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SCRTD METRO RAIL PROJECT

Preliminary Engineering

ANALYSIS OF THE FLAT FARE COLLECTION SYSTEM ALTERNATIVE

WBS 16 CAE 11

Prepared by

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SUMMARY

This report presents an analysis of the feasibility of instituting a flat-fare collection system for the Metro Rail line. Both the adopted graduated-fare collection system and the alternative flat-fare system are described. The alternatives are then evaluated in terms of capital cost; annual O&M cost; system reliability; passenger convenience; administrative requirements; ridership and revenue; and fare equity.

The results of the analysis indicate several important conclusions. Relative to the graduated-fare system, a flat-fare system would result in capital cost savings of 47 percent and O&M cost savings of 18 percent. The flat-fare system would also be significantly more reliable, provide greater convenience to the patron, and enjoy slightly reduced administrative requirements. Moreover, the flat-fare system produces greater revenues: $2.0 million additional Metro Rail revenues and $17.7 million additional total SCRTD (bus and rail) revenues.

Counterbalancing these advantages, however, is the fact that the flat-fare system is less equitable than the graduated-fare system. In order to make a final determination of the costs and benefits of the two systems, the value of equity to society and how best to achieve equity must first be addressed.

CHAPTER 1

INTRODUCTION

The fare collection system adopted by SCRTD for the Metro Rail line is an automatic barrier system that will provide the District with a broad degree of flexibility to set fare policy, including graduated (zone) fares, peak/off-peak fare differentials, regular and reduced fares, single-trip and multi-trip fares, and intermodal transfers. The implementation of a graduated fare introduces a significant degree of complexity in that the system must be capable of selling media for a variety of fares and then checking the fare media at both entry and exit to ensure that the proper fare has been paid.

As part of on-going efforts to reduce the cost of the Metro Rail Project, Booz, Allen & Hamilton Inc. was retained to examine the practicality of instituting a flat-fare structure for the rail line. This report compares the capital and annual operating and maintenance costs of a flat-fare barrier system to those of the adopted graduated-fare barrier system. It assesses operational advantages of implementing a flat fare collection system and the potential impacts of a flat fare on ridership and revenue. The analysis addresses only the costs of the initial equipment. The cost of retrofitting the flat-fare system to handle graduated fares is not analyzed. It should be noted, however, that the total cost of purchasing flat-fare equipment and retrofitting such equipment may exceed the cost of purchasing the adopted system, depending on when the system is modified and the complexity of the graduated-fare system adopted.

This report contains three additional chapters. Chapter 2 briefly reviews the graduated-fare collection system that has been adopted for Metro Rail and describes the alternative flat-fare system. Chapter 3 compares the flat-fare system to the graduated-fare system with respect to several evaluation criteria, including: capital cost, operating and maintenance cost, system reliability, administrative requirements, passenger convenience, ridership and revenue, and fare equity. Chapter 4 presents the report conclusions.

CHAPTER 2
DESCRIPTION OF ALTERNATIVES

The barrier fare collection system that SCRTD currently plans to implement on Metro Rail is described in detail in the Fare Collection Operational Criteria (WBS 16 CAE 11), June 1983, prepared by Booz, Allen & Hamilton. This chapter gives a summary description of that system and describes how the flat-fare system would differ.

2.1 ADOPTED GRADUATED-FARE COLLECTION SYSTEM

The adopted fare collection system for Metro Rail has been developed to provide SCRTD with flexibility in setting fare policy. It will be capable of accommodating the following fare elements:

- A graduated (zone) fare
- Regular (adult), reduced (student, elderly, handicapped) and free (employee, dependent) fares
- One-way, round-trip and multi-trip (stored-ride or stored-value) fares
- Monthly and/or biweekly passes for specific zones
- Transfers to/from buses or light rail without payment of a second base fare
- Peak/off-peak fare differentials
- Employee passes.

