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The future of emerging technologies in public transit in Greater Toronto Area

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THE FUTURE OF EMERGING TECHNOLOGIES IN PUBLIC TRANSIT IN GREATER TORONTO AREA

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THE FUTURE OF EMERGING TECHNOLOGIES IN PUBLIC TRANSIT IN GREATER TORONTO AREA

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ABSTRACT

In communities throughout the world, strong and convenient public transportation makes valuable contributions to economic development, increased safety, energy conservation, a cleaner environment, less traffic congestion, and an improved quality of life. Whether it's a disabled person on her way to a doctor appointment, a child on the way to the library, or an elderly person going to buy groceries, rails, buses and vans connect people to their community. While transit serves many purposes, one of the most important of which is to provide critical access and mobility for transit-dependent and lower-income residents country wide, it also reduces the pressure on critical commute corridors by offering a convenient alternative to driving alone. People who are dependent on public transit, the young or the old, the disabled or the low-income, deserve a first-class system. A survey was conducted by City Pulse Toronto (CP 24) and the question they put to the viewers was "Would improved public transit convinces you to give up your car?" The result was amazing that 96% of the people using cars opted for Public transit.

In the last decade statistics depict that the cities that have adopted emerging technologies in public transit are reaping the benefits of their increased rider ship by almost three fold. It is disappointing to see that the transit-using trend in Greater Toronto Area (GTA) has decreased in the past five years except in the regions where transit agencies are updating their systems. Throughout the North America and other parts of the world, transit agencies are deploying automatic vehicle location and control fleet management systems, electronic and interactive customer information systems, and contact/contactless fare collection systems to save costs, improve operations and management efficiency and provide better service to customers.

In this project an effort is made to depict the extent of adoption of advanced technology in the provision of public transportation service in Greater Toronto Area. The focus is on some of the most innovative or comprehensive implementations, categorized under two types of services/technologies, Automatic Passenger Counting and Electronic Fare Payment. Another objective of this study is to assemble the knowledge on successful applications of advanced technologies, the issues in their implementation, the goals and benefits of Intelligent Transportation System's integration. The study focuses on institutional, operational and technical barriers with the expectation that this will lead to more widespread adoption of ITS systems and techniques.

ACKNOWLEDGMENTS

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GLOSSARY OF ACRONYMS

AFC Automatic Fare Collection

APTA American Public Transportation Association

APC Automatic Passenger Counting

AVL Automatic Vehicle Location

BVG Berliner Verkehrsbetriebe

CLUB Contact less technology Users Board

CTA Chicago Transit Authority

CVO Commercial Vehicle Operations

EFC Electronic Fare Collection

EPS Electronic Payment System

FTMS Freeway Traffic Management System

ITSO Britain, the Integrated Transport Smart card Organization

ITSA Intelligent Transportation Systems America

MDP Metropass Discount Plan

NAFTA North American Free Trade Agreement

NYCT New York City Transit

POP Proof Of Payment

SVT Stored value ticket

TSO Transit Security Officers

TVM Ticket Vending Machines

UITP International Union of Public Transport

WMATA Washington Metropolitan Area Transit Authority

CHAPTER 1
INTRODUCTION

1.1 Introduction

Intelligent Transportation Systems (ITS) is a broad range of diverse technologies applied to transportation to make systems safer, more efficient, more reliable and more environmentally friendly, without necessarily having to physically alter existing infrastructure. The range of technologies involved includes sensor and control technologies, communications, and computer informatics and cuts across disciplines such as transportation, engineering, telecommunications, computer science, finance, electronic commerce and automobile manufacturing. ITS is an emerging global phenomenon benefiting public and private sectors alike. For example, ITS makes it possible to implement a number of government regulations and processes (e.g., customs and immigration clearance, transportation safety compliance, road/bridge toll collection) more economically, and to improve corporate productivity through time savings, reduced operating costs and energy consumption, and enhanced reliability and safety.

The importance of implementation of ITS Technologies in Public Transit cannot be ruled out. Electronic Payment System deployments continue to rise in each and every part of world; we are seeing an increase in applications for parking systems (both on-street and off-street); fuel purchases; fast food drive-thru purchases; in-vehicle services payments, as well as for toll applications and transit. EPS deployments are beginning to achieve interoperability among the various transportation applications (64).

Advancements in card technology have created new capabilities and opportunities for transit fare systems. The technological advancements include: radio-frequency proximity cards; contact chip/stored-value bankcards; combined contact/radio-frequency cards (combi-cards); improved microprocessors; and development of multi-application software. The opportunities this type of technology can provide are: security, multi-function capability, open software solutions, data capacity and portability, and the "contactless" potential. The added value of Smart Cards versus existing card solutions is the security of the transaction. Smart cards offer secure data banks, requiring on-board, rewriteable, flexible memory solutions. A considerable benefit of the contactless smart card for a transit application is the quicker transaction time through the fare box or turnstile (63).

The use of Automated Passenger counting (APC) is also on rise in developed countries. Transit systems use APC for a variety of purposes including ridership analysis, route productivity, schedule adherence and information reporting. This project will examine the spectrum of current and planned fare systems including the technology that makes them possible and the current challenges transit managers are confronting. Transit managers across the North America are exploring and adopting coordinated fare payment systems that promise greater flexibility in fare structures, less expense in collection, and greater convenience for riders. Transit, like other service areas, has the desire to reduce the use of cash payments while improving customer convenience. New card technology offers

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transit managers the opportunity to integrate a new generation of electronic fare media and equipment that will provide more cost-effective distribution and more secure fare collection process. The objective of this exercise is to learn about the state-of-the-art in automated fare ticketing and Automated Passenger Counting, and understand how it can be applied in GTA where there are several sector urban transport operators. Furthermore, since there have not yet been many applications of this technology in Canada, this project will attempt to put into context the advantages and disadvantages of introducing it in that environment, where the majority of the users are low-income populations. A brief discussion of the barriers and challenges in the implementation of the cited emerging technologies is also addressed in the research.

The Automatic Fare Collection (AFC) and Automatic Passenger Counting (APC) Systems of the cities reaping the benefits of the successful implementation of the cited technologies are studied in detail and recommendations are based on the lessons learned from those cities. The lessons and implications of this research are applied to the case of GTA where the AFC and APC systems have yet to commence.

1.2 GOALS AND OBJECTIVES

Task.1 Collect and review relevant literature, research findings, and other appropriate material. Identify key information that needs to be exchanged by public transit agencies to implement the APC Systems and Smart Card payment System interoperability, including but not limited to data elements; policies (e.g., payment, reconciliation, and operations) and technologies. Describe and critique pertinent issues and identify information gaps.

Task.2 Identify Institutional, Functional, Data, Technical barriers to implementation of Emerging/ITS Technologies in public Transit with emphasis on APC and interoperable smart card systems. Summarize strategies that have been, and recommend strategies that may be, adopted to overcome the institutional barriers identified.

Task.3 Identify transit agencies that have recently implemented, or are currently designing or implementing APC and interoperable or simple smart card systems. Identify commonalities and differences in the information exchanged among the agencies. Compare the findings with current trends and new developments within the transit industry.

Task. 4 Thoroughly study different cities of world that have adopted or are adopting the emerging technologies cited and compare the scenario to the case of GTA transit.

Task5 Visit some of the cities studied and record observations from other cities and Subsequently formulate key lessons.

Task.6 Get acquainted with the products available in the market, by surveying different companies performing research in APC and Smart card Technologies

Task.7 Interview transit service managers, ITS Managers working on ITS related projects in Greater Toronto Area discussing the present system, future plans and barriers in implementation of emerging technologies in GTA and finally suggest remedies.

Task.8 The lessons and implications of the research are applied to the case of Transit agencies in GTA and conclusions and summary of findings are formulated and recommendations are forwarded to propose or dispose and predict the potential applications of the technologies in the GTA region.

1.3 RESEARCH QUESTIONS

Future/Applicability of AFC and APC for Transit Agencies of GTA

1. Does the Transit Agencies of GTA need to replace its fare equipment?
2. Are line-ups at ticket booths and slow boarding of busses and streetcars an issue?
3. Does Transit Agencies of GTA need an improved sales network?
4. How flexible is the fare system?
5. Is inter modal transfer a problem?
6. Is transaction speed an issue?
7. Is Rider ship and revenue impacts considerable?
8. Is fare evasion currently a problem?

Potential Effects of an AFC System on TTC and other Transit Agencies of GTA Customers

8. The Operational Considerations of AFC like

a) Fare evasion an issue for TTC and other Transit Agencies of GTA?
b) Counterfeiting and Fraud an issue?
c) Reduced Theft (External & Internal) an issue?
d) Reduced Equipment Maintenance Costs an issue?
e) Availability of Improved Management Information and issue?

CHAPTER 2

AUTOMATIC PASSENGER COUNTING AND TRANSIT AGENCIES OF TORONTO

2.Introduction

The development and implementation of Automatic Passenger Counter (APC) systems in North America has been underway since the mid-1970s. Since that time, about 37 transit systems in North American have either tested or installed APC systems. As of 2003, only about thirty transit systems are currently using APC's for ongoing data collection.30 Coincidentally, over this same period, almost every major transit system in the United States has installed registering fare boxes. Two transit systems, Seattle and Ottawa, have been using APC's since the late 1970s and have the most advanced APC programs in terms of ongoing, system wide data collection and information reporting and utilization. Several transit systems are currently in the process of procuring APC systems.

2.1 Description of an APC System

An APC system consists of hardware and software to count the number of persons boarding and alighting a bus at a specific location. The hardware usually consists of sensing devices located at the door areas of the bus, and a computer to process and store the sensor data. In addition, a receiver is used to receive location information that is processed and stored by the on-board computer. Odometer information can also be collected to assist in the locating of the bus. The software processes the sensor and location data in preparation for data transfer for further processing. This processing is done in the office where software is used to create a file containing time, location, and detailed count information (35).

The APC system being tested uses active infra-red sensors located just above the door areas but on the interior of the buses .the receiver to collect location information is a global positioning system (GPS) unit. The on-board computer processes and stores information from the counting sensors, the GPS unit, and the odometer. A portable data collector downloads this information, which is then transferred to a PC for processing (30).

2.2 General Benefits

APC offers several benefits:
Collect more data at a more detailed level, more often than with manual checkers:

- Analyze data at finer levels of detail.
- Improve the timeliness of data.
- Save on costs of passenger counting.

Improve planning and scheduling:

- Monitor trends in usage and ridership.
- Reallocate resources to fit actual demand.

Measure the success of your agency by getting reliable ridership figures

2.2.1 Benefits to an agency

Automatic passenger counting data is crucial. APC data gives loads and loads of information to drive the scheduling process. It gives you an insight into traffic movement (36).
- Know where to add or eliminate service.
- Get a picture of what traffic is doing every single day.
- Automate NTD reporting

2.3 APC and TTC

In June 1999, the TTC awarded a contract to Infodev Electronic Designers to install an APC system on two of TTC buses - a New Flyer low-floor bus, and a Classic bus. Infodev staff indicated that they have configured the sensors and software for similar bus types but not specifically these buses. Thus, it was expected that some fine-tuning would be required to determine the optimal calibration parameters for the sensors and software to accurately count our customers.

The sensors, computer hardware, and software were installed on the two buses in August 1999. Since this date, TTC Planning staff conducted many short-duration manual counts for comparison with the APC data retrieved from the on-board computer. The data and results were forwarded to Infodev. They analysed the data and made adjustments to the software to improve the count accuracy. In November, some changes were made to the sensors and their physical layout. TTC have since received updated software to account for these hardware changes and are continuing to test the accuracy of the APC count information (35).

2.4 Current Position of Automatic Passenger Counter Systems in Toronto

For getting information about the current state of affairs of APC in Toronto Bernard C. Farrol Senior Planner, TTC Planning Department was contacted and the following information is based upon his comments.

- 10 buses operating out of Eglinton garage have been outfitted with APC equipment
- Data transfer from the buses is currently done with IR transceivers but will be converted to radio-frequency transmission
- The software to take the field (APC count) data and match with our schedules and stop patterns will be tested over the next few months.

- Infodev Electronic Designers are solely responsible for the installation of Automatic Passenger Counter Systems in Toronto

- Infodev's APC system is now being tested on streetcars. It uses RF Speed Spectrum 2.4 GHz modems to download data

Once the bus has returned to the garage, it is important to transfer the data in the on board microcomputer to a PC computer for analysis. To do this automatically, an intelligent spread spectrum modem installed inside the bus communicates with the PC computer in the garage. The data is transferred while the bus is in the garage.

2.4.1 Collection of the Necessary Data

The APC hardware has been collecting passenger count and bus location information since its installation in August 1999 in a few buses. TTC Planning staff processed the APC data and confirmed that the necessary information is being collected by the APC system. The data collected are (35):

- Bus start-up clock time
- Number of on and offs at each door every time the doors are opened
- The door-open and door-close clock times
- The bus location (GPS co-ordinates) every time the doors are opened
- The odometer reading every time the doors are opened
- The clock time, bus location, and odometer reading when the bus is stationary for more than 15 seconds
- Bus shut-down clock time

2.4.2 System Reliability

Since the installation of the on-board systems, the APC has been functioning reliably. The data, as listed above, have been consistently recorded by the on-board computer and verified after the data were downloaded (35).

2.4.3 Counting Accuracy

It was stated earlier that Infodev had to configure the sensors and software for both the New Flyer low-floor and the Classic buses. Thus, after the APC system installation and the initial comparison of APC and manual count data, fine-tuning to the sensors and software was necessary. Since the initial installation, TTC have received several updates to the software program that interprets the raw sensor data. A representative from Infodev came to the TTC in November 2002 to modify the configuration of the sensors and to change their sensitivities. Further refinements still have to be done to account for the door geometries and for the boarding and alighting behaviour of TTC customers. This will improve the counting accuracy.

2.5 APC Vs. Traffic Checkers

When using manual checkers, it may become difficult to keep control of costs while at the same time achieve an acceptable level of data quantity and accuracy. Manual counting is labour intensive and time consuming:

- Checkers have to physically be on the vehicle.
- Professional staff must spend time scheduling the checkers.
- Manual count data must be edited and refined before it is usable.

Traffic checkers can give you counts, though not very accurate. It is a very difficult job, almost impossible to do perfectly. Checkers make all sorts of errors:

- Numbers are in error when many people board and alight.
- People counted "IN" may be marked "OUT" (and vice-versa) by mistake.
- They forget to count themselves, their colleagues or the driver.

Traffic checkers can tell you where there is congestion, when drivers are dragging the street, detours, etc., just like the information can be produced using software with no human intervention.

In a 200-bus APC system, it takes 80 checkers to obtain data from just half the vehicles running for six hours. It is harder to schedule checkers and they are worn out in the counting process. Where checkers might observe only one day, the APC observes every day.

2.6 APC and small Agencies

The agency's size does not matter. APC works well with smaller properties because they do not usually have the scheduling and processing resources to make the most of manual count data. APC system, once installed, requires no human intervention. Data is collected, transferred and processed automatically. For example, a 20 - 30 bus property should equip about 20% of their fleet, while a larger transit authority - 800 to 1000 vehicles - would gain valid data with only 10% of their vehicles being APC-equipped. Another advantage small properties have over bigger ones is that they can actually see their operation and keep track of everyone, while larger properties may be slower to respond because of bureaucracy or resources (30).

2.7 Conclusions and Recommendations

After studying thoroughly different APC Systems and current TTC situation following points are forwarded to industry people to take into account.

1. The latest and sophisticated APC Technologies should be adopted with out wasting any time in order to get its full benefits.

2. Further testing and refinement of the Bus Stops stop-determination software is needed.
3. TTC should purchase more APC systems to outfit at least twenty more buses at Eglinton garage.
4. TTC should purchase and test the infrared data transfer link.
5. APC techniques should be used in combination with AVL latest technologies because it provides real-time stop and route identification and tracking, next stop announcement, and arrival and departure times. Moreover, it can be linked to high-speed infrared or radio data transfer devices. Back at the garage, analysis and reporting software provides easy-to-use set up and data analysis.
   i. Record information for schedule performance analysis and slow traffic zone identification.
   ii. Analyze running time and provide the data needed to rework schedules and perform traffic analysis.
   iii. Learn important information about your system's stops:

   1. How many riders use the stops?
   2. How often are the stops used?
   3. Should a stop be eliminated?
   4. Should a stop receive amenities?

- The pace of implementation of APC technologies in TTC is very slow. It should be expedited because out of four phases only phase one has been completed. New committees should be formed and Studies should be conducted to chalk out plans for collecting necessary data from the cities that have successfully implemented the APC Technologies and ripping the benefits.

- Teams of experts should be sent to the Cities, which have successfully implemented the APC systems to study those systems critically.

