TTC Fare Collection Study

TORONTO TRANSIT COMMISSION

October 2000

TABLE OF CONTENTS

1. Introduction

This report presents the results of a review of automatic fare collection (AFC) technology that has been undertaken by TTC staff. The review includes:

- a critical assessment of the TTC's current fare collection system;
- a discussion of state-of-the-art AFC systems operating elsewhere;
- a discussion of the effects these systems have had on passengers, operations, operating costs, and capital costs; and
- an evaluation of the potential costs and benefits associated with implementing an advanced AFC system at the TTC.

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 micro-processors 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. In February and March 2000, TTC staff visited Berlin, Paris, London, New York, Chicago, and Washington D.C. to obtain real-life information regarding the reasons for implementing AFC systems and their effects on passengers, operations, costs, benefits, and risks.

2. Overview 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; and
- 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:

- simple: customer-friendly, easily understood and used by riders and staff;
- quick: allowing fast transactions (turnstiles/boardings, purchases);
- flexible: adaptable to changing fare strategies, loyalty schemes, and integration with other systems;
- economical: providing for cost-effective administration, maintenance, 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; and
- information-rich: providing data for marketing, finance, service planning, and workforce productivity.

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 ridership 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.

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, magnetic or smart cards;
- Fare collection procedures – pay-on-entry, pay-on-exit, proof-of-payment, honour fare; and
- Fare collection equipment or technology – fareboxes, electronic registering fareboxes; 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” (ie. - 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 Metropass 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.

<u>Fare Structure and Policy</u>

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 Transpo 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.

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.

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 contactless)

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.

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. Fare checking is typically done by roving fare inspectors. This is the approach used on the 501 QUEEN streetcar line in Toronto. 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, eg. - 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 fareboxes, such as is used by the TTC, to electronic registering fareboxes, 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.

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.

3. Current TTC Fare Collection System

This section of the report 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).

3.1 The Passengers' Perspective

The TTC has a flat fare, pay-on-entry, system which is easy to understand from a passenger perspective. 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.

Fare Media

In addition to cash (exact fare only; no change provided on surface services), the fare media accepted for travel include tokens, tickets, and passes. Exhibit 1 below lists the current TTC fare types and prices, and Table 1 below, summarizes the 1999 annual ridership by fare type.

Exhibit 1 – TTC Fare Media and Prices

T T C F A R E S / P A S S E S

	Adult	Student*/Senior**	Children***
Cash	$2.00 Cash	$1.40 Cash	50¢ Cash
Tokens/Tickets	5 - $8.50 10 - $17.00	Tickets *only* 8 - $9.00	Tickets *only* 10 - $4.00
Metropass *MDP by mail. Best value! 12 month subscription*	Monthly $88.50 Annual per month $81.00	Monthly $75.00 Annual per month $69.00	Fill in the boxes on your Metropass in pen. Your Metropass is valid only with: • **ADULTS** require a TTC Metropass Photo I.D. **OR** a valid Driver's Licence. • **SENIORS** require a TTC Senior's Metropass Photo I.D. **OR** a valid Driver's Licence. • **STUDENTS** must use their **TTC Student Discount Card** photo I.D.
Family·Group·Single Day Pass	ONLY $7.00	**Single** MONDAY - FRIDAY, or SATURDAYS - Good for ONE person, unlimited one-day travel on all regular TTC routes after 9:30am weekdays or all day Saturdays.	**Family/Group** SUNDAY & HOLIDAY - Good for up to 6 persons, maximum 2 adults, with up to 4 children/youths*. (*Youths = 19 years of age or under.) Unlimited one-day travel on regular TTC routes Sundays & Holidays.

Transfers are free and can be used at TTC transfer points on day of issue for a one-way continuous trip. Transfer must be obtained where you pay your fare, transfer is not valid at station where transfer is obtained, transfer is not valid for stopover, and is not transferable.
This Fare Card is available for downloading and printing at www.city.toronto.on.ca/ttc/fares.htm

* TTC STUDENT DISCOUNT CARD must be shown or adult fare required.
**SENIOR: 65 years of age or over, must show proof of age when depositing fare, or adult fare required.
***CHILD - 12 years of age or under (children under 24 months - free)

Table 1 - 1999 Ridership by Fare Type

Fare Media	Percent of Total 1999 Ridership
Tickets (adult, senior, student & children)	29.9 %
Metropass (adult, senior, student & Twinpass)	29.3 %
Tokens (adult only)	21.1 %
Cash (adult, senior, student & children)	17.0 %
Day Pass/Family Pass	1.4%
Other (premium express, GTA pass, blind etc)	1.3%

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.

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.

<u>Fare Purchases</u>

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 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 collectors' 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, Davisville, and Dundas), where credit card purchases are accepted by station collectors. 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 Metropass sales period. The TTC is evaluating a new token and Metropass vending machine which would accept both cash and debit transactions.

In 1996, the TTC introduced a 12-month pre-authorized payment plan, the Metropass Discount Plan (MDP), which includes a discounted monthly price and the convenience of having Metropasses mailed to the customer each month. Currently, there are over 31,000 MDP subscribers, which represents 25% of all Metropass users. Market research indicates that customer satisfaction is very high, and customers indicate the “reduced cost” and “convenience” attracted them to the program. The major benefits of the MDP program for the TTC include:

- former ticket and token users have increased the number of transit trips they take by up to 40% after joining MDP;
- subscribers are committed to transit for 12 months; and
- the pre-payment program has reduced the amount of cash handled and processed within the transit system.

There are administrative costs associated with the program. Ten staff members are required to administer the MDP program and process applications forms. They also handle between 35,000 and 45,000 MDP customer enquiries annually.

Table 2, below, summarizes the TTC’s fare media sales by type of sales outlet in 1999:

Table 2: Fare Media Sales by Vendor Category

Fare Media Sales By:	**1999 Total**	**% of Total Sales**
Station Collectors	$291,139.5	62%
Ticket Agents	$129,752.0	27%
Token Vending Machines	$23,874.0	5%
MDP Program	$27,026.2	6%
Total (does not include cash fare payments)	$473,790.70	100%

<u>Fare Collection</u>

Access to the TTC system is controlled through the use of mechanical turnstiles in the subway system, and mechanical “drop-in” fareboxes on the buses and streetcars. The magnetically-encoded Metropass 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 farebox 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 farebox and are staffed by collectors who visually monitor the fare payment.

On surface vehicles, cash, tickets, or tokens are deposited in a farebox upon entering the vehicle. Paper transfers, day passes, and Metropasses are presented for visual inspection. There is a proof-of-payment (POP) system on the streetcar routes operating on Queen Street. Between 7 am and 7pm, seven days-a-week, passengers with valid proof-of-payment (eg. paper transfer, day pass, or Metropass) 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.

3.2 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 collectors' 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.

Table 3, below, summarizes the TTC's fare sales, collection, and processing costs for 1999. It shows that the TTC incurs approximately $0.07 of fare-related costs for every dollar of fare revenue collected and processed. A more-detailed breakdown is provided in Appendix I.

Table 3: FARE-RELATED REVENUES AND COSTS – 1999 ACTUALS
($000'S)

FARE-RELATED REVENUES	
Fare Media Sales/Cash by ($000's)	Total
Station Collectors	$ 291,140
Ticket Agents Paid Commission	120,650
Ticket Agents Not Paid Commission	9,100
Token Vending Machine	23,870
MDP Program	27,030
Coins Counted by Cashiers	127,650
Bills Counted by Cashiers	680
TOTAL SALES/CASH	**$ 600,130**

FARE- RELATED COSTS ($000's)	Labour & Fringes	Non-Labour	Total
REVENUE OPERATIONS	$ 3,520	$ 210	$ 3,730
Ticket Agent Distribution			
Token Vending Machine Attendants			
Revenue Collection & Processing			
TREASURY SERVICES:	$ 440	$ 240	$ 690
MDP Administration			
Customer Services			
Claims and Refunds			
STATION COLLECTORS	$ 25,900	$ 330	$ 26,230
Station Collectors & Suppliers			
Route Supervisors			
Administration, Clerks, Uniforms			
REVENUE/SECURITY EQUIPMENT MAINTENANCE	$ 2,040	$ 590	$ 2,630
Staff Supervision & Stationery			
Fareboxes & Transfer Cutters			
Subway, SRT Turnstiles & Station Equipment			
CONTRACTED SERVICES	-	$ 430	$ 430
Protected Delivery Service			
FARE MEDIA EXPENSES	-	$4,570	$ 4,570
Ticket, Tokens, Metropasses & Transfers			
Metropass & Student Photo ID Cards			
Commissions Paid to Agents			
TOTAL COSTS	**$31,900**	**$6,370**	**$ 38,280**

3.3 Fare Evasion

Fare evasion, which includes the use of fraudulent 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:

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

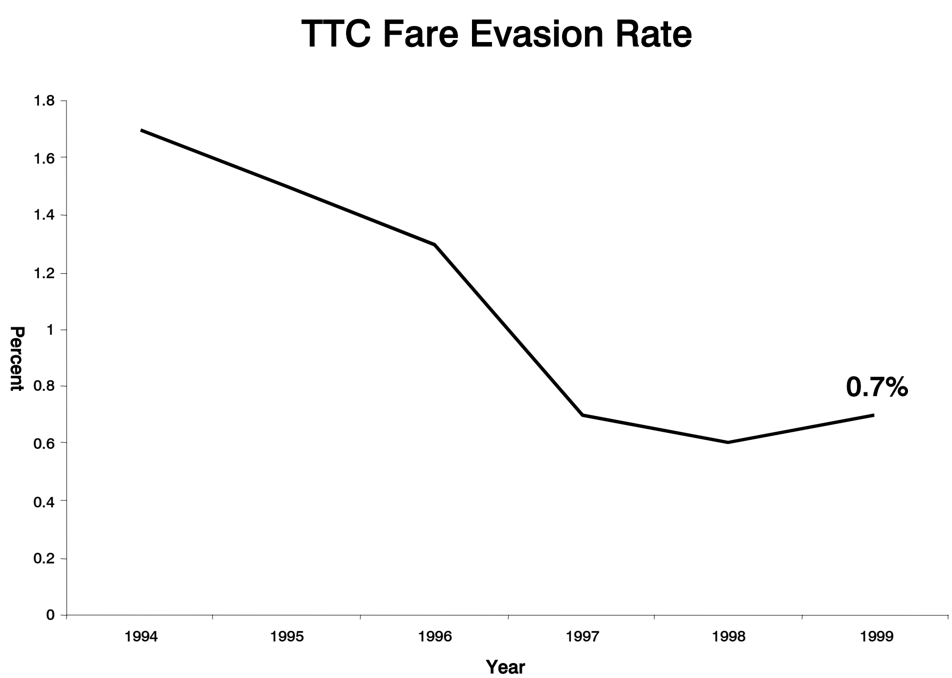
- **Transfers** – Customers transferring to the subway give their paper transfers to the Collectors at stations. These are checked for the proper time, date, and validity for the connecting routes.

- **Metropasses** - Photo identifications are checked to ensure the correct person is using the pass. Metropasses 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 examine each ticket, bill, and coin collected. Counterfeit tickets and bills, and foreign coins and slugs are recorded.

The following Exhibit 2 shows the TTC's system-wide fare evasion rate, since it was first measured in 1994, and Table 4, below, provides a breakdown of the 1999 Fare Evasion Study results by type of fare evasion.

EXHIBIT 2



Note: 1995 rate shown is an estimate only. No Fare Evasion Study was conducted in 1995.

TABLE 4
FARE EVASION BY TYPE

Fare Evasion Type	Fare Evasion Rate %					Estimated Annual Lost Revenue $ (000's)
	1994	1996	1997	1998	1999	1999
POP Program	1.0%	2.1%	2.4%	4.1%	4.8%	$ 674.9
Illegal Entry	0.26%	0.33%	0.31%	0.21%	0.32%	$ 362.1
Transfers	5.9%	4.4%	2.0%	1.5%	1.4%	$ 2,915.0
Metropass	1.7%	1.2%	0.4%	0.3%	0.8%	$ 1,410.7
Day Pass	N/A	1.6%	1.6%	1.6%	1.6%	$ 127.0
Foreign/Counterfeit	0.26%	0.04%	0.15%	0.2%	0.16%	$ 688.6
TOTAL	**1.7%**	**1.3%**	**0.7%**	**0.6%**	**0.7%**	**$ 6,178.3**

The following types of fare evasion are also known to occur within the TTC system, but the number of measured instances was found to be 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; and
- 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.

The TTC has been able to manage fare evasion problems as they arise within the current TTC fare system. For example, in the past few years, the TTC has addressed the following fare evasion issues:

- With the POP fare program on the Queen Street streetcar routes, after months of an intensified fare enforcement program, the measured POP fare evasion rate was reduced to 2.3% in June 2000. The program included improved signage, a passenger information campaign, and increased fare inspection.
- Transfer abuse has been reduced through improved transfer design (colour and enlarged printing of the date of issue) which was introduced in July 1998. As part of this program, there is now increased presence and enforcement by Surface Operations Route Supervisors who conduct transfer checks throughout the year.
- The introduction of improved ticket designs in May 1999 reduced fare evasion (fraud) for tickets.

Overall, as the above data shows, fare evasion has not been a major problem for the TTC, and improvements are being made to ensure that evasion rates remain low.

3.4 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 GTA.

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

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.

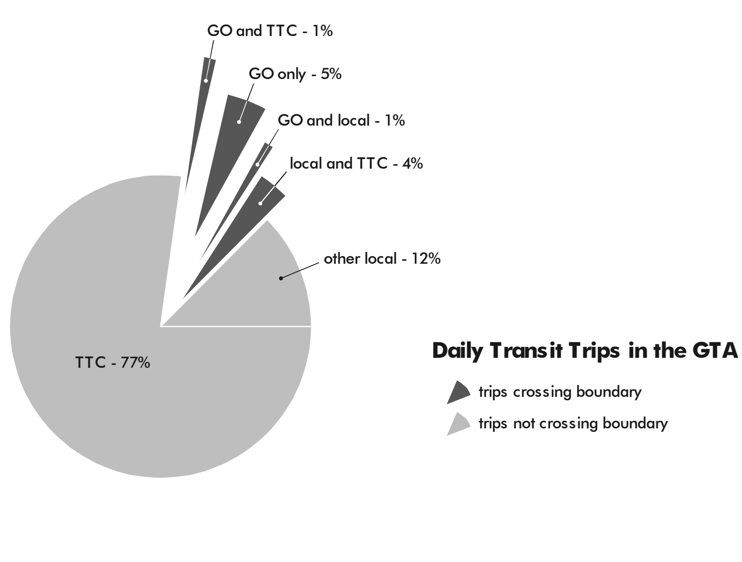
TTC – GO Transit – TTC
Passengers who ride the TTC immediately before and after a GO train or GO bus can use the TTC transfer from their first ride to board the second TTC vehicle.

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.

As shown in Exhibit 3, there are a number of distinct segments to the transit market in the GTA. The TTC carries approximately 80% of all transit trips in the Greater Toronto Area and, of this, over 90% are taken within the City of Toronto. Therefore, any proposed changes to fare collection systems or technologies to be used throughout the GTA must recognise the needs of the large number of TTC riders who travel entirely within the City of Toronto and are not affected by GTA inter-regional travel.

Exhibit 3 also shows that 6% of transit users in the GTA cross a municipal boundary and pay a second fare for their trip. This means that 94% of GTA transit users currently have the convenience of single-fare travel.

Exhibit 3 – Daily Transit Trips in the GTA



In November 1999, the TTC conducted consumer research with residents of the GTA who reside outside the City of Toronto and travel to Toronto, to better understand their needs, and to identify means by which to increase transit ridership.

Telephone interviews were conducted with over 1200 residents of the GTA who reside outside the City of Toronto and who make at least two round trips to and from Toronto in an average week. The results demonstrate that, of these cross-boundary travellers, 72% of respondents use only their car for the trip, 16% use a combination of a car and transit service, and 12% use transit only for their trip.

The market research indicates that travellers want, 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. From this research, there is no indication that changing current fare arrangements or practices within the GTA would be a significant factor in attracting new riders to transit.

3.5 Recap of the TTC's Current Fare Collection System

From the foregoing 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.
- Fare collection-related costs are low, at a 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" fareboxes 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.

4. Automatic Fare Collection (AFC) Technology

This section of the report 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 contactless “smart cards” (like a phonecard).

Coins, tokens, and paper tickets can be accommodated in simple mechanical fareboxes and turnstiles. These fare media generate handling costs, however, and provide a limited means of payment validation. For surface vehicles, farebox technology has evolved with the advent of electronic fareboxes 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.

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.

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.

4.1 Advanced Magnetics

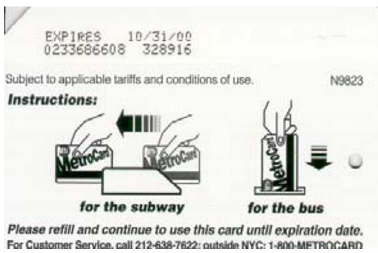
Magnetic stripe technology has been used for many years in transit and, until recently, represented the state-of-the-art in AFC systems. Both New York and Chicago introduced advanced magnetic stored-value tickets and passes in 1997 (see Exhibit 4)

Exhibit 4
Two Examples of Current Magnetic Fare Media

New York

front

back



Chicago

front

back

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. 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 Metropasses. The read-only nature of the Metropass means that data on the card is read, but new information is not transferred back. The Metropass's watermark magnetic stripe is very secure and hard to counterfeit.

The advantages of magnetic stripe media are:

- 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); and
- they can support multiple fare structures such as proof-of-payment, fare-by-distance, or by time.

