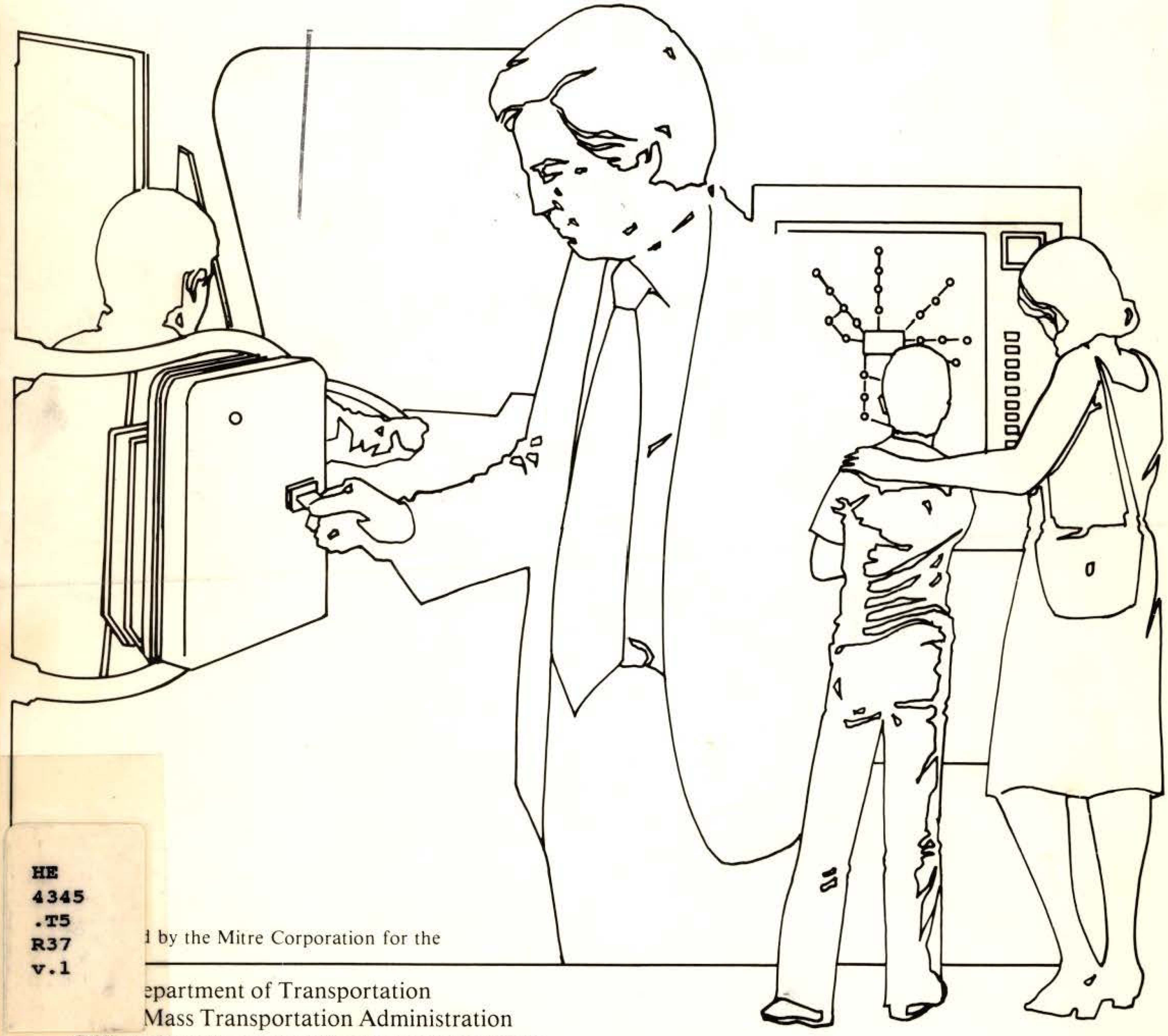
Self-Service Fare Collection

Volume I: Review and Summary



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16. Abstract

European transit properties have widely adopted a method of fare collection known as self-service. Instead of being monitored and controlled by vehicle drivers and station attendants, passengers are allowed virtually unrestricted access to transit service and are responsible for determining and paying the fare themselves; special inspectors are used to check compliance and to penalize passengers who have not paid the correct fare.

This report describes the European approach to and rationale for self-service fare collection; documents the experience European transit systems have had with using and enforcing these procedures; and discusses the relative merits of the alternative approaches to self-service with respect to their application in the U.S.

Volume II summarizes the information obtained from a survey of European properties. Volume III describes the hardware required to support self-service fare collection and discusses the trade-offs associated with the various options for its deployment and with the numerous features available through the hardware. Volume IV discusses the legal and labor issues associated with the implementation of SSFC in the United States.

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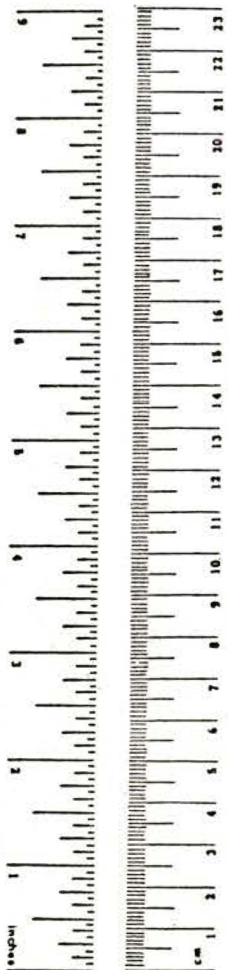
METRIC CONVERSION FACTORS

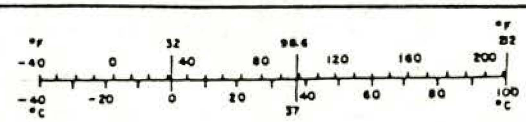
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1.0 INTRODUCTION

The Urban Mass Transportation Administration, U.S. Department of Transportation, in its efforts to raise transit system productivity, has investigated various improvements to transit fare systems. Numerous studies, design and development efforts, and demonstration projects have been undertaken to test such promising strategies as incentive, disincentive, and differential pricing; free fares, and pre-paid fares; and to evaluate such innovative collection techniques as automatic fare collection and credit card fare payment systems. As part of this effort, the Office of Service and Methods Demonstrations is currently sponsoring a program to demonstrate in the United States, a fare collection procedure widely used in Europe, generally known as self-service fare collection.

The European "self-service" form of fare collection, like many other self-serve operations such as gas stations, department stores, and unmanned toll booths, allows the customer relatively unrestricted access to the product or service. Direct monitoring of the patron's activity is reduced significantly but not to the point that the system becomes an "honor" system. In self-service transit operations the passenger becomes responsible for determining and paying the proper fare prior to making the trip. Complete monitoring or control of the payment of the proper fare is not performed by vehicle drivers, station attendants, or automatic equipment, instead all or nearly all responsibility for fare enforcement falls to special personnel who randomly check compliance.

This report provides an overview of the European approach to and rationale for self-service fare collection; documents the experience European transit systems have and with using and enforcing these procedures; and discusses the relative merits of alternative approaches to self-service with respect to their application in the U.S. Appendix A contains an annotated bibliography of recent literature relevant to self-service practices. Volume II summarizes the information obtained from a survey of European properties. Volume III describes the hardware required to support self-service fare collection and discusses the trade-offs associated with the various options for its deployment and with the numerous features available through the hardware. Volume IV discusses the legal and labor issues associated with the implementation of SSFC in the United States.

2.0 OVERVIEW OF SELF-SERVICE

During the past two decades, European transit operations have changed dramatically. As late as the early sixties, many European transit systems were highly fragmented collections of private operators using a variety of competing and complex fare structures and relying almost exclusively on conductors for fare collection. Then, facing rising labor costs and manpower shortages, many converted from crew operation to one-man operation. With the conductor no longer available to handle fares, the new one-man operations adopted different fare collection procedures. Some have transferred the responsibility for collecting and monitoring fares to the driver--an action which results in decreased service productivity, increased demands for higher driver wages, and increased reliance on simplified fare structures. The majority, however, have turned to a self-service form of fare collection in which the large conductor force has been replaced by a much smaller group of inspectors which check only a small percentage of passengers. The passenger must determine and pay the proper fare and is subject to a fine or some other sanction if proof of this payment cannot be produced for the inspector.

2.1 Characteristics of Self-Service

The intentional use of an enforcement procedure which checks substantially less than all system riders is the key element in self-service fare collection. A direct result of adopting this type of enforcement strategy is that passengers can determine and pay their fares without being monitored or controlled by drivers, station attendants, or access control devices such as turnstiles, and that each passenger must be provided with a receipt which is sufficient proof of payment and which is readily inspectable.

2.1.1 Self-Service Automation

Many European systems have evolved over the years into highly automated approaches incorporating a wide range of "self-serve" features. Nearly all have adopted a barrier-free system access philosophy. Since all fare enforcement is performed after the passenger has entered and begun using the system, entry control has been largely eliminated. Consequently, passengers are frequently allowed station access with little more control than the posting of signs cautioning users that entry requires the payment of fare. Although some European systems continue to use turnstiles and other access control devices, very often the gates serve only a counting function and afford little protection from unpaid entry except to the extent that they more clearly define the boundary of the "paid area". The same barrier-free concepts are also common on surface modes such as bus and light rail. Passengers are allowed "all-doors" access and egress through the use of passenger-actuated push buttons mounted in the interior and on the exterior of the vehicle.

Self-service automats or ticket vending machines are also a common characteristic of present European fare collection. Some systems such as those in Switzerland and parts of Germany rely extensively on such vending machines for the majority of their sales of single and multi-trip tickets with some having such complete coverage that on-board sales of tickets have been eliminated entirely. Other European properties use only limited numbers of self-serve vendors and prefer to rely on ticket agents, concessionaires, etc. for the majority of their ticket sales. This is due largely to their concern for the high capital costs of these machines compared to their potential utilization; a concern for revenue security, or, in some cases, because current coinage denominations within the country make the use of vending machines impractical.

In several instances, those European properties which have opted for only limited use of passenger-actuated vending have implemented a highly automated system to support their ticket/pass distribution network. Ticket agents and major outlets are often provided with relatively sophisticated hardware to issue tickets and maintain revenue/ticket counts. In some cases, the properties are considering expanding such automation to even the smaller outlets to reduce the administrative burden and to increase the number of ticket and pass types which these outlets are willing to dispense. A few properties are considering the use of "self-serve" automats which accept credit cards for the purchase of multi-trip tickets and passes.

2.1.2 Essential Hardware

Although the types of automation described above are common throughout Europe, such extensive automation is the result of incremental improvements and refinements. The primary feature of self-service is that each passenger must have a receipt which can be used as proof of payment during an inspection. Depending on the particular fare policies of the transit property, this receipt has to show sufficient information to prevent its reuse or its use for a purpose beyond that for which it was issued. As a minimum, the receipt has to contain time and date of issue; it may include line number, zone, and/or other information.

For most European properties, this receipt was not a problem since previously a receipt with similar data had been provided by a conductor. Many European properties, in fact, adapted the device (usually a hand-punch) used by conductors to allow passengers to provide their own receipts.

A device which provides documentation of fare payment is essential to nearly all forms of self-service. In most applications, a cancellor, or validator, accepts a ticket inserted by the passenger and encodes the ticket with the required information. Depending on the types of tickets used in the system, the validator may be equipped with features to allow for multi-trip tickets and to detect counterfeit tickets. Volume III of this report, which addresses the trade-offs involved in the selection of self-service equipment features, describes the functions and characteristics of validators in detail.

2.1.3 Fare Payment Procedures

Self-service systems are typically ticket-oriented systems. Unlike a "cash-into-a-farebox" system in which fare payment is synonymous with trip authorization, self-service operations cannot grant trip authorization through the surrendering of the fare without providing adequate proof-of-payment to the passenger in the event of an inspection. Rather than require the passenger to first surrender one fare payment media (e.g., a token) and then obtain another media for proof-of-payment (receipt), most self-service systems sell tickets of various types which, when properly validated, act as a receipt indicating when and where trip authorization took place. In essence, trip validation transforms the ticket into a receipt.

