate and would be of interest to transit agencies.

2.3 Drawbacks of Smart Cards

The cost of smart cards has been a huge deterrent for transit agencies considering smart card systems. The CTA purchases its smart cards at $3 to $5 per card, depending on the bulk lot (personal communication, August 4, 2006). In Singapore, the ez-link cards cost S$5.20 (≈ US$3.30) a piece compared to S$0.40 (≈ US$0.25) a piece for the old magnetic stripe cards (Segaran and Sim, 2004). It is noted that the smart card, however, is only part of the system. According to Poon and Chau (2001), the smart card system "may eventually cost only one-third of the old system due to improved efficiency and lower maintenance costs" as a whole.

Because the technology is relatively new, there is no single smart card standard that is used across all transit agencies. The technology is still developing and transit agencies that have implemented an older form of smart cards find it hard to keep up with the newer capabilities of smart cards. Evolving technology also means that transit agencies are constantly testing products that are not stable or fully established. This can translate into hiccups during the transitional period and result in higher costs or lower performance levels than expected.

Given the tracking capabilities of smart cards, there have also been concerns about data protection and loss of privacy. Smart cards and the associated databases can contain information about the customers and the trips they have made. This might cause customers to feel that their movements are constantly being monitored. In addition, should the smart card be stolen, private customer information might land in the wrong hands.

2.4 Differences between a Smart Card and a Magnetic Stripe Card

Magnetic stripe cards and smart cards are similar in many ways. To analyze how customers will perceive the relative advantage of smart cards over magnetic stripe cards, it is important to focus on their differences (see Table 2-1).

Table 2-1: Differences between Magnetic Stripe Cards and Smart Cards

	Magnetic Stripe Card	Smart Card
Use of Internet	♦ Card can be bought online	♦ Card can be bought and reloaded online ♦ Transactions can be viewed online
Usage Mechanism	♦ Card has to be inserted into slot	♦ Card need not have contact with reader and can be read at a short distance
Memory	♦ Limited memory storage – limited capabilities	♦ High memory storage – more innovative fare policies
Durability/ Security	♦ Flimsy and easily damaged ♦ Information can be lost through demagnetization	♦ Durable (plastic) ♦ Encryption is possible ♦ Value can be retrieved if card is lost

Because smart card information is generally linked to a database, the Internet allows transit agencies to keep track of the transactions of the smart card. Hence, smart cards can be reloaded online either automatically or at the customer's discretion. Recent transactions can also be checked on the Internet.

Besides purchasing and reloading the cards, the methods of usage are also different. Magnetic stripe cards have to be inserted into slots or swiped through a reader before the appropriate fare

can be deducted. If used on a bus to pay for a distance-based fare, the customer would have to first select the amount to be deducted. On the other hand, using a smart card is much easier as the customer only has to tap the card on the reader for the relevant fare to be deducted automatically. If the fare system is distance-based, the customer will tap the card again upon exit for the correct fare to be deducted.

Technologically, magnetic stripe cards have limited capabilities because of their relatively low maximum storage capacity of 140 bytes ("Smart Card Overview"). Therefore, it is not unusual to see individual transit agencies operate their own magnetic stripe card system without incorporating other transit agencies. Smart cards, however, hold up to 8 kilobytes of information and thus can perform a wider range of activities. These can include inter-operator regional trip-making, non-transit payments and innovative fare policies.

Lastly, the magnetic stripe on the magnetic stripe card is exposed to the environment and can be damaged easily. The data stored on the magnetic stripe can also be altered using a standard read/write device (Rankl and Effing 16). The smart card, however, is made of plastic, is more durable and has a longer life. The microprocessor within the smart card allows information to be encrypted, providing additional security. Because of this microprocessor, information can also be communicated with a database that records the balance on the smart card. If lost, this value can be recovered and refunded to the customer, thus providing additional security. A lost magnetic stripe stored value card means that any remaining value on the card is also lost.

2.5 Smart Cards in Public Transportation

Transit agencies in the U.S. have been slower than some leading operators in Europe and Asia to adopt smart card technology. The majority of multimodal transit agencies in the U.S. maintains fare collection systems which collect and process tickets, tokens and/or cash while their European and Asian counterparts have been experimenting with smart card technology for much of the past decade. Table 2-2 shows some of the transit operators both within and outside the U.S. which have implemented, or are in the process of implementing smart card technology. The smart card systems used overseas are more mature systems that tend to have other identification

and "e-money" (i.e. replacing cash by storing monetary value on the card) functions in addition to their basic transit card function. This means that besides using the card to pay for transit fares, the card can also serve as "virtual money" and be used to make other retail purchases. In addition, transit agencies overseas are also more likely to have inter-operator and multimodal smart cards. Thus, there are many lessons which transit agencies in the U.S. can learn from overseas experience.

The following subsections will describe six transit agencies/cities which have implemented or are in the process of implementing smart card systems. They include Hong Kong, Washington Metropolitan Area Transit Authority (WMATA), Singapore, Chicago Transit Authority (CTA), Transport for London (TfL) and Massachusetts Bay Transportation Authority (MBTA).

Of these, Hong Kong and Singapore are considered quite successful in that they have achieved penetration rates of at least 90%. WMATA and CTA are included as examples of how smart card applications are developing in the U.S. whereas TfL is an example of an aggressive European organization. These five transit agencies will be referred to extensively in Chapters 4 and 5 when the different policies to encourage the take-up of smart cards are defined and evaluated. Table 2-3 shows some key attributes of the smart card programs at these five transit agencies. In addition, full descriptions of their smart card programs can also be found in the Appendix. Finally, the MBTA is included as an agency in the process of implementing smart cards. It will be used as a case study to demonstrate how the guidelines can be applied. Together, these six transit agencies/cities will allow comparisons between U.S. and international systems, as well as systems in different stages of implementation. Experiences of other transit agencies will also be discussed where applicable.

2.5.1 Hong Kong's Octopus Card

Since its launch in 1997, the Octopus Card has extended its reach to non-transit uses including access control in offices and housing estates, retail sales in over 160 merchants, and identification and school-related payments on campuses. Octopus is truly a multi-operator, multi-purpose card which has now also been transformed into other forms including cell phone cases

Table 2-2: Transit Agencies in the U.S.A. and Worldwide Using Smart Card Technology (Not Exhaustive)

Year of Implementation	Transportation (Issuing) Authority	City (Country)	Name of Smart Card	
1997	Octopus Cards Limited	Hong Kong (China)	Octopus	*
1997	Tampere City Transport	Tampere (Finland)	Tampere Travel Card	
1999	Washington Metropolitan Area Transit Authority (WMATA)	Washington D.C. (U.S.A.)	SmarTrip	*
2000	Taipei Smart Card Corporation	Taipei (Taiwan)	EasyCard	
2001	Warsaw Transport Authority	Warsaw (Poland)	Warsaw City Card	
2001	East Japan Railway Company (JR East)	Tokyo (Japan)	SUICA	
2002	Ventura County Transportation Commission (VCTC)	Ventura County (U.S.A.)	Go Ventura	
2002	EZ-Link Private Limited	Singapore (Singapore)	ez-link	*
2002	Chicago Transit Authority (CTA)	Chicago (U.S.A.)	Chicago Card (Plus)	*
2003	Transport for London (TfL)	London (U.K.)	Oyster	*
2004	Korea Smart Card Co., Ltd	Seoul (South Korea)	T-Money	
2006	Beijing Municipal Administration & Communications Card Company Limited	Beijing (China)	Beijing Municipal Administration and Communications Card ("Yikatong")	
2006	Transperth	Perth (Australia)	SmartRider	
2006	Metropolitan Atlanta Rapid Transit Authority (MARTA)	Atlanta (Georgia)	Breeze	
2007 (planned)	Massachusetts Bay Transportation Authority (MBTA)	Boston (U.S.A.)	CharlieCard	*
Pilot Trial	Metropolitan Transportation Commission	San Francisco (U.S.A)	Translink	
Pilot Trial	New York City Transit	New York City (U.S.A)	MasterCard® PayPass® (Citi® credit or Citibank® Debit)	

* Used as case study

Table 2-3: Key Characteristics of Case Study Agency Smart Card Programs

Transit Agency	Uses	Available Options	Penetration Rates (Most Recent Data)	Alternative Fare Media
Hong Kong (Octopus)	♦ Transit ♦ Parking ♦ Retail ♦ Identification ♦ Building Access etc.	♦ Pay-Per-Use	♦ MTR: 90%	♦ Rail: Magnetic Stripe Cards ♦ Bus: Cash
WMATA (SmarTrip)	♦ Transit ♦ Parking	♦ Pay-Per-Use	♦ Rail: 60% ♦ Bus: 18%	♦ Rail: Magnetic Stripe Cards ♦ Bus: Cash or Paper Pass
Singapore (ez-link)	♦ Transit ♦ Retail ♦ Identification ♦ Building Access etc.	♦ Pay-Per-Use ♦ Concession Pass	♦ Rail (Heavy and Light): 96% ♦ Bus: 90%	♦ Rail: Single Use Smart Cards ♦ Bus: Cash
CTA (Chicago Card (Plus))	♦ Transit	♦ Pay-Per-Use (CC & CCP) ♦ 30-Day Pass (CCP)	♦ Rail: 27% ♦ Bus: 11%	♦ Rail: Magnetic Stripe Cards ♦ Bus: Cash or Magnetic Stripe Cards
TfL (Oyster)	♦ Transit	♦ Pay-Per-Use ♦ Period and Concession Passes	♦ Rail: 68% ♦ Bus: 50%	♦ Rail: Magnetic Stripe Cards ♦ Bus: Cash or Paper Pass

and watches. Less than five years since its launch, approximately 20% of the Octopus card transactions were already non-transit related (Smart Card Alliance, 2005). By 2005, 13 million cards are in circulation and there are 9.2 million transit and non-transit transactions daily. On the MTR, 90% of the rides are made using Octopus (personal communication, July 3, 2006).

The Octopus card is color-coded to differentiate between full and concessionary fares among children, adults, students and the elderly. There are two types of Octopus cards: sold and on-loan. Sold Octopus cards are special-theme cards which are introduced regularly and promoted as souvenir cards. On-loan Octopus cards are more commonly used and require a refundable deposit when first obtained. When returned to transit agencies, customers can request that their deposits be refunded. These On-Loan Octopus cards can be anonymous or personalized. Personalized Octopus has the user's name and photograph (optional) and can function as the child, adult, student or elderly card.

On the rail system, Hong Kong operates a distance-based fare system and Octopus is used mainly as a stored value card. Magnetic stripe cards are no longer available for stored value tickets but infrequent travelers can still purchase single trip tickets on magnetic stripe cards for rail. On buses, customers can pay the exact fare in cash if they do not pay by Octopus.

2.5.2 WMATA's SmarTrip Card

The SmarTrip Card was first introduced on the Metrorail system in 1999 after a demonstration program in 1995 and was accepted on Metrobuses in 2004. Since June 2004, all Metro-operated parking can be paid for only with the SmarTrip Card. Currently, WMATA is also in the process of introducing a combined SmarTrip and credit card.

The SmarTrip card can be used to pay the distance-based fares on the Metrorail system and flat fares on the Metrobus system. The smart card program has since been expanded so that the card can also be used on other Maryland and Virginia transit systems,

including Baltimore Maryland Transit Administration (MTA) and Maryland Area Rail Commuter (MARC), Ride On (Montgomery County), TheBus (Prince George's County), Loudoun County Transit, Arlington Transit (ART), Virginia Railway Express (VRE), City of Fairfax City University Energy-saver (CUE), Driving Alexandrians Safely Home (DASH) (Alexandria Transit Co.), Potomac and Rappahannock Transportation Commission (PRTC) OmniRide and Fairfax Connector, making it a multi-operator regional smart card.

In FY2005, 700,000 SmarTrip cards were sold, of which 560,000 were sold from SmarTrip vending machines located at the Metro station parking lots. This is a huge growth compared to the total of 500,000 cards sold in the previous 6 years combined (WMATA slides, 2006). The result is an increase in percentage of rides on Metrorail paid for by the SmarTrip card from almost 35% in the 1999 – 2004 period to more than 60% in early 2006. The percentage of rides on Metrobuses paid for by the SmarTrip card has also grown to approximately 18% since late 2004 when SmarTrip was first introduced on the buses (personal communication, June 26, 2006).

SmarTrip cards are available only as stored value cards. In addition to the SmarTrip cards, WMATA also still has magnetic stripe cards which can be used as either pay-per-use or passes.

2.5.3 Singapore's ez-link Card

Singapore's ez-link card was introduced in 2002 and made its complete transition to being the main fare medium after the phase-out of magnetic stripe cards in January 2003. The ez-link card can be used on buses, light rail and heavy rail operated by both SMRT and SBS Transit. Like the Hong Kong system, the Singapore fare system is distance-based for adults. The ez-link card is slowly becoming a multi-purpose card not unlike the Octopus card and can now be used in selected supermarkets, food and beverage outlets and government services. Its spread into school campuses is logical since compulsory student identification cards are incorporated into the ez-link cards. To date, over 8 million

cards have been issued and the average number of transit-related transactions per day is 4 million. The penetration rate of the ez-link cards is as high as 90% on buses and 96% on light/heavy rail (personal communication, July 24, 2006).

Concession passes are available only to full-time National Service (NS) men (compulsory army service for males when they turn 18) and students. Other than that, all ez-link cards operate as stored value cards. With the total phasing out of magnetic stripe cards, customers who do not use ez-link cards have to pay by cash on buses. On the metro and light rail systems, there are single use smart card tickets (called Standard Tickets) that can be bought from vending machines. The Standard Ticket is issued only for a specific destination and requires a S$1 (≈ US$0.63) deposit that is refundable if the card is returned to the General Ticketing Machine (GTM) within 30 days from the date of purchase.

2.5.4 CTA's Chicago Card (Plus)

In November 2002, CTA formally launched the Chicago Card, a stored value smart card, followed in January 2004 by the Chicago Card Plus which allows for a monthly pass in addition to the pay-per-use option that was already available on the Chicago Card. There are significant differences between the Chicago Card and Chicago Card Plus, as seen in Table 2-4. As such, they are marketed differently. The Chicago Card is targeted at customers who either have the inclination to use cash and do not have credit cards or do not have access to the Internet while the Chicago Card Plus is targeted at customers who are Internet-savvy and rely on online banking services. Both cards can be used on the rail and bus systems.

Table 2-4: Differences between Chicago Card and Chicago Card Plus

Feature	Chicago Card	Chicago Card Plus
Online viewing of transactions	Not Available	Available
Auto-reloading	Not Available	Available
Requirements	N.A.	Email address and credit card
Options Available	Pay-Per-Use	Pay-Per-Use and 30-Day Pass
Transit Benefit Program	Not Available	Available

To date, the Chicago Card and Chicago Card Plus are offered only for the adult full fare customers and only the 30-Day Pass and pay-per-use options are available. Customers, however, can still purchase magnetic stripe tickets, called Transit Cards, for reduced fares, weekly and other period passes and pay-per-use. As of May 2006, the penetration rates of Chicago Card (Pay-Per-Use) are 22.2% and 8.4% for rail and bus. For the Chicago Card Plus (30-Day Pass), the percentages are 5.2% and 2.2% for rail and bus (CTA Fare Media Summary).

In this thesis, CTA will be referred to extensively because information about the Chicago Card (Plus) program is readily available. For example, in Spring 2005, CTA conducted a survey which encompasses revealed preference and stated preference components. The revealed preference component observes the usage of CTA buses and trains, the use of its smart card, Chicago Card (Plus), and the mode of fare payment. The stated reference component provides various fare types with different fares and requires the survey taker to select the preferred option. In addition, he/she would indicate any changes in usage of CTA with respect to the selected option. Altogether, 2,400 questionnaires were distributed at stops. There were 3 types of questionnaires distributed (800 each) comprising of 3 different sets of stated preference options. Some 950 booklets were returned, including 232 Chicago Card (Plus) users and 718 non-Chicago Card (Plus) users. The survey identified issues regarding the Chicago Card (Plus) that will affect customers' decisions to take up the smart cards.

2.5.5 TfL's Oyster Card

The London Oyster card was officially launched on June 2003 in the Underground system. Since then, the Oyster is now accepted on buses, some 60 National Rail (NR) stations, the Docklands Light Railway (DLR) and trams. The card offers both passes and the pay-per-use option (also known as Pay-As-You-Go (PAYG)). Both options can be loaded onto the Oyster card concurrently. In terms of passes, only Bus Passes and Travelcards (passes that can be used on the Underground, DLR, selected NR stations, bus and tram) of 7 days or longer periods are available on Oyster.

Freedom Passes are also available only on Oyster. These passes allow residents of London who are aged over 60 or have an eligible disability to travel free during certain times within designated areas. In addition, there are Oyster photocards for children and students to receive free and discounted travel. Adults need photocards to purchase certain weekly, monthly or annual season tickets. With the exception of the 7-Day Bus Pass which is available on both Oyster and printed magnetic stripe tickets, the rest of the weekly, monthly and annual season tickets are available only on Oyster. Printed magnetic stripe tickets are still issued for single trips, One- and 3-Day Travelcards, One- and 7-Day Bus Passes and Travelcards sold by NR.

The current fare media share of Oyster on the Underground is almost 70% while that of the bus is approximately 50% (BMR Oyster Report). As in the case of CTA, there is readily available information about the Oyster program, provided by TfL, which will be used extensively in Chapters 4 and 5.

2.5.6 MBTA's CharlieCard

The CharlieCard is planned for implementation in 2007. Together with the CharlieTicket, this new AFC program is being implemented to replace the current token system and reduce cash payments.

The CharlieTicket is the magnetic stripe card version of the CharlieCard, currently accepted at converted subway stations with new fare gates and vending machines and on the Silver Line – Washington Street vehicles. In May 2005, MBTA first introduced the CharlieTicket on the Blue Line in the subway system when a new fare gate system was installed at the Airport Station. Since then, MBTA has been gradually installing new vending machines that dispense CharlieTicket and new fare gates that accept CharlieTicket and CharlieCard in the subway stations. To date, the CharlieTicket is accepted in 35 subway stations and is available as a stored value ticket, or as a pass. The pay-per-use version is not accepted at unconverted subway stations but the CharlieTicket monthly pass can be swiped at the turnstile or fare box at unconverted stations and buses.

All monthly passes are available only on CharlieTicket.

MBTA has started rolling out the CharlieCard by issuing new smart card Senior Citizen or Transportation Access Pass (T.A.P.) IDs for reduced fare customers from September 2005. This new card has stored value and can be used only at converted stations. On buses and unconverted stations, the card is shown to the MBTA staff and the customer then pays the appropriate fare by cash. To reload the CharlieCard, customers can either make use of the new vending machines at converted stations or the fare boxes on the Silver Line – Washington Street vehicles.

It is expected that the CharlieCard will be available to all customers in 2007. When the CharlieCard is introduced, the CharlieTicket will remain as an alternative. One difference between the CharlieCard and the CharlieTicket is that the CharlieCard will allow both a stored value ticket and a pass to be loaded onto the card concurrently. When the CharlieCard is fully implemented, the MBTA is expected to offer a range of price incentives to speed its acceptance as part of a comprehensive system-wide fare structure modification.

3 ADOPTING SMART CARD TECHNOLOGY

This chapter lays out the framework for a more detailed discussion in later chapters of the distribution, operational, usage and fare strategies designed to encourage the take-up of transit smart cards. It discusses the factors that are important in the adoption of smart card technology (Section 3.1) and explains why the various policies to be discussed in Chapters 4 and 5 are critical from the perspective of the customer (Section 3.2).

3.1 Factors Influencing the Adoption of Smart Card Technology

Lee, Cheng and Depickere (2003) listed nine adoption factors that influence the adoption of a technological innovation. These factors were selected based on adoption models presented by Aubert and Hamel (2001) and Plouffe et al. (2001) to assess the factors that influence individuals' adoption of a smart card. For the purposes of this thesis, the following factors will be used:

- Relative advantage
- Perceived usefulness
- Ease of use
- Result demonstrability
- Quality of support

Relative advantage is defined as the level to which an innovation is superior to the technology that it is replacing (Lee, Cheng and Depickere (2003); Aubert and Hamel (2001)). In the context of transit, smart cards will be more readily accepted if customers see its relative advantage over the previous fare medium being used, typically cash on buses and magnetic stripe cards on rail. The capabilities of smart card technology should be developed such that it is clear to customers that smart card technology is preferable to cash or magnetic stripe card technology. Customers will adopt smart cards more quickly when they realize that smart cards have higher performance levels and a wider range of uses than previous fare media. The differences between a smart card and a magnetic stripe card discussed in Section 2.4 can potentially be developed to become relative

advantages of smart cards over magnetic stripe cards.

Perceived usefulness is the perception of a smart card's utility in an individual's routine (Lee, Cheng and Depickere (2003); Aubert and Hamel (2001)). If the smart card can increase a customer's utility in using transit, the customer will be more likely to take up the smart card. One of the most obvious ways that smart cards improve a customer's transit experience is the convenience that smart cards offer. If the customer sees the usefulness of a smart card, he/she will be more willing to make the switch to smart cards.

The ease of use of smart cards is determined by the perception of the ease with which smart cards can be made usable in daily tasks (Lee, Cheng and Depickere (2003); Aubert and Hamel (2001)). Hence, the smart card system should be user-friendly and not be too complex for customers to comprehend. The infrastructure supporting the smart card system is important in encouraging customers to adopt the technology. Complicated infrastructure systems can overwhelm the customer and hinder the understanding and familiarization with the technology.

The degree to which the unique features and benefits of a smart card are readily discerned by the customer is referred to as the result demonstrability (Lee, Cheng and Depickere (2003)). In Section 2.2, the benefits of smart cards have been illustrated. The transit agency will need to make clear the differences between smart cards and other fare media so that the benefits of smart cards can be easily understood. The superiority of smart card technology can be promoted in the policies adopted by transit agencies. In addition, transit agencies can also provide additional incentives for smart card users to create a clearer difference between smart cards and previous fare media.

Lastly, the quality of support is also important in persuading customers to accept smart cards. It is the perception of accessibility, rapidity and how the support is provided for the smart card system (Aubert and Hamel (2001)). The transit agency should ensure that the support for the smart card system is adequate and easily accessed by customers. Especially during the transitional period, the technology is not stable and will be more

prone to problems. Transit staff should be well-trained to help the customers, so that the transition for customers will be easier and less frustrating.

3.2 Customers and their Use of Smart Cards

In order for transit agencies to select appropriate strategies to encourage customers to switch to smart cards, they need to understand how customers perceive the smart card. Customers will compare the benefits of switching to smart cards with their experience using existing fare media. Different customers will have different needs and it is useful to classify customers by their mode of travel and frequency of travel. There are significant distinctions in the travel habits of customers traveling by different modes and with different frequencies.

Mode of Travel

Customers traveling by bus and rail will have different expectations of smart card technology since the infrastructure supporting the two modes varies. On rail, customers need to go through fare gates before they board the trains; bus customers pay as they board. The transaction times on rail are faster because there are more fare gates per station and customers usually pay by a non-cash fare medium. On buses, customers pay one after another, typically by cash which slows things down even more. The emphasis on the benefits of using smart cards is clearly different in these cases. Rail customers will be used to the utilization of a non-cash fare medium and fare gates whereas bus riders will need to 'learn' to use the smart card. Also, bus riders will potentially be able to see a larger improvement in their transaction times than rail customers will.

The use of the smart card on the transit system also includes the process of obtaining and reloading the card. Rail stations are also usually manned while bus stops are not. Transit agencies need to consider how their infrastructure and support staff will help ease the process of customers purchasing and reloading the smart cards. Decisions on the usefulness of existing infrastructure should be linked to whether customers using different modes will find the infrastructure useful. This will affect the amount of sunk

costs in installing new infrastructure.

Frequency of Travel

The frequency of travel will determine the customer's needs for fare types and fare media. Commuters make trips frequently and tend to use passes. They will expect passes to be available on smart cards if the transit agency wants them to use smart cards. In addition, the superiority of the technology should allow them to reload the pass on the smart card automatically, doing away with the standard practice of obtaining a new card each month. If however they choose to use stored value smart cards, the necessity to frequently add value to the card will be a concern of these customers. They will thus expect smart cards to make this process more convenient than it was with magnetic stripe cards.

On the other hand, infrequent travelers, such as visitors, are more likely to purchase short period passes or single trip tickets. The provision of such fare types is necessary to cater to the infrequent traveler's needs. In addition, they are more likely to question the value of using smart cards as compared to other forms of fare media, especially if there is a charge for the card; the cost of the card will be a concern.

Based on the usage of transit, transit agencies can help discern the potential of smart card technology by introducing different policies for these customers. It must be clear to frequent travelers that they have attractive options because they use the transit system regularly. At the same time, transit agencies also need to provide reasonable alternatives for the infrequent traveler.

3.3 Framework for Chapters 4 and 5

The different adoption factors identified here indicate that there is a range of policies that will affect the willingness of customers to take up smart cards. In Chapter 4, the distribution, operational and usage policies will be discussed in terms of their effectiveness in encouraging customers to use smart cards by making the use of smart cards easy and attractive. In Chapter 5, various fare policies geared towards

distinguishing smart cards from other fare media through modified fare structures and incentives will be reviewed.

4 DISTRIBUTION, OPERATIONAL AND USAGE POLICIES OF TRANSIT AGENCIES

This chapter discusses the distribution, operational and usage policies that are used by transit agencies to encourage the take-up of smart cards which can heavily influence the outcome. Distribution policies, aimed at ensuring the widespread availability of smart cards by allowing easy access to the cards, are discussed in Section 4.1. Operational policies which can facilitate the day-to-day use of smart cards are discussed in Section 4.2. Finally, policies governing the usage of smart cards are discussed in Section 4.3.

4.1 Overview of Distribution Policies

Before customers can use smart cards, they must know about the cards and have access to them. TCRP Report 32 (31) states that "one of the most important factors in determining the success of any stored-value program is the availability of the cards and the ease of reloading and checking remaining value on them." For smart cards, the policy on sales outlets will directly affect the ease with which customers can obtain the cards (Section 4.1.1). Similarly, the number and distribution of card reloading and value enquiry locations will ensure the continuous usage of smart cards and affect the take-up rate (Section 4.1.2).

4.1.1 Sale of Smart Cards

After a customer decides that he/she needs a smart card, the next step would be for him/her to find an easily accessible channel through which to acquire a card.

Experiences of Transit Agencies

Smart cards can be bought through the same channels that are already offering magnetic stripe cards or tickets. Transit agencies that currently employ smart cards tend to prefer manned ticket offices or retail outlets where customers can make purchases in person (see Table 4-1).

Table 4-1: Smart Card Sales Channels

Transit Agency/City	Hong Kong	WMATA	Singapore	CTA	TfL
Manned Ticket Outlets at stations/terminals	11	3	42	×	Over 300
Retail Outlets	Over 6,000	6	×	229	Over 2,200
Vending Machines	×	42	×	×	×
Phone	×	×	×	✓	✓
Online	×	✓	×	✓	✓
Mail	×	×	×	✓	×
Transit Benefit Program	×	✓	×	✓	×

Among the five transit agencies studied, CTA is the only agency that does not sell its Chicago Card at ticket offices in rail stations. However, customers can still visit the CTA Headquarters to purchase a Chicago Card in person. To make it easier for bus riders to acquire smart cards, they can also usually be purchased at participating convenience stores and news agents. In Singapore and Hong Kong, by virtue of the transit network structure, customers can also purchase smart cards from ticket offices located at major bus terminals.

Usually, transit agencies will need to pay these retail outlets a commission fee to sell the tickets. For example in London, the commission to sell Oyster PAYG is 2% and for the various season tickets, the commission rates are between 3% - 5%. For its magnetic stripe cards, CTA's commission rates range from 0.7% for the 30-Day Pass to 2.3% for the 7-Day Pass. However, WMATA is a unique case whereby no commission is paid to the few retail outlets that currently sell SmarTrip cards.

Transit agencies have also moved towards remote sales outlets such as the Internet, phone and mail in order to reach bus riders. When purchased through these channels, customers enjoy the convenience of having the smart card delivered to their doorstep, although they are not able to use the smart cards until they have been delivered – typically several days

after the purchase. CTA allows customers to purchase the Chicago Card by phone and online, as well as by mail.

Few transit agencies, however, sell their smart cards through vending machines. For example, WMATA has limited SmarTrip vending machines at stations where there are parking lots. However, this strategy was carried out more to cater to the customers who were mandated (after a parking lot operator fraud scandal) to pay their parking fees at these Metro station parking lots by SmarTrip cards and was not an explicit strategy to encourage more transit users to use SmarTrip cards. Also, selling smart cards through vending machines means that the cards are not registered at the time of purchase (explained in Section 4.2.3). Transit agencies will have to provide an easy way for these customers to register their cards.

On top of the channels mentioned above, TCRP Report 32 (31) also recommended employer distribution. While the report referred to "any prepaid (or post-paid) fare medium", employers can also make use of smart cards to transfer commuting benefits to employees in place of transit vouchers.

In the U.S., under the Internal Revenue Code Section 132 (f), employers are allowed to set aside up to $105 in pre-tax earnings each month to pay for commuting costs such as public transit, vanpool fares and employee parking, including parking at transit stations. In return for paying the full cost of employees' commuting benefits, employers receive a tax deduction. Smart cards thus offer an efficient and effective way to distribute the transit benefits directly from employers to employees. As a result, employers can be ensured that the benefits are used strictly for employee commuting.

Many transit agencies including New York City Transit (NYCT), Massachusetts Bay Transportation Authority (MBTA) in Boston and the Bay Area Rapid Transit (BART) in San Francisco participate in similar transit commuter benefit programs. Employers are able to purchase transit vouchers for distribution to their employees. However, with smart cards, employers no longer have to physically distribute the vouchers. Instead, employers

are able to transfer specified amounts into the smart cards of the employees simply through the Internet. Both CTA and WMATA have transit commuter benefit programs in conjunction with their smart cards.

Ubiquity of Sales Channels

The accessibility to smart card sales outlets cannot be neglected. In the recent CTA survey, Chicago Card (Plus) users were asked to state where they purchased and reload their Chicago Card (Plus) (see Figure 4-1). Most surveyed customers purchased their Chicago Card (Plus) over the Internet. This survey reflected the preference for the Internet even though the number of sales outlets had increased to over 200 Jewel, Dominick's and Currency Exchanges outlets in February 2005. This is because the survey was carried out immediately after the expansion of sales outlets. Hence, the survey results do not give a true indication of the effectiveness of this means of distribution. As a comparison, there are almost 600 sales outlets for Transit cards, in addition to vending machines at rail stations. Understanding that ubiquity of sales locations is necessary in increasing the take-up of Chicago Card (Plus), CTA is currently looking into expanding the number of retail locations where Chicago Card (Plus) can be purchased to 600 – 700.

While TfL has attained an Oyster share of almost 70% on the Underground,, CTA lags far behind with less than 30% Chicago Card share on its rail system. This may be partially attributable to the difference in number of ticket and retail outlets where the respective smart cards can be bought (Table 4-1: TfL – over 2,500; CTA – 229) and partially attributable to the fare type restrictions on the card (explained in Section 4.3.2). Having said that, WMATA has significantly fewer manned ticket and retail sales outlets than CTA but still attained higher penetration rates than CTA because there are SmarTrip vending machines in rail stations that have parking lots. In Washington D.C., the penetration rate of SmarTrip cards on the Metrorail has grown to more than 60% from mid-2004 to early 2006. It seems likely that the lack of sales outlets within CTA rail stations and bus terminals has had a negative impact on the Chicago Card penetration.

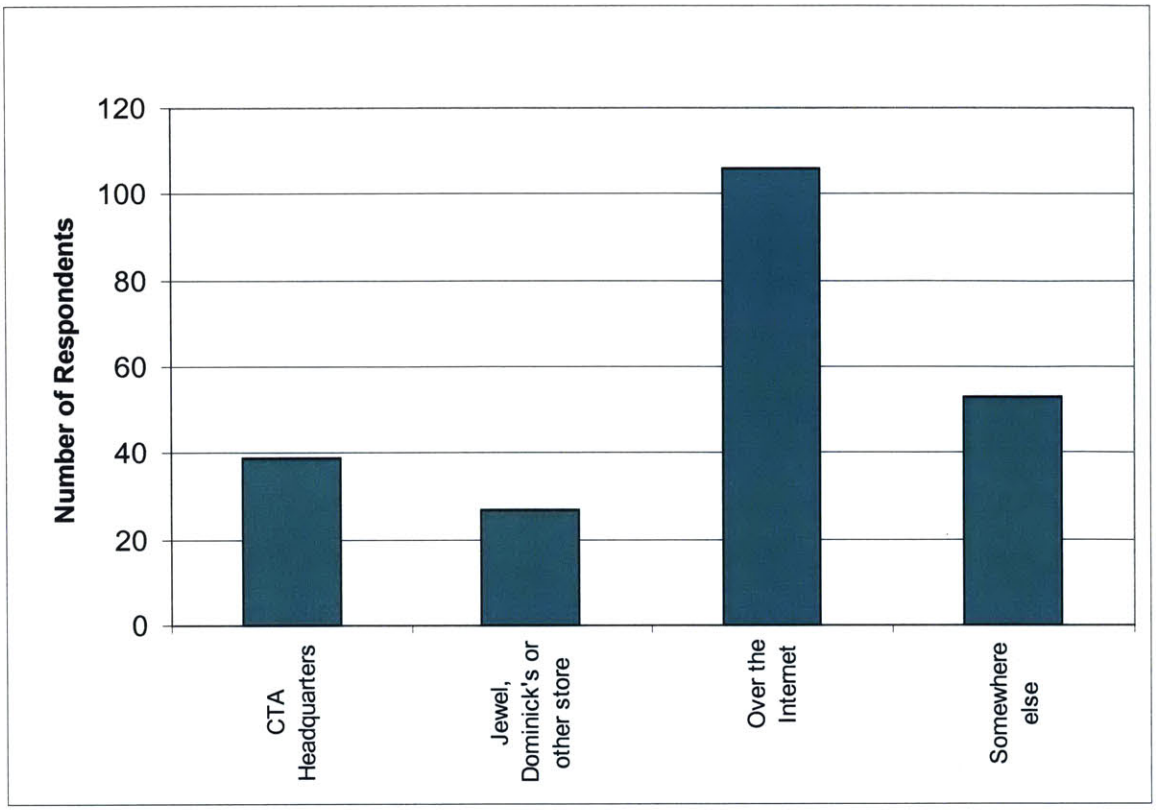

Figure 4-1: Channels through which CTA Chicago Card (Plus) were Purchased *(CTA Spring 2005 Survey)*

Another observation is that Tfl, CTA and WMATA have all ventured into remote sales outlets much more aggressively than Singapore and Hong Kong have (only the variants of and special theme Octopus are sold online). This is most likely due to the culture in the Asian cities where online shopping is not as prevalent as it is in Western countries.

Characteristics of Sales Channels

In a recent internal study ("How much do we spend selling tickets?", 2006), TfL estimated for its various sales outlets the volume of transactions, the cost per transaction, the value per transaction and the percentage cost of transaction with respect to the revenue of the transaction.

This study found that a high volume of bus rider transactions were still conducted on the bus. This confirms the conventional belief that bus customers tend to pay cash more often

as they are less likely to have easy access to ticket sales outlets. Manned ticket offices and self-service vending machines are the most popular means of purchasing tickets for the Underground. The Internet and Call Center carry the smallest share of transactions.

In terms of value per transaction, the TfL study found that customers tend to use the Internet or Call Center to purchase high-value tickets such as monthly or annual season tickets. For example, an annual Travelcard for two zones (Zones 1 and 2) currently costs £888 (≈ US$1,681). Because pass-holders can plan well in advance, the Internet and Call Center are also useful for their purposes. However, the Internet and Call Center receive relatively low volumes of high-value ticket transactions because such tickets are long-period passes and hence require less frequent purchases. Due to these low Internet and Call Center transaction volumes, as well as the high costs of supporting web and phone sales, the Internet and Call Center have high costs per transaction compared with vending machines, on-bus sales and manned ticket offices.

Another possible sales channel is transit commuter benefit programs. The number of employers and employees participating in the Transit Benefit Program in Chicago through the Chicago Card Plus has been increasing over time as shown in Figures 4-2 and 4-3. Indeed, the program is convenient for both employers and employees, and also encourages the take-up of the Chicago Card Plus. However, because the program also supports with the (magnetic stripe) Transit Card, existing employers and employees enrolled in the Transit Card Transit Benefit Program are less likely to switch to the Chicago Card Plus Transit Benefit Program than new employers and employees.