CHAPTER 3

AFC SYSTEMS

3.BACKGROUND

Smart cards are a secure, widely accepted media for cashless payments for a wide spectrum of financial transactions, including automatic fare collection (AFC) activities within transit districts. Currently very few smart card electronic-payment media systems are operating on transit systems across the nation. Use of smart cards can greatly increase the level of convenience and facilitate transfers for transit riders and can increase efficiency and reduce costs for transit providers. Smart cards used on public transit can have widespread application outside of transit. They can be linked to other modes of transportation (e.g., parking and highway tolls) and other industries like retail, banking, and security.

A seamless smart card electronic-payment system benefits transit passengers and operators, as well as other potential user. However, transit operators face substantial challenges in integrating smart card-based AFC equipment from different manufacturers because of the lack of interoperability (28). This problem needs to be remedied, before widespread deployment can proceed. Some examples of the complicating factors in GTA are:

- Application of multiple fare-payment systems and technologies in GTA.
- Inadequate communication protocols and information exchange among transportation clearinghouses
- Absence of a single application programming interface to foster interoperability
- Intellectual property barriers that do not allow for open architecture in GTA.

3.1 Introduction

Transit fare collection technology has evolved from the manual-based systems in use before 1970 to automated systems with computer-based hardware and software. These major advancements in fare collection have been made possible through advances in the design of fare media, the use of microprocessors and software in fare collection equipment, and the development of sophisticated control and data communications systems. A more-recent innovation has been the development of contactless smart cards, which have very quick transaction speeds required in transit applications.

A number of major transit properties have introduced, or are testing AFC systems. In 1997, both New York and Chicago replaced their paper tickets with magnetically encoded stored-value cards (fare cards) and passes. Contactless smart cards have recently been introduced in Hong Kong, Seoul (Korea), and on the rail system in Washington D.C. Contactless smart cards are also being investigated, tested, or planned for implementation in Paris (France), Berlin (Germany), London (England), and Chicago (USA).

In addition, there are local smart card initiatives underway in Burlington and Ajax in Ontario, and on GO Transit's Richmond Hill service.

The information in the following part of project is based on interviews with the service managers and planners of TTC. In addition to that being a regular user of TTC most of the material in the sections below are based on my day-to-day observations.

3.2 Abridgment of Fare Collection Systems

The fare collection system is a key interface between a transit agency and its passengers. It directly affects the way in which passengers experience and perceive the transit agency and its services. In general, the transit passenger expects a fare system that:

•Is fast, easy to understand and use, with reliable fare transactions
•Offers payment options that suit their particular travel needs (frequent, infrequent, weekly, daily, cross-boundary, short-distance, etc)
•Allows easy transfers between modes and different transit providers
•Provides easy access to fare media

In order to meet the needs of both the passenger and the transit operator, the fare system should be:

• Flexible: adaptable to changing fare strategies, loyalty schemes, and integration with other systems.
• Economical: providing for cost-effective administration, maintenance, and capital investment.
• Reliable: meeting high standards for reliability, and easy to maintain.
• Secure: minimizing the potential for fraud and fare evasion, providing a secure environment for revenue, and meeting privacy requirements.
• Information-rich: providing data for marketing, finance, service planning, and workforce productivity.
• Simple: customer-friendly, easily understood and used by riders and staff
• Quick: allowing fast transactions (turnstiles/boarding, purchases)

Not all of these objectives are mutually compatible and, in order to achieve one objective, another one might have to be compromised. For example, the objective of increasing cross-boundary rider ship in a region may require changes to the fare system, which would be incompatible with an objective of increasing fare revenues or reducing operating costs.

3.3 Components of Fare Collection Systems

Fare systems consist of various components:

- Fare structure or policy: flat fare, fare-by-distance, fare-by-time-of-day, transfers between modes, concession fares
- Fare media: tickets, tokens, passes, cash, and magnetic or smart cards;
- Fare collection procedures: pay-on-entry, pay-on-exit, proof-of-payment, honour fare
- Fare collection equipment or technology: fare boxes, electronic registering fare boxes; and turnstiles, equipment to read magnetic stripes, smart cards or proximity cards.

While these components are often discussed in isolation from each other, they are, in fact, highly inter-related, and changes in any one of these components of a fare system can require changes to some or all of the remaining components. In addition, a fare collection system must be supported by systems for ticketing and fare media distribution, fare and revenue processing, and a data/information system.

Fare collection systems that are automatic. (i.e. an AFC system) involve fare media incorporating magnetic stripes, or smart cards which can record fare payment information and be read automatically by readers installed on turnstiles and on transit vehicles. The TTC's Metro pass is a simple AFC system that has a magnetic stripe, which allows passengers to use a swipe reader on subway turnstiles to enter the system.

Following is a more-detailed description of each of the components of a fare system.

3.3.1 Fare Structure and Policy

There are a number of choices to be made in establishing a fare structure. Fares can be one price for travel anywhere in a market area a flat fare or they may vary by distance travelled. Fares can vary by time period or be kept constant at all times. Different structures may require different fare collection arrangements and equipment. London (England), and Paris (France) use a fare-by-distance fare structure. Vancouver (B.C.) and OC Transport in Ottawa offer a time-of-day pricing differential which allows customers to travel for a lower fare during off-peak times, such as midday. Washington D.C uses a fare-by-distance and time-of-day pricing differential. Berlin (Germany) has proof-of-payment system with no barriers or turnstiles in the rapid transit system at all. (17, 65)

The choice of fare media is dictated, to some extent, by the fare structure or policy. Token fare payment, for example, is most commonly used in flat fare systems, where the fare structure is expected to remain constant. Multi-ride paper tickets, also called strip tickets, are often used in fare-by-distance systems or in proof-of-payment systems. Multiple ride tickets are validated by a time or date stamp, using a ticket validator, provided either at the station or on-board the vehicle.

3.3.2 Fare Media

Transit operators typically accept fare payment with one or more of the following media:
- Cash
- Tokens
- Paper tickets
- Paper passes
- Magnetic tickets or cards (paper and plastic)
- Smart cards (contact or contact less)

Cash is still one of the most common payment methods in most transit properties. Tokens, paper tickets, and magnetic tickets are also used extensively throughout North America and Europe. In the last five years, many transit properties have begun investigating or introducing smart cards as stored-value fare media or passes.

3.3.3 Fare Collection Procedures and Equipment

A basic choice when establishing a fare collection procedure is to determine whether the system will be open or closed. In a closed system, payment for transportation must be made before access is allowed to board buses, streetcars, or rapid transit trains. This is the approach used in most of the TTC system. In an open system, passengers are required to have a proof of payment. (POP), but there is no checking of fares on entry to the system. Roving fare inspectors typically does fare checking. Open and closed systems may introduce unique requirements for fare collection equipment, and the supporting communications networks and data collection systems. Fare gates provide the entrance and exit control required for the implementation of a closed fare collection system. Fare gate equipment includes the passenger admission control device, e.g. - turnstiles or control gates, and token acceptors or magnetic ticket readers. Different fare collection equipment may be used by rail systems compared to surface transit systems. Many rail system operators control access to their stations with mechanical turnstiles or fare gates. The controlled-access approach to fare collection helps ensure fares are paid, but there are capital and operating costs associated with this equipment. In a zone- or distance-based AFC system, the entry gate determines that the fare medium contains at least the minimum fare, and updates the medium to indicate the entry station. At the end of the ride, the consumer inserts the fare medium again to exit the station. At that time, the gate decrements the fare value based on the zone or distance travelled. One approach is to decrement the maximum fare at entry, and return value upon exit, thus encouraging the customer to pass the medium upon exit. On surface vehicles, a number of transit operators throughout the United States and Canada have converted from simple mechanical fare boxes, such as is used by the TTC, to electronic registering fare boxes, which count and verify the currency or fare medium tendered by each boarding passenger. For fare-by-distance or zoned transit systems, on surface vehicles, some form of ticketing device is required which indicates the amount paid and the fare zones in which the ticket is valid. Often, the driver is required to specify the zone on the ticket that is issued, which is then retained by the passenger as proof-of-payment. Fare inspectors can use a portable device to validate the fare payment (15).

Many European cities, such as Berlin (Germany) and Rome (Italy) have an open, proof-of- payment system. The proof-of-payment (POP) approach relies on passengers purchasing a ticket before boarding a transit vehicle. No physical barriers or turnstiles are required and the speed of passenger boarding is increased. Fare payment enforcement is conducted through random inspection, with fines levied on passengers who do not have a valid fare receipt or ticket.

CHAPTER 4

4 Current TTC Fare Collection Systems

This section of the project describes the TTC's, current fare collection system, and provides a critical appraisal of the system with respect to passenger convenience, fare processing procedures and costs, fare evasion, and the way in which the system integrates with other transit service providers in the Greater Toronto Area (GTA).

4.1 The Passengers viewpoint

The TTC, Mississauga, Brampton and Vaughan Transit have a flat fare, pay-on-entry, system, which is easy to understand from a passenger perspective. But the TTC is fully integrated between its various modes, and the fare collection system allows easy, convenient transfers between surface and rapid transit services, often with no barriers or transactions whatsoever. This is critical for the TTC as the TTC's grid-based transit network means that most passengers must transfer to complete their transit trip.

4.1.1 Fare Media

As described in section (3.3.2), the fare media accepted for travel include tokens, tickets, and passes. Monthly passes are available for adults, seniors, and students. The monthly Metropass is valid for unlimited travel in a specific month on all regular TTC services within Toronto. The Metropass is not transferable two people cannot share the same pass in the same calendar month and photo identification is required. The passes are magnetically encoded to facilitate their use in specially equipped turnstiles at each station, and to allow access to free parking at designated commuter parking lots. On surface vehicles, the passes are presented to the driver for visual inspection.

According to a customer service representative of TTC, day passes and family passes are also available which allow one person unlimited travel on any one day after 9:30 am weekdays or all-day Saturday. On Sundays, holidays, and for some special days, the Day Pass allows up to six people, including a maximum of two adults, unlimited one-day travel. The TTC also has a Convention Transit Pass, which is valid for unlimited travel on all TTC services for duration of the convention, and is priced according to the number of days and number of passes required.

Passengers who have to take more than one bus, streetcar, or rapid transit service to complete a single trip, may have to obtain a free paper transfer from transfer-dispensing machines at each subway station, or from the driver after boarding surface vehicles. The many passengers transferring at subway and RT stations with integrated surface route terminals do not require a paper transfer. When required, transfers must be obtained when passengers pay their fare, and can be used only on the day of issue for a one-way continuous trip. Transfers are not valid for stopovers. For example, a passenger is not permitted to get off a TTC vehicle, do some shopping, and then use the transfer to board another TTC vehicle.

In Mississauga Transit the Ticket can be used for duration of two hours from the time of purchase.

4.1.2 Fare Purchases

According to the TTC personnel contacted fare media can be purchased from staffed collectors. Booths at each of the TTC's 65 rapid transit stations, or from 1,200 independent agents are located throughout the City of Toronto. Tokens can also be purchased from 131 token vending machines, which are located at all unstaffed rapid transit station entrances, where access is gained through full-height turnstiles. They are also provided at some busy stations to reduce queuing at the collector's booths during peak periods. Station collectors and token-vending machines accept cash only when selling or issuing media, except at four subway stations (Union, Yonge/Bloor, Davis Ville, and Dundas), where station collectors accept credit card purchases. Credit card purchases are limited because of the cost of sales commissions, communications infrastructure constraints, and because transaction times would significantly increase customer line-ups especially during the concentrated Metro pass sales period. The TTC is evaluating a new token and Metro pass vending machine, which would accept both cash and debit transactions.

Fare Collection Access to the TTC system is controlled through the use of mechanical turnstiles in the subway system, and mechanical drop-in fare boxes on the buses and streetcars. The magnetically encoded Metro pass can be swiped to access the rapid transit system, or shown to the driver on surface vehicles. Subway passengers who choose to pay with cash, tickets, or tokens deposit their fare into a fare box in front of the station collector before proceeding through a manually controlled turnstile. Day passes are presented for visual inspection. Passengers using discounted fare types, such as senior, child, or student tickets must present the required identification to the collector before passing through the controlled turnstile. Automated turnstiles accept tokens and monthly passes. Crash gates are opened during the rush hours to assist in accommodating high volumes of passengers. When these gates are open, they are equipped with a fare box and are staffed by collectors who visually monitor the fare payment. On surface vehicles, cash, tickets, or tokens are deposited in a fare box upon entering the vehicle. Paper transfers, day passes, and Metro passes are presented for visual inspection. There is a proof-of-payment (POP) system on few streetcar routes. Between 7 am and 7pm, seven days a week, passengers with valid proof-of-payment (e.g. paper transfer, day pass, or Metro pass) may board the streetcar through the centre or rear doors. Passengers who board through the front door, and deposit a fare, are given a paper transfer as proof of payment, even if they are not transferring to another route. POP was introduced in 1990 to speed up passenger boarding, reduce vehicle dwell times and, thereby, improve running times and increase transit operating speeds. The POP program is currently unique to the Queen Street streetcar services, and has not yet been extended to other routes. Fare enforcement is conducted, on a regular basis, by a team of Transit Security Officers. When TTC staff was inquired about the reduction of dwell time, they were hopeful that the cited measures would reduce it.

4.2 Fare Revenue Accounting and Processing

The TTC's approach to fare media and sales, and the extensive use of mechanical fare equipment, results in there being a higher value of cash handled in the TTC system than would be the case with a more-automated system. Station Collectors directly handle cash and sell fare media. Formal monitoring procedures and field audits are used to control and verify proper cash handling by collectors, and these procedures have been successful to the degree that disciplinary action due to funds irregularities has been virtually eliminated. Each collector booth is fully alarmed, including CCT monitoring, and contains a vault for safe storage of money collected from fare sales, which is collected by a contracted security service, and delivered to the bank for counting and reconciliation. The TTC is changing its fare media supply process, so that it will be more efficient, safer, and more secure. Surface vehicle operators have no involvement with selling fares and handle no cash. Each farebox is equipped with a clear glass window to allow the operator to observe the fare deposited. The fare is then dropped into a sealed vault to ensure the integrity of the revenue accounting process. Each farebox vault is assigned, and keyed, for each specific Division, and operator waybills document the route, bus, and vault number used in revenue service. Farebox vaults from buses, streetcars, and collectors booths and token turnstiles are emptied daily by Revenue Collection staff, using security procedures, which minimise the risk of robbery and collusion. Revenue Processing staff remove bank notes (bills), paper tickets and transfers, and garbage from the farebox revenue, after which the tokens and coins are mechanically sorted, wrapped, and boxed by denomination. The one and two dollar coins are more efficient to process, compared to manual bill sorting and counting. However, the increasing volume and weight is becoming a problem for distribution and collection.

4.3 Fare Evasion

One of the biggest factors in the revenue losses is fare evasion. The use of deceitful fares is a continuing concern for any transit operator, and the way in which the fare collection system is operated can have a significant effect on fare evasion rates. Every year, the TTC's Internal Audit Department, with the assistance of Transit Security Officers (TSO) from the Corporate Security Department, conduct a fare evasion study. Tests are conducted throughout the transit system, during a three-month time period, and fare evasion rates for the following areas are measured (Jim Sinikas):

- POP Program: The audit team records the total number of passengers on the streetcar, and the number of passengers with invalid fare media. A team of TSO and auditors board a streetcar and the Operator makes an on-board announcement indicating a fare inspection will be made and asks passengers to have transfers and passes ready for inspection. The auditors record the number of passengers perceived to be evading a fare by counting the number of people who exit the streetcar immediately after the announcement is made, and attempt to board the next streetcar. Illegal Entry. At subway stations, this is calculated as the number of individuals illegally entering the paid area of a subway station via the driveways used by surface vehicles, as a percentage of all paying customers using

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those same stations. Plainclothes auditors observe the number of people entering the station away from the entrance turnstile areas.

- Transfers: Customers transferring to the subway give their paper transfers to the Collectors at stations. These are checked for the proper time, date, and validity for the connecting routes.

- Metro passes: Photo identifications are checked to ensure the correct person is using the pass. Metro passes with no numbers, or incorrect numbers, are recorded and counted as invalid. Foreign and Spurious Receipts (Fraud). Once a month, farebox revenues are sampled, and Revenue Operations staff examines each ticket, bill, and coin collected. Counterfeit tickets and bills, and foreign coins and slugs are recorded.