Single-trip tickets, which account for between 15 and 25 percent of ridership in most European systems, are usually sold without validation so that the passenger can obtain tickets whenever convenient and not just immediately prior to making a trip. A few systems (Geneva's for example*), validate single-trip tickets at time of issue, but the majority of European systems prefer not to tie ticket availability to trip execution either because of the potential excuse it may offer fare evaders, or because of the greater workload required in driver sales. In Cologne, for example, drivers sell tickets, not receipts, for single-trips; the passenger, not the driver, validates the ticket to complete the fare payment activity.

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*Throughout this report city names have been used to refer to the transit properties serving the city and its surrounding area; Appendix B lists the organization name and address for the transit companies.

Multi-trip tickets are a common feature of self-service systems. In flat-fare systems or in systems which offer different ticket types for different zones of travel, multi-trip tickets frequently take the form of multiple single-trip tickets, i.e., the passenger purchases a booklet of tickets or a perforated strip of tickets which can be used and validated individually. Some systems prefer this form of multi-trip ticket because individual tickets may be distributed among family members thereby obtaining "family" discounts; others dislike individual tickets for the same reason.

The majority of self-service multi-ride tickets are single documents which can be used repeatedly by the passenger without folding, tearing, or otherwise altering the ticket. Such multi-ride tickets either must be oriented during validation so that validation information is stamped on unused portions of the ticket or used in conjunction with a special type of validator which simultaneously cuts a portion of the ticket during each validation so that subsequent insertions of the ticket will result in validation information being printed on unmarked sections of the ticket.

A few self-service systems use a multi-trip ticket which can be used for multiple rides of varying length, i.e., multiple zones. Munich, for example, sells multi-trip tickets which contain a number of sections, each with a value equivalent to the cost to travel a single zone. By folding the ticket prior to validation, the passenger may use the same multi-trip ticket for any combination of trips and zones until the value of the ticket is exhausted.

The ease with which multi-trip tickets can be used is one of the primary advantages of self-service. Such documents have been used by European systems to appeal to the "middle ground" in the transit market --those that would be attracted by a multiple trip-oriented payment that is more convenient than single-trip payment and less restrictive than period-oriented methods such as passes.

2.2 Self-Service Configurations

The actual number of variations of self-service fare collection in use is as numerous as the number of cities which have adopted it. Each property has adapted the concept to its own particular needs and differs from others in its approach to ticket availability, ticket distribution, vending, validation, system and vehicle access, enforcement and maintenance. In some cases, an individual property will use different self-service features to support different modes of transport.

In 1973, Werz[1] attempted to classify these varied approaches into five categories based on the type and location of supporting equipment in use:

a. Issuing and validating equipment installed at stops only (Swiss system).

b. Validating equipment installed on the vehicles and ticket issuing equipment installed at the stops (German system).

c. Validating equipment installed on the vehicles but little or no use of ticket issuing equipment (Continental system).

d. Issue-only equipment installed on the vehicles (British system).

e. Issuing and validating equipment installed on the vehicles.

The latter two of these categories have achieved only limited application. The so-called British system, because of its issue-only nature, can be applied only where passengers do not use or do not have prepayment tickets and thus buy their tickets singly; the implementation has been viewed by most European properties as cumbersome and space-consuming since it involved the introduction of turnstile devices onto vehicles. The approach which includes both vending and validation on vehicles has also grown very little. On-board vending has largely been limited to installations on trams because of the less severe vibration and electrical problems encountered on this mode compared to buses; major properties which originally began with on-board vending have withdrawn. Although some properties are reconsidering on-board vending for future application, at present this option is not considered attractive.

The Swiss, German, and Continental systems represent the most frequently preferred and adopted approaches to self-service. Most properties began their self-service operations with these ultimate configurations in mind and therefore introduced self-service through step-by-step regional integration beginning first with one or more lines and then expanding to greater and greater coverage. Some have chosen to implement self-service not by piece-meal geographic increments but by successive system-wide modifications to the basic concept.

The two most common alternative approaches begin with either:

a. The introduction of a self-service, unrestricted access system without implementation of typical self-service vending or validation equipment; or

b. The introduction of self-service validators and multi-trip tickets but without providing passengers unrestricted access to vehicles.

Brussels, for example, began its self-service by allowing pass-holders unrestricted access to its vehicles and, even though they have since adopted validators and multi-trip tickets, these ticket-holders must still enter through a single door since vehicles have been equipped with only one validator. The Hague began its self-service operations with the installation of individual validators on its vehicles and gradually modified its trams to permit unrestricted, "all-door" access; its buses still provide only a single validator and front door access only.

Because these "starter" options also represent a self-service configuration in their own right if further extensions are not intended, they have been addressed as separate options in this report. Ottawa-Carleton, for example, is beginning a three-year demonstration in which pass-holders will be allowed unrestricted access on the routes serviced by articulated buses; no introduction of validators is planned. Copenhagen is beginning to convert to a multi-trip ticket based fare system using validators on its buses but its drivers will continue to supervise fare payment and will monitor the use of the validator to ensure payment of the base fare; inspectors will check to ensure that riders do not use a base-fare ticket for travel through a greater number of zones than authorized.

3.0 EUROPEAN EXPERIENCE

During the past 10-15 years, self-service systems have changed markedly as a result of not only a substantially increased dependence on automation but also numerous refinements to fare structures, enforcement and maintenance procedures, and vehicle inventories which have been made to derive maximum advantage from self-service. Since its introduction, European properties have gradually adopted diverse fare structures designed to appeal to and attract ridership from new market segments; have modified enforcement and maintenance procedures to minimize fraud and maximize equipment availability; and have deployed increasing numbers of high capacity vehicles such as articulated buses and multi-car trams to increase service productivity.

3.1 Fare Structures

Because vehicle drivers are not involved in the fare collection process, that is, because they are not responsible for monitoring payment, for computing and verifying fares, or for distinguishing or collecting transfers, pass types, etc., the fare structure, whether simple of complex or whether supported by a few or a variety of payment instruments, has little effect on driver work load or service productivity in self-service.

Although the original reason for introducing self-service--the severe labor shortage experienced in Europe during the 1960's--is no longer relevant in today's excess labor market, European properties continue to adopt and expand self-service operations partly because of labor costs but primarily because of the opportunities afforded by self-service to:

a. Integrate transit modes and local operations into regional networks providing a common fare structure and "through ticketing".

b. Increase revenue through the implementation of fare structures more closely reflecting the cost and value of the service received.

c. Increase transit ridership by offering a diverse fare structure with a variety of incentives and discounts designed to appeal to broader segments of the population.

For many transit properties, regional integration has been the primary stimulant to self-service. Copenhagen, for example, adopted self-service so that the entire regional network could be covered by a single fare structure. Altogether, 38 bus and 5 railway companies operate through a single management authority and agree to use a common fare structure. In The Hague, which has been using self-service for some years and which at present supports four distinct flat-fare structures, conversion efforts are under way to introduce a zoned-fare structure covering the entire region. As in other areas, this shift to more complex zone-based fares has been necessary to maintain transit revenue levels comparable to that prior to regionalization. Both of these properties offer a variety of discounts and incentives to encourage ridership. The types of discounts offered by these and other selected European properties are summarized in Table I and discussed briefly below.

TABLE I - DISCOUNTS OFFERED IN EUROPEAN SELF-SERVICE SYSTEMS

City	Multi-Trip	Period Pass				User Discounts				Point Of Sale	Off-Peak	Short Trip
		Day	Week	Month	Year	Student	Elderly	Handicapped	Other			
BERN	√	√	–	√	√	√	√	√	√	–	–	√
BRUSSELS	√	–	√	√	√	√	–	–	√	√	–	–
COLOGNE	√	√	√	√	√	√	√	√	√	–	√	–
COPENHAGEN	√	–	–	√	–	√	√	√	√	√	–	–
DUSSELDORF	√	–	√	√	–	√	√	–	√	–	√	–
GENEVA	√	√	–	√	√	√	√	√	√	–	–	√
THE HAGUE	√	√	–	√	√	√	√	–	√	√	–	–
MILAN	√	–	√	–	√	√	–	–	√	√	–	–
MUNICH	√	√	√	√	√	√	√	√	√	–	–	√
PARIS	√	–	√	√	√	–	√	√	√	–	–	√

3.1.1 Multi-Trip and Pass Discounts

Most cities offer discounts for multi-trip tickets and passes:

- To encourage the prepayment of fares
- To reduce sales of single-trip tickets
- To reduce sales of tickets by drivers

As shown in Table II, multi-trip ticket sales account for 30 to 74 percent of revenue and 23 to 61 percent of passenger-trips while passes account for 23 to 64 percent of all passenger-trips. Combined, these two fare payment methods account for 26 to 95 percent of passenger revenue and 56 to 97 percent of all passenger-trips. The use of passes and multi-trip tickets has continued to grow or remain fairly steady through the years (Table III).

Discounts on multi-trip tickets offered by the cities listed in Table IV range from 0 to 74 percent. Typically, the level of discount offered is the result of several considerations:

a. The greater the availability of single-trip tickets from sources other than the driver, the lower the discount on multi-trip tickets. Consequently, Geneva, which as a matter of policy does not provide driver sales, offers a very low discount on multi-trip tickets. Cologne which uses considerably fewer wayside vending machines than Munich, offers a higher mutli-trip discount.

b. The more specialized the multi-trip ticket, the greater the discount. Consequently, Milan's multi-trip tickets, which must be used on specific days and specific routes (see Volume II), require a greater financial incentive to encourage their purchase than the general purpose multi-trip tickets used in other cities.

TABLE II - SALES, REVENUE, AND PASSENGER TRIP DISTRIBUTION BY FARE PAYMENT TYPE

City	Year Of Data	Single-Trip (%)			Multi-Trip (%)			Passes (%)		
		Sales	Revenue	Trips	Sales	Revenue	Trips	Sales	Revenue	Trips
BERN	1977	82.89	24.89	14.90	16.73	39.79	31.19	0.38	35.32	53.91
BRUSSELS[a]	1977	-	-	-	-	73.50	53.67	-	26.50	46.33
COPENHAGEN[b]	1977	-	69.00	47.00	-	-	-	-	31.00	53.00
GENEVA	1977	-	35.00	21.40	-	30.70	23.40	-	34.30	55.20
THE HAGUE[c]	1977	-	14.50	7.10	-	63.40	60.50	-	22.10	32.40
MILAN	1977	-	73.60	43.66	-	25.11	32.47	-	1.29	23.87
MUNICH	1975	21.40	6.30	3.10	66.90	51.10	33.00	11.60	42.60	63.90
PARIS[d]	1977	-	48.78	37.74	-	-	-	-	51.22	62.26

[a] Multi-trip ticket data includes single-trip sales.

[b] Data from old system of operation, no multi-trip tickets available (See Volume II).

[c] Revenue percentage splits are approximations.

[d] Single-trip ticket data includes carnet sales information.

Source: Bern[2]; Brussels[3]; Copenhagen[4]; Geneva[5]; The Hague[6]; Milan[7]; Munich[8]; Paris[9].

TABLE III - PERCENTAGE OF PASSENGER-TRIPS COMPLETED USING MULTI-TRIP TICKETS AND PASSES

City	1965-66	1975-76	1977
BERN	76.00[a]	85.00	85.10
BRUSSELS	14.05[b]	16.96	46.33
GENEVA	71.00	80.20	78.63
THE HAGUE	81.40	92.40	92.90
MILAN	59.97	49.69[c]	56.34
MUNICH	82.40	96.91	(d)

(a) Estimated from 1946 and 1955 data.

(b) Passes introduced in 1965.

(c) Severe coin shortage in Italy which started to alleviate 1977-78.

(d) Data not available.

Source: Bern[2]; Brussels[3]; Geneva[5,10]; The Hague[6,10]; Milan[7,11]; Munich[8,10].

TABLE IV - DISCOUNTS OFFERED ON MULTI-TRIP TICKETS

City	Multi-Trip Discount (%)
BERN	12.5 - 20.4
BRUSSELS	25.0 - 42.5
COLOGNE	33.0
COPENHAGEN	25.9 - 55.5
DÜSSELDORF	30.5 - 33.3
GENEVA	4.2 - 8.3
THE HAGUE	16.3 - 39.7
MILAN	54.2 - 73.7
MUNICH	16.7
PARIS	0.0 - 37.5

Sources: Bern(12); Brussels(13); Cologne(14); Copenhagen(15,16); Düsseldorf(17); Geneva(18); The Hague(19); Milan(20); Munich(21,22); Paris(23).

c. The more use made of other incentives and disincentives, the lower the discount on multi-trip tickets. For example, The Hague uses a point-of-sale discount to discourage on-board sales and thus does not offer as substantial a discount as other systems.

d. The longer the travel distance, the higher the discount. Most systems use this type of discounting either to appeal to the commuter or to compensate for the lack of vending machines in outlying areas.