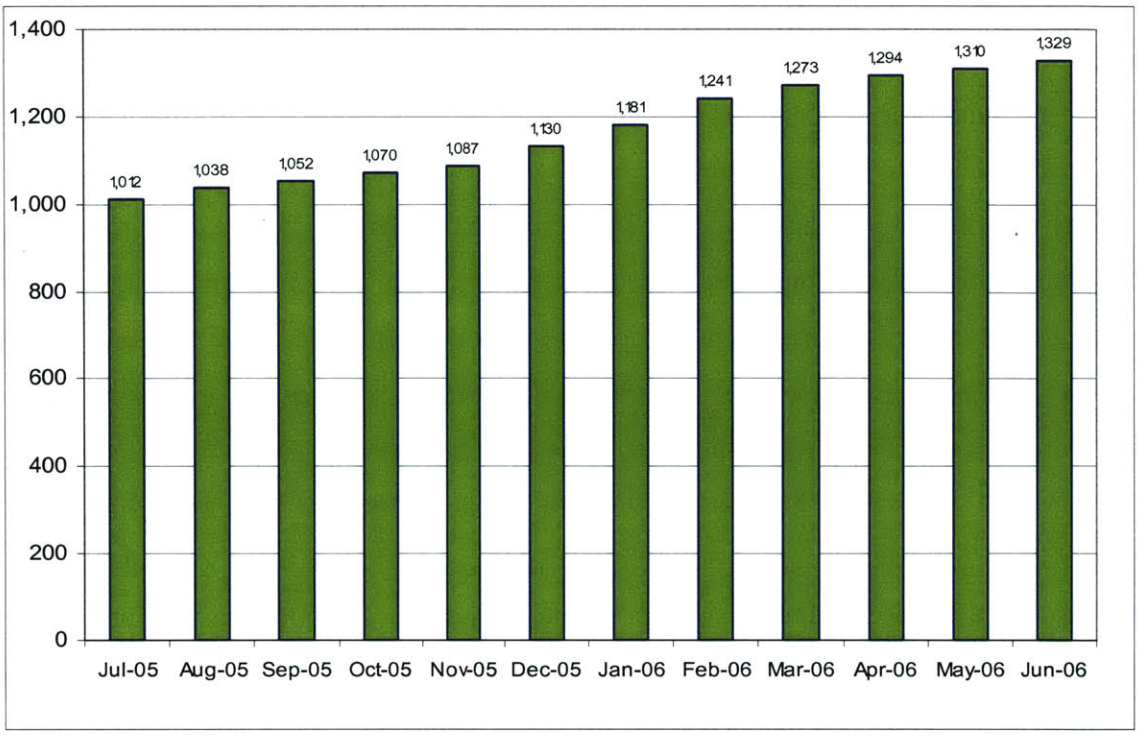

Figure 4-2: 12-Month Summary of Employer Participation in the Chicago Card Plus Transit Benefit Program

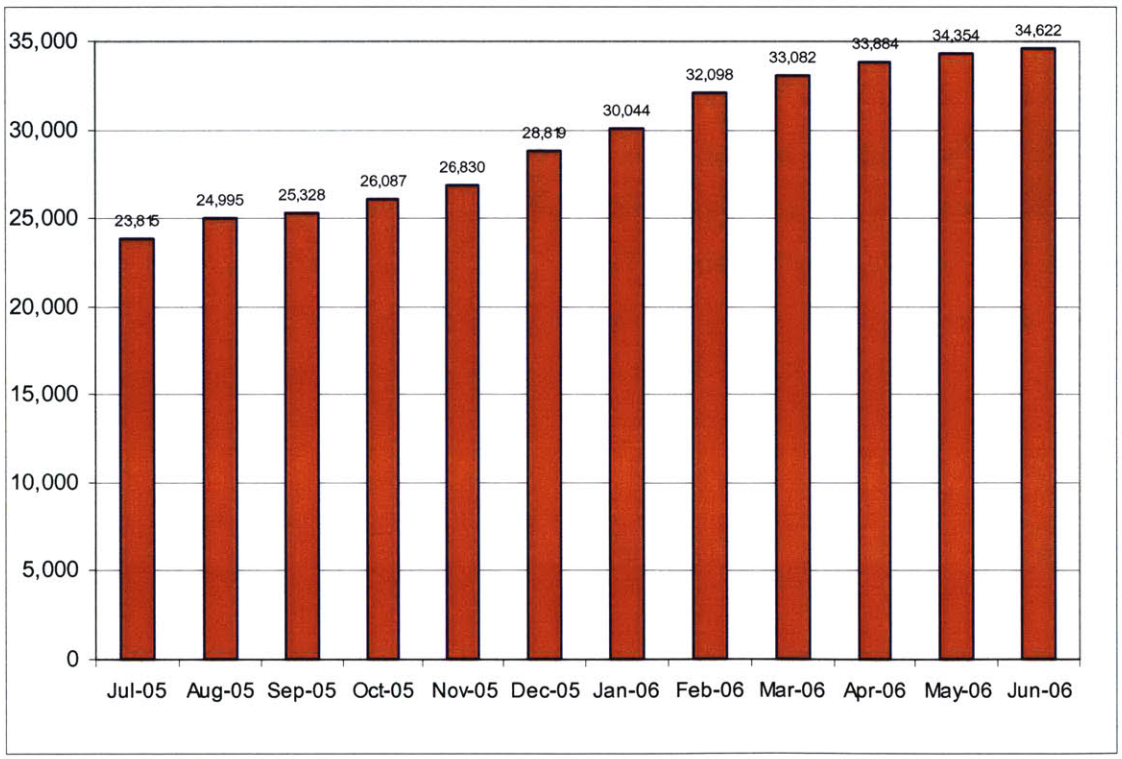

Figure 4-3: 12-Month Summary of Employee Participation in the Chicago Card Plus Transit Benefit Program

4.1.2 Value Reloading and Balance Checking

Once a customer purchases a smart card, value has to be added to the card so that the card can be used continuously. While customers only purchase their cards once, they will constantly need to reload the cards to make their trips. The need to frequently reload the card makes the ease of value reloading very important in encouraging customers to use smart cards.

Value Reloading Channels

Table 4-2 shows the different methods with which a customer who chooses the pay-per-use option can reload a stored value smart card at the case study transit agencies. These customers usually reload their cards through self-service machines, not unlike the vending machines for magnetic stripe cards. Customers can pay by cash, debit/credit cards or Electronic Funds Transfer at the vending machines. Vending machines, however, are also usually located at rail stations and may not be convenient for bus riders. There have been several interesting solutions to this problem.

Table 4-2: Pay-Per-Use Value Reloading Channels

Transit Agency/City	Hong Kong	WMATA	Singapore	CTA	TfL
Manned Ticket Outlets at stations/terminals	✓	×	✓	×	✓
Retail Outlets	✓	×	✓	✓	✓
Auto-Reloading (from a credit or debit card account	✓	×	✓	✓ (Chicago Card Plus)	✓
Vending Machines	✓	✓	✓	✓	✓
Phone	×	×	✓	×	✓
Online	×	×	×	✓	✓
Others	×	✓ (Metrobuses)	×	×	×

On its Metrobuses, WMATA has installed special fare boxes that not only read the fare off the SmarTrip cards, but also allow customers to check the card value and add value to the card on buses. CTA has also introduced their "Touch-n-Go" devices installed at 65 Currency Exchanges and the CTA Headquarters where customers can check the card

balances and reload their cards. These locations have been specifically chosen to be near busy intersections to serve bus riders. The Octopus in Hong Kong can be reloaded by cash at any retail or manned outlet that accepts the Octopus as a form of payment. Similarly, TfL and Singapore also have reloading locations outside rail stations. Typically, these retail outlets also sell smart cards.

Similar to the sales of smart cards, transit agencies will also need to pay commission when making use of these retail outlets to allow customers to reload their smart cards. For the "Touch-n-Go" devices, CTA pays a commission rate of 1.8%. This figure is comparable to the commission rates paid by CTA to sales agents.

In a broader sense, technology now allows customers to reload their smart cards through other means. Automatic reloading is popular with transit agencies employing smart card technology, as seen with TfL, CTA, Singapore and Hong Kong in Table 4-2. Whenever the value in the smart card drops below a certain value – usually zero or slightly above zero, the smart card can be reloaded automatically. Depending on how the customer and the transit agency have set up the transaction with the bank, the amount reloaded could be charged to a credit card or deducted from a debit account. This means that the customers do not have to worry about not having enough money to complete a trip.

Besides auto-reloading, the Internet and the telephone are also options for customers to add value to their smart cards. Customers can use the Internet to either manage their auto-reloading transactions or stipulate an amount to be added to the smart card on a one-time basis. TfL requires the customer to designate an Underground or DLR station to which the stipulated added value is 'sent' so that the customer's Oyster card can 'receive' the added value when the card is read by an Oyster reader. A similar program allows calling in by phone to reload the smart card and have the card read by a reader thereafter to receive the added value. Both TfL and Singapore provide such a service.

Passes can also be reloaded in similar ways, although not all transit agencies necessarily offer passes on smart cards (see Table 4-3). Many transit agencies have manned ticket

offices that allow customers to purchase passes. In Singapore, customers can purchase monthly concession passes using vending machines located at selected rail stations. In London, TfL also allows customers to renew their Travelcards (but not Bus Passes) online or by phone by designating an Underground or DLR station as when adding value to the Oyster PAYG card. Currently, of the five transit agencies studied, only CTA allows 'auto-reloading' for passes – the credit card will be charged $75 for a new 30-day pass on the 27th day of the current 30-day cycle.

Table 4-3: Pass Reloading Channels

Transit Agency/City	Hong Kong	WMATA	Singapore	CTA	TfL
Manned Ticket Outlets at stations/terminals	Passes not available	Passes not available	✓	×	✓
Retail Outlets			×	×	✓
Auto-Reloading (from a credit or debit card account			×	✓ (Chicago Card Plus)	✓
Vending Machines			✓	×	✓
Phone			×	×	✓
Online			×	×	✓

Checking the Value of Smart Cards

Customers also need to be able to check the value on their smart cards to ensure that there are sufficient funds to complete their planned trips, although some transit agencies do allow customers to make a last trip and register a negative balance on the card (see Section 5.1.1)

Whenever value is added to the card, customers know the new balance on the card. Similarly, when they use the card on buses or on rail, the balance is sometimes indicated on the reader or fare gate upon entry and/or exit. In addition, if the smart card can be used for non-transit applications, it is the norm for the balance to be shown on the receipt.

However, there are times when customers would like to check the balance *before* using

the card. For instance, customers using Metro station parking lots operated by WMATA are required to have enough value on their SmarTrip cards before exiting. TfL has installed special card readers at Underground stations and CTA's Touch-N-Go devices also allow customers to check the value on their cards. In Hong Kong, Octopus Enquiry Machines are located at all MTR and KCR stations. Otherwise, most vending machines located in rail stations are equipped with the "Check Value" function.

For smart cards linked to online management systems, customers can also check the value on the Internet. CTA, however, only allows Chicago Card Plus customers to check their balances by phone and online. The rationale is that since Chicago Card Plus is equipped with the auto-reloading feature, there is no need for customers to frequently check the value on their smart cards.

Availability of Reloading Locations and Methods

Before the 60 Touch-N-Go units were introduced in December 2005, customers could reload their Chicago Card in person only at CTA rail stations or the CTA Headquarters. Otherwise, they would have to enroll in the auto-reloading program which is available only to Chicago Card Plus users who link their cards to a credit card. As expected, in the CTA Survey conducted in Spring 2005, the auto-reloading program and vending machines at train stations are clearly the most popular means for reloading cards (see Figure 4-4).

Not surprisingly, all five transit agencies studied offer vending machines at rail stations as an option for customers to reload their smart cards. This is the common practice for reloading magnetic stripe cards and thus, naturally becomes the most direct way of encouraging customers to switch to smart cards by leaving the reloading process unchanged. However, this benefits rail customers more than bus customers.

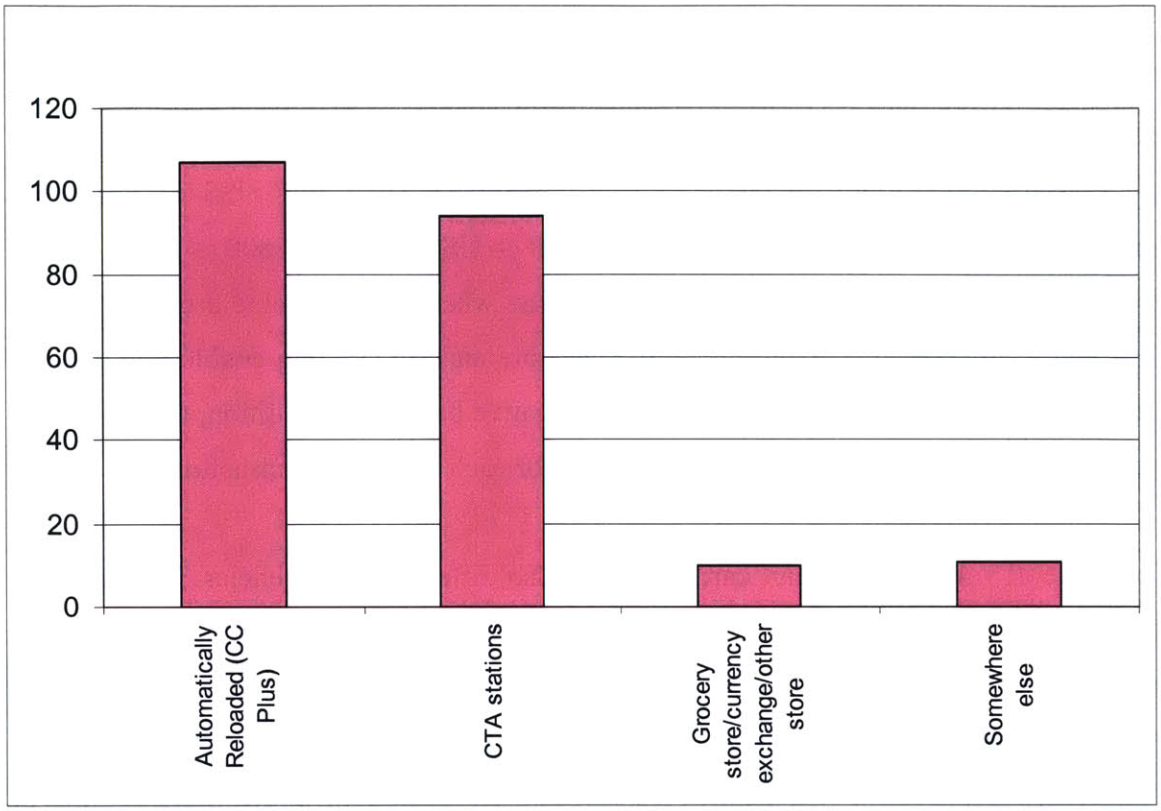

Figure 4-4: CTA Chicago Card (Plus) Reloading Channels ***(CTA Spring 2005 Survey)***

Auto-reloading should solve this problem for bus riders. Yet CTA provides the auto-reloading service only for its Chicago Card Plus, and not Chicago Card, customers. Also, because the auto-reloading feature is tied to a credit card, customers without credit cards cannot take advantage of this option. In Singapore, customers have the option of using either a debit or credit card account to pay for reloading. This will allow customers who do not have credit cards to take advantage of auto-reloading.

On the other hand, WMATA does not offer this service at all. Instead, bus riders can reload their SmarTrip cards on buses using the special fare box described earlier. While these fare boxes are innovative and specific to bus-riders, customers would still have to spend time reloading their cards on the buses if they realized only onboard that there is insufficient value. However, WMATA feels that after the initial learning period, customers will be able to add value using these fare boxes no slower than to insert coins and bills (personal communication, July 31, 2006).

Characteristics of Reloading Practices

Under the auto-reloading scheme, the range of values that can be added to the smart card tend to be similar across these agencies. CTA allows reloading of $10, $20, $30, $40 or $60; Oyster cards can be reloaded at either £20 (≈ US$38) or £40 (≈ US$76); customers using Octopus cards can reload at either HK$250 (≈ US$32) or HK$500 (≈ US$64). It is interesting to note that while auto-reloading occurs when the card value drops to $10 for CTA and £5 for TfL, the Asian cities of Singapore and Hong Kong enable reloading of the smart card value when it drops to zero or negative balance. In addition, the Singapore system charges a small fee (S$0.25 ≈ US$0.16) for each reloading transaction.

The range of value that a smart card can store also differs across agencies. For example, ez-link cards allow only a maximum of S$100 (≈ US$64) whereas the Octopus allows up to HK$1000 (≈ US$129) if the card is topped up using cash or Electronic Funds Transfer. In contrast, WMATA and CTA both allow up to $300 to be stored on the card. An interesting observation is that while WMATA and CTA allow for much higher values to be stored, the smart cards can only be used for transit (or parking) purposes. On the other hand, while having a lower stored-value capacity, both the ez-link and Octopus cards can be used for non-transit purposes on top of paying for transportation. This is important because if smart cards that can be used for non-transit purposes have high stored value limits, this could possibly encourage criminals to steal them. To solve this problem, Singapore has stopped allowing ez-link cards that have auto-reloading capabilities to be used for non-transit purposes.

Interaction of Sales and Reloading Channels

While the CTA survey indicates that customers prefer to add value at CTA rail stations, the option to purchase Chicago Card (Plus) at the same locations is not available. This means that customers need to find an alternative location to purchase their cards before being able to add value at more convenient locations. Since the magnetic stripe Transit Cards could be bought easily from vending machines and paying by Transit Cards is no different than paying by Chicago Card (Plus) in terms of fares (at the time of the survey), customers are more likely to use Transit Cards strictly from a convenience standpoint.

Interaction of Checking of Balance and Auto-Reloading

Auto-reloading is a useful way to replace the need to repeatedly check the balance on the smart card. In WMATA's case, customers who park their vehicles at Metro station parking lots have to ensure that their SmarTrip cards have sufficient values before exiting to avoid a vehicle disrupting the flow of exit vehicles. Using a SmarTrip card with the auto-reloading feature would end this problem. Unfortunately, WMATA does not currently offer auto-reloading on SmarTrip cards, although it plans to implement it within the next two years as part of their system upgrading.

Although auto-reloading reduces the need for customers to check the value on their smart cards, there is no reason to eliminate other means of checking the balance at rail stations or bus terminals. TfL does not differentiate its customers and allows all Pay-As-You-Go customers to check the balance at readers installed at Underground stations.

4.2 Overview of Operational Policies

Operational policies dictate how smart cards are used on a day-to-day basis. The use of smart cards can occur at different stages. Initially, customers can either be gently encouraged to use the new media or forced to obtain a smart card to continue paying the same fare (Section 4.2.1). When the use of smart cards becomes more ubiquitous, transit agencies need to focus on how the infrastructure can improve the customer's daily transit experience (Section 4.2.2). At the end of the customer's experience with the smart card, be it due to a loss or expiry of the card, customers will also expect their inconvenience to be minimized (Section 4.2.3).

4.2.1 Switching to Smart Cards

Depending on the goals of the transit agency, there are different approaches to the transition to smart card technology.

Transitional Strategies of Transit Agencies

Some transit agencies opt for a complete switchover; while others allow the concurrent

use of magnetic stripe cards and smart cards (see Table 4-4). There are also transit agencies that stagger their introduction of smart cards by introducing the technology first on the rail system and then on buses. Singapore, Hong Kong and London, having customers used to magnetic stripe card technology for many years, chose to switch to smart card technology for many of their commonly used fare types. In Singapore, all fare types including the single trip ticket on the rail system is available as a smart card. Hong Kong accepts magnetic stripe single trip tickets while in London, depending on the fare type, some tickets are available only on Oyster whereas other fare types are available on both magnetic stripe cards and smart cards.

Table 4-4: Transitional Patterns of Transit Agencies

Transit Agency/City	Hong Kong	WMATA	Singapore	CTA	TfL
Complete Switchover (CS) or Concurrent Use (CU)?	CS	CU	CS	CU	CS/CU
Staggered Rail and Bus Transition?	N	Y	N	N	Y
Single Trip Ticket/Alternative Fare Medium	Magnetic Stripe Card	Magnetic Stripe Card	Limited Use Smart Card	Magnetic Stripe Card	Magnetic Stripe Card

Time Frame for Transition

Another issue with the transition to smart card technology is the time frame for the transition. Poon and Chau (2001) argued that Hong Kong's Octopus was successful because of the "short overlap time during cut-over from a contact-based system to a contactless system." Singapore had a similar short period of approximately eight months. In its rollout plan, Transperth, the transit agency in Perth, Australia, is planning a two-month period of smart card/magnetic stripe card parallel use to allow customers to finish any remaining value on the magnetic stripe cards before converting completely to smart cards known as the SmartRider. However, there is no complete agreement on the best approach. Initially, TfL's Prestige contract specified a dramatic launch for the Oyster cards but, based on advice from Hong Kong and Singapore, TfL finally decided to gradually increase the available features (TfL Report, 2005). The idea was to test each new smart card feature thoroughly, and if possible, conduct trials before launching it.

Arrangements for Exchanging Existing Fare Media to Smart Cards

During this transition period, transit agencies need to have a plan for customers who were previously using magnetic stripe cards. If a complete switchover is planned, transit agencies should ensure that customers have ample time in the switch to smart cards to recover their remaining value on the magnetic stripe cards. During the switchover from magnetic stripe cards to ez-link cards in Singapore, magnetic stripe cards were no longer revalued only seven months after the formal introduction in November 2002, although any remaining value could still be refunded until four years from the date of issue or last revaluation as long as the card was issued or last revalued after August 1, 2000. Transperth plans to allow customers to transfer any remaining balance on the magnetic stripe card to the SmartRider card during the two-month transitional period after the SmartRider card is fully introduced.

Similarly, transit agencies can also encourage customers to switch to smart cards by ensuring that they do not lose any value on their magnetic stripe cards. In a move to attract more customers to convert to SmarTrip cards, WMATA recently announced the elimination of a maximum $7 trade-in value for magnetic stripe card. Previously, the magnetic stripe cards had to be unused or have less than $7 remaining before the value could be transferred.

Issues of Switching to Smart Cards

Hong Kong, Singapore and London all chose to convert from magnetic stripe card technology to smart card technology for their major fare types. Perhaps as a result, these three transit agencies have also attained higher penetration rates than their counterparts in the U.S. Clearly, a complete switchover is advantageous to obtaining high penetration rates. Arguably, the short transitional period from magnetic stripe card technology to smart card technology has also bolstered the take-up of smart cards. Even though London has been introducing features gradually, since its formal introduction of Oyster in June 2003 till the present, the Oyster program has gone through more changes than the CTA's Chicago Card has since its formal introduction in November 2002.

Hence, it is of paramount importance to decide from the beginning if a complete switchover is desired. If a complete switchover is desired, a relatively short transition period where adequate support is given to customers to change from the old fare medium to the smart card is the key to attaining high penetration rates. At the same time, the need for less frequently used tickets such as the single trip tickets must still be satisfied, be it through magnetic stripe card technology or smart card technology. On buses, customers can continue to pay cash, if necessary. However, on rail, there will still be a need to purchase tickets to enter the fare gate. The transit agency can choose to use a limited use smart card which is cheaper than the smart card used for stored value or passes or magnetic stripe tickets. The decision depends on the relative cost of installing new vending machines that dispense limited use smart cards versus retrofitting existing fare gates to allow smart card and magnetic stripe card entry.

However, it is also important that if the transit agency decides to keep the magnetic stripe cards as an option, the eligible fare types should be limited. In Hong Kong, only the single journey tickets and 1-Day Tourist Pass are available on magnetic stripe cards. If concurrent use of magnetic stripe card and smart card technology is desired, transit agencies must then make a clear distinction between the use of magnetic stripe cards and smart cards in terms of other policies.

4.2.2 Infrastructure and Daily Operations

While readers and other smart card equipment are necessary, decisions on this infrastructure can also play a part in encouraging the take up of smart cards. It is essential that the smart card infrastructure can adequately support smart card customers. However, it would be even better for customers if they get to enjoy exclusive benefits because they own smart cards.

Go Lane Pilot Program in Chicago

In Chicago, CTA introduced a pilot program called Go Lane in June 2005 whereby rail stations dedicate one turnstile for customers paying with Chicago Card (Plus). Similarly,

on buses, the left-side of the bus entrance is kept exclusive for Chicago Card (Plus) users whereas all other customers use the right-side of the bus entrance. Hence, customers using the smart cards can expect to enter the buses more quickly than those who do not use these cards. WMATA is also planning to install similar SmarTrip-only express lanes at 3 Metrorail stations in Fall 2006.

CTA has evaluated the program and decided to expand it. Existing low-floor buses were all retrofitted such that special signage will direct customers to the left-side of the entrance where the Chicago Card (Plus) reader is installed. In future, this will be a standard feature on all new buses. All turnstiles in rail stations are also currently equipped with Chicago Card (Plus) readers. The dedicated Go-Lane turnstiles will still be included at high volume rail stations where space allows.

Use of Smart Cards on Articulated Buses

Another operational issue is the use of smart cards on articulated buses. Because of its length and number of doors, the bus operator is unable to ensure that all customers enter only by the front door. In Europe, it is common for passengers to enter through any door under the proof-of-payment (POP) system. Hence, even when transitioning to smart card technology, customers will expect to board the same way. Readers at the middle and rear doors should thus allow customers to tap in and tap out if necessary. CTA intends to experiment with multiple readers, such as at the rear door, as a long-term goal for their smart card project. This may be possible when the existing fare boxes are replaced, thus expanding the Go Lane project.

Auto Mode Feature in Singapore

When Singapore first introduced the ez-link cards on buses, customers had to both tap in and tap out because Singapore's adult fares are distance-based. Customers were supposed to alight only from the rear door and if the customer had to alight from the front door for any reason, the bus driver had to switch the mode of the front door reader from 'entry' to 'exit'. After the "Auto Mode" feature was introduced in February 2003, customers no longer need to inform the bus driver. Front door readers are set in both 'entry' and 'exit'

mode with the reader detecting whether the customer is alighting or boarding, selecting the appropriate smart card mode and adjusting the fare deducted from the card. Previously, failure to inform the bus driver to switch mode would result in the maximum fare being deducted from the ez-link card. In addition, since the front door card reader was programmed to be on 'entry' mode, it would mean that the customer would be charged for another new trip for nothing. Having such an Auto Mode feature is essential in introducing smart cards on distance-based bus fare systems.

First Class Rail Readers on Trains in Hong Kong

In August 2004, KCR installed separate first-class Octopus readers on its East Rail trains. The readers are installed next to the gangway doors leading to all first-class compartments, thus allowing customers to ride in the first-class compartments even if they had previously entered a standard-class compartment. Doors between the standard and first-class compartments are secured so that only customers who pay for first class travel can enter.

For transit agencies with distance-based fares, it is necessary to constantly monitor the outcomes and rectify any problems which may arise. When implementing smart card technology, transit agencies need to keep note of existing customer habits, such as alighting from the front door when buses become too crowded to move to the rear door, and design the smart card system around these protocols. In the same way, KCR in Hong Kong also made changes after monitoring their customers.

4.2.3 Registration of Smart Cards and Card Replacement Policy

As mentioned in Section 2.2, one advantage that smart cards have over magnetic stripe cards is that customers who register their cards can recover the balance on the smart card even if the card is lost or stolen. Magnetic stripe cards do not offer this benefit; once lost, the value on the card is gone.

Registration of Smart Cards

With smart card technology, it is possible to 'deactivate' the smart card if it is reported lost or stolen. Depending on how long the transit agency takes to blacklist a lost or stolen card, the customer (or the agency) would only have to bear the loss of card value up to the time the entire transit network can be notified of the blacklisted card.

Since smart cards with auto-reloading require some form of registration, they are usually protected against fraud. Table 4-5 shows the card registration practices of the case study transit agencies. For instance, CTA's Chicago Card Plus has the auto-reload feature and is automatically registered. On the other hand, customers using a Chicago Card are not required to register it. In the U.S., some transit customers are concerned about privacy and are cautious about registering their cards. Hence, transit agencies generally keep registration voluntary for pay-per-use smart cards unless the cards come with the auto-reload feature.

Table 4-5: Card Registration Practices of Transit Agencies

Transit Agency/City	Hong Kong	WMATA	Singapore	CTA	TfL
Is Registration Available?	✓ (for pay-per-use with Auto-Reloading and personalized cards)	✓	✓ (for pay-per-use with Auto-Reloading, concession passes and personalized cards)	✓	✓
Is Registration Compulsory?	✓	×	✓	Y – Chicago Card Plus; × – Chicago Card	Y (for certain types of tickets)

However, transit agencies that offer smart cards with passes tend to require registration in order to protect their higher values. As mentioned above, the Chicago Card Plus which is the only way a customer can purchase a 30-Day Pass is automatically registered. Concession passes double as IDs for students in Singapore and so the transit agency knows who the card belongs to. In London, TfL makes registration compulsory for

holders of monthly or annual season tickets. To make registration more widespread, Oyster cards bought online or by phone are also automatically registered.

Card Replacement Policy

With card registration, it is possible for transit agencies to make refunds to customers when a smart card is returned or needs to be replaced. There are several occasions in which a customer will need a replacement smart card:

- The smart card is stolen or lost.
- The smart card is faulty or damaged.
- The smart card has expired.

Most transit agencies charge a replacement handling fee when processing lost or stolen cards. Cards can be replaced immediately when customers visit replacement offices or customers have the option to request a replacement by phone, mail or online but have to wait for delivery of the replacement card.

Transit agencies generally have similar damaged card policies. CTA treats damaged cards the same as lost and stolen cards and still charges the $5 replacement handling fee. TfL's website has instructions on how to replace a damaged card, but does not indicate whether there is a replacement charge. One of the more specific damaged card policies is seen on the Transperth website. The website states that if the smart card is found to be "faulty and determined that the fault is not as a result of misuse", the customer is entitled to a free replacement card. However, if the card was found to be damaged intentionally, normal replacement handling fees apply. But clearly, it may not be easy for the transit agency to determine whether the card is damaged as a result of misuse.

As mentioned in Chapter 1, card replacement is a consideration transit agencies should be aware of. Dreifus and Monk (1998) suggest that returned cards be tracked over time to ensure that the damaged card show patterns of defects previously before being returned. With smart card technology, transit agencies should be able to retrace the smart card's usage – this is not possible with a magnetic stripe card.

Although transit agencies generally inform customers of procedures for replacements of stolen, lost or damaged cards, none of the five transit agencies studied make provisions for card replacement when a smart card reaches the end of its lifecycle. Some transit agencies, however, do explain that the card will stop working if not used for an extended period of time. If an Oyster PAYG card is not used for 2 years, it will become inactive and needs to be reactivated through the Oyster Helpline before it can be used again or have the balance refunded (if the card is registered). Similarly, if an Octopus card is not used for a long period of time, the company will deactivate the card and reactivation will require the customer to pay a reactivation fee.

Issues of Registration and Card Replacement

The fact that all five transit agencies provide some form of registration and hence can refund lost card value suggests strongly that registration is important in the implementation of a smart card system. Interestingly, both Hong Kong and Singapore do not offer registration for 'normal' pay-per-use cards. However, since both cities have converted (almost) completely to smart cards, the result of this operation is effectively the same as the magnetic stripe card: lost cards do not render refunds. In contrast, TfL, WMATA and CTA allow customers to decide if they want to register their pay-per-use cards. In the cases of WMATA and CTA, this can be viewed as an incentive for customers to use smart cards instead of magnetic stripe cards since both types of cards are still in use concurrently for pay-per-use.

If customers are expected to use smart card technology beyond a smart card's lifecycle, it is advisable that transit agencies explain card renewal procedures so that customers can obtain any refundable amounts on their expired cards. This is necessary as customers should not expect to be penalized for using the card to the end of its lifecycle. Customers who had to purchase the card will question the need to purchase a new card. On the other hand, an 'on-loan' system such as Hong Kong's could be the solution to this problem. Since the smart cards are technically only 'on-loan' to customers, customers can transfer their old deposit from the expired card to the new card and continue using a new 'on-loan' card.

4.3 Overview of Usage Policies

The usage practices of a smart card depend on the transit agency and its environment. Some transit agencies allow multiple uses of a smart card to pay for different people or different fare types (Section 4.3.1). They may also decide to limit the fare types available on smart cards (Section 4.3.2). Looking beyond individual transit agencies, smart cards can also link transit agencies to other sectors (Section 4.3.3).

4.3.1 Multiple Use of a Smart Card

Multiple use of a smart card can be either passback or multi-fare.

Passback

Passback refers to a single smart card being used to pay for more than one person on a pay-per-use basis. With magnetic stripe card technology, customers of transit agencies such as CTA have been able to use a single card to pay for several people under pay-per-use and so, the Chicago Card also allows up to 7 customers to board using the same card. However, TfL, WMATA, Singapore and Hong Kong do not allow passback because their rail fare systems are distance- or zone-based. The distance- or zone-based fare systems necessitate customers tapping in and tapping out for the correct fare to be deducted and hence passback will not work.

Multi-Fare Type

Multi-fare type refers to a single smart card holding more than one type of fare ticket which can be used on different occasions. Although TfL does not permit multiple customers to use a single Oyster card, it does allow each Oyster card to concurrently carry up to three Travelcards and/or Bus Passes, as well as the Pay-As-You-Go option. An advantage of this is that customers can choose different ticketing options at different times. For instance, a customer who usually travels within 2 zones can purchase a Two-Zone Pass for his/her daily commute but still use the Pay-As-You-Go option when traveling outside these two specific zones. Another advantage of carrying more than one pass at a time is it allows purchasing passes in advance. When the current pass expires,

the pass for the following period will commence automatically.

This scheme can become even more useful if combined with passback. In Chicago, Chicago Card Plus users who use the 30-Day Pass option can also allow up to 7 customers to ride on the same card. In this case, the first customer is not charged a fare but the subsequent riders will be charged on a pay-per-use basis.

For transit agencies with zonal fares, allowing for multiple fare types to be carried on a single card will be beneficial to the customer who can choose to make use of the different tickets to ride transit at the lowest cost. In the U.S. context, customers who take the commuter rail are likely to benefit since they will be able to purchase different commuter and subway or bus tickets on a single card.

In addition, the ability to carry more than one pass on the smart card could complement the auto-reloading feature usually implemented only with pay-per-use. Customers will not have to worry about forgetting to purchase a new pass for the following period if they are allowed to have more than one pass on a smart card at any time.

4.3.2 Fare Type/Fare Media Restrictions on Smart Card

Transit agencies which offer both smart card and magnetic stripe card technology do not have to offer all fare types on both fare media.

Experiences of Transit Agencies

At the extreme, there are transit agencies such as TfL and Hong Kong which allow only limited fare types to be available on magnetic stripe cards, for example, single trip tickets. However, transit agencies should consider the existing share of the fare type when deciding which fare types should be available only on smart cards.

Generally, Hong Kong and Singapore do not offer adult passes since their fare systems are distance-based but in London, Chicago and Washington D.C., many commuters use

passes for their work trips. TfL has taken the step of making major passes available only on Oyster. Specifically in October 2003, four months after the formal introduction of Oyster, monthly and annual Travelcards were no longer available on printed tickets. In September 2005, weekly Travelcards were also removed as a printed ticket option and are now available only on Oyster.

CTA and WMATA, however, do not offer a wide range of pass options on their smart cards. CTA limits its 30-Day Passes only to Chicago Card Plus users while WMATA's SmarTrip card works only on a pay-per-use basis. At present, for all fare types, WMATA and CTA still allow magnetic stripe card technology. While CTA is seriously considering moving towards a restricted contactless fare payment system, WMATA seems content to keep its magnetic stripe cards as an alternative for customers.

The lack of availability of passes on smart cards has had a strong impact on smart card penetration. In the CTA Survey, when asked for the reason for not using Chicago Card (Plus), approximately 12% of the non-Chicago Card users reported that they use reduced fare tickets, U-Pass (for college students) and weekly passes, none of which are available on Chicago Card (Plus).

Figure 4-5 shows that both the number of bus rides made using 30-Day Passes and the percentage of 30-Day Pass trips made using the Chicago Card Plus have increased over time, although Chicago Card Plus trips are still only a distinct minority. Figure 4-6 shows a similar pattern for 30-Day Pass CTA rail usage. In fact, use of Chicago Card Plus looks set to overtake the use of magnetic 30-Day Passes. The journeys made with magnetic stripe cards have stabilized at around 800,000 rides per month, indicating that new users are much more likely to use the Chicago Card Plus. All these indicate that customers have a strong interest in Chicago Cards which allow for passes.

In September 2005 in London, 7-Day Travelcards were made available only on Oyster, with the refundable deposit of £3 waived. While customers using the monthly and annual Travelcards had already been limited to Oyster since October 2003, it was more than 2

years after the introduction of Oyster that the 7-Day Travelcards were discontinued on printed magnetic stripe tickets. As clearly shown in Figure 4-7, the restriction of 7-Day Travelcards to Oyster has stimulated a sharp increase in the use of 7-Day Travelcards. Among all Travelcards, the percentage of 7-Day Travelcard usage increased from slightly over 20% in July 2005 to 50% in April 2006. It appears that during the change, the Monthly Travelcard also experienced a slight increase in usage, possibly from previous 7-Day Travelcard users switching to Monthly Travelcards. Since the initial increase, the use of the 7-Day, Monthly and Annual Travelcards has stabilized. Comparing CTA and TfL, it is clear that mandating passes on smart cards is a quick and easy way to create a large customer smart card base.

