CHAPTER 4

FARE STRUCTURE DEVELOPMENT AND EVALUATION PROCESS AND EFFECTS

INTRODUCTION

Thus far, this report has described the general approach to making fare-related decisions in the transit industry. Chapter 2 reviewed the development of fare policy and the overall fare decision-making process, while Chapter 3 discussed the range of fare strategies and payment options, as well as the general process for evaluating alternative strategies. This chapter examines the specific methodologies that various transit agencies use to develop and evaluate fare structure modifications. This chapter also assesses the effects of the resulting fare decisions on ridership and revenue. The information presented here is based on the findings of the case studies carried out as part of the project. (Although this chapter focuses on the fare structure aspects of the case studies, some of the case studies also looked at the selection and procurement of new fare collection technologies and equipment; these findings are discussed in Chapter 8. The case studies themselves are presented in a separate document.)

THE CASE STUDY PROCESS

Selection of Case Study Sites

To develop an understanding of the issues and methods used by transit agencies of different sizes and modal orientations in making fare-related decisions, the project team conducted detailed case studies of 12 U.S. transit agencies. Candidate agencies were identified on the basis of the background research conducted in the initial phase of the project. The selection focused on agencies that were known either to have done significant fare restructuring or implemented innovative fare structures or to have implemented—or be planning to acquire—electronic fare collection systems, media distribution systems, or both. In addition to the 12 case study sites, the team identified a set of "backup" sites—for use if the information available from any of the original sites was insufficient. The case study sites were presented to the Project A-1 Panel for approval, following consideration of 60 potential sites.

Table 26 lists the case study sites and backups, grouped by size (monthly ridership). The distribution of case studies was as follows:

- Largest systems—3 (CTA, MBTA, and NJT)
- Very large systems—1 (Seattle/King County Metro)
- Large systems—3 (BSDA, DART, and OCTA)
- Medium systems—1 (TARC)
- Small systems—2 (MVRTA, Madison Metro)
- Very small systems—1 (GLPTC)
- Commuter rail systems—1 (SCRRA)

The Case Study Agencies

The case studies focused on two key issues: fare collection/distribution technology and fare policy/structure. In six of the cases (CTA, MBTA, NJT, Seattle Metro, MVRTA, and SCRRA), the researchers considered technological improvements—along with structural changes. These systems have or are procuring new equipment. MVRTA has magnetic card readers, CTA and MBTA are in the electronic fare collection equipment procurement process, NJT is procuring ticket vending machines (TVMs), and SCRRA, a new system, recently acquired its automated vending machines (AVMs). The findings related to selection of technology are presented in Chapter 8. In the other six case studies, the researchers focused on structural changes only. In each of these cases—and in several of the former—a significant structural change has been introduced recently (i.e., within the last couple of years). This list of cases represents a broad range of fare structures. Information on the basic fare structures, along with other general information, is presented in Table 27. The key fare-related aspects of each case are summarized as follows:

- CTA (Chicago)—CTA undertook major fare structure evaluations in 1986 and 1989 and implemented a market-based restructuring in 1990, with several changes in fare levels and types and prices of passes since then. CTA is procuring electronic fare collection equipment.
- MBTA (Boston)—MBTA plans to procure a new electronic fare collection system; it has a zonal system with a service-based differential (higher fare on rail than on bus).
- NJT (New Jersey)—NJT operates a statewide bus, LRT, and commuter rail system and has a complicated zonal fare structure; this structure was recently simplified considerably. NJT has used innovative fare research and evaluation procedures. In addition, NJT has installed electronic registering fareboxes and is acquiring AVMs.
- Seattle/King County Metro—Seattle Metro recently installed electronic registering fareboxes and considered the purchase of bus ticket processing units; this will facilitate the use of post payment for employer-subsidized passes. Seattle Metro also sells monthly passes through ATMs. Finally, Metro—along with the other operators—is studying regional fare integration options.

TABLE 26 Case studies and backups

Location/System	Mode: HR	Mode: LR	Mode: Bus	Mode: CR	Category: Struc.	Category: Tech.	Key issue of interest
Largest Systems (> 10 million passengers/mo.)							
NYMTA	X		X		X	X	new AFC, devel. structure
CTA	**X**		**X**		**X**	**X**	**new AFC, devel. structure**
MBTA	**X**	**X**	**X**	**X**	**X**	**X**	**new AFC, devel. structure**
SEPTA	X	X	X	X	X		first deep disc, 80% prepay
NJ Transit		**X**	**X**	**X**	**X**	**X**	**complex struc., innov. eval.**
Very Large Systems (5-10 million passengers/mo.)							
MTA (Balt.)	X	X	X	X		X	has AFC, dist.-based
Metro (Seattle)			**X**		**X**	**X**	**TRiM units, postpayment**
Metro (Houston)			X			X	TRiM units, smart bus
AC Transit (Oakland)			X		X		deep disc.
Large Systems (2-5 million passengers/mo.)							
BSDA (St. Louis)		**X**	**X**		**X**		**simp. struc,. deep disc, new LRT**
SD Trolley/SDTC		X	X				regional integ. w/o AFC
DART (Dallas)			**X**		**X**		**reduced fare, elim. zones**
RTD (Denver)			X		X		deep disc, annual pass
OCTA (Orange Co, CA)			**X**		**X**		**annual fare inc., doing restruc.**
Medium Systems (1-2 mllion passengers/mo.)							
TARC (Louisville)			**X**		**X**		**recent deep disc.**
GRTC (Richmond)			X		X		deep disc., no pass
Small Systems (500,000-1 million passengers/mo.)							
MVRTA (Dayton)			**X**		**X**	**X**	**mag. rdr, deep disc.**
Metro (Madison)			**X**		**X**		**deep disc.**
TTDC (Norfolk)			X		X		deep disc., fare cutter
STA (Spokane)			X			X	mag. rdr.
Very Small Systems (<500,000 passsengers/mo.)							
LANTA (Allentown, PA)			X		X		deep disc.
GRATA (Grand Rapids)			X		X		deep disc.
GLPTC (Lafayette, IN)			**X**		**X**		**deep disc.**
Commuter Rail Systems							
SCRRA (So. Calif.)				**X**	**X**	**X**	**new system**
MNCR/LIRR (New York)				X		X	studying new tech.

- BSDA (St. Louis)—BSDA recently opened a light rail line; the fare structure was revamped (simplified) in conjunction with the introduction of LRT, although the structure remains complicated because of its unique two-state and multiple jurisdiction service and funding arrangement—each jurisdiction can set its own fares.
- DART (Dallas)—DART has instituted two unusual fare restructurings: 1) reducing the cash fare and 2) raising it to its previous level but subsequently eliminating the zonal structure. DART recently developed a new structure, using innovative research methods; it will be implementing LRT and commuter rail in the next 2 years and is procuring AVMs.
- OCTA (Orange County, California) — OCTA has changed various aspects of its fare structure every 1 to 2 years; these changes have included eliminating, and

TABLE 27 Case study properties—overview

Property	Service Area Population (million)	Annual Passengers (000)	Modes: Heavy Rail	Modes: Light Rail	Modes: Bus	Modes: Comm. Rail	Type of Fare Structure	Current Cash Fare (Peak)
CTA (Chicago)	3.70	508,720	X		X		flat, p/o-p*	$1.50
MBTA (Boston)	2.60	303,737	X	X	X	X	zonal, bus/rail diff.	$0.85/$0.60+
NJ Transit	7.50	160,561		X	X	X	zonal	$1.20/1.00+
Metro (Seattle)	1.60	83,653			X		zonal, p/o-p	$1.10
BSDA (St. Louis)	2.30	42,873		X	X		flat	$1.00
DART (Dallas)	1.70	50,362		X**	X	X	flat	$1.00
OCTA (Orange Co., CA)	2.40	46,266			X		flat	$1.00
TARC (Louisville)	0.80	24,912			X		flat, p/o-p	$0.85
MVRTA (Dayton, OH)	0.60	13,708			X		flat	$0.90
Madison (WI) Metro	0.20	9,303			X		flat	$1.00
GLPTC (Lafayette, IN)	0.10	1,862			X		flat	$0.50
SCRRA (So. Calif)	NA	2,500				X	zonal, p/o-p	$3.50

* Peak/off-peak on bus only
+ Rail/bus cash fares (MBTA, NJT)
** LRT to open in 1996

Annual Passengers = unlinked trips (1992 Section 15 data)

subsequently reintroducing, discounted tickets; introducing and then eliminating a peak/off-peak differential; introducing and then eliminating an express surcharge; and several changes to its transfer policy and pricing.

- TARC (Louisville, Kentucky)—TARC recently (1993) implemented a deep discount plan. TARC had not changed fares since 1980.
- MVRTA (Dayton, Ohio)—MVRTA is one of the smallest—and was one of the first—systems to install magnetic card readers on its buses; MVRTA instituted a deep discount fare structure in 1993, the first fare change since 1982.
- Madison Metro (Madison, Wisconsin)—Madison Metro implemented a deep discount plan in 1991 and has experienced considerable success in terms of the effect on ridership and revenue.
- GLPTC (Lafayette, Indiana)—GLPTC implemented a deep discount plan as a promotion and then made it permanent because of its strong support from riders.
- SCRRA Metrolink (Southern California)—SCRRA, a relatively new system, has already adjusted its distance-based fare structure to increase ridership; it is considering some further restructuring. The agency has AVMs that accept credit and debit cards.

The case study agencies have different types of fare structures. The key fare structure elements, summarized in Tables 28 and 29, are as follows:

- Fare differentiation by distance, time-of-day, type of service, or combinations thereof; as shown in Table 28, four of the agencies have some type of zonal or distance-based structure, four have a peak/off-peak differential, and four have an express surcharge or bus/rail differential. Four of the agencies have none of these types of fare differential.
- Transfer pricing—as shown in Table 28, two of the agencies have no intramodal discounted transfer charge (actually, MBTA does offer free intrastation transfers on its rapid rail lines), two charge $0.10, and the others offer free intramodal transfers. Only SCRRA offers free intermodal transfers (depending on the specific agreements with the bus operators with which it intersects).
- Prepaid options—as shown in Table 29, all of the agencies offer a monthly pass, with breakeven levels ranging from 24 to 59 trips per month; only two of the agencies provide weekly passes (none offers biweekly passes); all but two (MBTA and Seattle Metro) offer discounted multi-ride tickets or tokens (These agencies each recently eliminated bulk purchase discounts; this is discussed later in this chapter).

Table 28 indicates that all of the case study agencies have made fare changes within the last several years. Over two-thirds of the agencies have made changes since January 1993, and one of the others (NJT) may revise its fare structure soon. Only GLPTC, the smallest of the case study agencies, has now gone longer than 5 years without modifying its fares.

These case studies provide interesting insights into the different approaches transit agencies take in developing and applying fare policies and in making decisions regarding fare changes in both the structural and technological areas. The case studies have also provided an opportunity to assess the true effect of fare changes on transit use.

The Case Study Process

The general approach to collecting and analyzing data was as follows:

- A letter introducing the project and the case study analysis framework was sent to a contact person at each of the selected agencies. In some cases, this was the General Manager, in others, the head of planning, revenue collection, finance, or some other relevant department.
- A follow-up call was made to elicit 1) a commitment to participate and 2) the name of the contact person (if different from the initial contact).
- Information was requested, and, where deemed appropriate by the researcher, a site visit was arranged. Follow-up calls were made, where necessary, to request additional data or, in several cases, to reiterate the request for initial data.
- Data were reviewed and analyzed, and additional data were requested, if necessary.
- The draft case study was written up and submitted to the agency contact person for review. Case studies were then revised as needed.

The individual case studies describe the experiences of each of these agencies in their efforts to develop fare policies and evaluate potential improvements, as well as the effects of the fare changes they have made and (where appropriate) their equipment procurement processes. These reviews are presented in a separate report, *Fare Policies, Structures, and Technologies: Case Studies.* The rest of Chapter 4, along with Chapter 8, summarizes and analyzes the case study findings.

TABLE 28 Case study current fare structures

Agency	Effective Date of Fare Structure	Cash Fare (Peak)	Differential Fares			Transfers	
			Zone	Speed	Time	Same Mode	Diff. Mode
CTA (Chicago)	Aug. 93	$1.50		$1.75	$1.25*	free	$0.30
MBTA (Boston)	Sept 91	$0.85/$0.60	$1.25	$1.50		free (HR only)	none (full fare)
NJ Transit	Jul. 90	$1.20/$1.00	**			none	none***
Metro (Seattle)	Feb. 93	$1.10	$1 50		$0 85	free	
BSDA (St. Louis)	Aug. 93	$1.00				$0.10	$0.10
DART (Dallas)	Jan. 95	$1.00		$2 00		free	
OCTA (Orange Co , CA)	Jul. 94	$1.00				free	varies+
TARC (Louisville)	Oct. 93	$0.85			$0.50	free	
MVRTA (Dayton, OH)	Apr. 93	$0.90		$1.00		free	
Madison (WI) Metro	Mar. 93	$1.00				free	
GLPTC (Lafayette, IN)	Feb. 88	$0.50				$0.10	
SCRRA (So. Calif)	Mar. 94	$3.50	$1/zone		$0.75	NA	free++

* CTA: peak/off-peak on bus only

** NJT has complex zone structure. The local bus fare for a 10-mile trip is $1.90; the local rail fare for a 10-mile trip is $1.95.

*** NJT charges an incremental zonal fee for rail feeder trips.

\+ OCTA has various transfer agreements connecting operators.

++ SCRAA: maximum one-way fare is $9.50 (7 zones); SCRAA has transfer agreements with connecting operators.

TABLE 29 Case study prepaid fare options

Agency	Monthly Pass		Weekly Pass		Other Prepaid Options (% Savings)
	Price*	Breakeven**	Price	Breakeven	
CTA (Chicago)	$88 00	59			10 Tokens @ 12 50 (17% discount)
MBTA (Boston)	$20-72	33			none
NJ Transit					various discounts, depending on mode and zones
• Local Bus/LRT	$28-56	37			
• Inter-town Bus/Comm. Rail	$90-270	28			
Metro (Seattle)	$39 50-57 50	36-38			3-mo pass $109; annual pass $435
BSDA (St Louis)	$35 00	35	$11 00	11	10 tickets @ $8 (20% discount)
DART (Dallas)	$30 00	30			11 tickets @ $10 00 (9% discount)
OCTA (Orange Co , CA)	$37 50	38			10 tickets @ $9 (10% discount)
TARC (Louisville)	$20 00	24			10 tickets @ $4 50 (47% discount)
MVRTA (Dayton, OH)	$25 00	28	$6 50	7	7 tokens @ $5 (21% discount)
Madison (WI) Metro	$34 00	34			10 tickets @ $7 50 (25% discount); wkday pass $28
GLPTC (Lafayette, IN)	$21 00	42			10 tickets @ $4 (20% discount)
SCRRA (So Calif)	$80-272	23-29			10 tix @ $25-85 (10-27% disc); round-trip: $6-18 (5-14% disc)

* Monthly pass price shown is for peak period; range represents multiple zones.
** Breakeven rate is based on full (single-ride) peak cash fares.

FARE STRUCTURE DEVELOPMENT PROCESS

As corroborated in the case studies, the process for developing fare policy and making changes to the fare structure varies widely from one transit agency to the next. It was found, in conducting the case studies, that differences occur in the following key aspects of the fare policy and structure development process:

- The frequency of and impetus for fare evaluations and changes and
- The nature of the evaluation and fare change methodologies.

These are discussed in the following sections.

Frequency of and Impetus for Fare Evaluations and Changes

The frequency of fare changes at the case study agencies is shown in Table 30, along with the nature of the most recent change, the impetus for this change, and the nature of the fare change process. As indicated, the frequency is not necessarily related to the reasons for change. It does appear to be linked to the size of the agency, though—none of the smaller case study agencies conducts frequent reviews, while most of the larger ones do. Five agencies have implemented some type of fare modification every 1 to 3 years (at least over the past 15 years). These are typically not major restructuring; in some cases, only one fare element may be modified (e.g., the monthly pass price is raised, or the base cash fare is raised while everything else remains the same). The nature of the changes is discussed below. Nevertheless, these agencies are at least reviewing the fare structure or levels frequently.

In considering this issue, it is important to distinguish between agencies that have an official policy or requirement to review fares regularly versus those that conduct reviews or make changes as needed. For instance, CTA has instituted some type of modification every year or two of late; however, the more recent of these changes have involved adjustments to monthly pass prices only. These changes have been made to address a particular problem—inadequate revenue—rather than to address a policy calling for annual or biannual fare reviews. NJT and BSDA also have made frequent fare adjustments to address particular problems or needs. In contrast, Seattle Metro has an official policy to conduct a fare review every 2 years, and OCTA routinely reviews fares as part of its annual short-range planning process. The APTA Annual Fare Summary reports that only 3 percent of its respondents have formal regular fare review policies or requirements; most North American agencies change fares as needed.

Only 24 percent of the APTA respondents reported a required minimum fare recovery ratio, and only 15 percent even have a fare recovery goal. Only two of the case study

TABLE 30 Case study fare change policies

Agency	Frequency of Fare Changes	Nature of Most Recent Change (Year)	Impetus for Change	Nature of Change Process
CTA (Chicago)	every 1-2 years	increased pass prices, reduced token disc. (93)	need for addtional revenue	comp studies of alt strategies, staff review in-between
MBTA (Boston)	2 since 1982	raised cash to $0 85 (rail), $0 60 (bus) (91)	fare recovery, additional revenue	staff review, as recommended by top mgmt
NJ Transit	every 1-2 years	increased most cash fares, reduced no of zones (90)	complexity/inconsistencies	mkt research (elasticity anal), staff review
Metro (Seattle)	every 1-3 years	elim disc tickets (93)	need for additional revenue	staff review every 2 years
BSDA (St Louis)	every 2-3 years	elim express surcharge, reduced transfer to $ 10, set LRT=local (93)	ridership loss, integ LRT, simplify	comp studies of alt strategies & fare levels
DART (Dallas)	3 last 10 years	elim zones, reduced price, reduced disabled fare (90)	ridership loss, low fare recovery	comp studies of alt strategies & fare levels
OCTA (Orange Co , CA)	every 1-2 years	intro discount tickets, made transfers free (94)	ridership loss	comp studies of alt strategies, staff review in-between
TARC (Louisville)	no change '80-'93	intro. deep discount, inc cash by 42%, intro. passes (93)*	low fare recovery, additional revenue	mkt research study (focus on deep discounting)
MVRTA (Dayton, OH)	no change '82-'93	intro. deep discount, inc cash by 50% (93)	low fare recovery, additional revenue	study (focus on deep discounting)
Madison (WI) Metro	2 since 1987	reduced ticket discount, intro wkday pass, inc everyday pass (93)	need for additional revenue	mkt research study (focus on deep discounting)
GLPTC (Lafayette, IN)	infrequent	replaced cards with tokens (90)	increased burden on operators	study (focus on deep discounting)
SCRRA (So Calif)	ongoing refinement	reduced some fares, elim 1 zone (94)	low ridership	ongoing evaluation of fare levels & strategies

* TARC had monthly passes before 1993, but they were available only through certain employers.

agencies—MBTA and OCTA—have required ratios; yet, MBTA has implemented only two fare changes since 1982 (although a recent fare policy statement calls for more frequent reviews). In three other cases (DART, TARC, and MVRTA), unacceptably low fare recovery ratios were cited as key reasons for recent fare changes. Like MBTA, these agencies have made relatively infrequent fare adjustments; both TARC and MVRTA changed fares in 1993, and this was the first fare modification for each in over a decade. Both agencies benefit from a dedicated local funding source, which was strong enough throughout the 1980s to obviate the need for increased fare revenue.

Most agencies review their fare structures only in response to a particular problem (e.g., declining revenue or ridership) or some type of outside pressure (e.g., a public outcry). The problems prompting an agency to undertake a fare review or make a change are many and varied. The major reasons for case study agencies to review or change fares are summarized in Table 30. An unacceptable fare recovery ratio is one impetus; others are described in the following paragraphs.