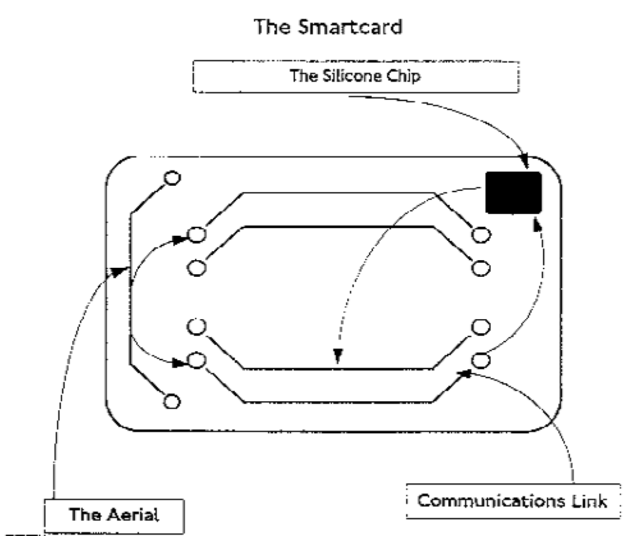
The disadvantages of magnetic fare media are:

- the relatively high maintenance costs of turnstile and farebox 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.

4.2 Smart 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 (see Exhibit 5, below). There are two types of smart cards: contact and contactless.

Exhibit 5 – The Basic Smart Card

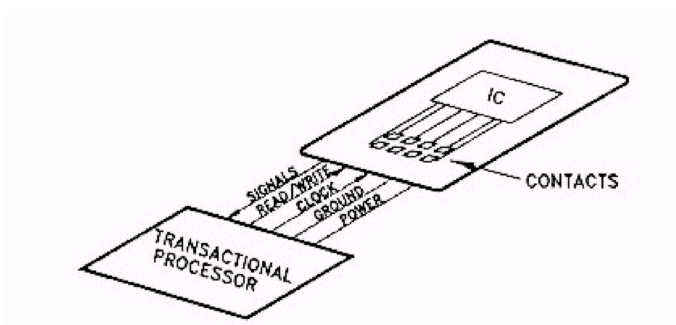


<u>Contact Smart Cards</u>

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

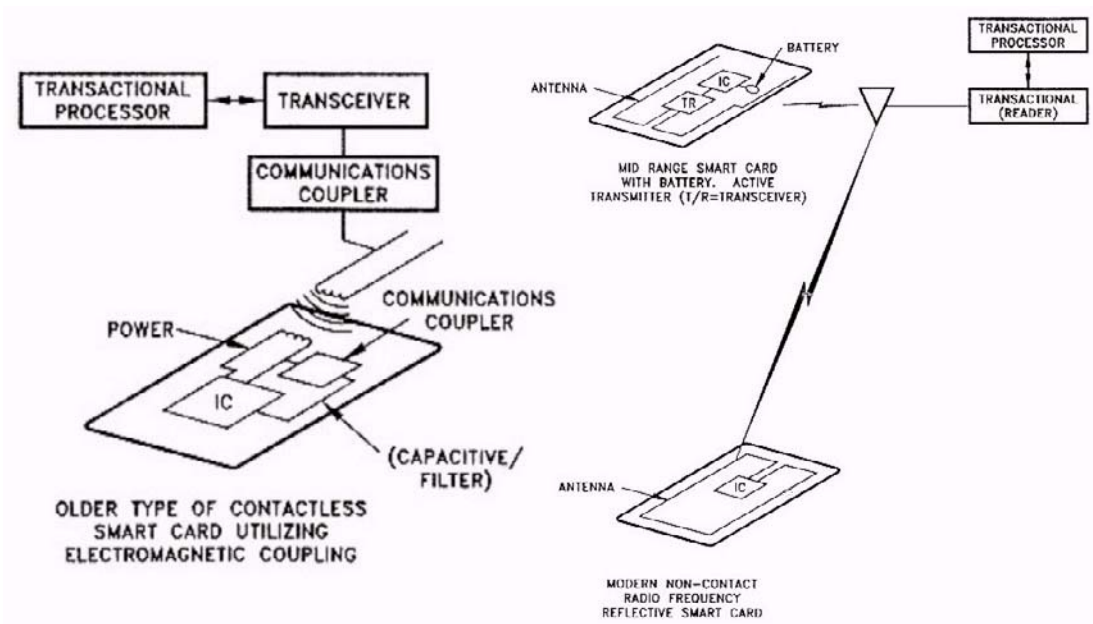
Contact Type Smart Card



<u>Contactless Smart Card</u>

There are two types of contactless smart cards (See Exhibit 6, below). 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.

Exhibit 6
Smart Card Communication Technology



The second type of contactless smart card -- which 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 contactless card is between a few centimetres and as great as 75 meters.

The advantages of the contactless smart cards are:

- they are durable -- much more 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 contactless 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 smart card system in 1998, and the cost per card was $10.

Exhibit 7, below, illustrates some current transit system smart cards.

Exhibit 7
Two Examples of Smart Cards

Washington

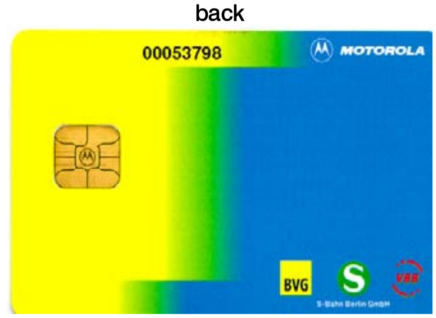
front

back

Berlin

front

back



4.3 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.

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

Ticket-vending machines (TVMs) allow self-service ticket purchases for flat-fare and distance-based transit systems. Simple TVMs 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.

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.

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.

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, a private PIN number must be input by the customer 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.

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 the 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 for customers.

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 ridership 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 – in-service, off-line;
- real-time credit authorization for fare payment; and
- debit account access for fare payment

4.4 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 passes, 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;
- improve management information: AFC systems provide management information, such as fare media sales by location, actual number of trips made on AFC passes, and equipment diagnostics, which enable transit agencies to improve the efficiency of their business practices; and
- 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.

5. Staff Observations on AFC Systems in Other Cities

In the spring of 2000, TTC staff visited Berlin, Paris, London, New York, Chicago, and Washington D.C. to obtain information regarding their reasons for implementing AFC systems, the effect AFC has had, or is expected to have, on customers, operations, and operating costs, and known or projected benefits and risks. Documentation of staff's observations of the AFC systems in these cities is contained in Appendices A through H. The different cities visited each had their own objectives for implementing AFC systems or testing smart cards. The following section summarizes the information obtained from the site visits, and from research material obtained from UITP, APTA, and other transit properties. Commentary is also provided on whether the issues or problems observed in the visited cities apply to, or are an issue in Toronto.

The transit properties visited 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. Table 4 summarizes the status of each of the AFC systems observed.

TABLE 4
Status of Implementation of AFC at Properties Visited by TTC Staff

City: - fare policy	Technology Change	Status
New York - flat fare - barriers in all rail stations	bus & rail: - magnetic cards replaced paper tickets, but not tokens - cash, debit/credit accepted	1997: magnetics in revenue service
Chicago - flat fare - barriers in all rail stations	bus & rail: - magnetic cards replaced paper tickets and tokens - cash, debit/credit accepted	1997: magnetics in revenue service 2000: - smart card pilot test - sales by bank ATM's
Washington - distance-based & time-based - barriers in all rail stations	rail: - added smart cards to magnetic system - cash, debit/credit accepted bus: - cash & paper tickets (no change, yet)	1999: smart cards in revenue service 2001: magnetics & smart cards planned on buses
London - distance-based - barriers in some rail stations	bus: - cash, paper tickets & smart cards rail: - install barriers at all stations - add smart cards to magnetic system - cash, debit/credit accepted	1999: electronically issued tickets on buses 2002: smart cards planned in revenue service (bus & rail)
Paris - distance-based - barriers in all rail stations	bus & rail: - add smart cards to magnetic system - cash, debit/credit accepted	2002: smart cards planned in revenue service (bus & rail)
Berlin - distance-based - honour fare	bus & rail: smart card pilot test	Smart Card test: Oct./1999 - April 2000
Burlington - flat fare	bus only: add smart card to paper	1995: smart cards in revenue service

5.1 Primary Reason for Implementing AFC: Need to Replace Old, Failing Infrastructure

Virtually all of the properties contacted 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 lead 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.

5.2 Customer Impacts of AFC

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, the smart card was being used by 73,000 rail passengers, which represents 23% of the Metrorail 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.

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.

- **Extensive sales network.** 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.

Does TTC need an improved sales network?: 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. Metropass purchasers can pay by pre-authorized debit, and receive their Metropasses by mail.

- **Offering new fare options.** 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.

- **Eliminating the need for exact fare**. 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 exact fare payments have not been identified as a major concern by TTC riders.

- **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.

Are intermodal transfer a problem at the TTC?: The physical integration of the TTC's surface and rapid transit system provides easy, fast, convenient transfers between modes, often with no barriers or transactions whatsoever.

- **Contactless smart cards are easier and faster to use than magnetics.** Transactions are very fast with Washington's smart card, much faster and easier than trying to correctly insert the old magnetically-encoded paper ticket into a reader. New York's customers have difficulty swiping their magnetic fare cards in subway turnstiles. Approximately 15% of the subway AFC transactions are unsuccessful on their "first swipe" attempt. New York is trying to improve this through customer education, and by cleaning the magnetic readers more frequently. In Chicago, members of the disabled community are part of a smart card test. They have indicated that the contactless nature of the card is extremely beneficial for people who have visual impairments or who have limited mobility in their arms.

Is transaction speed an issue for the TTC? The TTC's manual "drop-and-go" farebox payment system is fast and easy for customers. The TTC's magnetically-encoded read-only monthly Metropass is very reliable, and customers find it relatively easy to use the "swipe" readers to access subway turnstiles. On balance, the TTC does not have a problem pertaining to the speed of fare transactions. TTC customers with mobility impairments or other disabilities would benefit from the convenience and "forgiving" nature of contactless smart cards.

5.3 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 visited by TTC staff, 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.

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 city-wide 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.

5.4 Operational Considerations of AFC

AFC systems can produce a range of operational benefits for the transit operator that include:

- reducing the number of fare evaders entering subway systems, primarily by introducing bigger, more physically-imposing turnstiles which are much harder to hop over;
- reducing the level of fraud because new AFC cards, notably smart cards, are more difficult to counterfeit;
- reducing the amount of internal and external theft because AFC allows improved financial control and tracking of cash sales and transfers;
- improving fare equipment reliability;
- 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; and
- improving management information for purposes of marketing, planning, and equipment maintenance.

Each of these is discussed below.

<u>Fare Evasion</u>

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. Another factor contributing to the reduction in fare evasion over this time period was an extensive city-wide 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 Transport's 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 ticketless 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. They 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; and
- significant reduction or elimination of fraudulent purchase of reduced-fare passes.

Berlin's subway system is completely barrier-free. Customers are required to produce proof-of-payment upon request by a fare inspector. Berlin's fare evasion rate was reported to be 10%. The possible future introduction of a smart card system would provide that system with the opportunity to install turnstiles as a means of enforcing systematic payment of fares. It is expected that this physically-controlled entry system would significantly reduce fare evasion.

Is fare evasion an issue for the TTC?: The TTC's fare evasion rate is 0.7%. This is much lower than was reported by the cities and systems visited by TTC staff. It is unlikely that any program or investment, such as AFC, could push this evasion rate significantly lower.

<u>Counterfeiting and Fraud</u>

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 (ie - 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 significantly reduce or eliminate the fraudulent use of foreign coins. With this fraud dealt with, it is unlikely that significant further reductions in fraud could be achieved through measures such as AFC.

<u>Reduced Theft (External & Internal)</u>

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.

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.

<u>Reducing Equipment Maintenance Costs</u>

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.

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.

<u>Improved Management Information</u>

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 boardings), 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 are 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.

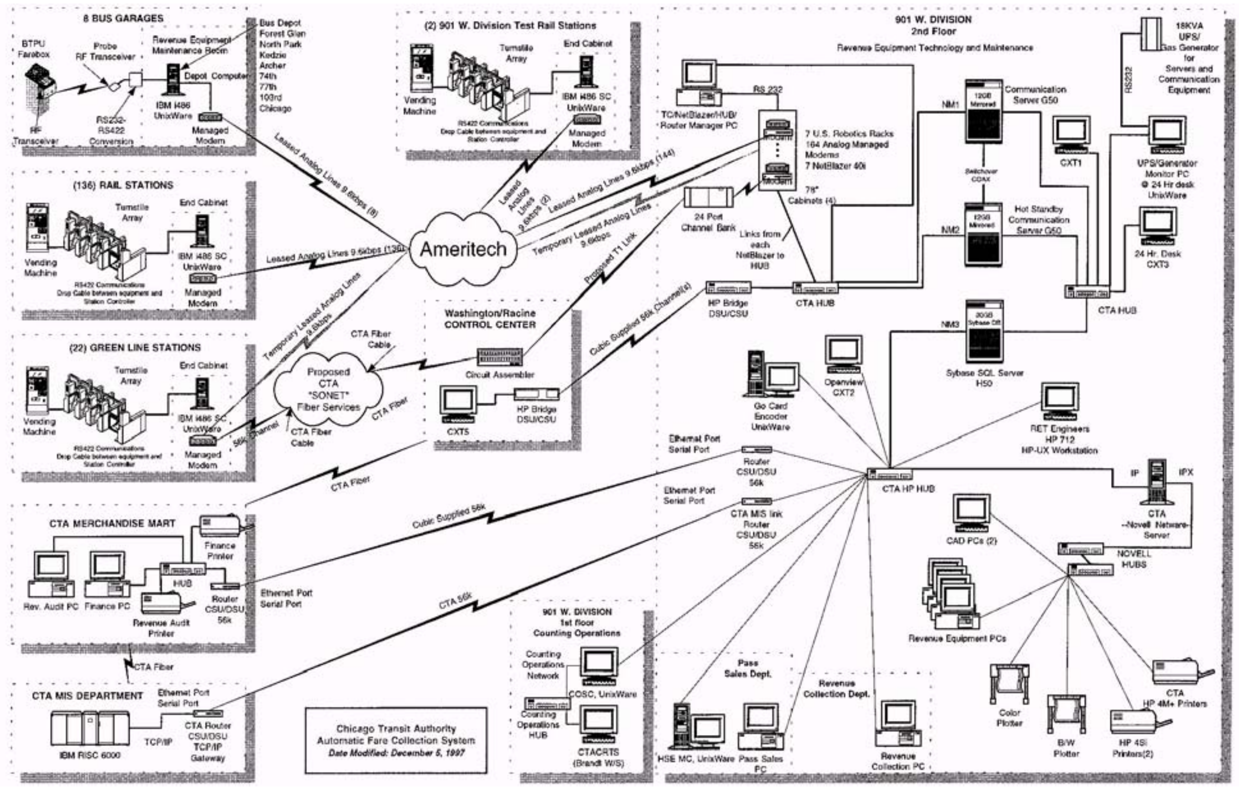
<u>AFC Computer Requirements</u>

Virtually every property visited emphasized the critical importance of the "back office" computer system -- the software database and communication infrastructure – because it is fundamental to the AFC system. The computer system defines the security architecture and the maintenance support system for all AFC system components.

Most of the AFC systems observed, and the bank card systems, have centralized computer systems. Exhibit 8 illustrates Chicago's AFC network. Paris, is proceeding to implement a decentralized computer system which they hope will result in savings.

In 1997, Hong Kong's contactless smart card project began full operation. At the 1999 UITP conference, the General Manager of the Hong Kong AFC system, upon reflecting on that system's efforts and difficulties in getting its AFC up and running said, *"there is a huge upsurge in smartcard interest, from internet E-commerce to life critical health care records, but one should not underestimate the challenges in bringing such applications from concept to reality."*

Exhibit 8
Chicago: Automatic Fare Collection System Network



5.5 Cost and Workforce Implications of AFC

Operating Costs

In all of the AFC systems which staff visited and which were in actual operation, there were insufficient operating cost savings to offset the capital investment required for the system.

London and Paris have prepared business cases that include estimated revenue increases and operating savings, but their systems are not yet in revenue service and, hence, their business cases cannot be verified. Operating costs increased in Washington, even though the smart card system was added to their existing magnetic system and, thus, could exploit economies of scale associated with their already-existing power and communications networks.

Chicago reported achieving operating savings of $16.5 million annually, which would result in a 10-year payback period on their capital investment of $225 million. Chicago did not provide an itemization of where or how these savings were achieved. It is reasonable to assume that some of the cost savings would have been the result of labour savings associated with changing subway ticket clerks to customer assistants.

Chicago subway ticket clerks no longer sell fare media, because customers now purchase all fare media from vending machines in the stations. The ticket clerks became customer assistants, who stand in the fare control area (subway entrance) and help customers access the system and use the new AFC vending machines. The customer assistants are paid at a lower wage rate than the ticket clerks, and fewer are required because they do not work in the late evening. After 8pm, contracted security personnel maintain a presence at each station.

Workforce Increases

The introduction of AFC in New York resulted in a one percent workforce increase which, given the immense size of New York's system, equates to an increase of approximately 400 positions. These people were required to provide AFC support in the following areas.