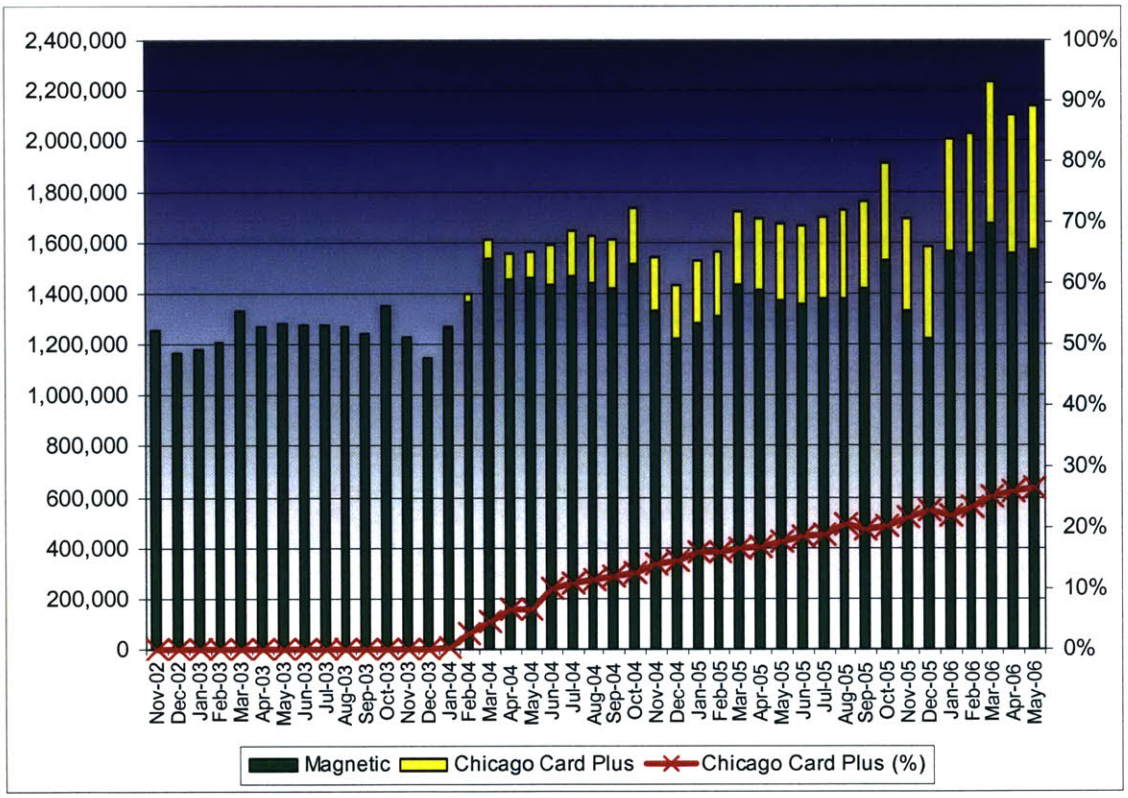

Figure 4-5: CTA Monthly 30-Day Pass Usage on Bus

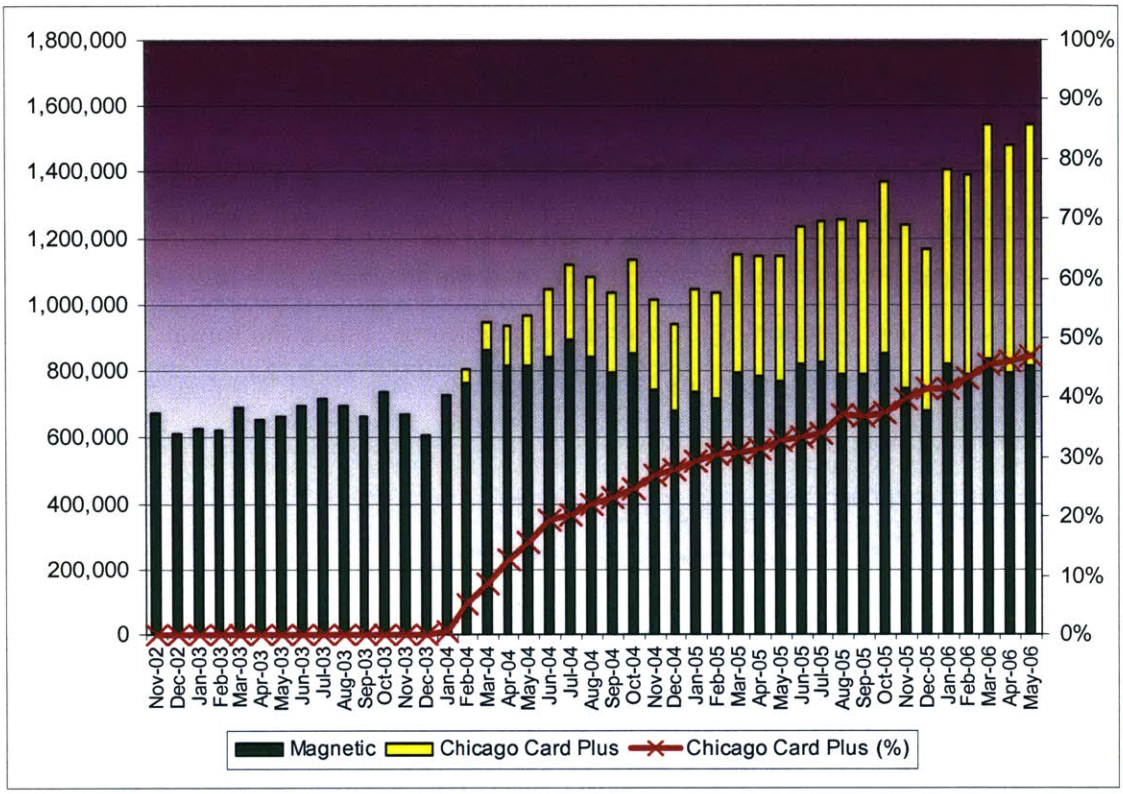

Figure 4-6: CTA Monthly 30-Day Pass Usage on Rail

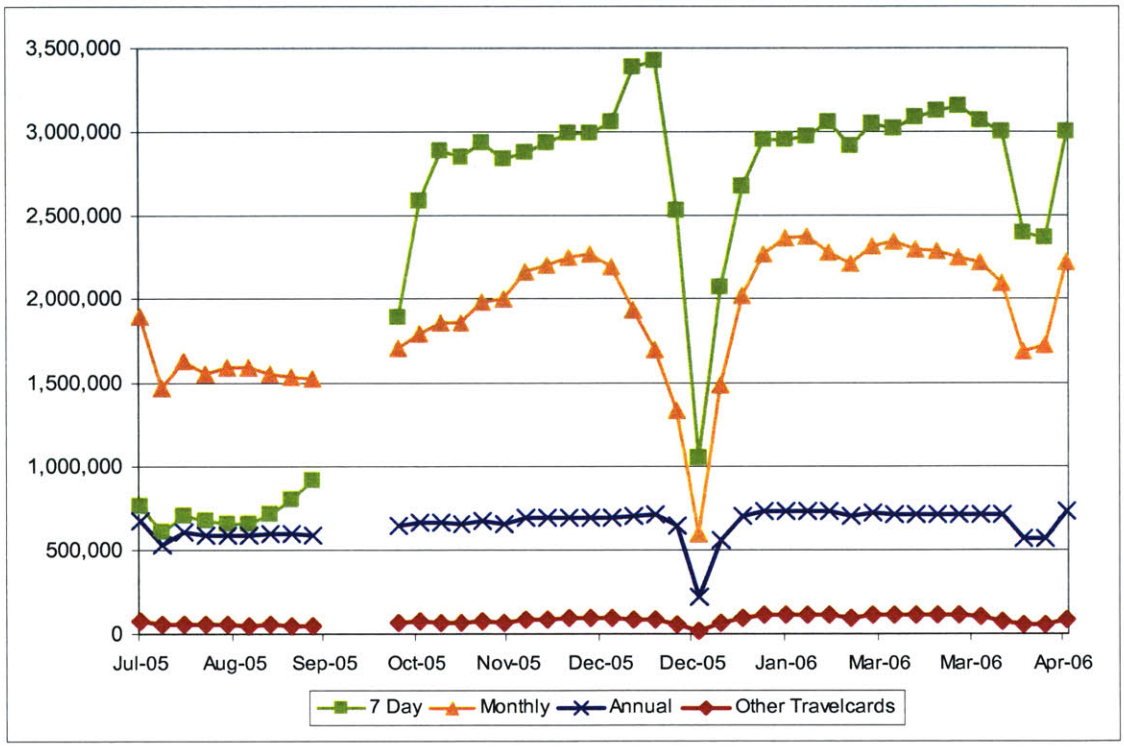

Figure 4-7: Breakdown of Weekday Oyster Travelcard Use on the Underground (Data for August 18, 2005 to September 17, 2005 Not Available)

4.3.3 Multi-Operator and Multi-Purpose Smart Cards

As noted in Chapter 2, overseas transit agencies tend to have taken the lead in rolling out multimodal and multi-purpose smart cards. To ensure a broader customer base, it is important that transit agencies consider expanding the reach of their smart cards. A multimodal smart card encourages customers who ride different transit systems to use it because of the convenience of using a single card. Should the functions or applications for which the smart cards can be used be expanded, the customer base is likely to increase as customers who ride transit and have a use for the alternative function will be encouraged to use the smart card. Table 4-6 summarizes the functionality of the smart cards of the case study transit agencies.

Table 4-6: Multi-Operator and Multi-Purpose Smart Card Systems

Transit Agency/City	Hong Kong	WMATA	Singapore	CTA	TfL
Multi-Operator	✓	✓	✓	✓	✓
Multi-Purpose	✓	✓	✓	×	×

Multi-Operator Smart Card

Since public transportation plays a much more important role in major Asian and European cities than in U.S. cities, it comes as no surprise that Singapore, Hong Kong and TfL (National Rail) all have smart cards that can be used throughout their public transportation networks. Similarly, both Washington D.C. and Chicago enjoy two of the highest transit usage rates in the U.S. and have large bus and rail networks which suit the multimodal configuration. In addition, smart cards in Singapore, Hong Kong and Washington D.C. are multi-operator. Hong Kong, the most successful pioneer in transit smart card application, utilizes the Octopus in all kinds of public transportation, including rail, subway, buses, trams, minibuses, taxis and ferries. The Singapore rail, light rail and bus systems all use the same ez-link card. SmarTrip customers can use WMATA, as well as several other transit agencies around the metropolitan area. Lastly, in Chicago, the Chicago Card (Plus) is also accepted on most Pace buses.

Multi-operator systems should be encouraged when the coverage area in question has

more than one transit agency and customers are likely to use more than one transit system. The ridership on a single transit agency might not be enough to support a smart card system but when transit agencies pool their ridership and resources, the smart card system may become justifiable.

The ability to use a single card for various modes and various transit operators could potentially provide discounts when changing modes or using different transportation services. This will positively influence the take-up rate of smart cards because customers now view the rides on various transit systems as one transit experience. This transfer discount issue is further explored in Chapter 5.

Multi-Purpose Smart Card

Just as it is truly multi-operator, Hong Kong's Octopus can also be used for a wide range of non-transit applications, including building access, identification, vending machines, photocopiers, convention registration and school attendance-taking, as well as for purchases at participating convenience stores, supermarkets and apparel/retail outlets. Singapore's ez-link cards can be used to make donations, at selected retail, food and beverage outlets, to borrow library books, to function as student IDs and for building access. WMATA has arrangements with certain U.S. government departments to combine the SmarTrip card with building access capabilities. In addition, the SmarTrip cards are used exclusively to pay for parking fees at Metro station parking lots.

The most recent development in multi-purpose smart cards is dual use smart cards which combine the functions of debit/credit cards and transit payment. The card combines a magnetic stripe which allows it to be used as a normal debit/credit card with a contactless chip used for transit applications. WMATA, in conjunction with Citibank, has introduced the Citi® Platinum Select® SmarTrip® MasterCard® which allows users to pay for their transit trips as well as other retail transactions. Singapore has announced a new dual functionality card in association with Visa Asia Pacific and the New York City Transit has also launched a similar program in conjunction with MasterCard and Citibank in July 2006 (Visa Press Release, 2006; ContactlessNews, 2006).

The use of smart cards for non-transit applications is the most widespread in Hong Kong. Not only does Octopus have its own loyalty rewards program which allows customers to earn rewards by presenting the Octopus at any Octopus Rewards Partner retail outlet at the time of purchase, it has also produced variants of the Octopus cards in the form of watches, key fobs and cell phone covers. The number of non-transit transactions has grown tremendously over the years. Initially, the company – Octopus Card Holdings – was permitted to have only 15% of its transactions as non-transit. However, in 2000, it applied and obtained a Special Purpose Deposit-taking Company authorization from the Hong Kong Monetary Authority to increase its non-transit transactions to 35%. Still, Rueter (2006) reports that Octopus "has had a hard time weaning customers from cash for retail payments". Currently, almost 20% of the Octopus transactions are for non-transit purposes. While this has increased from about 15% in early 2005, it is still far from the allowed 35% limit.

5 FARE POLICIES

Chapter 4 discussed how distribution, operational and usage policies can help encourage customers to switch from traditional fare media to smart cards. In this chapter, the ways in which fare policies can influence the take-up of smart cards will be explored. Fare policies are defined to include any options that affect the overall fare structure of the transit system (Section 5.1). These policies can include a variety of fare types and associated usage rules for different market segments. They are also associated with the price levels of the different fare types and fare media included in the fare structure. Smart cards offer a host of new ways to modify fare policies, offering customers more choices and transit agencies the potential to increase both ridership and revenue.

Section 5.2 will address the implications of some of the fare policies. Specifically, the fare policies that CTA and TfL have recently implemented will be evaluated. Lastly, in Section 5.3, two fare models that are currently used to predict transit ridership and revenue will be described and critiqued with reference to their ability to predict smart card adoption during its introduction.

5.1 Overview of Fare Policies

There are two ways in which customers can pay for their trips: pay-per-use or passes. When paying on a per ride basis, customers use either cash to pay for each trip or a stored-value ticket which deducts the cost of each trip from the value in the ticket. When the value depletes to zero, the card value has to be replenished. Alternatively, customers can purchase passes which allows them to make unlimited trips within a fixed period. Customers can enjoy discounted fares if they make enough trips on passes.

Traditionally, transit fare policies have been limited by the functionality of the available fare media. Besides cash which is used to pay on a per ride basis, paper tickets and magnetic stripe cards are used commonly as weekly or monthly passes. Special cards are also available for senior citizens and disabled customers as well as others entitled to reduced fares.

While magnetic stripe cards can be programmed to work as either pay-per-use tickets or period passes, the capability of magnetic stripe cards to offer more options is restricted because of their lack of processing ability. On the other hand, smart cards contain microprocessors which allow transit operators to provide a variety of innovative fare policies. TCRP Report 94 states that new electronic payment technologies including smart cards offer "a greater range of payment options..." (11) Specifically, smart card technology can:

1. enhance fare policies that are already offered using magnetic stripe card technology;
2. facilitate innovative fare policies; and
3. alter the actual cost of travel to customers through penalties and incentives.

5.1.1 Fare Policies Enhanced With Smart Card Technology

Existing fare policies can be enhanced with smart cards in three respects:

1. Types of passes
2. Distance-based fares
3. Negative balances

a) Types of Passes

Smart cards, like magnetic stripe cards, are used extensively as period passes which allow unlimited rides within a fixed period. Weekly and monthly passes are the most common types of period passes, although some transit agencies, with the increased flexibility provided by smart cards, are experimenting with passes for odd periods such as a few hours or several days or months. TfL allows customers to purchase Travelcards for odd periods (for example, 4 months) at their Underground stations. Warsaw Transport Authority in Poland offers tickets for 60, 90 and 120 minutes.

In addition to period passes, smart cards can also operate as concession (discounted) passes for specific market segments. In Singapore, Hong Kong and London, child, student and senior citizen passes allow these target groups to enjoy concession fares

when traveling on the transit network. In Tampere, Finland, registered war veterans travel free-of-charge when they present their special passes. Mandating smart cards for these types of passes is common and logical because transit agencies require these customers to go through a registration process to obtain their reduced (or free) fares. These customers will typically be more willing to switch to smart cards to obtain their reduced fare (or free) rides.

Smart card technology essentially allows customers to use identical smart cards but with different fare types encoded. Hence, transit agencies will be better positioned to develop new fare types catering to different market segments. At the same time, smart card technology makes it easy to revise the fare category for a customer. For example, when a customer moves up to a new age group and has to pay a different fare, the card reader can price the fare automatically with respect to the birthday encoded in the card.

b) Distance-Based Fare Systems

While flat or zonal fares are the norm in the U.S., distance-based fares will become more manageable with smart cards. Typically, transit agencies have been unwilling to introduce distance-based fare systems, particularly on buses, due to their complexity and administrative difficulties. However, with smart cards, automatic calculation of fare stages is possible on bus as well as on rail. In Singapore, bus operators used to manually update the fare stages on the readers so that the appropriate fares are deducted when the customer alights from the bus. However, operators sometimes fail to update the fare stages accurately, thereby charging customers the wrong fare. In August 2004, the Vehicle Location System (VLS) was launched which means that the fare equipment on buses have the fare stages automatically updated using the Global Positioning System (GPS) and the bus odometer. As such, the VLS combined with smart card technology makes distance-based fares easier to manage.

Another issue with distance-based fare system is exit control. On rail, it is not as significant a problem since most rail stations have fare gates at the entrance and exit.

However on buses, customers need to be educated on the fare deduction process. The Singapore system notes the entry stage and the maximum fare of the journey when the reader first registers the ez-link card. When the customer taps out upon alighting from the bus, the correct fare is calculated and deducted from the ez-link card. It is important that customers realize that the maximum fare can be charged if they do not tap out of the system.

TCRP Report 94 (2003) suggests that distance-based fares are perceived to be "able to generate greater revenues than lower flat fares" and are deemed to be more equitable as "a higher fare should be charged to cover the higher operating costs associated with serving longer trips..." (16) Hence, smart cards could potentially increase a transit agency's revenue by permitting changes in fare policies.

c) Negative Balances

As with magnetic stripe cards, stored value smart cards could potentially permit negative balances to ensure a last trip for customers who have less than the required fare on their card. Even if they do not have enough cash, they will still be able to make one last trip home. WMATA, TfL and Singapore all allow negative balances on their smart cards.

Allowing for such a policy effectively differentiates the smart card from cash. In addition, it removes the insecurity of bus riders who might find themselves stranded without a place to reload their cards. Because smart cards are more durable and customers are expected to re-use them, this will also decrease the chances of customers discarding negative-balance cards which would result in a loss of revenue to the transit agency. A point to note is that Singapore and Hong Kong charge the transit users a refundable travel or card deposit when purchasing the smart card. The deposit thus acts as a form of security for the transit agency in the case of negative balances on the cards.

5.1.2 Innovative Fare Policies Used by Transit Agencies

The above-mentioned fare policies might be familiar to customers accustomed to

magnetic stripe cards. However, transit agencies worldwide have also been exploring a wider range of fare policies that are more innovative.

a) Selected Line Pass

In Warsaw, Poland, the transit agency has introduced a 30-day pass for a selected line of the customer's choice. Priced at two-thirds the normal 30-day pass, this type of pass would be attractive to customers who use a single route to commute to work. This Individual City Travelcard for one selected line is also applicable on bus routes. There is a list of non-overlapping sections of bus routes heading in the same direction where this pass can be used to travel on more than one bus, provided that customer transfers to a corresponding bus linked to the first bus. Naturally, this will give transit users more choices and the ability to purchase the fare type best suited to their needs.

b) Free Transit Zone

In a bid to encourage transit use, some transit agencies have defined free transit zones. One such agency is the Tri-County Metropolitan Transportation District of Oregon (TriMet) for which any trip that begins and ends in the Fareless Square in Portland is free. Such free transit zones provide transit agencies with another form of incentive to encourage customers to use smart cards. Transperth has set up a Free Transit Zone on their rail system whereby customers using their SmartRider cards would be allowed to travel free within the zone. Customers using other fare media would still have to pay for their travel within the zone. Being able to record the entry and exit stations, the smart card technology can supplement the operation of a Free Transit Zone.

c) Incentives on Airport Express Lines

Another area in which transit agencies can choose to differentiate their smart card products from other fare media is in the operation of airport lines. Many cities have airports located some distance from the core and some agencies such as Hong Kong's MTR provide a special rail line that serves the airport from downtown. However, to

access the airport line, customers are likely to have to transfer from their origin to a rail station in the downtown area. Customers using Octopus are entitled to a complimentary feeder service when traveling to or from the airport on the Airport Express. In addition, Airport Express customers can also enjoy a free same day return journey when they use either the Same Day Return Ticket (a single use magnetic stripe ticket) or Octopus.

d) Flexibility of Changing Student Fares

As mentioned earlier, students can enjoy discounted fares with concession passes. Other than discounted rates, there could also be fare policies targeted at students or young children. Tampere City Transport offers School Tickets which permit ticket holders to make no more than two free journeys per school day. These two journeys are meant for school travel and hence should occur between 6.30 a.m. and 5.00 p.m. Nottingham City Transport in the U.K. conceived an "easyride<16" card, targeted at customers younger than 16. This card allows young customers unlimited travel before 9.45 p.m. After 9.45 p.m., customers must have value stored in the card to allow them to pay adult fares. These fare types are useful in recognizing that students make trips to school. However, they are also flexible enough to be able to charge the student different rates outside school commute times.

e) Variant of a 30-Day Pass

Tampere City Transport also has a Commuter Ticket which is valid for a maximum of 50 journeys over a period of 30 consecutive days starting from the first day of use. In this case, the customer pays less for a Commuter Ticket than a 30-Day Pass. The ticket expires when either 50 journeys have been made, or 30 days have passed, whichever comes earlier. The option of a Commuter Ticket in conjunction with a monthly pass gives customers another alternative and the opportunity to save money, depending on their travel habits. Tickets can also be combined with another Stored Value Ticket to supplement the customer's other needs such as paying for more than one person or paying the additional fee for late-night trips.

As an extension to the Commuter Ticket, transit agencies can also consider giving discounted rates for journeys made within 30 consecutive days but beyond the 50th journey. Since smart card technology is more flexible than magnetic stripe card technology, the smart card will be able to calculate the cheapest fare for the customer. As long as the fares are reasonably priced, both the transit user and transit agency can benefit from this scheme.

f) Non-Consecutive Day Pass

Nothingham City Transport has a special ticket called the "easyrider anytime" which targets the less frequent traveler. This ticket gives customers unlimited rides for any 2-, 5-, 10- or 20-day period. The unique utility of this card is that the days do not have to be consecutive. Hence, customers can hold on to the card and make unlimited rides on separate days. In addition, because it does not require any photo ID, it can be shared among different people on separate days.

If passes can be used on non-consecutive days, a weekday pass can also be created for the working population who commute on weekdays. The "Weekday Pass" can then be combined with pay-per-use or another pass similar to the "easyrider anytime" for the customer to make trips on weekends.

g) Price Capping

To encourage customers to use smart cards, transit agencies have also started looking into price capping. Daily price capping ensures that customers do not pay more than a certain amount daily. In London, this cap used to be set at the cost of a printed One Day Travelcard. However since the fare change in January 2006, the price cap has been reduced to 50p less than the price of the printed One Day Travelcard, making it cheaper to travel on an Oyster Pay-As-You-Go card than on a printed One Day Travelcard. If only the bus or tram is used, the cap will then be set at 50p less than the price of a One Day Bus Pass. WMATA and CTA are also looking into daily price capping to better serve their customers.

It is important to note that the cap may not be in competition with the price of a pass of a corresponding time period. In TfL's case, the One Day Travelcard and One Day Bus Pass are still offered only on printed tickets and hence, offering the daily price caps encourages customers to use Oyster.

The potential of price capping need not be limited to a one day period; the same concept could be applied to a week or a month. Beyond that, the price cap can also be applied to part of a day, a week or a month. For instance, the weekly cap can be used to ensure that customers do not pay more than a specific value *for their weekday trips only*. In the same way, TfL's Oyster capping rates include both an off-peak and a peak rate. If not enough rides are made to reach the peak cap, the customer only has to pay the off-peak cap plus the rides made during the peak period.

Price capping gives customers the ability to easily make changes to their travel plans. More importantly, customers do not have to worry about which tickets to purchase before traveling. Also, customers do not have to worry about spending more than they need to and can save the trouble of purchasing additional tickets if their travel plans change. The biggest incentive for customers under price capping, however, is the fact that they can save money if they travel frequently within a capping period.

5.1.3 Fare Policies Associated with Pricing of Fares/Smart Cards

The lack of "smart" fare media often restricts a transit agency to conduct selected fare hikes or reductions. This is especially true for buses where cash is often the only fare medium used. Pricing policies, however, are not restricted to mere fare hikes or reductions. This section describes the following pricing policies:

- cost of the smart card
- price differentials and other bonuses
- off-peak/peak pricing
- transfer discounts
- other pricing policies

a) Cost of the Smart Card

Transit agencies vary in their handling of the cost of smart cards. There are four ways in which a transit agency can treat this cost:

1. It can absorb the cost.
2. It can pass the cost on to the customer.
3. It can partially subsidize the cost and pass the remainder along to the customer.
4. It can charge a refundable deposit.

Initially, Singapore provided a "free" first ez-link card to each citizen during its transition to smart cards. The original price was quoted at S$15 where S$10 was for the stored value and S$3 was a refundable travel deposit. The remaining S$2 was a refundable card deposit which was waived, essentially making the card "free." Customers thus pay S$13 when they first purchased their cards. However, the policy was changed in November 2003 and any new purchases of the ez-link card will now cost S$15, consisting of a S$7 stored value, a S$3 refundable travel deposit and a S$5 non-refundable card cost (S$5 ≈ US$3). The non-refundable card cost is waived for senior citizens.

On the other hand, Octopus cards that are "on-loan" require customers to pay upfront a refundable deposit of HK$50 but allow customers to get back the deposit (less handling fees) when the cards are returned (HK$50 ≈ US$6). CTA and WMATA both charge a $5 card fee for each smart card whereas TfL requires a refundable £3 deposit for Pay-As-You-Go and 7-Day Bus Pass holders (£3 ≈ US$6). Although these transit agencies require an upfront cost for the smart cards, from time to time, they have also waived the cost for customers.

Making customers pay for the cost of the smart card is a significant deterrent to customers taking up smart cards. However, if the transit agency absorbs the cost of the card, the customer might view the card as being free and will be more likely to discard the card or hold on to more than one card per person. Transit agencies will find it very expensive to keep up with the upfront and maintenance costs in the long run. Hence, the idea of a refundable deposit appears to be more practical as customers will re-use their

cards and transit agencies do not have to absorb the entire cost of the cards. The fact that transit agencies have been waiving the cost of smart cards from time to time indicate that customers are more likely to be encouraged to adopt smart cards when there is no upfront cost to the card.

b) Price Differentials and Other Bonuses

Like magnetic stripe cards, smart cards offer many ways to provide bonuses and/or trip discounts to their users. To differentiate smart cards from other fare media, transit agencies can allow these bonuses and/or trip discounts to be available only on smart cards. TCRP Report 32 shows various transit stored-value discount and bonus options that could potentially be used with smart card technology (30). It also explains the transit/card usage impact for each option. Some relevant points include:

- To encourage retention of cards, an add-value bonus is recommended.
- To encourage card use, a per-ride discount for all rides (differential pricing) and frequent use bonuses are recommended.
- To encourage higher transit use, per ride discount above a threshold and frequent use bonuses are recommended.

To increase the take-up of smart cards, transit agencies have set aside special bonuses available only to smart card users. Different transit agencies have taken a variety of approaches in terms of the bonuses and discounts.

Add-Value Bonus

An add-value bonus is given when a customer reloads his/her smart card. This bonus is usually a percentage of the amount that has been added. CTA eliminated the 10% upfront bonus for magnetic stripe cards in April 2004 but retained the bonus for Chicago Card (Plus). For its SmartRider cards, Transperth has chosen to give add-value bonuses depending on the method of reloading. Notably, auto-reloading provides customers with a 25% discount while adding value at vending machines, on board on buses and ferries, by phone or online, at Transperth InfoCenters and authorized SmartRider retail outlets

provides a 15% discount.

As observed earlier, an add-value bonus encourages customers to retain their smart cards. If smart cards were given free, this will be a good complement so that customers will not discard their cards. Transit agencies can choose to set a specific requirement for award of the bonus. Setting a higher requirement will encourage customers to reload a higher value each time. In CTA's case, the 10% upfront bonus used to be applicable for every $10. Since January 2006, the requirement was increased to $20. Transit agencies can also encourage the use of a specific reloading channel by giving a higher bonus when the customer reloads using this channel, as in the case of Transperth.

Price Differentials

To make smart cards more attractive, transit agencies can set fares on other fare media higher than those for smart cards. CTA and TfL have demonstrated how differential pricing can encourage many customers to switch to smart cards. In January 2006, both transit agencies introduced major fare changes related to the use of various fare media. At CTA, cash and magnetic stripe card fares were made more expensive than smart cards on the rail system. In the case of TfL, cash fares were increased dramatically such that at times, they are double the corresponding Oyster fares. For instance, traveling in Zone 1 on the Underground costs Oyster users £1.50 while cash users would have to pay £3 for the same trip. In contrast to CTA and TfL, Singapore and Hong Kong use distance-based fares and give a slight discount to customers who pay using their stored-value smart cards rather than cash.

If no discount or bonus is given, the main incentive for customers to use stored value fare media such as smart cards becomes convenience. This, however, may not differentiate the smart card from the magnetic stripe card effectively for customers who want immediate results of the benefits. Customers are usually very concerned about how much they pay for their trips since cost is a major factor. The attractiveness of receiving discounts directly can potentially encourage a large customer base to switch to smart cards quickly.

c) Off-Peak/Peak Pricing

Smart card technology has also made it easier to administer off-peak/peak pricing strategies. WMATA and TfL both employ such strategies. While WMATA does not differentiate between its magnetic and smart card users, TfL specifically offers off-peak discounts only to its Oyster customers. In a bid to encourage more customers to use Oyster (and also travel during off-peak times), TfL increased the duration of the off-peak period in the morning by half an hour with the latest fare change. This allows customers who travel between 6:30 and 7:00 a.m. to enjoy the benefits of discounted rides using Oyster PAYG.

Off-peak/peak pricing is partially designed to influence the travel patterns of customers and possibly reduce congestion on the transit network during peak times. It also attempts to match the customer's price for a trip more closely to the transit agency's cost of providing the trip as it is well-established that the cost of providing peak period services is significantly higher than off-peak services. By extending off-peak discounts only to smart card users, this differential becomes a powerful incentive to encourage more off-peak, infrequent customers to switch to using smart cards.

d) Transfer Discounts

Transit agencies can also provide incentives for smart card users by exclusively giving them transfer discounts when transferring. It is common practice in the U.S. for customers transferring to use paper transfer tickets which allow them free or discounted transfers. Usually, these transfers are applicable only within a given time after the first trip. Some agencies allow round-tripping, where customers can use the transfer for a return trip within a short time window. Some other agencies allow free transfers only on selected routes. Alternatively, customers can be asked to make known their intentions to transfer beforehand and pay for a transfer first before transferring to another bus. CTA used to operate in this manner before eliminating all cash transfers. Hong Kong and Singapore, which were both using magnetic stripe cards before switching to smart cards, allow customers to enjoy transfer discounts when transferring either way between bus

and rail by means of the magnetic stripe card. In summary, transit agencies have various forms of transfer policy.

Smart card technology can simplify all transfer policies, be they free transfers or discounts. The complexity of the transfer process can be minimized with the use of smart card technology. In addition, customers can also receive transfer benefits when transferring between different modes if they use a single fare medium which is accepted on both modes. Various transit companies in Hong Kong, including rail, buses, minibuses, trams, ferries and taxis, have established specific transfer arrangements. A single smart card can record the previous use of a mode and distribute the relevant transfer discount on the next leg of the journey.

CTA eliminated cash transfers in January 2006, making discounted transfers available only on the magnetic stripe Transit Card or Chicago Card (Plus). Customers who need to transfer have to use the magnetic stripe or smart card or pay the full price for each section of the journey. Customers using the ez-link card in Singapore also enjoy transfer discounts only if they pay with the ez-link card.

TCRP Synthesis 19 (1996) states that transfers will always be necessary if direct services are not available to all ridership and/or different modes are required to travel from the origin to the destination (4). For a transit network which relies heavily on feeder services and transfers, a significant portion of the ridership will make transfers. As with price differentials, the attractiveness of paying less with smart cards will encourage a critical mass of ridership to switch to smart cards if the transfer discounts are given exclusively to smart card users. In addition, the use of AFC systems to distribute transfers reduces the likelihood of fraud, thereby recovering revenue that used to be lost to transit agencies.

e) Other Pricing Policies

Hong Kong has one of the earliest smart card systems and has introduced a wide range of pricing policies. The fare incentives do not have to be limited to day-to-day discounts but

can also include promotional incentives that encourage customers to continue their use of smart cards.

Besides intermodal transfer discounts, discounts are also given for same day return journeys. Parking discounts are available at selected parking lots under the Park & Ride Scheme and frequent use bonuses have also been distributed in the form of extra travel value and additional rides. When a specific number of rides have been made, or a specific amount has been spent on traveling, the smart card automatically gives the customer additional travel value.

One of the most innovative promotional incentives, however, has to be the Fare Saver program on the subway system. Fare Saver readers are located at specific rail stations where customers can have their Octopus read. For each Fare Saver at one location, there is a corresponding station where if the customer travels from that station on the same day, he/she is entitled to a HK$2 discount for that trip. Since only customers who use the Adult Octopus are eligible, such a marketing strategy could encourage customers to use the smart card.

5.2 Results from Recent Smart Card Fare Policy Changes

In January 2006, CTA and TfL implemented significant changes in their fare structures to encourage customers to switch to smart cards. Sections 5.2.1 and 5.2.2 explain the main fare policy changes by the CTA and TfL respectively, as well as the early impacts of the policies on the ridership and customers' choice of fare media.

5.2.1 CTA Case Study

CTA's strategy with the introduction of Chicago Card (Plus) has relied on giving customers benefits unavailable to cash users. Since there is an alternative fare medium which any customer can choose to use, CTA makes special efforts to market and publicize Chicago Card (Plus) and differentiate the smart card from the other fare media. Since January 2006, however, CTA has also introduced financial incentives, making it

more expensive for customers to pay by cash than by Chicago Card.

Background

In January 2006, CTA implemented a new fare structure that offers Chicago Card (Plus) users benefits over cash and Transit Card users. Under the new fare regime, discounted cash transfers are eliminated, making discounted transfers at 25 cents available only on Transit Cards and Chicago Card (Plus). In terms of bus fares, Transit Card and Chicago Card users pay the same as before ($1.75) but cash users now pay 25 cents more to ride. In addition, the rail fares for Transit Cards and cash were increased by 25 cents while for the Chicago Cards, they remained at $1.75. Prices of the magnetic stripe weekly and daily passes were unchanged. To encourage higher usage of the Chicago Card (Plus), the threshold for the 10% bonus was also increased to $20. CTA also waived the cost of the card from December 2005 to May 2006 in anticipation of the new fare changes. These changes were designed to increase revenue from users less concerned about prices while providing several "safety valve" options for frequent users who could not afford the increase. For instance, the Chicago Card (Plus) fares were kept constant.

Early Impacts of Policies

i. Price Differentials

Figures 5-1 and 5-2 show the full fare rail ridership and percentage of rail ridership by fare type. On rail, cash payments have decreased almost to zero. (While turnstiles at rail stations no longer accept cash, bus fare boxes can still be placed at rail stations under special circumstances such as special events to handle large crowds.) Since Transit Card fares are the same as cash, it is no surprise that the number of rides using Transit Cards has also decreased. Among the fare media for full fare ridership, the percentage of rides using Transit Cards has dropped from 53% to 35% from June 2005 to May 2006. The increase in Chicago Card and Chicago Card Plus (Pay-Per-Use) from approximately 14% to 27% in the same one-year period is a strong indication of how the pricing policy has affected rail customers. It is interesting to note that at the same time, customers are also using more 7-Day Passes (≈6% increase from June 2005 to May 2006), even though these tickets remain on the magnetic stripe cards. By purchasing the passes which

remained at the same $20 price after the fare change, customers could still obtain a discount per ride as well as the potential for additional "free" rides.

On the bus system (see Figures 5-3 and 5-4), all Transit Card and Chicago Card (Plus) users continue to pay the same as before the fare change. While cash payments have dropped drastically, there are still close to 2 million rides per month paid by cash. This could be due to the lack of ubiquity in sales location for both the magnetic stripe cards and smart cards or simply due to the fact that a portion of the ridership is essentially inelastic with respect to small price increases. Even though customers are starting to make more use of Chicago Card and Chicago Card Plus (Pay-Per-Use) (7.5% increase), the up-take has not been as strong as in the rail system's case. Together with these two fare types, rides paid by Visitor and Fun Passes are also increasing at a similar rate (8.6%). Transit Card usage remains relatively constant at approximately 15%. The biggest increase in usage, however, comes from the 7-Day Passes with a 12.5% increase. It appears that even when customers realize that paying cash is more expensive than before, they do not have a strong enough incentive to switch to Chicago Card (Plus). Instead, they are using another fare type with which they are more familiar and allows them to obtain a similar discount.

To put things into perspective, a 7-Day Pass costs $20. If a customer uses the Chicago Card (Plus) and makes a rail trip ($1.75) and a transfer to bus ($0.25) each way 5 days a week, this would also cost $20, the same as a 7-Day Pass. In essence, the Chicago Card (Plus) is no different from the weekly pass in terms of cost. In fact, with the weekly pass, the customer can still make more than these weekday trips since the pass offers unlimited rides for 7 days. Hence, the customer who makes transfers can be expected to use the 7-Day Pass instead of the Chicago Card (Plus). The fact that 7-Day Passes are not yet offered on the Chicago Card (Plus) clearly has slowed the adoption of smart cards at CTA.