4.3.1 Types of Fare evasion

According to Project Engineer Service Planning TTC, the following types of fare evasion are also known to occur within the system, but the numbers of measured instances are insignificant:

- Individuals jumping over turnstiles to enter the paid areas in subway stations
- Students sharing photo identifications and student Metropasses
- Paying customers obtaining several subway transfers for use by acquaintances waiting at a nearby surface route
- One person using a Metropass at an unattended entrance, and then giving it to another person who goes to an alternate entrance at the same station

4.4 Fare Arrangements Between the TTC and other GTA Transit Operators

The TTC currently has only a limited degree of fare integration with other transit operators in the Greater Toronto Area (GTA). The Toronto municipal boundary acts as a fare zone boundary, and passengers using local transit services are required to pay a second fare either at the boundary, or upon entry to the TTC system. GO Transit operates on a fare-by-distance basis, while all local transit operators in the GTA operate on a flat-fare basis. To date, there have been difficulties in developing a co-ordinated approach to transit fare collection in the Toronto area.

Here are the fare integration programs that are currently in place for transit passengers who travel into and out of Toronto:

4.4.1 "GO monthly" and "GO Twin Pass"

A Twin Pass is a combined GO adult monthly pass and a TTC Metropass. available only from GO Transit. The GO monthly pass is valid for unlimited travel in one calendar month by the pass holder between two specified fare zones. Twin Pass holders can travel

with a companion on the GO system on Saturdays, Sundays, and statutory holidays at no extra charge. The Twin Pass is not transferable, and pass holders must sign the front of the GO monthly pass, and must produce a TTC photo identification card, or valid driver's license, upon inspection.

According to the information provided by customer service representative of GO Transit, the price of travel between York dale mall subway station and Airport is $ 3.5 one way. The cost of monthly pass for travel between Square One Mississauga and Union station is $123.

4.4.2 TTC-GO Transit-TTC, GO-Mississauga Transit or GO-Brampton Transit

Passengers who ride the TTC immediately before and after a GO train or GO bus can use the TTC transfer from their first ride to board the second TTC vehicle.

If a person rides Mississauga or Brampton Transit immediately after a GO train or GO bus, he pays just 50 cents per ride.

4.4.3 Greater Toronto Area (GTA) Weekly Pass

The GTA Pass is an accepted fare medium on all TTC, Mississauga, Brampton, Vaughan, Richmond Hill, and Markham transit routes, including specialized services operated by these systems. Customers in possession of a GTA Pass are not required to pay an additional fare when crossing into another municipal boundary. The GTA Pass is transferable, with conditions, and does not require an accompanying photo identification card. The price of GTA weekly pass is $41.25 per adult.

The travelers need, first and foremost, fast, reliable, convenient transit service. Better service was found to be much more important to both current users and potential future users of transit than changes to fare levels, structures, or collection practices. There is a strong indication that changing current fare arrangements or practices within the GTA would be a significant factor in attracting new riders to transit.

Summary of the strengths and weaknesses of the TTC's Current fare collection system:

From the preceding sections, here is a summary of the strengths and weaknesses of the TTC's current fare collection system:

• The pay-on-entry flat fare structure is simple, easy to understand, and easy to use for customers and staff. Fare transactions are quick.

• The full integration of all of the TTC's modes and services, together with the policy of free transfers between services, makes transferring between routes and modes easy and convenient. Seventy of stations do not require a transfer for boundary busses.

- Fare collection-related costs are low; at   rate of 7% of all fare revenues collected the system is economical and cost-effective to operate.

- Fare evasion and fraud are low, at a rate of 0.7%; the system is relatively secure.

- The low-tech "drop-in" fare boxes and limited-scale magnetic stripe readers are reliable and easy to maintain.

- There is limited flexibility in the current system to try new or innovative pricing structures, to provide event-specific fare promotions, or to attract or address niche market opportunities.

- There is no convenient way for inter-regional transit riders to pay the two fares required when travelling between Toronto and its neighbouring municipalities.

CHAPTER 5

5 Automatic Fare Collection (AFC) Technology

Introduction

This section of the project provides a brief description of current state-of-the-art automated fare collection (AFC) technologies, which include advanced magnetic swipe cards (like a credit card) and both contact-based and contact less smart cards (like a phone card) Coins, tokens, and paper tickets can be accommodated in simple mechanical fare boxes and turnstiles. These fare media generate handling costs, however, and provide a limited means of payment validation. For surface vehicles, fare box technology has evolved with the advent of electronic fare boxes that automatically count coins and paper currency. They can also be equipped with visual displays which register the amount paid, card readers, and various data collection features. In rapid transit stations, the introduction of more complex fare-by-distance fare structures has resulted in the implementation of magnetic card readers as an alternative to the standard token-access fare gate (52).

Modern fare collection systems involve automatic, or semi-automatic equipment which can have a wide range of functions including dispensing fare media, adding fare-value, calculating fares, decrementing remaining value, applying discounts, and tracking ride patterns of customers. Fare media for fully automated systems require some form of modifiable data storage capability which can have fare-value added or decremented from it. Modern AFC systems also feature data collection and processing systems, remote alarm and status monitoring, and a range of user-defined functions. They also utilise ticket or fare-media vending machines (TVM's) which accept cash, and credit or debit cards, and dispense a wide range of tickets including weekly, monthly, and special-event tickets, in addition to single and multiple-trip tickets (21).

The system or environment in which a card will be issued or used is a fundamental issue. Generally, cards will either be used in what is commonly referred to as an "open" (multiple card issuers and multiple service providers) or "closed" (a single card issuing organization) system. It is important to note that a system can and may evolve from a closed system to an open system. Two primary distinctions relevant to transit are: is the transit agency issuing and accepting it's own card; and is the transit authority accepting cards issued by other organizations. Historically, a closed system is how many transit agency fare programs have operated. Currently, transit authorities in North America are using three types of fare payment media: magnetic stripe card, credit card, and smart card. There are three types of smart cards: contact; contact less; and combi-cards. Extensive technological developments in many forms of payment media have recently occurred. The trend towards an "electronic cashless commerce" is a growing business practice being implemented worldwide. Interest from the financial, postal, and telecommunications industries are contributing to the rapid pace of technological advancement. Advancement in card technology will facilitate the acceptance of electronic payment media programs as a viable payment option for transit operators. Currently, stored-value and multi-use programs are in limited trials in U.S. cities. Multi-use transit

projects are already in operation in other parts of the world (20). Ultimately; the success of electronic payment programs will depend on the degree of acceptance of the media by issuers, merchants and, most importantly, consumers. System definitions and overviews are detailed below.

5.1 Closed System Definition

A "closed" system is one in which the card is issued by a single organization and can be used for that organization's services and other agreed upon service providers. Historically, a closed system is how transit agency fare programs have operated. Today, "closed" systems are also emerging at many large universities, such as the University of Michigan and Florida State University (32).

5.1.1 Closed Transportation-Only System Overview

Within a closed, transportation-only system, a transit agency or group of regional transit agencies issue fare media usable on any of the agencies' services. This system can be used to achieve an upgrade in the agencies' fare collection processes and/or generate additional rider ship and revenue. Individual agency functions such as card production, distribution, revenue settlement, equipment acquisition and maintenance can be provided by one or more of the member agencies, a system integrator (contractor), or by a new organization created by the agencies. To achieve maximum benefits and efficiencies, re-engineering of operational procedures will have to be achieved. Coordinating the acquisition of equipment, installation and subsequent maintenance procedures will make multi-agency fare collection settlements more complex, but potentially more cost-effective (37).

5.2 Open System Definition

The term "open" system can be interpreted differently. A truly open system can consist of multiple card issuers and multiple service providers (merchants). However, within the transit industry, an open system describes a fare payment system in which an outside organization's card (i.e., a bank or university) is accepted for use within the transit agency (37). There are three types of models that can be implemented in an open system. These models are discussed later.

5.2.1 Open System Overview

Within an open system, a transit agency accepts the fare payment media from one or more outside issuers. Open systems contain three principal models or scenarios in which a transit agency can participate:

1. A transit agency can become a "merchant" in a participating program. Within this model, the agency will have to pay a transaction fee for their customer's usage. The principal benefit to this model is the agency reduces the risks associated with investing in

rapidly changing technology and leverages infrastructure and card distribution costs with their partners. The card issuer will absorb this risk

2. The transit agency can become a formal partner; sharing the benefits and risks associated with such a venture. Partnering as a co-issuer of the card can result in additional revenues and maximum market penetration; or

3. The agency can administer its own payment program. This model allows outside issuer cards to be used provided the cards comply with the program's requirements. A primary benefit to any type of open system model is broader market penetration. In addition, successful partnerships will offer greater opportunity to generate additional revenue. However, with an open system, partnership agreements, issues and conflicts become more prevalent and complex. A major disadvantage of an open system is the transit agency will have less control over fare collection and less flexibility with pricing.

5.3 Multi-Use System Definition

The emergence of a multi-use smart card system is gaining interest with members of the transit community. The advent of integrated circuit "smart" cards and the use of stored value have created new opportunities to integrate more than one market with a single payment option. A multi-use application card can be established in various institutional environments including: transit-only, a more general public environment, or in an open system (30).

5.3.1 Transit Multi-Use Overview

Transit operators will implement a multi-use program for different reasons. The transit agency's goals and objectives are critical elements in determining the type of multi-use program that is pursued. Additional factors such as availability of funding resources and availability of technology will also influence the program type. The nature of the institutional setting and partnership agreements will depend on the program initiator's goals and the capabilities and constraints of the organization. Adopting a multi-use payment system will require a fundamental change in the way an organization has previously operated. These changes will impact the consumer, participating merchants, banks, clearinghouses, and transit agencies. Many of the legal, regulatory, and policy issues concern the integration of multiple service providers, card issuers, as well as future technology development and deployment environment (14).

There is growing commercial acceptance and availability of multi-use payment options, particularly in the banking and financial industry. Banks and financial institutions are extremely interested in seeing what the transit industry will do with multi-use cards because of the broad, geographically focused market transit provides access to. It is their hope that they can establish valuable partnership agreements with regional transit agencies, which in turn may provide opportunities to share card distribution, infrastructure and costs. More pilot tests are needed to see if a multi-use smart card can accommodate integrated electronic payment in diverse systems (3).

While many obstacles exist, there are benefits to a transit authority in implementing a multi-use system. Potential benefits include:

- The desire to promote integrated, seamless regional transit through a "universal ticket"
- Increase market base
- Generate additional revenues
- Improve data collection and ridership information
- Reduce fare collection costs and
- Improve customer convenience

5.3.2 Closed Multi-Use Systems

In a closed multi-use system the transit agency issued fare media can be used for other purposes such as telephones, or retail. The institutional support to carry out the production and distribution of cards, and the acquisition and maintenance of equipment can be provided by the agency, private contractor, or through a partnership with a separate company. The potential benefits to this system can include creation of an innovative, integrated fare system and increased market penetration. However, the transit agency's expanded role in a complex collection process with multiple merchants will be a primary disadvantage. This system will involve complex legal, regulatory, and political hurdles, which may be difficult to overcome (12).

AFC systems are continuing to evolve with respect to the use of advanced magnetic and smart card fare media, and the use of advanced fare-vending machines and distribution networks. Each of these is described below.

5.4 Advanced Magnetics

BART, the San Francisco Bay Area Rapid Transit system, introduced magnetic stripe cards into the transit fare collection system. Now, nearly 30 years later, the magnetic stripe card continues to be implemented in various transit systems across the country. Units located in computerized ticket machines and turnstiles read the magnetic stripe card. Ticket vending machines located in transit stations accept regular currency. The ticket value is then recorded onto the magnetic stripe. When the rider enters the system the turnstile read-write unit records the place and time of entry. For systems with a flat fare the reader deducts the fare from the value on the card and writes the remaining value. For systems with a distance-based fare, the exit station turnstile computes and subtracts the price of the trip based on length of trip, and in some transit systems, the time of day.
Both New York and Chicago introduced advanced magnetic stored-value tickets and passes in 1997 Magnetic fare media have magnetic encoding to store information regarding the amount of pre- paid stored value and advanced magnetic media have both read and write capabilities. They have the ability to collect ride data, as long as the reader in the turnstile or farebox contains the required computer software. Advanced magnetic stripe fare media uses both low and high coercivity formats, and data is read or verified by swiping the card through a reader or inserting the card into a reader which has

a transport mechanism. There are two types of magnetic ticket readers commonly used for magnetic ticket validation. There are reciprocating readers, which have a transport mechanism that pulls the magnetic fare card into the reader and, after verifying the validity of the ticket, returns it through the same slot. Chicago's new magnetic AFC system uses this type of reciprocating reader (16). There are also swipe-through readers, which require the passenger to manually pass the magnetic medium through the reader. New York uses swipe-through technology on the subway system, and reciprocating readers on their surface fleet. Both types of magnetic validators read the medium, process the information, rewrite updated information onto the magnetic stripe and, in the case of tickets, print the time of day, date, and route information onto the ticket. The TTC uses read-only swipe-through readers, to validate Metro passes. The read-only nature of the Metropass means that data on the card is read, but new information is not transferred back (13).

5.4.1 Advantages of magnetic stripe media

* Production costs per card are relatively low at $0.05
* The technology is proven, with years of system and vendor experience, and lots of transit applications
* Plastic versions are durable and have a reasonably long life expectancy (minimum 1 year)
* They can support multiple fare structures such as proof-of-payment, fare-by-distance, or by time

5.4.2 Disadvantages of magnetic fare media

* The relatively high maintenance costs of turnstile and fare box readers that must cope with dirty, bent, and damaged tickets. Readers must be cleaned often and replaced several times per year, depending on usage
* Lower reliability because low coercivity magnetic stripes can be accidentally erased or corrupted with things such as a refrigerator magnet
* They have limited data storage capacity. Data on high coercivity stripes is adequate for basic data, such as serial number, fare type, etc, but inadequate for things such as transaction history
* They can result in slower boarding speed compared to cash, flash-passes, or smart cards.

New York eliminated swipe technology on their buses due to the slow boarding speed and poor first swipe acceptance rates and they have limited security capability, and are relatively easy to counterfeit. Paris reported extensive counterfeiting of their paper magnetic tickets.

5.5 Credit Cards

A major benefit of credit cards is that it offers transit riders the convenience of a cashless fare payment medium. The major disadvantage of this payment medium is that the transit

authority incurs a risk of accepting invalid credit cards, and must pay the card issuer a transaction fee.

5.6 Smart Cards

Technically, "smart card" refers to a card with an embedded, pre-programmed integrated circuit or chip. However, many use the term to describe a variety of chipless automated cards.

Technological advances in data processing and communications have led to the development of new smart card fare collection technology. Microchips now enable manufacturers to produce pin-sized processors, which enhance both data-processing capabilities and data-storage capacity.

There are two types of smart cards: contact and contactless.

5.6.1 Contact Smart Cards

Contact smart cards have six to eight contacts through which power is obtained, when the card is inserted into a card-reader device. The power is conveyed from the terminal to the card via the contacts. This is currently the most-common smart card, and is being used by the financial and telephone industries, especially in Europe. An ISO standard has been adopted and published, and financial industry specifications have been drafted. In the transportation environment, contact smart cards remove the limited storage-capacity issue encountered with magnetically encoded tickets and cards. The disadvantages of contact smart cards are:

• The initial high cost of a card, (currently $10 per card) compared to magnetic stripe on paper or plastic ($0.05 per card)

• The high maintenance costs, since contact smart card readers are subject to the same dirt and foreign material contamination as magnetic stripe readers. The contacts in the terminal readers may malfunction if dirty

• Vibration and environment can cause operational problems, because the reader device is subject to jarring movement, vehicle cleaning, and harsh weather conditions. The utilization of terminal readers with moving parts, in conjunction with a sensitivity to outside elements, can cause problems in any transit environment

• Slow boarding speeds compared to walk-by or drop-in transactions with cash, tokens, or contact less smart cards. The transit rider must insert the contact card into the reader, and the card and terminal contacts must match-up to activate communication, as illustrated below.

5.6.2 Contactless Smart Card

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There are two types of contactless smart cards. The first use optical coupling for data transfer, which does not require physical contact between the smart card and the reader on the fare collection equipment. The transaction can take place in less than 0.1 seconds, compared to conventional magnetic systems, which require 0.5 seconds or more for the actual transaction, in addition to the time required to ensure successful physical contact is made between the card and reader. The second type of contact less smart card that uses radio frequency (RF) transmission also does not require insertion into a card reader to be scanned. The card contains a radio transponder that is activated only upon receipt of a specific radio frequency. Upon activation, the card generates a response that acts as an identifier. The reported communication range for the RF contact less card is between a few centimetres and as great as 75 meters (56).

Advantages of the contactless smart cards

The advantages of the contactless smart cards are:

• They are durable than thin plastic or paper and are suitable for many re-charges or reload cycles
• They allow fast boarding speed, even compared to walk-by transactions with other media. The contact less card need only be passed by or touched to the reader by the transit rider, and an audible beep provides positive feedback of proper communication;
• They have lower equipment maintenance costs because smart card readers are based on simple flat antennas with no moving parts, or cavities to collect dirt and
• Vibration and environment should not affect the reader device as readily as mechanical- based readers.