New York MetroCard Workforce Support Functions

Card Stock Production: • Staff to encode cards and wrap pre-encoded cards • Staff for inventory, quality control and security
Maintenance • MetroCard Vending Machines (MVM) maintenance ratios: 1 maintainer per 20 MVMs; 1 supervisor per 15 maintainers • MVM Maintenance Security: armed collecting agents teamed with maintainers (same ratio as maintainers). • Electronic Board Repair: 30 boards per MVM x 12% failure rate x 1.98 hours to repair each board
MetroCard Vending Machine Collection • Additional revenue collection trucks: trucks, maintenance and parking/housing costs • Additional revenue collection personnel • Additional personnel to process cash collected from machines
Data Processing • NYCT contracts out the majority of IT services • Back Office support positions • Security and negative list positions • Communications monitoring
Transaction Fees and MVM Cash Collection • Personnel required to reconcile cash collected vs MVM tallies • Personnel required for bank charge-backs
Customer Services • Customer Assistance Teams • Additional staff re: increased customer claims and transaction investigations

Chicago increased their fare collection and revenue equipment workforce, as a result of introducing AFC. For example, the number of turnstile mechanics increased from 14 to 44. They also expanded their customer service division to address both customer enquiries regarding how the AFC system works, as well as complaints regarding AFC equipment failures (incorrect amounts deducted from farecards, refunds requested, etc). In addition, a special staff unit was established to exclusively handle AFC refund transactions. The customer inquiries, problems, refunds, and complaints pertaining to AFC eventually ended up requiring approximately 260 interactions with customers per day. This converts to a daily "problem incident rate" of about 2.3 per 10,000 AFC transactions.

In Washington, WMATA already had a magnetic AFC system in place, so they required only marginal increases in workforce to deal specifically with the administration and distribution of smart cards. Approximately 15 to 20 agents are required to package, distribute, answer questions, replace lost, stolen, or damaged cards, and continuously update the customer database. The SmarTrip Helpline operates 7am to 8pm on weekdays. On weekends, there is no staff coverage, but customers can leave messages via voicemail or e-mail. The helpline handles approximately 1300 calls per month, and the following table categorizes the types of calls taken:

Customer Inquiries Regarding Washington's Smart Card	Percent of Total Calls
Card Problem: customer damaged card, card stopped working, etc	30%
Hot List: card lost, stolen or misplaced	26%
Information inquiries, confirmation of internet or e-mail purchases	22%
Banking/Transaction Problem	19%
Equipment problems (turnstiles, vending machine, parking lot readers)	3%
Total	100%

Capital Costs

The following table summarizes the AFC capital investments made in the cities visited by TTC staff. The size of the capital investment depends on the size of the transit property (number of stations, fleet size, etc), and whether or not an AFC system, with its power and communications networks, was already in place. In order to make the investments of the various properties more directly comparable, the total capital costs were normalized relative to the total weekday rides carried on each system.

City	**Total Weekday Passenger Boardings**	**Reported AFC Capital Investment (Canadian $)**	**AFC Investment per Weekday Boarding**
AFC Project Scope: Manual system replaced by magnetic system (centralized data system)			
New York	7 million/day	$ 1 billion	$ 145/boarding
Chicago	1.3 million/day	$225 million	$ 200/boarding
AFC Project Scope: Smart cards added & magnetic system upgraded (centralized data system)			
Washington	1 million/day	$ 75 million	$ 75/ boarding
London	6 million/day	$ 600 million	$ 100/boarding
AFC Project Scope: Smart cards added to existing magnetic system (decentralized data system)			
Paris	9 million/day	$ 114 million*	$ 12/boarding

*This is the number reported by Paris, but the authors believe that this is not a directly-comparable, all-inclusive number.

With the exception of London, none of the properties visited reported significant capital funding constraints, and all receive multi-level governmental funding for capital projects.

<u>Vendor Financing of an AFC Installation</u>

London and Rome were not provided with direct public funding for the capital cost of their AFC initiatives, so vendor financing arrangements were put in place. In these cases, the vendor, or a private sector consortium, is paying the up-front capital cost of the equipment, and will operate, maintain, and administer the smart card distribution and support functions. The vendor expects to recover the investment costs through a combination of annual lump payments and per-transaction fees, paid from ongoing government subsidies and/or customer and/or other non-transit commercial partners.

The London Transport (LT) smart card project is taking place under the British government's Private Finance Initiative, which is intended to attract private sector investment to public sector projects. In August, 1998, LT awarded a 17-year contract to TranSys, a private sector consortium. TranSys is responsible for:

- designing, building, implementing, maintaining, and providing service;
- providing the necessary financing arrangements to support the project; and
- the risk of whether the smart cards will meet the required performance standards.

The new services and equipment require a capital investment of approximately $600 million. Contractual payments are made monthly, and increase based on:

- implementation, delivery, and service performance; and
- smart card usage and availability.

Is vendor financing something the TTC should consider for an AFC initiative? 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 a 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.

5.6 Planning and Implementation of AFC Systems

The planning and implementation of an automatic fare collection in a large, multi-modal transit system is a massive project which requires fully-dedicated staff with extensive expertise. Each of the transit agencies visited by TTC staff required 8 to 11 years to plan, design, and implement an AFC system. Given the length of time required to implement a system, and the rate at which AFC technology is evolving, new AFC systems can be outdated before they are put into operation.

New York and Chicago began planning for new AFC systems in the early 1990's and, at that time, advanced read/write magnetics was the only proven technology available. By the time these cities completed installation of their new systems in 1997, their advanced read/write magnetic technology had become outdated compared to contactless smart card applications.

Paris began planning to replace their magnetic AFC system in 1990. They initiated several large-scale smart card demonstrations in 1993, with 38,000 RATP employees. In 1997, a regional pilot project was conducted which involved 1,000 customers, 43 subway and commuter rail stations, and 2 bus lines, to test customer reaction and acceptance. A combination transit smart card and electronic purse, for non-transit retail purchases, is currently being tested by 1,000 users. Paris plans to issue smart cards to 1 million annual pass holders in 2001, and then expand distribution to another 4 million season pass holders in 2002 and 2003.

London began planning their Prestige project in 1994. The vendor-financed contract was awarded in 1998. System design and development is taking place over a four-year timeframe, and equipment installation is planned to be completed in 2002.

5.7 Outstanding Issues

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

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 visited 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.

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" (eg-ticket booth or sales agency) to purchase "something" (eg-ticket, token, magnetically-encoded farecard, or smart card) from "someone" (eg - 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. In December 1998, bus customers were surveyed to determine why they did not purchase MetroCards, and the responses provided were:

- 30% cited the convenience of tokens/cash (faster and easy to carry in pockets)
- 14% cited problems with swiping the MetroCard or malfunctioning cards
- 14% said they use transit infrequently

At the TTC, people pay a higher price when paying for their fare with cash, but still 17% of annual rides are made with cash fare payments.

The introduction of debit and credit payment options at vending machines will reduce the amount of cash in general circulation within the transit system. In New York, 20% of vending machine purchases are made with debit and/or credit. In Washington, 6% of smart card transactions are made with debit or credit. However, both New York and Washington raised concerns about the use of stolen credit cards and the “bad debt” costs which are incurred when stolen cards are used for fare transactions before they have been “hot listed”.

<u>Concerns over Privacy of Personal Information</u>

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 which AFC’s may be capable of collecting may prove to be unavailable to the transit operator.

<u>Reliability and Enforcing the Use of AFC on Surface Vehicles</u>

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.

5.8 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 no clear financial business cases for the introduction of AFC in any of the cities visited. All properties who have converted from manual to AFC systems were required to increase their workforce to support the new AFC system.

- No evidence was provided to indicate that AFC, unto itself, had produced increases in ridership or revenue.

- No city had yet been able to generate third-party revenues from their AFC systems.

- No city which has adopted AFC systems has, or 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.

6. Applicability of AFC for TTC

One of the purposes of this fare collection study is to determine whether there is a business case to be made to implement an AFC system at the TTC, and whether there are additional compelling reasons, from the perspectives of customer convenience, security, or marketing opportunities, to support such a case.

All of the transit properties visited by staff 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. This is not the case in Toronto where the TTC's existing fare collection equipment is in good mechanical condition and does not require replacement.

Other than for infrastructure replacement reasons, the visited 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 ridership 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.

To recap, a good fare collection system is one which is:

- Simple: customer-friendly, easily understood and used by riders and staff;
- Quick: allows fast transactions (turnstiles/boardings, purchases);
- Flexible: adaptable to changing fare strategies, loyalty schemes, and useable on other systems;
- Economical: allowing cost-effective operation, administration, and maintenance ;
- Reliable: high level of availability, and easy to maintain;
- Secure: minimising the potential for fraud and fare evasion, providing a secure environment for revenue, and meeting privacy requirements; and
- Information-rich: providing data management decisions regarding marketing, finance, service planning, and workforce productivity.

The following table summarizes how the TTC’s current fare system rates relative to the characteristics and objectives of a good fare collection system. The rationale for these ratings is provided immediately after the table. This explanation, for the most part, repeats the Toronto “commentary” sections provided throughout Section 5. It is presented again here to allow quick cross-reference between that commentary and the following “rating” table.

System Characteristic or Objective	TTC's Current Fare System Rating
Customer convenience: - quick, simple - multiple payment options	 Excellent Fair
Ease of transferring: - inter-modal - inter-carrier	 Excellent Poor
Security: fare evasion, fraud, theft	Excellent
Economical: operating costs	Excellent
Flexibility: niche marketing, new fare options	Poor
Reliability: equipment maintenance	Good
Management information, data	Poor
Non-fare revenues	Poor

The TTC's simple flat-fare structure does not require technological intervention to ensure that the correct fare is paid. Fare collection is fast and easy to understand and use, from a passenger perspective. Customers can purchase fares from subway station collectors, over 1200 independent ticket agents located throughout Toronto, and 131 token-vending machines in the subway. Customer line-ups at collectors' booths do not occur on a daily basis. They do occur at the beginning of the month, when customers purchase their monthly Metropasses. To avoid these line-ups, Metropass purchasers can pay by pre-authorized debit, and receive their Metropasses by mail. TTC customers have expressed no dissatisfaction with the TTC's current fare collection system, and market research has indicated that changes to fare levels and fare media rank very low on customer's stated priorities.

The physical integration of the TTC's surface and rapid transit systems provides easy, fast, convenient transfers between modes, often with no barriers or transactions whatsoever. The TTC has in place a fully-integrated multi-modal transit system. It could be argued that New York's decision to implement an AFC system was partly driven by a desire to establish inter-modal integration of the type currently in place at the TTC.

Transferring between the TTC and other transit operators in the GTA is not particularly convenient for customers with respect to fare arrangements. There is a substantial amount of physical integration of transit routes and services in the GTA. Of the 1.8 million transit trips which are made each weekday in the GTA, approximately 50,000 require that two fare payments be made with two different fare media. The introduction of a GTA smart card would improve the fare payment transaction for these cross-boundary customers. Market research conducted in November 1999, indicates inter-regional travellers are much more interested in fast, reliable, convenient service than they are in fare levels or fare technology.

The TTC's current fare evasion rate is 0.7%, which is lower than those reported by the other properties surveyed. The fare evasion rates reported by other properties ranged from a 3.5 % rate in New York for subway fare evaders only, to 10% in Paris.

The TTC's fare system is relatively cost-effective, at an all-inclusive cost of $0.07 per $1.00 collected. The TTC's costs are lower than virtually all of the transit properties visited or contacted in the course of this study. Fare-processing costs in Canada have been reduced by the introduction of the one-dollar "loonie" and two-dollar "twonie" coins, which can be processed and wrapped automatically. In contrast, transit properties in the United States all have significant numbers of full-time staff dedicated to straightening, counting, sorting, and stacking one dollar bills collected from fareboxes. However, the increasing volume, and weight, of coins in circulation throughout the TTC's subway system, may necessitate an increase in staff for fare distribution and collection.

Two-thirds of the TTC's fare-related costs are the cost of staffing subway stations. With or without an AFC system, the TTC will continue to require a staff presence in each of the subway stations to provide direct face-to-face customer service, and to deal with matters pertaining to station operations, appearance, and security.

The TTC's current fare collection 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. For example, existing operational procedures make it difficult and potentially costly to introduce a new "pass" or a special promotional ticket for major events. Manual and visual inspection of fare media also limits the TTC's ability to consider alternative fare strategies based on distance travelled or time of travel (ie.-peak vs off-peak).

The TTC's current manual fare collection system provides virtually no data for management information and decision-making. The is no ridership data for special "target" marketing or service planning. The token vending machines are not electronically linked to a remote monitoring system and, hence, staff do not know when the machines are full, empty, or jammed until customers complain, or until staff inspect them.

In summary, while the TTC's current fare system is poor on the four areas noted, it rates quite highly in the critical areas of customer convenience, inter-modal transferring, security, efficiency, and reliability.

6.1 Operating and Capital Costs Implications of AFC at the TTC

For evaluation purposes, the following hypothetical AFC scenario was developed for the TTC:

Fare Policy:
- flat fare, pay-on-entry, free transfers between modes (no change)

Fare Media:
- contactless smart cards replace tickets, tokens, and Metropass
- approximately 400,000 smart cards required for TTC customers
- cash is accepted on surface vehicles and at subway station collectors booths (paper transfers are issued for cash payments, upon request)
- smart cards are accepted by all transit operators through the GTA

Fare Collection:
- smart card reader on all surface vehicles
- smart card reader replaces Metropass turnstile readers
- no change to farebox cash collection process (as with other cities)
- surface data automatically downloaded

Fare Sales:
- subway collectors sell smart cards and can add value onto smart cards
- passenger-operated vending machines accept cash or debit transactions
- preauthorized debit transactions can be made by phone or internet
- TTC ticket agents sell only pre-valued smart cards ($10 or $20 value), and cannot add-value onto smart cards

Potential Effects of an AFC System on TTC Customers

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.

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.

- 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.

Operating Cost and Workforce Implications of AFC

The following Table 5 summarizes the potential operating cost and workforce implications of AFC on the TTC. The potential workforce increases have been pro-rated based on the actual staff increases incurred by New York, Chicago, and Washington. Explanations of projected changes are provided following the table.

Table 5
Workforce and Operating Cost Implications of AFC for TTC

	Potential Savings		**Potential Increase**	
	Workforce	**$**	**Workforce**	**$**
Revenue Operations	(4)	($0.2 M)		
Station Collectors	(60)	($3.0 M)		
Fare Media Expenses (production costs – tickets, tokens, Metropasses)		($2.5 M)		
Administration and Data Management (card, administration/distribution,customer enquiries, data base management, claims, refunds)			+ 85	+ $4.2 M
Revenue Equipment & Maintenance			+ 44	+ $2.2 M
IT Annual Maintenance & Support			+ 28	+ $1.4 M
Sub-Total	(64)	($5.7 M)	+ 157	+ $7.8 M
Net Change			+ 93	+ $2.1M

Revenue Operations

The replacement of tickets, tokens, and Metropasses 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 farebox contents. Cash would still be accepted and, hence, there would be no change in the daily process of farebox revenue collection. Material expenses for tickets, tokens, Metropasses, and paper transfers would be eliminated, and this would result in an operating cost savings of $2.5 million annually.

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

Station Collectors

Approximately 85% of the station collector workforce is required to provide face-to-face customer service and to deal with matters pertaining to station operations, security, and appearance. The introduction of a smart card system would result in marginal labour savings in this core function.

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 approximately 60 positions 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, TTC staff have determined that 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"); and
- smart card administration (customer service, claims, and refunds).

The highest projected workforce increase is 85 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.

The TTC's current Metropass 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. Based on these ratios, and a database of 400,000 smart cards for all current TTC ticket, token, and Metropass users, AFC administration and data management activities could require up to 85 additional staff.

AFC Capital Cost Estimates

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 infrastructural 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. A detailed itemization of this capital cost estimate is provided in Appendix J.

Table 6 below, summarizes the capital cost estimate of installing a contactless smart card system on all surface vehicles, and in subway stations. Hardware and equipment unit costs were based on prices provided by various AFC system consultants, suppliers, and equipment manufacturers.

Table 6
Capital Investment Requirements – Contactless Smart Card AFC System for TTC
(order-of-magnitude estimate in Canadian $)

AFC System Requirements	Estimated Capital Cost	Description
Equipment		
Subway System Equipment	$ 32 M	• Retrofit existing turnstiles • Replace token vending machines • Subway station computers
Surface Equipment	$ 42 M	• Smart card readers with optional registering fareboxes (buses, streetcars, and WheelTrans) • Smart card readers at Metropass commuter lots • Garage and carhouse computer system
Central Computer Facility	$ 4 M	• Network computer hardware • Proprietary software (design and development
Total Equipment Supply	**$ 78 M**	
Facility Modifications	**$ 22 M**	• Subway electrical and communications modifications (power, cabling, ducting)
Other	**$ 14 M**	• Equipment spares, warranty, technical support
Subtotal	**$ 114 M**	
Standard Add-ons	$ 26 M	• Marketing, staff training, contingency
TOTAL ESTIMATED COST	**$ 140 M**	

These costs are within the same range, on a per-boarding basis, as those incurred by New York and Chicago when they converted from manual fare collection to automatic fare collection. Approximately two-thirds of the estimated costs are required for power upgrades, communications cabling, subway and surface AFC equipment (turnstiles, touch screen vending machines, smart card readers which optional registering fareboxes, etc).

7. Other Issues

Who Will Drive What?: 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 Franciso, 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 affect the decision and timing of implementing a smart card system at the TTC or on other systems.

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:

- 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; and
- access to university libraries and services.

Through its smart card initiative, the municipality of Venice is hoping to both improve its citizens' 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.

Global Inter-Operability

There are several smart card associations which are working toward 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.