Need for Additional Revenue

The need for additional revenue was the single most frequently cited impetus for pursuing a fare increase among the case study agencies. In six cases (CTA, MBTA, Seattle Metro, TARC, MVRTA, and Madison Metro), it was a major reason for a fare change. This is also an essential element of improving the fare recovery ratio, which also was cited as a major reason for considering a fare change (by four of the agencies). Increasing revenues through fare increases can be thought of as the demand side approach to improving the fare recovery ratio. It may be, for instance, that operating costs have not risen, but that other sources of revenue (e.g., dedicated tax receipts or state and federal subsidies) have declined. At both TARC and MVRTA, for instance, dedicated local tax receipts fell somewhat during the recession of the last few years, leading the agencies to consider fare increases for the first time in more than a decade.

A related reason for wanting to increase fare levels is to maintain pace with inflation. As inflation increases input prices for the agency, operating costs rise. To ensure that the fare recovery ratio remains steady over time, fare revenues will need to increase; therefore, a reasonable goal is to maintain a steady ratio of operating revenues to costs, while not inflicting a "real" fare increase on passengers. Interestingly, although this may be an easy way to market the fare increase to riders, not one of the case study agencies takes such an approach, and it is apparently quite rare in the United States, on the basis of the APTA findings. This type of policy is more frequently used in the more heavily transit-oriented cities of Europe. For example, both London Transport and British Rail employ such a strategy, increasing prices on a yearly basis but not altering the fare structure with every price increase.

Declining Ridership

Because U.S. transit agencies depend heavily on the subsidies provided by political bodies, there is a strong incentive to develop and maintain high ridership levels. Political acceptability will depend on both the absolute level of ridership and the equity effect of providing services to different groups and in different geographical areas. Thus, if total transit trip-making is low, or a small (or decreasing) proportion of the total trips are made in the service area, then the political acceptability of large subsidies for transit may wane.

DART, OCTA, BSDA, and SCRRA cited ridership levels as compelling reasons for considering fare revisions. DART was motivated by falling ridership levels to institute major fare restructuring in both 1984 and 1990. In the former instance, the agency reduced the cash fare from $0.70 to $0.50, while in the latter case, it eliminated the zone structure. An interim fare change in 1987 saw the fare raised to $0.75 in order to boost revenue. OCTA was spurred largely by declining ridership to conduct a major fare structure review in 1993, although the agency also was very concerned about maintaining revenue. BSDA had been experiencing steady ridership loss over the past several years when it decided to simplify the fare structure and to reduce some fare levels (the express surcharge was eliminated and the transfer charge was reduced). Finally, SCRRA reduced some of its fares in order to increase ridership, although the commuter rail system experienced a short-term jump in demand following the earthquake in early 1994. A new agency, SCRRA is fine-tuning its fare structure.

Fare Structure Complexity

Another impetus to considering modifications to a fare structure has been the concern that the agency's fare structure is overly complicated or contains unnecessary inconsistencies. This is tied to the goal of increasing simplicity from the rider's point of view—thereby increasing ridership—and reducing the administrative and operational burden caused by a complex fare structure.

Simplification was an important concern for BSDA in carrying out its 1993 fare study. The fare structure in the St. Louis area is complicated by the transit provider's unique institutional structure: the two participating Illinois jurisdictions (St. Clair and Madison counties) are each free to set their own fare levels for the service BSDA provides for them, and these fares often have differed somewhat from the fares BSDA sets for its Missouri service. The BSDA fare structure was complicated further by several fare differentials and upgrade transfer charges (for express and premium service), as well as a broad—and overlapping—set of prepaid passes (monthly and weekly, for each type of service) and discount tickets. Although BSDA was able to consolidate some of the fare options (e.g., through elimination of the express and premium differentials and passes), it was not able to convince the Illinois counties to accept a uniform fare structure.

At NJT, the complexity of the statewide zonal structure—as well as some inconsistencies in fare levels for essentially similar trips—has prompted an ongoing review of fares. The multimodal nature of the service, the very different types of markets served by the different modes, and the different types of markets in different parts of the state have combined to foster this complexity and inhibit reasonable adjustments. Thus, although NJT has reduced the number of zones and rectified some of the most glaring inconsistencies, the fare structure remains complex.

Simplification has also represented an important goal in fare restructuring at DART and OCTA. DART eliminated its zonal structure in 1990. OCTA has removed its peak/off-peak differential, its express surcharge, and finally its transfer charge (i.e., transfers are free) over the years. Seattle Metro strongly considered eliminating its zonal structure as well as its peak/off-peak differential in 1992 but decided to keep these strategies, because it was predicted that ridership would be lower without them. Of course, Metro had already greatly simplified its structure when it reduced the number of zones from 38 to 2 in 1977.

Apparently, these concerns over simplicity are shared by much of the U.S. transit industry—slightly more than a third of the APTA Fare Summary respondents have distance-based or zonal fares (similar to the percentage of the case studies); only 6 percent have peak/off-peak differentials (33 percent in the case studies). Many agencies assess the potential for these types of fare differentiation when considering new fare structure changes, but most decide that the administrative and operational issues associated with introducing and administering them outweigh any potential revenue or ridership advantages. The results of such evaluations conducted by the case study agencies are reviewed below.

Introduction of a New Mode

The introduction of a new type of service (e.g., a light rail or commuter rail line) typically triggers a review of the agency's fare structure; this represents the service-driven scenario described in Chapter 2. The motivating factor is the desire to integrate the new mode into the current system effectively, and considerations generally include 1) the need to select a fare level for the new mode, relative to that of the existing modes; and 2) the need to reevaluate the transfer policy—with the introduction of rail it is likely, for example, that much of the bus service has been redesigned to feed the new rail line and, hence, transfer patterns will have changed. Developing an appropriate integrated fare structure may be complicated by the fact that the new mode may have a different fare collection system from the existing service (i.e., POP versus on-board).

BSDA's 1993 fare change was timed to coincide with the opening of light rail, and the key decisions were to set the LRT fare equal to the local bus fare ($1) and to simplify the transfer policy and reduce the transfer fee (from $0.20 to $0.10). A small transfer fee was retained because of the POP system on LRT and the belief that even such a small fee would reduce the resale of unused transfer tickets.

At DART, the impending introduction of commuter rail and light rail (over the next 2 years) was a key reason for the most recent fare study (completed in July 1994). In this case, a technology-related decision regarding the POP system affected the development of the new fare structure significantly. Because DART initially decided not to purchase ticket validators with its new TVMs, the use of discounted multi-ride tickets was not considered practical on the rail lines. Thus, DART plans to discontinue its current multi-ride ticket once the light rail line opens, at which time the tickets will be phased out and weekly passes may be offered instead. DART also plans to charge the same fare ($1.00 at present) on LRT and local bus when the new line opens.

Introduction of New Fare Collection Technology

The direct impetus, in some instances, for evaluating the fare structure is the acquisition of some type of electronic fare collection technology (i.e., the technology-driven scenario). Because this technology facilitates use of a broad range of new fare options, an agency generally reviews the fare payment alternatives when it introduces electronic fare collection. In such cases, the new fare structure may involve no fare level changes (e.g., the base fare for a single ride may be kept at its existing level) but changes in the types and pricing of prepaid fare media. In New York, for example, NYMTA evaluated fare structure alternatives for its new electronic fare collection system and the stored value MetroCard. Various prepayment options and discounts have been explored to provide greater convenience to the riders, increase ridership, and reduce cash handling costs.

Among the case study agencies, CTA has undertaken a similar fare structure review to evaluate options for its forthcoming electronic fare collection system and stored value card. Seattle Metro has plans for a post payment/employer billing mechanism, although its implementation depends on the agency's ultimate decision whether to install bus ticket validators; in addition, Seattle Metro, along with other operators in the region, has begun planning a regional fare integration project—using a common medium (a pass) and fare collection technology. OCTA, in its recently completed fare study, examined the potential for eliminating transfers—probably in conjunction with implementation of a 1-day pass issued on the buses. The agency decided, however, that it probably would not pursue this strategy unless it had bus ticket validators. Finally, in contrast to the greater flexibility offered by electronic fare collection, DART's new fare structure has been influenced by the constraints of having AVMs without ticket validators. (Issues associated with selection and procurement of new technology are discussed in Chapter 8.)

Interest in Innovative Fare and Marketing Strategies

Because of concern over maintaining or increasing ridership, some agencies have restructured fares primarily to take advantage of the marketing potential of innovative pricing strategies. A deep discounting strategy—and an emphasis on prepayment in general—has often served as the focus for such activities. Market-based fare strategies have been implemented in an effort to target different ridership markets and to reduce cash handling through greater sale of prepaid media. Among the case study agencies, CTA, BSDA, TARC, MVRTA, and Madison Metro all undertook fare restructuring focused on market-based or deep discounting strategies in recent years.

A somewhat different marketing approach was shown in MBTA's decision not to increase fares through most of the 1980s. The agency adopted this approach to reflect its acknowledgment that there were significant disruptions to service and that service quality was generally low during the reconstruction and extension of the rail lines. Fare levels were preserved in an attempt to maintain ridership during construction. MBTA decision makers were concerned that, once lost, riders would be difficult to regain (because of changes in location of employment and residence and because of new behavior patterns).

There is no single motivation for review and modification of fare policies or structures. In the case studies, the most frequently cited reason for reviewing fares was the need for additional revenue; however, the desire to reverse declining ridership trends was an important impetus. Other reasons included simplification and introduction of market-based strategies.

The types of methodologies employed by the case study agencies in evaluating fare alternatives and developing recommended modifications are discussed in the next section.

Evaluation and Fare Change Methodologies

Chapter 2 presented an outline of a generic decision-making structure through which fare policies, structures, and technologies can be developed or identified. This process included all steps—from the definition of policy goals to the development of the final fare system. The process identified was not necessarily followed by all agencies at all times; the combination and order of steps depended on the nature of the decision to be made, the existing fare structure and technology, and the nature of the agency's general decision-making framework.

The case studies permit consideration of the procedures actually followed at different agencies and at different stages of fare decision making. Each case study discusses the fare development process in general, and, in most cases, documents the specific activities and methodologies followed in specific fare reviews. Several of these agencies' (CTA, OCTA, DART, and Seattle Metro) evaluation processes are outlined below, to show the types of methodologies used.

Chicago Transit Authority

CTA has performed two major fare structure studies in the last 7 years. The first, in 1987, evaluated the following types of fare strategies:

- Distance-based pricing,
- Peak/off-peak differential,
- Bus/rail differential, and
- Maximum prepayment.

The steps included in this study, which laid the groundwork for the subsequent study, were as follows:

- Identify Fare Policy Goals—Goals were identified and "strategic trade-offs" between specific goals were established through discussions with staff from various departments and selected Board members.
- Develop Evaluation Framework—Ten criteria were identified, and evaluation guidelines were defined for each criterion. Where possible, specific quantitative guidelines were provided. The criteria and guidelines are summarized in Table 31, along with the relative weights assigned each criterion; the criteria weights were based on interviews with CTA Board members. As shown in Table 31, ridership, revenue, and costs were considered the most important, while the provision of management information was ranked lowest.
- Define and Analyze CTA's Markets—Considerable effort was devoted to defining and analyzing the potential markets for CTA service. Elasticities were developed on the basis of the results of a series of "stated preference" surveys of riders and non-riders and were used to predict the effect of different fare options on ridership.
- Develop and Estimate Costs for Fare Options—Six different options were developed and evaluated in isolation—in order to understand the implications of each—even though it was acknowledged that actual fare structures might include a combination of strategies. The options included peak/off-peak differentials, distance-based pricing (zonal for rail only or systemwide, and rail point to point), modal differentials, and maximization of prepayment. Potential costs (capital and operating) were calculated for each option. The distance-based options were found to cost the most, largely because a new fare technology probably would be needed to implement such a strategy effectively.
- Evaluate Options—Each option was evaluated on a comparative basis according to each of the weighted criteria.

TABLE 31 Evaluation criteria and guidelines—CTA

Evaluation Criteria	Weight	Criterion Definition/ Evaluation Guidelines
Maximize revenue while minimizing ridership loss	80	ability to raise additional revenue; compared to base case
Maximize ridership while maintaining existing net revenue	80	ability to increase ridership without losing revenue; compared to base case
Ease of Implementation	20	phasing necessary to allow reasonable transition; reflected in costs and timing; evaluated using discounting
Reasonableness (public acceptability)	10	assessment based on experience from market research and public meetings
Revenue Protection	25	evaluated in qualitative terms, based on scope and likelihood of improvements in revenue protection
Cost	80	includes capital costs of fare equipment and station modifications, and revenue collection costs
Reversibility (risk)	20	ease with which an option can be implemented or abandoned; includes institutional, public relations, other factors
Maximize rides by disadvantaged	20	equity of fares, especially for the transportation disadvantaged; positive or negative effect
Simplicity	10	assess simplicity, ease of understanding, and convenience of use of each option
Management Information	5	assess extent of improvement in each of three areas: financial accounting/revenue control, operational control, mktg./planning

> The distance-based options received the lowest scores and were deemed not worth pursuing; the remaining options were recommended for further consideration. The overall conclusion regarding distance-based options was that "The high capital costs of the fare equipment necessary for distance-based charging could not be justified by additional revenue raised, as this method was no more efficient at raising revenue than the present flat fare system."

In the second study (1989 through 1990), which led to the introduction of a peak/off-peak structure and substantial prepayment discounts, the options for consideration were limited to those rated highly in the previous study. These were as follows:

- Peak/off-peak fare differential,
- Bus/rail fare differential,
- Premium for paying cash,
- Deep discounting of fare prepayment mechanisms, and
- Market segmented passes.

This effort involved the following steps:

- Conduct Research on Innovative Fare Structures Elsewhere—Information was compiled on other agencies' experiences with market-based fare structures.
- Conduct Market Analysis of Choice of Payment Methods—A rider survey was conducted on current use patterns and current and potential payment methods. The stated preference findings were used to predict shares of new payment methods.
- Develop a Revenue and Ridership Model—The revenue and ridership model developed for CTA incorporated the payment method shares model and a set of submarket elasticities (on the basis of previous CTA experience and industry experience).
- Evaluate Alternatives and Recommend a Revised Fare Structure—The study team developed five alternative pricing strategies and then developed a range of specific fare structures within each strategy. This task included identifying goals, implementation and operational issues, and evaluation criteria as well as the evaluation itself. The actual evaluation was conducted in two steps. First, the basic fare strategies were ranked according to the criteria; this ranking was done through discussions among members of the Fare Policy Task Force. Second, ridership and revenue projections were reviewed, and a general type of fare structure that satisfied CTA's goal of meeting a revenue target without losing ridership was selected; this option was selected at a consensus-building meeting of the Task Force. Six specific fare structure options were then developed on the basis of the selected general structure.
- Implement and Market New Fare Structure—The options were presented to the Board of Directors and then at a series of public hearings. The recommended structure was approved in February 1990 and implemented less than 3 months later.
- Evaluate the Fare Structure Effects—After the new fares were introduced, an evaluation was carried out.

Orange County Transportation Agency

Although OCTA has typically reviewed its fare levels every year or two, the agency has completed two major fare studies since 1980. The first of these, carried out during 1981 and 1982, evaluated alternative strategies (distance-based/zonal pricing, peak/off-peak differential, and flat fares) and developed recommendations for a new structure and long-term policy goals. The basic steps in this effort were as follows:
Identify Evaluation Criteria—The criteria included ridership and pricing efficiency (i.e., the extent to which the fare charged was related to the cost of providing the service), revenue effects, equity, user comprehension, driver requirements, accounting procedures, potential for fare abuse, cost of fare collection, and the likely political and public response.

- Develop Alternatives—The alternatives considered, besides the basic strategies (flat fare, retain the existing peak/off-peak differential, or introduce a zonal structure), included eliminating passes or a lower discount, eliminating multi-ride tickets, and introducing transfers. Each alternative included specific fare levels. Separate sets of alternatives were identified for local and express service.
- Identify Elasticities—These were determined from industry experience and by market segment (time and purpose).
- Evaluate Alternatives—The alternatives were evaluated using the above criteria. The resulting recommendations included 1) retain the peak/off-peak differential, 2) increase monthly pass prices and eliminate ticket discounts, 3) implement a zonal structure for express service only, and 4) over the long term, adopt a farebox recovery target and introduce frequent incremental fare increases (i.e., triggered by the need to increase revenues).

OCTA (then called OCTD) adopted some of these recommendations (retain peak/off-peak, increase pass prices) but rejected others (ticket discount was retained, flat fare for express was retained); the recovery farebox target was not adopted, although the agency has instituted frequent fare changes.

In 1993 and 1994, a second major study was conducted to review the existing fare structure and policy and develop recommendations for changes. This study included the following tasks:

- Conduct Peer Group Analysis—The study team reviewed the fare structures and fare elasticities used by 18 peer agencies.
- Develop Fare Elasticities by Market Segment—This was done on the basis of an analysis of OCTA ridership data, coupled with the elasticity figures used by the peers—particularly the other California agencies.
- Review Current Transfer Policy—OCTA has a very high rate of transfers and is concerned about the extent of transfer abuse and operator and rider confrontations regarding transfer validity. Thus, a key aspect of the study was to examine a range of alternative transfer policies. One possible approach considered was the elimination of

transfers in conjunction with introduction of a 1-day pass sold on the buses.

- Develop a Fare Change Model—A submarket elasticity approach was combined with a disaggregate disutility model.
- Review Current Fare Structure—The study team assessed the extent to which the existing fare structure was addressing the fare policy goals.
- Establish Evaluation Criteria—A set of evaluation criteria was developed on the basis of the agency's stated fare policy goals, and relative weights were assigned by members of the Fare Policy Task Force. The departments represented on the task force included grants and revenue, transit planning, transportation, facility maintenance, accounting, and marketing.
- Establish Evaluation Methodology—The evaluation criteria fell into two categories: quantitative (those pertaining to ridership and revenue) and qualitative (the remainder). The ridership and revenue criteria could be applied objectively, on the basis of projections from the Fare Change Model (i.e., percentage increase or decrease from the base case). The qualitative criteria, on the other hand, had to be applied more subjectively, because their effects are not easily measured. To facilitate this process, a set of guidelines to support the evaluation measures for each criterion was developed; these guidelines are shown in Table 32. The format for evaluating the alternatives was a matrix, using the measures suggested in Table 32. The ratings for the ridership and revenue criteria reflected the effects projected by the Fare Change Model. The ratings for the other criteria were based on the guidelines in Table 32. An example of the resulting ratings is shown in Table 33.
- Develop Alternative Fare Structures—The development of alternative fare structures entailed identifying combinations of specific options and setting pricing levels for each element. These alternatives were then evaluated (see Table 32), and preliminary recommendations were made. Additional specific fare structures were produced and evaluated; more than 30 scenarios were tested.
- Develop Set of Alternatives for Further Consideration—On the basis of the preceding assessment, coupled with specific concerns of OCTA staff, a "short list" of alternatives was developed for consideration by OCTA upper management. It was also recommended that OCTA streamline its process for making future fare changes. Because of the inherently political nature of making changes in the overall fare structure, it was suggested that OCTA continue to require the Board of Directors to approve specifically any changes to the fare system. It also was recommended that OCTA separate the review of potential fare changes from the short-range planning process.
- Select Fare Structure Modifications—The selection of a specific alternative was made by senior OCTA management and adopted by the Board of Directors. There were strong proponents (primarily the Transportation Department) of eliminating transfers and reducing the cash fare; however, it was felt that, because such an approach would mean a major fare increase for many of OCTA's riders, it would be highly inequitable and thus publicly unacceptable. On the other hand, management was opposed to a fare increase, in light of the economic problems in the County and the fact that ridership had been declining. Thus, the fare structure ultimately adopted included relatively minor changes from the existing structure; the key modifications were a 10 percent discount on prepaid tickets—which had been dropped in 1985—and the institution of free transfers. This structure was implemented in July 1994. Elimination of transfers was to be considered further, for possible implementation at some future date.