The primary disadvantage of contactless smart cards is the initial high media cost, compared to other media such as magnetic stripe on paper or plastic. Washington introduced a contactless smart card system in 1998, and the cost per card was $10.

5.7 Advanced Fare-Vending Machines And Distribution Networks
Office Ticketing Equipment

Office ticketing equipment allows ticket agents to quickly produce specific fare media, such as single ride tickets or weekly passes, by encoding either paper or magnetic fare tickets with the appropriate fare. Office ticketing machines have data collection and communications capabilities, and provide complete accountability for all transactions. Printed management reports can be produced, and digitized data can be communicated to the central computer.

Office ticketing eliminates the need for a transit property to stock many different types of pre- printed tickets. This simplifies ticket inventory security. In addition, office ticketing data collection and transaction documentation provides a means to settle and reconcile fare disputes.

5.7.1 Ticket-Vending Machines (New York, Chicago, Berlin, London)

Ticket-vending machines (TVM's) allow self-service ticket purchases for flat-fare and distance- based transit systems. Simple TVM's accept either coins or bills, and issue a single ticket or token for a predetermined fare category. Simple TVMs are used extensively in flat-fare systems throughout North America and Europe. Many properties have recently upgraded existing TVMs or purchased new full-feature TVMs, in order to enhance the user interface and provide the data-processing capabilities and communications links required for distance-based fare structures. Full-feature TVMs, such as those in New York, Chicago, Berlin, and London, dispense a variety of tickets and/or passes, accept credit or debit cards, and make change, in addition to providing automated fare and route information, through various user displays. Full-feature TVMs also offer data processing and communication capabilities, which provide a data link to a central computer for automated data collection, and equipment and maintenance support (17).

5.7.2 Touch-Screen Ticket-Vending Machines (New York, London, Berlin)

Recent advances in audio-visual graphics have stimulated the introduction of touch-screen technology to ticket vending. Touch-screen ticket-vending machines were observed in New York, London, and Berlin. They feature an interactive passenger information system which steps through the ticket-selection and purchasing process, and can also provide automated route information. Often one of the first selections is choice of language. In the event a customer makes an error or invalid entry during the ticket-selection process, the customer is instructed to re-enter a selection from a list of acceptable responses. This type of user interface alleviates the need for rows of mechanical push buttons, in addition to providing the capability of issuing a much-wider range of local and long-distance tickets (52).

5.7.3 Off-Site Ticket Issuing Terminals (London)

Many transit systems have arrangements with third-party vendors, or authorized ticket agents, to distribute fare media. With inexpensive tickets, the ticket agent is usually supplied with tickets pre-loaded with fixed values. However, when more-expensive long-life media are used, such as smart cards, and an agent is present to help, relatively inexpensive terminals can play the role of the TVM and load value onto the card as required. An analogy can be drawn to getting money from a bank machine (ATM). Expensive ATMs are used in unattended situations where security is needed, and inexpensive authorization terminals can be used inside supermarkets and other stores to authorize payment at a convenience counter or checkout. The third-party vendor can use a simple terminal to update a consumer's fare medium. Many point-of-sale terminals being used today can support many types of cards, which have the same electronics and communications, e.g.- bank magnetic stripe or smart cards. Since these terminals are

being produced in quantity for a broad market, they are much less expensive than transit-only terminals (56).

5.7.4 Debit and Credit Card Transactions (New York, Washington)

The majority of TVMs now offered by vendors are equipped to accept debit cards as a means of paying for fares. Debit cards are used to access a customer's bank account in order to access funds to pay for the cost of the fare. In most cases, the customer must input a private PIN number in order to authorize the transaction. A major issue for transit properties who implement this feature is the security required for the communications between the TVM and the banking institution. Encryption devices and secure lines are required by banking institutions to protect the integrity of each customer's personal PIN number. Second issue regarding the use of debit card is the fee charged by certain banks on each transaction from not only customer but also the transit agency.

It is becoming more common for TVMs to accept credit cards for the purchase of fares. This is an attractive feature when purchasing high-value tickets such as monthly passes. Both New York and Washington have introduced debit/credit vending machines as part of their new AFC systems.

Credit card transaction approval may be obtained either in real time or in a batch mode at he end of the day. Real-time approval provides the transit operator with the security of transaction authorization at the time of sale. Using direct-dial telephone lines, transaction authorization takes less than 30 seconds. The prevention of fraudulent use of a credit card is dependent on a cardholder reporting the loss or theft of a credit card in a timely manner. The absence of a cardholder's signature to validate the transaction remains a security issue, though by obtaining authorization at the time of sale, risk to the transit operator is minimized. In effect, batch approval is the reporting of the day's transactions at close of business. Any losses arising from the fraudulent use of a credit card must be borne by the transit operator. The real advantage of accepting credit cards for the purchase of fare media is the convenience it can provide to customers (39).

5.7.5 Remote Communications and Data Processing (New York, Chicago, Washington)

As multi-modal fare collection systems integrate bus, light rail, and heavy rail networks, central computing is essential for real-time remote communications and data collection. Remote communications between fare collection equipment and the central computer can be performed using existing telephone lines, dedicated lines such as fibre optics, and radio frequencies. The collected data is reduced or consolidated, and processed, resulting in timely reporting of rider ship statistics, revenue summaries, and equipment and maintenance statistics. Examples of data communicated from fare collection equipment to a central computer include:

- Ridership and fare transaction data

- Maintenance and service requests, repairs, fare vault full, machine jammed

- Equipment status i.e. in-service or off-line

- Real-time credit authorization for fare payment and

- Debit account access for fare payment

5.8 Potential Benefits of AFC

Advances in read/write magnetic and smart card technology provide the potential for transit agencies to achieve the following benefits:

- Make fare transactions easier for customers: Stored-value cards, which can have as much money as the customer wants on them, make fare transactions easier for customers compared to requiring customers to have the exact fare
- Make it easier for customers to transfer between modes: An AFC system can provide a single fare medium, which can be used on bus, rail, or between neighbouring transit operators, making it easier for customers to transfer
- Increase ridership and revenue by making fare transactions more convenient: The added convenience of AFC fare transactions may lead customers to make more trips
- Improved flexibility for new or innovative fare options: AFC systems can support many different fare options such as unlimited travel pass, peak and off-peak pricing, fare-by-distance, etc
- Reduce fare evasion: The introduction of an AFC system provides the transit operator with the opportunity to replace old, outdated, and easy-to-abuse turnstiles with new, much harder-to-evade high-level or gated entry turnstiles which physically prevent people from jumping over in order to avoid paying their fare
- Reduce fare fraud: The high data-storage capacity allows a high level of security encryption on an AFC card and in the reader devices
- Reduce internal and external theft of fare revenues: AFC offers transit operators the ability to improve financial controls and tracking of media sales, transfers, and cash transactions
- Reduce the cost of fare collection and equipment maintenance: The introduction of electronic fare payment options, such as debit, credit, or transferring funds via the internet or phone, may reduce the amount of cash transactions and, hence, cash handling costs of a transit operator. Smart card equipment is cheaper to maintain because it has fewer moving mechanical parts than magnetic AFC equipment
- Improve the reliability of fare collection equipment
- Opportunities to generate non-fare revenues: A transit AFC card can have commercial applications on the same card, which could facilitate co-promotions and generate third-party non-fare revenues.

CHAPTER 6
CASE STUDIES

This chapter depicts the success of AFC Systems implemented or under implementation in the different parts of world. Commentary is also provided on whether the issues or problems observed in the studied cities apply to, or are an issue in Toronto.

The following section also summarizes the information obtained from the site visits, and from research material obtained from UITP, APTA, and other transit properties. The transit properties studied were in various stages of implementing or upgrading their fare collection systems. New York and Chicago converted from manual fare collection systems to magnetic-based AFC systems in 1997. Washington's rail system, which is relatively new, was built with a magnetic AFC system, and smart cards were added to it in 1999. Paris and London have magnetic AFC systems currently in place on their subway and rail networks, and they are in the process of implementing contactless smart cards as a new fare payment option. Therefore, they were able to only outline their AFC objectives, and what they hope to achieve by introducing contactless smart cards.

6.1 New York City AFC System

6.1.1 Overview

Planning for a new AFC system began in the 1980s, because the token turnstiles were reaching the end of their life cycle, and had to be replaced. Another significant problem NYCT had to address was fare evasion. The old turnstiles were easy to jump and passengers could easily enter illegally through the poorly designed concessionary fare gates. The fare evasion rate for the subway was 7.4% in 1990. The paper transfers used on the surface network were also being abused.

In May 1997, NYCT introduced a new magnetic AFC system based on a magnetically encoded fare card (Metro Card) that can store value (e.g. $20), which is decremented each time the card is used or the fare card can be valid for a specified number of 24-hour periods (e.g. 1-day, 7-days etc). The entire network of subway and bus services was converted for Metro Card operation, at a budgeted capital cost of $1 billion ($690 million US) under contract to Cubic Transportation systems (36).

The primary objectives of the AFC system were to:

1. Upgrade the fare collection equipment, and in particular the subway station fare control areas
2. Reduce fare abuse
3. Offer customers greater convenience and a broader choice of fare options
4. Allowing fast transactions

Figure 6.1: Pictures of New York City Smart card, Fare box and vending machine (36)

6.1.2 Fare Evasion

NYCT was successful in reducing fare evasion in the subway system, through the redesign of the fare control areas, and the installation of modern high-gate turnstiles at unattended entrances

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6.1.3 AFC Advice from NYCT

- An AFC system is a massive investment, which affects all areas of the operation. There are risks associated with committing, system-wide, to proprietary hardware and software, because it is costly, and difficult, to change.
- Field tests of all equipment are important, to allow for AFC system modifications and adjustments prior to system-wide installation. Customers and staff should be involved in design and evaluation of the equipment. For example, the original ticket issuing machines were found to be impractical once NYCT began to install them in the station collector booths and, hence, had to be re-designed.
- The fare structure or policy (i.e. stored value cards and/or period passes) must be determined before the software system is developed, or else "you pay through the nose" for software modifications.
- Internal expertise and co-ordinated project management is critical.

6.2 Chicago AFC System

Overview

The new CTA Transit Card is a thin-plastic card with fare information encoded on a magnetic stripe (see Fig. 6.2). The Transit Card is available in either a stored value format or a time- based period pass. The stored value fare cards allow customers to add value to their card and pay as they go. Up to seven full fare customers can ride on a single stored value pass.

The card is read when a customer inserts the fare card into a reader on the subway turnstile or bus Fare box. All bus fare boxes and rail station turnstiles automatically deduct the correct fare. Each fare card use is a recorded transaction. The CTA processes 1.3 million transactions per day. The data that is recorded from each transaction is transmitted to a centrally located network computer, and it includes:

- Date and time the fare card was used
- Station or bus where the fare card was used
- Remaining value on the fare card and
- Value deducted or added to the fare card.

front   back

CTA Bus Farebox Reader

Figure 6.2: Pictures of CTA's Smart Card and Fare box Reader (16)

In addition to tracking card usage, the computer system monitors cardholder complaints or enquiries, and a new staff unit deals with

• Processing fare discrepancy reports from rail customer assistants, bus operators and bus garage supervisors
• Handling walk-in or phone calls refund requests
• Posting refunds
• Responding to enquiries

6.2.1 Operating Impacts

The introduction of the AFC system, particularly the extensive network of vending machines, enabled CTA to remove fare media sales from their subway ticket clerks. The clerks were converted to customer assistants, who help with riders problems encountered

when using the new AFC equipment (vending machines or turnstiles). This change benefited customers by eliminating line-ups, improved system security, and significantly reduced internal fraud because all fare transactions are now tracked and staff no longer handles cash (16).

Operating savings were achieved in the following areas

• Elimination of paper transfer printing, administration and distribution
• Less staff required to count bills, because bills are now stacked in vending machines
• The conversion of rail station ticket clerks to customer assistants, reduced the total number of staff required, because customer assistants only work days, and they are paid a lower wage.

6.2.2 AFC Advice from CTA

• Single-point-of-control project management was critical, and must be supported by a dedicated project team with extensive expertise
• The system should be designed with maximum fare structure flexibility, because after its in place, politicians and decision makers want the system to do everything (e.g. stored-value, unlimited ride passes, single ride tickets etc.
• There are risks associated with committing, system-wide, to proprietary hardware and software, because it is costly, and difficult, to change. For example, a part, which was originally purchased at a unit price of $0.08, has now been integrated into an updated $700 electrical board (16).

6.3 Washington AFC System

Overview
WMATA has a complex fare system with peak and off-peak fares that are also priced according to the distance traveled. Unlimited travel passes are available for 7 or 28 days. Exact fare, cash, tokens, tickets and flash passes are accepted on buses, which are equipped with registering fare boxes.

The rail system, which opened in 1976, was constructed with a magnetic AFC system in place. The original turnstiles did not working satisfactorily and WMATA has invested $25 million (US) to upgrade the magnetic turnstiles and also equip them with smart card readers. Subway riders pay-on-entry, by inserting a paper magnetically encoded fare card into the turnstile, or by passing the new contactless Smartrip smart card over the card readers located on the turnstiles (see Figure 6.3).

front

back

- Each passenger must have a card.
- Use the same card for both entry and exit.
- Low farecard value may be increased at designated fare vendors in participating Rail Stations.
- This card can be returned and replaced with a regular farecard, but cannot be exchanged for cash.
- This card must remain in the possession of the passenger and be produced on demand by WMATA Employee or Police.

If found, please return to:
WMATA
600 Fifth Street, N.W.
Washington D.C. 20001

107600 C0611

WMATA Smart Card Turnstile Reader

Exitfare

Figure 6.3: Picture of WMATA's Smart Card and Turnstile (66)

The new contactless smart cards were introduced on the rail system in May 1999, as part of a "smart fares program", which also included:

- Internet purchases of fare media (March, 1999)
- Credit card purchases of fare media from vending machines in subway stations (April, 1999)
- Fare simplification and integration policies (June, 2000)
- Debit card purchases of fare media from vending machines in subway stations (November, 2001).

6.3.1 Main objectives of the new fare program

The main objectives of the new fare program were as under (66):

•Attract new and retain existing riders-it was very confusing for customers to understand and use the complex fare tables, because WMATA's fare policy combines both fare-by-distance and peak and off-peak pricing
•Provide a single fare medium across all modes and, thereby, make inter-modal and inter-regional transfers easier for customers
•Be an industry leader by introducing advanced smart card technology
•Reduce customers reliance on cash for transit trips, and thereby, reduce cash collection and processing costs
•Reduce the perceived cost of transit trips and encourage customers to take new/additional trips

6.3.2 Present situation

- All turnstiles had been equipped with smart card readers
- Prior to implementation, a customer information privacy policy was developed, and the selling price of the smart card was set at $5, even though actual production cost was $10 per card.

WMATA is currently expanding the smart card system to the surface bus operation, at a cost of approximately $25M (US) to (41):

• Equip 1400 buses with new registering fare boxes, which will accept and validate coins/bills, add-value to either smart card or magnetically encoded fare cards, and issue magnetically- encoded transfers.

• Install computer and telecommunication equipment at 10 garages to read and collect fare data from the registering fare boxes. This will not change the current process of collecting fare revenue, but will enhance and improve financial control and reporting of surface transactions.

The new smart cards are an additional fare media option, and there are no plans to eliminate the magnetically encoded fare cards, which can be purchased from vending machines in the subway system, with cash, debit or credit. The Smartrip cards, which can also be used to pay for parking at WMATA's commuter parking lots, are sold over the internet, at 6 WMATA-operated sales facilities located in subway stations, 5 local government-operated commuter stores, at special outreach promotional events, and mail-in brochures are available throughout the subway system (66).

6.3.3 Ridership and Revenue Impacts

Customers find the SmarTrip card faster, more convenient, more reliable and accurate for turnstile activation and more secure than the paper magnetic fare cards. WMATA

attained a 23% market penetration, with subway riders, in less than one year. Sales have continued to increase and as of May 2000 they had sold 75,000 SmarTrip cards. The vast majority of smart card uses register their cards with WMATA, so that the cards can be disabled if lost or stolen, and privacy of customer travel data does not appear to be of concern to customers (41).

