

# The Costs of Transit Fare Prepayment Plans and Their Distribution Systems

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## ABSTRACT

A cost structure is outlined for the analysis of transit fare prepayment plans and estimates of the costs of prepayment in 11 transit companies. Twelve cost categories are analyzed: order preparation, order delivery, direct sales, recording and accounting, design, printing, inventory, advertising, miscellaneous handling, administration, general overhead, and cost of funds. In addition, the costs of alternative methods of distribution (e.g., transit-operated outlets, public and employer outlets, direct mail, and telephone order) are compared. Costs of prepayment by type of plan (passes, tickets, punch cards, and tokens) are analyzed and recommendations are developed for cost-saving strategies.

The last few years have witnessed an increased interest in transit fare prepayment. Spurred by the Huron River Group, Inc., report (1) on fare prepayment, UMTA's Office of Service and Management Demonstrations has conducted demonstrations on aspects of pricing (2-6), traveler responses (7,8), and distribution methods (6,9,10). However, the knowledge about the factors that explain the cost performance of prepayment plans is scant. The basis of this paper is the costing concepts developed by Ecosometrics, Inc. (10) in the design of the Sacramento demonstration on distribution systems for fare prepayment, and the results of research on the costs of transit fare prepayment plans in 11 transit companies are summarized (11). The transit companies included Southern California Rapid Transit District (SCRTD), Los Angeles; Southeastern Pennsylvania Transportation Authority (SEPTA), Philadelphia; Metropolitan Transit Commission (MTC), St. Paul; Municipality of Metropolitan Seattle (METRO); Queen City Metro, Cincinnati; Tri-County Metropolitan District of Oregon (Tri-Met), Portland; SunTran, Tucson; Dart, Delaware; Tidewater Regional Transit, Norfolk; Greater Richmond Transit Company; and Sacramento Regional Transit District. Analyzed as part of the study were 40 different plans including 20 pass plans (of which 9 were monthly passes, 2 were weekly passes, and the rest included diverse programs such as tourist passes, day passes, and annual passes), 11 ticket plans (of which 5 were 10-trip ticket books and 2 were 20-trip ticket books), 2 punch-card plans, and 3 token plans. The distribution methods analyzed consisted of transit-operated outlets, private and public outlets, employer outlets, direct mail, telephone order, and on-board sales programs. In addition, the fare prepayment plans featured several different methods of order delivery to outlets, such as delivery by transit staff, courier service, or postal service. This rich data base enabled the authors to develop parametric approaches to the costing of fare prepayment plans.

## OVERALL STRUCTURE OF THE PARAMETRIC APPROACH

The costing methodology employed consisted of a series of building blocks that related resource requirements (i.e., productivity parameters) and basic resource costs, such as wages and postage (resource parameters), to cost-driving variables (program parameters), such as the number of outlets, number of prepayment instruments sold, and so on.

The cost-estimating relationships were expressed in parametric fashion to gain flexibility in their use. The parametric representations of productivity relationships were standardized across many settings and systems to permit generalizations to other transit settings, thereby incorporating some of the features of standardized costing. Although the costing methodology traced the cost of incremental activities associated with prepayment plans, it nevertheless included the costs of inherited resources within the prepayment program, resources that were valued at replacement costs. In the discussion that follows, a fare prepayment instrument refers to the individual item purchased (e.g., 30 instruments may refer to 30 monthly passes, to 30 weekly passes, or to 30 ten-trip ticket books). A fare prepayment transaction refers to the actual sales activity and is usually equal to the number of instruments sold. An exception is the monthly pass with zone stamps, which corresponds to two instruments but only one sales transaction.

## COST CATEGORIES

Both capital (one-time) expenses and recurrent operating costs were considered. Capital costs included vehicles, equipment (e.g., pass counters, token wrappers, photographic equipment, telephones, and ticket or pass shredders), and promotional advertising campaigns. The recurrent or operating costs included labor (wages and fringe benefits), materials (envelopes, postage, business forms, etc.), space or rent, and miscellaneous services, such as commissions to outlets, courier service, design and printing, and normal advertising activities. All capital costs were amortized using capital recovery factors at 12 percent interest rates.

## FUNCTIONAL ACTIVITIES AND COST CATEGORIES

The operation of a fare prepayment program may involve as many as 21 separate activities, which were grouped into the 12 major cost categories presented in Table 1. These cost categories range from order preparation and delivery to sales outlets, recording and accounting, and other miscellaneous functional activities. From an analytical viewpoint these categories can be grouped into the two basic categories presented in Table 1. Transaction-oriented costs were those affected by the size and frequency of fare prepayment sales and deliveries. A second set of cost categories had been grouped into non-transaction-oriented costs because they were not directly

TABLE 1 Key Variables Affecting Prepayment Costs by Functional Activity and Sales Distribution Method