Dallas Area Rapid Transit

DART has made several major modifications to its fare structure, since its creation in 1983, having 1) reduced the base cash fare from $0.70 to $0.50 in 1984, 2) increased the fare from $0.50 to $0.75 in 1987, 3) eliminated the zonal structure in 1990, and 4) increased the fare from $0.75 to $1.00 in early 1995. The processes followed in making the 1990 change and in the 1993 through 1994 study are outlined here.

The review that led to the elimination of the zonal surcharges took place in 1988 and 1989. This review was prompted by management and staff concern that the zonal structure was 1) complicated and, therefore, confusing to riders and operators; 2) difficult to administer; 3) susceptible to fare abuse; 4) a disincentive to ridership; and 5) difficult to collect data on. Thus, a new structure design was undertaken; the key steps were as follows:

- Evaluate Basic Fare Strategies—This step involved an evaluation of the basic fare strategies: flat fare, continuation of the zonal structure, time-of-day differential, and service-based differential. The conclusions were that a service-based strategy (i.e., an express surcharge) made the most sense for DART and that the zonal structure should be discontinued.
- Develop Elasticities and Fare Model—Fare elasticities were developed on the basis of time series data, complemented with market surveys of different rider submarkets.
- Evaluate Alternative Fare Structures—A Fare Policy Task Force was established, which considered the estimated ridership and revenue effects of alternative fare structures. A recommendation was made and adopted (following review by the Board of Directors and the public at public hearings).

The second major study, undertaken in 1993 and 1994, was prompted by declining ridership and revenue, as well as the need to integrate the new commuter and light rail lines into the overall system. One of the key objectives of this study was to develop a new set of elasticities (on the basis of stated preference survey results) and develop a new fare model. The tasks were as follows:

- Review Past Fare Changes and Elasticities—As a prelude

TABLE 32 Evaluation criteria—decision guidelines—OCTA

Evaluation Criteria	Measures/Guidelines	Comments
Increase ridership	-2= >2% loss -1= <2% loss 0= 0.5% loss to 0.5% gain 1= <2% gain 2= >2% gain	based on model projections
Enhance revenue	-2= >2% loss -1= <2% loss 0= 0.5% loss to 0.5% gain 1= <2% gain 2= >2% gain	based on model projections
Support for seniors, disabled, children	-2= inc. actual fare sr/dis and child -1= inc. actual fare sr/dis or child 0= no change 1= dec. actual fare sr/dis or child 2= dec. actual fare sr/dis and child	because of subsidies actual sr/disabled fare can stay same even if posted fares rise
Simple to understand, easy to administer	-2= peak/off peak -1= express premium 0= no change 1= no transfers (with day pass) 2= no transfers (and no day passes)	rating can be "1" or "2" only if no peak/off-peak or express premium
Equitable by mode, market, distance traveled, time of day	-2= large inc. for major rider group -1= inc. in local pass breakeven rate 0= no change 1= fare differential 2= 2 or more fare differentials	rating can be "1" or "2" only if no inc. in pass rate; types of fare diff. express premium, peak /offpeak; discounted coupons
Flexible and convenient	-2= 2 or fewer options -1= 1 option less 0= no change 1= 1 or 2 new options 2= 3 or more new options	options: peak/offpeak, day pass, express prem., discount coupons,elim. of (or free) transfers
Sensitive to perceptions, needs of public	-2= large cash inc. w/o discount -1= large cash inc. w/signif discount 0= no change 1= reduc. to some mkts. 2= reduc.to some mkts., no increases	reflects extent of public opposition/acceptance and ability to market the structure to the public

to developing a new set of elasticities and a new fare model, it was necessary to review the elasticities—and methodologies for developing them—used in the prior fare changes. The ridership and revenue effects of these changes and the modeling procedures used were thus examined.

- Review Peer System Fare Structures—The fare structures of 14 similar-size transit systems were reviewed. This review suggested several areas in which DART could improve its current fare structure.
- Develop Fare Elasticities—An on-board survey was performed to learn the preferences of DART's riders regard-

TABLE 33 Fare structure scenarios evaluation—weighted

Evaluation Criteria	Weight	1) large cash pass incr., intra-exp. prem.	2) large cash incr., pass same, deep disc.	3) large peak cash incr., pk/o-pk, deep disc.	4) small cash incr., day pass, deep disc.	5) small peak cash incr., pk/o-pk, deep disc.	6) local same, intra-exp. prem., bi-wkly pass	7) local same, day pass, deep disc.	8) local same, pass decr., deep disc.	9) large cash decr., no transfer	10) local same, deep disc.
Increase ridership	6	-8.1%	-3.4%	-3.5%	-3.1%	2.4%	0.7%	0.1%	2.6%	-2.4%	2.5%
Enhance revenue	7	18.2%	5.6%	11.9%	9.2%	-1.4%	1.1%	1.3%	-3.3%	3.7%	-3.5%
Support for seniors, disabled, children	2	0	0	0	0	0	0	0	0	0	0
Simple to understand and administer	4	-4	0	-8	-4	-8	-4	4	4	8	0
Equitable by mode, dist., time-of-day	3	3	3	6	6	6	3	3	3	-6	3
Flexible, convenient	3	0	3	3	3	6	3	3	3	-3	3
Sensitive to perceptions of public	3	-6	-3	-3	3	3	3	3	6	3	6
Total Score, Qualitative Measures		-7	3	-2	8	7	5	13	16	2	12

Weightings: based on priorities established by OCTA management/staff

* Rating Key: (See Guidelines for specific measures)

2 = considerably better/greater than current structure
1 = somewhat better/greater than current structure
0 = generally same as current structure
-1 = somewhat worse/less than current structure
-2 = considerably worse/less than current structure

ing fare and service changes. Respondents were asked how they thought they would respond to a change in fare together with changes in service quality (e.g., headway, distance to a bus stop, and number of transfers required). On the basis of the responses to these and general use and fare payment questions, a set of fare elasticities was developed (through the estimation of discrete choice models) for individual market segments and service types.

- Develop Fare Change Model—These elasticities were used in the Fare Change Model. The procedure used in the model to estimate ridership is a two-step calculation: 1) allocate the base case ridership in each submarket among the fare medium options, using a "disutility model" for each submarket; and 2) estimate the change in ridership of each submarket, using the fare elasticity measure for that submarket. Revenue effects are then calculated on the basis of ridership changes and average fare values for each submarket.
- Review Fare Structure Elements—This involved identifying the individual elements of DART's fare structure (e.g., fare strategy, fare levels, and types and prices of passes, etc.) and reviewing the options for each element (e.g., flat fare versus peak/off-peak differential versus distance-based/zonal structure). Following a review of the advantages and disadvantages of the different options, preliminary recommendations were presented, suggesting either a specific option or further evaluation of two or more options. These recommendations provided input into the development and evaluation of alternative fare structures.
- Establish Evaluation Criteria—The criteria selected represented DART's fare policy goals as well as fare-related concerns expressed by members of the Fare Policy Task Force. A weighting scheme was developed by DART management and staff (i.e., the members of the Fare Policy Task Force).
- Establish Evaluation Methodology—The alternatives were evaluated using the evaluation criteria, the weighting factors, and a set of evaluation measures. These measures reflected the evaluation decision guidelines presented in Table 34. An example of an evaluation matrix is shown in Table 35.
- Develop Alternative Fare Structures—Identifying alternative fare structure scenarios involved assembling various combinations of specific options and then establishing pricing levels for each fare structure element. A range of scenarios was produced and tested in the Fare Change Model; approximately 20 scenarios were tested. This group was reduced to eight scenarios representative of the various combinations of the structural options and specific

TABLE 34 Evaluation criteria and decision guidelines—DART

Evaluation Criteria	Measures/Guidelines	Comments
Maximize revenue	actual % change from current	from fare model
Maximize ridership	actual % change from current	from fare model
Acceptable to the public	-1=large cash increase 0=no change 1=deep discount	reflects extent of public opposition/acceptance; "0" if large inc. and deep discount
Equitable in terms of impacts on different market segments	-1=higher % inc. for key markets 0=no change, or small impact 1=positive impact for key markets.	key mkt. seg.: sr, dis, low income; "0" if higher % increase for some pos. impact for others
Can be accommodated on light rail	-1=peak/off-peak differential 0=no change or multiride option 1=no peak/off-peak or multiride option	related to TVM capabilities; these ratings assume no ticket validators in LRT stations
Convenient for riders	-1="inconvenient" cash amount 0=no change 1=add'l. prepayment options	additional prepayment options: deep discount, weekly pass; inconvenient cash is other than $0.75 or $1
Simple to understand, easy to administer	-1=additional options 0=no change 1=no express surcharge or peak/off-peak	additional options; weekly pass, day pass, peak/off-peak; these are difficult to administer

pricing levels. On the basis of ratings of these scenarios, a final set of four scenarios was selected for further consideration.

- Evaluate Alternatives and Recommend New Fare Structure—The final scenarios were evaluated using the above methodology. The final recommendation, however, reflected other considerations—presented through discussions with DART's top management—beyond the application of the evaluation criteria.

A key issue in DART's decision on the recommended fare changes was the resolution of a technology decision: whether or not to include ticket validators at rail stations (either incorporated into the AVMs or as free-standing units). Because a POP system will be used for rail, use of a multi-ride option (i.e., trip-based, rather than time-based, as in a pass) will require that a prepaid ticket be validated at a station on each use; this prevents the use of a single ticket more than once. As of this writing, DART had not made a final decision whether or not to provide validators. Depending on the decision, the agency may eliminate the current multi-ride tickets and introduce weekly passes instead. Thus, although new fare collection and distribution equipment and technology generally are viewed as being able to accommodate a wider variety of fare strategies and media, this example shows how an equipment decision can limit the types of fare media that can be readily used.

Seattle/King Co. Metro

For the last 10 years, Seattle Metro has had an informal policy of reviewing its fare structure comprehensively every 2 years. The most recent comprehensive review took place in 1992. The process, directed by a task force with members from research and market strategy and the operations department (including representatives of the drivers), consisted of the following key steps:

- Review Background—This included review of the process for changes as well as fare levels and strategy and a review of fare policies and revenue needs.
- Review Specific Fare Elements—This focused particularly on youth fares, special fares for social service customers, and ticket books.
- Review Alternative Fare Structures—An econometric systemwide model was used with elasticities and cross

TABLE 35 Fare structure scenarios evaluation—DART

Evaluation Criteria	Weight	$0.75,pass inc,deep discount	$0.75,pass inc, wk. pass,day pass	$1,deep disc.	$1, wk. pass, day pass
Maximize ridership	10	-1.1%	-0.9%	-7%	-8.2%
Maximize revenue	10	4.9%	3.4%	13.0%	15.1%
Public Acceptability	8	8	0	0	-8
Equity	4	0	0	0	0
Accommodate LRT	7	0	7	0	7
Convenience	8	8	8	8	8
Simplicity of use, ease of admin	8	0	-8	0	-8
Total Score, qualitative measures		16	7	8	-1

-1 = worse / less than existing structure
0 = generally same as existing structure
1 = better / greater than existing structure

elasticities to evaluate ridership and revenue effects. The alternatives were modified until all revenue requirements were met. Other considerations were social equity, political acceptability, effects on operators and operations, and simplicity. Two alternatives were assessed—the first was to increase cash fare with the same basic structure, and the second was to eliminate zones and the peak/off-peak differential. At this stage, the Transit Committee reduced the revenue requirements (and hence the fare level) to ensure smaller ridership losses. Simplification was rejected because the ridership loss was predicted to be greater than with the alternative. The zones and time-based differential were retained.

Key Fare Development and Evaluation Issues

Although many fare development efforts include similar steps, the case studies demonstrate that the focus of the evaluation, as well as the order of the steps, can differ considerably. The different agencies follow differing approaches, and successive studies at the same agency can differ in structure. Besides the variation in intent or focus of the study, the development and evaluation efforts often reflect who is performing the study—i.e., particular agency staff, within one department or as part of a large task force, and often outside consultants. As part of this case study effort, the research team identified several key issues that point up the differences and similarities among the agencies; these issues are as follows:

- Goals and evaluation criteria,
- The role of interdepartmental task forces and the Board of Directors,
- Strategies and issues considered and recommendations, and
- Development of fare elasticities.

These issues are discussed below.

Fare Policy Goals and Evaluation Criteria

Typically, the key goals pursued in fare development studies are related closely to the reasons prompting the review in the first place. The goals cited by the case study agencies are summarized in Table 36. As shown, several goals are common to most, if not all, of the case study agencies. Increasing or maximizing ridership and increasing or maximizing revenue are the most frequent goals, the others listed support or are tied directly to these two goals. For instance, simplicity and convenience are related closely to ridership, and increasing fare recovery is linked directly to revenue.

Of the goals and criteria identified in Chapter 2, the least often used in the case study agencies, at least explicitly, are those related to "political" goals—maximizing political acceptability and achieving the recovery ratio requirement. As noted earlier, a formal recovery ratio requirement is rare. The political acceptability rating is not generally included as a specific goal, although the processes are designed so as to incorporate them—by Board involvement for example. In the 1981 OCTA fare review, one of the evaluation criteria was the likely political response, and political effects were noted at NJT in

TABLE 36 Case study fare structure development process

Agency	Key Goals and Evaluation Criteria	Interdepartmental Task Force?	Board Involvement	Key Issues & Strategies Evaluated
CTA (Chicago)	revenue, ridership, rev. protection, cost, equity	all key depts	staff presents recs	dist.-based, peak/off-peak, deep disc , bus/rail
MBTA (Boston)	rev , rid , simplicity, equity	staff and citizens	Advisory Board reviews recs	discounting, pricing levels, bus/rail
NJ Transit	equity, simp , consistency, rid., rev , labor/polit impacts	staff and citizens	dictated fare policies	reduc in no zones, removing inconsistencies
Metro (Seattle)	rev., rid , equity, polit accep. operator impacts	Met Council & staff	early & ongoing involvement	simplicity (elim zones, pk/off-pk), elim disc on tickets
BSDA (St Louis)	rid , simplicity, integrate LRT/bus	small group	staff presents recs	express/local, bus/LRT, transfer policy, fare reduction
DART (Dallas)	rid , fare recovery, public accep , equity, simplicity, convenience	all key depts	staff presents recs	dist -based, pk/off-pk , deep disc , bus/LRT
OCTA (Orange Co , CA)	rid , rev , equity, simp., conv , polit acceptance	all key depts.	staff presents recs	pk/off-pk, deep disc , transfer policy, fare reduction
TARC (Louisville)	fare recovery, revenue	several depts	ongoing involvement	pricing levels, pk/off-pk
MVRTA (Dayton, OH)	fare recov., rev , rid , operational impacts, equity, simp	several depts	issued goals, inv throughout	pricing levels
Madison (WI) Metro	rev , rid , equity, simp , prepayment, marketing	several depts	involving in estab goals	deep disc , pk/off-pk, 2-level pass (wkday-only)
GLPTC (Lafayette, IN)	ridership	several depts	ongoing involvement	none (disc introduced, as promotion, then made permanent)
SCRRA (So. Calif)	fare recov , conven , equity, compatible w/ LA rail system	Board & staff	ongoing involvement	zone refinement, reverse commut diff , promotion incentives

1993. For the management-related goals identified in Chapter 2, operational improvements often focused on reducing operator and rider interaction, which was thought to result in dispute (and, hence, probably delay), operator and passenger dissatisfaction, and, on occasion, assault of operators.

In virtually all cases, evaluation criteria are taken directly from goals. To identify the relative importance of the criteria, some agencies weight the criteria. Weighting is done by requesting members of a task force—or perhaps Board members—to rate the importance of each of a list of evaluation criteria. Ridership and revenue effects of a new policy usually receive the highest rankings and equity concerns the lowest. Ridership and revenue criteria tend to cancel each other out; thus, even though staff may assign them equal weights, one or the other must ultimately be given priority in selecting a fare alternative.

This ridership-revenue conflict has led, in several cases, to the identification of goals that link the two—e.g., increase revenue without losing ridership. This is a fundamental goal of the deep discounting strategy, which was the focus of several of the case study agencies. For instance, in the 1990 CTA fare study, this goal was achieved through the first year of the new fare structure (i.e., until the recession of the early 1990s caused CTA's ridership and revenue to drop sharply; this is discussed later in this chapter). The smaller case study agencies also have focused on this strategy. Typically, there had been a long period without a fare change, which had helped to sustain ridership levels. With the onset of the recession, these authorities were trying to increase revenue without losing riders. Deep discounting was identified as the most appropriate strategy in these cases.

Finally, although staff and management usually generate goals and criteria, some agencies involve the public in this process. For instance, early public participation in the setting of evaluation criteria was a feature of development at NJT and SCRRA. In 1993, at NJT, public suggestions were a major spur to a reconsideration of the fare structure. At SCRRA, the initial fare structure was developed to take into account the views expressed in the public meetings; for example, the integrated transfer policies with connecting local transit services were prompted largely by such comments. In other cases, public involvement is not invited until after preliminary recommendations have been developed.

The Role of Task Forces and the Board of Directors

Because fare policy affects many different aspects of a transit operation (e.g., finance, revenue collection, planning, operations, administration, and marketing), fare structure decisions ideally should have input from all affected departments. In recognition of this, all of the case study agencies have ongoing or specially convened fare policy task forces to address fare issues. As indicated in Table 36, the task force may include Board members (e.g., as with Seattle Metro and SCRRA) or even private citizens—perhaps in a separate group in addition to the staff task force (e.g., as at MBTA and NJT). Although the actual analysis and development of alternatives typically is conducted or supervised by a specific department—and the type of department varies from agency to agency—the task force generally is asked to review findings along the way and often to participate in activities such as weighting of criteria and making decisions on key issues.

Table 36 also summarizes the nature of Board involvement in fare decisions. The role of the Board differs according to the size of the agency. The most common mode among the larger agencies is that the Board does not get involved until the end of the process, i.e., after the recommendations have been developed. In contrast, the smaller agencies' Boards apparently were involved earlier in the fare studies—generally on an ongoing basis.

Strategies and Issues Considered and Study Recommendations

A fundamental difference among fare reviews lies in the types of fare strategies considered. On the basis of the case studies, most fare reviews address only a subset of the available fare differentiation strategies. As indicated in Table 36, few of the agencies typically consider all of the basic strategies in their fare policy and structure studies. In fact, the smaller agencies apparently tend not to consider zonal options explicitly at all, although a few have looked at peak/off-peak differentials and express surcharges. Most of these agencies undertake infrequent reviews; when they do, they focus primarily on fare levels and prepayment options (including deep discounting).

There is considerably greater variation in the types of studies carried out by the larger agencies. Although most reviews tend to focus on fare levels and prepayment (as at the smaller agencies), most of the larger agencies have conducted at least one comprehensive evaluation of the overall fare structure that has included an assessment of the potential for making major structural revisions. Typically, each agency conducts one full evaluation of all basic strategies (e.g., CTA in 1987, OCTA in 1981, DART in 1990, and Seattle Metro in 1993) and does not seriously reconsider the rejected options in subsequent studies. For instance, in the 1993 and 1994 studies for OCTA and DART, distance-based and time-of-day-based strategies were considered but were rejected before formal development and evaluation of alternatives were begun. In the latter cases—and indeed in most fare reviews—the "alternatives" developed represent combinations of different pricing levels (and discounts, where applicable) for the various elements of the fare structure (e.g., full local cash fare, reduced local cash fare, express fare, monthly pass price, and transfer price).

The fare structure evaluations have produced a range of recommendations; however, these recommendations have not always been accepted by the Board or top management. The most significant structural recommendations from the most recent comprehensive fare reviews are summarized in Table 37; for several agencies, results of prior major reviews also are presented. The evaluations and findings and recommendations regarding the basic fare differentiation strategies are discussed below.

Distance-Based Pricing. None of the case study agencies has considered or operates pure distance-based pricing and none of the smaller agencies has or has considered a zonal structure. SCRRA has been assessing the potential for station-to-station pricing, a variation on the current zonal structure. NJT, which inherited a pure distance-based system in 1979, removed it in favor of a zonal structure in 1982. Seattle Metro and MBTA also have limited zonal pricing. Seattle Metro originally had an extensive zonal system but simplified it to two zones in 1977. For MBTA, the zones are most relevant on the commuter rail, because, for most local bus and subway passengers, trips are made within the central zone.