There is work underway towards the development of an integrated mobility system such as this for the GTA. The concept is to develop a smart card which would access and link a wide range of urban and inter-city transportation modes, and tourist and other urban services and applications. The research project is lead by Moving the Economy, on behalf of a national consortium of 19 partners. This project will:

- study the feasibility of introducing a multi-application, multi-modal Canadian smart card for transportation, tourism, and urban services;
- develop initial system architecture, and recommend practices for implementing and integrating a range of applications;
- demonstrate the concept of inter-operability of multi-modal, multi-application smart cards through deployment in a medium-size urban setting (Burlington); and
- communicate the study results to transportation providers and decision-makers.

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.

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.

8. Summary and Conclusions

The process of collecting fares is an important point of interaction between a transit operator and its customer. A good fare collection system is one which is:

- simple, easy-to-use, and easy-to-understand for customers;
- quick and efficient, allowing fast fare transactions;
- flexible, allowing the use of various fare structures, policies, and incentives;
- usable on neighbouring transit systems;
- economical and cost-effective to operate ;
- reliable and easy to maintain;
- secure, with hard-to-counterfeit media and security of transactions for customers; and
- data-rich, providing information which management may exploit for marketing, planning, and other business processes.

Why Do Cities Adopt AFC?

TTC staff visited a number of cities which have implemented, or are in the process of testing or implementing automatic fare collection systems. The purpose of the visits was to determine what these cities were trying to achieve by implementing an AFC system.

The major reason given for implementing or testing new systems is to address the problem of ageing or failing fare collection equipment. Every city visited has been driven to seek out new fare collection equipment because their existing equipment was old and at the end of their usable or economic lives. Here are the other major reasons why these cities are implementing or trying AFC systems:

- Making Fare Transactions Easier for Customers: AFC systems provide the potential for simpler fare transactions for passengers, compared to requiring passengers to provide exact fares. They can also make fare transactions simpler in systems with very complex fares which vary, for example, by distance or by time of day.

- Making it Easier to Transfer between Modes: The introduction of AFC can allow customers to transfer between different modes, such as subway and buses, using the same fare medium.

- Increasing Ridership and Revenue by Making Fare Transactions More Convenient: Cities like New York and London speculated that the added convenience of AFC fare transactions will lead people to make more trips on those systems. Additionally, the flexibility of AFC, which allows for the introduction of new or innovative fare options, such as unlimited travel passes, may attract more riders.

- Reducing Fare Evasion: AFC systems provide the transit operator with the opportunity to replace old, outdated, and easy-to-abuse entry turnstiles with new, much harder-to-evade high-level or gated entry turnstiles which physically prevent people from jumping or leap-frogging over in order to avoid paying their fare.

- Reducing Fare Fraud: AFC holds the strong promise of reducing fraudulent fares because its high data storage capacity allows a high level of security encryption on the card and in the reader devices. Additionally, the precision of systematic data card validation should exceed the accuracy of visual inspection of fare media transactions.

- Reducing the Theft of Fare Revenues by both Transit Staff and the Public: AFC offers transit operators the ability to improve their financial control and tracking of media sales, transfers, and cash transactions. It also allows operators to reduce or restrict the cash-handling responsibilities of staff.

- Reducing the Cost of Fare Collection and Equipment Maintenance: AFC card readers, -- contactless smart card readers in particular -- have no moving mechanical parts and do not require physical interaction between card and reader. There should, therefore, be less wear-and-tear on the equipment and this should translate into a reduction in maintenance costs.

- Improving the Reliability of Fare Collection Equipment: New York City reported a dramatic increase in the reliability and availability of its new AFC-based turnstiles.

- Improving Management Information: AFC systems can provide valuable management information which will may lead to improvements in the efficiency of business practices.

- Generating Non-Fare Revenues through AFC Systems: AFC cards can have advertisements displayed on them, for purposes of generating revenues, and are capable of facilitating co-promotions with other commercial enterprises which might use the same card.

<u>Time Requirements to Plan and Implement AFC Systems</u>

The planning and implementation of an AFC system in a large multi-modal transit operation is a huge endeavour. In the cities visited and inspected by TTC staff, 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.

<u>Computer Requirements of AFC Systems</u>

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 visited 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.

<u>Summary of Key Findings from Other Cities</u>

TTC staff’s findings from the major cities visited 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 no clear financial business cases for the introduction of AFC in any of the cities visited. All properties who have converted from manual to AFC systems were required to increase their workforce to support the new AFC system.

- No evidence was provided to indicate that AFC, unto itself, has produced increases in ridership or revenue.

- No city has yet been able to generate third-party revenues from their AFC systems.

- No city which has adopted AFC systems has, or 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.

Outstanding Issues Pertaining to AFC Systems

Based on discussions with transit agency staff in the cities visited, TTC have identified these noteworthy outstanding issues pertaining to AFC systems:

- 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.

- 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 interviewed 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 it can be used by infrequent transit travellers. 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 interviewed has yet resolved how these customers' 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.

How Does the TTC's Current Fare Collection System Rate?

Having heard the objectives which caused other cities to test or implement AFC systems, TTC staff undertook to assess the TTC's current fare collection system relative to those objectives.

The assessment has shown that the TTC's existing fare system is both unique in the industry, and in many ways more effective than the fare systems used in other cities. By virtue of a combination of foresighted planning and facility design, political decision-making through the evolution of the former Metropolitan Toronto, and the unusual good fortune of being seemingly "behind-the-times" with a notably low-tech fare collection system, the TTC is in the enviable position of having a fare collection system which, for the most part, works quite well. Visiting experts from Europe, Asia, and the United States have consistently remarked about the simplicity, efficiency, and speed of the TTC's fare collection system, the unparalleled convenience of the TTC's inter-modal integration and fare-paid subway stations, and the TTC's low fraud and fare-evasion rates. Among those making these comments were the project managers for the AFC systems in London, England and Paris, France.

Here is a summary of the assessment of the TTC's fare collection system with respect to the key characteristics of a good fare collection system and the major objectives of those cities which are currently choosing to adopt AFC technology:

- Customer Convenience: The TTC's pay-on-entry, flat-fare system, under which customers deposit their fare into a farebox or flash or swipe their Metropass is, quick, simple, and easy to understand for customers. TTC customers have expressed no dissatisfaction with the current system, and market research has indicated that good quality, fast, reliable service is the attribute which is most important to customers. Changes to fare levels and fare media ranked very low on customers' stated priorities.

- Ease of Transferring: The TTC free-transfer system allows easy transferring between buses, streetcars, and subways. In contrast to most other transit properties worldwide, many of the TTC's rapid transit stations, and all of its busiest, high-volume stations, have been designed to allow passengers to make direct, transaction-free transfers between surface and rapid transit services. On the other hand, the TTC's fare system is inflexible and inconvenient with respect to transferring between the TTC and its neighbouring transit systems.

- Ageing Infrastructure – State-of-Good-Repair: The TTC's low-tech fare collection system, which consists largely of simple fareboxes, together with magnetic swipe readers for monthly passes, is currently in good mechanical condition and has few components which are prone to deterioration due to physical interaction with fare media.

- Security: The TTC's current fare evasion rate of 0.7 percent rates among the lowest of all cities surveyed. The strong security measures in place at subway ticket booths, together with the rigid supervisory tracking and auditing of all fare transactions and revenue processing, results in a near-zero rate of theft by either staff or members of the public.

- Economical: The TTC spends 7 percent of every dollar collected on the collection and processing of fares and fare revenues. This is notably lower than most other properties who reported fare collection costs of 10 to 15 percent or higher.

- Flexibility: The TTC's current fare media and collection system are relatively inflexible and provide few opportunities for fare innovations or to address or attract niche markets.

- Reliability: The TTC's fare collection and sales equipment is reliable, with the exception of token vending machines which are a source of frustration for customers.

- Management Information and Data: The TTC's current fare collection system does not generate any information or data for use by management. The only way by which TTC management can obtain information from its fare collection system is by requesting manual counting of fare media collected, or by manually taking readings of turnstile counters.

- Non-Fare Revenues: The TTC's current fare collection system provides few opportunities for generating non-fare revenues.

In summary, while the TTC's current fare system is poor in the four areas noted, it rates quite highly in the critical areas of customer convenience, inter-modal transferring, security, efficiency, and reliability.

The Potential for AFC in Toronto

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.

An AFC system could negatively affect the TTC's highly-prized, transaction-free, fare-paid, transfer arrangements within its rapid transit stations. Under current TTC ridership levels, upwards of 760,000 trips per day, or about 40% of all TTC daily trips, could be negatively affected by the need to introduce some sort of fare transaction where there is currently none.

It is projected that the introduction of an AFC system in the TTC would result in a net increase in workforce of just under 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.

Any proposal to have a 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 TTC or the City can repay a debenture or can repay the vendor; they are substantially the same thing.

Given these facts, together with the fact that the TTC's system currently works relatively well in terms of customer convenience, economical operation, security, and reliability, TTC staff conclude that there is not, at present, business justification for implementing an AFC system in Toronto.

Synopsis

AFC systems have the potential to both make customers' fare transactions easier, and to improve operational, management information, and financial aspects of transit operators' fare collections systems. Because AFC technologies are still relatively new and evolving, the cities which have, or are implementing AFC systems, have not yet produced sufficient evidence that they are actually reaping the benefits which are promised by the manufacturers of AFC systems.

The TTC's unique inter-modal integration, and simple, low-tech fare collection system, results in the TTC's current system operating quite well, with no pressing or urgent need to scrap or replace it. These facts, coupled with the high initial capital cost of implementing an AFC system in Toronto, and the projected increases in workforce and annual operating costs associated with an AFC system, lead to the conclusion that the TTC should not, at the present time, proceed with the procurement of an AFC system.

It is reasonable to expect that AFC technology will continue to evolve and converge in the short-to-medium term as international efforts are made to establish standardized technologies and specifications.

This being the case, and given that the TTC's fare collection system will become increasingly outdated over time, it would be prudent for the TTC to develop a plan for upgrading its infrastructure and facilities, notably in the areas of power and communication capabilities, so that the TTC would be better prepared to implement an AFC system when circumstances dictate a changeover in fare collection technology.

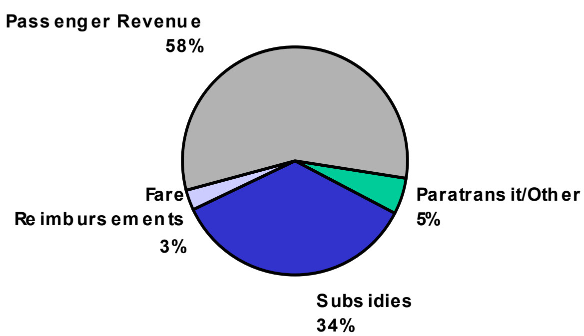
APPENDICES

Appendix A - New York A F C System Overview

The following information on New York City Transit's (NYCT) AFC program has been assembled from on-site interviews with NYCT staff, conducted in February, 2000, and other standard reference material.

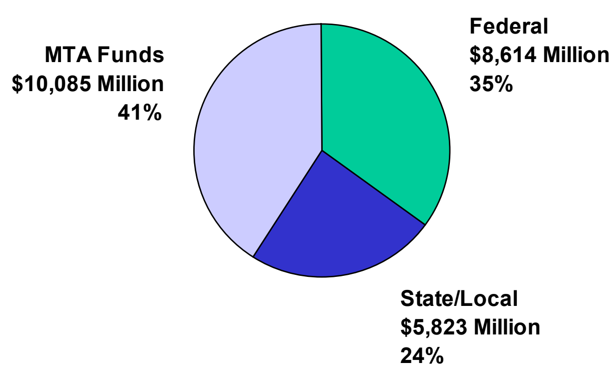
<u>New York City Transit (NYCT) Statistics</u>:
Annual ridership: 1.3 billion (unlinked trips)
Daily weekday ridership: 7 million
Subway lines: 30
Subway stations: 468
Subway cars: 6,000
Bus routes: 204 local and 31 express routes
Buses: 4,400
NYCT employees: 46,000
Revenue/cost ratio: 64%

NYCT 2000 Operating Revenue and Subsidies
(shown in US dollars)



	$Millions
Subway	$1,447.3
Bus 555.3	
Passenger Revenue	**$2,002.6**
Sr. Citizen Reimbursement	$13.8
School Reimbursement	90.0
Fare Reimbursement	**$103.8**
Paratransit	25.3
Other Operating Revenue	54.0
Total Operating Revenue	**$2,185.7**
New Gov't. Assistance and Other Resources	114.4
Subsidies:	
MTA Bridges & Tunnels (TBTA)	$137.7
State and City Operating Assistance	316.1
Metro/PBT Taxes	602.9
Urban Taxes	146.4
Total Subsidies	**$1,203.1**
Total Operating Revenue and Subsidies	**$3503.2**

NYCT 2000 Total Capital Funding
$24 Billion (US dollars)



AFC System Overview

NYCT has a simple flat fare policy, irrespective of distance travelled. Until the mid-1990's, subway fares were paid with tokens purchased with cash from subway station clerks, and bus fares were paid with either coins or tokens. Free paper transfers were given, upon request, to customers which allow them to transfer between buses, but customers were required to pay an additional fare to transfer to between the bus and the subway. Eligible students used passes which were shown, or "flashed", to bus Operators and Station clerks.

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.

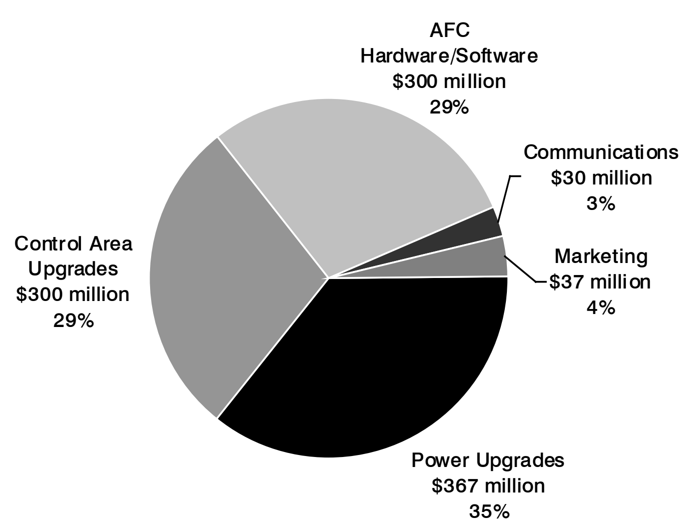
In May 1997, NYCT introduced a new magnetic AFC system based on a magnetically encoded fare card (MetroCard) that can store value (e.g. $20), which is decremented each time the card is used or the fare card can be valid for a specified number of 24-hour periods (e.g. 1-day, 7-days etc). The entire network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

- Upgrade the fare collection equipment, and in particular the subway station fare control areas;
- Reduce fare abuse; and
- Offer customers greater convenience and a broader choice of fare options.

The installation of AFC equipment in NYCT stations commenced in January 1994 and was completed in May 1997. The installation of electronic fareboxes in NYCT buses was accomplished borough by borough in 1995.

New York: AFC Capital Investment

$1 billion

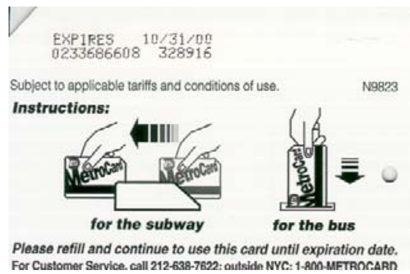


The magnetically encoded farecard is read or verified two different ways (see photo below). Customers "swipe" the card through a reader on the subway turnstile, or insert the card into a transport mechanism on the bus farebox (see photo below). NYCT tried swipe readers on their buses, but found that the bus readers were unreliable and this had a negative effect on boarding times. Hence they were forced to switch to transport readers which have proven to be more reliable. Approximately 15% of the subway transactions are unsuccessful on the "first swipe" attempt. Based on previous experience with token turnstiles being tampered with and damaged in unattended areas, NYCT does not plan to replace the swipe readers in the subway system.

New York

front

back



NYCT MetroCard Farebox Reader

NYCT has an extensive AFC sales network which makes card purchasing, and adding value to the fare card, as easy as possible for customers. There are over 1,000 automated vending machines with touch screen menus and the choice of four languages that are pre-selected depending on the communities they serve. The vending machines accept bills, coins and bank cards for debit or credit transactions (see photo below).

MetroCard Vending Machine

<u>Fare Incentives & Ridership Growth</u>

When MetroCard was first put into revenue service in 1997, only 23% of all NYCT trips were taken by MetroCard. NYCT staff indicated they did not believe this level of MetroCard market penetration would have increased without the introduction of fare incentives. After the NYCT made significant changes to their fare structure, and introduced the fare incentives listed below, 75% of all NYCT rides were taken by MetroCard users.

- **Free intermodal transfers**, effective July 1997, allowed free MetroCard transfers between bus and subway. The new electronic transfers are not controlled by location and direction and, hence, customers can make round-trips and trip-chain on a single fare, as long as they transfer within two hours of boarding the first bus, and do not board the same bus route.