Milan presents an anomaly in multi-trip discounts and usage. Due to a coin shortage in Italy, people frequently receive single-trip tickets as change from the many concessionaires who distribute tickets and receive commissions on their sales. Consequently, single-trip tickets are so common that an abnormally high multi-trip discount is necessary to reduce single-trip ticket usage.

Pass discounts generally follow the same pattern as multi-trip ticket discounts, but the level of the discount provided is usually greater than that for multi-trip tickets in order to compensate for the lower market appeal of a period-limited document and to stimulate pass usage as a means of fraud reduction (Section 3.2). With few exceptions, pass usage is very high in most European cities as a result, and efforts taken to discourage single-trip tickets sales usually yield increases in both multi-trip ticket and pass usage.

Low pass usage in The Hague has been attributed to the lack of public awareness of the system's fare structure. Consequently, almost all the decline in single-trip ticket usage (from 18.6 percent in 1966 to 7.1 percent in 1977) has resulted in multi-trip ticket increases.

Milan's low pass usage is partly due to the high cost of its passes; compared to the cost of the annual pass in other cities--300 to 650 times the single-trip fare--Milan's pass costs 500 to 1,000 times the cost of a single-trip fare.

3.1.2 Point-of-Sale and Other Discounts

Discounts are common on tickets purchased from machines or off-vehicle. Most cities incorporate this off-vehicle sales discount into their multi-trip ticket discount; a few cities charge a premium for on-board ticket sales. In Milan, for example, passengers who purchase tickets on-board are required to pay an additional 100 Lire for the ticket. Depending on the price of the ticket, this amounts to a 10 to 50 percent premium for an on-board purchase. Both Brussels and The Hague offer discounts of approximately 25 percent on multi-trip tickets that are purchased off-vehicle. Approximately 88 percent of passenger-trips completed with multi-trip tickets are made with tickets purchased off-vehicle.(6)

Other discounts include:

- User discounts
- Time-of-day discounts
- Special trip discounts

Most systems offer a variety of discounts directed at particular segments of the population including elderly, handicapped, students, veterans, tourists, and economically disadvantaged individuals. Most of these are offered through the system's pass structure; however, a few incorporate these discounts into special multi-trip tickets.

Time-of-day and special-trip discounts are less frequently offered. Cologne offers a discount of 25 percent on special multi-trip tickets which are usable only during off-peak times while both Geneva and Munich offer special fares for short-distance trips. In Geneva, the passenger buys a special ticket (approximately 40 percent reduction) which allows travel up to three stops from the point of purchase; in Munich, passengers may use children's tickets for short-trips not exceeding three stages (approximately six stops).

3.2 Fare Evasion and Fare Enforcement

Although inspection methods and penalties differ greatly among the European properties, all use inspectors to enforce fare payment and support it with some form of penalty; no European self-service system operates as an "honor" system. At some properties, enforcement strategies include relatively sophisticated procedures to detect and target particular fare evasion problems and established mechanisms to deal with persistent and different types of infractions with different forms of punishment.

3.2.1 Fare Evasion in Self-Service

Reported fare evasion rates in European self-service systems are very low--averaging between one and two percent of ridership. Considering the high volume of pass usage at most European properties and the relatively low number of infractions involving passes (Table V), the percentage of non-pass-holders who evade the fare is significantly greater; less than 50 percent of system ridership commit more than 80

TABLE V - TYPES OF FRAUD (%)

City	No Ticket	Invalid[a] Ticket	Time Expired Ticket	Wrong Zone Ticket	Forgotten Pass	Expired Pass	Wrong Zone Pass
COPENHAGEN	3.1	5.4	1.1	76.9	-	1.1	12.4
GENEVA	40.0	15.0	5.0	25.0[b]	-	15.0	-
MUNICH	44.3	27.4	0.4	3.3[c]	14.0	5.5	5.1

[a] Includes all fraud types that do not fall into other categories.

[b] Since Geneva uses a flat fare structure, it is assumed that this type of fraud must be due to the use of short trip tickets for long trips.

[c] Zone travel using short trip ticket.

Sources: Copenhagen[24]; Geneva[1]; Munich[8].

percent of fare violations. For this reason, many European transit companies take the view that each person induced to buy a pass reduces its overall fare evasion problem. Consequently, the reduction of fare evasion partly accounts for Europe's aggressive marketing of passes.

For most properties, the "no-ticket" type of infraction is much more serious than the "wrong-ticket" type of infraction since the former represents a total loss of revenue for the trip while the latter only a partial loss of revenue. Copenhagen's choice of self-service reflects a high concern for this distinction; its vehicle drivers continue to be responsible for ensuring the payment of the base fare. As a result, only 3.1 percent of the violators reportedly ride without a ticket compared to a greater than 40 percent violation rate in other systems (Table V); the majority of Copenhagen's infractions fall into the category covering the use of a base-fare ticket for travel beyond the base zone.

The Copenhagen approach, however, is not common. Most properties prefer to address the problem either through its penalty system or through its publicity campaigns. Paris, for example, imposes a higher fine on those individuals who do not have a ticket compared to those caught using a ticket improperly. Most German and Swiss systems direct the majority of their publicity towards the "Schwartzfahrer", those who travel without a ticket, and very little against the "Graufahrer", those who attempt to use their ticket improperly.

3.2.2 Inspection Procedures

European inspection strategies are diverse; in most cases, their present form is the product of refinements and adjustments made throughout a decade of reacting to site-specific fare evasion trends and characteristics. Table VI, which summarizes inspection and fraud statistics for selected self-service systems, illustrates the lack of consensus with respect to inspector staffing and uniforms and inspection coverage. Some systems psychologically screen applicants for inspectors and offer several weeks of training while others rely on former conductors or drivers who are unable to perform other duties. Some operate teams of inspectors either for security or saturation-inspection purposes, while others rely on individual inspection.

Because of the numerous factors which enter into considerations of staffing requirements to achieve a specified level of fraud, no single "rule-of-thumb" can be stated for determining the size of an inspection force. As a rough guide for initial staffing, one equipment manufacturer quotes a figure of one inspector per 20 vehicles,[25] which considering the actual inspector deployment of the cities listed in Table VI represents a reasonable average. Most European properties, however, base their inspection force on the number required to check a given percentage of ridership, with this percentage based on estimated fare evasion and the amount of the penalty. For example, when Munich initially established its enforcement procedure, its inspection goal was to check, on the average, every passenger every 15 days with the

TABLE VI - INSPECTION STATISTICS

City	Number of Inspectors			Vehicles Per Inspector	Passenger Trips (10^6) Per Inspector	Route Kilometers Per Inspector	Reported Inspection Rate (%)	Reported Fraud Rate (%)	Number Of Passengers Inspected Per Hour Per Inspector[(a)]
	Uniformed	Plainclothes	Total						
BERN	12	-	12	18.7	6.7	5.3	<5.0	<1.0	142.00[(b)]
COLOGNE	-	85	85	7.6	2.0	7.0	1.4	3.0	14.70
GENEVA	12	-	12	25.8	6.0	20.3	2.5	0.8-1.1	79.24
THE HAGUE	27	-	27	16.1	2.8	9.3	1.0	9.9	14.90
MILAN	70	30	100	30.0	6.1	13.5	<1.0	1.2-8.0	24.23[(c)]
MUNICH	-	135	135	6.7	3.3	14.0	3.0	1.4	52.61
VANCOUVER	12	-	12[(e)]	0.3	0.5	(f)	43.3	0.5	59.29

(a) Figures based on reported inspection rates and 1880 hours per year per inspector.

(b) Figure based on inspection rate of 4.0 percent.

(c) Figure based on inspection rate of 0.75 percent.

(d) Sea-Bus ferry system--two vehicles, three crewmembers per vehicle who act as inspectors, passengers captive for the 12 minute crossing.

(e) Number estimated based on operation hours and requirements for three crewmembers per ferry.

(f) Not applicable.

fine set to cover the revenue lost if a typical passenger defrauded the system for these 15 days. As Table VI shows, Munich does not presently meet this goal on a system-wide basis; it tends to compensate through special targeting and saturation inspection (see Volume II) and relatively high penalities for fare evasion (Section 3.3).

Comparison of the fraud rates and inspection rates in Table VI tend to confirm the close relationship between these two. Properties with fewer inspectors or low inspector productivity are unable to achieve high inspection rates and generally experience higher fraud rates. In The Hague, for example, the combination of a low rate of inspection and a low fine for fare evasion contributes to a very high fraud rate. In contrast, Vancouver's high rate of inspection yields a very low fraud rate even though Vancouver's only "penalty" for fare evasion is the embarrassment experienced on being caught and asked to pay the fare. Milan again represents an atypical situation; although its inspection force is large, and capable of providing coverage comparable to cities such as Munich, it does not achieve high inspection rates. Milan has relatively low inspector productivity partly because it operates three-man teams using at least one uniformed inspector and partly because it confines its inspections primarily to off-peak periods and surface modes of transportation. Consequently, although officially reporting a fare evasion rate of 1.2 percent, Milan estimates actual fraud may be as high as 8.0 percent.

In general, self-service operations which have low inspector productivity in terms of number of passengers checked experience higher fare evasion than systems with high productivity. The relationship is not a cause-and-effect relationship but rather the result of a combination of factors including the fraud rate itself and whether or not uniformed inspectors are used. Since the amount of time an inspector spends with a fare evader is substantially more than the amount of time required to check the receipt held by a passenger who has complied with fare structure, properties which have high fare evasion rates also experience low inspector productivity. Cologne, The Hague, and Milan appear to have low productivity as a result of having to stop and fine passengers more frequently than other cities. In some respects, this is reminiscent of the familiar "downward spiral" commonly cited as a problem in transit service; the greater number of apprehensions prevents inspectors from checking an adequate number of passengers and the lower inspections tend to encourage a greater number of passengers to evade the fare.

The choice between uniformed and plainclothed inspectors also has a significant effect on inspector productivity and is an issue widely debated among European transit management. Many which use plainclothed personnel cite their greater apprehension of fare evaders as justification for their use. These properties claim that while uniformed inspectors are able to check greater numbers of passengers, their visibility permits the passenger to spot enforcement activities easily and thereby escape apprehension either by avoiding inspection or by validating tickets just prior to inspection. If significant numbers of passengers do indeed escape apprehension in this manner, the reported fare evasion rates have little relationship to the actual fraud being experienced by the property. Properties using plainclothed inspectors, therefore, claim with some justification that their methods yield statistics closer to the actual fraud rate.

Although most properties which use uniformed personnel exclusively are required to do so by law, many support the use of such highly visible individuals precisely because they are visible. These properties claim that the role of inspection is not to apprehend violators but to show that the system is being inspected and to heighten the passenger's perception that evading the fare is not cost-effective, i.e., "to keep the normally honest passenger honest". Almost all take some steps to minimize the potential number of passengers which can escape once an inspection has commenced, including the use of teams to cover all doors and the disabling of validating devices by the driver just prior to inspection activities.

3.2.3 Fare Evasion Penalties

Table VII compares the penalties for fare evasion imposed by selected European properties. Several of these, notably Cologne and Copenhagen, refer to their penalties as premium fares, but the net result is the same as those which label the penalty as a "fine". Generally, fines in self-service operations average 20 to 30 times

TABLE VII - FINES, PENALTIES, AND COLLECTION STATISTICS

City	Minimum Fine ($)	Repeat Offender Penalty ($)	Ratio Of Minimum Fine To Single-Trip Cost	Fine Payment Method (%)			Fraud Rate (%)
				On-the-Spot	Mail	Other	
BERN	13.70	-	33.3	-	-	-	1.0
BRUSSELS	16.67	(*)	25.0	50.0	40.0	10.0	5.0
COLOGNE	10.00	(*)	13.3	25.0	<74.0	<1.0	3.0
COPENHAGEN	10.00	(*)	25.0	40.6	55.8	0.0	0.22
GENEVA	27.40	219.20	40.0	-	-	-	0.80-1.10
THE HAGUE	2.50	20.00	4.3	80.0	15.0	5.0	9.90
MILAN	6.25	(*)	25.0	←100.0→		0.0	1.20-8.00
MUNICH	20.00	250.00-300.00	26.6	40.0	60.0	0.0	1.40
PARIS	3.75	-	7.5-22.0	-	-	-	-

*Actual penalty determined by court.

the base fare. Geneva's very high fine is partly a result of having to share the administrative burden--and proceeds--with the local police. Geneva began its self-service operations in 1969 without police support but being unable to collect delinquent fines effectively, contracted with the police to administer its collection functions and, to pay for this, doubled its fine.