The fare task force in Seattle considered abandoning the zone structure during the 1992 review in order to simplify the fare structure. CTA considered zonal pricing in 1987 but rejected it after the evaluation. The conclusion was that "the high capital costs of the fare equipment necessary for distance based charging could not be justified by additional revenue raised, as this method was no more efficient at raising revenue than the present flat fare system." Since then, zonal options have not been revisited, and the new electronic fare collection system being developed is not configured to facilitate distance-based pricing (i.e., with exit turnstiles to calculate distance traveled, as in WMATA and BART). DART eliminated its zonal pricing system in 1990; the zones were removed in favor of a service-based policy, because this was seen as the optimal choice in terms of "equity, fare collection, understandability, revenue and ridership." When a zone-based system was proposed for OCTA in 1981 (on a limited basis for testing operational implications), the Board rejected the suggestion. In 1994, a zonal structure was considered but rejected early in the evaluation.

Thus, even with the advent of electronic technologies, transit agencies typically are not increasing their consideration of distance-based/zonal pricing strategies. The complexities associated with design, implementation, administration, and understanding by riders are seen as major barriers, and the theoretical benefits (e.g., greater revenue and greater equity) generally are not viewed as worth the cost involved.

Peak/Off-Peak Differential. In contrast to zonal pricing, this fare differentiation strategy has been seriously considered by some of the smaller operators (e.g., Madison Metro and TARC). TARC has had a peak/off-peak differential since 1980 and decided to retain the peak surcharge for cash only in 1993; discounted tickets have the same price all day. The peak/off-peak structure was retained for cash in order to encourage commuters to purchase tickets. Madison considered a peak/off-peak structure in a preliminary stage of the 1991 fare study, but it was rejected for operational reasons.

Most of the larger agencies have considered time-of-day pricing at one time or another, but only two (i.e., CTA, on bus

TABLE 37 Case study sources of elasticities and evaluation results

Agency	Results of Evaluation (with year of study)	Source of Elasticity
CTA (Chicago)	87: dist -based not cost-effec , consider pk/off-pk 91: intro disc , new pass (wkday-only), intro pk/off-pk (bus)	market segment elasticities from time series analysis, stated preference survey, & experience elsewhere
MBTA (Boston)	91: raise fares, consider deep discount	systemwide, from time series analysis
NJ Transit	93: consolidate some zones, remove fare inconsistencies	mkt seg elas from time series anal and stated pref. survey
Metro (Seattle)	93: keep zones and pk/off-pk 94: elim discount on tickets	mkt seg elas from time series anal and experience elsewhere
BSDA (St Louis)	91: intro deep discount 92: elim. express surcharge, simplify transfers, LRT=local fare	systemwide, from experience elsewhere
DART (Dallas)	84: reduce fare; '87: raise fare by 50%; '90: elim zones 94: raise cash to $1, inc disc., LRT=local, CR=express	mkt seg. elas from stated pref survey; prev elas from time series anal
OCTA (Orange Co , CA)	81: keep pk/off-pk, dist -based on express, elim discount 94: keep flat fare, intro disc , free transfers, no expr surcharge	mkt seg elas from time series anal and experience elsewhere
TARC (Louisville)	93: mkt research found very high % of infreq riders	mkt seg based on experience elsewhere and professional judgement
MVRTA (Dayton, OH)	93: intro deep discounting, inc. cash fare	mkt. seg based on experience elsewhere and professional judgement
Madison (WI) Metro	91: inc cash fare, intro disc , no pk/off-pk 92: intro wkday pass, raise everyday pass	mkt seg based on experience elsewhere and professional judgement
GLPTC (Lafayette, IN)	88: deep disc , introduced as promotion 90: replace punchcards with tokens	mkt seg based on experience elsewhere and professional judgement
SCRRA (So Calif)	94: reduce some fares	experience elsewhere

only, and Seattle Metro) offer it for full-fare riders. In other cases, operational concerns, particularly related to the transition from peak to off-peak (or vice versa), have caused the agencies to reject this option. At CTA, for example, concerns about the agency's ability to prevent rail ticket agent "skimming" of revenues led to the decision to introduce a differential on bus only. At DART, the peak/off-peak option was rejected after the preliminary evaluation stage, because its revenue and ridership effects were deemed insufficient to offset the operational and administrative complexities. OCTA had a peak/off-peak differential for some years but eliminated it in 1985, when the agency decided that the disadvantages of the strategy—administrative and operational difficulties, confusion among users, and lower revenue than in a flat fare structure—were more significant than the ridership and equity advantages. On the other hand, the agency retained a peak/off-peak differential for reduced fares (e.g., senior citizens and riders with disabilities) and continues to do so today.

Service-Based Differential. This category covers differentials by mode (e.g., bus-rail) or type of service (e.g., local-express). Among the case study agencies, only MBTA has a bus-rail differential: $0.85 for rail, $0.60 for bus. CTA removed its $0.10 rail premium in 1988, although, there is a differential during off-peak hours (driven not by the desire to charge more for rail but by operational constraints on the rail system precluding a peak/off-peak differential. Both BSDA and DART recently addressed the issue of pricing new LRT lines; in both cases, the decision was to charge the same on LRT as for local bus. Both agencies had established integration of bus and LRT and fare simplification as key goals. For its new commuter rail service, DART opted to charge the same as on its express bus service—$1 higher than the local/LRT rate.

Four of the case study agencies have a premium fare for express service (i.e., MBTA, NJT, DART, and MVRTA). OCTA had an express premium until 1992; reinstitution of the differential was considered in 1994 but rejected because of the desire to avoid any fare increases then. BSDA eliminated the higher express fare in 1993 for its Missouri service, although the two Illinois counties maintained the express premium for their BSDA service. The elimination of the express surcharge at DART was evaluated during the recent study, but the agency decided to retain the differential in order to maximize revenue.

Thus, the use of fare differentiation on the basis of distance, time of day, or service quality has decreased somewhat as agencies have sought to increase convenience to the rider and ease of administration of fare collection. At the same time, there has been an increasing push for expanding the use of prepaid fare mechanisms targeted to different market segments. The smaller agencies in particular have embraced deep discounting as a means of raising the cash fare without losing ridership, and the larger agencies have at least considered this approach; some have adopted adeep discount option—others have preferred to minimize cash fares and have decided against it.

The introduction of electronic fare collection will significantly expand the opportunity to offer a wide range of fare options and discounts for prepayment—all using a single farecard, thereby maximizing rider convenience and minimizing operator and administrative requirements. Selecting the appropriate mechanisms and pricing levels in such a system, however, considerably complicates the development and evaluation process. NYMTA, in its 2-year fare structure development effort, developed and evaluated more than 1000 fare packages; the study included extensive surveying of riders and non-riders and development of a complex ridership-revenue model and evaluation methodology. CTA also conducted a fare development study for its electronic fare collection system. The initial phase of the effort has focused on identifying a range of options and developing a new fare model designed to evaluate these new options; the development and evaluation of potential fare packages will be conducted in a later phase. Thus, while these and other agencies will continue to employ the general development and evaluation steps described in this chapter, certain aspects of the process, particularly identifying potential options and packages and estimating ridership and revenue effects, will grow in complexity.

Development of Fare Elasticities

As shown in the case studies, there are several ways of developing elasticities for use in predicting the ridership effect of a fare change. There are also differences in the application of elasticities; some agencies use a single systemwide elasticity, while others use a different figure for each mode. What is becoming increasingly common, however, is to identify a series of elasticities representing the various submarkets constituting total ridership.

The sources of elasticities for the case studies are summarized in Table 37. The major types of sources include the following:

- Time series analysis of the agency's historical ridership data—this often includes a regression analysis to isolate the effects of fare changes from other factors, such as service changes, employment, or fuel prices;
- Before-after ("shrinkage") analysis for a particular fare change;
- Use of a demand function, often on the basis of the results of stated preference surveys (i.e., asking how people would respond to various fare options and changes, or alternatively asking them to "trade off" fare changes with level-of-service changes);
- Review of industry experience, particularly for agencies of similar size and with similar characteristics; and
- Use of professional judgment in adjusting figures derived from the above sources.

There are also various types of elasticity equations; the most common are those known as point elasticity, shrinkage ratio, midpoint arc elasticity, and constant arc elasticity. For small changes (i.e., less than 10 percent), each formula should produce roughly the same elasticity. The midpoint or constant arc elasticity formulas, however, generally are used where larger changes are involved—or where there may be a decrease in some fare categories.

The specific equation used influences the resulting elasticity figures but has a much smaller effect than does the basic source or derivation approach. In fact, the case studies have shown that the source and approach can affect the elasticities identified for an agency greatly. This is demonstrated dramatically in the case of DART, which has used several different methods over the years and has ended up with substantially different figures. For instance, following the 1987 fare change, two separate time-series analyses were performed—each considering several service-related and socioeconomic factors in addition to DART's ridership trends. These analyses yielded considerably different elasticities for the major service types (e.g., -0.64 versus -0.35 for local bus service). There were differences in the exact data used, assumptions made, specific analytical techniques applied, or combinations thereof. These differences underscore the difficulties inherent in identifying specific elasticity figures appropriate for use in forecasting the ridership effects of fare changes. The elasticity estimate depends heavily on the particular analysis technique and data used. Largely because of the discrepancy in the two sets of figures, DART decided to use stated preference analysis to develop elasticities for a new fare model in the 1993 and 1994 fare study. The aggregate elasticity for local service was determined to be -0.40.

The approach that many agencies take in identifying elasticities is to calculate figures on the basis of their own ridership patterns and corroborate—and possibly adjust—these numbers on the basis of figures from other agencies. This approach is used sometimes for developing market segment elasticities, for instance, on the basis of a single systemwide figure; industry guidelines on ratios of elasticities for different markets—e.g., off-peak elasticities are often found to be 1.5-2 times peak elasticities—are applied to derive figures for the agency. This approach was taken in the recent OCTA study and at CTA, for example. The OCTA study's peer review included the identification of the peer agencies' elasticities. With regard to available sources of industry experience, a recent APTA study, *Fare Elasticity and Its Application to Forecasting Transit Demand* (August 1991) developed systemwide and peak/off-peak elasticities for 52 U.S. bus systems. Finally, many agencies continue to use the long-time industry standard "Simpson-Curtin Rule" (roughly -0.30).

The Simpson-Curtin rule notwithstanding, there are no industry standards regarded as the most appropriate method for calculating or applying fare elasticities. Part of the reason is the difficulty inherent in isolating the effect of fare changes on ridership.

RIDERSHIP AND REVENUE IMPACTS OF FARE CHANGES

The fare level is only one of many factors that can affect transit ridership. Important influences include changes in the local economy (e.g., prices of goods, employment and unemployment levels, and household incomes), the level of service provided, changing development and regional travel patterns, and the costs—in money and time—of alternative forms of transportation. Isolating the direct effects of fare changes on ridership and revenue is, therefore, quite difficult. It is, however, important to understand the effects of fares on demand in making fare changes.

In conducting the case studies, the project team reviewed ridership and revenue changes over the past several years. The research team also reviewed the results of efforts to analyze fare and other factors' effects on ridership and revenue. This section presents the overall trends at the case study agencies (separated by size of agency), summarizes the effects of fare reductions (including reducing cash fares, introducing a deep discount, and reducing transfer charges), and discusses issues associated with identifying the effects on ridership of fares versus other factors.

Overall Ridership and Revenue Trends

In order to develop some understanding of the effects of fares on ridership and revenue, it is useful, first of all, to review the individual ridership and revenue trends and to compare them to those of similar-size agencies. Tables 38 and 39 and Figures 2 through 7 summarize the percentage changes in systemwide (unlinked) ridership and fare revenue for the case study agencies for the period from 1987 through 1992. (Earlier data are provided in several of the individual case studies. SCRRA is not included in this discussion, because it is a new system.)

Looking first at overall trends, the figures show that, in general, fare revenue was growing during this period: of the 11 agencies considered here, only DART, BSDA, and MVRTA

TABLE 38 Revenue—percentage change from previous year

	Largest Systems			Large Systems				Medium and Small Systems			
Year	NJT	CTA	MBTA	DART	SEATTLE	OCTA	BSDA	TARC	MADISON	MVRTA	GLPTC
1988	1%	8%	4%	3%	1%	2%	-1%	-3%	0%	-3%	11%
1989	7%	0%	2%	0%	15%	22%	4%	1%	-2%	0%	19%
1990	6%	3%	11%	-3%	8%	18%	-2%	-1%	4%	5%	27%
1991	4%	-4%	-4%	-11%	18%	0%	-2%	5%	4%	1%	27%
1992	0%	10%	36%	-10%	6%	4%	0%	-1%	0%	-6%	-12%

TABLE 39 Ridership—percentage change from previous year

	Largest Systems			Large Systems				Medium and Small Systems			
Year	NJT	CTA	MBTA	DART	SEATTLE	OCTA	BSDA	TARC	MADISON	MVRTA	GLPTC
1988	-1%	-3%	13%	-6%	11%	0%	-6%	6%	-5%	5%	8%
1989	-1%	-1%	0%	-18%	4%	14%	-5%	12%	-5%	29%	1%
1990	-3%	0%	7%	3%	4%	16%	-4%	-21%	1%	6%	22%
1991	-6%	-7%	-2%	6%	1%	5%	-2%	4%	3%	-17%	26%
1992	1%	-6%	2%	0%	1%	0%	-9%	9%	2%	2%	-2%

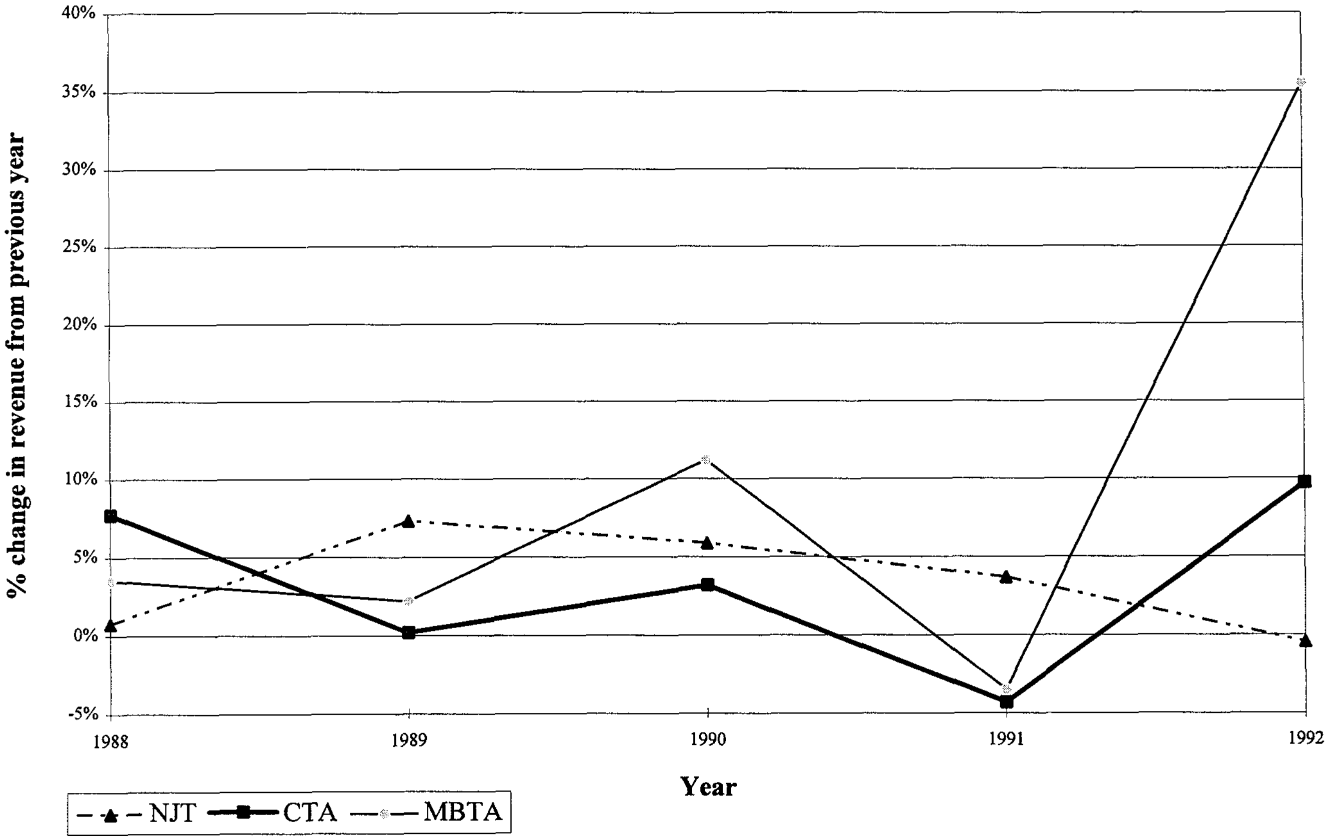

Figure 2. Change in revenue—largest systems.

lost revenue over the period as a whole. Individual fare increases enabled the agencies to increase revenues in most cases, with only 5 of the 18 increases during the period not producing higher revenue in the following year. Three agencies (i.e., NJT, CTA, and BSDA) lost riders, thus, BSDA was the only case study agency to suffer overall declines in both measures. GLPTC is notable for its very large overall growth in both revenue, 88 percent, and ridership, 64 percent. The 1990-1991 period appears to have been significant for most agencies, and this coincides with the onset of the recent recession. For three agencies (i.e., CTA, MBTA, and BSDA), both revenue and ridership fell in 1991; ridership also declined in that year at NJT, as did revenue at MVRTA and DART.

Differences by Size of Agency

Largest Systems

The revenue and ridership changes for the three largest of the case study agencies (i.e., NJT, CTA, and MBTA) are shown in Figures 2 and 3, respectively. The recession of the late-1980s and early 1990s hit these areas hard, leading to revenue and ridership declines on CTA and MBTA—and a ridership loss on NJT—in 1991; NJT's revenue rose in 1991 but by a smaller percentage than in the prior 2 years. The relative trends actually are quite similar for CTA and MBTA from 1989 to 1992, although CTA has apparently suffered more from the recession. Staff at all three of these agencies feel that the economic climate—specifically falling employment—contributed to the negative ridership trend in 1990 and 1991. The employment boom from 1985 onward had helped many agencies maintain nominal fare levels through much of the decade—without cutting service and while enjoying increased farebox revenues. When employment began to fall off, however, trip rates declined, and, at agencies such as CTA and MBTA, farebox revenues also suffered.