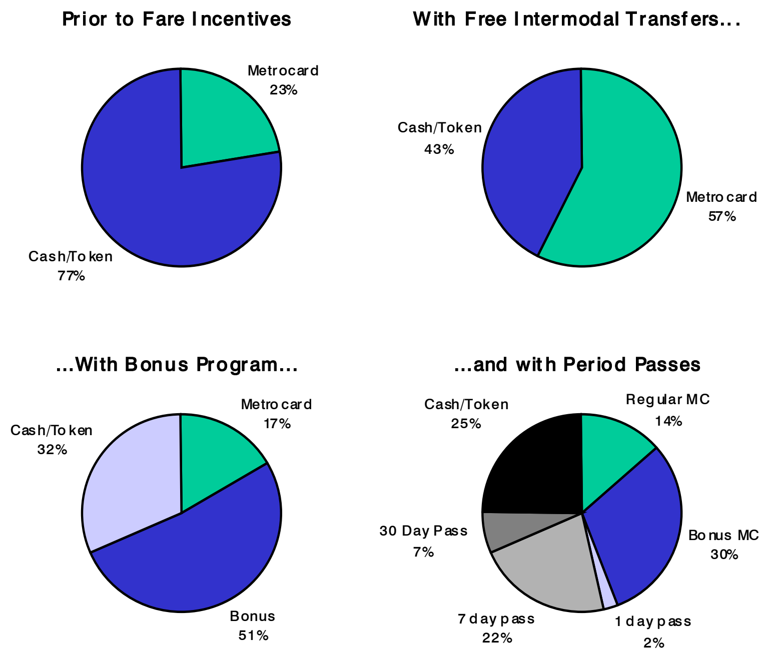
- **MetroCard Bonus Program**, effective January 1998, gave MetroCard customer a 10% bonus on purchases of $15 or more (e.g. a customer spending $20 received a $22 MetroCard)

- **Express Bus Fare Reduction**, effective March 1998, the express bus fare was reduced from $4 to $3.

- **Unlimited–Ride MetroCards**, effective July 1998, the 7-day, and 30-day and unlimited ride passes, which give customers a discounted travel rate, were introduced. In January 1999, the 1-day unlimited ride “Fun Pass” was introduced.

The following figure shows four snapshots of the overall NYCT (subway, local bus, and express bus) fare media market share. MetroCard market share increased from 23% to 57% with the introduction of free intermodal transfers. The bonus program increased the total MetroCard market share to 68%, and once unlimited ride passes were introduced 75% of all NYCT rides were taken by MetroCard users.

NYCT Fare Media Market Share



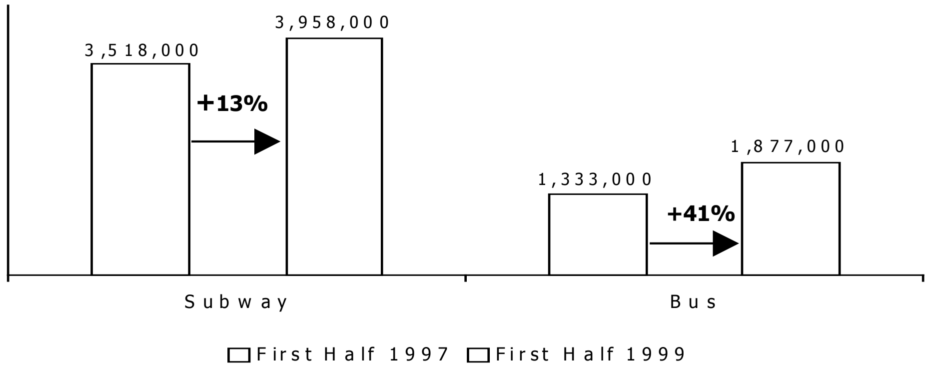
While MetroCard market share continued to increase with the introduction of each fare incentive, token use remains at 23% on the subway, and cash and token use at 30% on the bus. This indicates some customers are unwilling to switch to MetroCard regardless of the offer of fare incentives. When token users were asked in a December 1998 survey why they did not purchase MetroCards instead of tokens:

- 30% cited the convenience of tokens (faster, easy to carry, don't have to keep in wallet);
- 14% cited problems with MetroCard (problems swiping the card, malfunctioning cards);and
- 14% said they use the transit system infrequently.

MetroCard was used by over half of all express bus riders as early as March 1996, due to the convenience of using MetroCard over coins or tokens. With local buses and the subway, the largest growth in MetroCard market share occurred with the introduction of free intermodal transfers in July 1997, with about half of local bus riders and half of subway riders using MetroCard by September 1997.

Between January, 1997 and June, 1999, the total number of weekday unlinked trips on the system increased by 20%. However, this increase is not solely attributable to the AFC system, nor does it necessarily represent an increase in the number of new transit riders. For example, a customer who used to walk to the subway on their way to and from work made two unlinked trips. The same customer can now ride the bus to the subway for free and, hence, this same travel journey represents four unlinked trips (two bus trips and two subway trips). Also, the new electronic transfers, which were no longer controlled by location and direction, made several new travel patterns possible. Customers can now make a round-trip and trip-chain on a single fare. The other major factors that contributed to the ridership increase were: strong economic and employment growth (5%), reduced city-wide crime and population growth near the subway.

NYCT Average Weekday Ridership Increases



Even though part of the ridership increase can be attributed to economic growth, as well as population shifts and service increases, it is safe to conclude that most of the growth was due to the fare incentives. Much of the ridership increase from the fare incentives can be described as ridership elasticity resulting from a fare change, but the fare incentives offered more than just a reduced fare. MetroCard offered not only a lower average fare, but also a greater customer convenience and flexibility, which helped encourage customers to take more trips.

Operating Impacts

In spite of the significant ridership increase in New York, fare revenues dropped by 3.2%, and the overall revenue cost ratio dropped from 74% in 1997, prior to AFC, to 64% in 1999 after AFC implementation. The cost of increasing service for the additional riders has also been significant. Between 1997 and 1999, NYCT invested approximately $300 million (annualized) for added service, and approximately 400 cars will be added to the subway fleet and 631 peak buses will be required to meet ridership demand.

Technical and operating limitations produced a less controlled system of free transfers than originally conceived. The freedom to transfer between routes without location and direction restrictions and to round-trip and trip-chain on a single fare contributed to the unexpectedly large increase in bus ridership. Unrelated to the fare incentives, but a factor in the increase in express and local bus ridership, was the convenience of MetroCard over exact fare payment.

The introduction of AFC resulted in a one percent increase in workforce -- approximately 400 positions. These people were required to provide AFC support in the following areas.

MetroCard Related Operating Costs & Workforce Support Functions

Card Stock Costs: • Purchase approximately 100 million cards annually (@ $0.05 per card) • Staff to encode cards and wrap pre-encoded cards • Inventory and Security issues • Quality control/assurance costs • Cards have to be quality-inspected by the manufacturer (approximately $50,000 per vendor)
Maintenance Costs • MetroCard Vending Machines (MVM) maintenance: 20 MVMs: 1 maintainer, 15 maintainers: 1 supervisor • MVM Maintenance Security: armed collecting agents teamed with maintainers. (same ratio as maintainers) • Electronic Board Repair: 30 boards per MVM x 12% failure rate x 1.98 hours to repair each board

MetroCard Related Operating Costs & Workforce Support Functions (continued)

MetroCard Vending Machine Collection Costs
- Revenue collection trucks: trucks, maintenance and parking/housing costs
- Revenue collection personnel
- Additional personnel to process cash collected from machines – sorters used are less efficient than those used for booth cash counting

Data Processing Costs
- Increased telephone charges
- Mainframe utilization charges (NYCT contracts out IT services)
- Back Office support positions
- Software modifications to accommodate changing requirements
- Security and negative list positions
- Communications monitoring

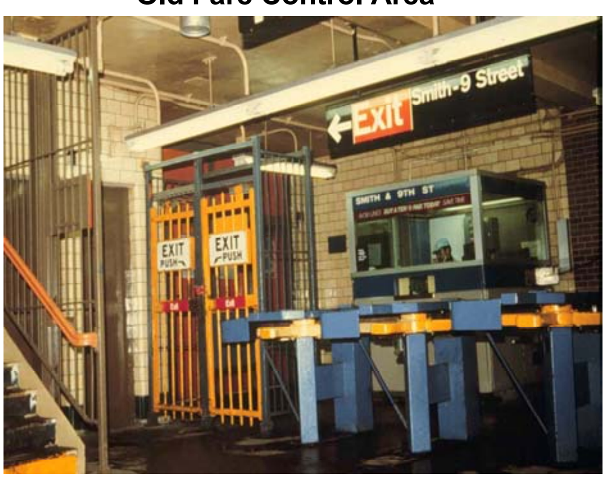
Transaction Fees and MVM Cash Collection
- Transaction fees: charges for debit/credit card usage depend on card usage (approximately 20% of MVM usage is card usage)
- Personnel required to reconcile cash collected vs MVM tallies
- Personnel required for bank chargebacks

Customer Services
- Customer Assistance Teams to assist in MVM roll-out. Provide customers with instructions and guidance
- Increased customer claims require increased transaction investigations

<u>Fare Evasion</u>

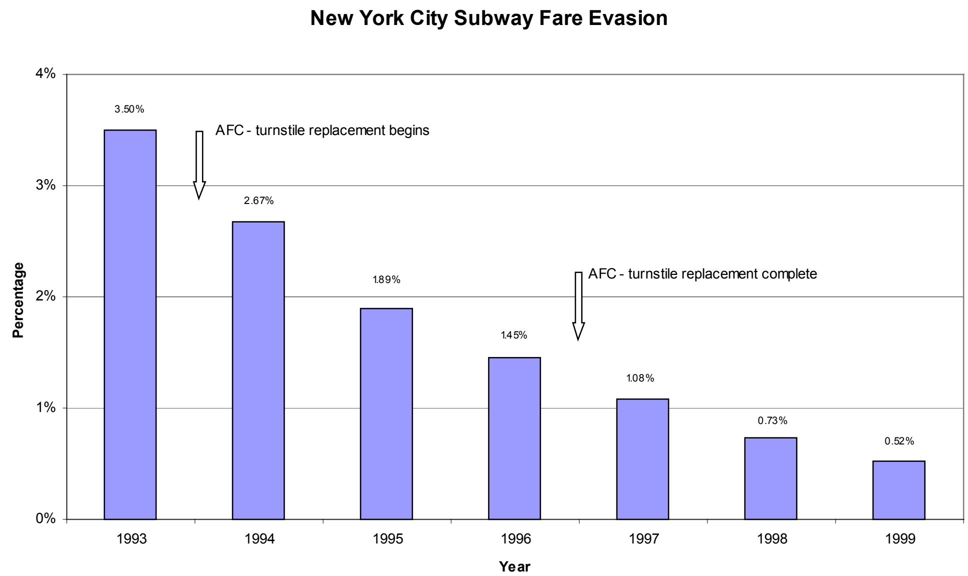
NYCT was successful in reducing fare evasion in the subway system, through the redesign of the fare control areas, and the installation of modern high-gate turnstiles at unattended entrances.

Old Fare Control Area



New Fare Control Area

Once per month, a system-wide count is conducted (every station over a 24 hour period), and the station collectors document the number of evaders observed illegally going over or under the turnstiles. Since these observations are made while the collector continues to sell fare media they are assumed to be under representative by a factor of 35%, which was derived by an more in-depth audit conducted in 1990. This methodology for estimating fare evasion has been used consistently since 1990 and, hence, the overall trend is considered accurate. The graph below shows the change in the ratio of fare evaders to fare payers in the subway system.



In 1993 NYCT's subway fare evasion rate was 3.50%, of which $22.5 million (US) annually (US) is considered recoverable revenue. By 1999, the evasion rate was 0.52%, which equates to $7.5 million (US), of which $4.5 million (US) is considered recoverable. Another factor contributing to the reduction in fare evasion over this time period was an extensive city-wide crime reduction campaign. The success of the campaign is reflected in the number of New York City police (NYPD) Transit Bureau felonies in 1999 has declined by 4.6% from 1998, and is down 70 percent from 1989.

Turnstile Maintenance

	Before AFC (token turnstiles)	1990 Projection	1999 Actual
Reliability (mean cycle before failure)	<30,000	>250,000	>1,500,000
Availability	90%	99.7%	99%
Maintainability (mean time to repair)	7.5 hours	0.5 hours	0.5 hours

AFC Advice from NYCT

- "You're not buying a fare collection system, you're buying a great big computer". The back office computer system is huge, complex and requires extensive expertise.
- 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. "You've got to be smarter than the AFC equipment manufacturers."
- 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.

Appendix B - Chicago AF C System Overview

The following information on the Chicago Transit Authority's (CTA) AFC program has been assembled from on-site interviews with CTA staff, conducted in January, 2000, and other standard reference material.

Chicago Transit Authority (CTA) Statistics:
Daily weekday ridership: 1.3 million (unlinked trips)
Subway stations: 156
Subway Cars: 1,000
Buses: 2050
Bus garages: 8
Revenue/cost ratio: 45%

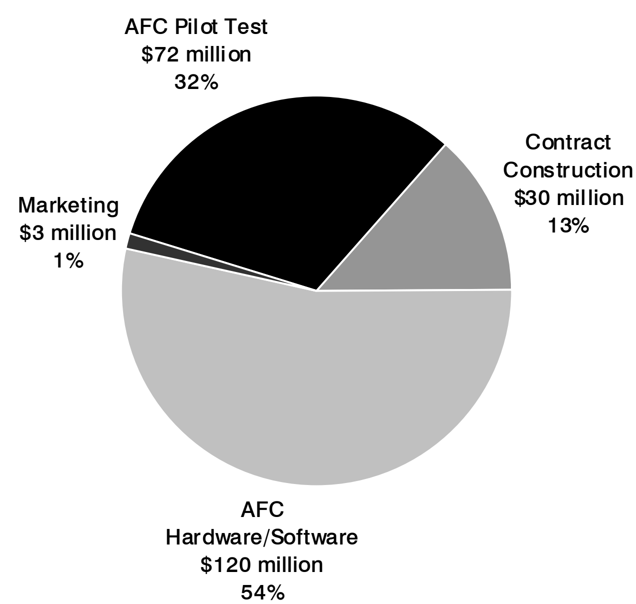
AFC System Overview

The fare structure for the CTA is a flat rate fare regardless of distance or time of day. The typical full fare customer will pay $1.50 when boarding with exact fare (cash) or the new magnetically-encoded fare card. After paying this fare, the customer is allowed two transfers within a two-hour period immediately following the initial boarding. The first transfer costs 30 cents, and the second transfer is free.

The CTA completed implementation of their new AFC system in June 1997. Planning for the new system began in the early 1990's, and implementation took place over a 27 month period under contract to Cubic Transportation systems. Much of the $225 million ($150M US) capital investment applied to retrofitting the CTA's 156 rapid transit stations, with appropriate turnstiles and farecard vending machines. Implementation of the 129 bus routes involved integrating the AFC farecard readers with the existing registering fareboxes, which have remained in service.

Chicago: AFC Capital Investment

$225 million



The primary objectives for introducing the new AFC system were to:

- Improve financial accountability by removing cash handling by subway ticket clerks and tracking all financial transactions, particularly cash and paper transfer transactions;
- Improve system security and reduce fraud and fare evasion by installing fare vending machines, which are more secure than ticket booths, and new turnstiles which are difficult for customers to jump over;
- Improve customer convenience by:
  - introducing new fare options: unlimited ride passes (1-day, 7-day) and a University pass
  - eliminating long line-ups at ticket booths during rush hour
  - eliminating the for customers to have exact fare
- Provide data so that CTA could manage the system better and more efficiently with:
  - ridership data to determine fare levels and market niches
  - maintenance data to deploy workforce more productively
  - more reliable fare collection equipment

<u>AFC System Overview</u>

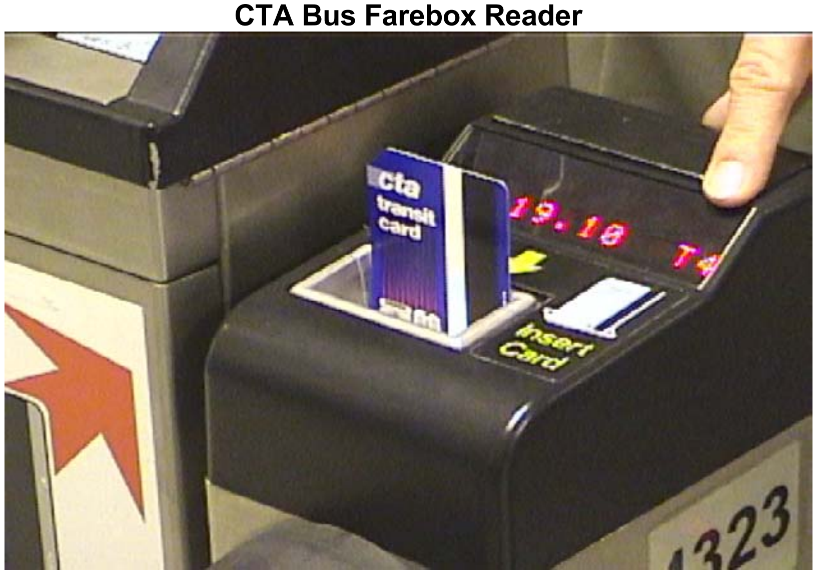
The new CTA Transit Card is a thin-plastic card with fare information encoded on a magnetic stripe (see photo below). The Transit Card is available in either a stored value format or a time-based period pass. The stored value fare cards allow customers to add value to their card and pay as they go. Up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

front

back

The card is read when a customer inserts the farecard into a reader on the subway turnstile or bus farebox (see photo below).

CTA Bus Farebox Reader



CTA AFC Subway Turnstiles

The time-based period pass allows a customer unlimited access to the CTA transit system during the time specified on the pass. For example, visitor passes are available in one, two, three and five 24-hour periods. The pass is activated the first time the customer inserts it into a bus farebox or rail station turnstile and it remains valid for the appropriate number of 24-hour periods. Additionally, there are seven and thirty day period passes available. These passes are also activated when they are first used on the CTA system. The expiration time and date are printed on the back of the pass as a convenience for customers.

Transit Cards can be purchased at any CTA rail station, from a transit card vending machine (see photo below), and from approximately 300 retail units at pre-valued denominations. The transit card vending machines, which are located only at rail stations allow customers to :

- purchase a new stored value Transit Card for a minimum of $1.50;
- add value to a previously-purchased fare card, in $0.05 increments, with a maximum value on the card of $100.00. The present average add-value transaction is $5.;
- receive a 10% bonus for each $10.00 they add to their card; and
- check the fare card value.