Most European fines or premium fares are established by local or state laws which fix absolute amounts for fare evasion penalties. In a few instances, these laws distinguish between types of violators but rarely differentiate types of infractions. Geneva, for example, fines elderly individuals and tourists substantially less; Bern has similar distinctions. As mentioned previously, Paris is one of the few systems which distinguishes between types of violations. Munich, as most other cities, applies the same penalty for all infractions; it will refund a portion but not all of the fine paid by a pass-holder who later proves possession, since full refunds would tend to encourage such forgetfulness.

Most European systems levy heavier penalties for repeat offenses. Geneva, for example, systematically doubles its fine for each repeat violation; on the fourth infraction the violator is taken to court for a possible jail term.

3.3 Maintenance and Support Services

Table VIII compares the personnel requirements reported by various European properties for enforcement, maintenance, and other support functions. As in enforcement, staff requirements for maintenance functions depend on a variety of factors including number and type of equipment used and its complexity; individual properties have tended to react to rather than plan for maintenance demands. Although many European systems are currently updating their equipment to more sophisticated devices including microprocessor-based hardware and change-making and bill accepting capabilities, most have adopted a "wait-and-see" attitude with respect to staffing changes, with some citing improved reliability and maintainability of new generations of equipment as a justification for new procurements.

3.3.1 Maintenance Characteristics and Costs

Maintenance philosophies vary from property to property. While some systems devote special groups to fare collection equipment maintenance, others perform these functions as part of their overall repair operation. Düsseldorf, for example, utilizes the same personnel for tram and fare collection repairs because similar skills are required to support both the trams' electronic control systems and the electronics in its fare vending machines.

Because of site differences in maintenance procedures, equipment age and complexity, and equipment mix, it is difficult to generalize the cost of maintenance for self-service equipment. As shown in

TABLE VIII - PERSONNEL REQUIREMENTS

City	Number Of Inspectors	Number Of SSFC Equipment Maintenance Men	Additional Personnel
BERN	12	10 (a)	Two money collectors Record keeping staff
BRUSSELS	10 (b)	14	Six maintenance personnel for automatic control gates Record keeping staff Money collectors and preventive maintenance crew
COLOGNE	85	25	Record keeping staff Legal staff
COPENHAGEN	40	3-4 (a)	
DÜSSELDORF		(c)	Record keeping staff Money collector
GENEVA	12	13 (a)	Two money collectors One lawyer Complaint, reception, and record keeping staff
THE HAGUE	27	2 (d)	Money collectors
MILAN	100 (e)	35	Two money collectors Record keeping staff Public relation staff
MUNICH	135	50 (f)	Money collectors-Teams of two men Record keeping staff Legal staff

(a) One shop manager included

(b) Assisted by 200 other STIB/MIVB personnel

(c) Maintenance performed by electrical shop personnel

(d) Two handicapped personnel; assisted by other shop personnel as required

(e) Assisted by conductors in suburbs

(f) Includes shop management staff

Table IX, reported costs to repair vending machines range from a low average of $250.00 per year to over $1,100.00 per year; average costs for validators are substantially lower because of their relative simplicity compared to most vending machines. For most properties these maintenance costs represent a small fraction of the system's total operating cost and also of the total revenue received through vending machines. Milan once again represents a unique situation; its maintenance costs consume approximately half the revenues received from its vending machines, not because its maintenance costs are excessively high, but because its machine revenues are very low (see Volume II).

3.3.2 Maintenance Problems

Most transit properties in Europe reported that fare collection hardware had two major problem areas--the printer mechanism and the time clock. Manufacturers of fare collection hardware, recognizing the problems associated with the printers and clocks, have incorporated advanced techniques into the new machines such as:

- Quartz crystal clocks
- Needle printers
- Microprocessor control
- Dry printing processes

Other types of maintenance problems are normally caused by jams in the ticket transport mechanism, the ticket validating mechanism, or the coin acceptor mechanism. The major causes of such jams are

TABLE IX - MAINTENANCE DATA ON VALIDATORS AND ISSUERS

City	Number Of Validators	Number Of Issuers	Validators Per Maintenance Man	Issuers Per Maintenance Man	Maintenance Cost Per Validator Per Year	Maintenance Cost Per Issuer Per Year	Repairs Per Validator Per Year	Repairs Per Issuer Per Year	Cost Per Repair Per Validator	Cost Per Repair Per Issuer
BERN	-	280[a]	-	28.00	-	-	-	16.5	-	-
BRUSSELS	2,000	50	142.8	3.60	120.00		1		120.00	
COLOGNE	2,750	208	110.0	8.30	186.62		-	-	-	-
COPENHAGEN (HT)	-	3,635	-	519.30	-	-	-	-	-	-
COPENHAGEN (DSB)	260	-	74.3	-	368.00	-	-	-	-	-
DÜSSELDORF	2,500	2,000/140[b]	-	-	71.40	34.25/ 1,135.71[b]	-	-	-	-
THE HAGUE	650	15	325.0	7.50	385.85		5		70.77	
MILAN	3,000	450	85.7	12.90	125.00	250.00	12	18.0	10.42	13.88
MUNICH	3,200	700	64.0	14.00	270.21		6		45.03	

[a]Includes 25 individual validators and all validators in issuing machines.

[b]Simple driver operated issuers/complex electronic automats.

wet or damp ticket stock which jam in printer and feed mechanisms of ticket issuing machines or in validator throats, and vandals who insert foreign objects such as slugs, chewing gum, etc., into ticket validators and coin acceptors.

4.0 GENERAL SYSTEMS BENEFITS

As noted in Section 3.1, modal integration and diversified fare structures are the primary stimulants for recent European conversions to self-service. Secondary benefits cited for the use of self-service include improvements in:

- Service productivity
- Equipment utilization
- Passenger statistics
- Fare collection costs

Many European properties cite increased service productivity as a result of the reduced dwell times facilitated by the all-doors access feature of self-service. Most have reported approximately a 10 percent service productivity improvement--some reporting this as a 10 percent decrease in trip time, some as a savings of one bus in ten, and some as a comparison with what operations would have been without self-service. For example, Geneva reported that by using unrestricted all-doors access and by requiring passengers to have a pre-paid fare to board the vehicle, dwell times of the vehicles at stops were reduced. The reduced dwell times led to a savings of personnel and equipment--"one bus in ten". One city, Cologne, reported that by switching to self-service it was able to recapture the approximately 10 percent productivity losses it incurred by shifting from conductors to driver-based fare collection.

As a result of self-service operations, European systems have made extensive use of high capacity surface vehicles such as articulated buses, single and double articulated light rail vehicles, and trailered light rail vehicles. Since passengers do not have to pass the driver when boarding, many doors can be added to vehicles. Vehicle doors are normally double width which allows simultaneous alighting and boarding. Standard buses usually have three doors, articulated buses have three or four doors while articulated or trailered light rail vehicles have as many doors as required (four to five). Again, the all-doors access feature of self-service permits the loading and off-loading of these vehicles in comparatively short dwell times. Contributing to the short dwell times is operational characteristics of the doors. They may be opened one-at-a-time, on-demand by the passenger after the driver has enabled them; or the driver may open all doors at once at high volume stops. The on-demand feature allows a passenger to alight or to board at the nearest door while the all-doors open feature allows a large number of passengers to quickly alight or board. All-doors access also contributes to a more uniform distribution of passengers on vehicles--which provides access between individual compartments and permits the use of trailered, unpowered cars which are not accessible from the lead vehicle.

In the area of passenger statistics, self-service can generally provide more detailed passenger data than was commonly available prior to its introduction. Usage (sales) of special ticket types and special discounts are readily obtainable by category and time-of-day ridership estimates constructed with minimal labor. A few European systems have cited its fare evasion statistics as an example of a major advantage--comparing it to the past in which it did not know fare evasion rates, types and locations and thus could not respond to fare evasion.

Finally, transit properties operating subsurface or metro type systems report that the introduction of self-service fare collection has allowed a significant savings in the cost of hardware. Without self-service fare collection, sophisticated electronic ticketing equipment and access control equipment would be required for the collection of fares. With self-service, the need for expensive fare collection equipment is reduced and the requirement for access control equipment is virtually non-existent. For example, Brussels and Antwerp originally installed electronic access control equipment in their Metro systems for fare collection and passenger control. However, both systems have discontinued the use of the access control equipment, have decided to introduce self-service with unrestricted system access, and have decided not to order any new electronic fare collection equipment.

5.0 APPLICATIONS OF THE SELF-SERVICE CONCEPT IN THE U.S.

As noted earlier, European properties introduced self-service fare collection at the time they switched to one man operation. Since that time they have refined and expanded other benefits that are associated with self-service fare collection, including:

- Increased ridership and revenue
- Increased operational efficiency
- Decreased fare evasion and fraud

Interest in using self-service fare collection techniques in U.S. transit settings is essentially derived from these associated benefits since U.S. transit properties have already minimized personnel on-board vehicles. The U.S. transit industry would welcome opportunities to increase productivity through the use of vehicles with greater passenger carrying capacities, to increase revenue through adoption of a graduated fare structure, to integrate transit systems under a single fare structure, and to make transit ridership more attractive and convenient. As the survey of European systems has shown, these opportunities are offered by the application of self-service fare collection techniques. Successful development of self-service fare collection systems for the U.S., however, requires careful examination, consideration and selection of the constituent elements of such systems, as well as investigation of the prospects for their workability in U.S. settings--particularly in the area of fare payment and enforcement.

As the description of European systems has indicated, a variety of approaches have been taken in implementing the self-service fare collection concept. Although all of the systems developed assign the passenger a more active and responsible role in fare payment and rely on random inspection for fare payment enforcement, they differ in terms of:

- Fare structures
- Fare payment media
- Vending modes
- Equipment configuration and location
- Operational procedures
- Specific inspection and enforcement methods

Successful use of the self-service concept in the U.S. will require development of self-service fare collection systems which tailor these variable elements to the particular nature and needs of U.S. transit properties. In order to establish a solid foundation for system development efforts, European systems have been surveyed and analyzed as reported in Volumes II and III and the concept's legal and labor implications for U.S. application have been studied.[26] Based on this preliminary work, five basic self-service configurations have been identified for their potential applicability in U.S. transit settings:

- Wayside Vending/Wayside Validation
- Wayside Vending/On-Board Validation
- Selected Location Vending/On-Board Validation

- Driver Monitored On-Board Validation
- Minimal Hardware.

The characteristics of each of these self-service demonstration options are outlined in some detail in Table X.

5.1 Wayside Vending/Wayside Validation

The distinguishing characteristic of this configuration is the location of ticket vending and validating equipment at all or most transit stops. Passengers purchase and validate tickets before boarding the vehicle. There is no requirement for passengers to interact with the vehicle driver and, therefore, they may use any available door for vehicle entry. The major advantages of this option are:

a. Driver responsibility for and involvement in fare collection are minimal.

b. Passengers determine their own fares which makes possible a complex yet flexible structure.

c. Passengers may board through all doors which decreases vehicle dwell time.

d. There are no on-vehicle equipment requirements and no vehicle down time due to fare collection equipment malfunction.

Some disadvantages associated with this option are:

a. High equipment costs (procurement and installation).

b. Requirements for weather and security safeguards and for special maintenance and servicing procedures.