To provide this capability, the system will require the following station equipment:

- Fare Gates: To read fare media on both entry and exit; to deduct the proper fare or to ensure the media is valid for the trip; to print rail-to-bus transfer information on tickets

- Ticket Vendors: To sell regular one-way and round-trip tickets to any station, accepting bus-to-rail transfers for credit

- Add-Fare Machines: To upgrade a ticket or pass if additional fare is required to exit through the fare gates of a particular station

- Bill Changers: To obtain change for use in the ticket vendors and add-fares, which will not accept paper currency

- Handicapped Gate: To provide accessibility to the platform by patrons in wheelchairs holding valid media.

Other equipment will include:

- Central Control Equipment: To permit Central Control to remotely monitor and control the status of equipment located in the stations

- Central Encoding Equipment: To pre-encode multi-trip tickets and passes for sale at SCRTD outlets, and to pre-encode dates and routes on bus-to-rail transfers (transfer-encoding equipment on buses for date, route and time is an option to be examined)

- Revenue Carts: To transport revenue from the station to the cash counting facility.

All Metro Rail patrons will require a magnetically encoded ticket or pass that will be read by the fare gates when both entering and exiting the Metro Rail System. Patrons will be able to purchase regular-fare one-way and round-trip tickets to any destination from ticket vendors located in each Metro Rail station. Other types of fare media will be available at SCRTD sales outlets. (Currently 250 banks and shops, located throughout the County, are authorized to sell SCRTD passes, tickets and tokens.)

If a patron is transferring from a bus, the ticket vendor will accept a machine-readable transfer card issued by the bus driver and give appropriate credit toward purchase of the Metro Rail ticket. Use of the ticket vendor by transferring patrons will be necessitated by the graduated fare structure of Metro Rail. It is not considered practical for the bus driver to collect the variety of fares dictated by such a fare structure. A single-value bus-to-rail transfer will therefore be issued by the bus driver.

Patrons wishing to transfer to a bus after riding on Metro Rail will so indicate to the ticket vendor when purchasing the ticket, pay an added transfer charge and receive a ticket encoded with transfer information. Transfer information will be printed on the ticket by the exit fare gate when the patron is leaving the Metro Rail System.

Tickets and passes will be valid for either a given value or between specific pairs of stations. Patrons riding to a station for which the ticket or pass is not valid will use an add-fare machine to pay additional fare. The add-fare machine will then re-encode the ticket or pass to permit exit.

2.2 ALTERNATIVE FLAT-FARE COLLECTION SYSTEM

The alternative fare collection system examined in this study has been defined to have the same capabilities as the adopted system, with one major exception. Instead of a graduated fare structure, the system will only accommodate a flat fare, which means the same fare will be paid to any destination on Metro Rail. Reduced fares will continue to be offered to students, the elderly and the handicapped. Multiple and pass fares will still be possible, as will peak/off-peak fare differentials and intermodal transfers. The proposed system has also been defined to permit upgrading to accommodate a graduated fare in the future.

The system would consist of the following station equipment:

- Fare Gates: To read fare media, including transfers, on entry and to permit free exit
- Ticket Vendors: To sell regular one-way and round-trip tickets to any station
- Bill Changers: To obtain dollar coins for use in the ticket vendors
- Handicapped Gate: To provide accessibility to the platform by patrons in wheelchairs and holding valid media

- Exit Gates: To permit free exit, supplementing the fare gates for exiting.

As with the adopted system, the flat-fare system would require Central Control equipment, central encoding equipment, and revenue carts.

Because a single fare will be valid to all destinations on Metro Rail, fare media will need to be checked for validity only once during the trip. Thus, fare gates will only read fare media on entry and will free-wheel in the exit direction. Exit gates will supplement the fare gates for exiting, but will be locked in the entry direction.

As with the adopted system, patrons will be able to purchase regular-fare one-way and round-trip tickets from ticket vendors, and other fare media from sales outlets. The tickets and passes will not be restricted to specific origin/destination combinations.