CTA Vending Machine

All bus fareboxes 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:

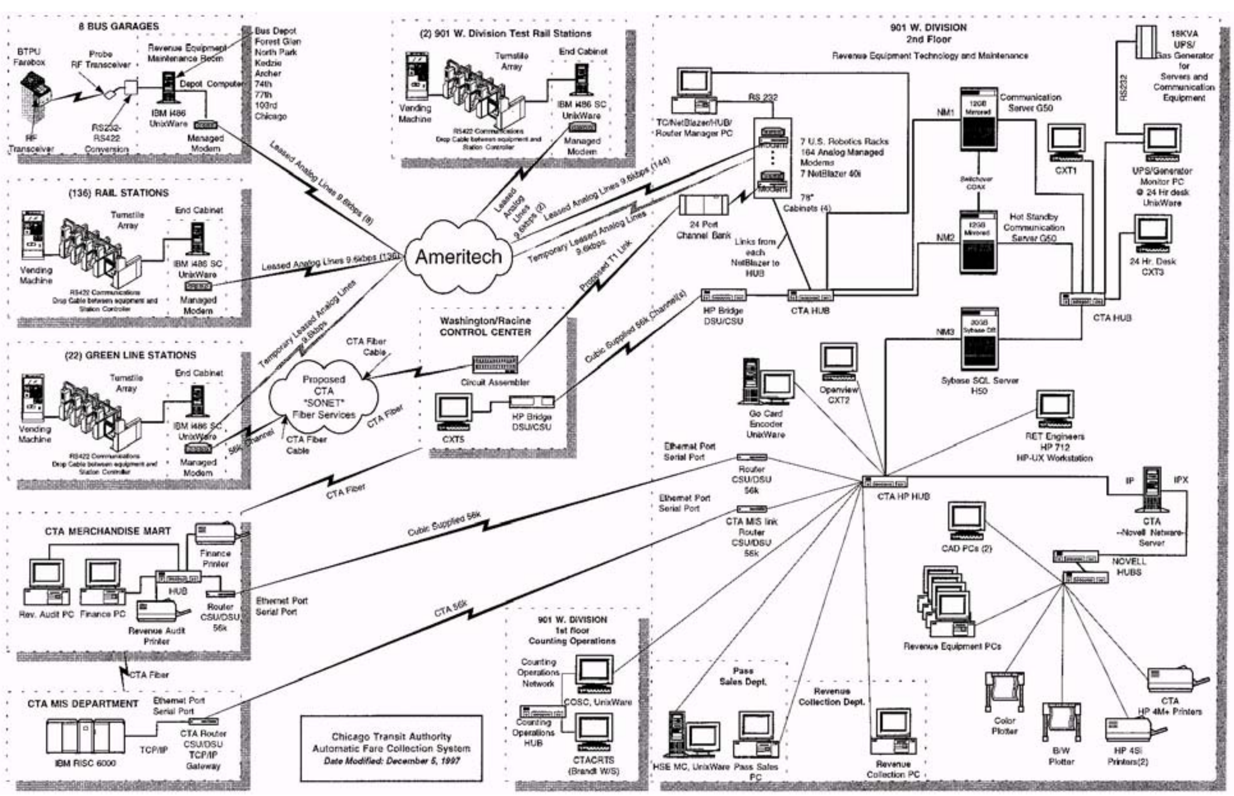
- date and time the fare card was used;
- station or bus where the fare card was used;
- remaining value on the fare card; and
- value deducted or added to the fare card.

In addition to tracking card usage, the computer system monitors card holder 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 call refund requests;
- posting refunds; and
- responding to enquiries.

Incident rates are tracked where there are identified discrepancies between card and central system balances. The current rate is approximately 2.3 problems per 10,000 magnetic stripe transactions.

CTA Automatic Fare Collection System Network



CTA Rail AFC Equipment (156 stations)	**CTA Bus AFC Equipment** (2050 buses and 8 bus garages)
- turnstiles: 853	- bus ticket processing units on fareboxes: 2500
- station control computers: 172	- data collection computers: 30
- station information computers: 250	- fare revenue vaults: 75
- vending machines: 347	

The infrastructure for a contactless smart card system was installed concurrently with the implementation of the magnetic system. CTA chose not to use smart cards from the start, because of the individual card costs ($10 per card), the relative newness of the technology and concerns about single source proprietary systems. Currently there is a pilot test of the smart cards with concessionary pass holders, and a limited number of cards are being made available to the general public.

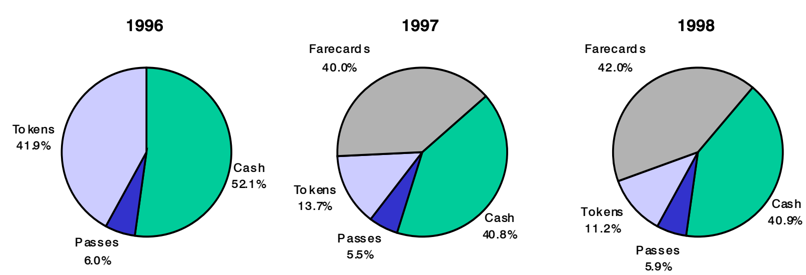
Customer Reaction and Fare Incentives

Currently there are 1.3 million Transit Card transactions per day. Currently 92% of the rail users purchase fare cards, but only 50% of the bus users purchase fare cards. The lower acceptance of AFC farecards by CTA bus riders is thought to be due to their more limited access to AVMs and the pre-valued farecards sold at convenience stores were priced too high ($13.50 and $16.50 was too much initial cash outlay) for some of the bus riders. The CTA is considering investing in electronic point-of-sale machines for the retail vendors to make it more convenient for customers who travel only by bus to purchase and add value to fare cards.

Cost-per-ride savings were offered as an incentive to switch to the new ticket media, through inter-modal ticketing with transfer discounts. It is believed that the discounts and transfers were responsible for a 75% migration from tokens and cash to the new fare media in the two-year period since the new ticket medium was introduced. Additionally period travel has been offered for the first time. The discounts for this were modest to start with, to ensure overall revenue was not greatly affected.

The following graph shows the breakdown of farebox revenue by fare media type, and highlights the growth in the use of fare cards.

CTA Average Daily Farebox Revenue



CTA staff are surprised how easily customers have accepted the new technology. When tokens were phased out in January 1999 there were very few customer complaints.

The AFC data allows CTA to analyze whether or fare media is priced at an appropriate level. Based on trip data of monthly pass users CTA decided to reduce the price of their monthly pass from $88 per month to $75, and allow the pass to be used for 30 consecutive days rather than a calendar month.

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 handle cash.

CTA's Customer Service Division was reorganized and expanded in early 1997 in anticipation of large increases in both enquiries regarding how the AFC system works, and complaints regarding AFC equipment failure (incorrect amounts deducted from farecards, refunds requested etc). Also, a special staff unit was established to exclusively handle AFC refund transactions. The new area of AFC customer inquiries, problems, refunds and complaints eventually resulted in a system-wide level of approximately 260 daily customer interactions. This converts to a daily "problem incident rate" of about 2.3 per 10,000 AFC transactions.

Additional revenue collection staff, AFC maintenance staff and customer service staff were required as a result of AFC. Nonetheless, the CTA was able to reduce their operating budget by approximately $11 million annually after implementing AFC. Specific details about how these savings were achieved were not provided but 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; and
- 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.

The AFC equipment reliability is highly dependent on usage and weather. Reliability is poorest in the summer due to high volumes of customer transactions and hot humid environmental conditions. Currently, the subway equipment is not achieving the specified 10,000 mean cycles between failures performance levels. Some components are starting to reach their life-expectancy of 3-years.

Planned System Enhancement

The CTA is currently negotiating with a financial institution to have CTA cards sold from standard bank ATMs.

AFC Advice from CTA

- Single-point-of-control project management was critical, and must be supported by a dedicated project team with extensive expertise. "You must be smarter than the manufacturers."
- 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.

Appendix C - Washington AFC System Overview

The following information on Washington Metropolitan Area Transit Authority's (WMATA) AFC program has been assembled from on-site interviews with WMATA staff, conducted in March 2000, and other standard reference material.

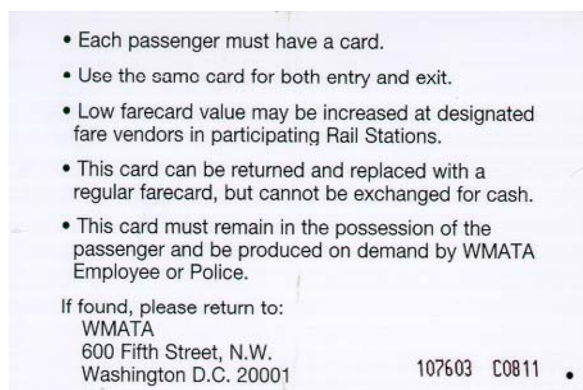
<u>Washington Metropolitan Area Transit Authority (WMATA) System Statistics</u>:
Annual ridership: 339.2 million (unlinked trips)
Daily weekday ridership: 1 million
Subway lines: 5
Subway stations: 78
Subway cars: 764 cars
Bus routes: 385
Buses: 1400
Revenue/cost ratio: 47%

WMATA has a complex fare system with peak and off-peak fares that are also priced according to the distance travelled. 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 fareboxes.

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 photo below).

front

back



WMATA Smart Card Turnstile Reader

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, 1999); and
- debit card purchases of fare media from vending machines in subway stations (November, 1999).

The main objectives of the new fare program were to:

- 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; and
- reduce the perceived cost of transit trips and encourage customers to take new/additional trips.

Smart card planning and implementation schedule:

- pilot test October 1998 to May 1999: 1,500 users – customers and employees, limited number of card readers at each station, and all parking lot exits. The pilot test was used to gauge customer acceptance and confidence in the technology, and to test the technical capability, fare structure integrity and record-keeping software.

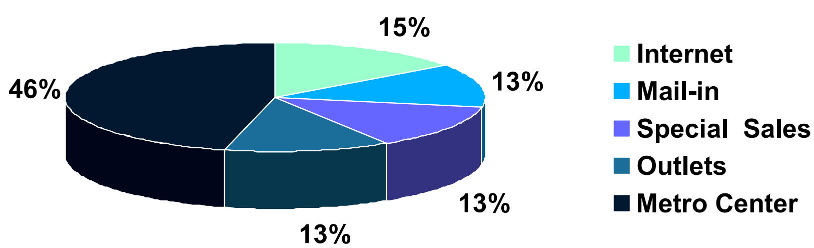
- Metrorail system wide in May, 1999: all turnstiles had been equipped with smart card readers by March 2000.
- prior to implementation, a customer information privacy policy was developed, and the selling price of the smart card was set at $5, even though actual production cost was $10 per card.

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

- equip 1400 buses with new registering fareboxes, 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 fareboxes. 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. As illustrated below, the majority of SmarTrip sales are made by face-to-face transactions with staff.

SmarTrip Smart Card Sales by Source



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 farecards. 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.

WMATA staff consider the new fare program a successful means of increasing ridership. Prior to the new fare program the annual rate of ridership increase was approximately 1.3% and 2.8% for rail and bus, respectively. Since the introduction of the SmarTrip 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 program and how much is due to economic and population growth. Although ridership increased, the simplified fare structure resulted in a $10M (US) loss of revenue.

Operating Impacts

WMATA increased their workforce for smart card administration, distribution and to staff the SmarTrip Card Helpline. Approximately 15 to 20 agents are required to package, distribute, answer questions, replace, update customer data base etc. Operating hours are weekdays 7am to 8pm. On weekends there is no staff coverage, but customers can leave messages via voicemail or e-mail. The helpline handles approximately 1300 calls per month, and the following table categorizes the types of calls taken:

Type of Customer Inquiry	Percent of Total Calls
Customer reporting damaged card, card stopped working, etc	30%
Customer lost or misplaced card, card reported stolen	26%
Information: inquiries about the status of Internet or e-mail smart card purchases	22%
Banking transaction difficulties: customer did not complete the transaction at a vending machine within the 45 seconds allotted	19%
Other: problems at turnstiles, vending machine, parking lot readers	3%
Total	100%

WMATA staff expressed concerns that the current back office system, which includes the smart card administration and distribution, is currently managing the maximum number of card holders. WMATA is investigating contracting out this function to a company which specializes in credit or bank card administration and distribution.

Card Reliability

Less than 1% of the cards purchased by WMATA have failed. The following table is a summary analysis of the failed SmarTrip cards

% of Failed SmarTrip Cards	**Problem:**	**Solution:**
66.5 %	Manufacturer faults: computer chip or electrical faults	Cards replaced under warranty, and manufacturer modified production process.
20.1%	Card damaged by customer or by postal service (e.g. antenna broken)	Increased customer education and sturdier packaging when cards are mailed to customer
13.3%	Card working when tested, but customer thought card had failed.	Increased customer education

WMATA staff indicated that the card replacement program was rather cumbersome. With $200 maximum value on the smart card, customers want immediate replacement, yet WMATA must ensure the appropriate financial controls are in place and verify the legitimacy of the refund.

Credit and Debit Card Transactions

There are currently 85,000 credit card and debit transactions per month, which represents $11.8 million in sales since April, 1999 and November, 1999 (5% of total rail passenger revenues). The ability to use credit and debit has also resulted in higher average sales, especially when loading SmarTrip transactions. Cash sales average approximately $4.40, while electronic sales average $17.10. In general customers have switched from purchasing one week's worth of transit trips with the paper magnetically-encoded fare card, to loading a full month's worth of transit trips on their smart card.

The debit card transactions are made mostly by pay-as-you-go customers, and as a substitute for cash. There is a high level of security, because each transaction requires customers to enter a PIN number, and this has resulted in very few or no chargebacks or disputes with financial institutions or customers. WMATA pays a flat fee of $0.18 to $0.20 for each debit transaction. Credit card transactions are less secure, because a stolen card, which hasn't be reported as stolen, can be used to purchase up to $200 in fare media, and VISA only reimburses a maximum of $50 for fraudulent purchases. In addition, WMATA pays 1.75% of the transaction value in commission to the credit card company.

WMATA Smart Card Vending Machine

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.

- Automate and streamline the labour intensive administration of the federally-subsidized tax-free transit benefit program, by having employers electronically interface with WMATA via the internet, and have the transit benefit (approximately $60 per month) loaded onto the customer's smart card at the vending machines located in the stations.

- Planned demonstration programs include
  - First Union/SmarTrip debit and transit card (1,000 participants)
  - Federal General Services Administration – employee identification card and transit card
  - Federal Transportation Adminstration's electronic payment system demonstration – single card for transit, tolls, parking and retail (14 private and public partners)

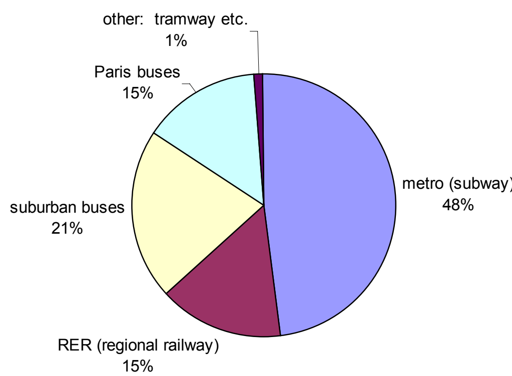
Appendix D - Paris AFC System Overview

The following information on Paris Metropolitan Transit Authority's (RATP) AFC program has been assembled from on-site interviews with RATP staff, conducted in February, 2000, and other standard reference material.

Paris Metropolitan Transit Authority (RATP) Statistics:
Annual ridership: 2.1 billion
Daily weekday ridership: 9 million
Subway lines: 14
Subway stations: 294
Bus routes: 60 routes within Paris, and 180 bus routes in the suburbs
Buses: 4,000
Employees: 40,000
Revenue/Cost ratio: 36%

RATP (Paris) Passenger Trips

2.2 billion trips annually / 9 million trips per day



Existing Magnetic AFC System

RATP has to replace its 1973 rail system fare collection equipment to address the following problems and issues:

- mediocre reliability of the old, low-coercivity magnetic stripe (approximately 7% of the monthly passes demagnetized every month);
- the limited memory capacity of the magnetic stripe restricted RATP's ability to make changes to their fare structure and pricing policies;
- insufficient system security (e.g. RATP estimated 0.7% of all passes were counterfeit),
- high cost of equipment maintenance (15% of capital investment per year); and
- fare evasion on the surface network ranges from an average of 15% to as much as 30% in some areas, because there is no systematic or mechanical pass validation (customers show or "flash their passes to the driver, who may or may not be paying attention).

Initially, RATP considered upgrading the magnetic system with a more advanced read/write magnetic technology. This would improve the reliability and memory of the magnetic ticket, thus enabling some evolution in fare structures, but it would not significantly reduce fare evasion in buses, or AFC maintenance costs and, hence, would cost more on a life-cycle basis. RATP also considered a contact smart card system, which has increased capacity memory, and enhanced security through the memory chip, making it virtually impossible to counterfeit.

However, it requires a transaction time of over 2 seconds, which is too slow for a transit environment.

The development of a contactless smart card, with high-speed transaction time (< 150 milliseconds) was deemed the best alternative to address these issues.

Development of a Contactless Smart Card

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; and
- 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.

RATP Smart Card and Turnstile Reader

Smart card reliability is ten times higher that RATP's current magnetic AFC system. The system is being designed to have an extremely high level of security between the pass and the reader, so that transactions need not be recorded individually. This concept of decentralized security is unlike most other transport or bank card transactions today, and leads to savings in terms of central data systems, and also guarantees personal freedom (ie. individual passenger trips made by card holders are not stored in the transit operators central computer. RATP believe their decentralized system will be able to easily manage 12 million daily passenger trips.