As shown in Figures 2 and 3, MBTA has experienced considerable fluctuation in ridership and revenue during the review period; in 1988, ridership rose dramatically, but it leveled off in 1989, following a fare change; the fare change apparently had little effect on revenue, though, because it rose only slightly. Following another substantial ridership increase in 1990, MBTA suffered a ridership loss in 1991. MBTA had calculated, through a regression analysis, that over half of the ridership loss after the 1991 fare increase could be attributed to the higher fares. During that year, however, the recessionary effects had been exerting downward pressure on ridership levels before the fare increase. The trend analysis performed in 1991 showed that ridership had been falling for the first 8 months of the year—before the fare increase—and thus the

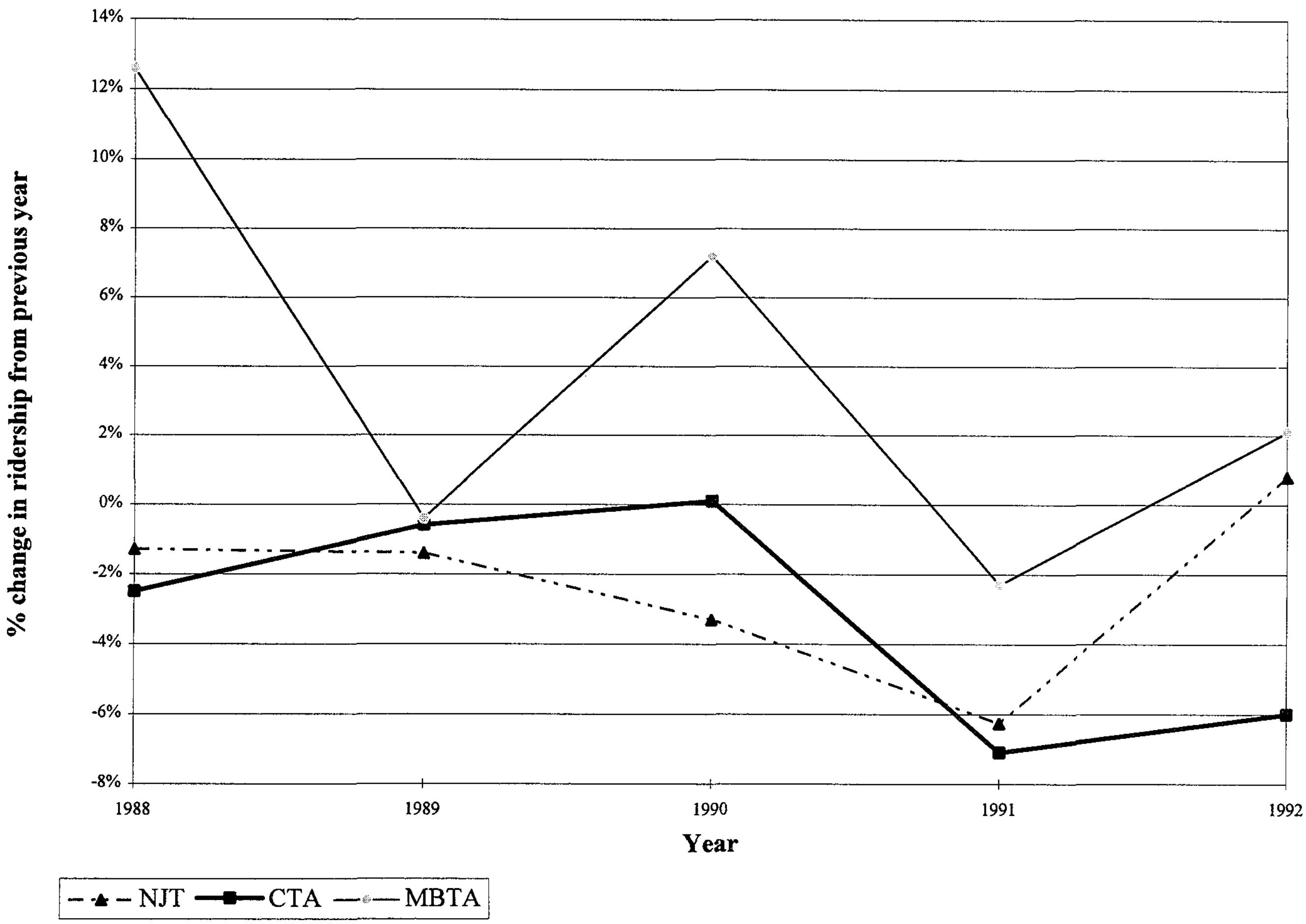

Figure 3. *Change in ridership—largest systems.*

regression analysis may well have overestimated the direct effects of the fare increase on ridership. Ridership recovered somewhat in 1992, despite the recession still strongly affecting the region, and the 1991 fare increase apparently led to the major jump in revenue in 1992.

As shown in Figures 2 and 3, NJT's revenue and ridership patterns were relatively consistent during the analysis period. Ridership declined somewhat (1 to 6 percent) every year until 1992, when it experienced a slight upturn; the loss deepened in 1991, consistent with the trend at CTA and MBTA. Conversely, NJT's revenues grew each year until 1992, when they remained essentially unchanged. In terms of specific modes, aggregate rail ridership increased after the 1988 fare increase, although the routes to downtown Manhattan suffered ridership losses—attributed to extensive lay-offs on Wall Street that year. Bus routes lost around 2.5 percent of their riders in the same period; roughly one-third of this loss was attributed directly to the fare increase, the remainder to the depressed economy.

Ridership on CTA was falling throughout much of this period, with a significant downturn in 1991. Following the 1988 fare increase, CTA experienced substantial revenue gain—but with a ridership loss. The next year (1989), the decline in ridership was much smaller, but revenue grew by an even smaller percentage than did ridership. Seeking to increase both revenue and ridership, CTA decided to introduce a deep discount on tokens as an integral part of an overall consumer-based pricing structure. The Authority succeeded in its goal of increasing revenue (the revenue target for the fare change was actually exceeded) without losing ridership. Ridership and revenue both fell sharply in 1991. The recession hit Chicago in early 1991, marked by rising unemployment and a generally slow economy. CTA planners blame the ridership and revenue losses solely on the economic downturn, rather than on any delayed fare structure effect. Because of the revenue loss, the Authority felt the need to increase fares in December 1991. This fare increase served to reverse the revenue decline—1992 fare revenue grew significantly; however, the fare increase also contributed to an acceleration in the loss of ridership, as ridership continued to decline. In order to continue the revenue growth, CTA has modified its pricing three times since mid-1992.

Large Systems

Figures 4 and 5 display the revenue and ridership changes for the four "large" case study agencies (i.e., DART, Seattle

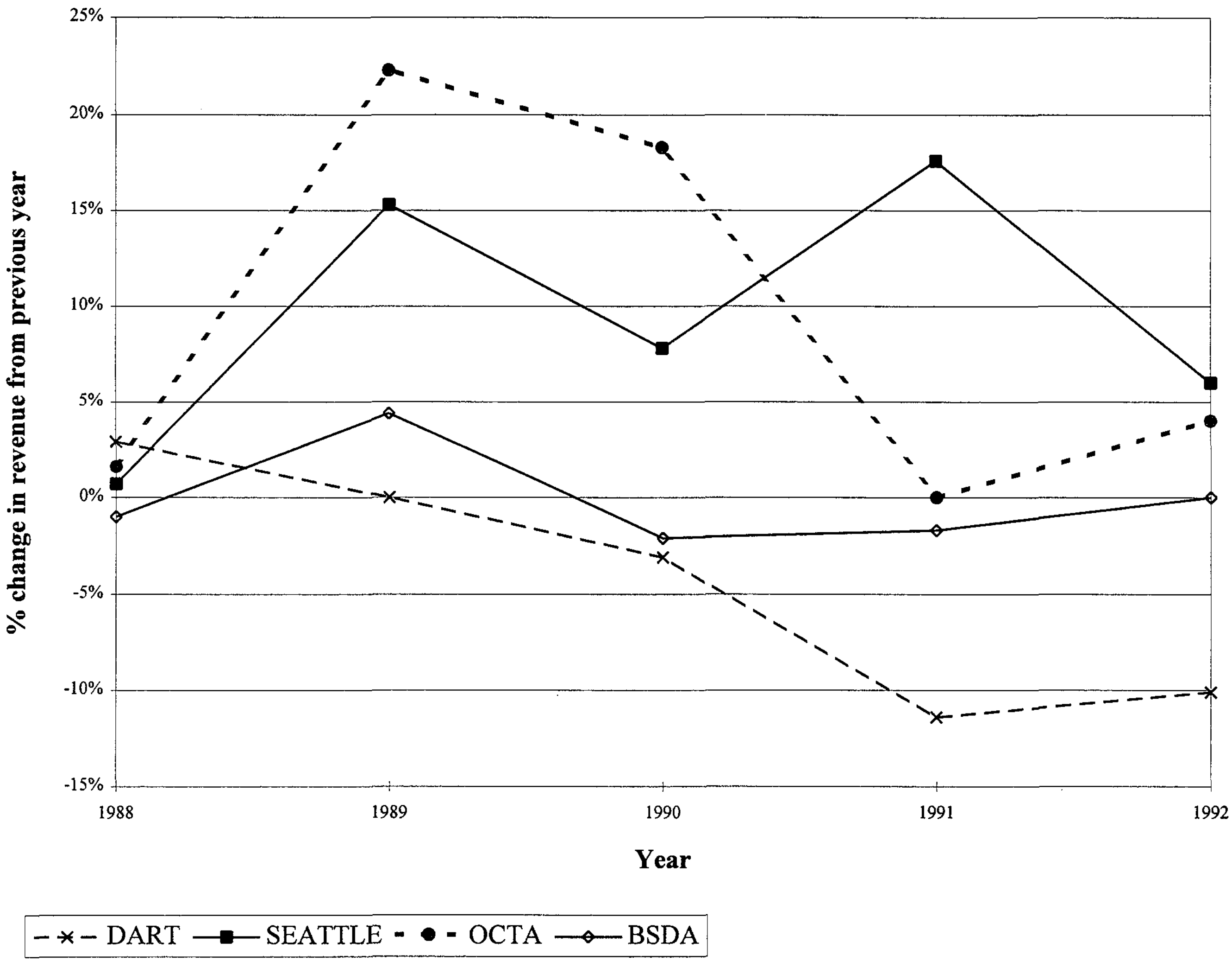

Figure 4. Change in revenue—large systems.

Metro, OCTA, and BSDA). The figures show that there has been considerable variation in each of these agencies' trends, i.e., in terms of the magnitude of year-to-year changes. On the other hand, there are general consistencies in the direction of the changes. Seattle Metro and OCTA experienced ridership and revenue growth (or, at worst, no change) each year, although the rate of ridership increase at both agencies dropped to essentially no change by 1991. Seattle Metro's ridership expansion occurred despite fare increases in 1989 and 1991. One of the key factors driving the ridership growth in general was the significant growth in employment during the late 1980s. This growth slowed considerably in 1990, however, and it has remained relatively even since then. As shown in Figure 4, the two fare increases resulted in strong revenue growth.

OCTA's ridership rose, along with revenue, despite annual fare increases between 1988 and 1991; in other words, the agency's revenue and ridership growth slowed greatly at the end of this series of fare increases. The leveling off of ridership in 1991 is attributed to a serious decline in the local economy. Orange County had benefited from a booming economy throughout the 1980s, but employment in the County dropped considerably beginning in 1991, as the recession finally reached Southern California.

In contrast to Metro and OCTA, BSDA lost ridership in every year of the analysis, although the percentage of the loss declined each year—until 1992; unfortunately, the agency gained revenue in only one of the years—1989. The ridership loss trend actually had begun in the early 1980s. BSDA had reduced service by a third during the decade (because of insufficient and declining operating assistance), and ridership had been further eroded by residential and employment shifts within the region—i.e., away from the City of St. Louis toward the suburbs. In an attempt to isolate the effect of the 1991 fare change, a regression analysis was carried out that considered cash fare, regional employment, and gas price, as well as a seasonal factor. None of the variables was found to be a significant factor in the loss of ridership. It was concluded that the service reductions and the increasing suburbanization of the

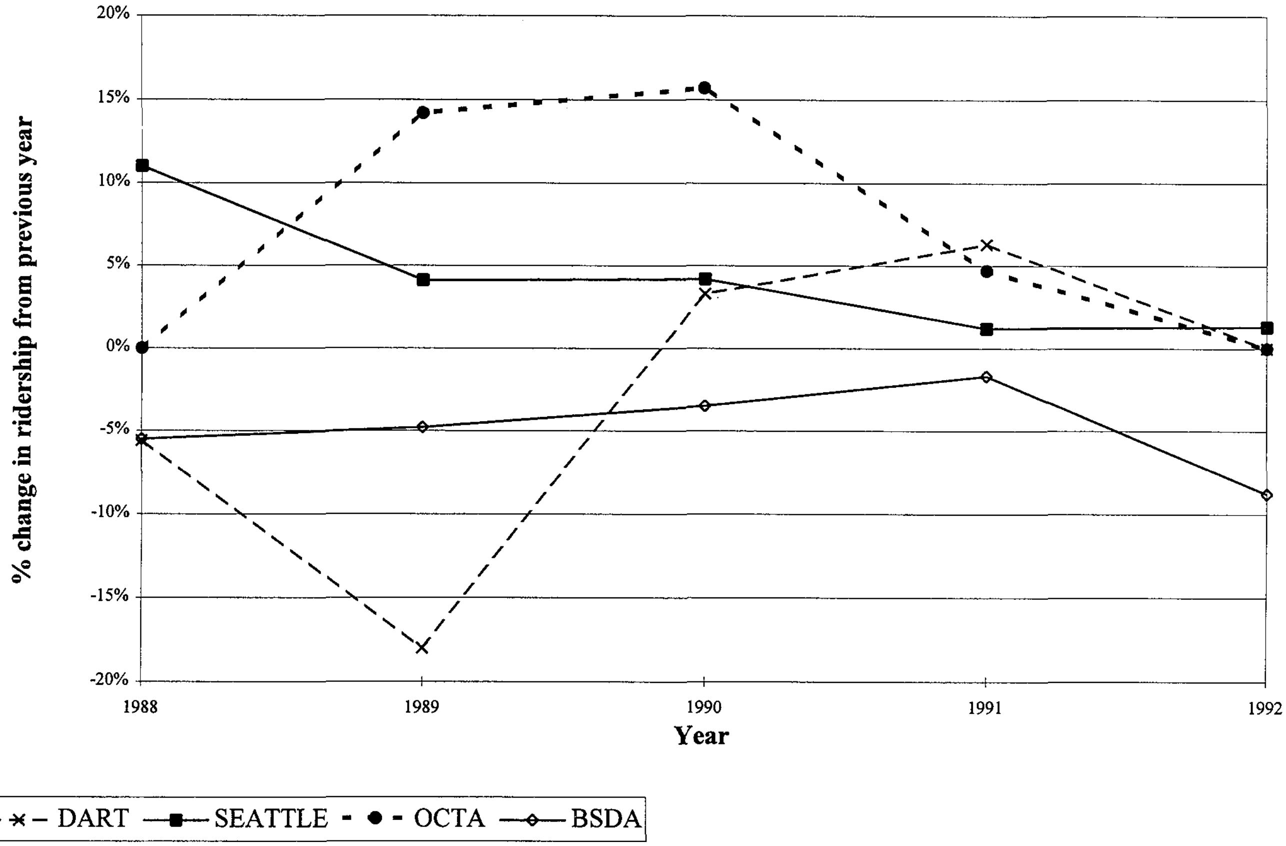

Figure 5. Change in ridership—large systems.

region, coupled with a lack of sufficient marketing caused this general downward trend. BSDA's ridership has grown since mid 1993—primarily because of the popularity of the new LRT line; however, the reduction of express fares also apparently has contributed to this increase.

DART experienced the largest single ridership loss of any of the large or largest agencies—18 percent in 1988 to 1989. In 1987, DART had instituted a 50 percent increase in the cash fare, while reducing service mileage. This change, in conjunction with falling gas prices that made automobile travel more attractive and increasing unemployment in the region (the result of the falling gas prices), resulted in the major ridership decline and then led to the 1990 fare modification (the elimination of zones). This effective fare decrease led to the reversal of the ridership and revenue trends, i.e., ridership increases in the next couple of years, but accompanied by revenue losses. Unfortunately, the ridership trend has now reversed again, with a decline in 1993.

To identify the long-term effect of fares and other factors on DART's ridership, a regression analysis was undertaken, looking at service provided, gas prices, and regional employment, as well as fares for the period between 1985 and 1993. It was found that there were strong statistical relationships between ridership and fares, revenue miles, and gas prices; amount of service was actually found to be the most important variable. Regional employment did not display a strong correlation, although it should be noted that City of Dallas employment figures were not available for all years and thus not used, and a significant portion of the regional employment is not well-served by DART. The analysis also revealed a downward trend beyond the effect that could be associated with the other factors; it was felt that this trend may be reflecting the trend of declining employment in the City. Thus, fares were determined to have a significant relationship with ridership over the long term (i.e., nearly a decade), although it is just one of several important factors.

Medium and Small Systems

The medium and small case study agencies are TARC, Madison Metro, MVRTA, and GLPTC. Revenue and ridership trends for these agencies are shown in Figures 6 and 7, respectively. Other than Madison Metro, these agencies demonstrate considerable variability in ridership over the period reviewed. In contrast, except for the large 1990 to 1991 change at GLPTC, revenue trends were relatively stable. It is important to note that these smaller agencies have tended to have very few fare changes over the last decade or more.

TARC did not change its fares between 1980 and 1993, and, as indicated in Tables 37 and 38 and Figure 6, revenue remained relatively stable. Ridership, on the other hand, was

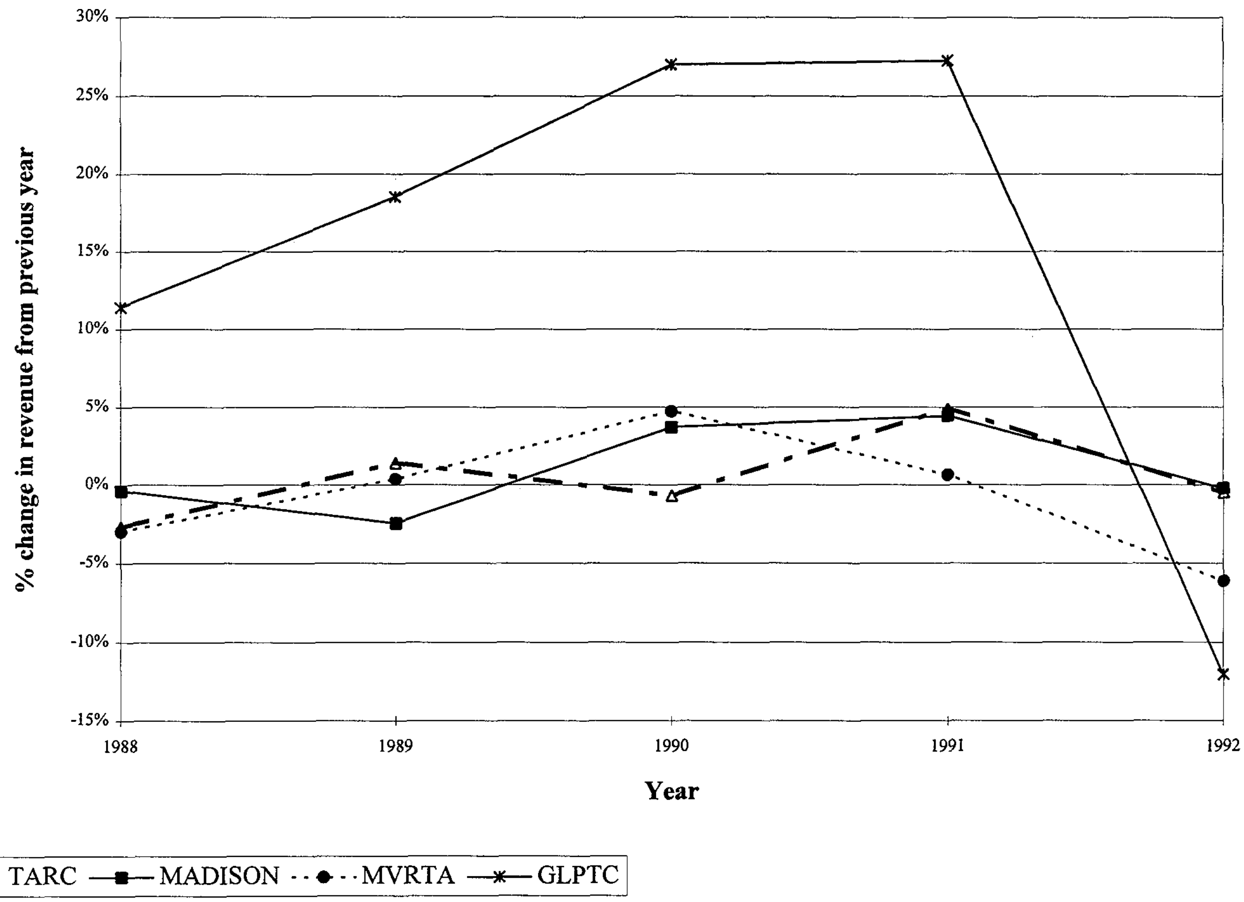

Figure 6. Change in revenue—small systems.

undergoing steady increases until a major drop in 1990—the largest 1-year decline of any of the case study agencies. The economic downturn in the area was felt to have contributed to this change, although ridership rebounded in 1991 and continued to grow in 1992. No detailed analysis was undertaken to explain this dramatic turnaround, and it is possible that inconsistencies in ridership data may explain at least part of this pattern.