Patrons transferring from bus will be able to insert the machine-readable transfer issued by the bus driver directly into the fare gate. Because a single fare will be valid to all destinations, it will be a simple matter for the driver to collect a through-fare for Metro Rail.

Patrons wishing to transfer to a bus after riding Metro Rail will pay the appropriate extra transfer charge when purchasing a Metro Rail ticket. Transfer information will then be printed on the ticket by the fare gate on entry and returned to the patron. A bus-to-rail transfer card will similarly be returned to a patron by the fare gate with printed rail-to-bus transfer information if the patron presses a button on the entry fare gate. One-way tickets not encoded for rail-to-bus transfer will be captured by the fare gate on entry.

Add-fare machines will, of course, not be necessary for a flat-fare system since any ticket valid for entry will be valid to all Metro Rail destinations.

Table 2-1 summarizes the similarities and differences between fare collection equipment of the adopted and alternative systems.

TABLE 2-1
COMPARISON OF EQUIPMENT FUNCTIONS

	Adopted System	Flat-Fare System
FARE GATE	Reads/encodes tickets, passes on entry and exit Captures expended tickets on exit Prints transfer info on ticket on exit	Reads/encodes tickets, passes, transfer on entry Captures expended tickets on entry Prints transfer info on ticket on entry Free-wheels in exit direction Returns bus-rail transfers upon request for transfer to a 2nd bus
EXIT GATE	Not required for adopted system	Locked in the entry direction Free-wheel in the exit direction
HANDICAPPED GATE	Reads E/H tickets, employee passes on entry and exit Captures expended tickets on exit Prints transfer info on ticket on exit	Reads E/H tickets, employee passes on entry Captures expended tickets on entry Prints transfer info on ticket on entry Free-wheels in exit direction
TICKET VENDOR	Accepts coin Gives change Encodes/prints 1-way, round trip tickets for all destinations from that station Accepts bus-to-rail transfers for credit	Accepts coin Gives change Encodes/prints 1-way, round trip tickets valid to any destination

TABLE 2-1 (Continued)

	Adopted System	Flat-Fare System
BILL CHANGER	Accepts dollar bills ($1, $5) Gives SBA dollar coins as change	Accepts dollar bills ($1, $5) Gives SBA dollar coins as change
ADD-FARE	Accepts coin Gives change Accepts/reencodes undervalue tickets, passes for exit	Not required for flat-fare system
CENTRAL ENCODER	Preencodes tickets, passes for sale in outlets Preencodes transfers for buses (option: install encoders on buses)	Preencodes tickets, passes for sale in outlets Preencodes transfers for buses (option: install encoders on buses)
CENTRAL CONTROL	Controls/monitors station equipment	Controls/monitors station equipment

KEY: __________ : Additional functions over the other system

_ _ _ _ _ : Changed functions over the other system

CHAPTER 3
EVALUATION OF ALTERNATIVES

The graduated-fare and flat-fare systems described in Chapter 2 were compared in an evaluation using the following criteria:

- Capital cost
- Annual operating and maintenance cost
- System reliability
- Passenger convenience
- Administrative requirements
- Revenue/ridership
- Fare equity

3.1 CAPITAL COST

The capital cost of a flat-fare collection system will be significantly lower than that of the graduated-fare collection system, for two key reasons:

- The required equipment need not be as complex.
- Fewer units are required.

Fare gates and handicapped gates that read fare media on entry only will be simpler and far less costly than those that must perform this function in both directions. Exit gates that free-wheel in the exit direction and that are locked to entry do not require ticket reading equipment and are even less expensive to purchase and install. Similarly, ticket vendors will not need to sell the same variety of ticket types, nor will they need to accept and read bus-to-rail transfers.

Fewer fare gates are needed for a flat-fare system because the exit rate through a fare gate will be faster when patrons do not need to insert and retrieve fare media and are instead permitted free exit.

Fewer ticket vendors will be required because patrons transferring from a bus will be able to bypass the vendors and instead insert their transfer media directly into the fare gate. In addition, no add-fare machines will be required for the flat-fare system.