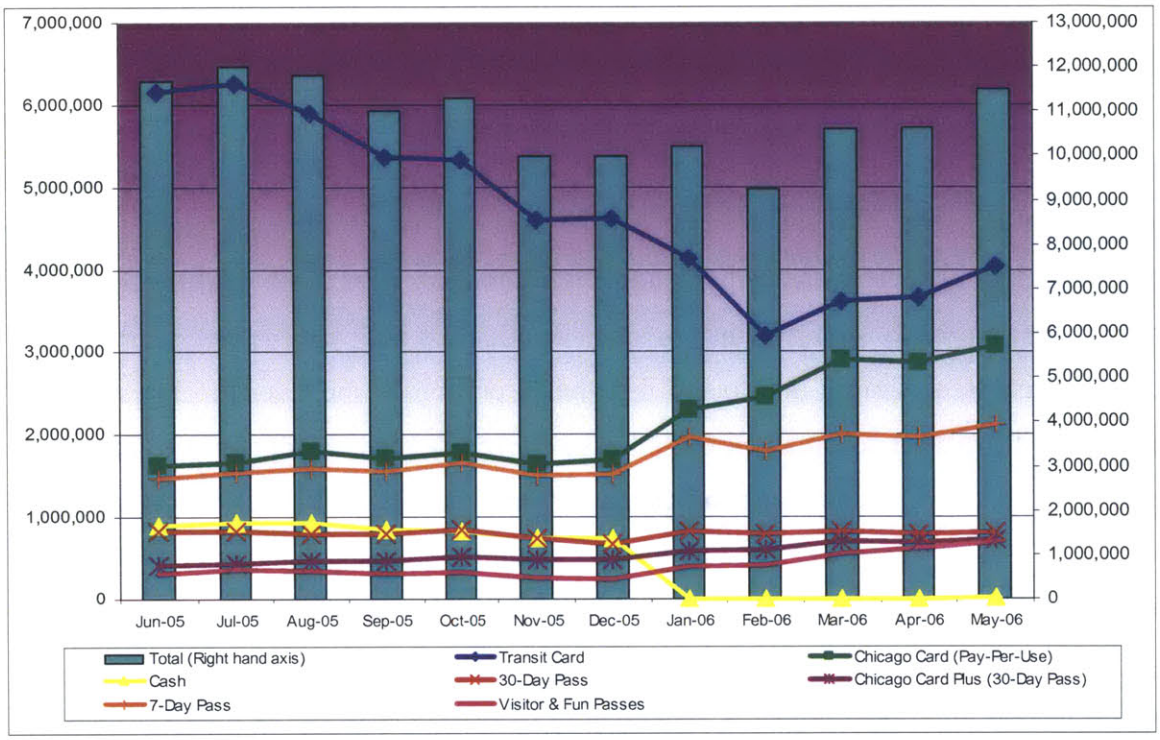

Figure 5-1: Monthly Full Fare Rail Ridership by Fare Type (Jun'05 – May'06)

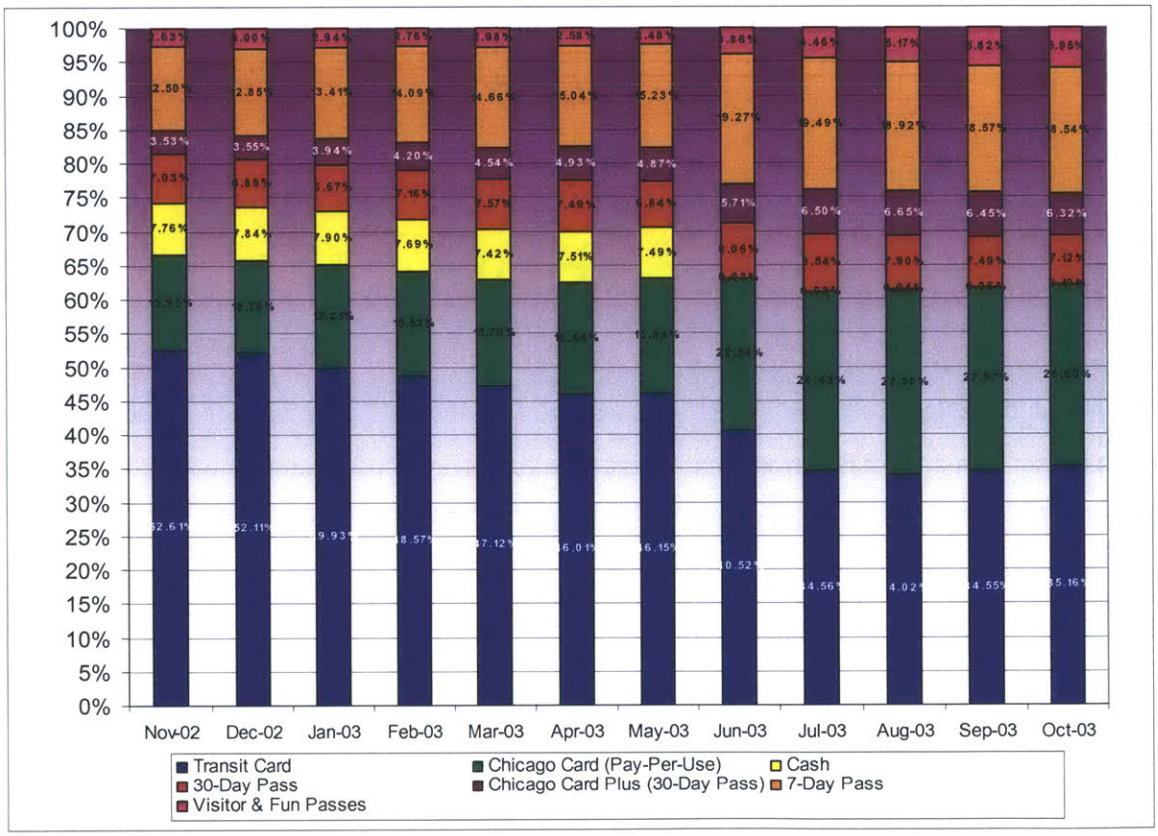

Figure 5-2: Monthly Full Fare Rail Ridership by Fare Type (Jun'05 – May'06)

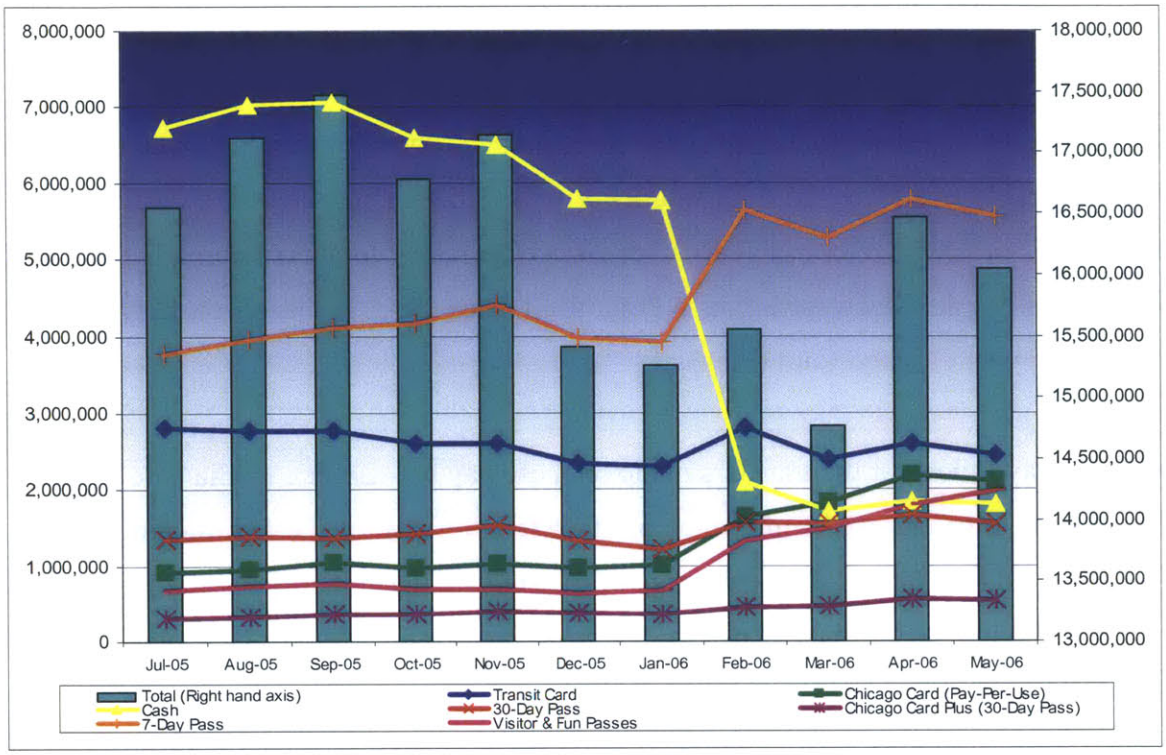

Figure 5-3: Monthly Full Fare Bus Ridership by Fare Type (Jun'05 – May'06)

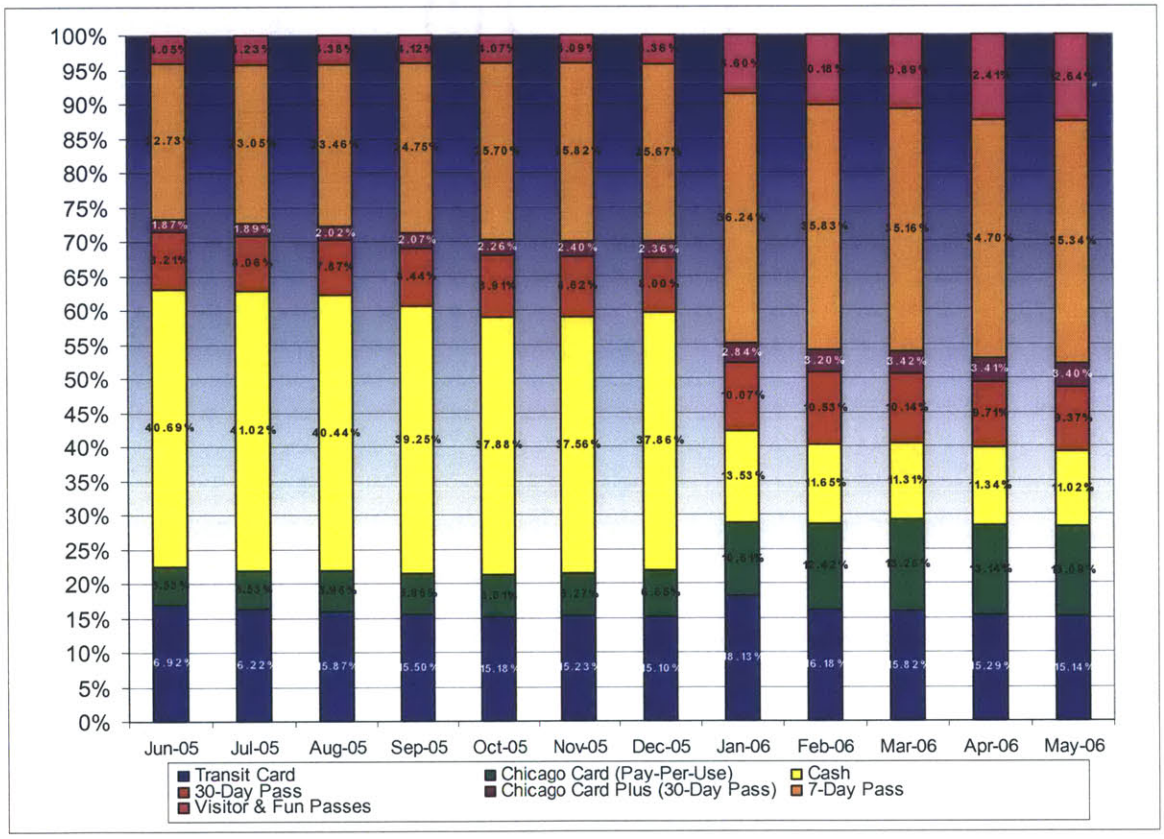

Figure 5-4: Monthly Full Fare Bus Ridership by Fare Type (Jun'05 – May'06)

ii. Elimination of Cash Transfers

Customers who pay by cash now have to pay for each link of their trip separately, resulting in a higher per linked trip cost than customers who use other fare media. Clearly, as shown in Figures 5-5 and 5-6, the numbers of cash transfers made between rail and bus (rail-to-rail transfers are not included) have since decreased to almost zero. The number of transfers has also decreased gradually on the Transit Card, as customers begin to rely more heavily on Chicago Card (Plus).

Another way to look at the transfers made on these pay-per-use fare media is to evaluate the percentage of unlinked trips which are transfers for each of the fare medium. In the Chicago Card (Plus) case, the percentage of transfers has been increasing gradually from 14.2% to 17.1% on rail and 27.6% to 32.7% on bus for the period of October 2005 to March 2006 (see Figures 5-7 and 5-8).

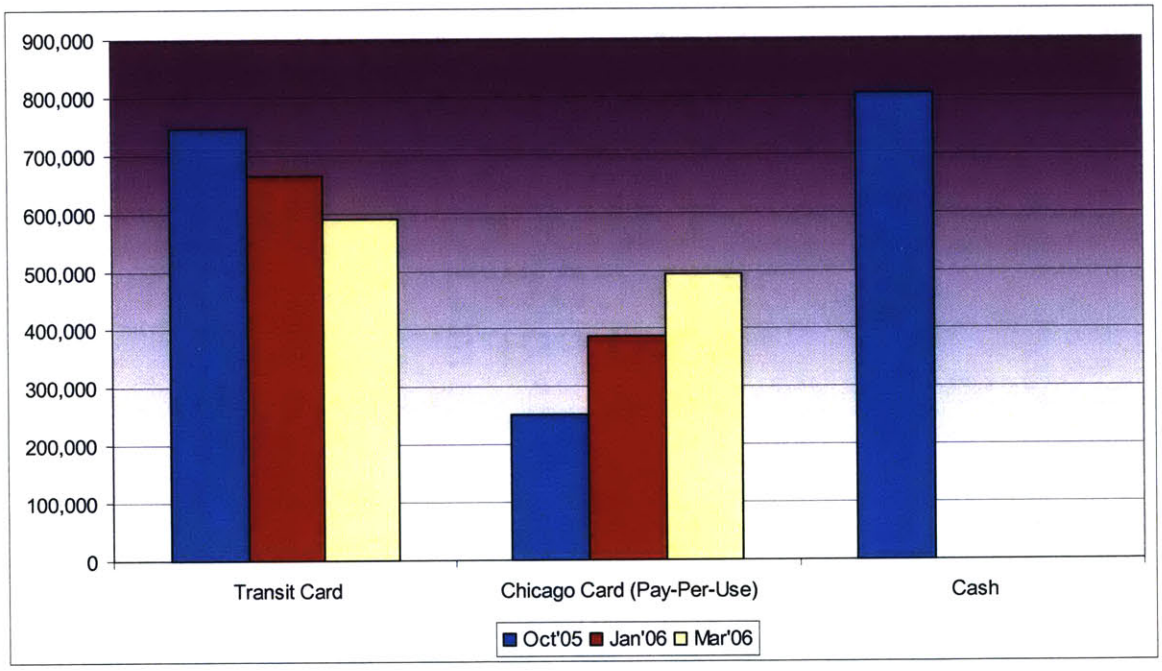

Figure 5-5: Number of Pay-Per-Use Rail Transfers

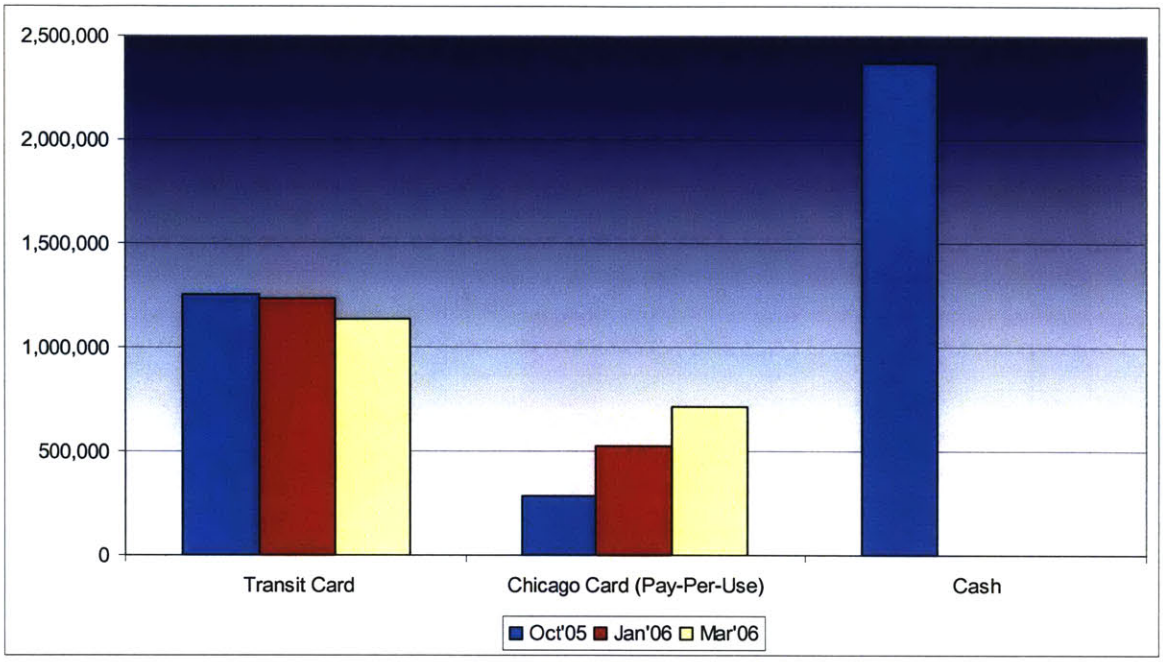

Figure 5-6: Number of Pay-Per-Use Bus Transfers

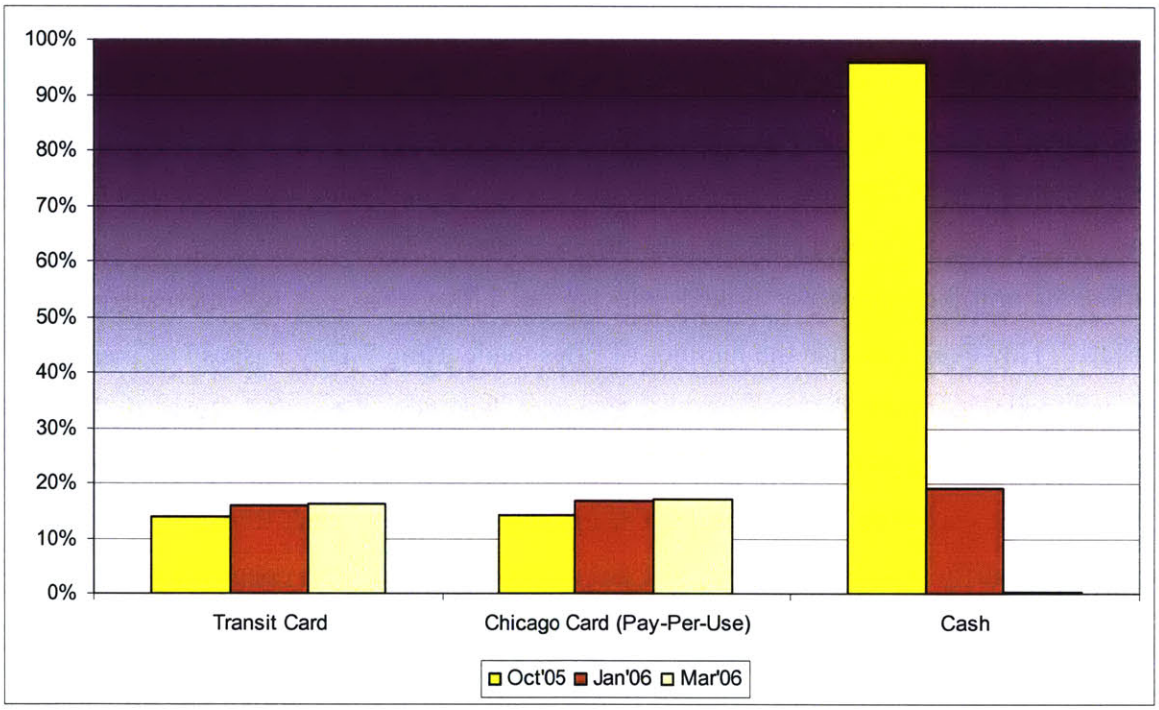

Figure 5-7: Percentage Rail Transfers for Transit Card, Chicago Card (Pay-Per-Use) and Cash

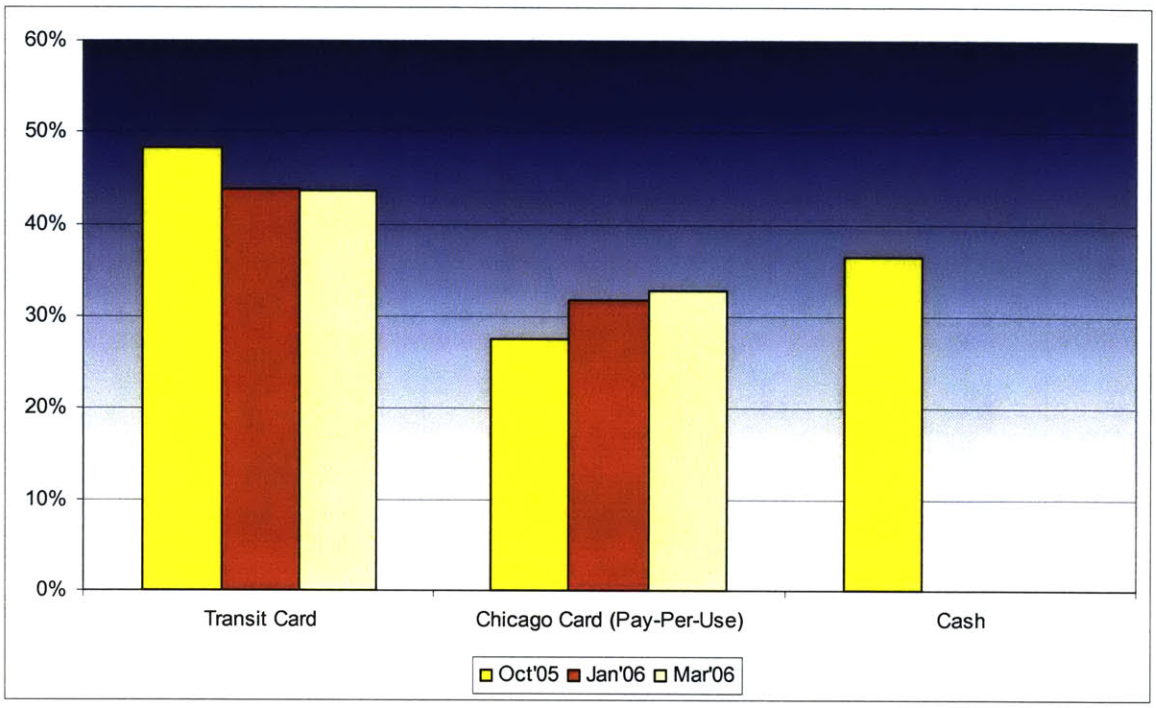

Figure 5-8: Percentage Bus Transfers for Transit Card, Chicago Card (Pay-Per-Use) and Cash

It has already been noted that there is an upsurge in customers using the 7-Day Pass and a reason could be that customers who make transfers are switching from cash to 7-Day Passes instead of to Transit Cards or Chicago Card (Plus). Figure 5-9 shows the number of unlinked rides per linked ride for the various magnetic stripe card passes. Notably, the number of unlinked rides per linked ride for the 7-Day Pass has not increased as we expected. However, because the number of rides made using 7-Day Passes has increased, we can conclude that the number of transfers has also increased. Essentially, the customers who have switched to 7-Day Passes are making as many transfers as customers who had been using the 7-Day Passes. Clearly, by eliminating cash transfers, customers do not necessarily switch to the Transit Card or Chicago Card (Plus) because passes offer a similar form of discount. Without making changes to the prices of the passes or making passes available on smart cards, CTA will find it hard to persuade pass holders to switch to smart cards.

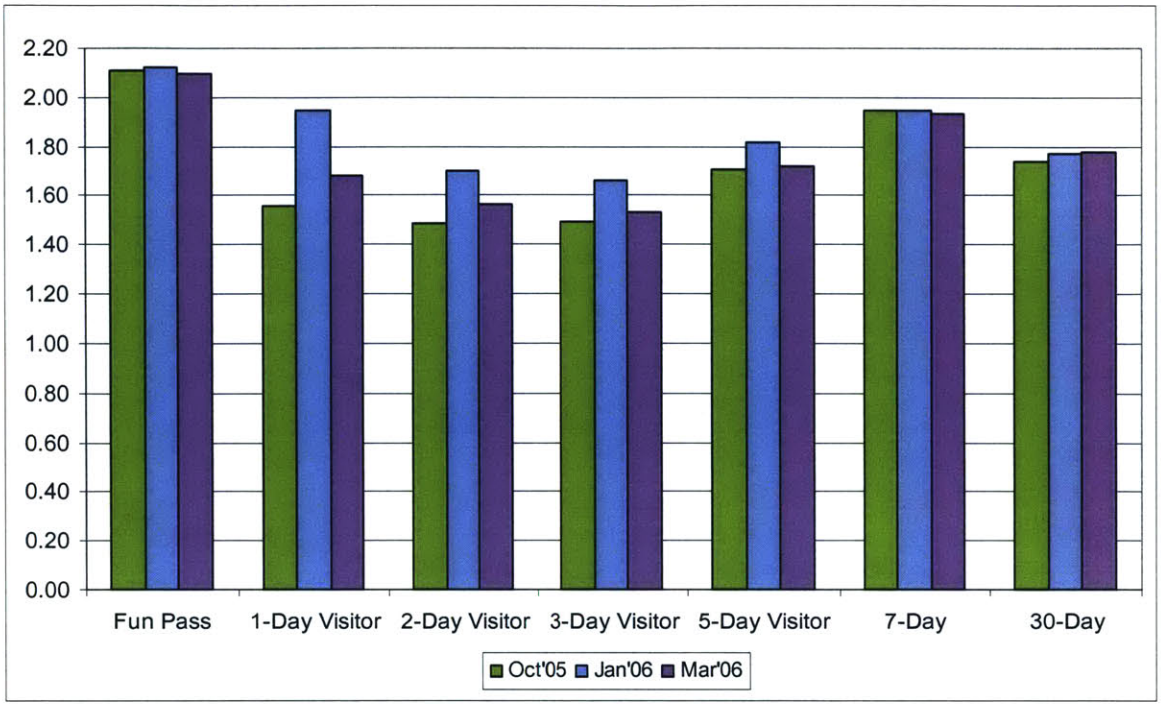

Figure 5-9: Unlinked Riders per Linked Ride on Passes

iii. Waiver of Cost of Chicago Card (Plus)

To encourage customers to use Chicago Card (Plus), CTA has waived the $5 cost of the card from time to time, most recently from December 2005 to May 2006 in anticipation of the new fare changes. In both January 2004 and January 2005, cost waivers were also introduced for three months. Figures 5-10 and 5-11 show the monthly Chicago Card (Plus) rail and bus ridership by fare type from November 2002 when Chicago Card was introduced till May 2006. As seen in both figures, whenever there is a cost waiver, there is an upsurge in the rate of increase in the number of rides, more significantly so for the Chicago Card (Pay-Per-Use). The Chicago Card Plus (30-Day Pass) uptake might have been hindered by the requirement of a credit card. Although CTA also made efforts to publicize and market Chicago Card (Plus) during the same periods, the free card still appears to be a strong incentive for existing cash and Transit Card users to switch to Chicago Card (Plus).

To complete the picture, Figure 5-12 shows the number of Chicago Card and Chicago Card Plus in circulation during selected periods. The increase between November 2005

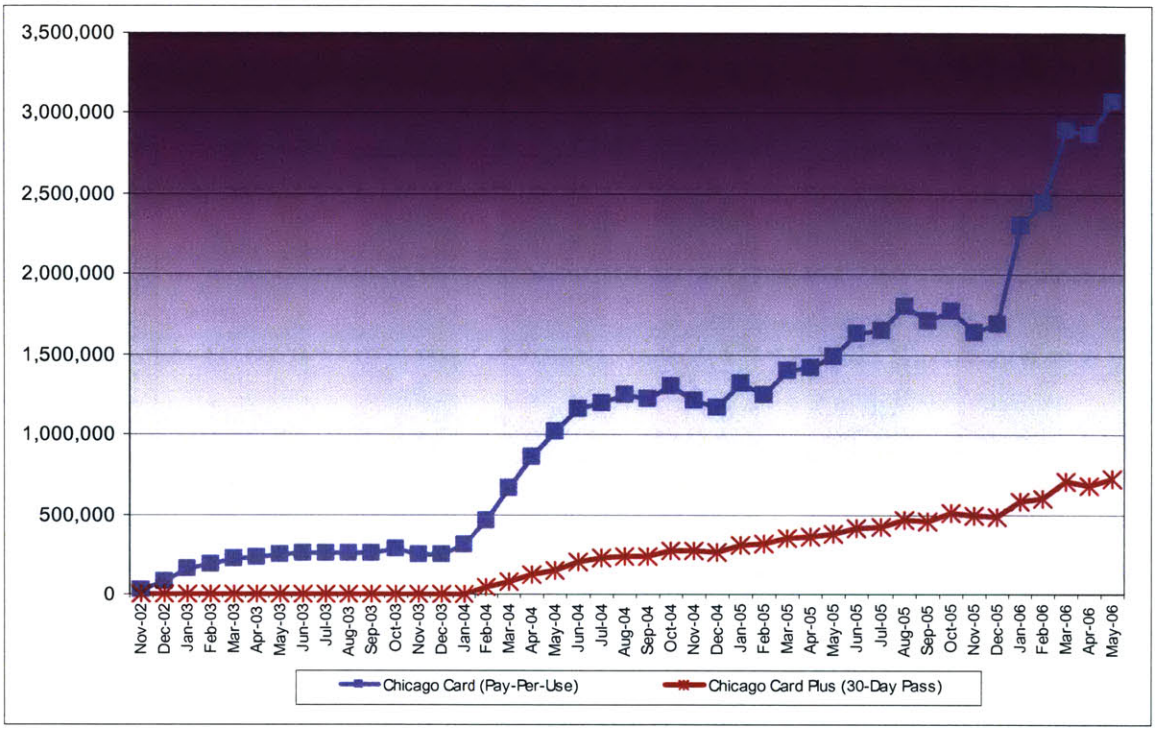

Figure 5-10: Monthly Chicago Card (Plus) Rail Ridership by Fare Type (Nov'02 – May'06)

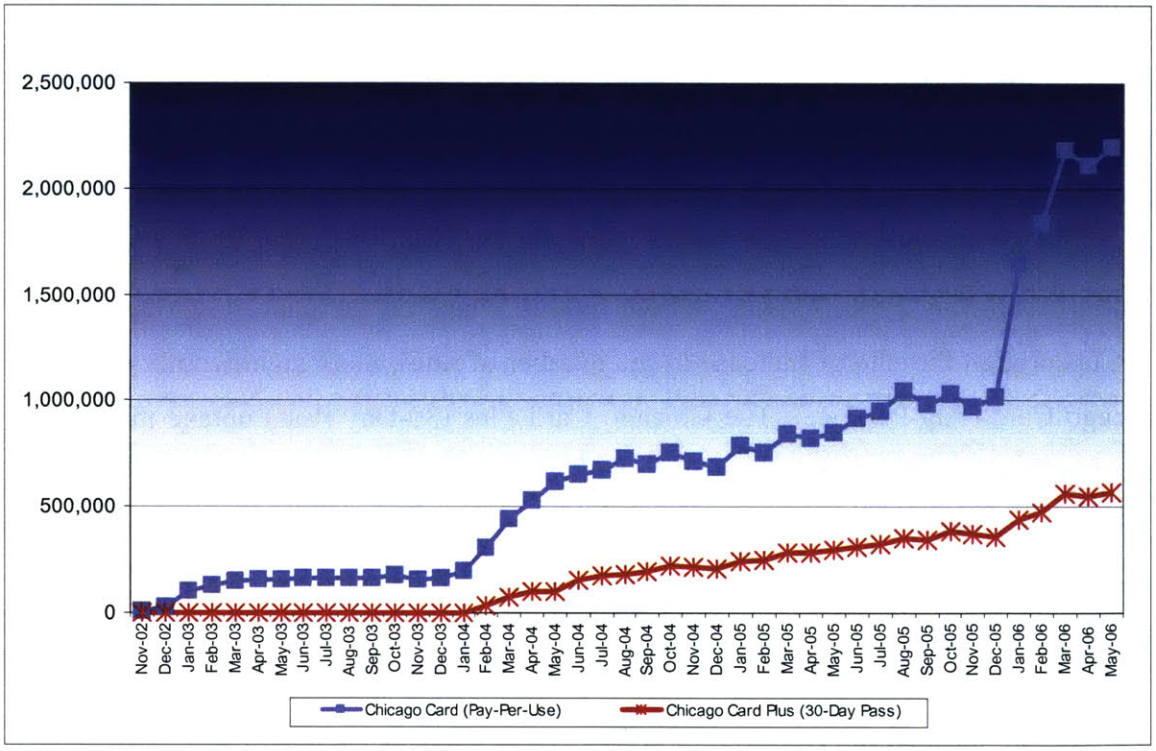

Figure 5-11: Monthly Chicago Card (Plus) Bus Ridership by Fare Type (Nov'02 – May'06)

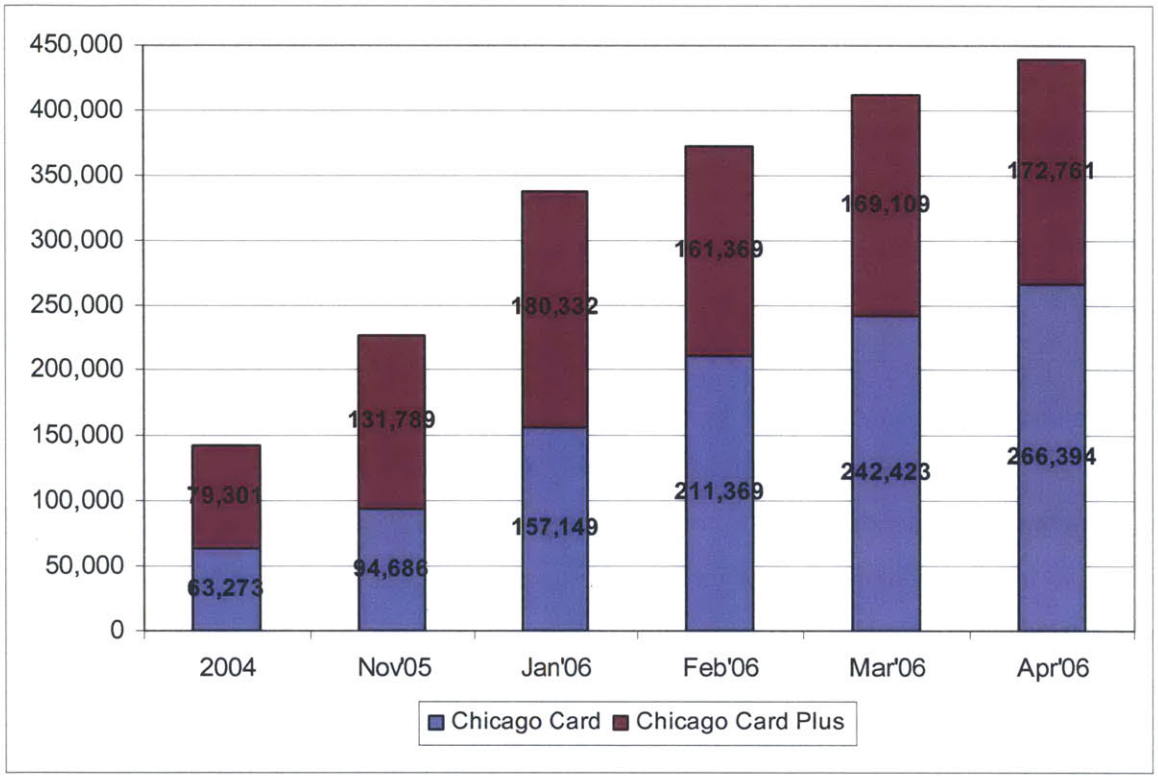

Figure 5-12: Number of Active Chicago Card and Chicago Card Plus

and January 2006 is apparent. Again, this suggests that distributing free smart cards is a good strategy to increase the circulation of smart cards quickly. Another trend seen in this figure is that the Chicago Card is increasing much more rapidly than the Chicago Card Plus. As mentioned earlier on, one reason could be that the Chicago Card Plus requires a credit card account so customers who do not have one will not be able to apply for the Chicago Card Plus. Another reason could be that the Chicago Card Plus mandates registration and customers who are uncomfortable with the process will not use it. Perhaps more telling is the fact that Chicago Card Plus can only be ordered through phone, mail, online or purchased at the CTA Headquarters but not at retail outlets. Hence, the up-take on Chicago Card has been quicker than Chicago Card Plus.

5.2.2 TfL Case Study

Since the introduction of Oyster in June 2003, TfL has followed a two-pronged strategy of incrementally restricting the availability of certain fare types to Oyster and introducing

financial incentives to switch to Oyster. For example, TfL eliminated printed season tickets and progressively limited the availability of certain Travelcards to Oyster. The new fare structure is designed to motivate customers to switch to Oyster cards by penalizing cash users. Notably, daily capping and off-peak pricing were introduced for Oyster PAYG in January 2005; Oyster users also pay lower fares than cash users since January 2004.

Background

In January 2006, the Underground Oyster single fares were decreased while cash fares were increased up to double the corresponding Oyster fares. Similarly, cash bus fares were also increased while Oyster fares were frozen at the previous year's level. The off-peak period where Oyster users can enjoy off-peak discounts was also extended half an hour later into the early morning. The daily price capping advantage of Oyster was further strengthened by reducing or freezing the daily caps for bus, the Underground, tram and DLR to 50p less than the cost of a printed One-Day Travelcard. In a bid to discourage customers from using printed Travelcards, the Family Travelcard and Zone 1 Travelcard were also withdrawn and replaced with other options on Oyster. However, printed magnetic Travelcards are still available from National Rail ticket offices, including the 7-Day Travelcards. Customers traveling from National Rail stations are likely to purchase these printed tickets, making up most of the magnetic stripe tickets still used in the TfL system.

Early Impacts of Policies

The large difference between Oyster and non-Oyster single fares is meant to discourage customers from using magnetic stripe cards and cash. Besides charging cash users a higher fare than Oyster users, Oyster users can also enjoy even lower fares during off-peak periods and weekends. The use of the various kinds of Oyster on the Underground and bus system has been increasing gradually as seen in Figures 5-13 and 5-14 which show Oyster usage over the past year.

Trips by most of the fare types including the Freedom Pass (both Elderly and Disabled),

Travelcards of odd periods, Bus Passes of more than 2 months and the Staff Passes have been relatively constant on both the Underground and the bus. These fare types were largely unchanged by fare changes in the past year.

Price differentials and daily price capping are two pricing policies that encourage customers to switch to Oyster PAYG. With Oyster PAYG, customers can enjoy lower single fares than when paying by non-Oyster fare media. Also, daily price capping is exclusive for Oyster PAYG users. Essentially, this encourages the use of Oyster PAYG as these customers pay less for an unlimited use of transit in a day if they make as many trips as they do on a printed One-Day Travelcard or One-Day Bus Pass.

Looking at weekday Oyster use on the Underground (see Figure 5.13), the 7-Day Travelcard remains the most popular fare type. Disregarding the dips during Christmas/New Year's Day and the Easter holidays, both the Monthly Travelcard and PAYG show increasing trends after January 2006, with the PAYG option increasing at a much faster rate. In fact, PAYG overtook the Monthly Travelcard around March 2006, approximately two months after the new fare structure took effect. It seems that the January 2006 fare change has affected the Oyster PAYG usage most. Its fare media share has increased slightly over 10% between July 2005 and April 2006 while the other fare media shares (with the exception of the 7-Day Travelcard) have all decreased in the same period. Notably, there was a sharp increase of 500,000 weekday trips made on Oyster PAYG just after the fare changes.