6.3.4 Planned System Enhancements

WMATA is planning a number of enhancements to make the SmarTrip card more attractive to customers. These changes include:

• Software upgrades that will allow the smart cards to calculate discounts, track travel patterns and increase or replenish the value on the card automatically, directly from credit card accounts, so that customers no longer have to use vending machines. The card will constantly calculate the best fare, and WMATA will guarantee the customer the cheapest trip for their specific travel pattern. For example, a passenger who buys a $5 one-day magnetically encoded paper pass, currently can take unlimited rides all day. Once the new software is installed, a SmarTrip cardholder who makes $5 worth of transit trips, will ride free for the rest of the day, as if using a one-day paper pass. WMATA will invest about $1.5 million in new software, and they expect to lose revenues from the discounts. However, they believe the discounts will attract customers to the program, which will boost WMATA ridership and overall SmarTrip card use (4).

6.4 PARIS AFC SYSTEM
Overview

At the end of the 1980's RATP began a research and development project for a contactless smart card, which would:

• Simplify passenger access to transit and make it easier to pay fares
• Reduce operating and maintenance costs compared to RATP's magnetic AFC system
• Reduce the fraudulent use of annual, monthly and weekly passes on the bus network
• Reduce counterfeiting of the out-dated paper magnetic tickets and passes
• Improve the flexibility of the fare system, and enable RATP to rapidly change the fare structure, as needed
• Increase revenues by attracting new riders through the development of a multi-service electronic payment card

RATP's smart card has both contact and contactless capabilities. The microchip in the card can function as a contactless transit card, and as a contact electronic purse for financial debit transactions. The security of the transport part of the card remains the responsibility of the transport operator, while that of the electronic purse will be under bank responsibility. This type of system architecture opens up opportunities for multi-service uses in the urban transport chain such as in car parks, tolling, taxis etc. as well as non-transit applications such as subscriptions, trading points (e.g. air miles) etc.

For transit travel, every customer will place the smart card within proximity (<10cm) of a reader with a pictogram, each time they board a surface vehicle or enter the rapid transit network (see photo below). Smart cards should be able to be read from within wallets or handbags. The transaction time will not exceed 150 milliseconds. Various fare collection options are being assessed to accommodate the commuter rail (RER) fare-by-distance strategy. These include pre-selection by the customer at the entry turnstile, or point of sale, with deduction of the total trip value (pre-debit), or alternatively, a post-debit system, with partial deduction upon entry, and the balance at exit (56).

Figure: 6.4: RATP Smart Card and Turnstile Reader (56)

6.4.1 Estimated AFC Maintenance Savings:

• The existing magnetic and electromechanical equipment requires considerable maintenance, estimated at an annual cost of 36M Fr (representing 19% of the current value of 191M Fr for the existing equipment)
• The new smart card equipment will be electronic, reducing the maintenance costs so that they will be only 7% of the value of the equipment. Maintenance cost reductions will be approximately 20M Fr per year once fully implemented (or 10M Fr per year if the magnetic ticket must be retained)
• An estimated 20M Fr of savings over three years will be saved during the transition period when the new electronic system will co-exist with the existing magnetic fare collection equipment

6.4.2 Outstanding Issue:

How will customers purchase a single ticket?

RATP assumes a disposable contactless ticket will be available in 2003-2004, at an initial unit cost of 0.86 Euro, and decreasing to a unit cost of 0.67 Euro. If this actually occurs, the existing magnetic equipment will be replaced. Alternatively, they will equip a limited number (1,400) of turnstiles with upgraded magnetic readers.

6.5 Ajax and Burlington AFC System Overview

The following information on Burlington's AFC program has been assembled from on-site interviews with Burlington staff, conducted by the author in April 2003, and updated by other standard reference material.

Electronic fare collection systems using contactless cards have been in operation in Ajax since 1991 and in Burlington since 1995. Both systems have proven to offer benefits to both passengers and the operator. The speed, convenience, simplicity, reliability and security associated with the Combo Card program (the name given to their smart card programs) is realized by both the passenger and the operator. Although the initial use of smart cards in Burlington and Ajax was limited to transit (including Para-transit), steps are now being taken to expand their use to other facilities and services, such as municipal payments, taxies and parking.

In 1991, the Ontario Ministry of Transportation of Ontario sponsored a smart card demonstration project in Ajax, a town with 60,000 residents located east of the City of Toronto. Many Ajax residents work in Toronto, and because of its location, it is a major GO Transit stop.

Ajax Transit owns and operates 20 full-size buses and five smaller buses and now the fleet has been expanded to 40 busses. The large vehicles are used on standard routes, while smaller buses are used either for Paratransit service or as community vehicles. Ajax Transit is also the sole transportation system for the local school board and caries approximately 3,800 students to and from school daily.

The smart card program was designed and implemented by a Toronto company (Precursor Limited) that specializes in fare collection systems. The software and all electronic equipment was designed and manufactured locally, except for the contactless smart cards that were imported from England. The cards were used until 1995, when they became prohibitively expensive and difficult to obtain. The system was then converted to smart cards using the Mi fare TM technology chips, which are credit-card-sized cards available from multiple suppliers.

In 1995, a similar smart card program was implemented in Burlington. Burlington has a population of 140,000, with many residents commuting to Toronto on GO Transit. Burlington Transit operates 30 regular sized buses and 13 small multi-purpose buses.
The Combo Card system requires the customer to "purchase" the smart card at the transit terminal or at the transit property offices. No deposit is required for the card, but the minimum cost is $10, which is instantly credited to the card. No name, address, or photo is required in order to safeguard the customer's privacy. However, the customer is given

a number that can be used in case of a dispute or it the card is lost or stolen. The number only relates to the specific Combo Card and not to the holder of the card. If the card is lost, for example, the owner of the card can call the transit authority and provide the number, which is not printed on the card.

The transit authority can then cancel the stolen card and reissue a new card with the remaining balance to the owner. Therefore, the cancelled card is no longer useful, and if the card is used it will not be accepted by the reader.

One of the advantages of the Combo Card purse system is that the customer can choose at anytime to use the card to pay for individual fares or a period pass. The period pass is automatically activated upon first use and expires after 31 days, a feature that permits its purchase any time of the month to avoid the monthly rush. The card is not disposable but its purse is reload able. The system works by the customer holding the card over the reader upon entering the bus. The system does not require the customer to remove the card from a wallet or purse. The reader displays the amount of the fare or the type of transaction to both the driver and the passenger.

If the rider changes routes within the appropriate time limit, the card will be recognized as a transfer, thus avoiding the need for paper transfers. If the customer wishes to pay for several riders, the driver must input the appropriate category and the number of riders, the fares will be deducted from the balance on the card. The time limit will not only recognize transfers, but also recognize when the card (pass type) has been passed to another user, thus reducing fraud.

Due to the ease of implementing different fare schemes, both Ajax and Burlington offer special fares to customers transferring from GO Transit. Burlington has also implemented a daily pass and a special fare that is automatically charged after 7 p.m. A reduced frequency discount fare scheme is to be tested shortly. Another recent initiative is the automatic $2.00 credit available to each card. If the user does not have the proper fare available in the stored value on the card, the customer will still be permitted to ride, but the credit is automatically deducted when the card is reloaded.
Both Ajax Transit and Burlington Transit continue to accept cash fares on their buses. Also, a rider may deposit money into the fare box at any time and have the amount added to the Combo Card.

The bus operators carry their own smart cards that must be used to start and end their shifts, thus creating a record associated with the work and routes they operate. Maintenance personnel download data from a bus during refuelling using a special high memory card. The same card can also be used to load a new fare structure, to load a list of lost or stolen cards, or to download certain bus maintenance data into the maintenance garage's computer.

On-line data retrieval is one of the most powerful features of the Combo Card program. The database permits instant generation of reports associated with driver, bus, route, time, location, individual cards, and even transaction records. Various regular reports

associated with day, month, and any other time period are available. Detailed analysis can be performed so that, for example, it is easy to evaluate a new fare structure, or to find the frequency of rides taken by pass holders, or to analyze trips taken by specific customer groups.

6.6 Hong Kong, Singapore And Kuala Lumpur AFC System

Overview

Usable on urban rail (Mass Transit Railway (MTR) and Kowloon Canton Railway (KCR), light rail (KCR)), bus (Kowloon Motor Bus, Citybus, New World First Bus. and KCR feeders) and ferry (Hong Kong and Yaumati Ferry), the system enables individual operators to implement their own fare collection methodologies such as distance-related, flat and monthly pass schemes in both barrier-based and barrier-free ticketing environments.

Each station and ferry terminal has its own local area network, which connects all barriers, validators, add-value machines, and ticket office processors to a local station computer, which is then linked to the transport operators central computer where detailed management reports of usage, revenue and performance are produced. In the case of mobile processors, located on buses, transaction data is collected at the fuelling bays using a wireless LAN connected to the Bus Depot computer.

All transaction data are transmitted to the Central Transaction Clearing House (CCH) for reconciliation and settlement of revenue between the service providers within 24 hours. In addition, the CCH also monitors card usage history and is capable of detecting any anomalies and establishing files of invalid cards for downloading to the processing devices. Security of the system is a combination of the inherent smart card encryption and authentications between devices overlaid with fully centralized transaction monitoring and audit trail capability.

In the first few days of operations some unfamiliarity with contactless operation of the card meant that an occasional retry was necessary, but after a very short period cardholders quickly adapted and gate throughput increased by 15%-20% above the previous magnetic system. It became apparent that the feature of not needing to take the card out of the cardholder's wallet or handbag was perceived as a major convenience.

Over the first 18 months of operations, there was a higher card failure than anticipated. The failure rate is correlated to way cards are used and stored by the cardholders. The cards were manufactured and tested to current ISO standards. It is believed that a more rigorous standard is required regarding accommodating expected in-service stress applied across the plane of the chip. Such stress can occur for example if the card is kept by the cardholder in a back pocket, where bending or flexing can occur when the cardholder sits or bends down or when the card is stored in a wallet or purse alongside a zipper or stud.

A new generation of cards incorporating a strengthened fabrication technique has been introduced with substantially improved results.

While the standard ISO smart card is accepted and preferred by the public, its small thickness of 0.76 mm imposes almost impossible constraints on the smartcard manufacturer to achieve target in-service failure rates of 0.1% per year. Embedding the chip in a watch or inserting the card in the protective envelope of a mobile telephone achieves both added value in terms of use and also provides the physical protection the chip requires (22).

The Octopus can be used in over 500 public telephones on MTR and KCR stations and also for the automatic photo booths also located with MTR. Expansion to other services, such as generic vending machines, is dependent upon development of a low cost reader/writer. With the huge market penetration of the Octopus card, there is much interest in expanding the applications outside of transport. Creative Star's policy is to particularly focus on those applications, which have some synergy with the core transport application. Dialog with other electronic-purse-scheme issuers is taking place although real opportunities are only likely to occur once a common contact/contactless smartcard standard is available.

In an overall sense with over 6200 pieces of equipment, 250 distributed computers, and over 4.2 million lines of unique software in the system there were occasional teething problems, but overall the system has performed well with only a few deep and intermittent problems still under investigation. One should not, however, underestimate the challenges in bringing such applications from concept to reality (22).

6.7 London AF C System

Overview

London Transport (LT) has had a system-wide bus and Underground ticketing system since the magnetically encoded Travel card was introduced in 1983. The LT Prestige project was initiated, under the Government's Private Finance Initiative, to replace the existing ticketing infrastructure, which was at the end of its life cycle, with a new integrated electronic ticketing system. It will be based on contactless smart card technology (see photo below). It will replace, over time, the paper and card based life-expired magnetic stripe ticket system (49).

Figure: 6.5 London's Prestige card (51)

The objectives of the new Prestige system are to:

• Make it quicker and easier for London Transport customers to pay for travel and use public transit
• Reduce opportunities for fraud and fare evasion Currently fare evasion due to ticket less travel is estimated to cost $100 M (£43 million) per year, and represents 3.47% of passenger revenues (49)
• Reduce line-ups at ticket offices
• Improve boarding speed on buses
• Offer greater flexibility for adapting or introducing new fare or ticketing policies (eg., peak and off-peak pricing)
• Improve financial accountability of cash fare payments
• Provide management data for marketing and service planning
• Improve the public perception of London Transport

In addition to the customer benefits, London Transport has estimated the a total of £23.0 million GBP annual operating savings will be achieved as outlined below:

• Reduced fraud and fare evasion from ticket less travel will increase revenues by £10.5 M. This will be achieved primarily through the installation of new turnstiles throughout the subway system and new ticket issuing machines on buses

Annual cost of ticket agent administration savings of £4.0 M

• Additional passenger revenue of £3.0 M will be generated from new passenger trips
• Passenger survey costs will be reduced by £2.0 M and
• Commissions on 3 rd party revenues will increase revenues by £3.5 M. LT will receive 50% of the commissions received on all third party revenues which will be generated when customers use the smart card to make non-transit purchases (49)

Smart cards will be phased in beginning in May, 2003, when they will replace the existing range of time-period passes, and concessionary passes, and gradually a stored value ticket, along with other new ticket products will be introduced (51).

There are several key future issues that have yet to be resolved. They include:

- Mechanisms for controlling the costs of consumables
- Interoperability with other transport and train operators
- The optimum means of providing one-day or single-ride tickets
- Third party opportunities and partnerships
- Will fare incentives be required for customers to switch to the proposed stored value ticket?

6.8 Berlin AFC System
Overview

On October 1, 1999 the Berliner Verkehrsbetriebe (BVG), S-Bahn Berlin and VVB, which is the transportation authority for Berlin and Brandenburg, began an in-service test of an electronic ticketing system. Between October 1, 1999 and April 30, 2000, approximately 27,000 test users were able to use a dual-interface, contact and contactless, smart card on:

- 2 metro or subway lines (30 stations)
- 2 bus lines (32 vehicles)
- 1 tram line (14 trams, 28 coaches)
- 1 section of the S-Bahn Berlin suburban railway line (7 stations)

A distance-based and time-based fare structure was being evaluated. The test users check-in at the beginning of their journey, and the maximum fare is deducted from the smart card. They checkout at the end of their journey, at which time the actual fare calculation is done and value is put back onto the smart card, as required.22

The objectives of the AFC system are to:

- Reduce operating costs related to:
- Paper ticket vending machines; and
- Passenger traffic counts surveys (500 to 600 passenger surveys conducted every two years).
- Increase passenger revenues with new distance-based and time-based fare structure, increasing trip making by occasional transit riders particularly if the system is linked to other travel opportunities. For example, a customer who uses the smart card primarily for parking may be more disposed to make transit trips since they have the card in their pocket anyway.
- Reduce fare evasion from ticket-less travel, which is estimated to be in the range of 8% to 10%

6.9 Key Lessons

1. Deposits may be unpopular, however they do deter cardholders from destroying expensive cards. The settings of deposit rates is critical to the overall cost of travel and could affect take up of SVT cards, and dissatisfaction can further be moderated by having a simple, fast refund process in place.

2. Multi-sourcing will be critical to overcome unexpected surges in take-up of cards and to keep unit costs down to a competitive level.

3. Registration, personalization and issuing of cards must be a simple and quick process.

4. SVT is simple to understand, however it is critical to inform customers of charges and balances on displays as they travel through the system at gate and buses devices.

5. Ticketing strategies are the key to success. The range of ticket products can confuse customers competing and conflicting products will hamper take-up of cards and SVT, which should be seen as complementary to other products available.

CHAPTER 7

OBSERVATIONS OF AFC FROM OTHER CITIES
7.ISSUES AND THEIR SOLUTIONS

After a detailed study and analysis of the successes and failures of AFC Systems in the different parts of world there was a need to critically answer the key question with regard to the future of AFC in Toronto.

Following is the list of key questions in the mind of ITS Managers and Decision Makers with regard to the introduction of AFC in TTC and my opinion/answers.

7.1 KEY QUESTIONS AND THEIR ANSWERS

1. Does the TTC need to replace its fare equipment
2. Are line-ups at ticket booths an issue for the TTC?
3. Does TTC need an improved sales network?
4. How flexible is the TTCs fare system?
5.Is intermodal transfer a problem at the TTC?
6. Is transaction speed an issue for the TTC?
7. Are Ridership and revenue impacts considerable?
8. The Operational Considerations of AFC like
a) Fare evasion an issue for TTC?
b) Counterfeiting and Fraud an issue for TTC?
c) Reduced Theft (External & Internal) an issue for TTC?
d) Reduced Equipment Maintenance Costs an issue for TTC?
e) Availability of Improved Management Information is an issue for TTC?
9. Is vendor financing something the TTC should consider for an AFC initiative?