Estimates of the capital costs (in 1983 dollars) for the two systems are presented in Tables 3-1 and 3-2. A comparison of the total costs on these tables shows that the flat-fare system could be expected to be almost as low as one-half the cost of the graduated-fare system ($11.0 million vs $20.5 million, respectively).

Equipment quantities were derived to satisfy year 2000 ridership levels defined in Design Directive DD-001, September 1983. System sizing criteria were based on those defined in Fare Collection Operational Criteria (WBS 16 CAE 11), July 1983. An exit rate of 35 people per minute was used for free-exit fare gates. Station sketches in Milestone 10 were used to determine the number of mezzanines in each station, which influences equipment quantities. Unit costs were derived from those in the Analysis of Alternative Fare Collection Systems (WBS 14 CAE 11), January 1983, and adjusted as necessary to reflect recent changes in equipment definition. Unit costs for flat-fare system equipment were based on recent prices paid for similar equipment, particularly at MARTA (Atlanta).

TABLE 3-1
CAPITAL COST ESTIMATE: ADOPTED SYSTEM

Item	Quantity	COST (1983 dollars) Unit	Total
Entry/exit Fare Gate w/console	150	30,000	4,500,000
End Fare Gate Console	25	18,000	450,000
Entry/exit Handicapped Gate w/console	18	35,000	630,000
Ticket Vendor	133	37,000	4,921,000
Bill Changer	99	11,000	1,089,000
Add-fare	52	27,000	1,404,000
Central Control Equipment	L.S.	100,000	100,000
Central Ticket Encoder	6	140,000	840,000
Revenue Cart	40	6,000	240,000
Spares	L.S.	10% of T.E.C.	1,417,000
Test Equipment	L.S.	150,000	150,000
Installation: Station	18	2,500	45,000
Installation: Central	L.S.	20,000	20,000
Training and Manuals	L.S.	200,000	200,000
Initial Media Supply	L.S.	957,000	957,000
Engineering and Contingencies	L.S.	25% of T.E.C.	3,544,000
Total Estimated Capital Cost			20,507,000

L.S. = Lump Sum
T.E.C. = Total Equipment Cost

TABLE 3-2
CAPITAL COST ESTIMATE: FLAT-FARE SYSTEM

Item	Quantity	COST (1983 dollars) Unit	Total
Entry Fare Gate w/console	85	20,000	1,700,000
Exit Gate w/console	40	11,000	440,000
Entry End Console	25	10,000	250,000
Entry Handicapped Gate w/console	18	24,000	432,000
Ticket Vendor	81	32,000	2,592,000
Bill Changer	50	11,000	550,000
Central Control Equipment	L.S.	100,000	100,000
Central Ticket Encoder	6	140,000	840,000
Revenue Cart	40	6,000	240,000
Spares	L.S.	10% of T.E.C.	714,000
Test equipment	L.S.	100,000	100,000
Installation: Station	18	2,000	36,000
Central	L.S.	20,000	20,000
Training and Manuals	L.S.	200,000	200,000
Initial Media Supply	L.S.	957,000	957,000
Engineering and Contingencies	L.S.	25% of T.E.C.	1,786,000
Total Estimated Capital Cost			10,957,000

L.S. = Lump Sum
T.E.C. = Total Equipment Cost

3.2 ANNUAL OPERATING AND MAINTENANCE COST

The annual operating and maintenance cost of a flat-fare collection system will be lower than that of the graduated-fare collection system, although the difference will not be nearly as significant as in the area of capital costs. Because the equipment will be simpler in operation and fewer in number, fewer field and shop technicians will be required. Similarly, less money will be spent on equipment parts and materials.

Fewer revenue collection crews (including security guards) will be needed to collect and transport Metro Rail revenue under the flat-fare policy because there will be fewer units of equipment to service at each station. For either alternative, however, a second shift of equal staff size will be employed at the cash counting facility to process Metro Rail receipts.