Unlike the other agencies, the economy of the City of Madison was not affected by the recent recession; the presence of two large and stable employers—the University of Wisconsin and the state government—has helped the local economy remain relatively strong. There was a steady downward trend in ridership through the 1980s (with a loss of over 30 percent in that decade), which was attributed largely to the suburbanization of the city, increasing real income, and falling real gas prices. Both revenue and ridership began to turn around in 1990, apparently because of an effective marketing campaign. The upward trends were then reinforced by a major route restructuring and service expansion and the introduction of deep discounting in 1991. Revenue increased again in 1993, while ridership remained roughly the same as in 1992, despite a second fare change.

MVRTA had a long-term strategy to increase ridership through the 1980s; thus, fares were not changed from 1982 to 1993. As shown in Table 39 and Figure 7, ridership had displayed substantial growth in 1988 and 1990, with the 1990 increase the largest single-year increase of any of the case study agencies. The economic downturn in 1990, however, affected ridership levels significantly (i.e., a 17 percent fall from 1990 to 1991), and this was attributed largely to increased unemployment and the closing of a large downtown department store. Generally, employment had been increasing during the 1980s but began to fall significantly in 1990. Revenue has displayed less variation, although it dropped somewhat in 1992. The 1993 fare change, in which fares were increased along with the introduction of a deep discount, has resulted in a substantial revenue increase, although ridership suffered a decline following the change, before stabilizing of late.

GLPTC experienced steady growth in both ridership and revenue during the period reviewed until both declined in 1992. GLPTC has a considerable amount of contract service, which has fluctuated over the past several years. An increase in the amount of this service (e.g., at Purdue University and to several apartment complexes) apparently spurred much of the ridership and revenue growth in the late 1980s. Some service reduction

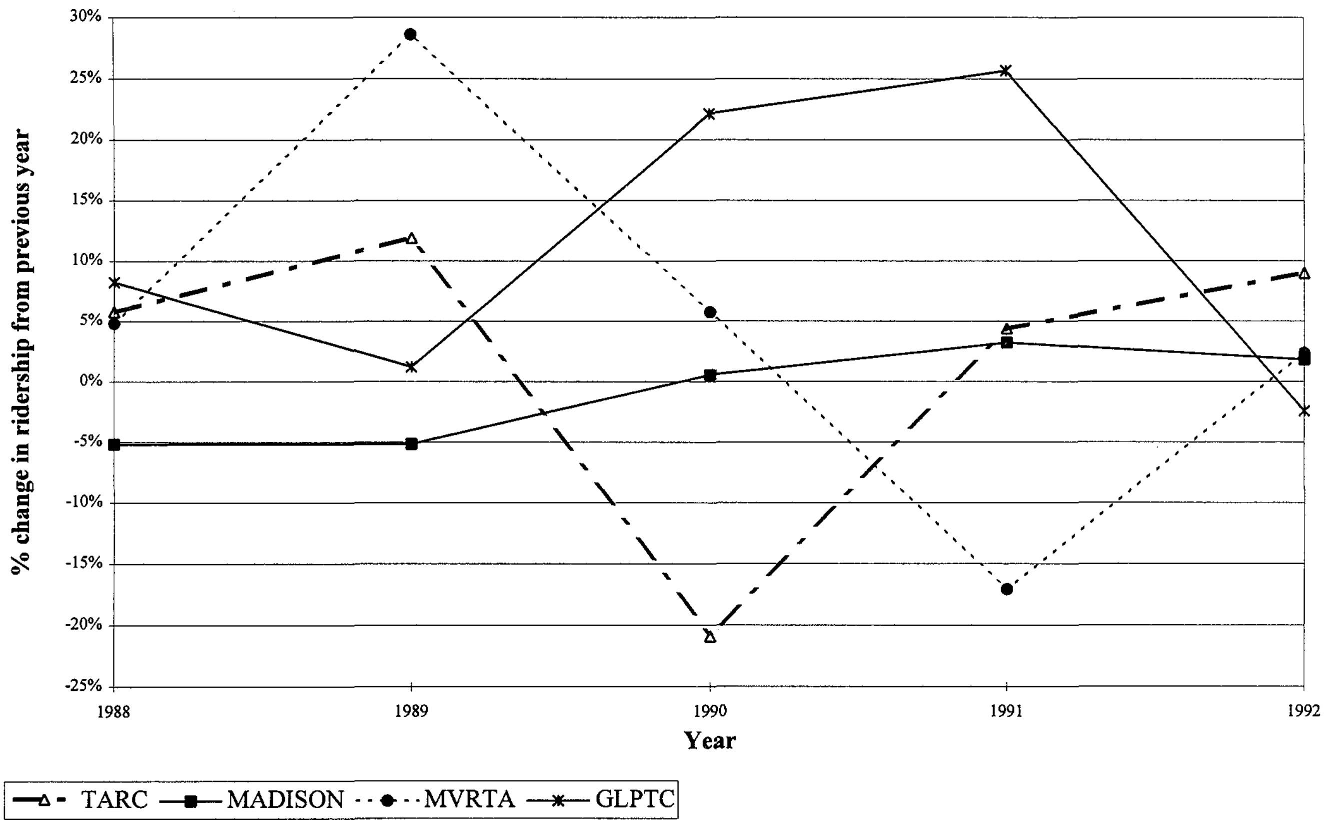

Figure 7. Change in ridership—small systems.

in 1991 was thought to have led to the fall in revenue and ridership in 1992.

Effects of Fare Reductions

This section discusses the effect on revenue and ridership of reducing fare levels. Two major categories of reductions are reviewed: lowering the cash fare and introducing a deep discount for prepayment. A third approach—reducing transfer fees—also is discussed briefly.

Reduction of Cash Fare

Cash fare reductions are relatively rare, given the general concern with maximizing revenue. Effective reductions have been introduced through prepaid discounts, but these typically accompany cash fare increases. Certain fare elements, however, have been lowered (e.g., the elimination of an express surcharge, as BSDA did in 1993); full cash fares have, on occasion, been reduced (e.g., at DART in 1984); and other agencies have considered such an action—as a means of boosting ridership. OCTA considered a fare reduction in its most recent fare study, in conjunction with elimination of reduced-price transfers. Fare reductions also sometimes are suggested by public officials or rider groups; for instance, it has been suggested on occasion that, because transit is a "public good," it should be provided free of charge.

The discussion here focuses on the revenue and ridership effects of reducing fares, although effects on operating cost (e.g., increases because of the need to add service, savings from reductions in bus running times, and the elimination of fare collection and evasion monitoring costs if fares are eliminated) are also likely. There may also be an effect on operators' morale of instituting free fares—possibly positive and negative. The positive effect would come chiefly through reductions in the frequency of confrontations between passengers and operators and of assaults on operators. Offering free service can lead operators to feel that their efforts have no value because they are providing a service that apparently has no value. Furthermore, eliminating fares can result in excessive crowding of vehicles, possibly discouraging former fare-paying customers from riding. Thus, the full effect must be assessed by any agency considering reduction or elimination of fares. Brief reviews of two instances of fare reduction from the case studies follow.

DART. At the time of its creation in 1984, DART lowered the base cash fare from $0.70 to $0.50 and the monthly pass price from $26.00 to $20.00, while removing the $0.10 transfer fee (in favor of free transfers). Comparing the period January to March 1983 with the period January to March 1984, ridership increased by 16 percent. DART also began a significant service expansion later in 1984. By late 1986, the fare change and service improvements had combined to produce a nearly 50 percent increase in ridership from the pre-DART level.

After a revenue loss of 11 percent in the first year of the new fares, fare revenue increased, but the increases did not outweigh the increased operating costs of the new services, and cost recovery fell to less than 25 percent in 1986. Thus, the fare reduction was reversed (as were many of the service improvements). The base fare was increased to $0.75 in February 1987 and monthly pass prices to $27. These changes increased the cost recovery ratio to 33.5 percent, but the loss of ridership (nearly 13 percent) exceeded expectations and the increase in revenue was less than half the anticipated amount.

One interesting finding from analyzing these fare changes was that the fare elasticity calculated for the fare decrease (adjusted for amount of service and gas prices) was -0.39, very close to that for the fare increase, -0.35. This suggests that riders display roughly the same degree of sensitivity to a fare decrease as to an increase; this result contrasts with other studies that found that ridership tends to be significantly less responsive to decreases than to increases (i.e., if an agency raises fares and then lowers them to the original level, ridership will be lower than if fares had remained constant).

BSDA. In conjunction with the opening of the light rail line in 1993, BSDA initiated a new fare structure. One of the changes within this package was to eliminate the express surcharge in Missouri, reducing the express cash fare from $1.30 to $1.00 and the express monthly pass price from $42.00 to $35.00 (i.e., the local fare and pass levels). At the same time, the cost of transferring was halved from $0.20 to $0.10, and a substantial amount of the express service was withdrawn. Comparing the year-to-year changes in ridership on the express routes that continued to operate revealed that ridership on those routes rose 9 percent from April 1993 to April 1994, in contrast to a 1 percent loss on all services, as well as a 10 percent loss on these express routes the prior year. There was considerable variation of ridership changes on the individual express routes: from a 17 percent drop to a 60 percent rise. Half of the routes, however, experienced increases of between 3 and 15 percent. (Data on revenue on these routes were not available.)

Introducing Deep Discounts

The use of deep discounting has been shown to be an important pricing and marketing strategy. In contrast to the reduction of cash fares, it involves offering a lower fare option through prepurchase of multi-rides (i.e., other than a pass). The strategy allows an agency to raise cash fares—and thus generate increased revenues—but can minimize or perhaps neutralize the ridership loss that would otherwise be expected with an increase. The case studies provide illustrations of deep discounting strategies that have been adopted in larger and smaller agencies, although such strategies are more heavily represented here among the smaller agencies. Summaries of the ridership and revenue effects of three of the case study experiences follow.

CTA. In April 1990, CTA introduced a consumer-based fare structure that featured a decrease in the unit price of 10 tokens (from $0.95 to $0.90) and increased the base cash fare from $1 to $1.25. By the end of that year, revenue had increased (in fact, the target revenue for the fare change was exceeded) without a loss in ridership. CTA also greatly increased the extent of prepayment (by token and pass), a key goal of the fare change; token use rose by 240 percent. Unfortunately, both ridership and revenue fell sharply in 1991—apparently because of the recession. Because of the revenue loss, CTA raised fares again in 1991. The deep discount was retained, although the level of the discount was reduced somewhat; nevertheless, token use increased by 44 percent in 1991, and overall prepayment rose again. Ridership continued to fall, although revenue rebounded in 1992. Thus, while the effects of the recession have masked the longer-term effects of the deep discounting approach, CTA management has considered it worth retaining—despite the need to generate greater revenue— because the strategy is perceived as minimizing ridership loss when cash fares are increased.

Madison Metro. In August 1991, Madison Metro raised the cash fare from $0.75 to $1.00 and introduced a 10-ride pack of tickets for $0.75 apiece. Ridership had been falling in 1988 and 1989 following a fare increase in 1987. Ridership stabilized in 1990. Restructuring of services in early 1991 was a major factor in maintaining that growth, but the deep discounting in August allowed Madison Metro to gain additional revenues, while ensuring continued ridership growth. Revenue has grown in each of the last 4 years, while ridership has been maintained.

GLPTC. In February of 1988, GLPTC introduced a 10-ride card at a 20 percent discount on the cash fare as a mail order promotion. No other changes in the fare structure were made. Direct mailings were sent to nearly every household in the GLPTC service area; by June of 1988, ridership had grown by 5 percent and adult fare revenue had grown by 11 percent. The FareSavers became a permanent part of the fare structure at the end of 1988, and ridership and revenue continued to grow in 1989. These increases were substantially in excess of the service increases in these years. This example differs from the others in that the sole fare change was the introduction of a discount, whereas the more common approach is to increase cash fares as well.

Reducing Transfer Charges

As indicated in Chapter 3, for many agencies, including those studied here, issues related to the policy and pricing of transfers between modes and between routes have been a key area of concern. Transfer payment is felt to be a major source of fare evasion and confrontation between operators and passengers. Thus, when considering reducing transfer prices, introducing free transfers, or abolishing transfers altogether, there are trade-offs between the effect on revenue and effects on operational efficiency, operator welfare, and passenger convenience. Two examples of case study agencies that have reduced transfer charges are discussed below; unfortunately, the ability to isolate the effects of these changes is hampered because the changes invariably came as part of general fare structure modifications.

DART. DART removed the transfer fee from its fare structure in 1984. The revenue and ridership effects of this were tied in with the effects of the lower cash fare; however, the agency noted a small increase in the share of transfer boardings in the year following the fare changes. It is noteworthy that the transfer fee was eliminated at the same time that the cash fare was reduced. A more usual approach is to increase the cash fare if free transfers are to be allowed or, conversely, to offer a lower cash fare where reduced price transfers are being eliminated.

OCTA. OCTA operated from 1977 until 1991 without charging for transfers. As part of a new fare policy in 1991, a transfer charge of $0.05 was introduced. At the same time, fares were increased. In 1993 and 1994, transfer policy was a key element of the fare policy review. The grid system means that roughly 47 percent of riders transfer at least once to complete their trips. This high rate of transferring, coupled with a concern about the level of transfer abuse and the extent of confrontations between operators and transferring riders, makes transfer policy a major issue for the agency. Various options were considered, including both allowing free transfers and eliminating transfers altogether (concomitant with a substantial cash fare reduction). Among OCTA senior management, there were strong proponents for the latter policy; however, because this would lead to a substantial fare increase for many of OCTA's riders, it was decided, instead, to return to free transfers for now. The possibility of eliminating transfers in the future has not been ruled out, however, and will be considered further.

Identifying the Effects of Fares Versus Other Factors

Fare is just one of many factors affecting transit use. The case study analyses show that economic variables (e.g., employment and gas prices), development patterns, transit service levels, and marketing all influence ridership. Transit agencies seek to identify the effects of fare changes on ridership and revenue in order to predict the effects of future fare changes. There is a need, therefore, to understand the nature of other factors affecting operating conditions and demand and to appreciate that different factors will be felt with different intensities and often with different time lags. For instance, increasing unemployment may result in an immediate ridership loss, while increasing suburbanization will have longer-term effects on ridership. In multimodal agencies, or where an agency faces competition from other area operators, the effect of other fare strategies also may affect ridership on a particular mode. For instance, bus and rail each will have their own fare elasticity measure, as well as "cross-elasticities" with respect to change in fare on the alternative mode. Furthermore, for each service, there is an elasticity with respect to other variables, such as service level or employment.

As discussed in the section on Development of Fare Elasticities, time series regression techniques are often used to isolate the effects of the different exogenous variables, with the aim of identifying elasticity values for use in future evaluations of possible fare changes. Although these are useful in identifying the relationships between the different variables and ridership, time series analysis depends heavily on the nature of the data used, the time horizon, and the specific model specification. For instance, two analyses of the same DART ridership period yielded quite different results. (A more complete discussion of the technical issues and problems associated with regression techniques can be found in the APTA report, *Fare Elasticity and Its Application to Forecasting Transit Demand*; this study describes the application of an advanced econometric model for developing fare elasticities.) The nature of the data available for each variable to be included in the analysis is crucial. The case studies have illustrated that the existing fare collection technology can impose significant constraints on the quality of ridership data that can be reported (as was the case at MBTA), and data storage procedures also may limit the availability of certain data (as at NJT, where historical data on the level of service of different modes was found to be unavailable in the 1990 fare study).

Another problem may involve identifying an appropriate data series for a particular non-transit variable. For example, different agencies in a region (e.g, metropolitan planning organization [MPO], transit agency, and city planning department) often maintain their own data series, and these do not always agree. This was the case for gas prices in Dallas—two different agencies had historical indexes that differed considerably for certain periods.

Even when relevant data are available, there can be difficulty establishing relationships that make intuitive sense. For example, employment trends affect trip-making on all modes of transportation and commuters are a major part of the transit market; however, many agencies, among the case studies and others, have been unable to demonstrate significant relationships between employment and demand. For example, no employment series appeared to be a useful explanatory variable in analyzing DART's ridership changes. The available series was for Metropolitan Statistical Area employment, which, during the period under consideration, was increasing. Much of this increase, however, was thought to be in the suburban areas and, therefore, unconnected with DART ridership levels.

Regression analysis has constraints associated with it—only a few of which have been noted here. There are also concerns that the effects isolated through these mechanisms are not useful as indicators of the effects that would be experienced with changes in fare levels or other factors in the future. (The accuracy of specific predictions is discussed in the individual case studies.) As mentioned under Development of Fare Elasticities, this has led analysts and planners to try alternative predictive methods, including stated preference techniques or the application of industry guidelines. Professional judgment is a crucial aspect of any approach.

CHAPTER 5

FARE PAYMENT AND COLLECTION TECHNOLOGY OPTIONS

INTRODUCTION

The final major parameter of the overall fare payment and collection system is the fare collection and media distribution technology (used in this report to refer to the type of fare payment media and equipment used in these functions). The technology used in fare payment and collection affects the efficiency of these functions and the range of fare strategies and payment options that can be employed. Moreover, improved technology can contribute to improvements in revenue control, data collection, operations planning, and service integration. Such improvements do not come without certain costs (i.e., beyond the actual expense of procuring the equipment and producing the fare media); these costs may include training of operating and maintenance personnel, education of riders, testing and installation of equipment, and development of new accounting and processing procedures.

Unlike industries such as telecommunications and information systems, the transit industry traditionally has been slow to embrace advanced technologies. Budgetary restrictions place significant constraints on all transit capital investments, thereby discouraging experimentation. Most transit agencies require that every new technology or piece of equipment be clearly demonstrated to be capable of holding up under the often severe mechanical and electrical operating conditions present in the transit environment. Any new technology must, therefore, be well proven before it is embraced for widespread transit application. Table 40 summarizes the history of technological developments in the fare collection area.

Agencies must understand both the benefits and the costs associated with introducing new fare technology. Whereas the previous chapters focused on fare policy and structure decisions, the next several chapters address technology and equipment issues. This chapter identifies and describes the different types of media and equipment used in the transit industry. Chapter 6 discusses emerging fare payment technologies, particularly electronic payment methods. Chapter 7 examines applications of electronic payment and developments related to the purchase and processing of fare media. Finally, Chapter 8 reviews the selection and procurement of new fare technologies and equipment, including a discussion of the costs and benefits associated with these technologies.

TYPES OF FARE COLLECTION SYSTEMS

General Types of Fare Collection System

The four basic types of fare collection system are as follows:

- Pay on entry (i.e., on boarding the vehicle)—typically involves a farebox; the most common approach for buses;
- Barrier (i.e., pay on entering or exiting a station or loading area)—involves turnstiles, gates, ticket agents, or combinations thereof; may involve entry control only or entry and exit control; the most common approach for rapid rail;
- POP—barrier-free; the most common approach for light rail; also used on commuter rail; and
- Conductor-validated—used only on commuter rail.

The basic fare system elements (i.e., fare media and types of equipment) and their typical application are summarized in Table 41. Not every type of collection system is used with every mode, and individual types of media are appropriate only for certain collection system and mode combinations. Therefore, the type of collection system is generally the first decision made in developing a new overall fare system. This may, in turn, limit the selection of a media technology, or, conversely, the selection of a media technology may require that the collection system choice be revisited.

Pay on entry is typically used on buses, although some bus systems in Europe use POP systems. Rapid rail lines are typically barrier (or gated) systems, although POP is used on some systems; some barrier systems involve entry control only, while others (e.g., distance-based magnetic ticket systems) use entry and exit control. Most commuter rail services have been conductor-validated systems, although the newer lines have tended to adopt POP; there is a single barrier commuter rail system (Metra Electric in Chicago). LIRR actually has implemented station designs that are unmanned but open and close automatically. Appropriate closed-circuit TV and motion sensors are installed to monitor station occupancy, and warnings are provided at closing to provide sufficient time for passengers to vacate the station before the AVM security gate closes and the station doors are locked. Light rail lines have used pay on entry, barrier, and POP, although as with commuter rail, the trend in recent years has been to use POP. The different types of media and equipment used in these systems are described in the following sections. The types of fare systems and technologies used for selected U.S. and Canadian transit agencies are summarized in Table 42. The next section reviews fare system applications abroad; some of these approaches are quite different from those in the United States and are thus of interest here.