Similarly, on the bus system, the use of Oyster PAYG has increased tremendously after January 2006 when it became more expensive to pay for single fares using non-Oyster fare media. The increase in fare media share of Oyster PAYG was almost 13% between July 2005 and April 2006. As with rail, there was also a sharp increase of approximately 500,000 weekday trips made on Oyster PAYG just after the fare changes. This suggests strongly that customers are now using Oyster PAYG to avoid the higher non-Oyster single fares.

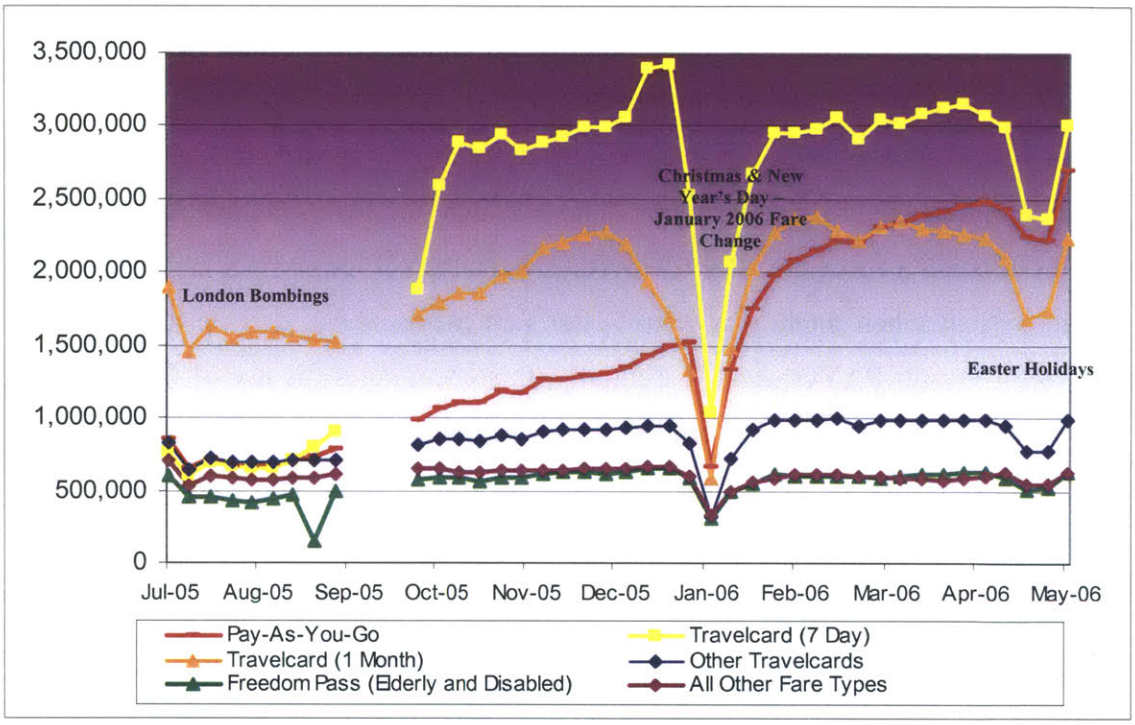

Figure 5-13: Weekday Oyster Use on the Underground by Fare Type (Data for August 18, 2005 to September 17, 2005 Not Available)

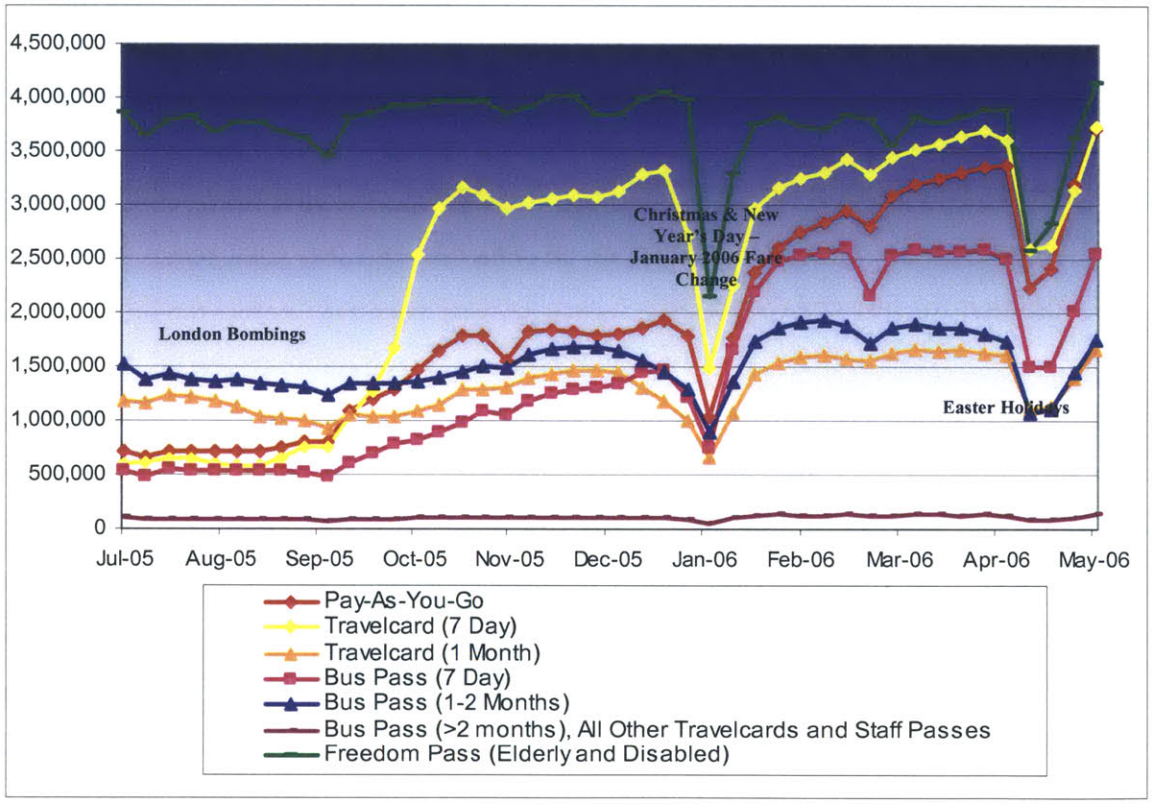

Figure 5-14: Weekday Oyster Use on Bus by Fare Type

The use of 7-Day Bus Pass also increased significantly (≈ 8%) over the same period of time, overtaking the 1-2 Months Bus Pass and Monthly Travelcard just after the fare change. It is interesting to note that although 7-Day Bus Pass is offered on both printed tickets and Oyster, more customers are now using Oyster 7-Day Bus Pass. Since each Oyster card can hold up to 3 Travelcards and/or Bus Passes and PAYG, it could be that the convenience of paying non-bus trips on one single card has encouraged customers to use Oyster instead of the printed 7-Day Bus Passes.

During the same period, the weekday magnetic use on the Underground has decreased. From Figure 5-15, it is seen that the One-Day Travelcard suffered a slight decrease after the fare change, when daily price capping on PAYG was capped at 50p lower than the price of the One-Day Travelcard. At the same time, the use of single tickets has also dropped sharply by approximately 1 million weekday trips per week. The use of daily price capping makes paying by Oyster PAYG cheaper than the One Day Travelcard and effectively encourages customers to use Oyster PAYG over the One Day Travelcard. The season tickets also experience a decreasing trend which might have stabilized. Clearly, the price differentials between Oyster and non-Oyster single fares and daily price capping have encouraged customers to switch from magnetic stripe tickets to Oyster PAYG.

When comparing the use of Oyster and non-Oyster fare media on both the bus and Underground (see Figure 5-16), it is not surprising to find that Oyster has overtaken the other fare media (i.e. cash and printed tickets) as the leading fare medium. While not shown in the chart, the percentages of paper Bus Saver tickets and cash payments on all bus journeys are very small at 0.4% and 6% respectively. A BMR Oyster Customer Research Report (2006) also indicates that the use of Oyster on buses (through March 2006) peaked at almost 50% in February 2006. The remaining 50% is made up of minimal on-bus cash sales, tickets bought from Roadside Ticket Machines (RTM) and printed Travelcards which are shown to the bus operators. On rail, the use of Oyster has been even more successful, reaching a penetration rate of almost 67% at the end of April 2006, with the remaining 33% magnetic stripe tickets. A large portion of these magnetic stripe tickets come from the National Rail which still sells printed Travelcards and other

magnetic single trip tickets. Currently, Oyster Travelcards are accepted at National Rail stations for which the Travelcard zone is valid. Oyster PAYG is accepted at limited National Rail staitons and so to travel from National Rail stations on the Underground, customers are more likely to purchase magnetic stripe tickets. In May 2006, TfL announced that the number of National Rail stations accepting Oyster PAYG will be increased from the current 60 to over 300. It is expected that with this move, the number of magnetic stripe tickets will diminish.

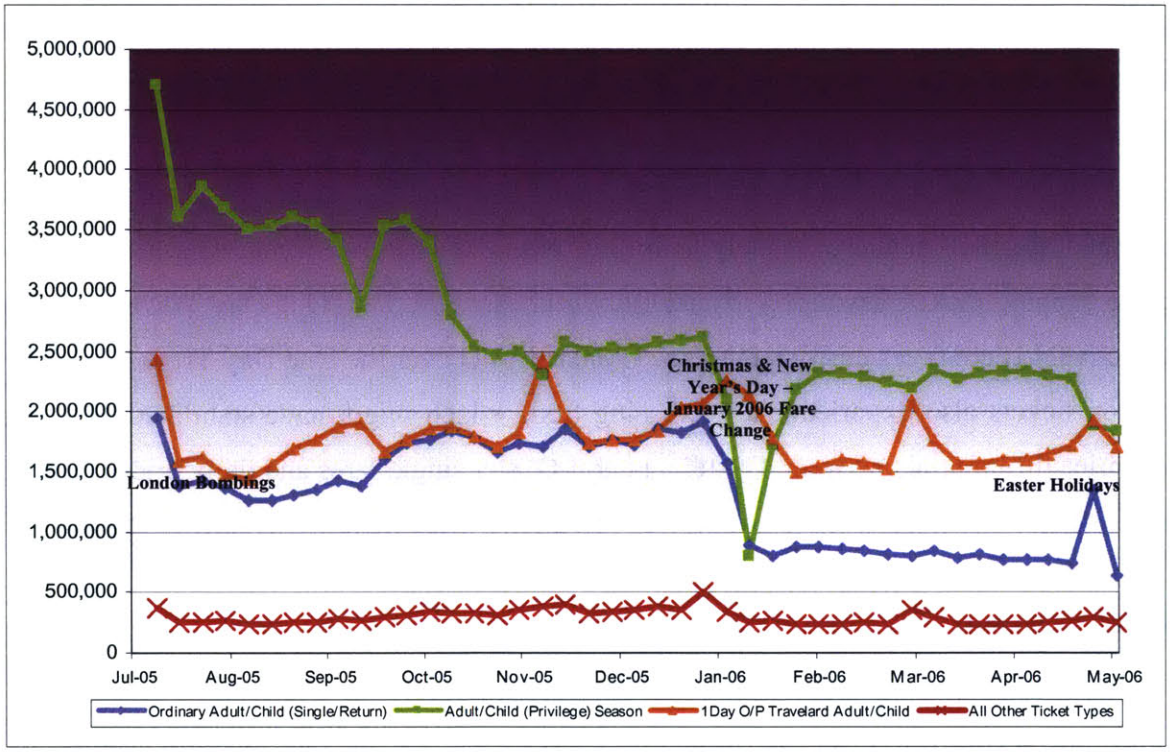

Figure 5-15: Weekday Magnetic Stripe Printed Ticket Use on the Underground by Fare Type

It is clear that with fare policies such as those implemented in January 2006, the use of Oyster can only increase while the use of non-Oyster fare media will continue to go down. It appears that if TfL intends to continue to encourage the switch to smart cards, Oyster PAYG has the most potential to increase its fare media share. Besides One- and 3-Day Travelcards, Travelcards for 7 days or longer are available only on Oyster (with the exception of limited 7-Day Travelcard sales at National Rail stations) and so it is the infrequent users that TfL must continue to target to convert to Oyster PAYG users. In addition, to eliminate the remaining 33% magnetic use on the Underground, Oyster must

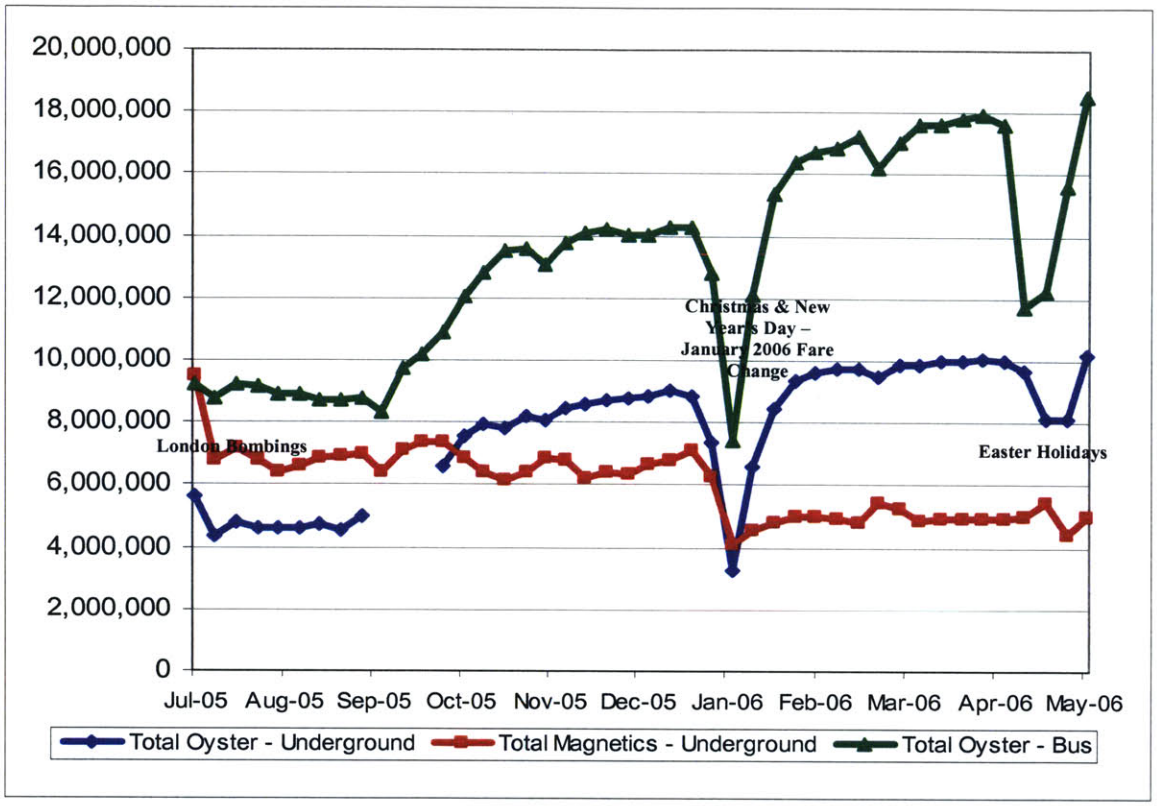

Figure 5-16: Total Oyster and Magnetic Stripe Card Use on the Underground and Bus (Oyster Underground Data for August 18, 2005 to September 17, 2005 Not Available)

be accepted and sold more widely at National Rail stations.

5.3 Fare Models

To justify the benefits of smart card technology, transit agencies must examine the impacts on ridership and revenue of new fare policies. Hence, a fare policy model needs to be flexible enough to:

1. allow transit agencies to include a new fare medium (i.e. smart card) when they want to test the impacts on ridership and revenue of fare policies and;
2. allow transit agencies to test innovative fare policies that were not originally in the fare model.

Transit agencies need to be able to evaluate how the take-up of the new fare medium will impact customers using the existing fare media based on existing fare policies. While a

fare type can be available on different fare media, the characteristics of each fare medium will lead to different take-up rates for each fare medium. A fare model which calculates the ridership and revenue based on fare types will not be sufficient. The fare model needs to be able to include new categories for each fare type that will be available on the new fare medium and be sensitive to the characteristics of the different fare media. Using a fare model that can easily include a new fare medium, comparisons of the ridership and revenue before and after the transition can then be made. These comparisons are essential for transit agencies to decide which fare type should be available on the new fare medium.

In addition, smart card technology provides the ability for transit agencies to become more innovative in terms of fare policies themselves. As mentioned in Section 5.1, the variety of fare policies has increased with the advent of smart card technology. A sensitive fare model is critical when analyzing these fare policies because an agency is interested in finding out which fare policies best meet the customers' needs and can improve their ridership and revenue. A fare model can predict the effects of the new policies and allow transit agencies to evaluate alternative strategies.

Understanding the impacts of the fare policies, the transit agencies can then make better plans to cope with the increase in smart card ridership. The predictions of the fare model will be important in supporting the planning of infrastructure and labor needed for the smart card program.

In the following sections, the Central Transportation Planning Staff (CTPS) fare model for MBTA and the CTA fare model will be described, evaluated and compared.

5.3.1 CTPS Fare Model for MBTA

In Boston, CTPS is the organization in charge of providing technical and policy-analysis support to MBTA. The fare model created by CTPS is primarily designed to predict the revenue impacts of a fare structure or pricing change. It also predicts ridership based on elasticity concepts. The CTPS model assumes a constant elasticity of demand with

respect to fare.

Background

Currently, the MBTA operates a cash, token and magnetic stripe pass system to collect fares. On buses, customers pay 90 cents per trip and can obtain a free paper transfer ticket to transfer to another bus. Discounted transfers from rail to bus are also given at a few selected rail stations. On rail, tokens at $1.25 each have to be used to pass through turnstiles. At converted subway stations, the tokens have been replaced by magnetic stripe stored value tickets called the CharlieTicket which are sold at new vending machines. In addition, monthly pass CharlieTickets (bus only, subway only and bus-subway Combo) are used on rail and buses.

A major change in the fare structure (including a fare increase) is planned for early 2007 along with the introduction of the smart card CharlieCard. As currently planned, the bus fare will be increased to $1.25 for CharlieCard users while CharlieTicket and cash users will pay 40 cents more. Similarly, the rail fare for the CharlieCard will be $1.70, 55 cents less than the CharlieTicket fare. Free transfers between local buses will be available only to CharlieTicket and CharlieCard users. As an additional benefit, CharlieCard users will also be able to receive discounted (or free) transfers between rail and bus. The subway-only monthly pass will be discontinued and replaced by the OnePass which allows a rolling month of unlimited travel on rail and bus and is priced lower than the current Combo Pass. The bus-only pass will remain as part of the CharlieCard initiative.

Prediction of New Ridership

Table 5-1 shows the inputs that are required for the CTPS fare mode. The existing and proposed fares, existing ridership and elasticity coefficients are categorized according to the fare type (cash or CharlieTicket, pass, and CharlieCard) for full and reduced fare rider categories and mode (subway, bus, commuter rail etc.). Elasticity coefficients measure the percentage change in ridership with respect to a change in fare, i.e. how sensitive the customers using a specific fare medium in a specific market group are to changes in fare. Both the diversion rates and elasticity figures are estimated from previous studies and

experience.

Table 5-1: CTPS Fare Model Inputs

Input	Description
Existing and Proposed Fares	♦ Categorized by fare type and mode
Existing Ridership	♦ Categorized by fare type and mode
Elasticity Coefficients	♦ Categorized by fare type and mode
Diversion Rates	♦ Interactions between cash and pass users ♦ Interactions between bus-only and subway-only/Combo pass users

In the CTPS fare model, there are two kinds of diversion rates that explain:

1. The interactions between cash and pass users. Depending on whether the ratio of the new cash price to the old cash price or the ratio of the new pass price to the old pass price is higher, there might be a shift in customers between cash and passes.
2. The interactions between bus and subway/Combo pass riders.

To recap, the demand function is defined as follows:

$$Q = \alpha P^{\beta}$$

where Q is the percentage change in quantity demanded, P is percentage change in price, α is a constant and β is the elasticity of demand. Using the above equation, the new ridership for each fare type and mode is calculated and then adjusted for the diversion effects for customers switching between cash and pass and between the different modes.

The following simple example shows the calculation of diversions between cash and passes. Relevant information for bus ridership can be found in Table 5-2. The new bus ridership paid by cash can be broken down into two steps:

1. Calculate the elasticity effects, B^1

$$B' = B * (\frac{P_2}{P_1})^{\beta} = 5{,}665{,}329 * (\frac{1.65}{0.90})^{-0.3} = 4{,}723{,}378$$

2. Calculate the diversion effects,

$$B'' = B' - \left[\left[\frac{(\frac{P_2}{P_1})}{(\frac{P_3}{P_4})}\right] - 1\right] * D_1 * B' + \left[\left[\frac{(\frac{P_3}{P_4})}{(\frac{P_1}{P_2})}\right] - 1\right] * D_2 * B^*$$

$$= 4{,}723{,}378 - \left[\left[\frac{(\frac{1.65}{0.90})}{(\frac{40}{31})}\right] - 1\right] * 0.05 * 4{,}723{,}378 + \left[\left[\frac{(\frac{40}{31})}{(\frac{1.65}{0.90})}\right] - 1\right] * 0 * 22{,}595{,}586$$

$$= 4{,}623{,}990$$

Table 5-2: Base Information for First Example

Item		Figure/Coefficient
Bus Cash Ridership, B	Existing	5,665,329
Bus Pass Ridership, B^*	New (assume calculated for elasticity effects)	22,595,586
Bus Single Fare	Existing, P^1	\$0.90
	New, P^2	\$1.65
Bus Pass Price	Existing, P^3	\$31
	New, P^4	\$40
Bus Elasticity Coefficient	-	-0.3
Diversion Rates	Cash to Pass, D^1	0.05
	Pass to Cash, D^2	0

Prediction of New Revenue

The revenue collected from pay-per-use is obtained by multiplying the ridership by the proposed fares. With regard to passes, CTPS estimates the relationship between the number of rides and the number of passes purchased based on past experience. Accordingly, the new number of passes purchased can be calculated from the number of rides made and is multiplied by the new pass price to obtain the revenue collected from pass users.

Problem with CharlieCard Users

It should be noted however, that because the CharlieCard does not currently exist, there are no existing CharlieCard users. Since the model is based on simple elasticity concepts, there is a need for a 'base CharlieCard ridership' so that the model can effectively predict the change in CharlieCard ridership due to changes in fares. To counter this problem, CTPS first assumes a penetration rate for the CharlieCard based on the corresponding discounts on CharlieCard fares (compared with cash fares). Depending on the discount given to CharlieCard users, a penetration rate is assumed based on a "penetration curve" (see Figure 5-17) developed loosely from other agencies' experience. The existing ridership for cash users is then split between cash and CharlieCard according to this penetration rate. For instance,

With a 25% discount for CharlieCard users, the associated penetration rate is 72%. Assuming the current bus ridership paying by cash is 20 million, the assumed base CharlieCard bus ridership will be 0.72*20 million = 14.4 million. The remaining 5.6 million rides will be allocated to cash riders, as seen in the previous example.

The base CharlieCard fare is assumed to be the same as the cash fare. Hence, using the same method shown in the first example, the 'new' CharlieCard ridership can be calculated.

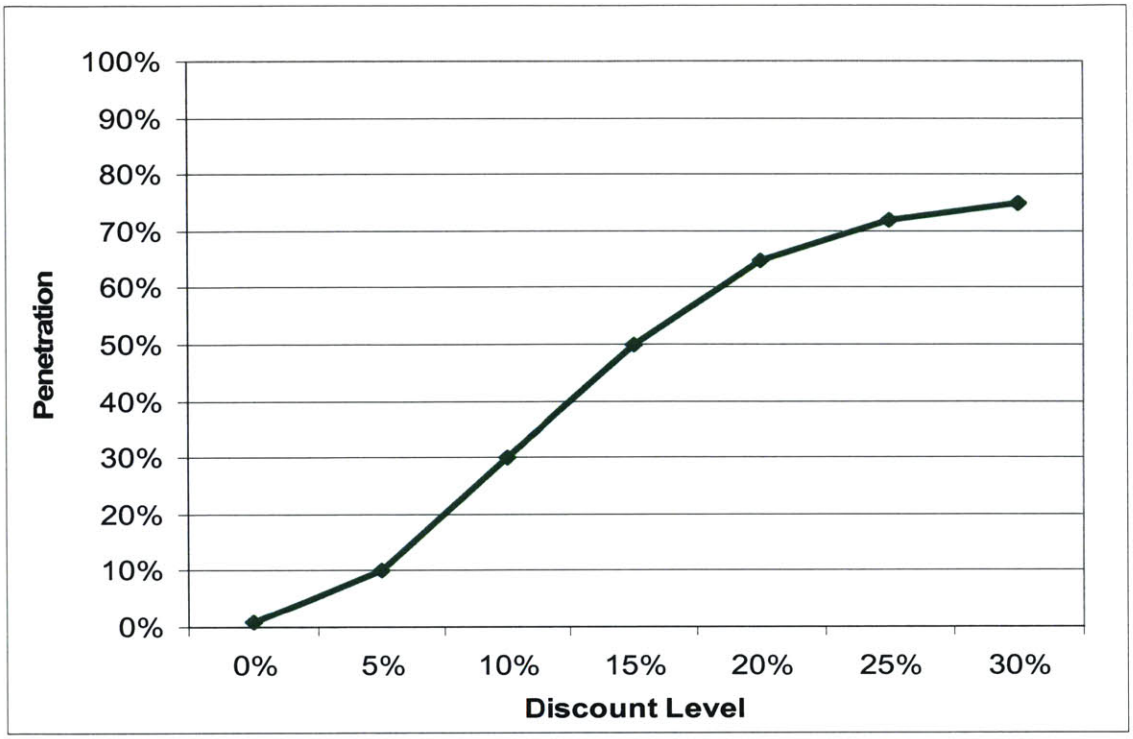

Figure 5-17: Charlie Card Penetration vs. Discount Level

5.3.2 CTA Fare Model

The CTA fare model was initially developed by TranSystems in 2000 and has since been updated by the the same firm and CTA staff to include ridership and revenue forecasts for the Chicago Card (Plus). It was developed to allow CTA to test the impacts of potential changes in fare structure on ridership and revenue. The CTA fare model incorporates a discrete choice model and elasticity concepts to predict the number of boardings (i.e. unlinked trips) and revenue that will result from proposed changes in fare structure or fare levels. The changes in ridership are first predicted for a sample based on a previous survey and then expanded to represent the actual CTA ridership base. Figure 5-18 shows a flow chart that summarizes how the CTA fare model works. The first 5 steps relate to the prediction of new ridership for the general fare media. A separate method is used to predict the new ridership for special fare media as mentioned in Figure 5-18.

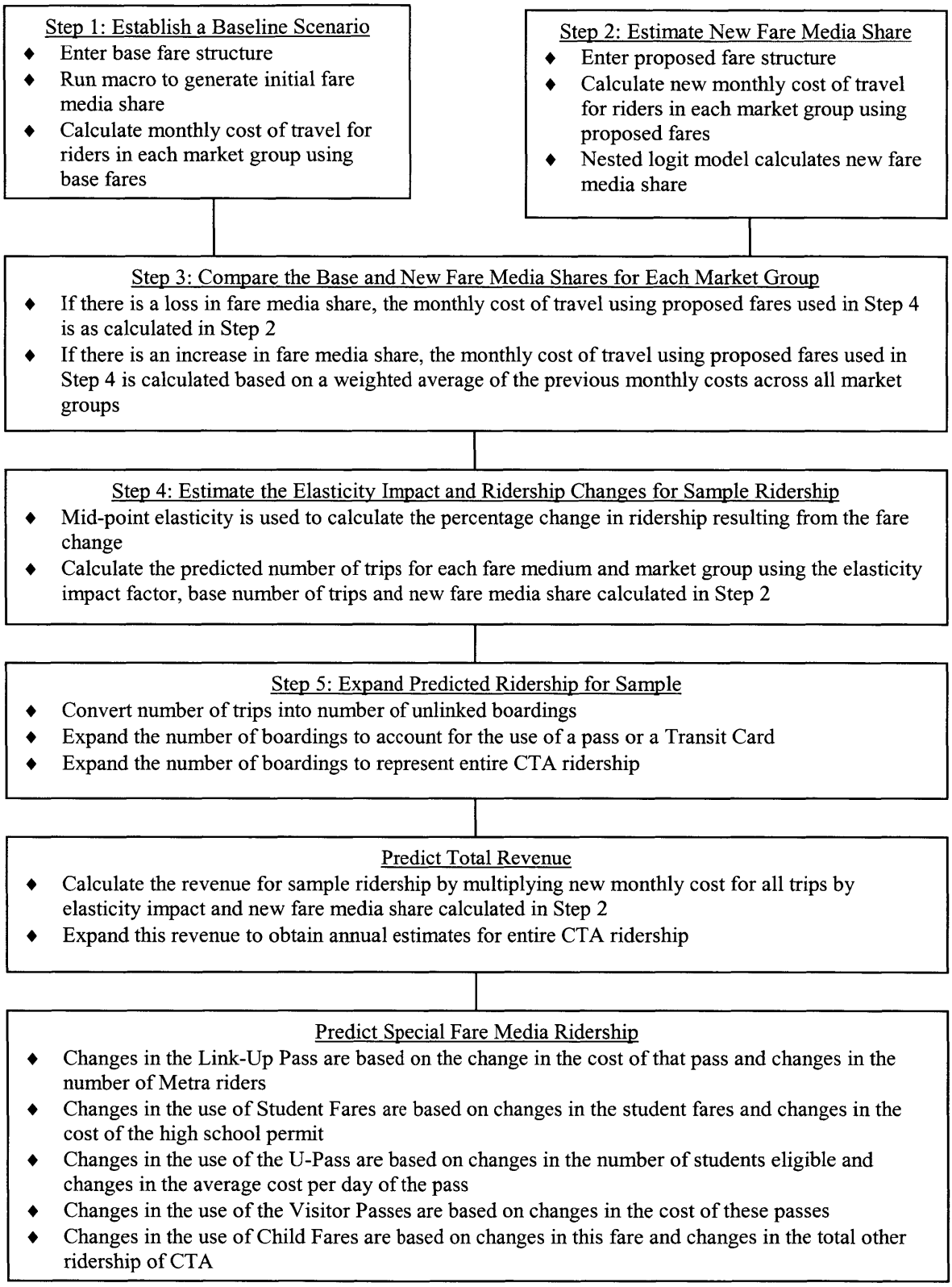

Figure 5-18: Flow Chart of CTA Fare Model ***(adapted from CTA Fare Structure Pricing Research and Update of Ridership/Revenue Fares Model)***

Understanding How Customers Change Their Travel Patterns Due to Changes in Fare Structure

For any changes in fare structure, customers may change their travel behavior and/or fare medium used. Customers can switch to an alternative fare medium to pay for the trips and/or adjust their travel behavior by changing the number of trips made. Hence, the CTA fare model has to be able to estimate:

- The effect of a change in relative fares on the choice of fare media
- The effect of a change in fares on ridership within a market group

The main fare media and fare types in the CTA fare model are shown in Table 5-3. They could also include any other proposed fare media. The market groups are defined through market surveys and are differentiated by their respective demographic information and type of fares paid (i.e. full fare or reduced fare). They are first divided into two main groups – Full Fare and Senior/Disabled Reduced Fare. These two groups are then further divided by the travel frequency, the use of rail and car ownership. In addition, other market groups are created to represent university and other students not using the U-Pass and reduced fare tickets respectively.

Table 5-3: Different Fare Media and Fare Types in CTA System

Fare Medium	Fare Type
Cash	♦ Pay-Per-Use (Transit Card)
Magnetic Stripe Cards	♦ Single and multiple day passes ♦ Pay-Per-Use (Transit Card)
Smart Cards	♦ 30-Day Pass (Chicago Card Plus only) ♦ Pay-Per-Use (Chicago Card (Plus))

Prediction of New Ridership – General Fare Media

Step 1: Establishing a Baseline Scenario

Before the fare model can be used, a survey is carried out and demographic information and subcategories of the customers surveyed established. The average number of trips (by time period and mode) made by each member of the market group was also estimated. (For example, OBR stands for off-peak one bus trip and one rail trip; PR stands for peak

with one rail trip; WBBB stands for weekend with three bus trips.) At the same time, the initial fare media share for each market group is estimated. (Note: In the CTA fare model, the term 'fare media share' rightfully should have meant the share of each fare type. However, in accordance with the fare model, the term shall remain as 'fare media share.') This involves running a macro in the fare model to calculate media-specific coefficients for later use in the nested logit model. After entering the base case ridership and fare structure for both the current and predicted scenarios, the macro is run to generate the initial fare media share. Finally, the monthly cost of travel for riders in each market group is calculated by multiplying the cost of the trip with the number of trips made.

Step 2: Estimating the New Fare Media Share

At this point, the new fare structure under the predicted scenario is entered. With the media-specific coefficients generated in Step 1 by the macro and variables including demographic information and new cost of trips, the utilities of different fare types for each market group are calculated. A nested logit choice model is then used to estimate the share for each fare type within a market group. The upper level of the nested structure computes the customer's preferences among the general groups of fare types: cash, pay-per-use and passes. The lower level of the nested logit tree evaluates the fare types within the pay-per-use category or pass category (see Figure 5-19).

Here, the fare model allocates the current ridership among the different fare types given the proposed fare levels. The change in ridership level is not yet accounted for.

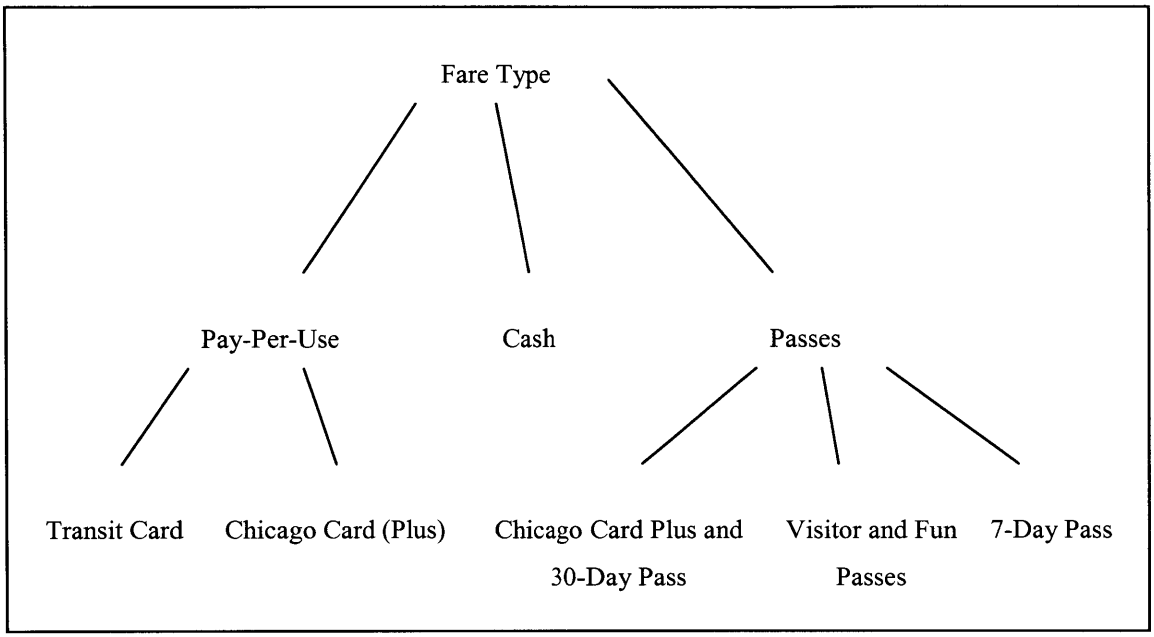

Figure 5-19: CTA Fare Mode Nested Logit Tree

Step 3: Comparison of Base and New Fare Media Shares

The base and new fare media shares are compared to see if there is a gain or loss for each fare medium and market group. If there is a loss in fare media share for a particular market group, the elasticity impact calculated in Step 4 will be based on the old monthly cost of travel (under current fares) compared with the new monthly cost of travel (under the proposed fares; calculated in Step 2). If there is an increase in fare media share for a particular market group, the elasticity impact calculated in Step 4 is based on a weighted average of the previous monthly costs across all market (under current fares) compared with the new monthly cost of travel (under the proposed fares; calculated in Step 2).

Step 4: Estimating the Elasticity Impact and Ridership Changes for Sample Ridership

Next, we consider any change in the total number of trips made because of the change in fares. The same customer surveys, together with past CTA experience, were used to develop elasticity coefficients that explain changes in the CTA ridership resulting from fare changes. The mid-point elasticity equation is then used to estimate the percentage change in ridership resulting from a fare change. The mid-point elasticity relationship is as follows:

$$\beta = \frac{\frac{(Q_2 - Q_1)}{(Q_2 + Q_1)/2}}{\frac{(P_2 - P_1)}{(P_2 + P_1)/2}}$$

where β is the elasticity of demand, Q_1 is the initial demand, Q_2 is the final demand, P_1 is the initial price and P_2 is the final price.

At this point, all changes in the future number of linked trips and revenue **due both to a switch in fare media and changes in ridership** are reflected in an elasticity impact factor. The elasticity impact factor is multiplied by the base number of trips and the new fare media share to estimate the new number of trips made for each fare medium and market group by mode and time period for the sample.

Step 5: Expansion of Predicted Ridership

To obtain the number of unlinked boardings, the trips made are then totaled based on the number of transfers for each trip. For example, a PBR trip is one linked trip but two boardings during the peak period. The number of unlinked boardings is further adjusted, recognizing that customers using a pass or a stored value card are likely to make more trips than customers paying by cash. Also, since the base case information comes from a sample of ridership, the results are also expanded to reflect total ridership.