Cost Category	Cost Element	Sales Distribution Method				
		Transit-Operated Sales Outlet	Public and Private Sales Outlet	Direct Mail Program	Telephone Order Program	On-Board Pass Sale
Transaction oriented						
Order preparation						
Sales outlet	Labor, equipment	Per outlet served	Per outlet served	-	-	-
On-board sale	Labor	-	-	-	-	Per day issued
Order delivery						
Staff	Labor, vehicles	Per outlet served	Per outlet served	-	-	-
Courier	Courier service	Per outlet package	Per outlet package	-	-	-
Certified mail	Postal service	Per outlet package	Per outlet package	-	-	-
Direct sales						
Transit-operated outlet	Labor	Per transaction	-	-	-	-
Public and private outlet	Commissions	-	Per revenue dollar	-	-	-
Direct mail program	Labor, materials	-	-	Per transaction	-	-
Telephone order program	Labor, materials	-	-	-	Per transaction	-
Recording and accounting						
Recording sales	Labor	Per transaction	-	Per transaction	Per transaction	-
Accounting sales	Labor	Per transaction	Per transaction	Per transaction	Per transaction	-
Accounting on-board sales	Labor	-	-	-	-	Per day issued
Non-transaction-oriented						
Design	Design service	Per design change	Per design change	Per design change	Per design change	-
Printing	Printing service	Per unit of volume printed	Per unit of volume printed	Per unit of volume printed	Per unit of volume printed	Per unit of volume printed
Inventory	Storage	Per unit of volume stored	Per unit of volume stored	Per unit of volume stored	Per unit of volume stored	Per unit of volume stored
Miscellaneous handling	Labor, equipment	Per instrument handled	Per instrument handled	Per instrument handled	Per instrument handled	Per instrument handled
Advertising	Labor, media	Per instrument advertised	Per instrument advertised	Per instrument advertised	Per instrument advertised	Per instrument advertised
Administration	Labor	Per program size category	Per program size category	Per program size category	Per program size category	Per program size category
General overhead						
Transit-operated outlets	Labor	Per dollar of labor	-	-	-	-
Headquarters	Labor	Per dollar of labor	Per dollar of labor	Per dollar of labor	Per dollar of labor	Per dollar of labor
Cost of funds	Interest	-	Per day of delay	-	-	-

related to the transaction per se, although in a loose sense they may have been correlated with total sales volume (e.g., advertising). This segmentation of the 12 major cost categories into the two cost groups provided the basis for the structure of the cost model.

In Table 1 each cost category is disaggregated into detailed components all the way down to the cost elements. Also presented in Table 1 are the key variables that dominated the cost behavior within each function. Table 1 summarizes the analytical framework of the cost methodology and its building-block structure.

As shown in Table 1, order preparation and order delivery costs were driven primarily by the number of sales outlets served. Direct mail and telephone order programs did not require bulk order preparations or deliveries because each order taken by mail or telephone was processed individually. Direct sales costs at transit-operated outlets and at headquarters for direct mail and telephone order programs were a function of the number of sales transactions. The only sales costs recognized for public and private sales outlets (including employer programs) were the expenses incurred in sales commissions. This does not imply that there were no other costs involved in these activities but simply that these costs were not borne by the transit company. Similarly, there were no costs for recording individual sales transactions at public and private outlets because this function was performed at the outlets at no extra cost to the transit company.

Finally, the costs of some functional activities (e.g., design, printing, and inventory) were incurred irrespective of the sales distribution method used. Overhead costs were computed separately for transit-operated outlets because the rent and supplies for this space were usually independent of the transit company's headquarters offices.

#### DESCRIPTION OF COST CATEGORIES

##### Order Preparation Costs

Order preparation consisted of preparing a new supply of fare prepayment instruments for distribution to sales outlets and on-board sales. In the case of sales outlets (transit operated, public, and employer) these costs included the labor and equipment costs involved in assembling and packaging the appropriate number of instruments for each outlet and preparing invoices for the outlets.

The labor requirements of order preparation for sales outlets varied from a high of 1.20 to 1.40 man-hr per outlet preparation in Los Angeles and Seattle to 0.11 man-hr per outlet preparation in Philadelphia. These labor requirements appeared to be more dependent on internal procedures followed than on the size of orders. Some transit companies required that the contents of each order be carefully recorded (e.g., noting serial numbers) before distribution to outlets. Typical labor requirements for this function were 0.25 man-hr per outlet preparation when normal procedures were followed. Equipment requirements consisted of token wrappers, three of which were used by Cincinnati's Queen City Metro, and a pass counter, used in Sacramento.

The order preparation costs of on-board sales covered the labor requirements of preparing passes for driver pickup. These labor requirements varied between 15 min per day of pass sales in Sacramento to 30 min per day for weekend passes in St. Paul and Tucson. Some economies of scale appeared to be present as shown by the longer preparation time per day for weekend day passes than for the daily pass program.

##### Order Delivery Costs

Delivery of fare prepayment instruments to outlets,

whether transit operated, public, or employer, was performed by one of three modes: transit staff, courier, or certified mail. Half of the transit companies interviewed used transit staff delivery, if not for all outlets, at least for those outlets with the greatest sales volume. Staff delivery times per outlet were found to decrease by city size and distance between outlets. In Seattle the 25 outlets served by staff were located downtown, thereby requiring only 10 min of delivery time per outlet delivery. In Portland the staff delivered plans to all 109 outlets, some located 18 miles from downtown Portland, thus requiring 60 min per outlet delivery. Half of the transit agencies used vans for staff delivery and the other half used large or intermediate-sized automobiles. Philadelphia's SEPTA used an armored truck for staff deliveries.

An alternative to the high costs of order delivery by transit staff was courier service. SEPTA was the only transit system interviewed that used a courier service. In that case 75 packages were delivered each week to outlets at a cost of \$5.00 per package delivery. However, because of the limited insurance coverage of local messenger service, additional insurance coverage was secured by the transit company.