Fare Collection Trends and Applications Abroad

With regard to type of fare collection system, one of the major differences between European transit systems and those in the United States is that most systems in Europe use the

TABLE 40 Significant events in development of fare collection systems

1838	Boston - First commuter fares on a railroad (Boston & West Worcester RR)
1900	France - Automated TVM
1912	England - Automated TVM
1927	Philadelphia - First automobile park and ride lot and first bus-rail transfer facility for non-commuter rail line
1930	London - High volume passenger-operated TVM
Late 1950's	United States - Large banks in U S issue credit cards
1964	London - First magnetic ticket system in Europe LIRR - First magnetic ticket system in U S
Mid-1960's	Japan - Kei-Hanshin-Kyuko commuter network introduces punched card tickets for use in "open mode" turnstiles
1965	Chicago - CTA begins designing single slot multi-coin turnstiles
1966	Chicago - ICGRR (Metra Electric) begins first stored ride application
1967	Montreal - MUCTC installs magnetic tickets/punched hole bus to rail transfers London - London Transport tests stored value ticket concept for buses
1968	London - Victoria Line magnetic tickets Lindenwold - PATCO line opens with stored ride plastic tickets Lindenwold - Plastic tickets are recycled - a first
1969	CTA and PATH buy single slot coin turnstiles from English company Paris Metro introduces magnetic ticket system with central control
1970	England - First computerized commuter rail fare collection starts on British Rail's Scottish Regional Line in Glasgow using Litton Industries equipment
1972	San Francisco - BART opens with stored value tickets and fare by distance United States - ATMs are introduced
1974	Energy crisis at peak - fares/fare collection efficiency draws great attention San Francisco - BART introduces centralized Data Acquisition System (DAS)
1976	Chicago - CTA purchases single slot/multi-coin turnstiles from Duncan Washington, D C - WMATA opens with stored value tickets and fare by distance structure, with peak/off-peak fares
Late 1970's	Fares approach $1 - use of currency grows
1979	Atlanta - MARTA starts operation with "body free" transfer stations like TTC
1980	Lindenwold - PATCO does in-house design of high reliability ticket vendors
Early 1980's	Electronic Registering Farebox - first installations at Ft Worth and Dallas Need for common ticket for regional operators discussed by MPOs such as MTC (Oakland) and RTA (Chicago); fare media integration becomes hot topic NJT introduces Ticket Office Machines (TOMs) purchased from Almex
Mid 1980's	ATM, Point of Sale (POS) and Electronic Funds Transfer (EFT) expands dramatically
1981	Boston - MBTA introduces high coercivity (HiCo) magnetic swipe readers San Diego Trolley starts operation with proof of payment system
1982	Chicago - CTA starts Merchandise Mart tests with HiCo swipe readers Portland - Tri-Met implements Self Service Fare Collection (SSFC) on buses (in 1984 it discontinued SSFC for conventional operator monitored system)
1983	New York - MTA conducts a major study of fare collection technology and applications worldwide (ADL Study) New York - LIRR tests Autelca TVMs (adapted Swiss Rail models) for self service sale of tickets - first for commuter rail system in USA
1986	New York - LIRR is first to offer transit/commuter rail self service credit card use for TVMs
1987	San Francisco - First regional ticket (AC/BART Plus) is introduced by AC Transit and BART Los Angeles - Long Beach Transit introduces swipe readers on buses
1989	New York - Swipe reader/writer developed to meet NYCTA's needs New York - LIRR tests acceptance of debit (ATM) card use for TVMs
1990	New York - PATH's New Fare Collection System starts with stored ride tickets and monthly passes New York - Color graphics for passenger interface introduced in USA on TVMs (PATH) New York - LIRR introduces "full feature" TVMs with payment by cash, credit and debit (ATM) cards and with central network controller NJ Transit completes its pilot program to test hand held ticketing devices
1991	New York - NYCTA awards contract for HiCo turnstile swipe reader/writers Phoenix - Phoenix Transit introduces employer billing system - first in USA - designed by in-house staff Canada - Smart cards introduced on several Canadian bus properties
1992	Los Angeles - Metrolink Commuter Rail System started with POP system New York - NYCTA successfully completes its customer test of AFC system with 1,887 people participating Washington, D C - Virginia Railway Express introduces "cashless" AVMs by Schlumberger (accepts credit and debit cards only) ADA compliance becomes mandatory
1993	San Francisco - TransLink Project in Bay Area starts with Bus Ticket Validators (BTVs) and ticket use in BART gates Los Angeles - Fare Debitcard (Metrocard) Project starts revenue service test AT&T announces its entry into contactless smart card applications
1994	Manchester (England) - begins test of contactless multi-use smart cards London - London Transport begins test of contactless smart cards on buses Dublin - Dublin Bus and partners conduct pilot test of contact smart cards for transit and other uses (telephone, toll, parking) Paris - RATP begins second stage of contactless smart card test Southern California - smart card test (contact and contactless) conducted on buses in three systems (Gardena, Torrance, LA DOT)
1995	Washington, DC - WMATA conducts 12-month trial of contactless smart cards on rail, bus, and parking lots Phoenix - Phoenix Transit begins to accept commercial credit cards for fare payment on buses; first transit agency to do so

POP concept—or "open system" as it is called there—for both bus and rail systems. AVMs are used for rapid transit and light rail systems; AVMs, window sales, and conductor fare collection (with on-board penalty fare) are used for commuter rail systems. Bus systems have validators at stops in some cities or, more frequently, inside the bus (at the rear entrance). Cash fares (at a premium) are collected by the bus driver. Tickets are sold through outlets along the routes. With the advent of systems based on personal computers (PCs), compact-disk—read-only-memory (CD-ROM), and miniaturization of electronics, compact self-service fare and schedule information "terminals" are provided in many railway stations and at airports. All fare and schedule information is available at the touch of a button; "information pillars" in Germany are an example. These systems provide a choice of "conversation" language; English, French, German, and Italian are the main choices.

In the fare technology area, a key difference in the European, Asian, and Australian systems is the greater use of electronic fare payment in general, and smart cards in particular. Some agencies, particularly in Europe, have implemented various types of smart card tests and applications; several of these involve multiple use of cards (i.e., for purposes other than transit). The smart card applications are discussed in the next three chapters and in Appendix A. Examples of other types of applications for individual countries and cities are summarized below. This list is not meant to be exhaustive but to highlight the range of approaches in place.

TABLE 41 Fare system elements

Fare Collection System	Fare Media	Fare Equipment	Mode (N. American systems) bus	LRT	rapid rail	com. rail
pay on entry	cash/token	farebox	X			
	paper ticket	TVM, validator	X	X		
	magnetic ticket	validator, TVM	X			
	smart card	validator	X			
	credit/debit card*	TVM, ATM	X	X		
barrier	cash/token	turnstile/gate		X	X	
	paper ticket	TVM, validator		X		
	magnetic ticket	validator, TVM		X	X	X**
	smart card	validator		X	X	
	credit/debit card*	TVM, ATM		X	X	
proof-of-payment (barrier-free)	cash/token	-				
	paper ticket	TVM, TOM, valid., hand-held		X	X	X
	magnetic ticket	-				
	smart card	-				
	credit/debit card	TVM, ATM		X	X	X
conductor-validated	cash/token	-				
	paper ticket	TVM, TOM, valid., hand-held				X
	magnetic ticket	-				
	smart card	-				
	credit/debit card*	TVM, ATM				X

* for purchase of other media

** Metra Electric only current barrier commuter rail system in U.S.

France

Paris. In the Paris metropolitan region, more than 1,800 new AVMs have been introduced for passengers using mass transit, commuter rail, and intercity trains. These AVMs use touchscreen technology. Most AVMs accept coins and credit and ATM cards but not bills—France has high denomination coins, as do most European countries. These AVMs are used to sell mass transit trip tickets and monthly passes. The second type of use is for commuter rail lines and intercity tickets. These are coin and card AVMs as above, although some AVMs accept only credit and ATM cards. The third type, which accepts only credit and ATM cards, is designed for making seat reservations and purchasing intercity tickets. These AVMs are networked nationwide and their reservations software uses American Airlines software.

Germany

Koln. Koln's KVV trams have AVMs installed at the rear door entrance area. These are coin accepting machines, some with built-in validators and some with free-standing validators. Cash fare passengers pay a premium fare to the driver. Zone changes are controlled remotely by the operator.

Switzerland

SBB Railway. All Swissrail ticket offices are equipped with ticket office machines (TOMs) connected to a train information network. When a ticket agent enters a rider's trip plan, a customized schedule is printed showing boarding times, connect times, fares, whether restaurant service is available, and so forth. This system covers boats and trains and most regional PTT bus connections, i.e., the entire national network.

Zurich. The Zurich region has a truly integrated system that includes a multitude of transit services, all with POP fare collection. Their 1,500 streetside AVMs are at all bus stops and at rail stations. Most AVMs are no more than 2 years old. They accept coins and one denomination of bill (CHF20) and give change. The passenger enters a 4-digit destination code that represents the destination (zip) code. Stops are listed alphabetically with corresponding code. The ticket sales record from/to data (keyed to the zip code), which is used for revenue allocation. AVMs have built-in validators, and, at selected stations and stops, free-standing validators are also provided.

Singapore

The Mass Rapid Transit in Singapore introduced a common stored value farecard recognized by Mass Rapid Transit, Singapore Bus Service (SBS), and Trans-Island Bus Services (TIBS). SBS and TIBS (2,500 buses altogether) are private sector operators, and Mass Rapid Transit is a subsidiary of a state-owned holding company. The three operators established a jointly owned company, TransitLink, to facilitate the operation. Mass Rapid Transit started with a stored-value ticket and "last ride bonus" feature, but this feature has been eliminated. The farecards are not retained by the system when value is exhausted.

TABLE 42 Types of fare structures and technologies for selected rail properties

Agency		Fare Structure	Equipment: AVM's	Equipment: TOM's	Equipment: Validators	Fare Media	New Initiatives/ Recent Developments
Commuter Rail							
Los Angeles	SCRRA	Zone	Y	Y	Y	Paper tickets and passes	Credit and debit card acceptance
Long Island	LIRR	Zone	Y	N	N	Paper tickets and passes	First in US to introduce credit/debit cards
Ft. Lauderdale	Tri-Rail	Zone	N*	N*	N*	Magnetic tickets and passes	Interfaces w/Miami Metrorail system
Philadelphia	SEPTA	Zone	Y	N	N	Paper tickets and magnetic passes	Credit and Debit (ATM) cards for window sales
Toronto	GO Transit	Zone	Y	Y	Y	Optically sensed tickets	First POP system for commuter rail; now adding AVM's
Washington, DC/ Virginia	VRE	Zone	Y	Y	Y	Paper tickets and passes	Cashless AVM's; AVM's that give verbal intructions (for visually impaired)
Light Rail							
Toronto	TTC	Flat	N	N	N	Cash fares front door, POP back door, magnetic passes for subway	POP feasibility demonstration for Queen Street streetcars
Los Angeles	LACMTA	Flat	Y	N	N	Paper tickets and passes	First LRT system with Central Data Collection System and CRT screens for AVM's
San Diego	MTS	Floating Zone	Y	N	Y	Paper tickets	First POP system in US

* to be installed

Legend: AVM's Automated Vending Machines
TOM's Ticket Office Machines

Agency		Structure	Equipment: AVMs	Equipment: Gates: Entry Control	Equipment: Gates: Exit Control	Equipment: Swipe Reader	Fare Media	New Initiatives/ Recent Developments
Heavy Rail								
Atlanta	MARTA	Flat	Y	Y	NR	N	Tokens and magnetic passes	Introducing AVM's to vend pre-encoded passes; will accept contact smart cards
Boston	MBTA	Flat	N	Y	NR	Y	Tokens and magnetic passes	Planning new AFC system
Chicago	CTA	Flat	N	Y	NR	Y	Tokens and magnetic passes	Installing new AFC system
London	LT	Zone	Y	Y (inner zone only)	Y (inner zone only)	N	Magnetic tickets	Tested contactless cards
New York	NYCTA	Flat	N	Y	NR	Y	Tokens and magnetic stored value tickets and passes	Installing read-write swipe units (first of its kind)
Philadelphia	SEPTA	Flat	N	Y	NR	Y	Tokens and magnetic passes	Token vending machines
San Francisco	BART	Distance-Based	Y	Y	Y	N	Magnetic tickets	Introducing credit/debit card AVM's
Washington, DC	WMATA	Distance-Based	Y	Y	Y	N	Magnetic tickets	Tested contactless cards

Legend: NR = Not required

Instead, passengers purchasing a farecard are required to pay a deposit of S$2.00, which is then "eaten into" in order to permit the completion of the journey. The passenger retains the farecard but at next "topping up," the "deposit value" is restored. Farecards are sold through AVMs and initial purchase or revaluation can only be done by direct debit (ATM cards). A nationwide smart card system (CashCard) is being developed and will be introduced over the next 5 years; although this is primarily a banking system, TransitLink is expected to seriously consider using the CashCards for trains and buses.

Japan

Tokyo. In Tokyo and elsewhere in the country there are two types of cards. Prepaid Cards are a substitute for coins and bills and cannot be used directly in the faregate. They can be used in a ticket vending machine (TVM) to purchase mass transit tickets or for other commodities vended such as sodas and cigarettes. The second type is the Stored Value Ticket (SVT), which can be used directly in the faregates and also to purchase commodities. Almost all systems use plastic cards and tickets. Japan Railroad East in Tokyo is also testing voiceactivated ticketing.

Sapporo. Gated systems such as in Sapporo and several other cities have open mode gates. The barrier is always open. The passenger is required to insert a ticket in the transport as in the United States. If the ticket is valid, nothing happens and the passenger enters. If the ticket is not valid, the barrier closes. For trip tickets, the tickets can be inserted in any one of four ways and still be read by the gate.

Australia

Adelaide. Adelaide's State Transportation Authority (STA) operates buses, trams, and trains in its metropolitan region. All tickets are magnetically encoded. Tickets must be inserted in validators (fitted on all vehicles) on each boarding. Single-trip and day-trip (day pass) tickets are paper, and multi-trip (10-ride) tickets are produced on more durable material.

New South Wales. The CityRail division of the New South Wales State Rail Authority (SRA) operates a statewide rail network with (294 stations) emanating from Sydney. CityRail purchased new fare collection equipment in 1991. This system will have more than 1,000 pieces of equipment: three types of AVMs, TOMs, faregates, and associated computer equipment. Faregates will be installed only at high-volume "inner" area stations. One of the three types of AVMs is the Authority To Travel Machine (ATTM), which is designed for low-volume stations that do not have conventional AVMs. This machine issues a non-magnetic ticket for minimum fare and provides "proof of station of origin" for the passenger. When more than minimum fare is needed, the conductor collects the fare increment. The Authority to Travel ticket must be surrendered at the TOM at a destination station, and credit will be given for purchase of a magnetically encoded ticket to use on the buses. A return trip ticket can also be purchased from the TOM.

Mexico

Monterrey. Sistena de Transporte Colectivo Metroney in Monterrey has an entry and exit controlled system with stored-value plastic tickets that recirculate. Equipment was provided by Cubic. The system was modelled after the Singapore system.

South America

Most of the fare collection systems operating in South America are of French (CGA) design and are patterned after the systems in France.

TYPES OF FARE MEDIA

The basic types of fare media are as follows:

- Cash,
- Token,
- Paper ticket,
- Magnetic ticket,
- Smart card,
- Debit card,
- Credit card, and
- Transit voucher.

These media can be used to pay the fare directly or to purchase the actual payment medium. All of the above media—except perhaps paper tickets—can be used as a means of purchase, although cash, debit card, credit card, and transit voucher (along with personal check in some places) are the typical purchase media. This section focuses on the payment media, rather than those used primarily for purchase.

Cash. Cash is the oldest, most common means of paying for transit rides. It is readily obtainable and requires no special sale or distribution arrangement. On the other hand, riders are invariably required to use exact change; the level of inconvenience represented by this depends to a certain extent on the fare level. Cash—particularly dollar bills—also presents difficulties to transit agencies. Bills are costly to process, and cash, in general, provides opportunities for theft by transit employees. The use of dollar bills also poses problems on some bus systems, because older fareboxes have difficulty accepting bills.

In response to the currency-related problems, a new dollar coin has received considerable transit industry support in recent years. Meanwhile, many agencies seek to minimize the amount of cash they have to handle by promoting the use of prepaid fare options. The cashless system has great appeal throughout the industry. Nevertheless, most operators—particularly the small and medium bus systems—recognize that it will be difficult to eliminate the use of cash in their systems completely.

Tokens. Tokens, which have been used by transit agencies for several decades, are relatively easy for passengers to buy and use and are easily handled by existing money room equipment. Drawbacks to their use include the facts that they can be 1) easily counterfeited and 2) hoarded by riders seeking to avoid having to pay future fare increases. Partly for the latter reason, tokens offer an agency limited flexibility in changing their fare structures. Tokens are also limited as to the range of fare options in which they can be packaged. They can be sold in bulk (e.g., in "10-packs") for convenience or to provide a discount but cannot be used for other options. The major cost to the transit agency is in acquiring, distributing, and recirculating the supply of tokens. Despite their disadvantages, tokens continue to be used by some agencies, including the largest and oldest rail systems (e.g., MTA-NYCT, CTA, MBTA, SEPTA, and MARTA).

Paper Tickets. All fare payment media other than cash and tokens are some form of ticket or card. Tickets and cards either contain printed information only or include stored information as well; the former category is referred to here as paper tickets, while the latter can be either magnetic-stripe tickets or smart cards. Paper (i.e., non-magnetic) tickets are widely used in the transit industry, particularly in POP systems. These tickets can be used for single-rides or multi-rides (a single multi-ride ticket or a "book" of tickets); in addition, flash passes can be in the form of paper tickets. Multi-ride tickets and passes sold through outlets usually do not require validation at the point of sale. Tickets requiring validation at the time of purchase are generally those sold through machines such as AVMs and TOMs. Printing done by machines in such cases has to be coordinated with the preprinted ticket stock to maintain proper printing registration. Systems that use validators cancel a ticket by physically altering the ticket by either clipping a portion of a multi-ride ticket and printing date, time, and location code, or by only printing the information. The validators can sense previous cancellations and clip or print accordingly. Where validators are not used, the easy visual verification of a valid ticket is an important aspect of ticket design. The ticket must be able to be verified quickly by on-board conductors and fare inspectors. Thus, the graphics must be clear, with valid dates and restrictions presented in a quickly readable form.

Magnetic Tickets. Magnetic-stripe tickets can be used for any type of payment option: single-ride, multi-ride, period pass, or stored value. They offer extensive flexibility to both the operator and the rider. Magnetic tickets are used mostly in systems that have gates and turnstiles to control access, egress, or both; however, they can be used in bus systems that have ticket readers and processing units attached to their fareboxes. The tickets can be used with different types of readers: read-write-print, read-write, and read-only swipe readers or transport units. Magnetic tickets can be pre-encoded by high-speed ticket encoders and distributed for sale by retail outlets or can be dispensed from AVMs and ticket office machines (TOMs). High-speed encoders are used by BART, for instance, to encode high-value and concession-fare tickets. MBTA contracts for service to encode a variety of monthly passes. Magnetic tickets—and indeed all electronic media—offer several primary advantages over printed (paper) tickets and tokens. They offer convenience and (presumably) ease of use to the rider. They allow for a higher degree of revenue control by a transit agency and can generate a considerable amount of data on ridership patterns. Perhaps more importantly, though, they give the agency tremendous flexibility in establishing fare options and levels. Furthermore, they facilitate regional integration, in terms of allowing multiple operators to use a single ticket while retaining their individual fare structures; examples of such efforts can be seen in the San Francisco and Los Angeles areas. The major drawback to the use of magnetic tickets is the cost of purchasing the necessary equipment (i.e., for electronic fare collection); the cost of equipping rail stations in particular can be very high. Magnetic-stripe technology is discussed further in the next three chapters. The benefits and emerging applications are addressed in Chapters 7 and 8; cost issues are discussed in Chapter 8.