Initially customers will be able to reload their smart cards at RATP ticket booths, vending machines (which only accept debit or credit) or at bank machines (ATMs) (see photo below). Eventually other methods for recharging will include: the Internet, at public phones, and by independent sales agents.

Customer recharging RATP's smart card at a Bank ATM

Fare Inspectors on the surface network will have mobile smart card readers, which will allow them to check whether or not the proper fare was paid and, if not, to collect the appropriate fare evasion fines directly from the electronic purse portion of the smart card. If the card if found to be fraudulent it will be disabled.

AFC system data will ensure proper attribution of revenues between various transit operators, because service usage can be monitored by mode and by transit operator on a daily basis. Remote control of equipment will also allow downloading of fare tables and equipment diagnostics.

<u>Planning & Implementation</u>

The contactless smart card has been under development in Paris since 1991, and has been successfully demonstrated, and even implemented, both in France and elsewhere:

- Several large-scale demonstrations at the RATP have been undertaken since 1993 in order to validate the technical solutions. For example, 38,000 employees use a contactless smart card on the transit system, and for building access control, and tracking of variable work hours.
- Regional pilot projects, in 1997, involved 1,000 customers, 43 subway and commuter rail (RER) stations, and 2 bus lines, to test customer acceptance. Two additional demonstrations, one with the RATP, and the other with the SNCF, are currently underway to better understand how the AFC system will deal with customers not using pre-paid media.
- A transportation-related electronic purse is being tested by a total of 1,000 smart card users at local retailers in Noisy-le-Grand, to purchase stamps, pop or candy from vending machines, newspapers, or to use the public telephones.
- The European ICARE project, coordinated by the RATP, and involving the cities of Constance, Lisbon, Paris, and Venice, has allowed for the testing of a multi-modal contactless smart card. 46,000 users have conducted 20 Million transactions in 1996 and 1997 using this media.
- In 1999, the bus fleets in the city of Nice and Amiens were equipped with the RATP smart card system.

RATP Smart Card with Electronic Purse

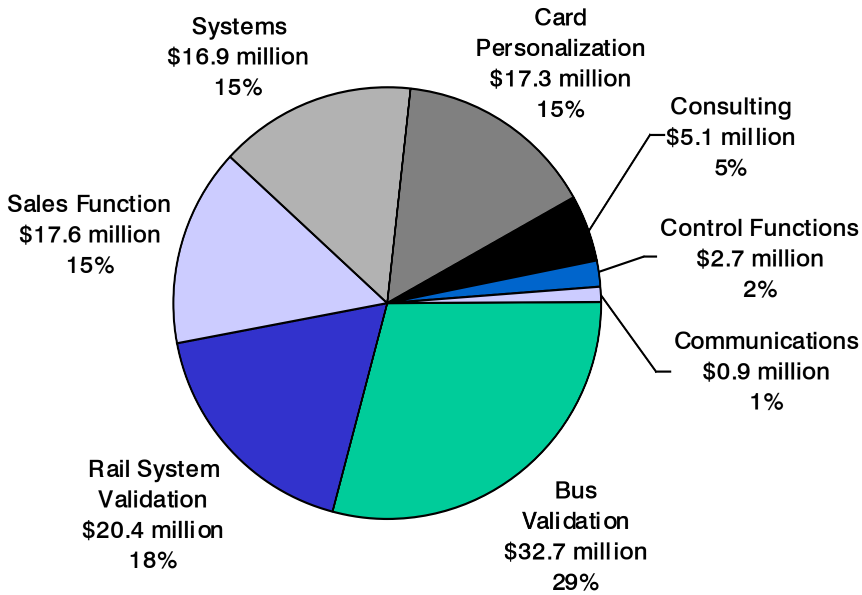
Paris will invest $114 million to phase-in the smart card system between 2000 and 2003.

- Phase 1 (2000-2001): 1 million annual pass holders will be issued smart cards. Every rail station with turnstiles will be equipped with two validators, as well as some bus lines. A "back office" personalization/distribution system will be developed as well as an initial Customer Service function.

- Phase 2 (2001-2002): 4 million monthly and weekly pass holders will be issued smart cards. All buses will be equipped. Each customer will be required to validate their smart card every time they board a bus or enter the rapid transit system. An approach to address ticket book users (magnetic tickets initially and ticket area on Personal pass if/when available) will also be determined.

- Phase 3 (2003 and beyond): Elimination of magnetic media for individual tickets will depend on the availability of a very inexpensive contactless card.

Paris Capital Investment: $114 million



Estimated Operating Impacts

Projected revenue increases:

- RATP assumes the introduction of a smart card system will result in a minimum 2% gain in passenger revenues (63M Fr annually).
- Making customers validate the smart card each time they use the transit system is expected to significantly reduce casual fare evasion. RATP reports that other cities, such as Marseille, Toulon, Orleans, and Toulouse, which have introduced this type of approach, have seen fare evasion rates drop between 3 and to 10 percentage points.
- Personalization of the smart card will eliminate fraudulent use of stolen or lost passes, and should increase revenues by 27M Fr per year.
- RATP currently loses approximately 39M Fr annually because of counterfeit magnetic tickets and passes. Once a smart card system is in place, they expect to regain this lost revenue.
- Once fully-implemented, the tele-loading of smart cards, via the Internet or phone system, should result in annual operating savings of 2M Fr.
- Fraudulent purchase of reduced fare (concession) passes will be virtually eliminated, and this is expected to result in an annual gain of 17M Fr.

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.

Estimated cost of implementing smart cards:

- When fully implemented, 3.5 million smart cards will be acquired every year for replacement purposes, assuming a useful life of four years per card. Two thirds of the cards will be for RATP users, at a cost to the RATP of 7M Fr per year.
- The initial cost per smart card will be 30 Fr, evolving to a target cost of 10 Fr. Contactless tickets are anticipated to be available as of 2003, at an initial cost of 0.30 Fr per ticket.
- It is estimated that 1 million personalized smart cards can be sold each year (200,000 cards per year at the central RATP office, and 800,000 at 100 off-site local distribution points).
- Sub-contracting of smart card personalization and distribution will be required for the first four years of implementation, at a cost of 5M Fr per year in 1999 and 2000. All renewals and new customers will be handled internally as of 2003.
- Smart card system security, to prevent counterfeiting and system inviolability, is expected to cost of 2M Fr per year, increasing in cost towards the end of the system's life.
- Three or four major promotion campaigns are contemplated at a cost of 20M Fr.
- The new system will require a special effort to assist customers during the transition period. This is estimated at a cost of 140 M Fr during the transition, with a maximum of 60M Fr in 2001. This has been taken into consideration in the financial analysis.

<u>Technological and Commercial Partnerships</u>

From the outset of the contactless smart card project, RATP identified two critical elements that were needed to ensure the success of the project:

- interoperability at the widest possible level; and
- development of a business model that would avoid sole proprietary manufacturing and instead allow tendering under more financially acceptable conditions.

As a result, the project was developed with a constant effort to build a federation of partners on the technological, commercial and institutional levels, not only in the Ile-de-France region, but also nationally and internationally. A licensing system was also put in place, so that there would be no industrial monopoly and so that development costs could be shared.

- The RATP has been working closely with the national rail system (SNFC) to develop an integrated solution, that can be used not only in Ile-de-France, but that could be proposed by the SNCF elsewhere in France.
- The European ICARE project, coordinated by the RATP, and involving the cities of Constanz, Lisbon, Paris, and Venice, has allowed for the testing of a multi-modal contactless smart card. 46,000 Europeans have conducted 20 Million transactions in 1996 and 1997 using this media.

- The European CALYPSO project, involving banks in the four ICARE project sites, to expand the project to an electronic purse. The ambition is to be the basis for an international standard for management of payment, fare collection, and other services.
- The CLUB (Contact Less Users Board) is a world-wide network of potential organizational users, initiated by the RATP and its European partners. It includes 28 transit operator associations, representing 160 transit systems and service providers.
- The MODEUS enterprise has been created to expand the development of the electronic payment concept. It brings together financial institutions (La Caisse d'Epargne, La Poste, la Societe Generale), and the RATP and SNCF, to share their experience and combine their commercial strength in order to create a transportation-related electronic purse.

The situation is becoming one of mature technology and with diversified suppliers that would permit tendering under satisfactory conditions. This has been further enhanced through the development of international standards (ISO 14443 for contactless data transmission, and CEN 1545 for transportation-related data definitions).

At this point in time, it is not feasible to estimate the economic benefit of the electronic purse, but its implementation will likely further improve the economic benefits, by further spreading the expenses of card distribution, and by encouraging ridership by infrequent users.

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 0.3 Fr, and decreasing to a unit cost of 0.15 Fr. 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.

Appendix E - Berlin AFC System Overview

The following information on Berliner Verkehrsbetriebe's (BVG) AFC program has been assembled from on-site interviews with BVG staff, conducted in February, 2000, and other standard reference material.

Berliner Verkehrsbetriebe (BVG) Statistics:
Annual ridership: 1.0 billion (unlinked trips)
Subway stations: 169
Subway cars: 1,383
Tram cars: 558
Buses: 1,420
BVG employees: 15,000
Revenue/cost ratio: 40%

Fare System

On surface vehicles customers pay upon entry and can purchase tickets from the driver. BVG would like to change this system to increase financial control and reduce fare collection costs. There are no barriers or turnstiles within the metro or subway system. Customers must show proof-of-payment, upon request of a fare inspector, with paper tickets or passes that are purchased from vending machines or sales booths within the stations. BVG is considering the installation of turnstile barriers to reduce fare evasion within the subway system. They also anticipate that by 2008 they will receive no operating subsidy. Therefore, any AFC investment must guarantee a net operating gain through increased revenues and/or reduced operating costs. However, the operating costs savings need not cover the initial capital investment of the AFC system.

Test of Electronic Ticketing

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:

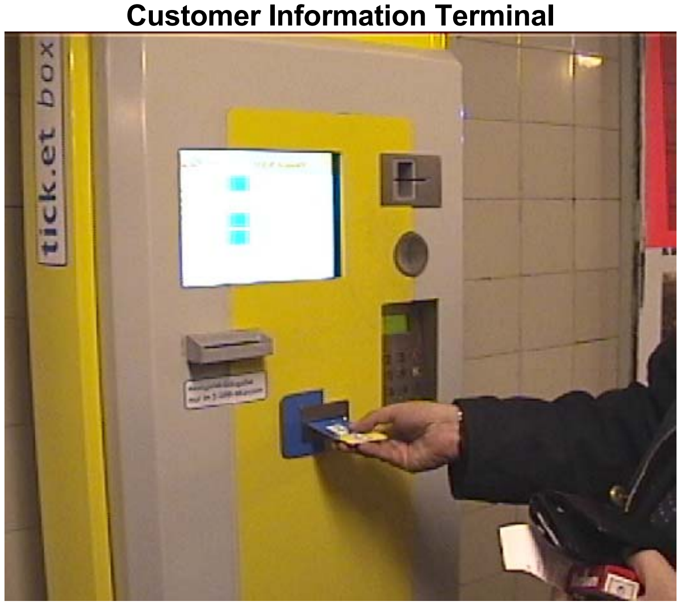
- 2 metro or subway lines (30 stations);
- 2 bus lines (32 vehicles);
- 1 tram line (14 trams, 28 coaches); and
- 1 section of the S-Bahn Berlin suburban railway line (7 stations).

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 check-out 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 (see photo below).

Subway Smart Card Check-In Terminal

Information terminals, within the stations, allowed test users to check their card data, and also provided customer service information such as travel, routing, timetable/schedule and fare information to the general public.

Customer Information Terminal



The objectives of the AFC system are to:

- reduce operating costs related to:
  - paper ticket vending machines; and
  - passenger traffic count 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%. It was noted by BVG that reducing ticket-less travel may not necessarily increase revenues, because the trip may not be made if it's no longer free; and
- provide a new income base from non-fare revenues:
  - other businesses paying to have access/use of transit smart card

The purpose of the in-service test was to assess:

- public acceptance of the smart card and the check-in/check-out procedure. Currently more than 160,000 season ticket holders buy once per year, and they are inspected no more than 5 times per year, on a random basis. With the new AFC system they must present their ticket, at least twice per day, when travelling, or more than 700 times per year including the reloading process;
- technical infrastructure and system reliability;
- general system requirements: back office requirements, card administration/distribution, hot-listing cards, system security, system maintenance, high level of equipment quality control (maximum 2 hour maintenance turn-around); and
- AFC operating costs for: maintenance of equipment, terminals, cards and communication lines, distribution of cards and card management, customer claims and reimbursements, and call centre needs.

The test cost $38 million (50M DM). The following summarizes the pilot-test system requirements:

- 460 check-in and check-out terminals (130 fixed, 330 mobile);
- 45 information terminals, which allowed test users to see, and print out, all transactions stored on the card;
- 40 ticket vending machines or reloading machines (25 fixed, 14 mobile);
- 20 vending machines for BVG staff;
- 33,000 smart cards;
- 30 portable card control units (for proof-of-payment inspection);
- 5,000 customer wallets, which would allow customer to see the remaining balance on their card; and
- Back office infrastructure for statistical data collection: station computers, communications lines, fare calculation and reconciliation software.

<u>Preliminary findings</u>

Customer reaction:
There was a learning curve for customers to know where to place the card on the target. Some people would put the card on the information screen, rather than the target. The card must be presented within 10 cm of the target.

Reliability:
Although, customers were supposed to be leave the card in a wallet, observations by TTC staff using the "tick.et" smart card, was that it took several attempts to check-in or out even when the card was placed directly on the target. Many of the check-in/check-out terminals on the surface vehicles did not work.

Bus Smart Card Reader

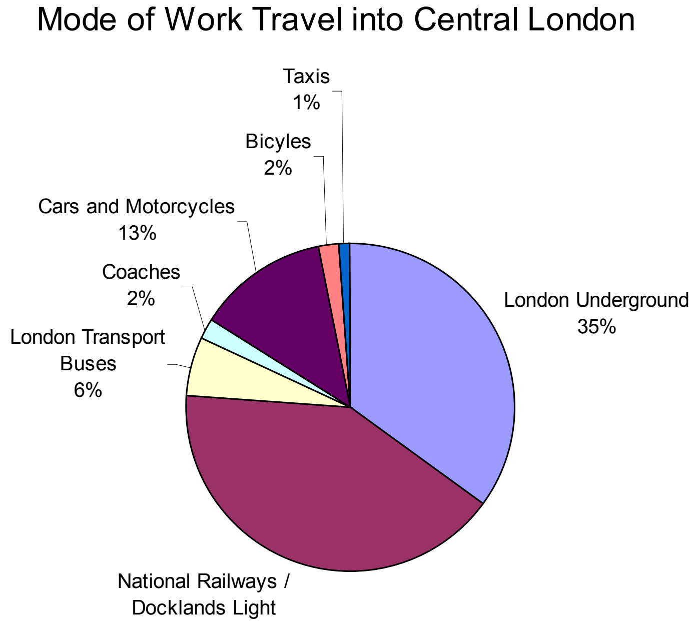
Privacy of Passenger Travel Data:
Privacy was a very important issue. Customers dislike state institutions having access to personal travel profiles. Therefore encryption and very secure measures had to be taken, even during the pilot test, to ensure and demonstrate European Community data protection laws were adhered to.

Back Office is the "Boss":
The software, data base and communication infrastructure define the entire system. Smart cards and reader terminals can be exchanged or replace, but not the back office. The back office requirements define the security architecture and the maintenance support system for all AFC system components.

Appendix F - London AF C System Overview

The following information on London Transport's (LT) AFC program has been assembled from on-site interviews with LT staff, conducted in February, 2000, and other standard reference material.

<u>London Transport (LT) Statistics:</u>
Daily weekday ridership: 6.5 million passengers
Subway (underground) stations: 271
Subway network: 392 km (244 miles)
Buses: 6,000 (both private and publicly-owned)
Bus routes: 700



London Transport (LT) has had a system-wide bus and Underground ticketing system since the magnetically encoded Travelcard 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.

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 ticketless travel is estimated to cost $100 M (£43 million) per year, and represents 3.47% of passenger revenues;
- reduce line-ups at ticket offices;
- Iiprove 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; and
- Iiprove 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 ticketless 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 (see photos below);
- 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 3rd 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.

Private Finance Initiative

The LT Prestige project is taking place under the British government's Private Finance Initiative. This requires that a suitable amount of risk be transferred to the private sector, that competition is sought, and that value for money is achieved. The initiative is intended to attract private sector investment to public sector projects, creating partnerships between them, and allowing early implementation of projects traditionally pursued under capital expenditure but which are delayed due to a lack of funds.

In August, 1998 LT Prestige awarded a 17 year contract to TranSys, a private sector consortium, with four principal shareholders: Electronic Data Systems Ltd, Cubic Corporation, International Computers Ltd and WS Atkins. The new services and equipment are being implemented over four years, requiring a capital investment of approximately $600 million (£250M). The following figure summarizes the scope of the Prestige project.

ASSETS

- Gates
- Ticket Machines
- Smart Card Reading Devices
- Computer Systems
- Communications Network
- Back Office Systems

NETWORK

- 6,000 buses
- 273 stations
- 2,300 retail outlets (PASS)
- 16,000 Smartcard Devices

CUSTOMER BASE

- 866 million tube journeys per annum
- 1,267 million bus journeys per annum
- 6.6m journeys a day

SERVICES

- Fares Revenue & Collection
- Smartcard - 8 Million
- Maintenance & Asset
- Call Centres
- Retail Network management

In LT Prestige, London Transport's role has been to set output-based service requirements, but not to specify technical applications. The choice of the most appropriate solution is the responsibility of TranSys, the LT Prestige contractor. The contractor is also responsible for:

- design, build, implementation, maintenance and service provision;
- providing the necessary financing arrangements to support the LT Prestige project; and
- risk of whether the chosen ticket medium will achieve the required performance standards.