TABLE X - CHARACTERISTICS OF SELECTED "SELF-SERVICE" DEMONSTRATION OPTIONS

	Wayside Vending/Validation	Wayside Vending/On-Board Validation	Selected Location Vending On-Board Validation	Driver Monitored On-Board Validation	Minimal Hardware
Equipment/Configuration	Ticket dispensing and ticket validating devices at all or most stops	Ticket dispensing devices at most stops; ticket validators on all vehicles (redundant/ replaceable)	Ticket dispensing devices at selected stops; ticket validators on all vehicles (redundant/replaceable)	One ticket validator per vehicle	None
Fare Structuring Possibilities	Flat and/or Zone	Flat and/or zone vendors; Zone requires special device on validators	Flat and/or Zone vendors Zone requires special device on validators	Flat and/or Zone Zone requires special device on validators	Flat and/or Zone
Ticket Type - Single/Multi/Pass	Any	Any	Any	Any	Passes/single trip
Transfer Procedures	Not compatible with conventional procedures**	Not compatible with conventional procedures**	Not compatible with conventional procedures**	Compatible (Driver issue of receipt)	Compatible (Driver issue of receipt)
Passenger Access Configuration	All doors access	All doors access	All doors access	Driver door access only	All doors access for pass-holders; cash passengers use driver door
Driver Responsibilities	Minimal; some on-board sales	Validator status monitoring; some on-board sales	Validator status monitoring; some on-board sales	Validator status and usage monitoring; some on-board sales/ transfer issuance	On-board single trip sales; issuance of receipts/transfers
Maintenance/Servicing Requirements	Special provisions for monitoring equipment performance, repair, and machine collection and stocking (mobile teams)	Special provisions for monitoring, repairing, and servicing wayside vendors; (mobile teams) validators must be redundant or replaceable)	Monitoring, maintenance and servicing of vendors; validators must be redundant or replaceable	None	None
Environmental/Security Requirements	Protection from adverse weather; vulnerable to vandalism/break-ins	Protection of vendors from adverse weather and threat of vandalism/break-ins	Varies with selection of location	None	None
Advantages	-Flexible fare structure possible -System independent of number/ type of vehicles used -Equipment failure does not affect vehicle -No vehicle installation requirements -Driver responsibility minimal -All doors access	-Driver responsibility minimal -Validator malfunction can be identified promtly -Validator maintenance can be part of routine vehicle service -All doors access -Flexible fare structure possible	-Lower capital costs -Reduced maintenance/servicing requirements -Reduced environmental/security requirements -Incremental implementation -All doors access -Flexible fare structure possible	-Low capital costs -Incremental implementation -Minimal vehicle modification required -Compatible with current transfer procedures -No maintenance/environmental demands -Flexible fare structure possible	-No capital costs -No maintenance/environmental demands -Compatible with current transfer procedures -No vehicle modification -Incremental implementation -Some all doors access
Disadvantages	-Capital costs -Maintenance/servicing requirements -Weather and security requirements -Transfer procedures not compatible	-Capital costs -Validation equipment installation dependent on type of vehicle -Failure of on-board hardware can lead to vehicle down-time -Potential reliability problems from vibration/ power source -Transfer procedures non-compatible	-Requires alternative ticket distribution system and associated costs -Possible reliability problems for validators from vibration/ power source	-Limited passenger access -No reduction of driver responsibility -Single validator increases prospect of vehicle down-time -Requires alternative ticket distribution system and associated costs	-Driver responsibilities undiminished -Less flexible fare structure possible -Incentives/discounting must be done via passes

*Requires ticket distribution system

**No surrenderable transfer documents

5.2 Wayside Vending/On-Board Validation

The distinguishing characteristic of this option is the location of ticket validating equipment on-board the transit vehicle; vending would take place from machines off-vehicle as in the all wayside option. This option has many of the same advantages and disadvantages associated with the all wayside option except that separate installation of validators aboard vehicles involves additional installation and maintenance costs, and validator malfunctions could lead to vehicle down time. Validating equipment may also have reliability problems resulting from vibration and electromagnetic interference.

5.3 Selected Location Vending/On-Board Validation

This option is essentially a modification of the previous option and is distinguished by a more limited complement of automated vending equipment. Vending equipment would be located in selected areas, e.g., high volume stops, transfer points, secure areas. This, of course, requires the establishment or continuation of an alternative distribution system for tickets and passes, e.g., agents or concessionaires. Many of the advantages and disadvantages of this option are similar to the wayside vending options discussed previously. This option, however, mitigates some of the weather and security constraints associated with wayside vending configurations since the costly vending equipment can be placed in secure and protected locations. It also reduces the level of capital investment required since vending machines are not required at all or most stops. It does not, however, fully replace alternative fare payment modes, i.e., driver or retail outlet ticket sales.

5.4 Driver Monitored On-Board Validation

This option is distinguished by the absence of ticket vending equipment and by the use of a single validator located near the vehicle driver. Ticket sales are conducted by drivers, agents, concessionaires, etc., all passengers must board the vehicle through the driver door in order to buy a ticket, validate a prepurchased ticket, or show a pass. The driver monitors, in effect, all fare payment by selling single-trip tickets, assuring validation of prepurchased tickets and verifying passes. The advantages of this option are:

a. Low capital and installation requirements and costs.

b. Minimal maintenance, environmental and security requirements and costs.

c. Minimal vehicle modification requirements.

d. Reduction in on-board cash handling.

Since all passengers must pass by the driver, disadvantages include:

a. Limited vehicle access.

b. No diminishment of driver responsibility for fare monitoring.

5.5 Minimal Hardware

The distinguishing characteristics of this option are the absence of any self-service ticket vending and validating equipment, limited provisions for prepayment, and unrestricted passenger access. All riders except those using passes must enter through the driver door in order to pay fares. Since pass-holders are not required to show passes to the driver, they may use any available door for vehicle entry.

In order to provide non-pass-holders with proof of payment, vehicle drivers issue receipts showing the information required for enforcement. There is no provision in this option for the use of multi-trip tickets. The advantages of this minimal hardware option are:

a. No capital or installation costs.

b. No requirements for vehicle modification or equipment support.

The disadvantages include:

a. Continued driver responsibility for and involvement in fare collection.

b. Limited fare structuring possibilities since incentive pricing must be accomplished via passes. Complex fare structures would place heavy demands on the driver.

5.6 Option Assessment

These five self-service fare collection configurations or possible demonstration options were identified through study and analysis of European systems and evaluation of the applicability of particular system components to U.S. transit environments. Any one of the five or variations of them could be an acceptable and desirable approach. In order to facilitate the selection of an alternative or alternatives which would provide the best demonstration opportunities, an effort has been made to evaluate the relative merits of these five identified options in terms of specified measures of attractiveness. These were derived from consideration of the self-service concept itself and from the objectives associated with a proposed demonstration, and were weighted according to their significance for both self-service implementation and demonstration. The criteria employed and the associated ranking factors were, in order of their relative assigned weight:

- Fare structure flexibility
- Service/productivity improvement
- Low implementation costs
- Decreased driver responsibility
- Minimization of additional operating requirements
- Minimization of special equipment requirements
- Minimization of modification of present system characteristics

Each of the five options was scored in terms of these measures, as seen in Table XI. Using the scores and the relative weights assigned each measure, a composite score was derived for each option. They were then ranked in a continum of most attractive to least attractive. A fuller discussion of the measures and the scoring rationale can be found in Appendix C.

As shown by the relative attractiveness ranking, the Wayside Vending/Validation option emerges as the best overall alternative, followed by the Selected Location Vending/On-Board Validation configuration. Both offer excellent opportunities for demonstrating the self-service fare collection concept and techniques. The second ranked alternative, however, is felt to have the greater potential for being adopted and accepted by the U.S. transit industry and, therefore, deserves the highest demonstration priority for the following specific reasons:

a. It offers substantially lower capital costs because vending equipment is less extensively used.

b. It offers greater revenue security because equipment installation locations can be selected judiciously.

c. It presents fewer environmental problems since protected equipment locations can be chosen.

d. It mitigates passenger behavior modification requirements since "payment" would continue to be made on-board the transit vehicle.

e. It offers opportunities for phased, incremental implementation of a self-service fare collection system unlike the full wayside vending alternatives.

f. It offers opportunities to demonstrate the automated vending component of self-service fare systems, unlike the two remaining options.

Although MITRE's analysis suggests that this alternative has the greatest potential for successful implementation and demonstration, it should be noted that options or alternative selections would also have to be evaluated in terms of site specific priorities, objectives, and restrictions, i.e., legal and labor issues and route and fleet configurations, before a final selection of a specific self-service configuration is made.

TABLE XI - SELF-SERVICE DEMONSTRATION OPTIONS: ATTRACTIVENESS RANKING

Measures of Attractiveness	Relative Weight	Wayside Vending/ Validation	Wayside Vending/ On-Board Validation	Selected Location Vending On-Board Validation	Driver Monitored On-Board Validation	Minimal Hardware
LOW IMPLEMENTATION COSTS						
Capital/Installation	3	4	5	3	2	1
Operating	4	4	5	3	2	1
FARE STRUCTURE FLEXIBILITY	9	1	2	3	4	5
SERVICE/PRODUCTIVITY IMPROVEMENT	7	1	2	2	5	4
DECREASED DRIVER RESPONSIBILITY	5	1	2	2	5	4
MINIMIZATION OF ADDITIONAL OPERATING REQUIREMENTS						
Preventive Maintenance	1	4	5	3	2	1
Unscheduled Maintenance	2	3	4	3	5	1
Revenue Collection	1	5	5	3	2	1
MINIMIZATION OF SPECIAL EQUIPMENT REQUIREMENTS						
Environmental	1	4	5	2	2	1
Security	1	5	5	3	2	1
MINIMIZATION OF REQUIRED MODIFICATION TO OR CONSIDERATION OF PRESENT SYSTEM CHARACTERISTICS						
Vehicle Inventory	1	3	4	4	2	3
Transfer Procedures	1	4	4	4	2	1
SCORES*		80	113	98	132	110
RELATIVE RANKING		1	4	2	5	3

*Scores = Total of ranking values x relative weight values

KEY: Most Attractive = 1
Least Attractive = 5

6.0 CONCLUSIONS AND RECOMMENDATIONS

For more than a decade European transit systems have been developing and successfully implementing SSFC systems. Study of these systems indicates that use of SSFC techniques and equipment have enabled European transit properties:

a. To adopt flexible fare structures which allow for integration of transit modes and local operations into regional networks, more precise and attractive pricing of transit services, and greater recovery of costs.

b. To relieve vehicle drivers of responsibility for the administration of a wide range of fares and fare payment options and for the verification and enforcement of fare payment.

c. To improve service productivity and facilitate the use of high capacity vehicles through the streamlining of passenger boarding and alighting.

Analysis of the European SSFC systems has also revealed that their success is not derived from development of a certain set of operational procedures and employment of appropriate hardware alone. Procedures and hardware have been tailored to the requirements of both transit passengers and properties; effective management and support frameworks have been established; the expanded information requirements have been recognized and met. European SSFC systems have been successful because they have been highly responsive to passenger requirements for ease of use, convenience, efficiency and economy and because the development, implementation and continuing operation of these systems have been conducted in terms of these requirements. Success, however, has not been purchased at the price of increased levels of fare evasion and fraud.

European systems' use of systematic spot checking and penalty assessment by teams of special enforcement personnel has proved to be a satisfactory substitute for driver, conductor, or automatic equipment enforcement.

These findings suggest that the SSFC concept has considerable potential for enhancing the quality and quantity of local public transportation in the United States through its provision of means by which more flexible fare structures can be adopted by U.S. transit systems and through its positive effects on service productivity. Since, however, SSFC would be a significant departure from current U.S. transit systems' fare collection procedures, a series of demonstrations are recommended in order to provide operational examples of the use of SSFC technique and equipment in a variety of settings. These demonstration projects should draw upon the operational models and accumulated experiences provided by European systems but be designed to accomodate the legal, social, institutional and labor characteristics of U.S. sites. Such demonstrations would provide both encouragement and data sources for further and continued application of SSFC techniques. Through demonstration, the feasibility and workability of these techniques can be tested and evaluated, the nature and extent of benefits to be gained can be identified, and a body of data assembled for use by interested transit properties. The working SSFC systems established through demonstration projects can then be used to test a variety of pricing and/or service innovations and strategies.

REFERENCES

(1) H. Werz, "Automatic Fare Collection in Surface Transport", Proceedings of the 40th International Congress of the International Union of Public Transportation, No.7, The Hague, 1973.

(2) "Verwaltungsbericht-1977", (Annual Report), Städtische Verkehrsbetriebe Bern, 1978.