The number of fare enforcement police will not be affected by the selection of a flat-fare policy. Nor will the number of ticket encoding clerks, since the same number of passes and transfers will need to be pre-encoded. (This assumes that bus-to-rail transfers for the adopted system will be re-encoded and returned to the patron by the ticket vendors for use on Metro Rail. The alternative of having the vendor capture the transfer and issue a new Metro Rail ticket would increase media costs for the adopted system.)

Estimates of the annual operating and maintenance costs (in 1983 dollars) for the two systems are presented in Tables 3-3 and 3-4. A comparison of these estimates shows that the flat-fare system would be almost 20 percent less costly to operate than the adopted system: $4.2 million vs $5.1 million. Estimates of personnel require-

TABLE 3-3
ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE: ADOPTED SYSTEM

		COST (1983 dollars)	
Item	Quantity	Unit	Total
Labor:			
Field Technician	29	42,000	1,218,000
Shop Technician	8	45,400	363,200
Revenue Collector	16	33,900	542,400
Revenue Clerk	16	33,900	542,400
Transit Police	10	37,400	374,000
Security Guard	7	34,200	239,400
Ticket Encoding Clerk	7	33,900	237,300
Maintenance Supervisor	4	46,400	185,600
Revenue Supervisor	3	41,000	123,000
Materials and Supplies:			
Ticket Supply	L.S.	957,000	957,000
Parts and Miscellaneous	L.S.	324,000	324,000
Total Estimated Annual O&M Cost			5,106,300

L.S. = Lump Sum

TABLE 3-4
ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE: FLAT-FARE SYSTEM

Item	Quantity	COST (1983 dollars) Unit	Total
Labor:			
Field Technician	19	42,000	798,000
Shop Technician	5	45,400	227,000
Revenue Collector	11	33,900	372,900
Revenue Clerk	16	33,900	542,400
Transit Police	10	37,400	374,000
Security Guard	5	34,200	171,000
Ticket Encoding Clerk	7	33,900	237,300
Maintenance Supervisor	3	46,400	139,200
Revenue Supervisor	3	41,000	123,000
Materials and Supplies			
Ticket Supply	L.S.	957,000	957,000
Parts and Miscellaneous	L.S.	220,000	220,000
Total Estimated Annual O&M Cost			4,161,800

L.S. = Lump Sum

ments and unit costs were based on the Analysis of Alternative Fare Collection Systems (WBS 14 CAE 11), January 1983, and Operating and Maintenance Cost Estimate (WBS 17 BAB), June 1983. An estimate of the number of technicians needed for the flat-fare system was based on the anticipated differences in equipment reliability between the two fare collection systems, as discussed in the following section.

3.3 SYSTEM RELIABILITY AND PASSENGER CONVENIENCE

Because the system and its equipment will be simpler in design, the flat-fare collection system would be both more reliable and more convenient than the graduated-fare system.

System reliability was measured by the number of patron-trips per failure. Estimates for system reliability are presented for the two systems in Tables 3-5 and 3-6. A comparison of these tables shows that the flat-fare collection system could be expected to be three times as reliable as the graduated-fare collection system.

These reliability estimates are based on information provided by Kaiser Engineers for the Analysis of Alternative Fare Collection Systems prepared by Booz, Allen & Hamilton, and are based primarily on the experiences of BART and WMATA. Improvements in fare collection technology can be expected to increase the reliability of both a graduated-fare system and a flat-fare system.