Smart Cards. Smart cards are an emerging technology in transit fare payment. The smart card is technically an integrated circuit card that contains a microprocessor (i.e., a computer chip) and has built-in logic. The term also has been used to describe generally a range of automated types of card technologies, including integrated circuit memory cards without microprocessors and radio frequency identification cards and tags, also often without microprocessors. All types of smart cards can store large amounts of data, which can be altered and updated in accordance with the logic built or programmed in; other features and the different types of cards are described in the next chapter.

An advantage of smart cards is that they offer a greater measure of security than magnetic-stripe cards and, in fact, can be used as a security access instrument as well as an instrument for stored value. Smart cards also can maintain different accounts within their memory for different clients or agencies. In addition, the "contactless" smart card offers the advantage of not having to be inserted into—or swiped through—a reader; rather, the card only has to be placed close to the reader for a transaction to be processed, i.e., there is no actual contact between the card and the fare collection equipment. This results in less wear on the equipment; such a card is also easier to use by transit riders who might have difficulty using a more conventional fare medium (i.e., because of a disability). Currently, the major drawback to the widespread use of smart cards in transit applications—besides the lack of in-service testing—is the high unit cost of the card itself. Depending on the exact type and capabilities of the card, smart cards cost anywhere from $3.00 to $10.00 each—considerably more than the $0.10 to $0.60 unit cost of a magnetic ticket. As their use expands in other areas (e.g., banking and telephone usage), the production cost should drop somewhat. Moreover, the longer life of a smart card suggests that it should have a life cycle cost advantage over less durable fare media. Cost issues are discussed in Chapters 6 and 8.

Smart cards have seen growing use in a range of applications, particularly banking, health care, and telephone usage. Although the United States has been slow to adopt this technology, the use of smart cards is flourishing in Europe, where they have been in existence for more than 10 years, with France leading the way. Only in the last few years, however, has the smart card technology been applied to public transportation. There are some applications around the world (discussed in the next chapter), and the technology is beginning to be tested in several U.S. cities.

Other Media. The preceding sections discuss the range of payment media that have been used to any wide extent in the transit environment to date. Other advanced media developed for use in other industries are sometimes suggested for consideration as transit payment media. Three such technologies are as follows.

Bar code cards have been used in a public transportation application, by the Netherlands Railways, for verification purposes. Student passes include a bar code and are verified by inspectors, using hand-held bar code readers. This equipment has helped reduce pass misuse. There could be use of bar code cards in fare-payment-related applications in the coming years; a federally sponsored study of potential transit applications in the United States is being conducted. (Additional details on the Netherlands project are presented in Appendix B.)

Optical (laser) storage cards are best suited for storing large amounts of data write-once-read-many format. Data are stored using digital and optical techniques. A credit-card-size card can provide storage capacity of up to 4 megabytes (i.e., 1,600 typewritten pages of text). Typical uses being tested include military dog tags and storage of field-repair manuals; however, the greatest potential application may be for storage of personal medical records. Currently, there does not appear to be any practical transit application for this technology. (Additional details on this technology are presented in Appendix B.)

Holographic cards are manufactured by a process which embosses a distinct pattern (hologram) onto the card by laser-driven optical methods. When used for machine verification, the card is inserted in a reader. An infrared beam checks the authenticity of the card used. Current applications include use as stored value cards for British Telecom's and Swiss PTT's "Phonecard." When the card is used, it is temporarily held by the reader unit. Depending on the units used (e.g., length of telephone call), the appropriate value is thermally erased from the hologram. The concept is, therefore, essentially a stored value method. This technology is more secure than magnetic tickets but less flexible and very capital-intensive. The use of these cards for transit does not appear to be imminent.

TYPES OF EQUIPMENT

This section summarizes the key characteristics of the major types of equipment used in fare collection and distribution systems. Current technology is described and new or developing technologies are identified.

The major pieces of equipment found in a fare collection or distribution system are as follows:

- AVMs,
- TOMs,
- Turnstiles,
- Fareboxes,
- Validators,
- Hand-held devices,
- Ticket processing units (TPUs), and
- Other equipment (e.g., central computers and addfare machines).

These pieces of equipment are described below.

AVMs and ATMs

Passenger-operated AVMs (also often called TVMs) can be furnished with various features. Depending on the number of features to be provided, the complexity of AVMs can vary from issuing a single ticket type with exact fare to those that sell a variety of types and accept various payment means (see Table 43). The number of ticket types sold, the number of button selections needed, the method of fare payment, the change giving technique, and passenger interface requirements are the key elements that affect the cost of AVMs. The options are many and varied. Representative forms of AVM operating functions are as follows:

- Exact fare: 1) accept coins only or bills and coins; 2) accept credit and debit (ATM) cards;
- Fare acceptance with change giving: accept coins and/or bills; give change in coins;
- Cards/no cash: accept only credit and debit cards—no cash; and
- Ticket issue: 1) print tickets on paper stock (primarily roll feed and guillotined ticket); 2) magnetically encode and print tickets (primarily roll feed and guillotined ticket); 3) encode and issue tickets from stack feed; or 4) dispense pre-encoded tickets from stack feed.

Older machines selling only one or two ticket types and accepting only coins represent the simplest AVMs, as at PATCO. These machines dispense pre-encoded plastic tickets from a stacker. Newer machines, such as at LIRR are more complex, with three forms of fare payment: coins and bills, credit card, and debit card. Recirculating change is provided and the AVM issues over 100 ticket types using multiple ticket stock rolls. AVMs also vend tokens. Machines that do not accept any cash but accept credit and debit cards have been recently introduced by Virginia Rail Express (VRE). With higher fares and no dollar coin in general circulation in the United States, most AVMs already accept bills. Credit and debit card acceptance, especially for purchase of multi-ride, pass media, or both, has seen increased use in recent years. Finally, the ability to enable multiple agency services to be used with a single ticket has required increasing the use of stored-value tickets. This creates a need for the AVM to have the capability to read the value left and add value to it in a similar manner to WMATA's ExitFare machines.

AVMs have been designed with a wide variety of graphics and passenger interface characteristics. The range of features includes pushbuttons and light-emitting-diode (LED) displays; pushbuttons and cathode ray tube; and, more recently, the "soft" buttons associated with touchscreen technology as provided by Agent Systems' AVMs at LIRR. The use of different audible tones for different functions is especially helpful to those with visual disabilities. VRE, for example, recently introduced AVMs that can "talk" and can, thus, guide those with visual disabilities through the procedure; this is in addition to Braille instructions on the panel. The use of color graphics is also increasing in AVMs, and CD-ROM and similar large and cheap non-volatile memory storage devices are being used to give passengers information on fares and schedules. Germany, for example, has introduced "Information Pillars" in several major railway stations. These devices have a color screen

TABLE 43 AVM use by selected properties

		Ticket Types						Fare Payment Method			
Agency	Ticket Technology	Single Trip	Round Trip	Multi Trip	Weekly Pass	Monthly Pass	Stored Value	Coins	Bills	Credit Card	Debit Card
BART	M						X	X	X		
BART (1)	M						X		X	X	X
LIRR (2)	P	X	X		X	X		X	X	X	X
Metra Electric (3)	M	X	X	X	X			X	X		
MNCR	P	X	X		X	X		X	X		X
NJ Transit (4)	P	X			X	X		X	X	X	(Future)
PATH (5)	M			X			(Future)	X	X	(Future)	(Future)
PATCO (6)	M	X	X					X			
VRE	P	X	X	X		X				X	X
WMATA	M					X	X	X	X	(Future)	(Future)

M = Magnetic P = Paper

Notes:

(1) This applies to a small order of new equipment only.
(2) Introduced a few touchscreen and "cashless" AVM's, then phased in full-service AVM's by Agent Systems
(3) First AFC system in U.S.
(4) NJT's new AVM's must vend PATH magnetic tickets.
(5) Color CRT for passenger display. Hi-Co magnetic tickets.
(6) Stacker fed, pre-encoded tickets in AVM's

driven by a PC- and CD-ROM-based system. There is one menu "selection" device (pointer) and one button to get a hard copy. The user can get all fare and schedule information on trips between any two points in the German railway system. The screen converses in three languages—English, French, and German.

ATMs used for banking also provide a readily usable network of machines that can serve as point-of-sale units. As described in Chapter 7, Seattle Metro sells monthly passes through ATMs. WMATA and Portland TRI-MET at one point sold fare media through ATMs as well; these two programs were discontinued when the participating banks were purchased by other banks. In Seattle, as the month progresses, the purchase price of the pass is prorated; this provides a method for relieving monthly sales peaks. The ATM industry has become extremely competitive and is getting more market-minded and comfortable about testing ATM technology for a variety of uses. Some of the new sales and marketing techniques could have merit for transit use.

AVMs that use the electronic funds transfer (EFT) method for fare payments are generally linked to a local network controller at the agency. The controller, in turn, is linked to a service bureau, which authorizes and stores all payment transactions. All sales require a positive authorization from the clearinghouse. At NJT, this system is part of a larger network that includes TOM sales. Implementation of credit and debit card fare sales has been expanding as noted below:

- 1986—LIRR introduced credit card AVMs,
- 1987—NJT introduced credit card AVMs,
- 1991—LIRR introduced debit and ATM card AVMs,
- 1992—Metro-North introduced debit and ATM card AVMs,
- 1992—VRE introduced AVMs that accept only credit and debit cards, and
- 1993—SCRRA introduced credit card and ATM card AVMs.

The use of ATMs and EFT in the transit industry is discussed in Chapter 7.

Validators

Validation is the process of canceling a ticket by the passenger prior to the journey. This can be done manually or automatically. Manual validation can be as simple as purchasing a day pass from an outlet and scratching off boxes reserved for the month and day of the month. The day pass is only valid for the day scratched off.

Automated validation can be accomplished in two ways—tickets purchased from ticket agents or AVMs can be inserted in the validator to cancel a ticket prior to the journey, or the AVM or the ticket agent's TOM can print the date, or date and time, on the ticket at the time of purchase. The "canceled" ticket can be presented to the on-board crew as proof of payment of fare for that trip. Validators are also called Cancellors by some agencies.

Validators are compact (approximately 10 by 4 by 8 in.) and can be readily installed in convenient locations within stations, on platforms, or on vehicles. Passengers can insert their tickets into a slot to validate a trip prior to boarding. Reciprocating-type validators transport the ticket into the unit, process the ticket by printing or altering the magnetic code or both and then returning the ticket appropriately validated. This technique is generally used for magnetic tickets. Certain types of validators (i.e., read-write-print) can print value or trips remaining on stored value or multi-ride tickets after deduction of the appropriate fare for a trip. An alternative to the transport-type validator is a swipe-through reader. In this format, the passenger "swipes" the magnetic-stripe ticket or pass through a slot, and the reader verifies that the ticket is valid. Swipe readers can be mounted on fareboxes or on turnstiles. Paper and printed ticket validators generally do not have a ticket transport. The insertion of the ticket is detected, and a trip is deducted by clipping a portion of the side of the ticket and printing the date, time, and location code to show a canceled trip. Optical sensing is available to determine where the validator should print the next cancellation.

Validators can also be provided with passenger selection buttons—to select one of several destinations. Displays can be provided to indicate selections and to provide instructions. Validators for rail use are usually self-contained units with microprocessor-based electronics, registers, ticket transport (if needed), displays, buttons, and power supply. Data can be stored locally in electronic registers or stored in a data module that can then be processed at a central location. Validators can also be mounted on top of electrically released turnstiles to provide an economical access control method.

Validators are used in several POP systems, where the burden of purchase of a validated ticket or validation of a previously purchased ticket is placed on the passenger. Some systems have stand-alone validators; others have them incorporated in the AVM cabinet. Such validators can also be used as ticket readers when used in the read-only mode for magnetic ticket systems. For example, multi-ride tickets can be inserted to read trips remaining or stored value tickets inserted to read amount remaining.

TPUs (or bus ticket validators) are recently developed attachments for fareboxes. TPUs can issue paper transfers or issue and accept magnetically encoded tickets. The TPU is controlled by the keypad on the farebox. Some functions can be automatic. For example, if a passenger deposits the base fare and the transfer charge, a transfer can be automatically produced by the TPU. Pre-encoded tickets from either an AVM or another TPU can be processed by the TPU and have a ride or value deducted. The remaining value can be printed on the ticket either after each deduction or after a set number has been reached such as one twentieth of the original value. This technique "saves" print lines and reduces or eliminates ticket replacement on a vehicle. A passenger display provides a readout of the rides or value remaining at each use of the ticket. Transaction records for all tickets and transfers processed by the TPU are recorded in the farebox memory. Upon probing (data extraction from the farebox) all records from the TPU and transactions from the farebox are extracted for further processing by the local and/or central computers of the agency.

TOMs

TOMs are automated ticket dispensers, operated by ticket agents. TOMs are compact—several manufacturers make units that are smaller than a desktop computer. A TOM consists of a keypad for entry of certain alphanumeric values (such as station origin-destination codes and passenger category) and typically some function codes associated with the ticket issue process. Generally, a few buttons are reserved for the most commonly requested destinations. Associated with the keypad is a display unit to show amount due to the station agent and to the passenger. A printer unit makes up the third major module. Multiple printers are provided in some cases to issue tickets from different rolls or from rolls of different widths. TOMs can be programmed to accommodate hundreds of ticket types on the basis of origin-destination combination, category of passenger, and ticket type. Fares can be programmed into the TOM by solid state data modules, or telephone lines can be used for downloading fares and uploading statistical data.

In a POP system, a TOM must sell advance purchase tickets that then require subsequent validation by the passenger in a validator. The TOMs also need to issue a ticket with date and time printed thereon for immediate use of the ticket. Another important consideration is that issued tickets must be of a size and material suitable for subsequent insertion into a validator. TOMs can be equipped with magnetic ticket readers that provide many benefits. A ticket reader provides means for the station agent to sign on. The reader can also read several data items and verify authenticity of the user. In systems in which magnetic tickets are used, the reader can assist in decoding malfunctioning tickets. In systems in which credit cards are used for fare purchase, credit verification can be included in the TOM. TOMs provide the following advantages over manual pre-printed ticket selling methods (i.e., for commuter rail applications):

- Prints (and encodes, if applicable) tickets only when needed, and provides greater flexibility in issuing many varied ticket types;
- Improves accountability by providing means to audit data at various levels of detail for each agent's tour of duty; also eliminates the need for agent-to-agent revenue reconciliation; and

- Automates data collection and reporting to tie revenue collection data to ticket issue data.

TOMs with communication (modem) links can be used at high volume outlets as point-of-sale terminals. Key technological advances have been in the areas of printer technology and capabilities for use of magnetic cards.

Fareboxes

Fareboxes are used on buses and on some light rail vehicles. Electronic registering fareboxes (ERFs) allow automatic registration of coins, tokens, bills, and tickets, as well as recording of trip-related data such as zone fare, type of service, and category of passenger. The revenue and data collected and transferred to money rooms' systems can be tracked electronically with cashbox ID and vault ID systems. ERFs are also beginning to be configured with swipe readers, TPUs, or both.

Recent developments related to ERFs include the introduction of a transactional database capability so that each fare payment can be recorded as a unique event within the associated "fields" for each trip. This allows the generation of much more meaningful statistics by using a relational database at the central computer level that can enable individual tickets or boardings to be tracked. This basic approach can be used in employer billing programs, in which individual employers can be billed for trips made by their employees. Phoenix Transit has such a program; a magnetic swipe reader is used with a pass for employees of participating employers. Similar programs are being considered by several agencies, including those in Seattle, Washington; Santa Cruz, California; and Clearwater, Florida. Credit cards can also be used in the swipe readers in Phoenix.

It is envisioned that the next major farebox-related development will involve the integration of the farebox electronics with a central on-board "blackbox" for data transfer. As part of the development of "smart bus standards," a group consisting of transit agency and manufacturing personnel is developing practices and open standards for interfacing the various interchangeable transit vehicle devices and systems while permitting proprietary consideration. These devices are items such as the following:

- Automatic vehicle location devices,
- Fareboxes and TPUs,
- Passenger signs,
- Passenger counters, and
- Radios.

With a common standard it is expected that the vehicle would be equipped with a single cable to a "blackbox" to which all manufacturers would connect their devices. This will eliminate duplication of procedures (such as multiple sign-ons) required to be performed by the drivers, reduce the hardware clutter, and provide a means to access various data bases (e.g., the odometer reading and fares collected would be used to compute revenue per mile).

Turnstiles

Turnstiles (or faregates) are used for access and egress control in a barrier or closed fare collection system. The turnstile, which consists of the ticket reader or coin or token acceptor, as well as the actual barrier device, can be used for entry control, exit control, or both. Turnstiles can be used in the freewheeling mode in either or both directions and can automatically count entries and exits. Turnstiles operate in either a ticket transport or swipe mode, as discussed under magnetic stripe tickets, above. All ticket-transport-operated turnstiles in the United States use magnetic ticket technology and credit-card-size tickets—with the exception of Baltimore's MTA, which has Edmondson size (30 mm by 55 mm) tickets. Typically, the operation of an access and egress control turnstile system requires the ticket to be inserted into a slot. The ticket is transported over a magnetic-read head that reads the previously encoded data. Depending on the type of ticket and conditions of use programmed in the turnstile's microprocessor-based logic, the ticket data are appropriately altered and written on the ticket by the write head. Depending on the rides or value remaining, the ticket is returned or captured. Passes are always returned. When a ticket is processed, the barrier (usually a tripod) is released to permit entry. When the ticket is captured, it is retained within the turnstile.

Printing on the ticket in the turnstiles is a feature that is provided in some systems. For instance, 10-ride tickets can be printed to indicate the number of rides left. An alternative concept is to display to the passenger the number of rides left or the value remaining on an LED or similar display on the turnstile console. This approach has been used at PATCO and Metra, where remaining rides are displayed. In Hong Kong MTR and Singapore MRT the value left is displayed. This approach will also be used by MTA-NYCT and CTA.

All data pertaining to ticket type used, number of entries and exits by time period, access to servicing of turnstiles, and so forth are stored within the turnstile's electronic memory. These data can be shown by a visual readout at the turnstile, captured in a portable data unit, or by polling by a station controller (PC or equivalent). Data can then be transmitted to a central controller. Remote on and off and freewheel commands can also be issued from a central controller.

Hand-Held Devices

Hand-held data devices have seen a tremendous applications growth—especially because of miniaturization, availability of large amounts of memory in small chips, and portable modems on a card. Two types of hand-held devices are used in connection with transit fare collection functions: hand-held ticketing devices (HHTDs) and cellular telephones. HHTDs allow on-board validation and sale of tickets by roving fare inspectors. They are used to validate (time-stamp) prepurchased tickets and to sell tickets to riders boarding without tickets. HHTDs, especially for commuter rail and POP systems, show promise as the weight and the size of the units decreases because of significant reduction in the sizes of the electronic components and the advancements in battery life.

The recent expansion of the cellular telephone network and the proliferation of telephones and related devices has created opportunities for almost immediate data collection and monitoring of remote sites. For example, a portable computer can be outfitted with a farebox probe and a cellular phone and used to collect farebox data from remote sites. Providing portable cellular phones to station agents for opening day enabled SCRRA personnel to estimate crowd size, give accurate passenger information, assist with security, and call for aid in case of an emergency. Developments in portable data collection devices have reduced the size of an HHTD to that of a large, hand-held calculator. Some units have a built-in acoustic coupler for data transmission over a dial-up telephone line. A radio frequency device to access the cellular network could be substituted. A future application could be a device providing a keypad, display, and printer to a fare inspector. This device would allow the inspector to query a data base to verify information presented by a rider being challenged and/or to determine the rider's past violation history.