(3) "Rapport du conseil d'administration et du collège des commissaires à l'assemblée générale des associés", (Annual Report-1977), Société Des Transports Intercommunaux De Bruxelles, May 1978.

(4) "Beretning og regnskab HT-1977", (Annual Report), Hovedstadsområdets Trafikselskab, 1978.

(5) "Rapport de Gestion 1977", (Annual Report-1977), Transports Publics Genevois, April 1978.

(6) "Jaarverslag-1977", (Annual Report-1977), Haagsche Tramweg Maatschappij Den Haag, June 1978.

(7) "Dati Statistici-Servizi Urbani ed Interurbani-anno 1977". (Operating Statistics Pamphlet-1977), Azienda Trasporti Municipali Milano, 1978.

(8) "Report '75". (Annual Report-1975), Münchner Verkehrs- und Tarifverbund GmbH, June 1976.

(9) "Rapport Annuel-1977", (Annual Report-1977), Régie Autonome Des Transports Parisiens, May 1978.

(10) W. Latscha, "Progress in Automatic Fare Collection", Proceedings of the 37th International Congress of the International Union of Public Transportation, No.7, Barcelona, 1967.

(11) "Conto Consuntivo Dell' esercizio 1976", (Annual Report-1976), Azienda Trasporti Municipali-Milano, July 1977.

(12) "Auszug aus dem Tarif SVB", (Tariff Structure Brochure), Städtische Verkehrsbetriebe Bern, May 1977.

(13) "Société Des Transports Intercommunaux De Bruxelles-Tarifs", (Tariff Structure Brochure), August 1978.

(14) "Fahrplan '78", (Tariff Structure Report-78), Kölner Verkehrs-Betriebe AG, August 1978.

(15) "i hovedtal", (Operating Statistics Brochure), Hovedstadsområdets Trafikselkab, 1978.

(16) "Køre plan-busser og tog i hovedstadsområdet", (Tariff Structure Report), Hovedstadsområdets Trafikselskab, October 1978.

(17) "Rheinbahn Fahrplan 78/79", (Tariff Structure Report-78/79), Rheinische Bahngesellschaft AG, May 1978.

(18) "Transports Punlics Genevois-Tarif", (Tariff Structure Brochure), Transports Publics Genevois, August 1977.

(19) "Nieuwe tarieven ingaande oktober 1978", (Tariff Structure Brochure), Haagsche Tramweg Maatschappij Den Haag, October 1978.

(20) "Le nuove tariffe a «zone» sulle linee extraurbane dell'A.T.M.", (Tariff Structure Poster), Azienda Trasporti Municipali-Milano, July 1978.

(21) "MVV Verbund-Fahrplan-Winter 1978/79", (Tariff Sturcture Report-Winter 1978/79), Münchner Verkehrs- und Tarifverbund GmbH, October 1978.

(22) "Bartarif-Schemaplan für den Innenraum", (Inner City Transit Map), Münchner Verkehrs- und Tarifverbund GmbH, October 1978.

(23) "Metro et RER, funiculaire de Montmarte-Tarif", (Tariff Structure Brochure), Regie Autonome Des Transports Parisiens, July 1978.

(24) "Resultater af billetkontrol i Hovedstadsområdet-1977", (Fraud Statistics Brochure), Hovedstadsområdets Trafikselskab, January 1978.

(25) "Urban Transport-Presentation of Modern Fare Collection", Manufacturers Presentation, CAMP, (Société de Construction d'Appareils Mécaniques de Précision), Paris, 1978.

(26) Eiseman, Gloria G., "Self-Service Fare Collection--Review of Legal and Labor Issues Affecting U.S. Implementation," MTR-79W00119, The MITRE Corporation, McLean, VA., May, 1979.

APPENDIX A
ANNOTATED BIBLIOGRAPHY

Parody, Thomas E., and Daniel Brand, "Forecasting Demand and Revenue for Transit Prepaid Pass and Fare Alternatives", Presented at the 58th Annual Meeting of the Transportation Research Board, Washington, D.C., January 1979.

This paper presents a relatively quick and low-cost methodology for forecasting the demand and revenue impacts of alternative transit fare prepayment (TFP) instruments and transit fares. In addition, alternative TFP strategies and their price implications are derived in some detail from basic TFP objectives. The forecasting technique focuses on computing price elasticities by individual market segments using data from previous transit fare and service changes and then applying these results to forecast changes to the present transit system. The market segments are chosen so as to correspond with the issues being analyzed, thereby increasing the usefulness and accuracy of the procedure.

To illustrate how the technique can be used to forecast the impacts of different monthly transit pass programs along with increases in transit fares, a case study approach is used with local data from the Jacksonville, Florida transit system. The data required in the analyses are typically available from most transit properties; the methodology, is therefore, readily transferable to other areas.

Vendeventer, Ed, and Joel Woodhull, "S.C.R.T.D. Case Study: A Change From Flat Fares to Distance-Based Fares", Presented at the Transit Pricing Forum, Virginia Beach, Virginia, March 28-29, 1979.

The fare system previously used by the Southern California Rapid Transit District was a distance-based zone fare system. The fare for a trip on the system is determined by the bus driver. The number of fare possibilities caused problems and in 1974 a flat fare system was adopted to eliminate the many fare computations that were necessary. However, the flat fare system resulted in a subsidy to long-distance riders. To correct this, a zone system with a two zone base fare was implemented in 1975. Problems continued to persist, so in 1977 a distance-based express-bus fare system and a flat fare local bus fare system were adopted. This system simplified the bus driver's role and helped to reduce the conflict between suburban and city fares. In the year and a half of operating under its new fare structure, increases in the operating ratio, average fare paid, and ridership; decreases in the mileage operated; and an unchanged cost per passenger have resulted.

Canadian Surface Transportation Administration, Urban Transportation Research Branch, A Study of Transit Fare Policies, Fare Structures and Fare Collection Methods, A Working Paper, TP909, by Precursor, Ltd. Montreal, April 1978.

The project studies and brings together material on the three elements of transit revenue collection: fare policies, fare structures, and fare collection methods. Both theoretical aspects and practical experiences are examined through literature research, visits to transit properties, and meetings with manufacturers of fare collection equipment. Extensive information is collected in each of the three study areas with a representative sample of the data being presented. The material collected is presented as a review of the current status of the subject, and relates areas which are only just beginning to gain prominence.

Lippert, Dieter, "Vandalism Problems in Public Transport Systems", Public Transport Systems in Urban Areas, Vol. A2, International Conference and Exhibition, Swedish Trade Fair Foundation, Göteborg, Sweden, June 27-30, 1978.

In 1972 the Munich Transit and Tariff Corporation (MVV) was formed from a merger of pre-existing companies. It combined already existing transit and rail operations in the Munich area into one. At the same time, one-man operation of all trams and buses and a passenger self-service ticket operations were introduced. This resulted in an alienation of riders as a result of decreased personal interaction with transit employees, and increase in machine vandalism, and "free riders".

The U-Bahn, located primarily in densely populated areas and staffed 24 hours a day, had a lesser amount of damage due to vandals than the S-Bahn. However, when their police were transferred to another governmental level, they had to be replaced and it was not possible to establish an armed force due to financial reasons. Therefore the "ZSD" (Civilian Security Service) was formed.

Four reasons have been given for the decrease in vandalism since 1975:

1. "Damage is no longer possible or does not have such spectavular consequences"

2. Remote monitoring of stations

3. An effort was made to inform people that "public facilities are the property of the citizens themselves"

4. Police officers were encouraged to use public transport whenever in uniform.

Meyers, Edward T., "All's Fare", Modern Railroads, September 1978.

North American transit operators are concerned with charging reasonable fares that will both maintain ridership and help support operations, so that a suitable revenue/cost ratio is achieved. New and established transit operations have the same financial problems whether they have computerized magnetically encoded tickets or tokens (WMATA and Bart vs. NYCTA and PATH). Some undertakings have experimented with various forms of pre-paid passes, multi-ride tickets, and discounts for the elderly, handicapped, and students. In support of available fare options, more work needs to be done to reinforce the logic for the deficit operation of transit.

"PATH Test Automatic Ticket Cancelling System", Metro, September/October 1978.

The Port Authority Trans Hudson (PATH) plans to install an automatic ticket cancelling system on a permanent basis after completing six month test of Vapor Almex cancelling machines. Favorable machine performance and reliability and passenger acceptance were found.

Pedersen, Alfred E., "The Biggest Bargain in Denmark", Mass Transit, June 1978.

A reorganization of mass transit in Copenhagen started in 1973 and finished approximately in January 1979. This resulted in new transit and planning districts, elimination of trams, and an effort toward a SSFC system useable on a coordinated network of bus and rail.

Scheiner, James L., and Subash R. Mundle, "Cost Analysis of Current U.S. Surface Transit Fare Collection Systems", Presented at the 57th Annual Meeting of the Transportation Research Board, Washington, D.C., January 1978.

This research effort quantified the direct capital and operating costs of fare collection. Based on 1976 reproduction costs and an average 15-year life for fare collection equipment, the annual depreciation cost for systems with non-registering fareboxes was $38.00 per peak vehicle, compared with $225.00 per peak vehicle for registering systems. These depreciation costs average less than one-tenth cent per vehicle mile for non-registering, and just over one-half cent for registering. Annual operating cost of fare collection (including personnel, materials and supplies, service contracts, and accidents and insurance) for six case-study systems varied from a low of 1.3 percent to a high of 2.9 percent of the total operating cost. Although fare collection operating cost is very much dependent on particular procedures followed by the system, the two largest case-study systems--Seattle METRO and MBTA Surface Transit--each spent slightly less than 1.5 percent of their total operating cost on fare collection activities. The smallest case-study system, Westport Transit District, spent the largest porportion of total operating costs--2.9 percent --on fare collection. Fare collection activities were also observed to be quite labor-intensive. More than 84 percent of total fare collection operating costs for six case-study systems involved personnel costs.

Overall, the transit industry's practice of requiring exact cash fare on-board the bus is an inexpensive way to collect revenue, averaging under 2 percent of total operating cost. However, the placing of the administrative burden of fare payment on the consumer, while inexpensive, may not be efficient. The unanswered question of this study is: "Would a more convenient fare payment system attract sufficient additional revenue to offset the extra fare collection costs?"

U.S. Department of Transportation, Urban Mass Transportation Administration. Proceedings of the First National Conference on Transit Performance, Public Technology, Inc., NTIS, January 1978.

These proceedings include the addresses, issues and resource papers given at the conference along with summaries of problems and recommendations developed in workshop sessions. Subjects include trends in transit performance; concepts and indicators; revenue policy and pricing; service characteristics; labor-management relations; internal management; transit performance indicators; case studies of New York City, Southern California Rapid Transit District and Seattle Metro; the effects of fare changes; and an annotated bibliography.

White, Peter. "The Development of Monthly Travel Passes on European Urban Public Transport Systems", Public Transport Systems in Urban Areas, Vol. A2, International Conference and Exhibition, Swedish Trade Fair Foundation, Göteborg, Sweden, June 27-30, 1978.

Monthly travel passes have been introduced in European transport systems for several reasons: reduced operating costs, improved cash flow, simplified cash handling and control, and stimulation of off-peak travel. Monthly passes can also directly affect the passenger through reduced boarding time, reduced transfer time, equalization of perceived transit and auto costs, and improved transit image. It is suggested that surveys should be undertaken to provide an estimate for the number of trips per pass per month.

Appelmans, Paul, and Jacques Devroye, "Commerical Speed as a Productivity Factor in Urban Public Transport", International Union of Public Transport Review 26(1977):287-291.

Many factors are related to the concept of commercial speed. Route speed and deadhead time are two of its components. It is affected by punctuality, road conditions, vehicle types, methods of fare collection, the route layout including the location of stops, and various human factors. Commercial speed can be improved by making use of priorities for transport vehicles (in traffic), limitation of on-street parking, staggered work hours, and technical and conceptual planning. Each specific undertaking should be examined to determine additional aspects that can improve commercial speed in an area.

Naftalin, Arthur. "Mass Transit in Hamburg", Transportation Engineering, September 1977.