The greater reliability of the flat-fare system is a result not just of the lesser equipment complexity, but of the lower frequency of equipment usage. Patrons transferring from buses will bypass the ticket vendors, resulting

TABLE 3-5
RELIABILITY ANALYSIS: ADOPTED SYSTEM

Equipment	Reliability (MCBF)[a] Worst	Reliability (MCBF)[a] Best	Daily Use: Number of Patrons	Daily Use: % of Patrons	Daily Failures Worst	Daily Failures Best
Fare Gate (for entry and exit)	800	6,000	364,000	100	455	61
Ticket Vendor	100	400	124,000	34[b]	1,240	310
Add-Fare	100	600	15,000	4	150	25
Bill Changer:						
Free Area	200	1,500	62,000	17[c]	310	41
Paid Area	200	1,500	7,000	2	35	5
Total			364,000		2,645	503
Total Patrons per Failure					138	724

a. MCBF: Mean cycles between failures.

b. 34% of all patrons will use ticket vendors. This assumes that, of the 45% of patrons without prepurchased tickets or passes, one-half (23%) will purchase single-trip tickets and one-half will purchase round-trip tickets. Therefore, 45% of morning patrons will use vendors and 23% of patrons on the return trip will use vendors.

c. Assumes one-half of those using ticket vendors will use bill changer.

TABLE 3-6
RELIABILITY ANALYSIS: FLAT-FARE SYSTEM

	Reliability (MCBF)[a]		Daily Use		Daily Failures	
Equipment	Worst	Best	Number of Patrons	% of Patrons	Worst	Best
Fare Gate:						
Entry	800	6,000	364,000	100	455	61
Exit	50,000	100,000	364,000	100	7	4
Ticket Vendor	200	800	55,000	15[b]	275	69
Bill Changer (free area)	200	1,500	26,000	7[c]	130	17
Total			364,000		867	151
Total Patrons per Failure					420	2,411

a. MCBF: Mean cycles between failures.

b. 15% of all patrons will use ticket vendors. This assumes that 45% of patrons are without prepurchased tickets or passes, and 45% of these patrons do not already have fare-gate readable bus-to-rail transfers. Of these patrons (20% of all patrons), one-half (10%) will purchase single-trip tickets and one-half will purchase round-trip tickets. Therefore, 20% of morning patrons will use vendors and 10% of patrons on the return trip will use vendors.

c. Assumes one-half of those using ticket vendors will use bill changer.

in fewer transactions and a lower likelihood of failure. As noted previously, add-fare machines will not be needed at all.

The flat-fare collection system would be the more convenient system because its simplicity would make it easier for patrons to understand and use. Fewer steps would be required to use the system and there would be less chance of encountering a failure.

3.4 ADMINISTRATIVE REQUIREMENTS

The flat-fare collection system would be slightly easier to administer than the graduated-fare collection system. This would be due primarily to the slightly smaller staff of maintenance technicians, and the simpler maintenance requirements. A related consideration would be the level of assistance required by patrons using the system. Because the flat-fare system would be easier to use and less likely to fail, fewer stations might require station attendants during high volume hours of operation. The potential savings in station attendants was not addressed in this cost analysis.

Unfortunately, use of a flat fare would have no impact on the administrative requirements for pre-encoding and distributing bus-to-rail transfers, an operation that has not worked well on the Atlanta system. The only satisfactory method for eliminating this potentially troublesome operation would be to install encoding equipment on SCRTD buses.

3.5 RIDERSHIP AND REVENUE

To compare the ridership and revenue impacts associated with the alternative fare collection systems, it is first necessary to determine the flat fare consistent with the adopted graduated-fare schedule. The criterion established was to select that flat fare which generates Metro Rail ridership equal to ridership resulting from the graduated fare.

A $2.00 fare (in 1980 dollars*) was found to best meet the ridership criterion based on simulations run by the SCRTD Planning Department. The ridership generated at a $2.00 flat fare was estimated to be 365,504 riders per day, compared to daily ridership of 364,000 under the graduated fare system. The similarity in ridership is not surprising, since the average fare paid under the graduated-fare system would be approximately $2.00.

Annual revenue and cost impacts associated with each alternative fare system are compared in Table 3-7. The revenue data are based on simulations run by the SCRTD Planning Department. Daily revenues were converted to annual estimates based on the annualization factors of 308 days for bus service and 295 days for rail service specified in the Final EIS/EIR.** Since the ridership models are based on costs in 1980 dollars, revenues were converted to 1983 dollars to allow comparability with system costs.