Prediction of Ridership – Special Fare Media

There are several fare types which are not covered in the above methodology including Metra Link-Up Pass, U-Pass, reduced fare student rides, reduced and free child rides, visitor passes, paratransit and free rides. The estimation methods for these special fare types employ a simple elasticity model as shown in Figure 5-18.

Prediction of New Revenue

The new revenue for each fare medium and market group is obtained by multiplying the new monthly cost for all trips (i.e. peak, off-peak and weekend), the elasticity impact

factor and the new fare media share. As in the case of the predicted ridership, the revenues obtained are for the sample of ridership and should again be expanded to obtain annual estimates for the entire CTA customer population.

5.3.3 A Critical Assessment of the CTPS and CTA Fare Models

To evaluate the CTPS and CTA fare models, the two fare models are first critiqued and compared. The CTA fare model is then used to predict the ridership between June 2005 and May 2006 and compared against the actual ridership during the same period.

a) Comparison of CTPS and CTA Fare Models

To understand how a fare model should function, we compare the CTPS and CTA fare models and note the essential components of a fare model which can be used to predict the initial ridership of smart card users. Three critical aspects are discussed: the initial fare media share, the incorporation of new fare policies and diversions between fare media.

Initial Fare Media Share

Since most fare models used by transit agencies are based on simple elasticity concepts, the problem of the 'base smart card ridership' will be faced by any transit agency. Simply stated, at the time of prediction smart cards have not yet been introduced and so there is no initial (or base) smart card ridership. In the CTPS fare model, the initial penetration rate is assumed to be correlated with the level of discount given to smart card users as opposed to cash users. A 'base smart card ridership' can then be obtained using the penetration rate to split the cash and smart card users in the base cash ridership.

However, the relationship between the penetration rate and the level of discount is arbitrary. To illustrate this sensitivity, alternative relationships between the discounted level and the smart card penetration rate are shown in Figure 5-20. As Figure 5-21 shows, total revenue hardly changes when a 25% fare discount is applied with initial penetration ranging from 40% to 72%. The total annual revenue between the "Original" scenario as

depicted in the CTPS fare model and the "Choice 10" scenario differs by only approximately $9 million. However Figure 5-22 shows that the assumed penetration relationship strongly affects the mix of smart card and cash users. Specifically, between the "Original" and "Choice 10" scenarios, there is a decrease of almost 27.5 million CharlieCard users and an increase of approximately 25 million cash users.

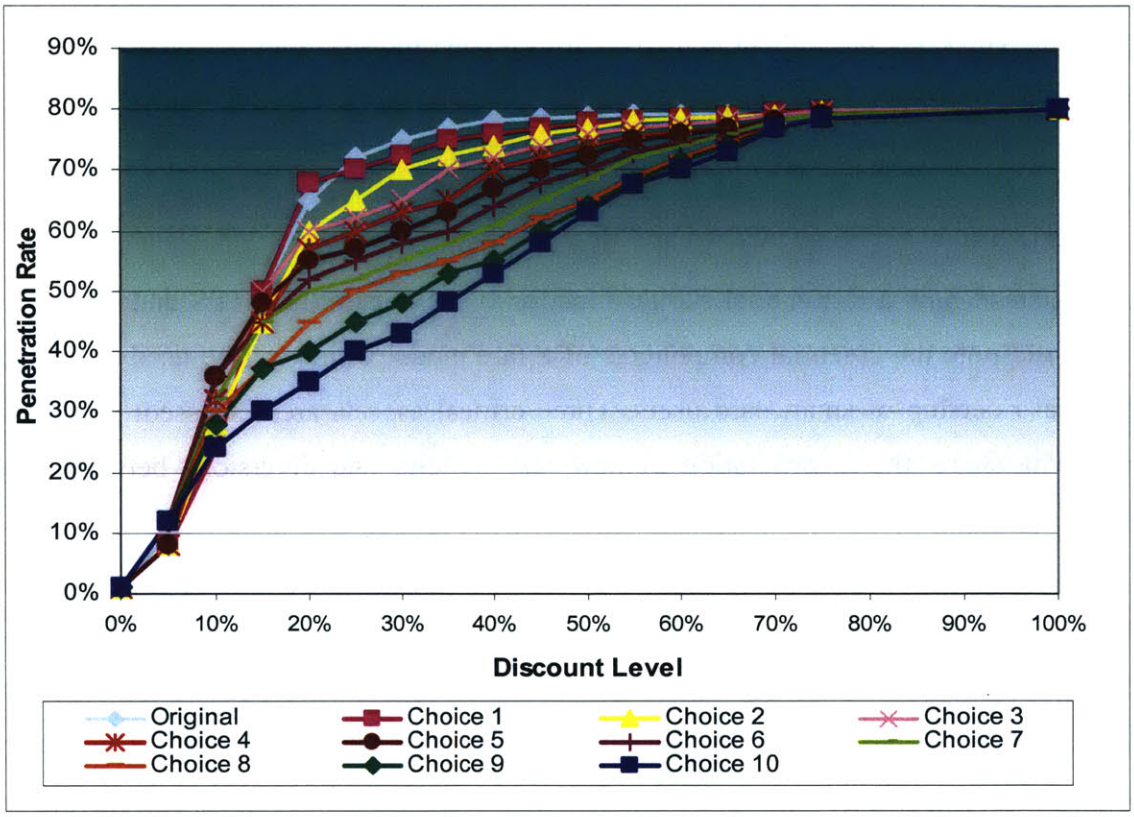

Figure 5-20: CTPS Fare Model Sensitivity Analysis: Penetration Rate vs. Discount Level

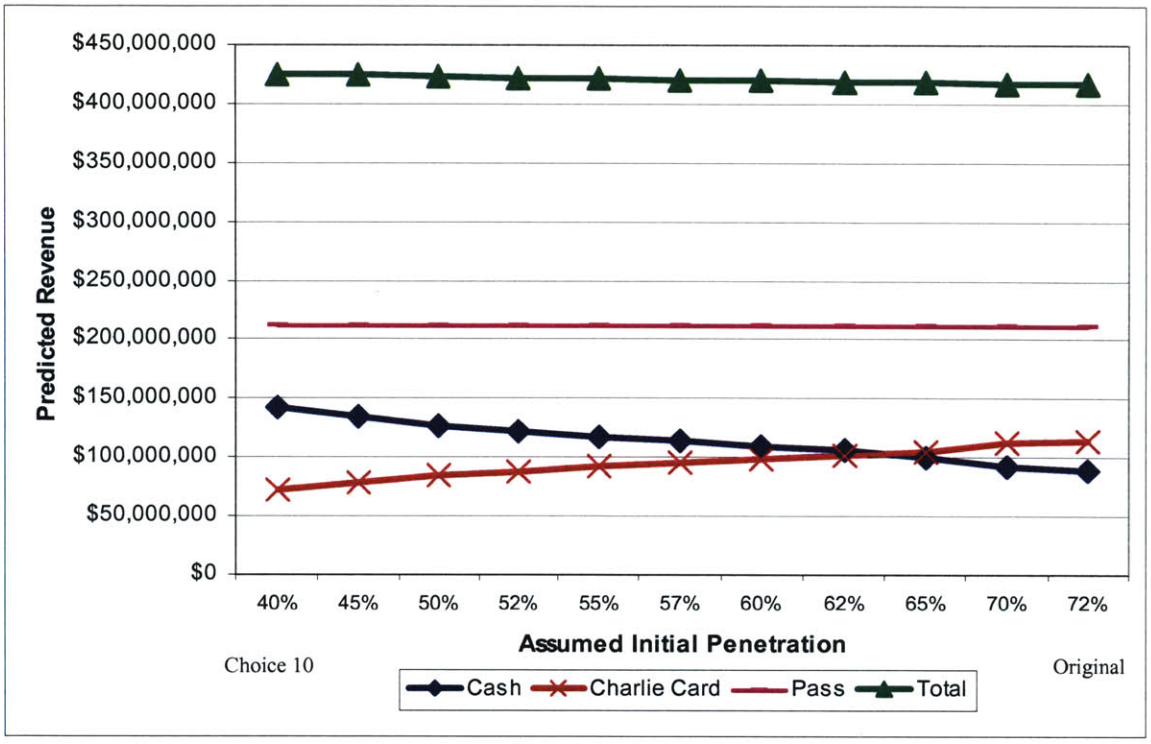

Figure 5-21: CTPS Fare Model Sensitivity Analysis: New Revenues at 25% Discount Level

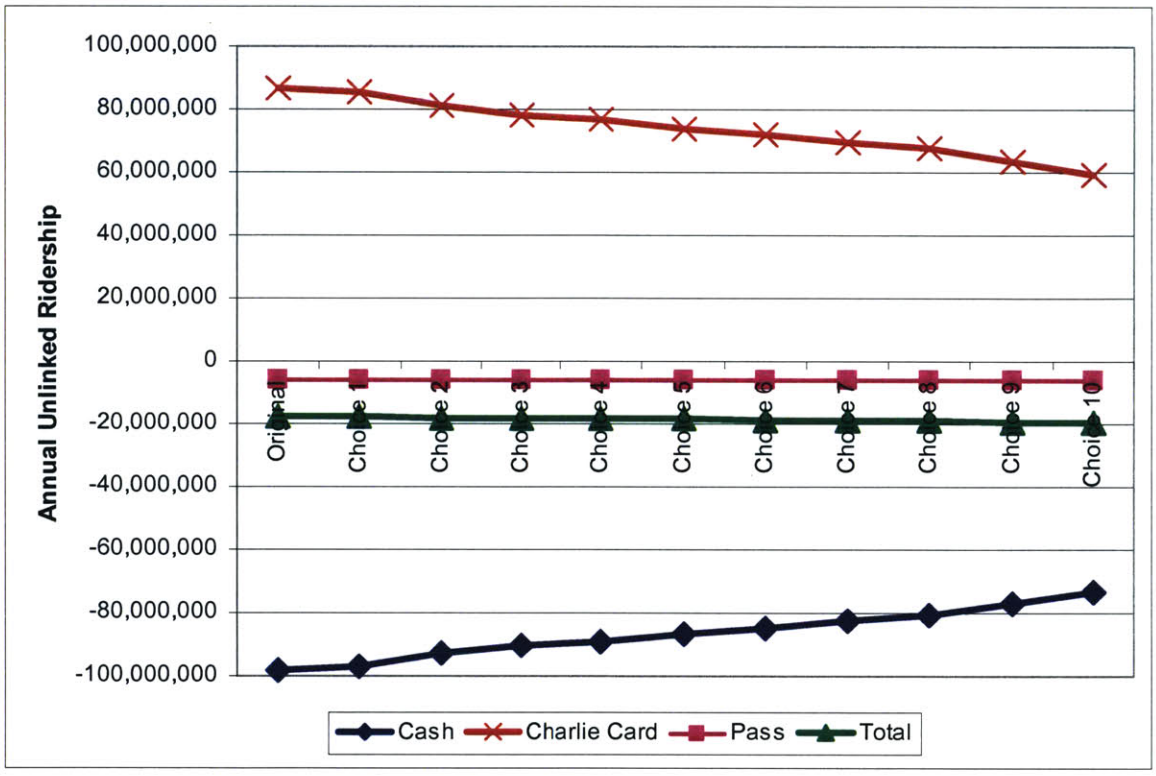

Figure 5-22: CTPS Fare Model Sensitivity Analysis: Change in Unlinked Ridership

In contrast, the CTA fare model does not explicitly require an initial smart card ridership since the initial fare media split is generated by means of a macro. However, because the macro generates new media-specific coefficients only for fare media with an existing base case ridership entered into the fare model, the media-specific coefficient for the fare type available on a smart card has to be assumed. When TranSystems first started using the fare model to predict the Chicago Card ridership, a media-specific coefficient similar to that of the Transit Card's was assumed, in conjunction with results of surveys. Over the years, the media-specific coefficient for Chicago Card (Plus) was adjusted until a sufficient base case ridership for Chicago Card (Plus) exists so that the macro can generate its own media-specific coefficient for this fare type (and medium). Once the media-specific coefficient for the smart card is known, the fare model can compute the new fare media share of all fare types including the smart card and allocates the current ridership into the different fare types by means of a nested logit model (Step 2 in Figure 5-18).

It can be argued that both methods are arbitrary in that they each depend on an initial assumption on penetration before smart cards are introduced. While neither method is perfect, the approach taken in the CTA fare model does appear be more robust than directly changing the initial penetration rate of the smart card as in the CTPS fare model. It allows the fare model to recognize that the smart card does not exist in the base case situation but still allocates a reasonable ridership and revenue to the smart card through the adjustments of a media-specific coefficient. The strength of the CTA fare model is that it relies on survey data, which gives a better indication of the true initial penetration rate than an arbitrary penetration-discount level relationship. From the survey data, transit agencies can have a better estimate of the media-specific coefficient. In addition, the incremental adjustments carried out over time as the fare media share of smart cards increases allow transit agencies to predict the smart card ridership more accurately in the long run.

Incorporation of New Fare Policies

Because smart card technology allows for more flexibility in fare policies, fare models should also take into consideration the possibility of new fare types which could be implemented in future. In this case, CTA's fare model allows one to predict revenues for various fare types as long as the attributes of each fare type are updated. In addition, the CTA fare model distributes the predicted ridership across time periods. The transit agency can charge different fares during off-peak periods, peak periods and weekends and use the model to predict the ridership and revenue impacts.

In contrast, the CTPS fare model aims to calculate revenue for the transit agency and does not emphasize the specific fare strategies. Instead, it calculates the revenue by taking a mode-based approach. To include a new fare type in the CTPS fare model, formulae in the cells have to be updated manually, making it cumbersome and ineffective to test different policies. CTA's fare medium/fare type approach would make it easier to update fare strategies.

Diversions between Different Fare Media

Both the CTPS and CTA fare models account for switches between fare media. In the CTPS model, these diversions are kept simple by adjusting the ridership with diversion rates based on literature and experience. The CTA fare model uses a more sophisticated method of allocating ridership into various fare types through a nested logit model, thereby accounting for customers who switch fare media as a result of the new fare structure. Because the nested logit model is based on survey data, the diversions between the different fare media in the CTA fare model are also more credible and dynamic.

To summarize, while the CTPS fare model may be sufficient for predictions of ridership and revenue based on existing fare structure, when transit agencies transition to smart card technology, there is a need for more sophisticated fare models which are sensitive to the effects of new fare policies. The CTA fare model is one of the more sophisticated fare models known to us and does allow for a wider variety of tasks to be undertaken.

b) Comparison of CTA Fare Model Ridership with Actual Ridership

To develop a better understanding of the CTA fare model, the predicted CTA ridership for June 2005 to May 2006 was compared against the actual ridership for the same period. Two separate predictions were carried out for 2005 and 2006. The ridership per month was then estimated based on the true monthly share of annual CTA ridership in 2005. In addition, the predicted ridership was also adjusted to match the actual breakdown between rail and bus. Figures 5-23 and 5-24 show the comparisons between the model predictions and actual ridership for rail and bus respectively.

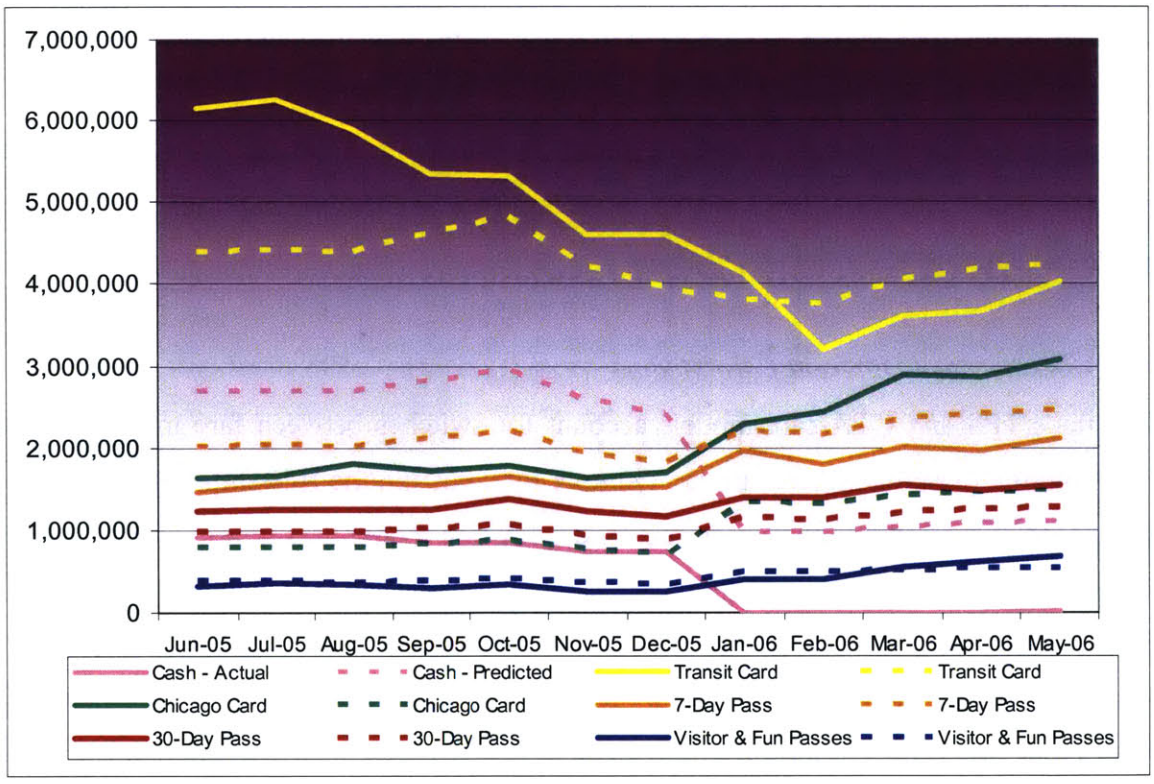

Figure 5-23: Comparison of Predicted and Actual CTA Rail Ridership

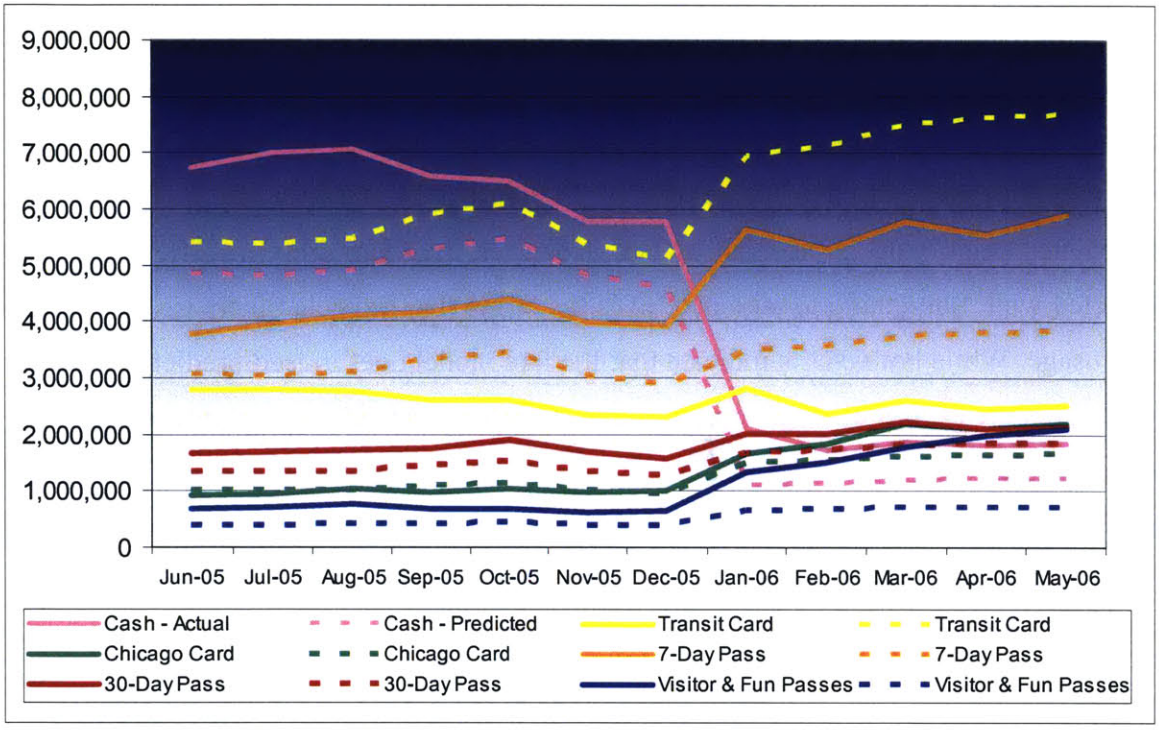

Figure 5-24: Comparison of Predicted and Actual CTA Bus Ridership

In both cases, there appear to be some discrepancies between the actual and predicted ridership, especially for cash, Transit Card, Chicago Card and 7-Day Pass. Part of the reason could be that the base ridership used in the CTA fare model for the first prediction for the year 2005 was not representative of the actual previous year (2004) annual ridership. In the two predictions for the years 2005 and 2006, the base ridership was the 2005 annual ridership. Another reason could be that a significant change in fare structure took place between 2005 and 2006. The CTA fare model is not as equipped to predict changes due to a very large change in fares. For example, the new fare structure resulted in the virtual elimination of rail ridership paid by cash. However, because the model works on elasticity concepts, it will be very unlikely for the model to predict a near zero ridership for cash. A near perfectly elastic relationship (elasticity coefficient = infinite) between the fare and ridership will be necessary for the model to predict a near zero ridership. A third reason is that the breakdown of ridership by months essentially assumes that the fare media split throughout the year is constant. However, this is definitely not the case when there is a significant change in the fare structure such as the one which occurred in January 2006.

Still, the model does predict the trend of each fare medium quite well. In Figure 5-23, the actual ridership using all fare media move in the correct direction after January 2006. The fare model correctly predicts that the 7-Day Pass and Transit Card usage will increase even though it may not have been expected. In Figure 5-24, the only fare medium which is predicted slightly off is the Transit Card. However, the sharp drop in cash payments is predicted well. Something to take note of is the larger than expected increase in Chicago Card usage. While both charts indicate that the fare model does indeed predict an upward trend, the increase has been greater than expected. This increase can be attributed to the waiver of the cost of the Chicago Card (Plus) and other non-fare policies that took place during the same period. Hence, while the fare model can be used to predict the impacts of fare policies, the impacts of distribution, operational and usage policies are still relevant and should not be neglected.

Lastly, it is also pointed out that while the ridership by fare medium is not predicted as well as expected, the total annual ridership and total revenue has been predicted quite well. Figure 5-25 shows the actual and predicted total bus and rail ridership for the period between June 2005 and May 2006. In particular, for the second part of the prediction (January 2006 – May 2006) where the base ridership used in the fare model was representative of the previous year, the prediction is almost perfect. For the year 2006, it appears that CTA will collect slightly higher than projected total revenue.

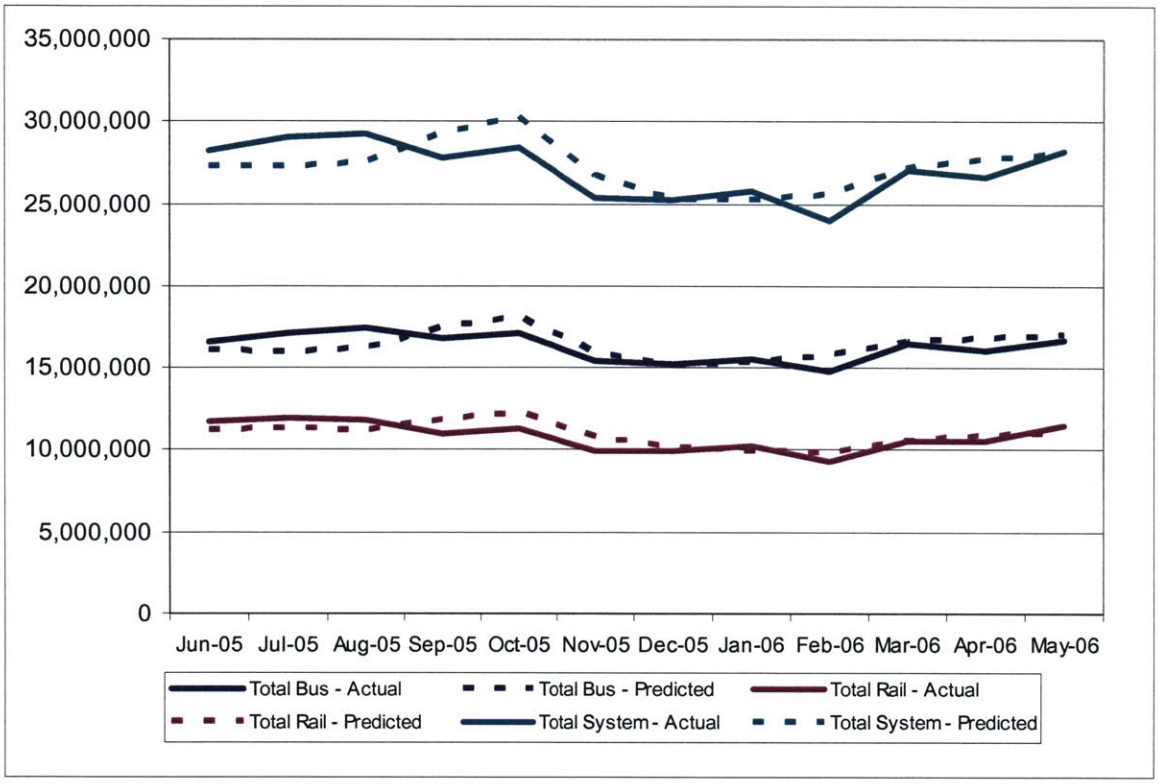

Figure 5-25: Comparison of Predicted and Actual Total CTA Ridership

6 GUIDELINES AND MBTA CASE STUDY

In this chapter, the policies evaluated in Chapters 4 and 5 are summarized in the form of guidance to transit agencies considering the transition to smart cards (Section 6.1).

The most effective strategies will directly affect the customers' utility in their use of the transit services and include:

- fare policy incentives
- the balance between restrictions and providing alternatives to smart cards for various fare types

Other strategies which more indirectly encourage customers to take up smart cards include:

- accessibility to smart card services
- capitalizing on the superiority of the technology
- use of a single card

The recommended guidelines are then applied to the MBTA in anticipation of their new AFC program (Section 6.2).

6.1 Guidelines for Transit Agencies

There are many issues that transit agencies need to consider in order to effectively encourage their customers to take up smart cards. However, the aim of this thesis is to provide a general strategic view on the implementation process of smart card technology. The following sections summarize the different policies discussed in Chapters 4 and 5 and recommend those which have proven to be most effective.

6.1.1 Use of Fare Policy Incentives

In order to speed up the uptake of smart cards, transit agencies should implement fare policy incentives which are favorable to smart card users. Incentives are useful to help

customers discern the benefits of smart cards. Because fare levels are usually the dominant concern of customers, fare incentives are an extremely effective way of differentiating smart cards from other fare media.

Price differentials can exist for normal single fares or for transfer discounts. Transit agencies can restrict transfer discounts to smart card holders as an added incentive for using smart cards. Such price differentials are required if different fare media exist together for the same fare types. Two issues underlie this statement. First, if other fare media exist concurrently, a significant distinction is generally necessary to encourage passengers to switch from their existing fare media to smart cards. Second, because the cost of travel is usually a major concern for customers (especially regular users), price differentials can be very effective to distinguish the different fare media from one another.

Creating price differentials essentially rewards regular customers for using smart cards, thus encouraging these customers to convert to smart cards. Another important implication of these differential fare policies is the opportunity for transit agencies to raise revenue from those customers whose demand for transit is inelastic and are willing to pay more for the "convenience" of making cash payments. Through such market segmentation, a new fare increase would be perceived as a postponed fare increase to regular smart card users, while the agency can collect additional revenues from their more occasional users who stick to other fare media.

Another type of fare policy incentive is a bonus which could be given exclusively to smart card users. Fare policies such as a frequent user bonus, add-value bonus and price capping can be used to encourage specific changes in customer behavior. Because direct fare comparisons are easy for customers to understand, bonuses are less salient than price differentials.

On the cost of the smart card, transit agencies have taken different strategies. As long as the customer has to purchase the smart card, the magnetic stripe card will appear more attractive because it has no cost to the customer. Hence, transit agencies should translate

this cost into a deposit which is refundable when the smart card is returned. In this way, customers will not feel that they are forced to purchase a smart card in order to be able to enjoy the benefits. Alternatively, transit agencies can also initially give customers free cards and subsequently charge them for replacement for lost cards. For example, if registration was required to obtain a free card, transit agencies can track the issuance of the free cards (and promote registration of smart cards), thereby reducing the risk of continually issuing expensive free cards to the same customers.

The key point here is to use fare policies to increase the customer's utility when using smart cards by making it cheaper (or more worthwhile) to use a smart card compared with other fare media.

6.1.2 Balance between Restrictions and Alternatives

Restricting fare types to smart cards is a highly effective way of inducing customers to convert to smart cards quickly. However, even though a complete switchover will easily ensure high penetration rates, it is not necessarily politically and financially possible in the U.S. Still, to establish a critical mass, some limitations are necessary in order to encourage large groups of customers to switch to smart cards quickly.

The restrictions should be limited to customers least likely to reduce their use of transit. One such group of customers use reduced fare passes which requires registration; for example, the Freedom Pass in London is available only on Oyster. As mentioned in Section 5.1.1, it is only logical that these passes are available on smart cards since they require registration. Also, in cities where customers rely heavily on passes for discounted rides, transit agencies should aim to limit passes to smart cards. This presents transit agencies with a good opportunity to obtain a critical mass of smart card users since customers who are used to purchasing passes are not likely to switch their fare type as shown in the case of the 7-Day Travelcards in Section 4.3.2.

On the other hand, transit agencies should still take into account infrequent travelers and provide alternatives for single trips. Since many transit agencies do not currently employ smart card technology for single trip tickets, transit agencies need to ensure that the infrequent travelers are not neglected. While single trip tickets can still function on magnetic stripe card technology, it is recommended that other major fare types be based primarily on smart card technology. Otherwise, transit agencies will need to take additional steps to distinguish smart cards from magnetic stripe cards.

6.1.3 Accessibility to Smart Card Services

To lower the barrier of entry to smart card use and to retain smart card customers, transit agencies must ensure that their customers' use of smart cards can be easily integrated into their daily routine. This would rely heavily on making sure that the smart cards are readily accessible to the public in terms of the initial purchase and for reloading.

A lack of convenient channels to obtain and reload the smart card can be a major deterrent to customers taking up smart cards. If sales outlets are not equipped with reloading facilities, it is another obstacle in the acquisition and use of smart cards. While rail customers can conveniently purchase and reload their smart cards in rail stations, bus riders also need to have convenient locations to purchase and reload their smart cards. A distinction between the purchase and reloading of the smart card is made at this point: the purchase of a smart card is a one-time event but reloading the card will occur throughout the use of the card. For this reason, the reloading locations should be more convenient than the sales locations.

While transit agencies generally do not sell smart cards through vending machines, this is one way to encourage the large-scale adoption of smart cards. First, vending machines can be easily deployed at various locations, including rail stations and bus terminals, allowing customers an easy way to acquire a smart card. Second, the use of vending machines in dispensing magnetic stripe cards is so ingrained in customers that not selling smart cards from vending machines might be seen as taking a step backwards. If self-

service vending machines are available in rail stations, transit agencies can do away with manned ticket outlets and deploy the transit staff for other customer services. Either way, it is important to have sales outlets inside rail stations, be they vending machines or manned ticket outlets as this provides rail customers with the most direct means of purchasing tickets.

For bus riders, remote means such as retail outlets need to be established. Just as rail stations should have both purchasing and reloading facilities, these retail outlets should also allow customers to do the same. All transit agencies except WMATA allow customers to purchase and reload their smart cards at selected retail outlets. This is especially useful for bus riders who do not typically visit rail stations. Transit agencies also need to ensure the ubiquity of the retail outlets. The problem of reaching out to bus riders will not be solved with only a few retail outlets offering smart card services.

In this increasingly technology-savvy society, the Internet is another useful channel for most people to administer their daily activities. Particularly in the U.S. where customers are used to purchasing items online, the Internet is a convenient channel to distribute and reload smart cards. More importantly, it does not differentiate between rail and bus customers and reaches out to many people at any one time.

6.1.4 Capitalizing on the Superiority of Smart Card Technology

Smart card technology provides many features not available with existing fare media. The benefits offered by smart card technology help increase the ease of using the transit system.

First, transit agencies should offer auto-reloading as an optional feature in the implementation of a smart card system. It reduces the need for customers to frequently check the balance of their cards and ensures that customers will always be able to make a trip. The Internet is a useful tool to manage the smart card transactions online and customers do not have to concern themselves with physically visiting reloading locations

to add value to their cards. More importantly, bus riders who do not have easy access to reloading locations can sign up for auto-reloading and do away with the physical aspects of reloading the card. The auto-reloading feature can also potentially substitute for the necessity to allow a negative balance on the smart card, especially if transit agencies are worried about a loss in revenue.

One other major benefit of smart card technology is the ability to allow customers to retrieve the balance on their smart cards if the cards are stolen or lost. This requires that the card be registered so transit agencies should make it easy for smart cards to be registered. This is especially true for high-value transactions such as long-period passes. For cards sold through vending machines, transit agencies should provide an easy registration process via the telephone or the Internet.

Employer-based transit commuter benefit programs are also efficient ways to distribute smart cards and should be encouraged where possible. It capitalizes on the benefits of the program and further benefits customers by making the program benefits more readily available, thereby integrating the benefits of smart card technology with the benefits of the program. At the same time, employers can do away with the hassle of physically distributing cards or vouchers to employees frequently and transit agencies do not need to distribute new cards and vouchers each month. The value of the transit benefit can be transferred to the same smart card each month electronically, hence saving cost and improving efficiency. In addition, the transit commuter benefit program has the potential to create a large smart card user base for transit agencies.

6.1.5 Use of a Single Card

It is strongly recommended that transit agencies issue only one type of smart card that allows concurrent use of multiple fare types, to maximize the benefits that a customer can receive. Both the pay-per-use and pass options should be allowed to be loaded onto one card concurrently, giving customers of smart cards a relative advantage over magnetic stripe cards which lack this function. The dual option also allows customers to use

different fare types on different occasions, thereby giving customers the opportunity to travel at the lowest possible cost using one card. As a complement to auto-reloading for stored value cards, transit agencies can allow customers to hold more than one pass on their smart cards so that customers can purchase multiple passes in advance.

In addition, there is no reason to complicate matters by limiting customers to certain benefits of a smart card and making them choose between different smart cards. The examples of the Chicago Card and Chicago Card Plus are clear. Customers who want to use a 30-Day Pass have to use the Chicago Card Plus. But without a credit card, a customer cannot purchase this card. The problem would be easily solved with a single card having the options of pay-per-use or pass, with or without auto-reloading.

Lastly, transit agencies can also incorporate the use of smart cards in transit-related programs such as the Park-and-Ride program. This can potentially encourage drivers who currently find transit cumbersome and inconvenient to start using transit.

6.2 Application of Guidelines to MBTA

MBTA is currently in the process of converting from cash and token payments to an AFC program. Contrary to most other transit agencies mentioned in the thesis, MBTA has been relying on cash and tokens for many years and uses magnetic stripe card technology only for its passes. Hence, the MBTA is an ideal case for application of the guidelines. In this section, the guidelines are compared against what MBTA has already done for the AFC program. In addition, recommendations are also made where there is still opportunity for MBTA to carry out these policies. Table 6-1 suggests some strategies that MBTA could carry out, in addition to those that have already been planned for the CharlieCard program.

Table 6-1: Summary of MBTA's CharlieCard Strategies

Guideline	What has MBTA done/planned?	What else can be done?
Accessibility to Smart Card Services	1. Install new fare gates and vending machines to sell CharlieTicket and reload CharlieTicket and CharlieCard 2. Sale of CharlieTicket passes online, by phone and by mail	1. Sell CharlieCard through vending machines 2. Sale of CharlieCard through the same channels
Capitalizing on the Superiority of Smart Card Technology	1. Incorporate CharlieCard into the Corporate Pass Program	1. Auto-reloading 2. Registration
Use of a Single Card	N.A.	1. Allow passes and pay-per-use options to be loaded on a single card
Balance between Restrictions and Alternatives	1. Senior and TAP IDs on CharlieCard 2. All monthly passes on CharlieTicket 3. Discontinuation of subway-only pass	1. All monthly passes on CharlieCard
Use of Fare Incentives	1. Proposed new fare structure	1 Daily or weekly price capping

The AFC Program in Progress

MBTA has started installing new fare gates and vending machines at which the CharlieTicket can be bought and reloaded. The CharlieCard can also be reloaded on these machines. However to date, there is no indication that the CharlieCard will be sold through these vending machines. MBTA depends solely on these vending machines to sell the CharlieTicket but plans to sell CharlieCards at retail outlets. It is strongly recommended that the MBTA sell the CharlieCard in rail stations in addition to the retail outlets planned, be it at manned ticket outlets or through vending machines. It has been demonstrated in Chicago that this scenario (where customers cannot purchase smart cards at rail stations) is ineffective in encouraging a quick take-up of smart cards. With the new fare vending machines, manned ticket outlets that used to sell tokens have been closed. The new vending machines do not necessarily have to be converted; a brand new machine which sells smart cards can be installed as well.

Since MBTA will be using the CharlieTicket and CharlieCard concurrently, infrequent

travelers will still be able to purchase single trip tickets on CharlieTicket through these vending machines.

MBTA plans to complete the installation of the new fare gates and vending machines in all subway stations by the end of 2006. This has been a problem with customers who purchase stored value CharlieTickets at one station and realize that they cannot use the ticket at other stations. Fortunately, this is just a temporary problem. At the same time, MBTA's new vending machines have also helped to ease the transition towards the CharlieCard initiative. Tokens are accepted at the vending machines and can be used to purchase the new CharlieTickets. This allows customers to trade in their tokens and become familiar with the new AFC system. When the CharlieCard is introduced, a similar process should be followed.