The U.S. Postal Service was used by 4 of the 11 transit companies interviewed to service low-volume outlets. However, certified mail was inadequate to serve the distribution of ticket books and tokens, which were too heavy to be sent economically by this method. Another problem of using the mail was its inadequate insurance coverage. Because the maximum liability of insured mail was only \$400, only 20 monthly passes valued \$20 apiece could have been sent per mail package. Guidelines will be presented later for choosing between these alternative delivery methods.

#### Direct Sales Costs

The direct sales costs included labor, materials, commissions, and equipment costs of selling prepayment instruments at outlets and by direct mail and telephone order. Of the 11 transit companies analyzed, 8 operated their own outlets. The labor requirements for effecting a prepayment transaction at transit outlets varied between 1.5 and 2.5 min per transaction; the time per transaction was inversely related to the number of sales transactions. At outlets where many photographs are taken for the prepayment instruments, the labor requirements exceed 4 min per transaction. Equipment requirements and costs included photographic equipment, validation stamps, and so forth.

All the transit companies analyzed used public and employer sales outlets. These included banks, savings and loan institutions, department stores, hospitals, schools, and employers. A significant number of the outlets charged a commission on sales. These commissions could be based either on a percentage of prepayment sales or on a fixed rate per instrument sold. Commission rates ranged from none to 3 percent (Los Angeles). In general, the larger companies appeared to incur greater commission rates than the smaller ones.

Direct mail sales of prepayment plans were conducted by five of the transit companies analyzed. The direct mail costs included labor requirements and materials, such as order forms, envelopes, and postage. Material costs alone were approximately \$0.50 per direct mail transaction. On the basis of the records of the companies analyzed, no relationship was discernible between the sales time per transaction (which varied from 1 to 6 min) and the

number of transactions. The reason for this was that other factors unique to each company, such as reporting requirements, credit card verification, and bad check follow-ups affected the transaction times.

Telephone sales were similar to direct mail order in that the transactions took place at the transit company headquarters. However, telephone orders were placed by charges to the customer's major credit card. Only one site, Wilmington, operated a telephone order service, and their records indicated that their labor requirements (3 min per transaction) were not significantly different from those of a direct mail program. Equipment and material costs included telephone installation and monthly service charges (\$30 to \$50 per month), bank credit card service charges (4 to 6 percent of sales), window envelopes (at \$0.03 each), and first-class postage.

#### Recording and Accounting Costs

A recurrent task in prepayment transactions was recording all sales and accounting for all revenue income. These two tasks were usually performed by different personnel at different times. Recording fare prepayment sales was a function that applied only to transit outlets and headquarters. Sales were recorded by a fare agent at the time the sale was transacted. No recording costs were incurred by the transit company at public and employer outlets. The labor requirements for recording sales depended on the procedures used and the volume of transactions. These labor requirements ranged from 0.25 min per transaction in the large outlets and headquarters to 3 to 4 min at the smaller transit-operated outlets.

Accounting costs were incurred in all the prepayment sales methods. Accounting operations included several activities, primarily posting the accounts receivable by the transit company accountants or making a book entry on the consignment accounts on a periodic basis as the sales outlets were serviced. Economies of scale were present in this function. The labor requirements per transaction varied from 0.08 min in the larger companies (SCRTD, SEPTA, and MTC) to 0.35 to 0.45 min per transaction in Norfolk and Tucson.

Accounting for on-board sales transactions also exhibited economies of scale. The accounting labor requirements varied from 1.0 to 3.5 hr per day, depending on the number of transactions.

#### Design Costs

Designing prepayment plans included choosing the dimensions of the instrument, the type of paper stock, and the artwork on both sides of the instrument. Tickets, tokens, and punch cards incorporated simple standardized designs with inconsequential costs. Passes were different altogether in that more attention was placed on the design and artwork to make the pass attractive, functional, and counterfeit free. The design costs of pass plans ranged from as low as \$57 per design for punch cards in Tucson to \$3,500 per design for passes in Philadelphia. Designs were changed every 6 months in some instances (Norfolk and Portland) and every 2 to 3 years in other cases (Tucson and Philadelphia). In general, these costs were minor, amounting to at the most \$5 (in 1981 dollars) per 1,000 instruments printed.

#### Printing Costs

Except for SunTran in Tucson, all the other transit companies analyzed used outside professional print-

ing companies for printing the prepayment instruments. As a general rule, printing costs were affected by four factors: the type of prepayment plan, the quality of materials and printing, the volume printed annually, and the printing frequency. There were economies of scale in printing; the unit cost of printing materials diminished until order sizes of between 100,000 and 200,000 instruments were reached and remained constant after this level had been reached. Costs per 1,000 instruments printed (in 1981 dollars) for orders of 150,000 and more were \$25 for passes, \$20 for ticket books, \$7 for punch cards, and \$75 for brass tokens of 0.984-in. diameter.

#### Inventory Costs

Inventory costs included the storage of prepayment instruments. Two factors affected the space requirements for fare prepayment storage: the type of prepayment plan and the size of each printing order. Thus, there was a cost trade-off between printing frequency and inventory space. Normal space requirements were 220 instruments per cubic foot for conventional plans. The storage costs were estimated as \$0.06 (in 1981 dollars) per cubic foot per month.