7.1.1 Is Replacement needed?

The Need to Replace Old, Failing Infrastructure
Virtually all of the properties studied indicated that, prior to investing in an AFC system, their existing fare collection equipment had reached the end of its life cycle and that it, therefore, had to be replaced. In the cities that were committed to maintaining a complex fare-by-distance or fare- by-time-of-day fare system -- Washington, London and Paris -- they required advance logic features in the system that would ensure that passengers pay the correct fare. For example, the magnetic AFC system currently in operation in Paris is approximately 30 years old and must be upgraded or replaced. After evaluating alternative AFC technologies, Paris concluded that a more-advanced magnetic technology would improve reliability and memory capacity and, thus, enable some evolution in the fare structure. However, it would not provide sufficient enhancements to fully meet customer expectations, and would not help to significantly reduce fare evasion in buses or reduce overall fare equipment maintenance costs. As a result, the Paris transit authority launched a research effort that led to the development of a contactless smart card, which would meet their fare system objectives. With a flat fare system, which is

used in New York and Chicago, technically advanced entrance and exit control gates are not required. Nonetheless, both New York and Chicago had to replace their old token subway turnstiles and registering fareboxes on their buses. In the early 1990's, when they began planning for replacement AFC systems, advanced read/write magnetics was the only option available for stored-value media, and it would also facilitate intermodal transfers between buses and subway.

- *Does the TTC need to replace its fare equipment?*

    The TTC's simple flat fare structure does not require technological intervention to ensure the correct fare is paid. The existing fare collection equipment is in good condition and does not require replacement immediately but with the passage of time it is becoming obsolete and it will be difficult for TTC to replace it altogether at a later stage. It needs replacement step by step following the lessons of other cities.

7.1.2 Are entry delays an issue?

Transit agencies have invested in AFC systems to make it quicker and easier for customers to pay for travel and use public transit. The expectation is that by increasing customer convenience, more transit trips will be taken and new riders will be attracted to the system. Washington customers think their new smart card is "cool, easy, and convenient". In less than a year, 73,000 rail passengers were using the smart card, which represents 23% of the Metro rail ridership. However, in New York, the key to customer acceptance of the magnetically- encoded fare card was the introduction of fare discount incentives. Prior to the introduction of fare incentives, such as free inter-modal transfers, express bus fare reductions, and unlimited-ride passes, 23% of the total transit trips were made using the MetroCard. After the big-discount fare incentives, 70% of all NYCT rides were made with MetroCard (20).

The AFC systems observed did increase customer convenience in the following:

- Reducing line-ups at ticket booths: In New York and Chicago, customers no longer have to line-up at ticket booths to purchase or pay for fare media. Both properties have modern vending machines in their subway stations that accept cash, and debit or credit cards. One of the primary goals of London's forthcoming AFC system is to reduce the lengthy line-ups at ticket booths.

    - *Are line-ups at ticket booths an issue for the TTC?*

        Line-ups at collectors booths do not occur on a regular basis, except at the beginning of the month, when customers are purchasing their monthly Metropasses, but most of the potential customers do not even think of wasting their time in line. In my opinion it is a big issue.

7.1.3 Is a new way of selling tickets required?

A key factor in customer acceptance of the New York fare card was the extensive AFC sales network which made MetroCard purchasing as easy as possible for both bus and rail riders. There are over 1,000 automated vending machines, with touch screen menus and multiple language options, which accept bills, coins, and debit/credit transactions. In Chicago, 50% of the bus users purchase fare cards, compared to 92% of rail users. The lower acceptance of the AFC fare cards by CTA bus riders is thought to be due to their more-limited access to add-value vending machines, which are located only in subway stations, and due to the fact that the pre-valued fare cards sold at convenience stores are priced too high ($13.50 and $16.50 is too much initial cash outlay) for some of the bus riders. The CTA are considering investing in electronic point-of-sale machines for its retail vendors to make it more convenient for customers, who travel by bus only to purchase and add value to fare cards (16).

- *Does TTC need an improved sales network?*

    Yes. Customers can purchase fares from subway station collectors, over 1200 independent ticket agents located throughout Toronto, and 131 cash- only token vending machines in the subway, which is not sufficient. Metropass purchasers can pay by pre-authorized debit, and receive their Metropasses by mail.

7.1.4 Are more fare options needed?

The AFC systems in New York and Chicago enabled these transit properties to introduce 1-day, 7-day, and 30-day unlimited ride passes, which are activated on the first day they are used. Over 30% of the daily transit trips in New York are now taken on these types of passes.

How flexible is the TTC's fare system?

TTC currently has two unlimited-ride passes, a one-day pass (Day pass) and a calendar month pass (Metropass). However, the current system is inflexible, making it difficult to implement fare changes and/or additional fare options to market to specific ridership groups or to encourage higher use of the TTC.

-Among needed features are debit, credit or cash payment, multilingual capacity and future upgrade ability.

The AFC systems in New York, Chicago, and Washington allow customers to have as little as $1.50 or as much as $200 on their transit fare card, depending on their particular travel needs. Washington's smart card can also be used to pay for commuter parking. Over half of all New York's express bus riders switched to MetroCard because they found it more convenient than tokens or coins for exact fare payments.

Is exact fare a problem at the TTC?
A flexible AFC fare medium would be a benefit for TTC customers, although TTC riders have not identified exact fare payments as a major concern.

7.1.5 Is Intermodal transfer a problem at the TTC?

• Facilitating inter-modal transfers
New York and Chicago have limited physical integration between their subway and surface networks. The introduction of an AFC system enabled them to better integrate their transit system and make it easier to transfer between modes.

The existing physical integration of the TTCs surface and rapid transit system provides easy, fast, convenient transfers between modes, with no barriers.

7.2 Ridership and revenue impacts

It is difficult to determine whether the added customer convenience provided by new AFC systems actually results in increased ridership. Most transit agencies studied simultaneously introduced AFC and changed their fare policy. New fare options, such as unlimited ride passes, free inter-modal transfers and high-value purchase discounts, were offered as incentives to encourage customers to switch to the new fare medium. It is virtually impossible to separate any ridership impacts associated with AFC from those attributable to the fare discount incentives, economic and population growth, or changes in the service provided. London and Paris believe that the introduction of smart cards will modestly increase ridership and revenues, but until their systems are actually in revenue service, this assumption cannot be evaluated.

In conjunction with the introduction of Washington's SmarTrip card on the rail system, that system simplified its fare structure by significantly reducing the number of fare zones on the surface network. Prior to the new fare program, the annual rate of ridership increase was approximately 1% and 2% for rail and bus, respectively. Since the introduction of the smart card, and the fare simplification, the average weekday rail ridership is up by 3.1%, and average weekday bus ridership is up 10%. It is unknown how much of this growth is attributable to the new fare structure and how much is due to economic and population growth. Although ridership increased, the revised fare structure resulted in a net annual loss of $15 M in fare revenue (66).

The new AFC system in New York enabled that city to introduce four new fare incentives, which contributed, to an increase in the number of weekday unlinked trips:

• Free intermodal transfers between bus and subway;
• MetroCard Bonus Program (10% bonus on purchases of $15 or more);
• Express bus fare reduction; and
• Unlimited ride MetroCards (1-day, 7-day, 30-day unlimited ride passes)

Between January 1997 and June 1999, the total number of weekday unlinked trips on the system increased by 20%. However, this increase cannot be solely attributable to the AFC system, nor does it entirely represent an increase in the number of new transit riders. For example, before AFC, a customer who used to walk to the subway and then take the

subway to and from work would have counted as two unlinked trips. After AFC, the same customer can now ride the bus to the subway for free and, hence, this same person making the same trip to work as before now counts as four unlinked trips (two bus trips and two subway trips). Also, the new magnetically- enabled transfers, which were no longer controllable by location and direction, made several new travel patterns possible with no increase in fare revenues. Customers can now make a round-trip and trip-chain on a single fare as long as those trips are taken within two hours. The other major factors that contributed to New York's ridership increase were strong economic and employment growth (5%), reduced citywide crime, and population growth near the subway. With the introduction of AFC, together with fare discount incentives, fare revenues in New York dropped by 3.2%, and their overall revenue/cost ratio dropped from 74% in 1997, prior to AFC, to 64% in 1999 with AFC. The cost of increasing service for the additional riders has been significant. Between 1997 and 1999, NYCT has invested approximately $300 million (annualized) for added service, and approximately 400 additional subway cars and 631 additional peak buses are required to meet ridership demand.

7.3 Operational Considerations of AFC

AFC systems can produce a range of operational benefits for the transit operator that include:
1. Reducing the number of fare evaders entering subway systems, primarily by introducing bigger, more physically-imposing turnstiles which are much harder to hop over
2. Reducing the level of fraud because new AFC cards, notably smart cards, are more difficult to counterfeit
3. Reducing the amount of internal and external theft because AFC allows improved financial control and tracking of cash sales and transfers
4. Improving fare equipment reliability;
5. Reducing equipment maintenance costs, notably with contactless smart card technology, which does not require physical interaction and does not suffer as much wear and tear
6. Improving management information for purposes of marketing, planning, and equipment maintenance

Each of these is discussed below.

Fare Evasion

New York was successful in reducing fare evasion in the subway system, through the redesign of its fare control areas, and the installation of modern high-gate turnstiles at - unattended entrances. The new turnstiles were installed between 1994 and 1997. In 1993, New York's subway fare evasion rate was reported to be 3.5%, which represented an estimated revenue loss of $34 million annually. By 1999, the evasion rate had dropped to 0.52%, which represents an estimated revenue loss of $7 million annually. 36Another factor contributing to the reduction in fare evasion over this time period was an extensive citywide crime reduction campaign. Overall, New York has been able to recover

approximately $27 million annually as a result of reduced subway fare evasion. The new AFC system in New York was intended to reduce transfer abuse on the surface network, because every fare would be validated by the AFC system. However, unforeseen technical and operating limitations produced a less-controlled system of free transfers than had been originally conceived. The new magnetically enabled transfers are not adequately controlled by location and direction. Therefore, customers are able to make round-trips and trip-chain on a single fare, as long as the customer does not board the same bus route, and transfers within two hours of boarding the first bus.

As part of the London Transports Prestige project, all 271 London Underground stations will be equipped with turnstiles. Currently, only stations in the central core are fully equipped with turnstiles, and fare evasion is estimated to cost $100 million per year this lost revenue equates to 3.47% of passenger revenues. As turnstiles are being installed, fare inspectors have been catching more fare evaders at the next available open station. The use of smart cards and the accompanying installation of turnstiles is expected to reduce fraud and ticket less travel, and increase passenger revenue by $24 million annually.

Paris reports a fare evasion rate of 10%, which results in annual revenue losses of $126 million.56They believe that the introduction of smart cards will result in increased revenues of approximately $13 million annually due to

- Systematic validation of all fares on buses
- Personalization of the smart card, which will significantly reduce or eliminate fraudulent use of stolen or lost, passes
- Significant reduction or elimination of fraudulent purchase of reduced-fare passes.

Is fare evasion an issue for the TTC?

The TTC's fare evasion rate is 0.7%. It is likely that any program or investment, such as AFC, could push this evasion rate significantly lower.

Counterfeiting and Fraud

Smart card technology is more secure than paper tickets, and than magnetics, because there is enough memory capability to allow for a high level of security encryption. In Paris, technological fraud (i.e. counterfeit tickets and passes) is estimated to be 0.7% of all subscriptions, or approximately $9 million annually.

Is fraud an issue for the TTC?

Counterfeit and spurious coins are estimated to account for 0.2% of revenues collected by the TTC. The TTC uses read-only swipe-through readers, to validate Metropasses. The read-only nature of the Metropass data is read off the card, but not transferred or updated back makes the Metropass.s watermark magnetic stripe very secure and hard to counterfeit. A recent decision to equip turnstiles with coin comparators is expected to

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significantly reduce or eliminate the fraudulent use of foreign coins. It is likely that significant further reductions in fraud could be achieved through measures such as AFC

Reduced Theft (External & Internal)

With Chicago's new AFC system, customers can no longer purchase fare media from ticket clerks. Instead, they must use ticket vending machines. The former ticket clerks are now customer assistants who help riders access the system and use the new ticket vending machines. This change notably removing all fare media sales from subway ticket clerks and installing fare vending machines enabled Chicago to improve system security and reduce the number of robberies. The vending machines are more secure than the former ticket booths, and the elimination of cash handling by staff eliminated internal theft and ticket booth robberies (16).

Chicago's AFC system also improved financial accountability because all transactions are tracked. Prior to AFC, ticket collectors could pocket cash payments, because cash fares were not deposited directly into a farebox and, hence, could not be tracked. There had also previously been extensive abuse of transfers. Illegal transfers were sold on the street in the downtown area. With the new AFC system, each transfer issued is recorded, and can be used only once.

The installation of automated ticket-issuing machines in London is also reducing internal theft, because drivers can no longer keep cash payments for personal lunch money.

Is theft an issue for the TTC?

The TTC has extensive financial controls in place. Collectors are audited on a monthly basis, and fund irregularities are rare. Each booth is fully alarmed, including CCT monitoring, and contains a drop-vault safe-storage system for sales revenues. Surface vehicle operators have no involvement with selling fares or handling cash, and the fareboxes on these vehicles do not allow drivers any access to the contents of the box. As a result of all these measures, the TTC's theft rate, both internal and external, is approaching zero. Therefore, this is not an issue for the TTC.

Reducing Equipment Maintenance Costs

Paris, London, and Washington are hoping to reduce their equipment maintenance costs by having customers switch to smart cards. Magnetic turnstile and farebox readers have many moving parts, and read heads must be cleaned continuously. The operating environment in which this equipment is located is generally poor, both on the subway and on surface vehicles. The use of dirty, bent, or damaged magnetically encoded paper tickets contribute to the maintenance costs. Alternatively, smart card readers have no moving parts, or cavities to collect dirt. By eliminating any need for physical interaction between the card and the reader, wear and tear on the readers should be significantly reduced which, in turn, should reduce maintenance costs.

In Paris, the existing magnetic turnstiles require considerable maintenance, estimated at an annual cost of $8 million, which represents 19% of the current value of $42 million for the equipment itself. The new smart card equipment will be electronic and contactless, reducing the maintenance cost rate to 7%. Paris projects that an estimated $4 million of savings over three years will be achieved during the transition period when the new smart card system will co-exist with the existing magnetic fare collection equipment It is further projected that maintenance cost savings will be approximately $4 million per year if the smart card completely replaces the magnetic system, or $2 million per year if the magnetic system must be retained. 56

Is equipment maintenance cost an issue for the TTC?

The TTC and Washington are relatively comparable in terms of total number of subway stations. Approximately 70% of the TTC's turnstiles are equipped with Metropass readers. The TTC has half the number of revenue equipment maintenance staff that Washington requires to maintain their magnetic AFC turnstiles and vending machines in their subway system. This would suggest that the TTC's equipment maintenance requirements are reasonable. Further benchmarking against other comparable properties would be required to corroborate this comment.

Improved Management Information

The AFC systems in New York, Chicago, and Washington have all increased the amount of information available to management to allow improvements in decision-making and business practices in the following areas:

-Service or route planning, and market analysis: Total daily ridership (passenger boarding), can be disaggregated by location (station or route) and by time of day, for use in these functions. However, origin/destination data is not available because surface vehicle exits are not monitored, and there are privacy issues regarding the use of individual passenger travel data.
-Financial controls and audit: Each sale transaction is recorded, by location and by ticket agent. This information is used extensively for the reconciliation of customer refunds on lost, stolen, or damaged cards.
-Pass pricing: Information on the actual numbers of trips made on passes is used to help set prices.
-Fare equipment availability: Fare equipment operating status is monitored remotely, and staff is dispatched in a timely fashion, resulting in a significant increase in availability. Also, management reports identify what repairs were required, who serviced the unit (turnstile or vending machine), and how long it took to repair, so that business practices may be altered for better productivity.
-More efficient servicing: Electronic equipment diagnostics make servicing faster, easier, and more efficient. Remote revenue collection reports indicate the amount of money in a vending machine's cash vault and, therefore, not every vending machine need be emptied every day.

Is availability of management information an issue for the TTC?

The TTC's current manual fare collection equipment provides virtually no data for management information and decision- making. The TTC would benefit from a system which provided remote information, was easier and faster to repair, and which could help in the development of a repair and servicing plan, which could be less frequent.

7.4 Vendor financing?

According to TTC service planner, such an arrangement is equivalent to generating capital funding by raising fares. For example, if the TTC were to increase fares by 5 cents, this would generate $15 million per year, which could be used to pay down the cost of a new AFC system or any other capital investment. The TTC has always resisted this because TTC customers already pay for over 80% of operating costs through their fare payments again unmatched virtually throughout the world. So, the proposal to have vendor finance the cost of installing an AFC system would not provide the TTC with any source of capital financing which the TTC could not do on its own, if it so decided. The bottom line is this: such systems are never free The TTC or the City can repay a debenture or can repay the vendor; the financial implications are substantially the same.