Mass transit in and around Hamburg has achieved a measure of success unparalleled elsewhere. It has overcome government fragmentation and developed an intergovernmental plan to guide the region's settlement and achieve transit ridership and development benefits. The success is due to the post WW II decision to rebuild the city on a traditional pattern and the city's unusually strong civil pride; the general public in Hamburg regards governmental direction and planning as desirable and essential, and public transit serves all social classes in Hamburg. However, the integrated system of bus, surface rail, underground, tram, and boat, faces a critical period as private auto use continues to increase.

Gutknecht, R., "Two-Part Fares--A New Marketing Instrument in Short-Distance Passenger Transport?", International Union of Public Transport Review 25(1976):292-294.

A "basic-charge" fare system that had been tried in the early fifties has recently been proposed (in an updated form) as an alternative fare structure. The "basic-charge" system divides a fare into two parts, one representing the fixed costs and the other the variable costs. This would be similar to the rate structures used by electric utilities. This has partially been carried out through the subsidization of capital equipment and encouraged by the introduction of "magnetic fare cards". However, the concept has not actually been tried in recent years.

Herskey, W.R.; D.J. Forkenbrack; M.J. Berla; B.A. Miller, and M.E. Dewey, Transit Fare Payment, Ann Arbor: The Huron River Group, Inc., August 1976.

Fare payment encompases all methods of paying for transit rides other than cash. Types of prepayment include: (1) those which allow the purchaser a fixed number of rides, usually over an unlimited time period (tickets, tockens, punch cards); and (2) those which are valid for an unlimited number of rides over a fixed time period (passes, permits).

A mail survey was first conducted to determine prepayment practices of a large sample of transit operators. This was followed by a detailed telephone survey of 146 operators, in which characteristics of both the systems and their prepayment plans were ascertained.

Four distinct user surveys were conducted to investigate the decisions made among available payment methods. Response to prepayment options seems to vary with trip purpose, frequency of transit use, and user characteristics. Employer-sponsored programs for distribution and/or subsidizing prepayment instruments are popular among users and seem to have significant potential.

The study concludes that fare prepayment can be an important element of a transit system's marketing program, both for attracting and holding riders and for building the system's image. More attention needs to be given to assuring that the transit operator's fare prepayment components fit together into a rational, comprehensive fare structure.

N.D. Lea Transportation Research Corporation. Passenger Admission Processing Systems, Lea Transit Compenduim, Current International Developments in Transit Technology, Volume III, Special Issue, 1976-1977.

This publication surveys passenger admission processing systems--all "procedures used by transit system operators to provide orderly, lawful passage of passengers through the transit system from point of entry to point of exit". Transit properties world-wide are surveyed. Data presented includes descriptions of and information concerning their status, fare collection procedures, passenger admission and revenue control, passenger flow, equipment manufacturer, and any problem or limitations that they have encountered.

U.S. Department of Transportation, Office of Transportation Systems Analysis and Information. Labor in the Transit Industry, by Dr. Robert C. Leib, Northeastern University. Washington, D.C.: Government Printing Office, May 1976.

The labor component of the transit industry in the United States has a pervasive impact on the industry. Labor compensation is the major operating cost element in most transit activities, comprising approximately 65 percent of the industry's operating expenses in 1974. In addition to its cost significance, transit labor, through its bargaining patterns and work agreements, influence such matters as service continuity and productivity.

This study examines the labor components of the transit industry to provide information which might be useful in developing future policies and programs. Among the matters examined are employment and compensation trends, labor/management relations, government involvement in transit labor, and employee productivity.

"Fare Collection Systems: A Review and Prognosis", Metro, November/December 1975.

A review is conducted of the fare collection equipment used in the United States. Its development is traced from the first Johnson fare box in 1905 to the Keene Vaccuum/ARCOM system introduced in 1968, and Cubic-Western Data's magnetized ticket developed for the Bay Area Rapid Transit system, the Central Gulf Railroad, and the Washington Metropolitan Area Transit Authority in Washington, D.C. These changes in fare collection systems are accompanied by different exact fare, security, statistical, and coin handling features.

J.W. Leas and Associates. The Selection of a Fare Collection System for MARTA's Integrated Bus/Rapid Transit Operation, Technical Report, Bryn Mawr, Pennsylvania, August 1975.

Six different fare collection systems were proposed for MARTA's integrated bus/rapid transit system. One no-barrier (self-service) and five barrier systems are considered. The basic criteria used to identify the recommended system were simplicity for patrons, minimal cost for procurement, operation and maintenance, minimal handling of monies in the purchase of a flat or reduced fare on both the bus and rapid transit networks and their interchanges, and the absence of station personnel. The chosen system is a barrier system using tokens, coins, passes, and transfers.

The Metropolitan Atlanta Rapid Transit Authority. Summary Report: Fraud Estimation Phase of the Fare Collection Study, September 1975.

The expected amount of fraud on a self-service fare collection system is estimated using European experience and analogous American "honor" situations. The most significant indicator of expected fraud is population size and the existance of rapid transit (No correlation with passenger income was found.). There is likely to be compliance if cost is low and penalties are high, but the best way to reduce fraud is to use public embarrassment as a deterrent coupled with the sale of passes and a fair and impartial enforcement policy.

U.S. Department of Transportation, Office of the Secretary, Office of Economic Analysis. Urban Transportation Decision-Making (Hamburg: Case Study), by Frank C. Colcord and Ronald S. Lewis, Tufts University, NTIS, January 1974.

Hamburg has an extensive transportation network, but no urban freeways. The road system is severely congested, affecting commuters and buses. Hamburg's transit system is multi-modal and quite large. The commitment to transit was made in 1904, and the system is still expanding. It handles approximately 70 percent of the commuters. The one problem it does have is automobiles. To improve both automobile transportation and transit, it is necessary to discourage auto travel (through parking reductions, auto free zones, etc.) in addition to continuing Hamburg's excellent transit operations.

Gutknecht, Dr. B., "Alternative Approaches to Public Transport Fares With Their Traffic and Revenue Implications", Proceedings of the 40th International Congress of the International Union of Public Transportation, No.5, The Hague, 1973.

This paper reports the findings of an investigation into alternative fare structures and their effects on transport services and revenue. Supply and demand and the elasticity of demand in relation to changes in fares are examined. Fares are optimum if they guarantee the absolute amount of revenue which is not affected by an increase or reduction of fares (price elasticity being unknown). The author concludes that "the scope for entrepeneurial actions has narrowed without exception, though to a varying degree, but many undertakings have not resigned themselves to the situation and are trying to operate fare policies within the remaining margin". This conclusion is followed by an evaluation of alternative fare systems. A separate section is devoted to free travel. A summary of the results of a survey of specific transit undertakings is included.

Hoel, Lester A. "What's New in Transit in Europe?", Technology Review, July/August 1973.

European countries have recognized the importance of the central city and transportation's role in maintaining the vitality of the city. Thus they have not let their investments in the public transit serving it deteriorate. Seven cities are selected that represent the various techniques that have been used to encourage transit use: Hamburg, innovation through cooperation; Gothenburg, restricting autos in the central cities; Montreal, a new underground metro of function and beauty; London and Paris, renewing older systems as needs changes; Rotterdam, a new Metro with construction problems and Runcorn, England, a new auto-free city with an exclusive busway. Europeans have tried to maintain and enhance cities by improving accessibility to city centers through better public transport and by enforcing accessibility within the CBD with streets reserved for pedestrians, shopping malls, etc. In Europe, innovations are accepted as necessary for the continued vitality of public transport and cities.

Werz, H., "Automatic Fare Collection in Surface Transport", Proceedings of the 40th International Congress of the International Union of Public Transport, No.7, The Hague, 1973.

The paper documents the spread of automatic fare collection and provides numerical data for transport systems intending to introduce it. Questionnaire replies received from 84 urban surface transport undertakings are analyzed and tabulated. One-man service and semiautomatic collection are the most frequently used in the U.S., France, and in the Benelux and Scandinavian countries. Germany, which uses the semiautomatic system, is now well on the way to complete automation. Six types of automatic systems are described and their advantages and disadvantages are discussed. The question of fraud prevention is reviewed, and the information obtained from transport organizations is tabulated. The percentages of loss of receipts of different systems are compared, and explanations are offered. Auxiliary services in connection with automatic collection are also outlined.

The economic aspects of the automatic system are detailed. Multi-journey tickets and the motives behind the introduction of automatic systems are discussed. The report concludes that fully automatic fare collection is not the most economic solution for undertakings in which drivers can be induced to perform secondary fare collection functions. A system which involves the installation of issuing and cancelling machines at the stops, is considered the most desirable form of automatic fare collection.

Fiedler, Joachin, "Economic Aspects of the Problem of Fare Evasion", International Union of Public Transport Review 17(1968):62-70.

Due to recent staff shortages and the need to introduce more economic operating methods, many transit facilities have introduced new forms of fare collection which place greater responsibility on passengers to pay their fares without having them verified. Spot checks are made to check the fares. The number of evaders vary by type of facility with rail rapid transit having the highest percentage. This violation rate is related to the ease of unsupervised access and egress. On a driver-only bus (no conductor) with entrance through the front door, supervision is high and fraudulent travel low. The rate of checking and the amount of fraud are mathematically related. A survey of fraud and a study of the time schedule of operations combined with knowledge of the type of facility can determine the amount and scheduling of checking required and can help to reduce fraud and deficits, thus maximizing profit.

Cirenel, M., "Mechanization of Ticket Issuing and Ticket Control on Metropolitan Railways", Proceedings of the 37th International Congress of the International Union of Public Transportation, No.3, Barcelona, 1967.

Rapid transit systems have implemented various types of mechanized fare collection procedures. Where platform loadings are involved, fare collection is easily implemented through the control of access and egress to the station area. Some type of machinery should be provided to reduce labor requirements and ensure the economical operation of the system. The machinery should be convenient, adaptable to changes in the fare structure, protect against fare evasion, be simple to operate, inexpensive, and facilitate centralized bookkeeping.

Latscha, W., "Progress in Automatic Fare Collection", Proceedings of the 37th International Congress of the International Union of Public Transportation, No.7, Barcelona, 1967.

A survey of 108 transit systems was conducted, revealing a trend toward one-man vehicle operation and the mechanization of fare collection brought about by economic and staffing problems. These developments have been assisted by improvements in ticket canceling and issuing machines, vehicle design, door operation, and fare structures. The improvements have been necessary to mitigate the loss of service time resulting from the change-over to one-man vehicle operation.

Quarre, L., "Simplification and Mechanization of Fare Collection on Public Transport Vehicles", Proceedings of the 35th International Congress of the International Union of Public Transportation, No. 7, Vienna, 1963.

The problems and characteristics of fare collection on public transport vehicles are examined. To compare the effects of implementing alternative types of fare collection, three indicies of productivity are developed. Almost one hundred different transit undertakings were surveyed, and various methods for issuing, cancelling, and inspecting tickets are discussed along with their advantages and disadvantages. It was concluded that the on-board collection of fares should be simplified, mechanized, and actively carried out to the maximum extent possible. The resultant system should improve the quality and speed of urban public transport and reduce its cost.

Robbins, R.M., and R. Postgate, "Passenger Fares: A Consideration of the Economic Aspects of Alternative Fare Structures", Proceedings of the 34th International Congress of the International Union of Public Transportation, No.7, Copenhagen, 1961.

The fare structures used by transit systems directly affects the economics of their operations. Fare structures (flat, zonal, and sectional), fare types (single, season, multiple journey, and carnets), and fare collection methods (by driver, conductor, and advance sale) all have different operational effects which are also related to characteristics of the user and his trip, i.e., simple fare structures are only appropriate with simple operations and short trip lengths. To maximize revenue and minimize costs (operating ratio-expense/revenue) of transit operations, lower labor costs of fare selling/collecting and increased vehicle capacity should be considered. Fare structure and transit policies are interdependent and should be considered as such in the transit operator's general policy.