#### Miscellaneous Handling Costs

Three of the 11 transit companies analyzed performed special functions on the operation of their ticket and pass programs. Norfolk, for example, counted all new passes arriving from the printer and destroyed unsold passes during the month that the passes were still valid. Wilmington and Portland both separated tickets from the farebox, weighed them, and destroyed the tickets with a shredding machine.

#### Advertising

Few of the transit companies interviewed operated on-going advertising programs. Three companies (SCRTD, SunTran, and METRO in Seattle) incurred monthly advertising and publicity costs. In addition to these companies, three others (Tri-Met, Sacramento Regional Transit District, and SEPTA) incurred one-time promotional campaigns to introduce new prepayment programs or to advertise new sales outlets. In amortizing the effect of advertising expenses, it was assumed that recurrent advertising expenditures would have a short-term effect on sales fully depreciable during 1 year. The one-time introductory promotional campaigns were assumed to have a sales effect within an 18-month period. These assumptions corresponded to the amortization rates of advertising for nondurable and durable goods (12). The costs of one-time introductory campaigns were estimated at \$0.03 to \$0.05 (1981 dollars) per instrument sold. The recurring expenditures were estimated to vary between \$0.12 per instrument sold for the Los Angeles monthly pass to the much larger \$0.65 to \$0.80 per instrument sold in Tucson and for the Los Angeles tourist pass.

#### Administrative Costs

Administration of the prepayment programs included operations such as staff supervision and administration of transit-operated outlets. In addition, there were the expenses of support and maintenance of the existing public and employer outlets and the marketing efforts in outlet expansion. The administrative

costs depended on the extent of effort committed to outlet promotion and expansion. In Philadelphia, where no significant outlet expansion programs were in effect, 52 man-hr per month were spent in supervisory activities. In St. Paul and Seattle, which had significant outlet promotion efforts, 100 to 173 man-hr were spent by supervisory personnel per month.

#### General Overhead Costs

The program overhead costs included general supplies, telephone, utilities, maintenance, and rent. These expenses were estimated as percentage of direct labor costs. The general overhead costs of the transit companies were estimated as a percentage of direct labor costs from the Section 15 Reporting System (13) and applied to all the direct labor costs incurred in the transit fare prepayment program.

#### SUMMARY RESULTS OF THE COST ANALYSIS

The costs incurred at each of the 11 case sites were analyzed in detail in order to develop the parametric cost equations that appeared in the technical report (11). A summary of the results of this analysis is presented here.

#### Fare Prepayment Plan Costs by Transit Company

The 11 transit companies reviewed offered a variety of fare prepayment plans to their riders. Nearly all of them offered at least one pass plan (usually a monthly pass) and an unlimited-duration ticket or token plan. The number of plans offered varied between one and four.

The principal plans offered by the 11 transit companies are presented in Table 2 along with their unit costs. Monthly passes in Los Angeles cost \$0.95 each, whereas in Norfolk they were only two-thirds that price. However, because Los Angeles pass holders used their pass more than 70 times each month, the cost per monthly pass trip in Los Angeles was only slightly higher than the cost per trip in Norfolk. Of the 11 transit companies, only those in Norfolk and Portland offered comparable programs, and their costs were remarkably similar. Both transit companies sold monthly passes and 10-trip ticket books. Costs per instrument were slightly higher in Norfolk than in Portland because of the difference in the size of the two programs. More than eight times as many plans were sold in Portland than in Norfolk, which reduced its unit costs by about 25 percent.

The unit cost per fare prepayment transaction has been disaggregated into its cost categories and is presented in Table 3 in order to provide an opportunity to compare costs across sites. As shown in Table 3, among the transaction-oriented costs, those for order preparation were fairly consistent across sites. Cincinnati was the most costly site in this category because of the cost of wrapping tokens. Norfolk had unusually high order delivery costs because all outlets were serviced by staff and relatively few passes were sold, thereby bringing the average cost up. Direct sales costs were extremely high for the four largest transit systems because of commissions paid to sales outlets. In Richmond and Tucson neither sales outlets were operated nor commissions were paid to public outlets. Accounting costs were relatively low for most programs except for Cincinnati's, and design costs were insignificant.



TABLE 2 Prepayment Costs in Selected Transit Companies

Location and Instrument	Cost (\$1981)	
	Per Instrument	Per Trip
Los Angeles		
Monthly pass	0.95	0.016
Tourist pass	1.82	0.171
Individual ticket (10) <sup>a</sup>	0.38	0.038
Ticket book (10-trip)	0.56	0.056
Philadelphia		
Monthly pass	1.02	0.018
Weekly pass	0.77	0.055
Token (10) <sup>a</sup>	0.54	0.054
St. Paul		
Monthly pass	0.96	0.020
Ticket book (10-trip)	1.45	0.145
Punch card (10-trip)	0.92	0.092
Token (20) <sup>a</sup>	1.44	0.072
Seattle		
Annual pass	8.91	0.018
Monthly pass	0.90	0.021
Ticket book (20-trip)	0.96	0.048
Ticket book (40-trip)	0.96	0.024
Cincinnati		
Token (20) <sup>a</sup>	0.48	0.024
Portland		
Monthly pass	0.45	0.009
Ticket book (10-trip)	0.41	0.041
Norfolk		
Monthly pass	0.61	0.013
Ticket book (10-trip)	0.49	0.049
Sacramento		
Monthly pass	0.58	0.012
Token (20) <sup>a</sup>	0.57	0.028
ID card	2.71	N.A.
Richmond		
Weekly pass	0.15	0.014
Ticket book (10-trip)	0.13	0.013
Ticket book (20-trip)	0.13	0.007
Ticket book (45-trip)	0.13	0.003
Wilmington		
Monthly pass	0.42	0.009
Strip ticket (10-trip)	0.11	0.011
Tucson		
Semester pass	2.96	0.019
Monthly pass	0.34	0.008
Punch card (20-trip)	2.96	0.148

<sup>a</sup> Assumed sold in quantities indicated.