All monthly passes are now available only on CharlieTicket and can be purchased at rail stations, online, by phone, by mail or at selected retail outlets. The Internet should continue to be used to sell these passes, as well as the stored value CharlieCard, when the CharlieCard is introduced. The new vending machines at converted stations have also started selling the monthly passes on CharlieTicket. It is again recommended that these machines be converted or a new type of machine be introduced at each station to allow the purchase of CharlieCard monthly passes from the vending machines when CharlieCard is formally introduced. Within 6 – 9 months, monthly passes on the CharlieTicket should be completely phased out. All monthly passes, in addition to the new Senior and Transportation Access Pass (T.A.P.) IDs, should be converted to CharlieCards by then.

Future Plans for the AFC Program

Currently, MBTA's transit commuter benefit program called the Corporate Pass Program enjoys a large customer base. Incorporating the transit benefit program into the CharlieCard initiative will allow MBTA to quickly establish a larger smart card user base. In addition, there will be no need to deliver the physical fare media to companies monthly, thereby potentially saving costs for the agency and the employers.

Some features that should be included in the CharlieCard program are auto-reloading and registration. Auto-reloading can be promoted as an advantage of smart cards which will make it very convenient for bus riders as they will not need to physically reload the card. Registration is essential to differentiate CharlieTicket and CharlieCard, which will be used concurrently in the foreseeable future. Only customers who have a registered CharlieCard will be able to retrieve value if the card is lost. These recommendations are in line with the idea that transit agencies should capitalize on the superiority of smart card technology to encourage customers to use smart cards.

Since MBTA has been operating on cash and tokens for a long time and the CharlieTicket is only being introduced, the perceived usefulness of the CharlieCard will be discounted because customers would have just warmed up to CharlieTicket before they are encouraged to switch to CharlieCard. In addition, as of July 2006, there do not appear to be any other distinctions between using the CharlieTicket and CharlieCard, except for the proposed price differentials which will be explained later. The distinctions are insufficient.

To distinguish the CharlieTicket and CharlieCard, the MBTA can allow both passes and stored value to be loaded on the CharlieCard concurrently. The MBTA is a multimodal system which consists of boat and commuter rail, as well as bus and subway services. The normal monthly passes are often only usable for specific modes and having the passes and stored value on the same card will allow customers to travel using the MBTA system beyond their daily commuting routes and services.

When converting to the new AFC program, MBTA has decided to discontinue the subway-only pass and instead focus on a Combo-pass which allows customers to travel on both the bus and subway. While the rationale of the new Combo-pass called the OnePass is to promote the use of transit and encourage multimodal travel, customers who used to be able to purchase the subway-only pass will now have to pay a higher price for the OnePass which some may deem not as useful for them. The MBTA should implement smart card technology to take advantage of the flexibility of the technology and allow for

more kinds of fare policies. A possible compromise for the discontinuation of the subway-only pass might be to create a Selected Line Pass and allow pay-per-use on the same card.

The MBTA plans to implement price differentials when the CharlieCard is introduced. Specifically, it is proposed that traveling on the bus by cash or CharlieTicket would mean that the customer would have to pay 40 cents more ($1.65) than if they were to use a CharlieCard ($1.25). On the subway, customers paying by cash or CharlieTicket will have to pay $2.25, 55 cents more than the $1.70 fare when using the CharlieCard. In addition, no free transfers between buses will be allowed if the customer pays by cash. MBTA further distinguishes the CharlieCard from CharlieTicket by allowing discounted transfers between bus and rail only on the CharlieCard. This corresponds to the proposition that price differentials affect customers directly and it is expected that such substantial differences in prices will encourage more customers to take up CharlieCard. The MBTA should resist efforts by various interest groups to change the initial fare structure proposals which provide clear and distinct benefits to CharlieCard users over CharlieTicket and cash users. Only by maintaining these significant differential policies will the MBTA ensure a high penetration of CharlieCards which will help the agency reduce its future operating costs.

In addition to the proposed price differentials, MBTA should also consider daily price capping or even weekly price capping with respect to the price of a 1-Day or weekly pass. This could potentially increase the use of the stored value CharlieCard (and reduce the need for weekly and/or visitor passes), as in the case of TfL's Oyster PAYG. Since passes are already available on CharlieTicket and CharlieCard, the MBTA needs to target the infrequent users to use CharlieCard. In this case, price capping is useful to attract these customers to purchase a CharlieCard as they are free to use the stored value card anytime they wish to but still potentially enjoy a discount if they travel frequently within the capping period. In essence, the CharlieCard customers will enjoy a "guaranteed lowest price" anytime they use the system.

7 CONCLUSION

The thesis evaluates the strategies for implementing a smart card system efficiently and effectively in transit systems. Using experiences from transit agencies that currently employ smart card technology, a set of guidelines addressing distributional, operational, usage and fare policies was developed. In this concluding section, the implications of the major findings will be discussed (Section 7.1), followed by suggestions for new topics for future research (Section 7.2).

7.1 Summary

Transit agencies need to understand the customer's perspective in taking up a new fare medium before they can implement the smart card system successfully. The five strategies discussed in Chapter 6 are essential for transit systems seeking to migrate from existing cash- or token-based or magnetic stripe fare payment systems to smart card systems. However, none of these policies are sufficient if implemented individually and exclusively.

The key is to attract a critical mass of smart card ridership quickly so that the smart card program can expand most effectively. To do so, this thesis suggests five strategic methods:

1. Use of fare policy incentives
2. Balance between restrictions and alternatives
3. Accessibility to smart card services
4. Capitalizing on the superiority of smart card technology
5. Use of a single card

Of the five strategies, the use of fare policy incentives is the most direct and effective means of attracting customers to use smart cards when a choice of fare media exists. Because the cost of travel is a significant factor to customers, the best way to convert customers to smart cards quickly is through price differentials, as evident in the TfL and

CTA cases. In January 2006, both agencies implemented new fare structures which increase fares significantly for those customers paying by cash or ticket while freezing fares for smart card users. The result has been significant increases in smart card penetration rates in both agencies. Even Hong Kong and Singapore which have largely converted to a smart card-only system give customers discounts when they use smart cards over other fare media.

The positive trends of the penetration rates are further encouraged by other fare policies that could accompany smart card technology. The increase in the use of Oyster PAYG in London can be partially attributed to daily price capping. This strategy is effective for targeting customers who do not travel frequently enough to purchase a period pass. At CTA, the waiver of the cost of the smart card has also helped to increase the uptake of Chicago Card (Plus). Transit agencies need to overcome the absence of an upfront cost for magnetic stripe cards. This thesis recommends either the provision of a free first smart card which is registered to prevent frequent re-issuances or the translation of the cost into a refundable deposit.

In terms of usage policies, it is found that reduced fare IDs and general passes provide the best opportunity to establish a large smart card user base. The former requires the users to register and thus becomes a logical candidate for smart cards. The latter is usually one of the more popular fare types and restriction of these passes to smart cards can build up a smart card ridership quickly since these customers are less likely to switch fare types. The discontinuation of printed 7-Day Travelcards at TfL has resulted in an upsurge of Oyster 7-Day Travelcards. On the other hand, the limitation of passes available on Chicago Card (Plus) was found to be one of the reasons why the uptake of Chicago Card (Plus) has been slower than other agencies. The only way to purchase a 30-Day Pass on a smart card is through the Chicago Card Plus which requires customers to have an auto-reload credit card account.

The combination of price differentials and restrictions on fare types is very effective in increasing the penetration of smart cards as illustrated by TfL. Through a combination of

restrictions and price differentials, the penetration rates of Oyster on rail and bus have reached 70% and 50% respectively in a short span of approximately three years.

Accessibility to smart card services, capitalizing on the superiority of smart card technology and the use of a single card aim to attract customers to take up smart cards while the combination of fare incentives and restrictions on fare types compels customers to convert quickly to smart cards. They do not impact the uptake of smart card users as dramatically but at a certain level, they are required and can clearly facilitate customers' adoption of smart cards.

First, the accessibility to smart card services is important because customers need to be able to initially obtain the smart card and subsequently reload it easily before they can be expected to use the card. Next, by capitalizing on the superiority of smart card technology, transit agencies should provide features such as auto-reloading, registration and transit benefit programs to provide customers with greater ease and security when using smart cards. Lastly, the ease of using a single card in which passes and pay-per-use can be loaded concurrently makes the entire transit system more convenient and affordable for customers.

7.2 Future Research

Suggestions for further research on the impacts of different policies are provided in this section.

Clearly, marketing and promotional activities will help induce customers to start using smart cards. However, the effects of these marketing strategies have not been explored in this research. One of the three ways in which the Land Transport Authority (LTA) in Singapore (a statutory board under the Ministry of Transport) undertook to expedite the transition to ez-link cards was "publicity through commercials and flyers to individual homes, highlighting the convenience of smart cards." (personal communication, March

21, 2006) It would be useful to understand how effective these marketing strategies are, and how they interact with the other policies discussed in this thesis.

As noted in Section 4.1, the distribution of sales outlets and reloading locations depends on retail outlets. The commission costs have been briefly mentioned. To further explore the feasibility and cost-effectiveness of the different distribution strategies, the costs of all sales/reloading channels need to be analyzed. The study conducted by TfL was meant to help determine which channels are most worthwhile to promote and develop in anticipation of current and future needs and could be a stepping-stone to further research in this issue. As smart cards progress to non-transit applications, the costs of providing sales/reloading channels will become more closely related to the provision of the smart card.

It will also be interesting and valuable to examine the different fare policies mentioned in Chapter 5. Since different transit agencies have different characteristics, it will be useful to understand which fare policy will work best for which kind of transit agency. In particular, off-peak/peak pricing can now be carried out more easily and be used as a tool to moderate the ridership levels in the system. The effects of this fare policy will be of interest to transit agencies who are concerned with the peak cost of transit operations.

It was suggested that to predict the smart card ridership upon implementation of the technology, media-specific coefficients in the CTA fare model could be adjusted based on survey data. While the macro in the model does not automatically generate a media-specific coefficient for the smart card, survey results will give transit agencies a better feel of how customers react to the new fare medium and a media-specific coefficient can be better estimated. A sensitivity analysis of how the ridership and revenue impacts will change with the media-specific coefficient for the smart card can be conducted to further evaluate the ability of the CTA fare model to predict the ridership and revenue changes prompted by the inclusion of a new fare medium. This will be useful to construct a fare model which is more suitable to predict changes in ridership and revenue due to significant fare changes.

APPENDIX: CASE STUDIES OF TRANSIT AGENCIES

A. Hong Kong's Octopus Card

A1.Introduction

Public transportation is widely used in Hong Kong, a special administrative region of China with almost 7 million people. Over 11 million passenger journeys are made every day on the public transportation network which includes the railway, bus, tram, minibus, ferry and taxi. Hong Kong's usage of smart card technology in the public transportation sector can be considered one of the earliest and most successful examples in the world. The smart card, known as the Octopus, is a joint venture formed by several public transportation companies, called the Octopus Cards Limited (OCL) (previously known as Creative Star Limited). These companies include Mass Transit Railway (MTR) (57.4%), Kowloon-Canton Railway (KCR) (22.1%), Kowloon Motor Bus (KMB) (12.4%), Citybus (5.0%) and New World First Bus (NWFB) (3.1%).

A2.Hong Kong's Smart Card Program

Launched in September 1997, Hong Kong's Octopus cards were quickly taken up by the people in Hong Kong. Three million cards were sold in the first three months. As the usage of Octopus increased, the list of services using Octopus also expanded over the years. More transportation agencies adopted Octopus, and even more merchants began to accept Octopus as a form of payment. The Octopus is a multi-operator, multi-purpose card which has transformed into other forms such as cell phone cases and watches. The table below summarizes the timeline of significant events in the development of the Octopus card. On the MTR system, the penetration rate of Octopus has reached 90% in 2005 (personal communication, July 3, 2006).

Date	Event
1997	♦ Sep: Launch of Octopus on Hong Kong's public transportation network
1999	♦ Octopus customers can now reload their cards at selected retail outlets ♦ Launch of the Automatic Add-Value Service (AAVS) ♦ Launch of Octopus Millennium Watch ♦ Nov: Extension of Octopus to 2 Maxicab routes
2000	♦ Octopus applied and obtained a Special Purpose Deposit-taking Company authorization from the Hong Kong Monetary Authority to increase its non-transit applications ♦ Octopus is adopted at a residential estate for access control ♦ Non-transit transactions accepted on Octopus, including convenience stores, fast food shops, photocopying, cake shops, vending machines, schools and car parks ♦ Extension of AAVS for Personalized Octopus Card to more banks
2001	♦ Creative Star becomes a profit making company from its earlier non-profit status ♦ Extension of Octopus to trams, peak tram, photocopying centers, public swimming pools, sporting venues and racecourse admission fees ♦ Extension of AAVS for Personalized Octopus Card to more banks ♦ Jul: Introduction of SchoolPlus Scheme at HKTA Ching Chung Secondary School; Students can use their cards to take attendance, buy food and borrow books from the library ♦ Nov: Introduction of Octopus for payments at over 430 7-Eleven stores
2002	♦ Extension of Octopus to cross-border buses, supermarkets, personal care centers, cinema ticketing and Electronic Service Delivery[1] (ESD) kiosks ♦ Mar: Introduction of Xpress-on cover for Nokia 3310 and 3330 cell phones to convert the cell phones into m-commerce devices

[1] The Electronic Service Delivery Scheme is a government-backed project that serves as a one-stop shop for public and commercial electronic services, as well as solutions that represent a combination of vision, commitment, industry know-how, business insight and e-commerce expertise. It is part of the Hong Kong's "Digital 21 IT Strategy." http://www.esd.gov.hk/home/eng/default.asp

2003	♦ Extension of Octopus to exhibition and convention registration, household outlets, congee shops, digital music kiosks, insurance machines, Wellcome supermarket chain, Chinese wet markets and Government parking meters ♦ Aug: Extension of Octopus to Red Minibus routes
2004	♦ Extension of AAVS to 19 financial institutions ♦ Mar: Extension of Octopus to Tsuen Wan First 'Cross Harbour Red' Minibus Route ♦ Jun: Extension of Octopus to Green Minibus routes ♦ Jul: Extension of Octopus to "Rehabus", a barrier-free transport service to the mobility handicapped, facilitating their daily travel to work, school, training center, or go out for shopping, entertainment and medical treatment. ♦ Aug: Introduction of Octopus "Rewards on the Go" - top 10 spenders with highest accumulated Octopus usage on a registered card or product at any Octopus retail outlet or car park wins prizes; Octopus readers are installed on gangway doors leading to first class compartments ♦ Sep: Introduction of Card Protection Plan in which customers can access a 24-hour free worldwide hotline to report the loss of Octopus cards, among other financial and non-financial cards; Reduction of liability period of lost cards for Personalized Octopus and AAVS users from 24 hours to 6 hours; Introduction of HK$7 Refund Handling Fee on customers who return their On-Loan Octopus less than 3 months after the date of issue; Introduction of a HK$20 AAVS Bank Switching Fee for customers who switch banks for their AAVS ♦ Nov: AAVS is extended to Octopus cards and products of any type
2005	♦ Extension of Octopus to apparel chain stores ♦ Oct: Octopus Holdings Limited becomes a holding company for Octopus Cards Limited. New subsidiaries were formed – Octopus Rewards Limited, Octopus Knowledge Limited, Octopus Connect Limited, Octopus Investments Limited ♦ Nov: Octopus Rewards Limited launches a new common loyalty program to earn rewards at leading Hong Kong merchants
2006	♦ Apr: Customers can now reload value either HK$250 to HK$500 through the AAVS with Dah Sing Bank/Mevas Bank ♦ Jun: First batch of taxis to accept Octopus

A3.Distribution, Operational and Usage Policies

On buses, customers either pay by cash or Octopus. On the trains, in addition to Octopus, magnetic stripe single trip tickets and Tourist 1-Day Passes are sold. There is a special Octopus package for tourists which includes Airport Express Single Journey tickets, three days of unlimited rides on the MTR, an Octopus with a stored value of HK$20 that can be used after the three-day unlimited ride period and the usual HK$50 Octopus deposit.

Should a customer need to return an On-Loan Octopus, he/she returns it to any Customer Service Center or Ticket Office at MTR, KCR (East Rail), KCR (West Rail), KCR (Light Rail) stations or New World First Ferry piers. For the Child, Elderly and Adult On-Loan Octopus, a Refund Handling Fee of HK$7 will be charged if the card is returned within 3 months from the date of issue. The fee increases to HK$10 if the card returned is a Personalized Octopus either issued on or after November 1, 2004 or issued before November 1, 2004 and returned within 5 years from the date of issue.

Over the years, the use of Octopus on the public transportation network has increased substantially. From being used only on the services of the five joint venture partners initially, the list of transportation services which accept Octopus has expanded to Maxicabs, trams, taxis, Green and Red Minibuses etc and also include the "Rehabus", a para-transit service. The range of services has also increased to parking, retail, self-service, leisure facilities and school payments. Customers can use Octopus to pay for photocopies, drinks at vending machines, shopping purchases etc. Access control, convention registration, identification purposes and school attendance-taking are among the other functions supported by Octopus. OCL also regularly holds promotional activities such as lucky draws and distribution of promotion coupons by registering the Octopus numbers of the cards on the readers in order to encourage customers to use Octopus more frequently.

Octopus also comes in other forms. Since introducing its Octopus Millennium Watch in 1999, OCL has started selling other designs of watches, watch key-chains and cell phone

covers which all operate like an Octopus card would.

To purchase an anonymous On-Loan Octopus, customers can visit MTR, Airport Express Line, KCR, KMB, New World First Ferry and New World First Bus Customer Service Centers and Ticket Offices at selected locations. Personalized Octopus has to be applied through selected MTR, KCR and New World First Ferry Customer Service Centers or participating financial institutions. Sold Octopus can be purchased online, at selected MTR and Airport Express Line Customer Service Centers, KCR East Rail Ticket Offices and all 7-Eleven and Circle K convenience stores while the variants of the Octopus card can be bought online.

There are several ways to reload the card. Cash can be used when adding value at manned retail outlets that accept Octopus for payment, Customer Service Centers or Ticket Offices at all MTR and Airport Express Line stations, selected KCR stations, KMB Sha Tin Central Bus Terminus, selected New World First Ferry piers, New World First Bus Admiralty (East) Bus Terminus and Citybus Central-Exchange Square Bus Terminus. In addition, Electronic Fund Transfer can be used to reload the Octopus at vending machines at selected car parks, MTR/Airport Express/KCR East Rail/KCR West Rail/selected KCR Light Rail stations and selected ATMs of AEON ATM Network (for AEON Credit Card users only). Both cash and Electronic Fund Transfer reloading allows up to HK$1,000 to be added to the Octopus.

The Automatic Add-Value Service (AAVS) is an optional service for customers to link their Octopus to accounts at participating banks and reload their Octopus. When the stored value of the card falls below zero, the card will automatically be reloaded. Initially, the reload amount was limited to HK$250 once a day. Recently, a few banks have started to give customers the option of either HK$250 or HK$500. More banks are expected to increase the reload amount in a bid to make reloading more convenient for customers. This service which began as an extra service for Personalized Octopus only was extended to all Octopus products in November 2004. If the customer decides to switch banks, he/she would be required to pay a handling fee of HK$20. Currently, 21 financial

institutions are participating in the AAVS program.

Since Personalized Octopus and Octopus with AAVS necessitate some personal information be collected, these cards offer more protection to customers than anonymous On-Loan Octopus does. If the Octopus is stolen or lost, customers can report the loss by phone. Customers would have to bear a lost-card handling fee of HK$20, as well as the card cost of HK$30 if it is an On-Loan Octopus. Previously, customers would also need to bear the loss of card value from unauthorized use or auto-reloading (if linked to AAVS) for the first 24 hours after the loss has been reported. In September 2004, the time frame was reduced to 6 hours, which is required for all frontline Octopus readers to receive information about the blacklisted card. In addition, a special Card Protection Plan was announced in September 2004 to gives customers access to a 24-hour free worldwide hotline whereby they can report loss of the card even if they are overseas. The refund on the remaining value on the card (less necessary charges) will be mailed to the customer within 7 days. Since transit agencies do not have any information about anonymous On-Loan Octopus, there is no means of refunding any loss incurred on this type of card.

When boarding a train or ferry, customers should touch the Octopus on readers present at the entry and exit. The customer needs only to touch the reader once when boarding the bus. Only cards with positive balance can be used. However, as long as the card has a positive balance at the beginning of the trip, a negative balance up to HK$35 is allowed on the Octopus for the trip. The Octopus needs to be reloaded for subsequent trips to be made. The remaining balance is shown on the reader each time the customer makes a trip and touches the card on the reader. In addition, the remaining balance is also printed on the receipt whenever the Octopus is used at a retail outlet. If the customer wishes to check the remaining value on the card at any other time, he/she can use the Octopus Enquiry Processor located at MTR, KCR East Rail, KCR Light Rail and KCR West Rail stations.

In August 2004, KCR installed separate first-class Octopus readers on its East Rail trains. These readers are installed next to the gangway doors leading to all first-class

compartments, thus allowing customers to ride in the first-class compartments even if they had previously entered a standard-class compartment. Doors between the standard- and first-class compartments are secured so that only customers who pay for first-class can enter.

A4.Fare Policies

There are two types of Octopus, the sold and the on-loan. Sold Octopus cards are special-theme cards which are introduced regularly and promoted as souvenir cards. There is no initial stored value, the remaining value on the card is non-refundable and the card cannot be returned. On the other hand, while there is a HK$50 deposit for On-Loan Octopus, this sum is refundable when the card is returned. There is also a HK$20 handling charge when purchasing an On-Loan Personalized Octopus card. A Personalized Octopus can function as a Child, Elderly or Adult Octopus and has the name (and photo, if desired) imprinted on the card. Students who want to enjoy student concessionary rates need a Personalized Octopus encoded with student status.

The Hong Kong transit operators have been actively pushing customers to use Octopus by introducing various transfer incentives and fare concessions. Various fare schemes have been initiated over the years by individual agencies and among the agencies. The table below shows a list of fare incentives that the major transit agencies in Hong Kong have carried out previously or are currently engaged in.

Transit Agency	Fare Incentives
MTR	♦ Discounted Adult and Concessionary fares on the MTR train service (as compared to single tickets) ♦ 50% off Airport Express from Kowloon Station or Tsing Yi Station when using Adult, Elder, Child, Student or Personalized Octopus with student status if taxi receipt of HK$60 or more is presented (till June 2006) ♦ HK$2 discount off next MTR ride on same day at designated stations when Adult Octopus is read at corresponding MTR Fare Savers ♦ Intermodal transfer discount on selected transportation services at designated MTR stations (New Lantao Bus routes, Green Minibuses, Kwun Tong Cross-Border Express) ♦ Special parking rates for Adult Octopus under MTR Park & Ride Scheme at selected parking lots ♦ Free MTR Connections to or from Airport Express stations (within one hour) ♦ Free return journey on Airport Express when traveling on the same day (offer is available on Same Day Return ticket too)
KCR	♦ Discounted Adult and Concessionary fares on the East Rail, Ma On Shan Rail, Light Rail and West Rail(as compared to single tickets) ♦ Light Rail Personalized Octopus Frequent User Bonus Scheme ♦ Flat HK$2 on West Rail to any destination for customers using Child and Elder Octopus when traveling on Saturday, Sunday and public holidays (till December 31, 2006) ♦ HK$2 rebate for West Rail passengers transferring from taxi when traveling from any station between Tuen Mun and Kam Sheung Road to any station between Tusen Wan West and Nam Cheong (till December 31, 2006) ♦ Intermodal transfer discount on selected transportation services at designated East/West Rail stations (Green Minibuses, franchised routes, NWFB routes) ♦ East Rail[2] One-Month Pass (till September 2006) and West Rail One-Month Pass (till December 2006) ♦ Six-month trial of Ma On Shan Rail One-Month Pass

[2] Applicable only for standard class trips, excluding trips to/from Lo Wu and Racecourse stations. Includes riding on the Ma On Shan Rail system.

	♦ "Ride 10 Get 1 Free" and "Ride 8 Get 1 Free" programs ♦ Fare Package for West Rail customers to transfer with a cross boundary route between Huanggang and West Rail Kam Sheung Road station ♦ "Second Trip Discount" program
KMB	♦ Flat fare of HK$2[3] or half fare (whichever is lower) for passengers aged 65 or above using Elder Octopus on all KMB and Long Win routes except racecourse routes, and Long Win "A" and "X" routes (till January 28, 2009) ♦ Same Day[4] Return discount for passengers taking a return journey on the same route or route group (not more than 9 other Octopus transactions between forward and return trips) (till February 18, 2009) ♦ Octopus Bus-Bus Interchange Scheme ♦ 10% discount on fares of HK$15 and above on all KMB and Long Win routes (except recreation and Airport "A" routes) ♦ 5% discount on fares between $10 and $14.90 on all KMB and Long Win routes (except recreation and Airport "A" routes)
Citybus	♦ 50% discount on same day return journey when traveling on Cityflyer between Airport and the city ♦ 50% discount on same day return journey when traveling on Citybus Hong Kong Disneyland Express Routes between Hong Kong Disneyland and the city ♦ Octopus Bus-Bus Interchange Scheme ♦ Section fare[5] concessions on selected routes ♦ Flat fare of HK$2[6] or half fare (whichever is lower) for passengers aged 60 or above using Elder Octopus on selected Citybus routes (till January 28, 2009)

[3] For a period of time, the concessionary fare for the elderly was previously a flat fare of HK$1 instead of the current HK$2.

[4] "Same Day" refers to the period between the start and end of service, i.e. 5 a.m. till 2 a.m. the following day for day services, and 10 p.m. to 7 a.m. the following day for overnight services.

[5] On longer routes, a customer may pay less when he/she boards the bus after a specified stop which is further away from the start of the route.

[6] For a period of time, the concessionary fare for the elderly was previously a flat fare of HK$1 instead of the current HK$2.

	♦ Same Day[7] Return discount for passengers taking a return journey on the same route or route group (not more than 9 other Octopus transactions between forward and return trips) (from February 19, 2006 to February 18, 2009) ♦ Special offers for Citybus members ♦ Advance Paid Day Return Pass ♦ Octopus 10% Fare Discount for Long-distance Services
New World First Bus	♦ Flat fare of HK$2[8] or half fare (whichever is lower) for passengers aged 60 or above using Elder Octopus on selected Citybus routes (till January 28, 2009) ♦ Same Day[9] Return discount for passengers taking a return journey on the same route or route group (not more than 9 other Octopus transactions between forward and return trips) (from February 19, 2006 to February 18, 2009) ♦ Octopus Bus-Bus Interchange Scheme ♦ Value packages ♦ Bus-Rail interchanges with KCR ♦ Advance Paid Day Return Pass

[7] "Same Day" refers to the period between the start and end of service, i.e. 5 a.m. till 3 a.m. the following day for day services, and 10 p.m. to 7 a.m. the following day for overnight services.

[8] For a period of time, the concessionary fare for the elderly was previously a flat fare of HK$1 instead of the current HK$2.

[9] "Same Day" refers to the period between the start and end of service, i.e. 5 a.m. till 3 a.m. the following day for day services, and 10 p.m. to 7 a.m. the following day for overnight services.

On buses, the Octopus Bus-Bus Interchange Scheme allows Octopus users to enjoy discounts when transferring from one specific bus route to another bus route one. The two bus routes can be operated by the same or different bus companies, thus giving customers more route choices. For senior citizens, there are special concessionary fares for senior citizens when they use the Elder Octopus. Discounts for return journeys carried out on the same day on the same route and for selected section fares are also available for Octopus users. For the discounted section fares, customers would have to touch their Octopus on the readers again when they alight because the full fare is first deducted when a customer boards the bus. The discount would be "returned" to the card when the Octopus is tapped on the reader upon alighting. Some bus companies also define a bundle of route segments that jointly offer a lower price when paid by Octopus than when paid individually. In terms of individual transit agencies, NWFB has arrangements with KCR to provide free or discounted transfers to/from designated KCR station. Transit agencies like Citybus also give their members additional offers when using their Octopus.

Over the years, the different transit agencies have experimented with other fare schemes too. The Advance Paid Day Return Pass was a predecessor of the Same Day Return discount and required the customer to select the option during the forward journey and pay for both the forward and return journey such that a 10% fare discount is given on the return journey fare. In addition, for selected routes, discounts between 5-10% were also given when customers pay by Octopus.

The rail operators also have their fair share of fare initiatives. Besides having lower fares when using Octopus and offering free or discounted transfers at designated stations for designated public transportation modes, both MTR and KCR also offer fare strategies of their own.

On the MTR system, customers who participate in the Park & Ride Scheme can enjoy parking discounts at selected parking lots. MTR also has special arrangements for its subway system with its special Airport Express Line for Octopus users. A more innovative way of offering customers travel discounts is the Fare Saver program. For

each Fare Saver reader at a specific station where the Octopus is waved, there is a corresponding MTR station at which the customer can enjoy a HK$2 discount off the fare of the next trip taken from this corresponding MTR station on the same day.

When traveling on the KCR system, children and senior citizens using Octopus pay a flat HK$2 fare on the West Rail during weekends and public holidays. Besides Green Minibuses, franchised routes and NWFB routes, customers transferring from taxi to West Rail also enjoy a HK$2 rebate at selected stations. Light Rail users with Personalized Octopus can benefit from the Light Rail Personalized Octopus Frequent User Bonus Scheme[10] which gives customers extra travel bonus when a specific amount of money has been used on the Light Rail system within a specific number of days.

KCR initiated the use of monthly passes on Octopus which allows unlimited rides on the specific route in one month. More recently, the introduction of the East Rail and West Rail One-Month Passes have again been extended so that customers can take advantage of the passes for a longer period of time.

In terms of past fare schemes, the "Ride 10 (8) Get 1 Free" program gave Octopus users a free domestic ride for every 10 (8) East Rail domestic trips made within one week from Monday to the following Sunday. Similar to the value packages on bus, KCR West Rail also came up with a fare package for customers transferring with a cross boundary route between Huanggang and West Rail Kam Sheung Road station. The Second Trip Discount Scheme once offered gave Octopus users a 20% fare discount when they make a second trip on the East Rail system.

This case study was compiled using information from:
Octopus Website
MTR Corporation Website

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[10] Adult: HK$3 bonus for every HK$30 of Light Rail travel accumulated within 6 days. Child/Senior citizen: HK$1.5 bonus for every HK$15 of Light Rail travel accumulated within 6 days. Student: HK$3.40 bonus for every HK$12 of Light Rail travel accumulated within 4 days.

New World First Bus Website

New World First Ferry Website

Citybus Website

Kowloon Motor Bus Co. Website

KCR Corporation Website

E-Mail Correspondence with Mr. Gary Lau from MTR Corporation

And other sources as listed in the Bibliography.

B. WMATA's SmarTrip Card

B1. Introduction

The Washington Metropolitan Area Transit Authority (WMATA) has the 2nd largest rail system and 5th largest bus network in the U.S. WMATA includes 86 Metro stations and 12,535 bus stops which serves 3.5 million people over a 1,500 sq. mile area, consisting of the District of Columbia, as well as two suburban Maryland counties (Montgomery and Prince George's), three Northern Virginia counties (Arlington, Fairfax and Loudoun) and three Northern Virginia cities (Alexandria, Fairfax and Falls Church). In 2004, 190 million people trips were made on the rail system and 146 million people on the bus system. As of early 2006, the percentage of rides on Metrorail paid for by the SmarTrip card is approximately 60%. The percentage of rides on Metrobuses paid for by the SmarTrip card is approximately 18% (personal communication, June 26, 2006).

B2. WMATA's Smart Card Program

WMATA's smart card is known as the SmarTrip card and stemmed from February 1995 when the GoCard developed by Cubic Transportation Systems, Inc was used in a demonstration program. Funded by Federal Transit Administration (FTA), this one-year long pilot involved 1,500 people, 19 Metrorail stations, 3 Metrobus lines and 5 Metro station parking lots. In May 1999, WMATA became the first transit agency in the U.S. to integrate the smart card technology system-wide into its fare payment system. The SmarTrip card has since been expanded so that it can now be used on other Maryland and Virginia transit agencies, including Baltimore Maryland Transit Administration (MTA) and Maryland Area Rail Commuter (MARC), Ride On (Montgomery County), TheBus (Prince George's County), Loudoun County Transit, Arlington Transit (ART), Virginia Railway Express (VRE), City of Fairfax City University Energy-saver (CUE), Driving Alexandrians Safely Home (DASH) (Alexandria Transit Co.), Potomac and Rappahannock Transportation Commission (PRTC) OmniRide and Fairfax Connector, making it a multi-operator regional smart card. The table below shows the timeline of significant events in the development of the WMATA smart card program.

Date	Event
Feb 1995	♦ Launch of 1-year long pilot testing of the smart card (known as GoCard)
May 1999	♦ WMATA officially launches the SmarTrip card on Metrorail and for Metro station parking ♦ SmarTrip Metrorail fares are the same as with other fare media; in additional, any purchase of $20 or more on the SmarTrip card earns a 10% fare bonus as with the magnetic stripe cards
Sep 2000	♦ Employers can now load their employees' SmarTrip cards using SmartBenefits[11], instead of issuing Metrocheks[12]
Nov 2002	♦ 90-day pilot testing of SmarTrip technology on Metrobus begins along the Arlington routes
Jun 2003	♦ 10% bonus on farecard and SmarTrip card purchases of $20 or more is eliminated.
Sep 2003	♦ Suspension of SmarTrip card sales due to production problem
Oct 2003	♦ Online sales of SmarTrip cards are resumed
Nov 2003	♦ SmarTrip fare boxes are installed on Metrobuses at the South Avenue Bus Garage
Mar/Apr 2004	♦ SmarTrip card sale events to ease transition to new parking lot payment system
May 2004	♦ All Metro station parking lots are equipped with SmarTrip dispensing machines
Jun 2004	♦ 06/28: All Metro station parking lots accept only SmarTrip cards to pay parking fees ♦ The SmarTrip Regional Customer Service Center
Jul 2004	♦ Sales of SmarTrip cards at "Live at Penn" event ♦ 07/21: Online sales of SmarTrip cards suspended due to short supply ♦ 07/22: All sales of SmarTrip cards suspended due to short supply

[11] SmartBenefits is a web-based program that allows employers to electronically distribute transit and Metro station parking benefits to their employees via adding value to the employees' SmarTrip cards. http://www.wmata.com/bus2bus/smartbenefits/pages/sbwhatisit.html

[12] Metrocheks are exchangeable farecard vouchers that can be used like normal Metrorail farecards. Any unused value can be exchanged for fares of equal or greater value for Metro passes, van pool, and commuter bus and rail services. http://www.wmata.com/bus2bus/smartbenefits/pages/mchowitworks.html

Aug 2004	♦ 08/09: All Metrobuses outfitted with new fare boxes accepting SmarTrip cards ♦ 08/16: Stored value capacity of SmarTrip cards increased from $200 to $300 ♦ 08/19: Resumption of online sales of SmarTrip cards
Sep 2004	♦ Distribution of free SmarTrip cards by Arlington officials
Mar 2005	♦ 03/14: Metro station parking lots no longer allow negative balances on SmarTrip cards for parking fees
May 2005	♦ Increase in the number of vending machines that sell SmarTrip cards ♦ On the spot replacement of lost/defective SmarTrip cards
Mar 2006	♦ Elimination of maximum $7 trade-in of magnetic farecard to SmarTrip card
Mar – Sep 2006	♦ Partnership with Zipcar to sell and register SmarTrip cards
Apr 2006	♦ Partnership with Washington Nationals to distribute free SmarTrip cards
Jul 2006	♦ WMATA announces plans for SmarTrip-only express lanes at 3 Metrorail stations

In FY2005, 700,000 SmarTrip cards were sold, of which 560,000 were sold from SmarTrip dispensers located at the Metro station parking lots. This is a huge growth compared to the total of 500,000 cards sold in the previous 6 years combined (WMATA slides, 2006).

B3. Distribution, Operational and Usage Policies

To ride the WMATA Metrorail system, one can pay using either a magnetic stripe farecard or a SmarTrip card. Currently, pay-per-use is available on both fare media. However, one-day passes and 7-day passes are only available on the magnetic stripe farecard. On the Metrobuses, SmarTrip cards are accepted as pay-per-use, in addition to cash and tokens and paper one-day and weekly bus passes. The magnetic SmartStudent Pass works on both the Metrorail and Metrobus systems. On buses, students show the pass to bus drivers who will have to verify the validity of the passes. WMATA made a specific decision not to allow magnetic stripe cards on Metrobuses when it installed the new SmarTrip fare boxes on Metrobuses, making the SmarTrip card, cash, tokens and paper passes the only means of fare payment on buses.

The SmarTrip card is truly a multi-operator card which allows customers to travel on several bus networks in the Washington D.C. Metropolitan Area. As such, it is necessary to build a regional service center where all smart card transactions from various transit agencies can be handled, including the development and operation of a smart card customer service centre, card management systems and the clearing and settling of smart card transactions. In June 2003, WMATA awarded the contract to design, build, operate and maintain the SmarTrip Regional Customer Service Center to the ERG Group and Northrop Grumman Information Technology. The SmarTrip Regional Customer Service Center opened in June 2004, allowing seamless travel across various transit agencies for customers.

Besides making the SmarTrip card regional, WMATA also moved toward developing a multi-purpose smart card. Specifically, WMATA has conducted several pilot projects

with other partners to make the SmarTrip card multi-purpose. In 2000 and 2002 respectively, WMATA teamed with the U.S. General Services Administration and U.S. Department of Education for a transit card with building-access capabilities. Approximately 2,000 cardholders were involved in the two projects that continue to operate till today.