7.5 Outstanding Issues

Based on study of six cities currently operating or developing AFC systems, together with a review of industry reports on this subject, the following outstanding issues have been identified regarding smart card technology:

7.5.1 Rapidly-Evolving Technology

As with any high-tech equipment, the technology of automatic fare collection systems is evolving very rapidly and there is, as yet, no consensus or standardization of this technology. The different cities studied typically had different card technologies, different reader technologies, different communication technologies, different computer technologies, different system architecture, and different financial and revenue reconciliation and processing arrangements. There are international efforts, through organizations such as the Integrated Transport SmartCard Organization (ITSO), the ContactLess technology Users Board (CLUB), and UITP, and locally, the Alternative Transportation Options Association of Toronto, an initiative of Toronto's *Moving the Economy* group, to establish international standards for AFC technology. No doubt, in time there will be convergence of this technology. However, at this time, transit properties buying AFC systems are required to choose from among different proprietary technologies offered by different manufacturers.

7.5.2 Cash, and Single-Ride Fare Payments

Even with the introduction of automatic fare collection systems and smart cards, all transit agencies plan to continue to accept cash fares, for the foreseeable future. The relatively high unit cost of a smart card, $10 per card, compared to $0.01 to $0.05 for a token or magnetically encoded fare card, makes it an impractical option for the single-ride, infrequent user. From the customer's perspective, a cash payment is simple and easy, because you pay when you board, and you don't have to go "somewhere" (e.g. ticket booth or sales agency) to purchase "something" (e.g.-ticket, token, magnetically-encoded farecard, or smart card) from "someone" (e.g. machine, transit employee, or ticket agent). In New York and Chicago, two cities with AFC systems in operation, cash fare payments represent 23% and 40% of their total annual rides, respectively. In New York, 30% of bus trips are taken using cash or tokens, even though the new magnetically encoded fare cards provide significant fare incentives (36).

7.5.3 Concerns over Privacy of Personal Information

AFC systems offer the transit operator the opportunity to collect information on the travel patterns of individual customers, so that services can be planned to better meet customer needs. However, in a number of cities, which have, or are planing to install AFC systems, customers have objected to transit operators tracking their whereabouts in terms of specific routes or times of travel. Thus, the data that AFC's may be capable of collecting may prove to be unavailable to the transit operator. Reliability and Enforcing the Use of AFC on Surface Vehicles AFC equipment with mechanical components installed on surface vehicles, such as buses or streetcars, appears to be less reliable than equipment installed within subway stations because of the more-demanding operating environment on surface vehicles. Additionally, various properties indicated that enforcing the use of AFC readers on surface vehicles is more difficult than within subway stations, where people are required to pass through a turnstile upon entry and exit of the system (59).

7.6.Summary of Key Findings From Other Cities

The main findings from the major cities, which have, or are in the process of, implementing AFC systems, are:

- The primary reason for implementing AFC is that ageing or failing fare collection equipment forced these cities into replacing their old systems with something new.
- In cities, which have adopted AFC technology, customer like it and use it.
- AFC systems have provided operators with improved financial controls and have a strong potential to reduce counterfeiting of fare media.
- There were clear financial business cases for the introduction of AFC in any of the cities studied. All properties that have converted from manual to AFC systems were required to increase their workforce to support the new AFC system.
- Evidence was provided to indicate that AFC, unto itself, had produced increases in

ridership or revenue.
- Most of the cities have generated third-party revenues from their AFC systems.
- Concerns over privacy of information may prevent transit operators from exploiting the travel behaviour data which AFC systems are capable of generating.
- AFC systems take upwards of ten years to implement in a major multi-modal transit system.

CHAPTER 8

CHALLENGES/ISSUES IN IMPLEMENTATION OF EMERGING TECHNOLOGIES

Before going into specific details of Applicability of AFC and APC for Toronto Area the general challenges in the implementation of the cited technologies are imperative to be discussed.

Based on the interviews of relevant industry personnel and related literature available in the books or web sites, this chapter briefly goes through the important aspects of issues and challenges faced in the implementation of ITS Technologies in public Transit

8.1 Integration Challenges

Project managers were told to rank selected integration challenges in a Liker scale of one to ten where one is the least important challenge and ten is the most important challenge.
The most highly ranked challenge is how to secure adequate funding and meet project budget. Although projects deployed so far showed no significant cost overruns, this result reveals the uncertainty surrounding securing sufficient funds to meet unanticipated budget expenses. Since project managers do not find it simple and easy to convince senior management of the significant benefits of ITS investments, many ITS projects have suffered reduction in scope due to lack of additional funds to pay for new essential needs that might emerge during the deployment phase (59).

Lack of consistency of management commitment ranked as the next most important challenge. Personnel changes in senior management, and political pressures both within and outside the agency may account for the inconsistent support. This occurrence may explain why there is the uncertainty in budgetary allocation for ITS projects. Technical and legal challenges were ranked as the next most important challenges. It is interesting to note that fear of information sharing was ranked the lowest. This ranking supports the view that agencies are getting the message that ITS is "here to stay" and that it can promote the benefits of information sharing.

8.2 Institutional Challenges

System integration demands special coordination and teamwork. ITS investments often represent a small budget of transit agencies and therefore are unable to compete with well-established and well-staffed programs for funding and management commitment. Even in agencies where there are ITS champions, the champions do not necessarily have the authority to make significant changes in the balance of power and control to favour ITS. Strong commitment shown by the Transport Canada leadership has induced some transit general managers to actually "try out" ITS.

Interviews of project and service managers revealed that senior transit managers who are not technology oriented and want to maintain the status quo, (that is "don't rock the boat" type) sometimes consider ITS as a liability. Some even fear that if they publicly support ITS initiatives, it might lead to downfall when something goes wrong. There are others, though, who are strong supports of ITS. To reduce the exhilaration and commitment of project managers and ITS enthusiasts, these managers attempt to control ITS funding, information sharing, staffing, and project expansion.

The project managers interviewed believe that the inability to estimate the true value of ITS benefits during the project justification stage (before deployment) is a barrier to integration. They advise that best practices and peer-to-peer knowledge sharing of ITS success stories can be a tremendous help in educating senior managers and other operating personnel of the benefits of ITS integration. Strong public awareness and education campaign through workshops, seminars, training courses, one-on-one field support, guidance documentation, conferences, handbooks, etc., must be implemented to alleviate some of these challenges.

8.3 Legal/Procurement Challenges

Transit ITS deployments, like other ITS implementations have survived several public-private partnerships. The concept of partnership is great, but the practicality of its implementation does not fit well into traditional contracting procedures and legal terminology. For instance, in partnerships, legal documents do not address clearly the balance between needs, costs, benefits, and risks that are shared by the partners. At the early stages of deployment (before contract award) there is a great deal of optimism in working together, but this wanes over time as the contact is awarded and the project is advanced in deployment. The legal and procurement staff has to work with the technical, operating, budgetary, and management staff to develop a fair and reasonable selection process during the vendor proposal evaluation. They are unable to change the competitive process in order to select the most capable bidder, which may not necessarily be the lowest bidder. Procurement and legal challenges of integration include issues such as acquisition of software and source code problems, rights to data, intellectual property, cost estimating, scope implementation issues, scheduling, system upgrades, warranty provisions, field tests requirements and acceptance criteria. Most large transit systems are still procuring proprietary software and hardware systems due to lack of open data and message standards (15).

TABLE 1

The Table below depicts the ranking of integration challenges in author's opinion in a Liker scale of one to ten where one is the least important challenge and ten is the most important challenge.

Integration Challenge	Rank
Budgetary constraints	8.0
Lack of consistency of management commitment	7.8
Difficulty of estimating the value of ITS benefits	6.9
Difficulties in developing new standards and protocols	5.8
Inability to do maintenance at cheaper cost because of lack of Source code rights to data	5.7
Ability of managing different systems with different platforms at different times	5.5
Ability to build large databases	5.4
Difficulty of evaluating the full costs of ITS projects	5.4
Difficulties in testing new standards and protocols	5.2
Need to replace and expand systems	5.2
Difficulties in new technology implementation	5.2
The need to developing multipurpose systems rather than single-purpose systems	5.1
Ability to ensure independence while integrating data	5.1
Degrading of systems due to aging	5.1
Lack of understanding of new standards and protocols	4.7
Ability to use acceptable transit standards on data messages, protocols	4.2
Fear of sharing information	3.0

Source: Relevant literature, research findings and interviews of ITS managers / Service planners of Transit agencies of GTA

8.4 Technical Challenges

Transit systems procure software systems for specific ITS applications. Some are procured for single purposes while others are not. These single-purpose applications are good only for the purpose of meeting single objectives. However, since ITS is multifunctional and multipurpose there is often the need to provide one system that meets multiple objectives. For this reason, transit systems face the challenge of moving these single-systems to multipurpose applications. Another challenge faced by transit systems in software procurement is difficulty of integrating different systems using different platforms or software languages. Transit managers have been more concerned also with major equipment acquisition and maintenance contracts. Many of the systems are aging and in need of replacement. When one part of the system is to be replaced and another part to be upgraded, it is often difficult to perform integration because of the competing interests of obsolescence, replacement and expandability. In large transit systems there are many functional departments that maintain a certain level of independence in decision-making and work-assignment. Because of the size complexity and dependence of one department to another, there is the challenge of building large databases of technological systems for individual units while ensuring jurisdictional independence (19).

Another challenge is the use of emerging transit standards to design open and modular software systems, common data messages, and standardized communication protocols.

8.5 Operational Challenges

Large transit systems perform 24 hours, seven-day operations in large geographic areas where dynamic changes of service conditions occur. These changes are experienced in the form of road-closings and detours, service changes, bus stop changes, track maintenance and construction, and service disruptions.

The challenge of integrating systems to meet these dynamic service/operational changes is perhaps the most difficult of all challenges facing the systems integrator. Added to this problem is the identification of new but essential operating needs at a later stage in the integration process. How dynamic can a software system be integrated to meet such unanticipated changes in operations?

In system integration projects, the contractor's role is to design, install, integrate, test, and in some cases operate the system for a certain specified warranty period. The transit agency, on the other hand, is responsible for data collection and development, project management, quality control and monitoring activities. High quality data should be provided and updated by the transit agency. Due to the difficulty of maintaining uniformity and recurrent update of data, there is the problem of providing schedules changes/files and protocols, geocoded information, maps, etc. This problem makes integration and testing complex to achieve.

Another operational challenge is site preparation and development of operating procedures for system installation in the field. The need to provide adequate communication and telecommunication network at the site as well as securing the requisite permits and licenses can be a challenge in high traffic, high density urban areas where large transit systems operate.

Installation of field equipment by non-labour-union staff can also be an issue. To overcome this union personnel can be made to "shadow" contractors' personnel when installation is being done.

8.6 IMPLEMENTATION LESSONS

The integration challenges discussed above can be met by transit agencies with optimism and expertise.

Two basic lessons can be provided for large scale ITS integration efforts: project management and industry-wide lessons.

8.6.1 Project Management Lessons

Transit managers identified the following lessons to meet the challenges described.
Maintain senior management support at all times: This should be done through frequent briefings of issues and concerns, support network with other sister agencies and securing resources for the long-term.

- Establish dedicated project management team: Project management success is based on two key factors: commitment and excitement. Commitment must be by providing direction, knowledge, resources and support. Excitement must be by sharing enthusiasm, be proactive and positive-minded and a sense of responsibility towards the successful completion of the project. Project champions must be available to pursue these factors or goals. ITS champions are persons who fully understand the benefits to the program and they are willing to go the extra step to see the project fully deployed and operational. It is important that the team must come from all parts of the agency including operations department, operations planning department, information systems department, and engineering department (1).

- Develop "partnership within partnership": It is imperative that strong links and friendship be established between the key personnel representing the project team's departments. When the same personnel are maintained in the project management team, there is consistency and improvements in knowledge base and familiarity with the project. It is essential to increase the knowledge base among procurement and legal staff to speed up processing of internal documentation of ITS projects. For instance, there is no reason why one or two lawyers could not be designated at all times to be the legal experts on ITS in an agency (64).

- Participate in multi-level planning, project implementation, ITS societies and committees: This would bring staff exposure and training, and better coordination of ITS activities.

- Perform regressive testing at all stages during project implementation: Poor software version control and configuration management requires that any software update must be tested in relation to all other previous changes. This will allow for better tracking and management of software.

- Experiment with innovative projects and end fear and frustration "at not knowing" the experience of implementing new technology (7).

- Expect delays in project implementation: Most ITS deployments experience schedule delays. Part of the reason for the delays is poor schedule management and mismatch of vendor-user expectations. Because delays are unavoidable, project managers must use this time to their benefit, by cleaning up any outstanding tasks.

8.6.2 Industry-wide Lessons

Beyond the boundaries of individual transit systems, a few lessons can be learned for the benefit of the industry.

Technology is not new to transit. The transit industry's involvement in new technology dates back to the early part of the century. Technology should not be misconstrued as something new or different.

Transit must learn ITS as part of the technological advancement that is changing the world around it.

- Role of education and training: On-site and off-site training of transit professionals in essential areas such as standards applications, business needs analysis, project management skills, technology/software engineering management and communications networking could go a long way in alleviating some of the challenges enumerated. Professional curriculum in ITS taught in colleges and universities could also help with infusion of new ideas. ITS project managers who are technically equipped, people-oriented and also understand the operational issues could do a better job than those who possess none or few of these qualities.

- Know your project and contractor well: Transit agencies need to develop and analyze their project requirements as well as find out the performance capabilities of the potential contractor through phone calls to sister agencies, competitors, and industry trade publications.

- Learn and work together: The project manager of the transit agency must be proactive and should get involved in all phases of the project life cycle. He must not just manage paperwork (as some are known to do) but do research and assess the extent of risks and scheduling expectations with the contractor.

- Involve manufacturers in the process: The intelligence in many ITS systems used to be mostly in the application software. Now, it is also being incorporated in hardware. Thus, the need to involve the manufacturers of these systems in requirements definition, interface development and integration testing is essential. In traditional contracts, manufacturers may serve as passive subcontractors. In ITS contracts, subcontractors should be made to play an active role in the integration process.

- Innovative contracting: Better contracting language including penalty clause/liquidation damages in the contract can provide the level playing field for performance by the contractor (25).

8.7 Conclusions

Integration of ITS deployments in transit systems can be complicated to achieve if adequate precautions are not taken to ensure that institutional, technical, operating, and stakeholders concerns are addressed.

Four levels of integration were described:

1) Institutional Integration,
2) Data Integration,
3) Functional Integration, And
4) Technology Integration.

All four are to exist in order to achieve full integration. At a minimum, functional and data integration developed in an open standardized format must be achieved through the planning and design process. Institutional coordination feeds off of a good planning and design process that fosters interagency cooperation. Learning about and applying emerging standards is key to all integration efforts. In addition, training in ITS architecture and metropolitan deployment is essential to facilitate the development of an ITS integration strategy (59).

The results of the study of transit properties support the notion that system integration is more of an institutional challenge than a technical problem. The will to experiment and integrate ITS is the will for the future.

8.8 Recommendations

A local integration strategy at the agency level linked to a regional ITS integration strategy developed using the regional/provincial/national system architecture will help in mainstreaming ITS into the work fabric of the agencies. It will also ensure national interoperability and compatibility of ITS deployments.

CHAPTER 9
Future/Applicability of AFC for TTC

The transit properties studied indicated that their primary reason for adopting an advanced AFC system was the need to replace ageing fare collection equipment that had reached the end of its life cycle. Other than for infrastructure replacement reasons, the studied transit properties indicated that they were investing in new or updated AFC equipment in order to:

- Make it quicker and easier for customers to pay for and use their systems and, thereby, to increase rider ship and/or revenues
- Facilitate transfers between different modes, such as between bus and subway
- Reduce fare evasion and fraud
- Reduce internal and external theft
- Reduce the cost of maintaining their fare collection equipment
- Improve management information for decision-making and
- Generate new non-fare revenues

9.1 Potential Effects of an AFC System on TTC Customers

Positive Impacts

The introduction of a smart card AFC system could benefit TTC customers in the following ways:

- Smart cards are more convenient than "exact fare", and customers would be able to choose how much money they want to store on the smart card. There would be no risk if the card were to be lost or stolen, because smart cards can be rendered invalid, and the unused money transferred onto a new card. Parents could give their children a smart card with "transit money" that could not be spent on other things.
- Smart cards can be programmed to keep track of actual trips taken and determine the most economical fare. The system would keep track of the actual number of trips taken within a 30-day period, and apply the monthly discount if appropriate. Customers would not have to estimate at the beginning of the month whether or not they were going to take enough trips to justify the cost of a monthly pass.
- If the smart card were to be valid for use throughout the GTA, cross-boundary riders would not have to purchase two, or more, types of fare media.
- Subway stations in the downtown core are not physically designed to allow transaction-free transfers between surface services and the subway. At these locations, customers, who paid their fare with a ticket, token, or cash on the surface vehicle, must show, or hand-in, a valid paper transfer to the station collector(s). With a smart card system in place, customers would be able to gain access to the subway through any turnstiles equipped with a smart card reader.
- Customers who currently use tickets to pay for entry to the subway about 30% of subway customers would be able to gain faster entry because they would be able to use

their replacement fare medium their smart card at any reader-equipped turnstile. This would alleviate the need for such customers to have to stand in any line-ups.