Focusing on the non-transaction-oriented costs, printing costs were high in Philadelphia, Seattle, Cincinnati, and Norfolk. In Seattle and Norfolk relatively small volumes were printed of some of the plans; in Cincinnati costs were exclusively minting costs for tokens. A special printing process was used in Philadelphia to reduce the opportunities for counterfeiting, which explained its high printing costs. Inventory and miscellaneous handling costs were minor for most systems. Advertising costs were insignificant for most programs, although they were significant in some systems. More than \$0.10 was spent on each fare prepayment instrument sold at the three sites with advertising programs. Administrative and overhead expenses were high for the large fare prepayment programs and the two demonstration sites.

As a percentage of cost, direct sales costs clearly increased with the size of the program. Once again this reflects the fact that managers in small programs could usually persuade banks and department stores to sell fare prepayment plans without charging a commission. At large volumes, however, most public outlets required a commission on sales or another form of payment.

Order delivery, accounting, printing, inventory, and overhead costs generally increased as a percentage of total costs as the size of the program decreased. Thus, although direct sale was the dominant cost factor in large programs, accounting, overhead,

printing, and delivery incurred the most costs in small fare prepayment programs. Understanding the differences in the cost elements is critical when planning a fare prepayment program.

Generally, large fare prepayment programs incurred a higher unit cost than small programs as shown by the data presented in Table 3. Transit companies with large fare prepayment programs spent proportionally more money in two aspects of the program than companies with small programs. These included

1. Sales commissions to public outlets (small transit companies could usually secure a network of public outlets without having to pay commissions) and

2. Advertising (small transit companies with set programs usually did not advertise).

As shown in Table 3, the largest fare prepayment programs spent \$0.86 (in 1981 dollars) for each instrument they sold. Average-sized programs spent \$0.44 per instrument and small programs spent only \$0.14. In both Sacramento and Tucson high costs were incurred, in part because of the demonstration activities at these sites.

#### Costs by Type of Prepayment Plan

The prepayment plan cost estimates for the 11 transit companies are summarized in Table 4 according to the major types of instrument. In this section a comparison of the unit costs of the fare prepayment plans in all 11 transit companies are presented. For a true cost comparison, however, the standardized costs of operating selected fare prepayment plans are also presented. As shown in Table 4, the cost per trip was generally higher for the short-term instruments (such as 10-trip ticket books and weekly passes) than for prepayment instruments of longer-term duration. The cost of issuing a weekly pass was only two-thirds the cost of issuing a monthly pass because the normally higher volume of weekly passes sold each month resulted in some economies of scale. A weekly pass program, however, was twice as expensive as a monthly pass program on a per-trip basis. This was generally because of the higher printing and delivery costs.

However, because the prepayment programs at the 11 sites were not identical, too much should not be read into the comparisons presented in Table 4. Instead, the costs of a typical program have been estimated by standardizing some of the resource costs and program parameters. Thus, the standard costs presented in Table 5 assumed 1981 wage rates of \$8.25 per hour for order preparation, delivery, and outlet personnel; \$9.50 per hour for accounting personnel; and \$11.00 per hour for supervisory personnel. Fringe-benefit rates of 36.2 percent and headquarters overhead rates of 39.5 percent were assumed. Prepayment instruments were assumed to be sold at headquarters, at two transit-operated outlets, and at 150 outlets, of which two-thirds charged 2 percent commissions on sales. Staff delivery times were assumed to be 30 min per outlet delivery. No promotional expenses were included among the costs. The resulting costs by type of plan are presented in Table 5.

As shown in Table 5, weekly passes and 10-trip ticket books were the most costly of the six plans to implement because they were consumed and replaced so rapidly. Tokens were slightly more expensive than tickets of the same quantity. Monthly passes and 40-trip ticket books, the two plans with the longest duration, were the least expensive. Thus, when decisions are made on the selection of an appropriate

TABLE 3 Unit Transaction Costs by Cost Category, 1981

Site	Cost Category <sup>a</sup> (\$1981)											Total Cost
	Order Preparation	Order Delivery	Direct Sales	Recording and Accounting	Design	Printing	Inventory	Miscellaneous Handling	Advertising	Administrative	Overhead	
Los Angeles	0.017	0.010	0.601	0.033	0	0.040	0.002	0	0.116	0.025	0.049	0.893
Philadelphia	0.002	0.015	0.432	0.054	0.001	0.153	0	0	0	0.005	0.082	0.744
St. Paul	0.026	0.020	0.839	0.026	0.001	0.045	0.001	0	0	0.034	0.026	1.018
Seattle	0.059	0.008	0.388	0.027	0	0.117	0.001	0	0.260	0.029	0.036	0.925
Cincinnati	0.075	0.044	0.004	0.131	0	0.110	0.002	0	0	0.023	0.091	0.480
Portland	0.016	0.038	0.174	0.070	0.002	0.044	0.002	0.010	0	0.007	0.062	0.425
Norfolk	0.020	0.105	0.112	0.079	0.003	0.129	0.004	0	0	0.002	0.063	0.537
Sacramento	0.027	0.033	0.233	0.070	0.003	0.028	0.001	0	0	0.153	0.225	0.773
Richmond	0.006	0.030	0	0.030	0	0.018	0.002	0	0	0.004	0.045	0.137
Wilmington	0.002	0.002	0.014	0.043	0	0.030	0.001	0.013	0	0.005	0.022	0.134
Tucson	0.029	0.037	0	0.068	0.001	0.066	0.006	0	0.431	0.057	0.134	0.829
Weighted avg	0.017	0.017	0.463	0.043	0.001	0.079	0.002	0.001	0.063	0.021	0.061	0.768
Percent of total	2.2	2.2	60.3	5.6	0.1	10.3	0.3	0.1	8.2	2.7	8.0	100.0