WMATA also first issued a dual contactless and magnetic stripe card in partnership with the First Union National Bank in 2000. This project was transferred to Citibank when the two banks merged. Starting in April 2005, WMATA and Citi® introduced a 30-month pilot project, the Citi® Platinum Select® SmarTrip® MasterCard® which combines the functions of the SmarTrip card and a credit card. The card acts as both a contactless card for transit payment and a magnetic stripe card for credit card transactions. There is a 5% cashback bonus on all Metro purchases (including Metrorail, Metrobus and Metro parking) for the Citi® Platinum Select® SmarTrip® MasterCard® users.

WMATA has also partnered with many other groups and companies, including Zipcar and the Washington Redskins, to distribute and sell SmarTrip cards. WMATA actively promotes the use of these cards during sales and promotional events in conjunction with activities occurring in the Washington D.C. Metropolitan Area.

WMATA provides general services as summarized in the following table to support the operation of SmarTrip.

Function	Details
Sale of Cards	Online, Metro sale offices, retail outlets, commuter stores and vending machines at Metrorail stations
Check Value	Vending machines at rail stations, fare boxes on Metrobuses, by phone
Add Value	Vending machines at Metrorail stations or on Metrobuses
Multiple Traveler Use	Not possible – each traveler must have his/her own card
Replacement of Stolen/Lost Cards	By phone, mail, online or on-the-spot at the Metro Center Sales Center
Registration	Voluntary

Altogether, there are 6 retail outlets in the Washington Metropolitan Area that sell the SmarTrip cards. In contrast, there are more than 60 locations which sell Metrorail farecards. To add value to a SmarTrip card, customers can use vending machines at Metrorail stations. However, more unusually, WMATA also provides the ability to add value to SmarTrip cards on Metrobuses. The same fare box that deducts the fare from the SmarTrip card can be used to add value. On both the vending machines and the fare box on Metrobuses, customers must remember to touch the card on the reader at the beginning and at the end of the transaction. In the beginning, the allowable stored value capacity of the SmarTrip card was $200 which has since increased to $300, allowing customers to use the card for a longer period of time before adding value to the card. In contrast, the Metrorail farecard allows a stored value of up to $45 only.

A negative balance is allowed when making a trip on the Metrorail or Metrobus system. However, the card has to be reloaded before it can be used to enter another Metrorail station or Metrobus. On the other hand, to pay for parking at Metro station parking lots, the SmarTrip card must have sufficient funds to cover the parking fee: the customer must top up the SmarTrip card before he/she can exit the parking lot.

The customer may transfer the value of a used farecard or Metrochek (worth $7 or less) or an unused Metrochek or farecard (of any value) toward the value of a SmarTrip card. Previously, the farecard has to be at most $7 in value before it can be traded for a

SmarTrip card with the same value. Each trade-in requires a separate transaction

If the SmarTrip card is registered, any value on a lost card can be replaced, minus a $5 replacement fee. On-the-spot replacement is now available at the Metro Center Sales Center: the customer purchases a new card and adds value to it. The remaining balance on the lost card is transferred to the new card within 5 business days. Otherwise, the customer would have to report the loss at to the SmarTrip Regional Customer Service Center by phone or by sending a letter or an email.

B4. Fare Policies

The SmarTrip card itself costs $5. In terms of fare and pricing policies, WMATA does not differentiate between the SmarTrip card and the rest of the fare types. No discount or benefit is given to a SmarTrip card user. Even the 10% bonus that used to be available for purchases of $20 or more was eliminated for both the farecard and SmarTrip card in June 2003. However, WMATA has been looking into a "fairest fare" policy that would determine the best fare product for a given time period for a customer based on his/her usage of the Metro system during that period.

This case study was compiled using information from:
WMATA Website
Smart Card Alliance, Inc: Washington Metropolitan Area Transit Authority – SmarTrip
E-Mail Correspondence with Mr. Craig Maxey
And other sources as listed in the Bibliography.

C. Singapore's ez-link Card

C1.Introduction

Singapore's smart card, called the ez-link card, is used on the transit system which includes the Mass Rapid Transit (MRT), the Light Rail Transit (LRT) and the buses. The transit system consists of more than 290 bus routes, 67 MRT stations and 43 LRT stations, operated by SBS Transit Ltd, SMRT Trains Ltd and SMRT Buses Ltd. Everyday, approximately 5 million trips are made on the transit system, spreading all over the city-nation of more than 4.4 million people. To date, more than 8 million ez-link cards have been issued. The penetration rate of the ez-link cards is as high as 90% on buses and 96% on light/heavy rail (personal communication, July 24, 2006). In addition to transit applications, the ez-link card can also be used for certain non-transit purposes.

C2.Singapore's Smart Card Program

EZ-Link Pte Ltd is in charge of the sale, distribution and management of the ez-link cards, choosing Citibank, N.A. to be the stored-value card issuer. On the transit side, Transit Link Pte Ltd is the acquirer and card services agent. For non-transit applications, QB Pte Ltd is the card acquirer. The ez-link card was first introduced as a pilot contactless smart card program in January 2001 in schools for payment purposes. In April 2002, the ez-link cards were officially sold and used on the transit system as part of a switchover from the pre-existing magnetic stripe card system. This transition program which allowed both the magnetic stripe card and the more sophisticated ez-link smart card to be used for payments would last till January 2003 before the ez-link card became the main fare medium, with the magnetic stripe cards being phased out. The table below shows the timeline of significant events in the development of the ez-link card in Singapore.

Date	Event
Jan 2001	♦ Pilot program of payments in schools
Jan 2002	♦ 01/14: Selected participants can purchase the ez-link card for use on the MRT/LRT system and certain bus routes
Apr 2002	♦ 04/13: The ez-link card was introduced for sale at all TransitLink ticket offices located at bus terminals and MRT/LRT stations, as well as 5 NTUC FairPrice stores and 3 Cheers outlets
June 2002	♦ 06/27: Introduction of Bus Concession Pass[13] (BCP) on ez-link cards ♦ 06/27: Interim card for seniors who have yet to receive their ez-link cards, in anticipation of fare increases in July 2002 which allow ez-link card users to pay less than cash and magnetic stripe card users
July 2002	♦ Fares[14] for adults and senior citizens (off-peak[15]) on the MRT/LRT system and all fares across the board on buses are increased, with the smallest increase in ez-link card fares, followed by magnetic stripe card fares and then cash fares (bus only) ♦ Introduction of personalized ez-link cards by Singapore Mint
Oct 2002	♦ 10/01: Introduction of Train and Hybrid Concession Pass on ez-link cards ♦ 10/14: The Standard Ticket, a single trip use smart card, replaces the magnetic stripe Single Trip Ticket
Nov 2002	♦ Introduction of Stored Value Recovery (SVR) Scheme and library compliance for personalized ez-link cards ♦ 11/16: Magnetic stripe cards are no longer sold or revalued at any vending machines or ticket offices ♦ 11/20: Introduction of Giro[16]-linked ez-link cards

[13] Bus concession passes are available only to fulltime National Servicemen, primary, secondary and tertiary students, as well as children. In addition, there are also train concession and hybrid (bus and train) concession passes.

[14] The adult fare system in Singapore is distance-based on the MRT/LRT system and express and trunk bus services. Senior citizens, children and students pay flat fares for their rides.

[15] The off-peak period is designated as 9a.m. till end of operations for SBS Transit services and 9a.m. to 4.30p.m. and 7p.m. till end of operations for SMRT Bus and Train services.

Dec 2002	♦ 12/01: The entire transit system becomes fully ez-link operational
Jan 2003	♦ Complete transition to ez-link smart card system ♦ Customers now have to pay the normal $5 deposit when purchasing the Adult ez-link card (previously waived)
Feb 2003	♦ A new feature, Auto-Mode, allows passengers to alight from the front door without having to inform the bus driver to change the mode on the front door reader to register the exit
Apr 2003	♦ 04/13: The first two of six new Card Replacement Offices were opened
Aug 2003	♦ Launch of Auto-Credit card top-up with VISA: up to 7 ez-link cards can be linked to a debit or credit card ♦ ez-link card users can now use the QB "Tap and Give" Kiosks till September 2003 to make $1, $2 or $5 donations to charity ♦ 08/26: Refund of $1 deposit on Standard Ticket now available at any 7-Eleven stores, in addition to General Ticketing Machines (GTMs) at train stations
Sep 2003	♦ 09/10: ez-link cards can now be used to purchase movie tickets and bowling games at Cathay Cineleisure Orchard. ♦ Introduction of six-month Mobile Top-Up pilot program at Anglo-Chinese School (Barker Road): customers can top up their ez-link cards by phone and receive the added value from Fixed Location Processor (FLP) situated in the school
Oct 2003	♦ 10/25: The "Tap and Give" Program is extended, in cooperation with Majlis Ugama Islam Singapura (MUIS), to allow Muslims to contribute their annual alms through their ez-link cards ♦ 10/30: A commemorative ez-link card is introduced in conjunction with Aquarama 2003, the 8th International Aquarium Fish and Accessories Exhibition & Conference
Nov 2003	♦ 11/04: There is now a non-refundable $5 deposit on all new adult ez-link cards
Dec 2003	♦ 12/13: Tertiary students who have graduated are allowed to continue the use of their tertiary ez-link card as long as they re-validate their tertiary cards as ordinary adult ez-link cards

[16] GIRO is an electronic direct debit mechanism used by billing organizations to collect payments from customers. It is a tripartite mechanism between billing organizations, customers and the bank. Previously, GIRO-linked magnetic stripe cards were also available. http://www.abs.org.sg/interbankgiro.htm

Apr 2004	♦ 04/06: ez-link cards can now be used to pay for digital-media and digital-camera print orders on the Fujifilm Digital Print Centre (DPC), a self-service photo kiosk ♦ ez-link card users can now purchase drinks on limited Coca-Cola GTMs which allows cashless payments
Nov 2004	♦ 11/01: ez-link cards that are GIRO-linked or have Auto Credit Card Top-Up facilities will not be accepted at non-transit retailers and merchants, with the exception of selected school canteens. ♦ A 5-month Mobile Top-Up pilot is introduced at Eunos and Yishun MRT stations
Jul 2005	♦ The adult ez-link fares increase by 1 to 2 cents for buses and 1 to 3 cents for trains while adult cash fares and single trip ticket fare increase by 10 cents across the board
Aug 2005	♦ The City Shuttle fare increase makes paying by ez-link card cheaper than paying by cash
Apr 2006	♦ 04/20: Visa Asia Pacific announces an agreement with QB Pte Ltd and EZ-Link to embed ez-link functionality in Visa credit, debit and prepaid cards

C3.Distribution, Operational and Usage Policies

Opting to convert fully to the smart card system, Singapore gradually phased out the magnetic stripe card between April 2002 and December 2002. At the beginning of the program, each Singaporean and Permanent Citizen was entitled to one free ez-link card (i.e. no deposit was required) as long as the ID number is recorded to prevent duplication. In the following months, the ticket offices stopped selling and revaluing the magnetic stripe cards. More Card Replacement Offices were also established to facilitate the refund of the magnetic stripe card value. Any remaining value on the magnetic stripe card could still be refunded until four years from the date of issue or last revaluation as long as the card was issued or last revalued after August 1, 2000. At the same time, the Standard Ticket was introduced, replacing the existing magnetic stripe Single Trip Ticket. The Standard Ticket is a cheaper contactless smart card which can only be used for a single trip on either the MRT or LRT on the day of purchase. It requires a deposit of $1 which can be returned when the card is returned at any 7-Eleven store or GTM.

To use the ez-link card on the MRT/LRT system, the customer only has to tap the card on the reader when entering and exiting the fare gate, just as he/she would insert the magnetic stripe card when entering and exiting the fare gate. However, to use the ez-link card on buses, the customer would now have to tap the card on the reader when boarding and alighting the bus. This results in an extra step whereby the customer must remember to tap out or else he/she will be charged the maximum fare which is registered on the card when the entry reader first reads the card. The actual fare for the corresponding trip distance is then deducted from the card when the card is again tapped on the exit reader when alighting. Thus, when the ez-link card was first introduced on buses, it was required that passengers board through the front door and alight at the rear door because the two readers were programmed to operate differently. If the passenger wanted to get off from the front door, he/she would have to notify the bus driver to change the mode of the front reader to allow him/her to exit properly. A month after the complete switchover to ez-link cards, the Auto-Mode feature was introduced, ending the hassle of switching mode and the necessity to alight from the rear door. The Auto-Mode feature allows the entry

readers to be set at both 'entry' and 'exit' modes, and identify the correct mode for a card that is tapped on the reader.

In August 2004, the Vehicle Location System (VLS) was launched. Fare equipment on buses updates the fare stages automatically using the Global Positioning System (GPS) and the bus odometer. Hence, bus operators no longer have to update the fare stages manually.

To purchase an ez-link card, customers can visit Passenger Service Counters within MRT stations or selected ticket offices at bus terminals and MRT stations. To add to and check the value the ez-link card, the customer can choose to use either the GTM or Add Value Machine (AVM). The AVM and GTM have similar functions. In addition to checking and adding value by debit card, the GTM allows reloading using cash, issues Standard Tickets and activates/deactivates the GIRO link on the card. For a small fee, customers can also choose to reload at any 7-Eleven stores and one McDonald's outlet. EZ-Link Pte Ltd also worked with a Mobile Top-Up service whereby customers can call in to add value to their cards and then proceed to Fixed Location Processors (FLPs) at limited MRT stations to receive added value. The ez-link card has a minimum reloading value of $10 and maximum reloading value of $100.

Singapore's ez-link cards also allow for auto-reloading under the GIRO-link program and the Auto Credit Card Top-Up facility. The GIRO-linked ez-link card would automatically be reloaded with a pre-specified amount when its stored value falls to zero or lower when used on the bus or MRT/LRT. The Auto Credit Card Top-Up facility program also allows customers to pay automatically for a small charge per auto-reload transaction using their Visa credit cards. Thus, customers do not have to worry about the balance in their bank accounts. However, from November 2004, ez-links with either the GIRO link or Auto Credit Card Top-Up facility would not be able to be used for non-transit applications because if lost, these cards could potentially be used to pay for non-transit applications by other people which could be far higher amounts than transit applications.

If a concession card or a Giro-Linked/Auto Credit Card Top-Up ez-link card is lost, the customer should call the TransitLink Contact Center or visit any of the 6 Card Replacement Offices to request for immediate replacement. A replacement fee would be charged but the remaining value on the card can be refunded. The concession card can also be reapplied for through mail. Concurrently, the Stored Value Delivery (SVD) Scheme offered by the Singapore Mint for personalized ez-link cards returns the remaining balance on lost cards when customers notify the Singapore Mint.

The ez-link card aims to be a multi-purpose card which allows for both transit and non-transit applications. QB Pte Ltd, the company in charge of promoting ez-link's non-transit capabilities, has introduced various non-transit applications over the years, including innovative Coca-Cola vending machines, paying alms and donations and paying at certain retail and food & beverage outlets. It is also used as a student ID card in all educational institutions.

Starting from November 2002, personalized ez-link cards with the option of library compliance can be bought from the Singapore Mint by phone or online. If desired, the personalized ez-link card can be encoded with the customer's ID number to double up as a library card to borrow books at all public libraries (Singapore Mint Press Release, 2002). The Singapore Mint also sells commemorative and special-theme ez-link cards, as does QB with the special-theme cards. Merchants can also choose to use the ez-link cards as loyalty cards. On top of that, several corporations have also incorporated building access capabilities within ez-link cards.

Recently, it was announced that in conjunction with Visa Asia Pacific, a new dual functionality card will be produced. This new Visa card would function as a magnetic stripe Visa credit, debit or prepaid card and also work as a contactless ez-link card (Visa Press Release, 2006).

C4.Fare Policies

There are two types of fares on the Singapore transit system: distance-based and flat fares.

Flat fares are set aside for students, children and senior citizens during off-peak period. Adults pay distance-based fares on both the MRT/LRT system and buses. As such, concession passes are available only for students and children. Senior citizens also require a senior citizen ez-link card to enjoy discounts during the off-peak periods. Students (primary, secondary and tertiary) have special student IDs issued by the Ministry of Education which double up as ez-link cards. Hence, there was a need for a change in December 2003 to allow graduating tertiary students to continue to use their student IDs as adult ez-link cards so that the cards would not be wasted.

When the ez-link cards were first officially sold in April 2002, the S$2 refundable card deposit was waived, essentially making the ez-link card "free". The S$3 refundable travel deposit was still applicable. This first card was given "free" to each Singaporean and Permanent Citizen. To prevent waste of cards, each customer was limited to 3 new purchases per queue for subsequent cards. Three months later, the public transportation sector raised the fares for adults on the MRT/LRT and bus system. Notably, the increase was higher for magnetic stripe cards (which were still in use simultaneously till Jan 2003) than for the ez-link cards. On the MRT/LRT system, the adults pay a 4-cents increase on ez-link cards and a 5-cents increase for magnetic stripe cards. While previously paying 60 cents and 70 cents respectively when the ez-link card and magnetic stripe card were used, after the fare change, seniors now pay 64 cents and 65 cents instead during the off-peak period for the corresponding fare media. On the bus, the fare increases for cash, magnetic stripe card and ez-link card were 10 cents, 5 cents and 3 cents respectively.

In January 2003, the normal S$5 deposit resumed for the adult ez-link cards. Cards cost S$15 to purchase – a S$3 refundable travel deposit, a S$2 refundable card fee and a S$10 stored value. In November 2003, the original S$2 card fee was increased to S$5 and became non-refundable. Cards bought at S$15 now only have a S$7 stored value after deducting the S$3 refundable travel deposit. Subsequent reloadings still have to be in multiples of S$10.

The transit fares were again increased in July 2005 where increases on the adult ez-link card were between 1 cent and 2 cents for buses and between 1 cent and 3 cents for trains.

Adult cash fares on buses and Standard Tickets were increased by 10 cents. One month later, the City Shuttle bus experienced a similar bus fare increase: the adult ez-link card was increased by 1 cent and cash fares were increased by 10 cents.

While the fares have been increased from time to time, the transfer discount available only to ez-link users has remained unchanged.

This case study was compiled using information from:
TransitLink Website
ez-link Website
QB Pte. Ltd. Website
E-Mail Correspondence with Mr. Silvester Prakasam from Land Transport Authority, Singapore
And other sources as listed in the Bibliography.

D. CTA's Chicago Card (Plus)

D1.Introduction

The Chicago Transit Authority (CTA) operates the 2nd largest public transportation system in the U.S., enabling customers from the City of Chicago and 40 surrounding suburbs to carry out their daily activities through a large network of over 151 bus routes and 7 rail routes. Each day, 2000 buses serve more than 12,000 posted bus stops while 1190 heavy rail cars serve 144 stations. On a typical weekday, there are 1.5 million rides on the CTA system.

D2.CTA's Smart Card Program

CTA started a pilot program in August 2000 to test the feasibility of smart cards, known as the Chicago Card. In November 2002, the first batch of Chicago Cards was formally rolled out. Fourteen months later in January 2004, an enhanced version of the original card, called the Chicago Card Plus, was introduced. As of May 2006, the percentages of full fare rides made on Chicago Card (Pay-Per-Use) are 26.8% and 13.1% for rail and bus. For the Chicago Card Plus (30-Day Pass), the percentages are 6.3% and 3.4% for rail and bus (CTA Fare Media Summary). Besides the CTA system, the Chicago Card (Plus) can also be used on Pace buses. The table below shows the timeline of significant events with regard to the CTA smart card program.

Date	Event
Aug 2000 – Jan 2001	♦ Pilot Program: 3500 cards issued at limited rail stations, CTA Central Office and 2 Dominick's Finer Foods locations
Nov 2002	♦ Introduction of Chicago Card ♦ 10% bonus for every $10 value added on a Chicago Card (applicable to magnetic stripe cards too)
Jan 2004	♦ Introduction of Chicago Card Plus ♦ Automatically charged with pre-determined amount when value falls below $10 (using credit card authorization) ♦ Waiver of $5 cost of card till Mar 31, 2004
Apr 2004	♦ 10% bonus discontinued on magnetic stripe cards but retained on Chicago Card
Jan 2005	♦ Waiver of $5 cost of card till Mar 31, 2005
Feb 2005	♦ Expansion of Chicago Card Sales Outlets to Jewel, Osco, Dominick's and Currency Exchanges
Jun 2005	♦ Go Lane Boarding Pilot Program[17] at 8 rail stations and on 10 bus routes
Aug 2005	♦ Expansion of Go Lane Program: increase in the number of Go Lane buses and addition of one more bus route
Dec 2005	♦ Waiver of $5 cost of card till Mar 31, 2006 ♦ Dec 1: Touch-N-Go[18] units at 65 Currency Exchanges and CTA Headquarters that allow customers to check card values and add value to cards
Jan 2006	♦ Increase in cash fares and magnetic stripe card fares on rail only by 25 cents (but not on Chicago Card (Plus)) ♦ 10% bonus for every $20 added value on Chicago Card (Plus) ♦ Elimination of cash transfers (magnetic stripe cards or Chicago Cards required for 25 cents reduced fee transfers)
Mar 2006	♦ Waiver of $5 cost of card till May 31, 2006

[17] An express fare payment lane will be designated on the left-side of the bus entrance for Chicago Card (Plus) customers and the right side will be reserved for customers paying with a magnetic stripe transit card or cash. Rail stations will dedicate one turnstile for those paying with Chicago Card (Plus).
(http://www.transitchicago.com/news/ctaandpress.wu?action=displayarticledetail&articleid=116777)

[18] CTA's innovative Touch-n-Go unit is an electronic touchpad for customers to check balances and add value to their Chicago Cards. Touch-n-Go units are available at 65 Currency Exchanges and CTA head quarters. (http://www.chicago-card.com/cc/pos/index.html)

D3.Differences between Chicago Card and Chicago Card Plus

CTA has two types of smart cards: the Chicago Card and the Chicago Card Plus. In terms of technology, both the cards are essentially the same. However, the two cards are programmed to operate differently. The Chicago Card is the simpler of the two, having only a pay-per-use capability whereas the Chicago Card Plus allows for both pay-per-use and a 30-Day pass. On the pay-per-use option, auto-reloading will occur whenever the balance drops to $10. A pre-specified amount ($10, $20, $30, $40 or $60) will be added to the account balance. In addition, the Chicago Card Plus requires online registration that enables online management of the trip transactions. This online management feature necessitates an email address and a major credit card to link the trip transactions to the bank account because the Chicago Card Plus does not store information on the card. In contrast, the Chicago Card records the transactions and balance on the card. For the Chicago Card, registration is hence not compulsory but is encouraged. Because of these differences, the Chicago Card and Chicago Card Plus have been marketed differently. The Chicago Card is targeted at the customers who either tend to use cash and do not have credit cards or do not have access to internet. The Chicago Card Plus is targeted to make payments convenient for customers who are internet-savvy and rely on online banking services.

D4.Distribution, Operational and Usage Policies

The following table shows a summary of the differences in the operations of the 2 types of Chicago Cards.

Function	Chicago Card	Chicago Card Plus
Options Available	Pay-Per-Use only	Pay-Per-Use or 30-Day Pass
Sale of Cards	CTA Headquarters, selected outlets, by mail, online, by phone	CTA Headquarters, by mail, online, by phone
Checking Value	Vending machines at rail stations and selected locations, off-site Touch-N-Go locations	Online, by phone
Adding Value	Vending machines at rail stations and selected locations, off-site Touch-N-Go locations	Online using credit card or Transit Benefit dollars, Auto-reload
Multiple Customers (Passback)	Up to 7 customers can board on a single card	Up to 7 customers can board on a single card if on pay-per-use basis. If on 30-Day basis, first customer does not pay, subsequent (up to 6) customers can ride as pay-per-use
Replacement of Stolen/Lost/Damaged Cards	Request for replacement by phone or online. If registered, remainder value on card can be retrieved, minus a $5 replacement fee.	Request for replacement by phone or online. Remainder value on card can be retrieved, minus a $5 replacement fee.
RTA/CTA Transit Benefit Program[19]	Not Available	Available

CTA still accepts the magnetic stripe Transit Cards, passes and cash as alternatives to the Chicago Cards. The Reduced Fare, U-Pass and 7-Day Pass options are not yet available on the Chicago Cards as of now. Using the Chicago Cards is easy on the CTA system; a customer only has to tap the card on the touchpad at the rail turnstile or when boarding the bus since the fares are flat. With the Go Lane Program, Chicago Card/Chicago Card Plus can have access to their own boarding lanes on buses and in rail stations, thereby making the smart cards even more attractive to use and decreasing the bus stop dwell times.

19 The RTA/CTA Transit Benefit Program is a program that allows a company and its employees to take advantage of tax laws to reduce commuting costs. Federal law will allow individuals to set aside up to $105 in pre-tax earnings each month to pay for transit commuting costs. (http://www.rtachicago.com/infocenter/transitcheck.asp)

Previously, sale locations of the Chicago Card and Chicago Card Plus were limited. A customer would either have to travel to the CTA headquarters to obtain a card for immediate use, or wait up to 7-10 business days if the card is ordered by mail or online. Since February 2005, there are 229 locations, including the CTA headquarters, where customers can buy either zero-valued cards and/or $20 (with an additional $2 bonus) Chicago Cards. In comparison, there are almost 600 sales outlets for the Transit Cards number. These locations are in Chicago and its neighboring areas, but concentrated mostly in Chicago. Chicago Card Plus is still only available through the CTA headquarters, by phone or online.

Prior to December 2005, to check or reload the Chicago Card value, customers had to use the vending machines at CTA rail stations. But since then, customers can also use 66 off-site Touch-N-Go locations. Since the Chicago Card Plus has the auto reloading feature and thus there is no need for the user to check or top up the card value manually, these options are not available to the Chicago Card Plus user. As mentioned earlier, the Chicago Card Plus does not store the card balance offline and hence restricts itself from utilizing the Touch-N-Go units. The Chicago Card Plus value can only be checked by phone or online.

Paying for multiple customers traveling together (also known as "passback") is possible on both the magnetic and Chicago Card (Plus). The Chicago Card Plus, however, could be used a 30-Day pass or pay-per-use. If the customer has chosen the option of a 30-Day pass, the Chicago Card Plus can still be used to pay for up to 6 other customers on a pay-per-ride basis. The additional customers enjoy all transfer benefits as long as the group travels together throughout the trip. The fares for the additional pay-per-use rides will be charged to the credit card, along with an automatic $10 credit to the Chicago Card Plus for future pay-per-use rides. Suppose the customer decides to terminate the account, the $10 credit (as with the $10 minimum balance on the pay-per-use option) must be used up by the customer before the account becomes permanently disabled.

If a card needs to be replaced, the customer must report the loss of the card, and then

either go to the CTA headquarters to pick up a new card, or wait for a replacement card to arrive by mail.

D5.Fare Policies

In terms of fare policies, CTA has been increasingly using cost waivers and fare incentives given to Chicago Card and Chicago Card Plus customers.

The cost of the cards was first waived in January 2004 when the Chicago Card Plus was launched in a bid to encourage local employers to participate in the RTA/CTA Transit Benefit program by utilizing the online management capabilities of the Chicago Card Plus. Anticipating the surge in demand from the fare increase implemented in January 2006, the cost was again waived for 3 months before being extended till May 2006 due to an increase in ridership as a result of the Dan Ryan Expressway construction works.

The first fare incentive was the 10% bonus for every $10 added to the Transit Cards and Chicago Card (Plus). In April 2004, this was discontinued on the Transit Cards but retained on the Chicago Cards, making it clear that the smart cards were the most cost-efficient fare medium.

In January 2006, CTA implemented a new fare structure which affected cash users and Chicago card users differently. Under the new fare regime, cash transfers are eliminated, making discounted transfers at 25 cents only possible on Transit Cards and Chicago Card (Plus). While bus fares were not increased for either Transit Cards or the Chicago Cards, cash users now pay 25 cents more to ride. In addition, the rail fares for Transit Cards and cash were increased by 25 cents while for the Chicago Cards, they remained at $1.75. In summary, only the Chicago Card (Plus) users did not experience a price hike. To encourage higher usage of the Chicago Card (Plus), the threshold for the 10% bonus was also increased to $20.

This case study was compiled using information from:

CTA Website

E-Mail Correspondence with Mr. Jeff Busby

And other sources as listed in the Bibliography.

E. TfL's Oyster Card

E1. Introduction

Transport for London (TfL) operates the Underground (a.k.a. the Tube) system, the Docklands Light Railway (DLR), about 60 National Rail (NR) stations, the bus system and two tram networks, on top of other transportation responsibilities in Greater London. Each day, 6.3 million bus journeys and 3 million Underground journeys, out of the approximate total of 30 million daily journeys, are made in Greater London.

E2. TfL's Smart Card Program

In 2002, TfL, together with TranSys and London Underground, started a £1.2 billion smart card program. Their aim is to create a world-class ticketing system that would allow London's commuters to travel faster and more conveniently in a cashless system. The pilot program included 80,000 Underground and bus staff who were given the smart cards, called Oyster cards, to use in August 2002. In May 2003, 200 cards were distributed to the public. The success of these initial phases thus far led to the formal introduction of Oyster cards in June 2003 for the Monthly and Annual Travelcards. By November 2002, 6000 buses and 255 Underground stations were equipped to process the Oyster cards. The table below shows the timeline of significant events with regard to the TfL smart card program.

Date	Event
Aug 2002	♦ Oyster Cards issued to TfL staff as pilot program
May 2003	♦ Limited introduction of Oyster Cards to the public
Jun 2003	♦ Introduction of Oyster Cards in the Underground (fares stay the same)
Oct 2003	♦ Introduction of Oyster Cards on buses ♦ Monthly and Annual Travelcards available only on Oyster
Jan 2004	♦ Underground fares frozen at 2003 levels for adult single Underground and DLR journeys across all zones for Oyster card holders using Pay-As-You-Go[20] ♦ Flat discount rates at weekends ♦ Under-11s travel free on buses
Jan 2005	♦ Oyster Pay-As-You-Go and 'early bird' discounts to reduce use of cash on buses and promote off-peak[21] travel
Feb 2005	♦ Implementation of Daily Price Capping: Passengers on the Underground, bus, tram or DLR will never pay more than the price of a One-Day Travelcard,
Mar 2005	♦ TfL unveils plan to incorporate e-money on Oyster
Sep 2005	♦ 7 Day Travelcards are now only available on Oyster at TfL ticketing outlets; Refundable deposit of £3 waived from 14th August till a later date ♦ Free bus and tram travel and reduced Underground and DLR fares for Under-16s (with Oyster photocards) ♦ Automatic reloading available at Underground and DLR stations; Pay-As-You-Go Oyster Card will be reloaded with either £20 or £40 whenever the card balance falls below £5 at the barrier

[20] "Pay-As-You-Go" was formerly known as "Pre-Pay".

[21] Off-peak is defined as before 0630h and after 1900h on weekdays and all day on weekends on the Underground, and before 0630h and after 0930h on weekdays and all day on weekends on buses.

Jan 2006	♦ Oyster fares are frozen or reduced while cash fares are increased dramatically (Cash fare up to double Oyster fare) ♦ Daily Price Capping is reduced to 50p less than the 2006 price of a One-Day Travelcard or Bus Pass ♦ Extra 30 minutes for early morning Oyster discount on bus (off-peak now starts at 0700h) ♦ Zone 1 Travelcard and Family Travelcard are withdrawn
May 2006	♦ TfL announces deal between the Mayor, Tfl and Department for Transport to extend the number of National Rail stations using Pay-As-You-Go from the current 60 to over 300, lessening the need to have two separate tickets for overland rail and TfL services
Sep 2006	♦ Free Bus and Tram Travel for Under-18s in full time education (with Oyster photocards)

E3. The Different Fare Types on Oyster

The Oyster Card can be used on the Underground, the DLR, the bus system, the tram and 60 National Rail stations (increasing to 300). TfL first introduced the Oyster Cards for season tickets (Monthly and Annual Passes) in 2003 and gradually phased out the use of paper Travelcards for these periods. In October 2003, 7-day Travelcards and Bus Passes became available on Oyster Cards too. At the same time, the Freedom Pass[22] was also converted to Oyster Card.

In January 2004, Pay-As-You-Go on the Oyster Card was launched for the Underground and DLR. Pay-As-You-Go allows commuters who do not travel on a regular basis to first load the card with a specific amount of money and pay for each trip as they travel. Four months later in May 2004, Pay-As-You-Go was also made available on the bus system.

There are also Oyster photocards for children and students to receive free and discounted travel. Adults would need photocards to purchase certain weekly, monthly or annual season tickets.

E4. Distribution, Operational and Usage Policies

The following table summarizes Oyster Card operations.

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[22] The Freedom Pass enables permanent residents in a London borough, aged 60 or over or with an eligible disability, to travel free on London's public transportation system, including the bus, Underground, trains, DLR and trams. The freedom pass is paid for by the resident's local borough council.

Function	Details
Sale of Cards	Underground stations, DLR stations, selected National Rail ticket offices, ticket machines at tram stops, London Travel Information Centers and Oyster Ticket Stops, online, by phone
Checking Value	Online, touch screen ticket machines or card readers at Underground stations
Adding Value	Online, by phone, at Oyster Ticket Stops, at Underground station ticket offices or touch screen ticket machines, London Travel Information Centers and selected London National Rail ticket offices
Multiple Use	Up to 3 Travelcards and/or Bus Passes and Pay-As-You-Go on a single card
Replacement of Stolen/Lost Cards	Report loss online
Replacement of Damaged Cards	Request for replacement at any Underground station
Registration	Compulsory on monthly or longer period Travelcards

Currently, only the One-Day and 3-Day Travelcards, One-Day and 7-Day Bus Passes and Travelcards issued by National Rail are available as printed tickets. Cash can also be used, albeit at a higher cost, on all systems. The following table summarizes the available Oyster and printed ticketing options on the various modes.

Ticket Type	Oyster or Printed?	Mode
Pay-As-You-Go	Oyster	All modes[23]
Group Day Tickets	Printed	Underground, DLR
Point to Point Season Tickets	Printed	Underground, DLR
One-Day, 3-Day Travelcards	Printed	All modes
7-Day, Monthly and longer period Travelcards	Oyster	All modes
Bus Saver	Printed	Bus
One-Day Bus Pass	Printed	Bus
7-Day Bus Pass	Oyster and Printed	Bus
Monthly and longer period Bus Passes	Oyster	Bus
Freedom Pass	Oyster	All modes

Using the Oyster Card on the TfL network is easy; at the start of the journey, the customer has to touch in by placing the Oyster card flat on a designated yellow reader; at the end of the journey, the customer again touches out on a reader unless he/she is traveling on the bus or on the tram. The customer should touch out on a reader even if the Underground or National Rail station does not have gates.

There are many options available to check, add value or purchase an Oyster Card. Because London has an elaborate network, the stations are extremely accessible and checking/adding value or purchasing the card can be done very easily. There are 8 London Travel Information Centers, over 2200 Oyster Ticket Stops, 32 National Rail stations and many more Underground stations selling Oyster Cards. Oyster Cards can also be bought online or by phone. However, this would require an additional 3 – 4 days for the card to arrive by post.

Reloading the card by phone or online would require the customer to designate a Underground or DLR station where the reloading value can be collected after 24 hours. Alternatively, the customer can sign up for Auto Top-Up where the Oyster Card would

[23] All modes would include the Underground, the bus, DLR, tram, selected National Rail destinations and scheduled Riverboat services (Pay-As-You-Go). For Travelcards, a 33% discount would be given for Riverboat services.

automatically be reloaded with either £20 or £40 whenever the card balance falls below £5. The balance has to be detected at either the Underground or DLR gates/readers. This function is currently not available on buses but is expected to come into service in 2006.

Registration is compulsory for monthly or annual season tickets. The option is also available for 7-Day Travelcards and Pay-As-You-Go Oyster Cards. If the customer has bought the Oyster Card online or by phone, the card would automatically be registered. However, customers can still register their Oyster Cards at Underground stations and Oyster Ticket Stops if registration was not carried out when the card was first bought. Registration ensures that the value on the Oyster Card (Pay-As-You-Go or monthly and longer period Travelcards) is protected lest the card be stolen or lost. It also allows the customer to receive useful information on planned service disruptions to their daily journeys. If a card needs to be replaced, the customer should report the loss of the card (if registered) online to stop someone else from using it.

While not permitting multiple customers to use a single Oyster Card, each Oyster Card can carry up to 3 Travelcards and/or Bus Passes, as well as the Pay-As-You-Go option, concurrently. This allows customers to select different ticketing options at different times and also to use a single ticket for different modes.

E5. Fare Policies

In terms of pricing policies, TfL has been gradually increasing the fares on non-Oyster media more quickly than on Oyster Cards. Numerous incentives were offered to encourage existing printed ticket and cash users to switch to Oyster Cards.

During the first fare increase since the Oyster Cards were introduced in January 2004, Oyster fares were kept constant on the Underground and DLR while cash fares were increased. Cash bus fares were also increased to £1 while paying by Bus Saver cost only 70p. A year later in January 2005, cash bus fares increased again to £1.20, but remained at £1 for Bus Saver and Oyster users. In addition, off-peak discounts were also introduced

on Oyster Pay-As-You-Go on buses.

On 27th February 2005, daily capping was introduced into the TfL public transportation system. Regardless of time of travel and mode, the customer would pay no more than the cost of a One-Day Travelcard when using Oyster Pay-As-You-Go, no matter how many journeys they make in Zones 1 – 6.

January 2006 saw the most dramatic fare change since the introduction of Oyster Cards. The Underground Oyster single fares were decreased while cash fares were increased up to twice their corresponding Oyster fares. Similarly, cash bus fares were also increased while Oyster fares were frozen. In addition, off-peak travel discounts were made available only on Oyster Cards. On buses, this off-peak period was also extended half an hour later into the morning. The advantage of using the Oyster Card is further developed with daily capping; the daily caps for bus, the Underground, tram and DLR were reduced or frozen to 50p less than the cost of a printed One-Day Travelcard. In a bid to discourage customers from using printed Travelcards, the Family Travelcard and Zone 1 Travelcard were also withdrawn and replaced with other options on Oyster.

Using the Oyster Card is advantageous not only to adults but also to children and students. Over the past 2 years, children and students with valid Oyster photocards are entitled to either free or discounted travel on various modes.

This case study was compiled using information from:

TfL Website

And other sources listed in the Bibliography.

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