Contractual payments made monthly, and increase based on:

- implementation, delivery and service performance; and
- smart card usage and availability.

Performance below a threshold level leads to payment abatements and the contract can be terminated at any time with two years notice.

Smart cards will be phased in beginning in August, 2002, 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.

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; and
- will fare incentives be required for customers to switch to the proposed stored value ticket?

New LT Turnstiles

LT Bus Ticket Issuing Machine

Appendix G - Hong Kong , Singapore And Kuala Lumpur AFC System Overview

Hong Kong System Overview
Source: May 1999, UITP presentation by Brian Chambers (General Manager, Creative Star Ltd., Hong Kong)

On the 1st of September 1997, following 3 years of development and testing, one of the world's largest contactless smartcard projects, the "Octopus" system, began full public operation. The system has been implemented and is operated by the Creative Star consortium. In less than 18 months of service over 5 million cards have been sold, over 1.2 billion transactions taken place and over $2.25 billion ($8 billion HK) of electronic cash used in the process.

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 (Hongkong 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 operator's 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 centralised 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 smartcard 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.

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.

- - - - - - -

As part of the evaluation and development process for the introduction of London Transport's Smartcard, representatives from London Transport, LT Prestige and the TranSys consortium carried out a benchmarking visit to Hong Kong, Singapore and Kuala Lumpur. The following is a summary of their findings.

LT Prestige Summary

Hong Kong, Singapore and Kuala Lumpur are three very different systems, although they share a number of similarities. All have migrated from existing magnetic strip Stored Value systems, and are progressing or have progressed from magnetic ticketing towards contactless smartcards.

- *Hong Kong introduced smartcards in September 1997 and has achieved 85-90% market penetration on its Mass Transit Rail (MTR) service and 70% on buses.*

- *Singapore are implementing smartcards for system-wide implementation by 2002, shortly before London.*

- *Kuala Lumpur has introduced smartcards to co-exist with magnetics, although the strategies for roll-out are unclear and confusing.*

In all three cases, there is extensive inter-modal travel and fares are cheap, with political influence regulating the interoperability between service providers. There is little period travel of the type which dominates London, and travel agreements ensure that there are no major barriers to the further developments taking place.

Where smartcards are in use, there are currently magnetic products in existence and, the technology works well and is seen to aid ease of passenger travel. In Hong Kong, there is clear preference for smartcards and all magnetic SVT tickets have been phased out – with only single tickets remaining (at a price premium). Singapore plans to do likewise within six months of their smartcard launch. The message and advice offered by both Hong Kong (Creative Star) and Singapore (LTA) was "keep it simple". In Kuala Lumpur we could not detect a clear strategy, and as customers, we found the choices very confusing. This is an important message for London – there should be no conflicting or competing products – only complementary.

Means of buying cards and tickets vary between automatic selling and at ticket offices. Adding value to cards and tickets also varies, and the range of machines to support the ticket infrastructure is quite mixed. The impact on single ticket machines where Stored Value

Ticketing (SVT) is in place is marked, and queues at ticket offices were only seen where there was a clear absence of machines to provide the same service.

In all cases, deposits (for the cards) were applied – to customer displeasure. The proportion of deposit to initial outlay varied. Fares are cheap by comparison with London, so the effect of the deposit to cover the card production and issue costs is significant. In London there would be a lower proportion – a basic deposit might be the equivalent of say three or four journeys only, compared with the Hong Kong average of 10 journeys. It is also clear that a deposit is necessary to deter card "mis-use". Political concern exists in all three countries over the status of the deposit – safeguards are necessary to support instant returns.

Whilst initial customer concerns over the deposit seemed to indicate that smartcards might be unpopular, actual take-up demonstrates the fact that people recognise the benefits. However it is necessary to recognise that there is a cultural difference between the UK and these countries that influences this area in that (We are advised) the societies of far eastern states tend to accept the imposition of changes without question far more than in the UK.

Personalisation and registration is treated warily. People wish to protect their anonymity. The issue of personalised cards can become a tiresome business if the process is drawn out and time consuming, as was witnessed in one site.

The ticket product mix was straightforward. There are few period schemes, and only in Singapore is there a Carnet type product (daypass) – for tourists. The view amongst operators leans clearly towards SVT only.

System failures are few and far between – the smartcard technology was seen to work well – however some misunderstanding by a few passengers was observed – good assistance will be a key factor, especially around launch, and for a good time after that.

In Hong Kong, the system uses Sony manufactured smartcards. Early problems were noted with supply, and costs per card are approximately £1 higher than is expected for London. Both these points may point to the fact that HK smartcards are single sourced. Competition through multiple sourcing should reduce costs and guarantee supply.

<u>Key Lessons</u>

1. *There is assurance that contactless smartcard technology is operationally robust enough to deliver the business aims and requirements of London Transport and its key stakeholders.*

2. *Deposits may be unpopular, however they do deter cardholders from destroying expensive cards. The setting 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.*

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

4. *Registration, personalisation and issuing of cards must be a simple and quick process.*

5. *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.*

6. *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.*

Appendix H - Ajax/Burlin gton AFC System Overview

The following information on Burlington's AFC program has been assembled from on-site interviews with Burlington staff, conducted in April, 2000, and the Ontario Ministry of Transportation's *Ontario Universal Transportation Smart Card – Final Report*, *November 1999* and 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 ComboCard program (the name given to their smart card programs) is realised 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. 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 Mifare ™ 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 ComboCard 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 ComboCard 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 ComboCard 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 reloadable.

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 ComboCard.

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. Data from a bus is downloaded by maintenance personnel 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 ComboCard 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 analyse trips taken by specific customer groups.

Appendix I - TTC Fare Related Sales And Costs

FARE RELATED SALES & COSTS - 1999 ACTUALS
($000'S)

FARE MEDIA SALES/CASH BY ($000'S):	Total	NOTES
Station Collectors	$ 291,139.5	
Ticket Agents Paid Commission	120,649.2	
Ticket Agents Not Paid Commission	9,102.8	
Token Vending Machine	23,874.0	
MDP Program	27,026.2	
Coins Counted by Cashiers	127,650.3	
Bills Counted by Cashiers	683.1	
TOTAL SALES/CASH	**$ 600,125.1**	2

FARE COLLECTION RELATED COSTS ($000'S):	Labour	Fringes	Non-Labour	Total	NOTES
REVENUE OPERATIONS					
Ticket Agents	$ 501.4	$ 100.3	$ 12.5	$ 614.2	2, 4a
General Administration	356.2	71.2	4.6	432.0	2, 4a
Token Vending Machine	166.3	33.3	3.6	203.2	2, 4a
Revenue Collectors	1,167.1	233.4	8.5	1,409.0	2, 4a
Revenue Processing	549.7	109.9	91.2	750.8	2, 4a
Vehicle Servicing Costs	42.1	17.7	61.3	121.1	3, 4c
Patten Building Costs (Maintenance Only)	118.8	49.9	32.5	201.2	3, 4c
Sub-Total	$ 2,901.6	$ 615.7	$ 214.2	$ 3,731.5	
TREASURY SERVICES:	$ 370.0	$ 74.0	$ 240.0	$ 684.0	2, 4a
STATION COLLECTORS					
Shortage Allowance	$ -	$ -	$ 90.9	$ 90.9	3
Uniforms	-	-	88.0	88.0	3
Stationery	-	-	68.9	68.9	3
Cleaning of Uniforms	-	-	44.2	44.2	3
Other Non-Labour	-	-	38.5	38.5	3
Collectors/Suppliers	18,937.5	4,734.4	-	23,671.9	3, 4b
Route Supervisors	780.4	156.1	-	936.5	3, 4a
Divisional Clerks	815.5	203.9	-	1,019.4	3, 4b
Administration	225.1	45.0	-	270.1	3, 4a
Sub-Total	$ 20,758.5	$ 5,139.4	$ 330.5	$ 26,228.4	
REVENUE/SECURITY EQUIPMENT MAINTENANCE					
Staff Supervision & Stationery	$ 392.7	$ 78.5	$ 3.9	$ 475.1	3, 4a
Fareboxes & Transfer Cutters	249.8	104.9	246.0	600.7	3, 4c
Subway Turnstiles & Station Equipment	834.3	350.4	326.9	1,511.6	3, 4c
SRT Turnstiles	21.6	9.1	8.7	39.4	3, 4c
Sub-Total	$ 1,498.4	$ 542.9	$ 585.5	$ 2,626.8	
CONTRACTED SERVICES					
Protected Delivery Service	$ -	$ -	$ 430.2	$ 430.2	2
FARE MEDIA EXPENSES					
Ticket, Tokens & Metro Passes	$ -	$ -	$ 1,575.7	$ 1,575.7	2
Transfers	-	-	1,072.7	1,072.7	3
Metro Pass Photo ID Cards	-	-	172.8	172.8	2
Student Photo ID Cards	-	-	507.7	507.7	2
Commissions Paid to Agents	-	-	1,238.5	1,238.5	2
Sub-Total	$ -	$ -	$ 4,567.4	$ 4,567.4	
TOTAL COSTS	**$ 25,528.5**	**$ 6,372.0**	**$ 6,367.8**	**$ 38,268.3**	

Notes:
1 - CAUTION SHOULD BE EXERCISED WHEN USING THE ABOVE NUMBERS FOR DECISION MAKING PURPOSES.
2 - Data provided by Revenue Operations - Finance Department
3 - Data provided by Budgets - Support Services Department
4 - Fringe Rates:
a - 20 % Non-Union
b - 25 % Union (if Vacation/Stat. Holiday/Floater costs are already included)
c - 42 % Union (if Vacation/Stat. Holiday/Floater costs are not included)
5 - Vehicle Servicing Costs are no longer collected by vehicle, therefore, the 1992 costs have been used

Appendix J - TTC AFC Capital Cost Estimate

	Appendix J - TTC AFC Capital Cost Estimate					
	Order-of-Magnitude Cost Estimate in Canadian $					
	Item Description	**Quantity**	**Unit**	**Unit Price**	**Total 2000$**	**Remarks**
1	***EQUIPMENT SUPPLY***					
1.1	**Subway System:**					
1.11	Ticket Vending Machines (TVM's)	131	ea	$120,000	$15,720,000	At high volume stations, computer based c/w touch panel/display screen, capable of accepting coins, & no giving change & issuing various types of tickets upon selection. Assumes cash, credit card & debit card acceptance.
1.12	Collector TVM's	131	ea	$50,000	$6,550,000	Collector operated TVM's analyses, upgrades & issues tickets; adding value to stored value tickets, refunding tickets, controls easier access gate turnstile.
1.13	Smart Card Readers to Existing Easier Access F/G & Mosler T/S	27	ea	$15,000	$405,000	Retrofit existing turnstiles with readers
1.14	Smart Card Readers to Existing Met-Pass Turnstiles	116	ea	$10,000	$1,160,000	Met-Pass t/s have some electronics & power feed, assumes less retrofitting required.
1.16	Smart Card Readers to Existing TOMSED Turnstiles	115	ea	$10,000	$1,150,000	Retrofit assumes some electronics & power feed, therefore less retrofitting required.
1.17	Smart Card Readers to Existing Passimeters	131	ea	$10,000	$1,310,000	Retrofit assumes some electronics & power feed, therefore less retrofitting required.
1.18	Smart Card Readers to Existing High Gate Turnstiles	72	ea	$16,000	$1,152,000	Retrofit existing turnstiles with readers
1.19	Subway Station Computer System & End Cabinets	66	Loc	$40,000	$2,640,000	Audits, monitors, controls, data transfer functions for al AFC equipment at each station; display monitor & warr system for intrusion, cash vault full, ticket stock low or empty; interface to Central Computer Facility. Cost as ITS, includes taxes,
1.20	Automatic Registering Fare Box c/w Card Reader & Transfer Dispenser for Collector's Booths & Crash Gates	161	ea	$19,000	$3,059,000	New. Accepts coins & bills based on recognition or electronic parameters, assumes change card feature wherein passenger can overpay & the change is return in the form of a stored value for transit use only.
	Subtotal Subway System Equipment				**$33,146,000**	
1.2	**Commuter Parking Lots & Surface Vehicle Fleet Fareboxes: (Bus, Streetcar & Wheeltrans)**					
1.21	Automatic Registering Fare Box c/w Card Reader & Transfer Dispenser - Buses & Streetcars	1751	ea	$21,000	$36,771,000	New. Includes RF data link. Also see notes 1.20. May have some difficulty with space requirements/installatio Customization of lower half of farebox may be necessa
1.22	Automatic Registering Fare Box c/w Card Reader & Transfer Dispenser - Wheel Trans Buses	220	ea	$21,000	$4,620,000	New. Also see notes 1.21
1.23	Smart Card Readers to Existing Met-Pass Readers at Commuter Parking Lots	29	ea	$10,000	$290,000	Retrofit existing with readers
1.24	Garage/Carhouse Area Computer System	9	Loc	$40,000	$360,000	Excludes Lansdowne, Davenport, Eglinton. Includes Comstock & Lakeshore. Cost as per ITS, includes taxe duties, supplier mark-ups.
1.25	Commuter Parking Lot Computer System	17	Loc	$40,000	$680,000	Qty based on 15 parking lots, 1 for RSEM & 1 for OTC Audits, monitors, controls, data transfer functions for A equipment at each parking lot & interface to Central Computer Facility. Cost as per ITS, includes taxes, dut supplier mark-ups.
	Subtotal Surface Equipment				**$42,721,000**	

	Appendix J - TTC AFC Capital Cost Estimate					
	Order-of-Magnitude Cost Estimate in Canadian $					
	Item Description	**Quantity**	**Unit**	**Unit Price**	**Total 2000$**	**Remarks**
1.3	**Central Computer Facility:**					
1.31	Central Computer Facility Equipment - Hardware	2	ea	$770,000	$1,540,000	Located in existing TTC facility. Cost as per ITS, includes taxes, duties, supplier mark-ups
1.32	Central Computer, Station & Depot Software (Proprietary) c/w Design & Development	1	LS	$1,900,000	$1,900,000	Cost as per ITS, includes taxes, duties, supplier mark-ups. Based on 2 Central computers, 66 stations, 9 garages, 15 parking lots, 1 RSEM & 1 OTC.
1.33	System Integration, Communications Equipment & Data Lines Network	1	LS	$930,000	$930,000	Allowance for upgrades to data processors, telephone lines, modems, fibre optic interfaces, etc. Cost as per ITS, including taxes, duties, supplier mark-ups and allowance made for system integration.
	Subtotal CCF				**$4,370,000**	
1	**TOTAL EQUIPMENT SUPPLY**				**$80,237,000**	
2	***FACILITY MODIFICATIONS & INSTALLATION***					
2.1	Install/Test Subway Equipment	1	LS	$5,000,000	$5,000,000	
2.2	Install/Test Surface Equipment	1	LS	$4,300,000	$4,300,000	
2.3	Subway Facility Electrical Modifications	66	Loc	$195,000	$12,870,000	Allowance for power, communications cabling, equipment, underfloor ducting, construction staging, removals & restorations, work during non-revenue hours, etc. (As per RTEP 1994 report).
2.4	Commuter Parking Lots Facility Electrical Modifications	17	Loc	$50,000	$850,000	Allowance for power, communications cabling, equipment, in underground ductbanks, construction staging, removals & restorations, etc..
2	**TOTAL FACILITY MODIFICATIONS & INSTALLATION**				**$23,020,000**	
3	***OTHER***					
3.1	Equipment Spares	1	LS	$7,600,000	$7,600,000	Allow 10% of equipment cost
3.2	Warranty/Maintenance	1	LS	$4,300,000	$4,300,000	Allowance for 1 year
3.3	Bonds, Insurance, Manuals & Documentation, Record Dwgs, Supervision, Technical Support, Travel & Accommodation, Temporary Facilities	1	LS	$2,300,000	$2,300,000	Allowance
3	**TOTAL OTHER**				**$14,200,000**	

Appendix J - TTC AFC Capital Cost Estimate

Order-of-Magnitude Cost Estimate in Canadian $

	Item Description	Quantity	Unit	Unit Price	Total 2000$	Remarks
	Total Cost for Above Items				**$117,457,000**	
4	***ADD-ONS***					
4.1	Design, Management, Public Awareness, Marketing, Staff Training				$11,500,000	Allowance for Unforeseens. 5% on equipment, 20% on balance.
	Subtotal				**$128,957,000**	
4.2	Project Contingency				$16,200,000	Allowance for Unforeseens. 5% on equipment, 25% on balance.
	Total Estimated Cost (Before GST Rebate)				**$145,157,000**	
4.3	GST Rebate @ 4/7 of total/1.07x.07 = .037383	-0.037383			($5,400,000)	
	Total Estimated Cost in Year 2000 $				**$139,757,000**	
				Say $M	**$140**	

Qualifications:

Figures represent order-of-magnitude construction costs including applicable taxes & contractor indirect costs.
Cost escalation to planned implementation period is not included.
1999 TTC Operating Statistics used as reference.
Smart Cards purchases are not included.
Sheppard Subway is excluded.
Existing low exit turnstiles remain with no AFC components.
Estimates are based on entry control(free exit) system, typical for flat fare.
Excludes garage/carhouse facility modifications for revenue vault islands.
Estimate assumes existing turnstiles can be retrofitted with smart card readers.
Refer to Remarks column for specific information items included.
Estimates are for discussion purposes only and are subject to change.