<sup>a</sup> Computed by dividing each cost by the total number of monthly transactions at each site.

TABLE 4 Average Unit Costs for Selected Prepayment Plans

Instrument	Cost (\$1981)	
	Per Instrument	Per Trip
Annual pass (one plan)	8.91	0.018
Semester pass (one plan)	2.96	0.019
Monthly pass (nine plans)	0.69	0.014
Weekly pass (two plans)	0.46	0.035
Ticket book (20-trip) (two plans)	0.55	0.028
Ticket book (10-trip) (six plans)	0.53	0.053
Token (20 each) (three plans)	0.83	0.038

TABLE 5 Standard Costs per Instrument for Six Fare Prepayment Plans by Cost Category

Cost Category	Instrument Cost (\$1981)					
	Monthly Pass	Weekly Pass	10-Trip Ticket	20-Trip Ticket	40-Trip Ticket	20-Token Roll
Order preparation	0.010	0.010	0.002	0.005	0.010	0.020
Order delivery	0.025	0.025	0.006	0.012	0.023	0.012
Direct sales	0.303	0.080	0.080	0.147	0.281	0.147
Recording and accounting	0.044	0.023	0.023	0.030	0.044	0.030
Design	0.002	0.001	0	0	0	0
Printing	0.038	0.038	0.020	0.020	0.020	0.026
Inventory	0.002	0.002	0.002	0.002	0.002	Negligible
Administration	0.011	0.003	0.003	0.005	0.010	0.005
General overhead	0.035	0.024	0.014	0.021	0.033	0.027
Total per instrument	0.470	0.206	0.150	0.242	0.423	0.267
Total per trip	0.011	0.021	0.015	0.012	0.011	0.013

fare prepayment plan, the relative costs presented in Table 5 should provide an indication of the monthly and unit costs that will be incurred.

#### Standard Delivery Costs by Alternative Delivery Methods

As discussed earlier, three methods were generally used in the delivery of prepayment plans to outlets, namely, transit staff delivery, courier delivery, and certified mail delivery. To compare the costs of alternative delivery methods, standard costs of a typical system were developed by using identical assumptions to those presented earlier.

Based on these three methods of delivery, the standard cost of delivering fare prepayment plans to each sales outlet can be as low as \$2.05 per outlet with certified mail or more than \$20 per outlet if staff are used for the delivery. The actual cost per outlet in a particular setting will depend on the number of outlets served, the average distance between outlets, the density of the city, and the number of fare prepayment instruments delivered to each outlet. Given this information, it is possible to choose the least costly method of fare prepayment delivery.

Figure 1 shows the costs of servicing each outlet in a medium-density environment. All three methods of fare prepayment delivery are represented. Certified mail costs increase as the number of passes sent per outlet increases. Courier delivery costs are not affected by the volume of passes sent to each outlet but rather by the number of outlets served. It is assumed that more than 50 sales outlets are served during each delivery period. Transit staff delivery costs depend on the distance (and time) between outlets. The delivery costs per outlet for 1- and 2-mile average distances between outlets are shown in Figure 1.

With the costs of the three delivery methods superimposed on Figure 1, it is possible to determine which method results in the least cost to the transit company at different volumes of passes delivered. Certified mail is the least costly method at volumes below approximately 50 passes per outlet. Beyond that volume, transit staff delivery is the most economical method if outlets are typically spaced 1 mile apart. If the distances between outlets are greater than 1 mile, courier service is less costly.

Any one of the three methods can be the lowest-cost delivery method depending on the set of conditions under which the transit company is operating.

Moreover, because the same volume of passes is usually not sent to all sales outlets, utilization of more than one delivery method could result in the lowest operating cost to a transit company. For example, in a low-density site where outlets are typically spaced 2 miles apart, transit staff should be used for the delivery of passes to high-volume outlets only; that is, staff delivery should be employed only when more than 50 passes are delivered to an outlet. For those outlets receiving less than 50 passes, certified mail should be used. Thus, the combination of staff and certified mail delivery will result in the lowest operating cost for the program.

#### Standard Sales Costs by Sales Method

Standard costs following the assumptions presented earlier were developed for five sales methods, including transit-operated sales outlets, public and employer sales outlets, public outlets with sales contracts such as the Seven-Eleven contract with Portland's Tri-Met, direct mail order, and telephone order programs. The standardized sales costs by sales method are summarized in Figure 2, which also shows that with the exception of sales contracts that provide variable commission rates, sales distribution methods exhibit economies of scale at relatively low sales volumes. At high volumes all five methods have constant average costs.