Negative Impacts

A smart card system could also result in some negative customer impacts, such as:

• Typically, the customer pays a deposit for a smart card, which is usually some portion of the unit cost of the smart card itself. This helps deter customers from destroying a relatively expensive card. In Washington, customers pay $5 for their smart card, which is half of the actual unit cost of $10 per card. This additional cost essentially represents a fare increase for transit customers.

• According to Jim Sinikas of TTC, currently, approximately 760,000 transaction-free transfers are made per weekday on the TTC at its physically integrated fare-paid multi-modal subway station. It is unclear whether or not AFC system logic could accommodate these types of transfers. If it cannot, these customer-trips would have to undertake some form of fare transaction where they currently do not have to. In New York, even though customers must swipe or insert their smart cards each time they transfer between buses and/or the subway, the technical software limitations produced a less-controlled system of free transfers than originally conceived. With the new AFC system, New York transit riders can transfer between routes without location and direction restrictions, and round-trip and trip-chain travel is possible on a single fare, which results in revenue losses.

• Smart card systems are, to date, incapable of efficiently or effectively accommodating fare transactions of infrequent or one-time-only riders. Therefore, these customers would be forced to pay cash fares.

9.2 Operating Cost and Workforce Implications of AFC

Revenue Operations

In my poit of view the replacement of tickets, tokens, and Metro passes with a smart card would have a relatively small impact on the revenue operations workforce, which is already small; a saving of four positions was calculated owing to the elimination of the task of removing tickets from fare box contents. Cash would still be accepted and, hence, there would be no change in the daily process of fare box revenue collection. Material expenses for tickets, tokens, Metro passes, and paper transfers would be eliminated, and this would result in an operating cost savings.

The introduction of vending machines, which accept debit and credit cards, would reduce the total amount of cash sales, but not eliminate it. Chicago and Washington report debit credit purchases represent 20% and 6% of their total vending machine sales, respectively.66'16 However, if cash sales at vending machines were to increase significantly, additional staff would be required to collect and process this cash.

Station Collectors:

The introduction of smart cards, which can be re-loaded automatically, would reduce sales at collectors. Booths, and provide a large percentage of customers with turnstile access. This would result in workforce savings of whose current duties include:
• Collecting fares at crash gates which provide quick access for large surges of passengers entering the station, mostly during peak periods and
• Staffing second and third positions in collectors booths to sell fare media and reduce line- ups.

Workforce Changes Associated with AFC

Based on the experience of properties such as New York, Chicago, and Washington, who have AFC systems in operation, it would be necessary to increase workforce in the following areas as a direct result of introducing automatic fare collection and/or smart cards:

• Revenue equipment maintenance (turnstiles and vending machines);
• Information Technology support staff (network and communications links);
• Computer back office support, and database management (security and hot listing)
• Smart card administration (customer service, claims, and refunds)

The highest projected workforce increase is additional staff for smart card administration and data management activities that include:

• Back office support positions, to maintain and update the card status list (hot list);
• Reconciliation of vending machine transactions and bank charge-backs; and
• Customer service, enquiries, lost, damaged, stolen cards.

According to TTC, current Metro pass Discount Program (MDP) requires ten administrative support staff for similar types of activities. Current staff requirements are 1 staff for every 3,000 MDP subscribers. Similarly, in Washington, the ratio is 1 staff for every 4,000 smart card users.66 Based on these ratios, and a database of 400,000 smart cards for all current TTC ticket, token, and Metro pass users, AFC administration and data management activities could require up to 85 additional staff.

AFC Capital Cost Estimates

According to TTC staff estimating the capital costs of a smart card AFC system for the TTC is difficult because there are many unknowns, particularly in the areas of system software development and infrastructures upgrades and retrofits. On the other hand, prices for individual items of hardware, such as new turnstiles and station computers, can be estimated with reasonable confidence. It was assumed that there would be no expansion of the current fare collection system. For example, the number of fare vending

machines has not been increased, but the existing machines are assumed to be replaced by modern touch-screen debit/credit vending machines. Based on the information gathered from other properties regarding the upgrades and purchases they undertook to install AFC systems, TTC staff have prepared an order-of- magnitude estimate of the cost of installing a smart card AFC system throughout the TTC's subway, bus, and streetcar networks. This capital cost estimate is $140 million as revealed by project engineer service planning TTC.

9.3 Time Requirements to Plan and Implement AFC Systems

The planning and implementation of an AFC system in a large multi-modal transit operation is a huge venture. In the cities studied, there was typically a span of eight-to-eleven years between the time that a decision was made to convert to AFC and the time by which the AFC system is expected to be in actual revenue service. With technology changing so quickly, this time requirement means that the AFC technology selected for implementation will likely be out of date by the time that that technology is put into revenue operation.

9.4 Computer Requirements of AFC Systems

AFC systems are highly dependent on huge computer systems, which require a dedicated and highly skilled Information Technology (IT) workforce to support them. Virtually every property studied emphasised the importance of the back office computer system, which determines key characteristics of an AFC system such as system security, maintenance support requirements, and flexibility to be compatible with other systems.

9.5.Other Issues

9.5.1 Leadership and Momentum in the Smart Card Field

Smart card technology has not been fully adopted by standards organizations. Therefore, public transit operators can either wait for standards to be defined before implementing a smart card fare collection system, or they can proceed to implement a system and attempt to force the standards issue.

Paris and Hong Kong have chosen to proceed, and have taken a lead role in smart card research and development. However, they have taken two different approaches on the important issue of system architecture. Hong Kong's system, like most banking systems, is centralized, which means every transaction is tracked and stored in a central computer system. Paris is promoting a decentralized system, and individual transactions are not recorded. This may result in lower data systems costs, and aims to give the smart card holder greater assurance of anonymity. At this time, no one knows which system will set the standard in the long-term.

There is also a question of who will own the most popular smart cards in the future, and who will end up renting space on such smart cards, and paying the rental fee. In North America, smart cards are still relatively uncommon although, in addition to the transit-based initiatives in Washington and San Francisco, there are other smart card applications in use or entering into commercial application.

Bell Canada has, for a number of years now, offered a contact stored- value smart card for use in their pay telephones. American Express has recently introduced a contact smart card type of credit card, as opposed to the traditional magnetic strip, and VISA is planning to do the same in the near future.

Thus, if a commercial-based smart card, for example, were to come into common use and circulation, it might become harder for a transit agency to establish a competing smart card for its system; the transit operator might instead rent space on the commercial card, and pay a fee every time the card were used to pay for transit travel. At this time, all of this is largely speculative, but these are issues, which may eventually effect the decision and timing of implementing a smart card system at the TTC or on other systems.

9.5.2 Larger Municipal Initiatives: Making All Services More Accessible to Residents

Although smart card applications have traditionally been initiated by financial, commercial, or transportation agencies, more recently they are also being investigated by municipal and regional government agencies. For example, in Venice, Italy, a smart card test is currently underway which attempts to integrate a number of services for citizens and tourists, including (57):

• Payment of good and services, through an electronic purse facility, in a number of local retailers
• Payment and access to public transport (boats) and parking areas
• Payment and access to a number of selected museums and churches
• Access to university libraries and services

Through its smart card initiative, the municipality of Venice is hoping to both improve its citizen's quality of life and own an advanced tool for controlling and monitoring tourist flows and mobility demand in general.

Similarly, there is a broader European-based initiative to improve the lifestyles of city-dwellers by improving their access to the vast array of services, recreation facilities, libraries, schools, and governmental offerings, which are found in major metropolitan areas. One of the means of achieving this, currently being explored, is to establish a consistent smart card-based access to all of these city amenities. This is a laudable effort, and it provides another illustration that, in many instances, smart cards are still in a developmental stage (40).

9.5.3 Global Inter-Operability

There are several smart card associations, which are working towards regional and international inter-operability, or universal compatibility. There is a vision which would have a smart card allow an individual to use one's smart card to travel by local transit in one's home town, pay for a taxi, rent a car, purchase a railway ticket, purchase an airline ticket, and then travel to any other country and use this same single card to access this same range of transportation services there. So, among other things, your TTC smart card would be every bit as acceptable and functional when boarding a train in Zurich, Switzerland.

In Britain, the Integrated Transport Smartcard Organization (ITSO) is a national consortium of UK transport authorities, including rail and bus operators, and local and provincial government agencies, who are developing a national standard for the UK smartcard ticketing systems to enable seamless travel throughout the UK.
Over 160 cities, local communities, and European transit operators have joined to form a non- profit association called CLUB (ContactLess technology Users Board) to foster information exchanges and smart card product standardization, in order to promote contactless technology and to progress together (51).

There is a slow, but growing momentum to establish smart cards as a universal payment and transaction medium, and it would appear that there is much work to be done to get to that point.

CHAPTER 10
10 Conclusions and Recommendations

10.1 Summary of Key Findings and conclusions from Other Cities

In order to reach a certain set of conclusions and recommendations the Key Findings from Other Cities studied are summarized below:

- The primary reason for implementing AFC is that ageing or failing fare collection equipment forced these cities into replacing their old systems with something new
- In cities which have adopted AFC technology, customer like it and use it.
- AFC systems have provided operators with improved financial controls and have a strong potential to reduce counterfeiting of fare media.
- There were no clear financial business cases for the introduction of AFC in any of the cities studied. All properties that have converted from manual to AFC systems were required to increase their workforce to support the new AFC system.
- Evidence was provided to indicate that AFC, unto itself, has produced increases in rider ship or revenue.
- Cities that have adopted AFC systems expects to, eliminate cash as a means of fare transactions in their transit system.
- Concerns over privacy of information may prevent transit operators from exploiting the travel behaviour data which AFC systems are capable of generating.
- AFC systems take upwards of ten years to implement in a major multi-modal transit system.
- AFC technology is still evolving rapidly and, as yet, there is no consensus or standardization regarding these technologies.

10.2 Outstanding Issues Pertaining to AFC Systems

- Cash isn't going away: In those cities which have AFC systems in full revenue service, between 25 and 40 percent of all rides taken still use cash as their fare medium and, so, collection and processing costs still remain. No transit system studied has any expectation of eliminating cash from their fare collection system after AFC is in revenue service.
- How do infrequent users pay? The underlying problem for an AFC system is how infrequent transit travelers can use it. The customer who might use a transit system very infrequently, or who is intending to take only a single ride and wishes to spend no more than the cost of that ride, cannot be expected to purchase an expensive stored-value type of AFC card. No property studied has yet resolved how these customer's fare transactions can be efficiently handled upon implementation of an AFC system.
- Concerns over privacy of personal information: AFC systems offer the transit operator the opportunity to collect information on the travel patterns of individual customers, so that services can be planned to better meet customer needs. However, in a number of cities which have, or are planning to install AFC systems, customers have objected to transit operators tracking their whereabouts in terms of specific routes or times of travel.

Thus, the data, which AFC's may be capable of collecting, may prove to be unavailable to the transit operator.

• Reliability and enforcing the use of AFC on surface vehicles: AFC equipment with mechanical components installed on surface vehicles, such as buses or streetcars, appears to be less reliable than equipment installed within subway stations, because of the more-demanding operating environment on surface vehicles. Additionally, various properties indicated that enforcing the use of AFC readers on surface vehicles is more difficult than within subway stations, where people are required to pass through a turnstile upon entry and exit of the system.

10.3 Conclusions

1. An AFC arrangement in Toronto, under which smart cards would replace the TTC's tickets, tokens, and Metropasses, but cash would still be accepted, would be more convenient for customers than the current requirement for people to have exact fare available. It would result in faster fare transactions for all those people who enter the subway system and pay by means of tickets. AFC would facilitate cross-boundary travel between Toronto and its neighbouring municipalities, and it would have the potential to make fare purchases more convenient than under the current system.

2. An AFC system will positively affect the TTC's ridership levels, upwards of 760,000 trips per day, or about 40% of all TTC daily trips. It is projected that the introduction of an AFC system in the TTC would result in a net increase in workforce of just fewer than 100 positions, and a net increase in operating costs of approximately $2 million annually. It is estimated that it would cost approximately $140 million to fully equip the TTC system with AFC technology. This estimated cost of $140 million may be low, based on comparisons with the investments required in other cities but the benefits associated with the introduction of new systems are quite high.

3. Most operators in GTA agree that the introduction of the smart card will decrease maintenance costs of electromechanical-based gates, which will be replaced for fare collection purposes by electro-optical equipment, with a much lower breakdown rate. This benefit, however, only takes place if the electromechanical-based fare collection is replaced completely by the optical based readers. As is the case with most existing systems, both collection systems continue to coexist, resulting in much lower benefits because the electromechanical equipment will still be in use and will breakdown, albeit at a lower rate, due to lower usage.

4. Operators also agree that a smart card contactless system would allow a much faster rate of entry and exit/from the system thereby saving passenger time. There is also some agreement that the contactless smart card will decrease fraud, particularly when used for monthly passes and integrated fares, especially in systems where these passes are at present flashed at the driver, who does not have sufficient time to check them.

5. The introduction and success of a contactless card system, largely depends on how the general public views and embraces the system. In GTA there are a

number of constraints, which might make the introduction of a smart card contactless system a very challenging task. For example, in Washington and Hong Kong, an initial investment in the card of US$10 and US$6 respectively is required (non-refundable in the case of Washington and refundable in the case of HK). It is doubtful that individuals in Toronto could easily afford the deposit. This deposit is important because it represents a reserve for the clearinghouse, which, if well administered, could be a source of revenues. Therefore, a mechanism must be found to charge a much lower fee or to provide the cards for free, although the latter may induce wastage by the users. Other issues concern the "add-value" function of the card. How much money will the users be able to afford to deposit each time they add value to the card? If the amount is too little this means that they will have to constantly go back to the add-value machine and this may end up creating delays (which no doubt existed with the paper tickets)

6. The introduction of the contactless smart card in Transit Agencies will require a number of adaptations that should not be underestimated.

Some of these are:

    a) Elimination or minimization of the deposit for the card

    b) Low minimum required in stored value in the card

    c) Easy to use add value machines, which must be user friendly across a broad spectrum and

    d) A card that is resistant because most of the users will be low-income blue-collar workers who work in environments where cards can deteriorate quickly. While selecting the appropriate technology is crucial, the education campaign to prepare the users is as important for the success of the system.

Consequently, the schedule for introduction of these smart card systems must take the education campaigns into account.

10.4 RECOMMENDATIONS

It is recommended that:

1. Study the feasibility of introducing a multi-application, multi-modal Canadian smart card for transportation, specially urban transit services

2. Develop initial system architecture, and recommend practices for implementing and integrating a range of applications

3. Demonstrate the concept of inter-operability of multi-modal, multi-application smart cards through deployment in a medium-size urban setting (Burlington/Ajax/York Region etc.)

4. Communicate the study results to transportation providers and decision-makers

5. Approve initiation of a system-wide study of the improvements and upgrades to infrastructure and facilities which would be necessary to facilitate and

accommodate the implementation of an automatic fare collection system in the near future, for consideration

6. Steps should be taken to establish the framework for the Greater Toronto Area (GTA) implementation of a regional transit fare collection system based on the new GO Transit electronic fare collection initiative, and provide a defined system architecture, standards, policies, a common technology platform and an implementation strategy for all public transit operators in the GTA.

7. Though it is conservatively estimated that it would cost approximately $140 million to install an AFC system throughout the TTC subway and surface networks, and that operating costs would rise by approximately $2 million annually and that, the benefits related to such an implementation will lead to the cost benefit ratio highly in the favour of new AFC Systems in the Transit Agencies of GTA, the benefits approximately estimated by the city of New York and Chicago Transit after a Year of the implementation.

8. As there is much interest and activity around the world pertaining to smart card systems, there are lots of smart card-based AFC systems in revenue service in major multi-modal transit systems; many cities are at the developmental or testing stages, Toronto Transit Agencies should study the systems and analyse the lessons and save money and time by adopting them.

9. The Transit agencies of Toronto should review their infrastructure and facilities notably power and communications to determine what changes would be necessary to allow future implementation of an AFC system.

10. Staff of the Transit Agencies should closely monitor the industry progress and developments with respect to automatic fare collection, and report back on findings, which warrant action.

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