APPENDIX B
EUROPEAN AND CANADIAN SYSTEMS SURVEYED

Bern, Switzerland

Städtische Verkehrsbetriebe Berne (SVB)
Eigerplatz 3
3007 Bern
Switzerland

Brussels, Belgium

Société des Transports Intercommunaux de Bruxelles/Maatschappij Voor Het Intercommunaal Vervoer Te Brussel (STIB/MIVB)
15 Avenue de la Toison d'Or
Bruxelles-1050
Belgium

Cologne, West Germany

Kölner Verkehrs-Betriebe (KVB)
Scheidtweilerstrasse 38
5000 Köln 41
Germany-West

Copenhagen, Denmark

Danske Statsbaner (DSB)
Sølvgade 40
1349 København K
Denmark

Hovedstadsområdets Trafikselskab (HT)
Gothersgade 53
1123 København K
Denmark

Düsseldorf, West Germany

Rheinische Bahngesellschaft (RB)
Erkrather Strasse 30
D-4000 Düsseldorf
Germany-West

Geneva, Switzerland

Transports Publics Genevois (TPG)
Avenue de la Junction
Case Postale 237
1211 Geneve 8
Switzerland

The Hague, Netherlands

Haagsche Tramweg Maatschappij (HTM)
Lijsterbesstraat 2
2563 KW's--Gravenhage
Netherlands

London, England

London Transport
55 Broadway
Westminister
London SW1H OBD
England

Milan, Italy

Azienda Trasporti Municipali-Milano (ATM)
Foro Buonaparte, 61
20 121 Milano
Italy

Munich, West Germany

Stadtwerke München Verkehrsbetriebe
Einsteinstrasse 28
D-8000 München 80
Germany-West

Münchner Verkehrs- und Tarifverbund (MVV)
Postfach
D-8000 München 26
Germany-West

Paris, France

Régie Autonome Des Transports Parisiens
14 Rue Crillon 75004
Paris
France

Vancouver, British Columbia, Canada

B.C. Hydro Transportation System
850 South West Marine Drive
Vancouver, B.C. V6P 5Z1
Canada

APPENDIX C
SELF-SERGICE EVALUATION MEASURES

IMPLEMENTATION COSTS

Capital/Installation: costs of buying and installing required equipment and making necessary vehicle modifications

Operating: Costs of servicing equipment (preventive and unscheduled maintenance); of protecting equipment against theft, vandalism and break-in; of collecting revenue from vending machines or ticket outlets; of selling additional or supplementary tickets, i.e., concessionaire fees, administrative costs

Wayside Vending/Validation

Capital/Installation: high costs

- validators and complex vending machines required at all or most stops
- vehicle doors must be modified for all doors access
- equipment must be designed for wayside use and protected from weather and climate

Operating: high costs

- amount, location and complexity of equipment requires special procedures for malfunction monitoring, maintenance, and security; mobile teams required to support these activities
- revenue must be collected from scattered and numerous vending machines by special collection units

Wayside Vending/On-Board Validation

Capital/Installation: high costs

- same as above except validators required on all vehicles
- dual installation costs

Operating: high costs

- same as above except that validators can be maintained along with vehicles and are protected from weather and climate by on-board location

Selected Location Vending/On-Board Validation

Capital/Installation: moderate, adjustable costs

- validators required on all vehicles
- vending machines are not required at all or most stops
- vending machines can be located for ease of installation and protection from adverse weather conditions
- vehicle door modification for all doors access

Operating: moderate, adjustable costs

- validators can be serviced along with vehicle and are protected by their location
- vending machines can be located in secure areas
- vending machines can also be located for maximum utilization
- revenue must be collected and alternative ticket outlets provided

Driver Monitored On-Board Validation

Capital/Installation: relatively low costs

- single validator required on all vehicles
- no vending machines required
- vehicle doors need not be altered

Operating: relatively low

- validation equipment can be maintained along with vehicle and is protected by on-board location and driver monitoring
- use of single validator could result in vehicle down-time
- arrangements must be made for off-board ticket sales

Minimal Hardware

Capital/Installation: minimal costs

- vehicle doors must be modified for all doors access

Operating: minimal costs

- no maintenance, environmental, security or special revenue collection requirements

- arrangements must be made for off-board sale of passes and for single trip payment on-board

FARE STRUCTURE FLEXIBILITY

Fare Structure Flexibility: capacity to accomodate differential fare structures, incentive and discounted fares and changes in the amount or computation of fares, and to facilitate passenger self-service.

Wayside Vending/Validation

- enables a greater variety of fare instruments to be made available; most commonly used tickets can be sold by machines in single or multi-trip form while special discounted tickets and/or passes can be sold through an outlet system

- most readily accomodates changes to fare structure since such change requires only equipment adjustments

- ability to adjust to zone pattern with minimal effects on driver and less chance of human error

- offers greatest passenger convenience since vending machines would be located at all or most stops

- readily accomodates the implementation of zoned fare structure due to fixed location of validators

Wayside Vending/On-Board Validation

- same as above except that validators require special device for implementation of zoned fare structure and create need for driver to change zones on it, increasing possibility of human error

Selected Location Vending/On-Board Validation

- same as above except for reduced passenger convenience due to restricted availability of vending machines

Driver Monitored On-Board Validation

- same as above except that no tickets can be purchased through vending machines

Minimal Hardware

- offers least accomodation for flexible fare structures since it relies on the use of passes and single trip payment on-board; incentive and discounted pricing must be done through passes; zoned fares require the attention of driver for proper receipt issuance

SERVICE/PRODUCTIVITY IMPROVEMENT

Service/Productivity Improvement: potential for increasing efficient use of vehicles and personnel, i.e., decreased dwell time, increased trip speed, minimal vehicle down time

Wayside Vending/Validation

- has greatest potential for productivity improvement
- allows all doors access since fare payment is entirely accomplished off-vehicle
- no interruption of boarding/exiting due to use of on-board validators
- decreased dwell time since driver involvement in fare payment is minimal
- no vehicle down time due to vending/validation equipment malfunction

Wayside Vending/On-Board Validation

- has relatively high potential for productivity improvement
- allows all doors access
- some interruption of boarding/exiting by passenger use of on-board validators
- decreased dwell time since driver involvement in fare payment is minimal
- some possibility of vehicle down time if all on-board validators fail at the same time

Selected Location Vending/On-Board Validation

- same as above

Driver Monitored On-Board Validation

- least potential for productivity improvement
- driver door access only
- only one validator available which slows validation process and may lead to vehicle down time if validator malfunctions

Minimal Hardware

- some potential productivity improvement
- all doors access for passholders but driver door access only for cash-paying passengers
- no vehicle down time due to validator malfunction

DECREASED DRIVER RESPONSIBILITY

Decreased Driver Responsibility: potential for reducing the number of functions a driver is to perform in addition to driving vehicle

Wayside Vending/Validation

- involves no additional driver responsibilities
- minimizes extent of on-board driver sales by making vending machines available at most stops
- decreases security responsibilities of driver, i.e., less cash to safeguard and no responsibility for monitoring and challenging fare evasion

Wayside Vending/On-Board Validation

- same as above except driver monitors operating status of validator and is responsible for zone changing

Selected Location Vending/On-Board Validation

- driver responsible only for validator status monitoring and zone changing
- limited availability of vending machines would increase extent of on-board sales by driver as compared to automated vending modes

Driver Monitored On-Board Validation

- has net effect of increasing driver responsibilities
- driver responsible for monitoring both the status and usage of validator
- driver responsible for on-board sales with no decrease in number of sales from use of vending machines

Minimal Hardware

- has little or no impact on current level of driver responsibility
- no driver responsibility for monitoring equipment or usage
- monitors all single-trip fare payment
- issues receipts/transfer documents

MINIMIZATION OF ADDITIONAL OPERATING REQUIREMENTS

Preventive Maintenance: regular examination and routine servicing of equipment

Unscheduled Maintenance: service or repair of malfunctioning equipment

Revenue Collection: provision of means for collecting fare receipts

Wayside Vending/Validation

Preventive Maintenance: high operational requirements

- requires mobile teams to inspect and maintain both vendors/validators at scattered, numerous locations

Unscheduled Maintenance: high operational requirements

- special procedures must be developed for identification of equipment malfunction, i.e., systematic monitoring, failure indicators
- mobile teams must be organized for repair of malfunctioning equipment
- isolated equipment malfunction, however, has no effect on vehicle operations although it would affect passenger convenience

Revenue Collection: high operational requirements

- revenue must be collected from scattered and numerous sites by special collection units

Wayside Vending/On-Board Validation

Preventive Maintenance: high operational requirements

- same as above except that validators can be serviced along with vehicles

Unscheduled Maintenance: high operational requirements

- same as above except that continued validator malfunction can affect vehicle operations if not redundant or easily replaceable

Revenue Collection: high operational requirements

- same as above

Selected Location Vending/On-Board Validation

Preventive Maintenance: moderate operational requirements

- validators can be routinely serviced along with vehicle

- routine servicing of vending machines would require development of special procedures; depends on number and location of machines; less extensive arrangements than would be required for wayside locations since machines could be located for convenience of maintenance, i.e., only downtown or small number of accessible locations

Unscheduled Maintenance: moderate to high operational requirements

- validator malfunction could affect vehicle operations if not redundant or easily replaceable

- special procedures may be required for identification and repair of malfunctioning vending equipment but it could be located for convenience of identification of malfunction and maintenance, i.e., only downtown or small number of accessible locations

- vending machine malfunction has no effect on vehicle operation and little effect on passenger convenience

Revenue Collection: moderate operational requirements

- revenue must be collected from vending machines; nature and extent of collection provisions would depend on number and location of machines; machines could be located for ease of collection

Driver Monitored On-Board Validation

Preventive Maintenance: relatively low operational requirements

- validators can be routinely serviced along with vehicle

- no other equipment required

Unscheduled Maintenance: highest operational requirements

- malfunction of the single validator could lead to vehicle down time if not easily replaceable

Revenue Collection:

- no special procedures necessary

Minimal Hardware

Preventive Maintenance: no additional operating requirements

Unscheduled Maintenance: no additional operating requirements

Revenue Collection: no additional operational requirements

MINIMIZATION OF SPECIAL EQUIPMENT REQUIREMENTS

Environmental: protection from climate conditions and weather

Security: protection from vandalism/break-ins

Wayside Vending/Validation

Environmental: high requirements

- vending/validation machines must be designed for wayside use and need to be protected from weather and climate, i.e., shelters or enclosures

Security: high requirements

- vending/validation machines are vulnerable to vandalism/theft/break-ins; systematic monitoring may be necessary

Wayside Vending/On-Board Validation

Environmental: highest requirements

- same as above except that validators are sheltered from direct exposure by vehicles but are not protected from thermal shock, cold storage, vibration and electro-magnetic interference (EMI)

Security: high requirements

- same as above except that validators are somwhat protected by on-board location

Selected Location Vending/On-Board Validation

Environmental: moderate requirements

- vending machines must be designed to withstand possible adverse climatic conditions but can be located where shelter is available

- validators same as above

Security: moderate requirements

- vending machines need special protection but can be placed in safe or supervised locations

- validators same as above

<u>Driver Monitored On-Board Validation</u>

Environmental: minimal requirements

- validators protected by on-board location from weather/climate but not protected from thermal shock, cold storage, vibration and electromagnetic interference (EMI)

- no vending machine requirements

Security: minimal requirements

- validators protected by location and driver monitoring

- no vending machine requirements

<u>Minimal Hardware</u>

Environmental: no requirements

Security: no requirements

MINIMIZATION OF REQUIRED MODIFICATOPM TO PRESENT SYSTEM

Vehicle Inventory: vehicle compatibility and the extent of alterations required on vehicles in present system, e.g., door configuration, equipment installation

Transfer Procedures: provision of surrenderable transfer document

Wayside Vending/Validation

Vehicle Inventory: significant vehicle alterations required

- no equipment installed on vehicles
- door configuration must be suitable for all doors access

Transfer Procedures: high modification requirements

- procedures and/or equipment would have to be adjusted in order to make surrenderable document unnecessary or available

Wayside Vending/On-Board Validation

Vehicle Inventory: substantial modification required

- installation of multiple validators on vehicles
- door configuration must be suitable for all doors access

Transfer Procedure: high modification requirements

- same as above

Selected Location Vending/On-Board Validation

Vehicle Inventory: same as above

Transfer Procedures: same as above

Driver Monitored On-Board Validation

Vehicle Inventory: minimal modification

- no door configuration change required
- must be space for one validator near driver

Transfer Procedures: minimal modification

- driver can sell tickets and issue transfer documents

Minimal Hardware

Vehicle Inventory: significant modification

- door configuration must be suitable for all door access
- no space requirement for validators

Transfer Procedures: minimal modification

- driver has to issue receipts; receipts substitute for transfer documents

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