As shown in Figure 2, telephone order and direct mail programs are relatively expensive programs to operate with little or no economies of scale. In order to make them cost effective, they should only be employed at low volumes and marketed to those transit users without access to the less expensive sales outlets.

Depending on the sales commission rates asked by public and private sales outlets, it may be less expensive for the transit company to staff and maintain a sales outlet if high outlet volumes are obtained. In this analysis it was found that a staff-operated outlet is less expensive than public outlets charging more than 2.5 percent in commissions only at volumes of more than 10,000 pass sales per month. Because few staff-operated outlets meet this test, most staff-operated outlets must therefore be judged and justified on grounds other than pass sales. Finally, transit managers should seriously consider negotiating a contract with a retail chain for the distribution and sales of fare prepayment plans, because such contracts can be less expensive if public outlets charge higher commissions.

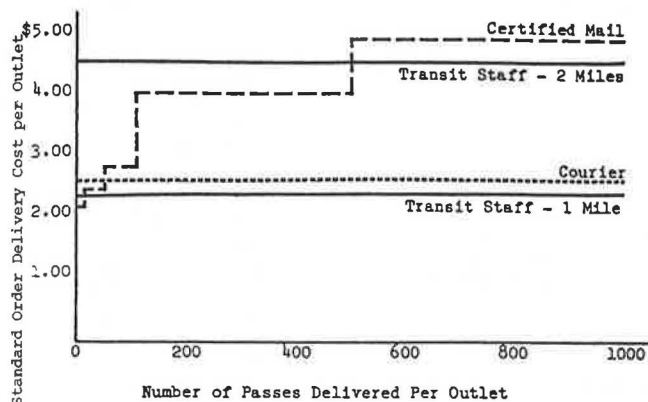


FIGURE 1 Comparison of delivery-method costs in a medium-density environment: 1981.

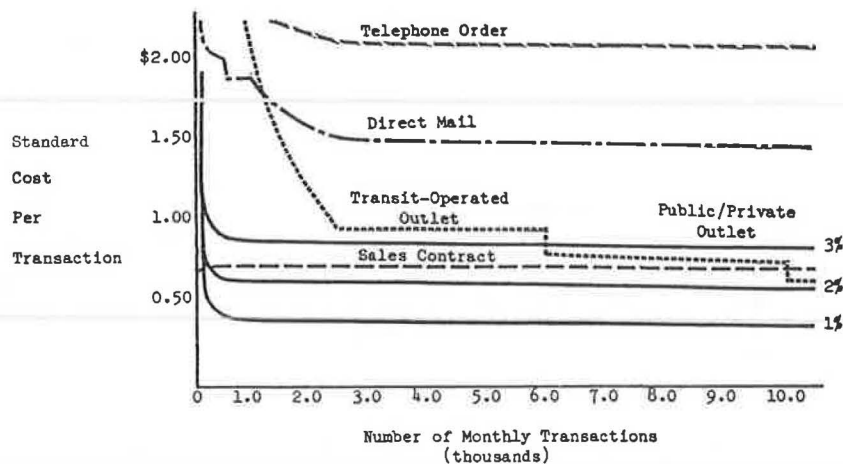


FIGURE 2 Comparison of average costs for five distribution methods at high sales volume: 1981.

In addition, contracting for the distribution and sales of fare prepayment plans frees the transit company from these activities.

#### CONCLUSION: THE NEED FOR COST REDUCTIONS

The authors have shown in a recently completed paper (7) that the potential benefits of transit fare prepayment programs can be between \$0.78 and \$1.05 per prepaid instrument sold. At these benefit levels, fare prepayment programs are cost effective if properly priced to avoid farebox revenue losses because the potential benefits exceed the costs presented in Tables 2 and 3. However, a conscious effort should be made by managers of large fare prepayment programs to reduce costs because there is no technical or operating reason why the unit costs of large programs should be greater than the unit costs incurred in medium-sized programs.

The opportunities for reducing the prepayment program costs are several. Staff delivery of fare prepayment plans to outlets should only be used when the distance between outlets is short. A cost-effective alternative to staff delivery is either a courier service or certified mail for the smaller sales outlets. Because the largest single cost of prepayment plans is the sales commission at the larger companies, every attempt should be made to develop a network of sales outlets without paying commissions. Finally, a more prompt collection of funds from sales outlets is warranted so that the transit company can earn interest on the revenues from prepayment collected in advance of services being rendered and thus take advantage of one of the benefits of prepayment programs.

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#### REFERENCES

1. Huron River Group, Inc. Transit Fare Prepayment. Office of Service and Methods Demonstrations, UMTA, U.S. Department of Transportation, Aug. 1976.
2. P. Bloomfield and J. Crain. Transit Fare Prepayment Demonstrations in Austin, Texas and Phoenix, Arizona. Final Report. Transportation Systems Center, U.S. Department of Transportation; Crain and Associates, Menlo Park, Calif., June 1979.
3. P.D. Mayworm. Demonstration Plan for the Student Transit Fare Prepayment Demonstration: Tucson, Arizona. Research Report 125-3. Office of Service and Methods Demonstrations, UMTA, U.S. Department of Transportation; Ecosometrics, Inc., Bethesda, Md., Jan. 1980.
4. P.D. Mayworm and A.M. Lago. Demonstration Plan for the Variable Work Hours/Employee Pass Demonstration: Duluth, Minnesota. Research Report 125-4. Office of Service and Methods Demonstrations, UMTA, U.S. Department of Transportation; Ecosometrics, Inc., Bethesda, Md., May 30, 1980.
5. J.I. Riese, A.M. Lago, and P.D. Mayworm. Management Plan for the Queen City Metro Monthly Pass Pricing Demonstration. Research Report 125-6. Office of Service and Methods Demonstrations, UMTA, U.S. Department of Transportation; Ecosometrics, Inc., Bethesda, Md., Dec. 1981.
6. Systan, Inc. Sacramento Transit Fare Prepayment Demonstration. Transportation Systems Center, U.S. Department of Transportation, Los Altos, Calif., July 1981.
7. A.M. Lago and P.D. Mayworm. Economics of Transit Fare Prepayment: Passes. In Transportation Research Record 857, TRB, National Research Council, Washington, D.C., 1982, pp. 52-57.
8. P.D. Mayworm, A.M. Lago, and J.M. McEnroe. Patronage Impacts of Changes in Transit Fares and Services. Research Report 135-1. Office of Service and Methods Demonstrations, UMTA, U.S. Department of Transportation; Ecosometrics, Inc., Bethesda, Md., Sept. 3, 1980.
9. D. Krechmer, F. Spielberg, and V. Milione. Evaluation of Employer-Based Transit Pass Programs. In Transportation Research Record 857, TRB, National Research Council, Washington, D.C., 1982, pp. 58-60.
10. P.D. Mayworm, A.M. Lago, and B.F. Beach. A Comprehensive Demonstration of Distribution Systems for Transit Fare Prepayment: The Sacramento Regional Transit Project. Research Report 125-5. Office of Service and Methods Demonstrations, UMTA, U.S. Department of Transportation; Ecosometrics, Inc., Bethesda, Md., Feb. 1981.



11. P.D. Mayworm and A.M. Lago. The Costs of Transit Fare Prepayment Programs: A Parametric Cost Analysis. Research Report 125-7. Office of Service and Methods Demonstrations, UMTA, U.S. Department of Transportation; Ecosometrics, Inc., Bethesda, Md., Feb. 15, 1982.
12. Y. Peles. Rates of Amortization of Advertising Expenditures. Journal of Political Economy, Vol. 79, Sept. 1977.
13. National Urban Mass Transportation Statistics:

First Annual Report, Section 15 Reporting System. Transportation Systems Center, U.S. Department of Transportation, Cambridge, Mass., May 1981.

Opinions expressed in this paper are those of the authors.

# Performance Assessment Methods and Results for Transit Automatic Fare Collection Equipment

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## ABSTRACT

Performance assessment methods and results for transit automatic fare collection (AFC) equipment are presented. The methods developed are based on the experience gained from a series of performance assessments conducted at eight U.S. and three foreign transit systems. The methods are intended to assist rail transit systems in their assessment of equipment, promote uniformity in applications, improve communications between companies, and help achieve a better understanding of problems and issues. The development effort has been conducted as part of the UMTA Rail Transit Fare Collection Project, the overall goal of which is to aid in the development of improved AFC systems for rail transit. The expected benefits from the project include improved operating efficiency and reduced labor and maintenance costs at the transit systems. In this source document for assessment methodology key AFC terms and concepts are defined, and performance methods as well as the results of the systems assessments and industry AFC contract specifications are presented and discussed.

UMTA, U.S. Department of Transportation, initiated the Rail Transit Fare Collection (RTFC) Project in 1979 in response to a critical need by the U.S. transit industry for improved automatic fare collection (AFC) systems.

Currently there exists a clear lack of standardization in both performance measurement and specification of fare collection equipment. This has resulted in, among other things, increased procurement costs and the need to regularly "reinvent the

wheel." In recognition of this, the RTFC Project was targeted at the development and application of uniform AFC performance assessment methods.

In this paper uniform performance assessment methods for AFC equipment are presented. In addition, the results of the systems assessments are summarized and discussed and compared with industry performance specifications.

## AFC SYSTEMS AND EQUIPMENT

An AFC machine is a self-service device that provides a fare collection revenue service or function and that represents a complete unit to a passenger. AFC machines include farecard or ticket vendors, automatic gates, addfares, transfer dispensers, and change makers for bills or coins or both.

An AFC machine subsystem is a part or assembly of parts that accomplishes a specific revenue function or transaction service and can be considered, for the sake of maintenance, a discrete unit. Major subsystems of AFC machines include bill validators, coin acceptors, ticket transports, transfer dispensers, barrier mechanisms, and control logic units.

Of the operating rapid rail and commuter rail systems in the United States, the following currently use AFC equipment: Metropolitan Atlanta Rapid Transit Authority (MARTA); Washington Metropolitan Area Transit Authority (WMATA); Bay Area Rapid Transit (BART), San Francisco; Port Authority Transit Corporation (PATCO), Philadelphia and Camden; Illinois Central Gulf (ICG), Chicago; Chicago Transit Authority (CTA); Port Authority Trans-Hudson Corporation (PATH), New York and New Jersey; Massachusetts Bay Transportation Authority (MBTA), Boston; New York City Transit Authority (NYCTA); Southeastern Pennsylvania Transportation Authority (SEPTA), Philadelphia; and Baltimore Metropolitan Transit Authority (BMTA). In addition to these, the Metro-Dade Transportation Administration (MDTA) system currently under construction in Miami will use AFC equipment.