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* The $2.00 fare in 1980 dollars is equivalent to a fare of $2.41 in 1983 dollars.

** See U.S. Department of Transportation, Urban Mass Transportation Administration, "Final Environmental Impact Statement and Environmental Impact Report, Los Angeles Rail Rapid Transit Project," December, 1983.

TABLE 3-7
ANNUAL REVENUE AND COST IMPACTS OF ALTERNATIVE FARE SYSTEMS
(millions of 1983 dollars)

	Annual Revenues		Annual O&M Costs		Annualized Fare Collection Capital Cost[a]
	Metro Rail	Bus & Rail	Metro Rail	Bus & Rail	
Adopted System	107.7	403.7	48.1	495.4	2.7
$2 Flat Fare	109.7	421.4	47.2	494.5	1.4

a. Annualized capital cost based on a 15-year life, 10% discount rate and nominal scrap value.

The conversion was made based on the U.S. city average Consumer Price Index (CPI) for all urban consumers for 1980 and 1983. (The 1983 average CPI was assumed to be equal to the average for January through November, the latest data available.)

Operating and maintenance (O&M) costs for Metro Rail and the combined SCRTD bus and rail systems are based on costs presented in the Final EIS/EIR. These costs were adjusted to reflect current cost estimates for the adopted and flat-fare collection systems. Total Metro Rail O&M costs are $48.1 million for the adopted system and $47.2 million for the flat-fare system.* The Final EIS/EIR estimate of bus O&M costs, $447.3 million, is assumed to be unaffected by the Metro Rail fare collection system.

Table 3-7 clearly illustrates that the flat-fare system generates greater revenues for both Metro Rail and the combined bus and rail systems while at the same time incurring lower O&M and capital costs. The marginal revenue production and cost savings resulting from implementation of the flat-fare system, rather than the adopted system, are presented in Table 3-8. The total annual benefit is $19.9 million, approximately 4 percent of the total annual costs (O&M and capital) of the bus and rail Locally Preferred Alternative.

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* The Final EIS/EIR indicates annual O&M costs for the Metro Rail Locally Preferred Alternative to be $48.5 million. This estimate is based on an estimated fare collection system O&M cost of $5.5 million (in 1983 dollars) cited in the <u>Analysis of Alternative Fare Collection Systems</u> (WBS 14 CAE 11), January 1983. (The January 1983 estimate of O&M costs was actually $5.3 million in 1982 dollars which is equivalent to $5.5 million in 1983 dollars.) The total O&M costs for Metro Rail under each fare collection system are calculated based on current estimates of O&M costs of $5.1 million for the adopted fare collection system and $4.2 million for the flat-fare system.

TABLE 3-8
MARGINAL REVENUE PRODUCTION AND COST SAVINGS
RESULTING FROM FLAT-FARE SYSTEM
(millions of 1983 dollars)

Additional Annual Metro Rail Revenues	2.0
Additional Annual Bus and Rail Revenues	17.7
Annual O&M Cost Savings	0.9
Annualized Capital Cost Savings	1.3
Total Annual Benefit[a]	19.9

a. Total annual benefit is equal to the sum of additional bus and rail revenues, O&M cost savings and capital cost savings.

3.6 FARE EQUITY

Equity can be defined in a variety of ways depending on the goals and objectives of the service provider. Two definitions are appropriate for application to pricing transit services: (1) that equal prices be paid for equal service; or (2) that individuals with equal ability to pay make equal payment and that payment be related to ability to pay. Each of these definitions is explored further below, and the extent to which equity is achieved by the two fare systems is examined.

The first definition of equity calls for equal payment for the same service. Two issues arise from this definition. The first concerns differences between the price of the service and the fare paid. Therefore, measures for payment and service are required to apply this definition. Two alternatives are available for measuring payment. The first, fare, is simply the user's direct out-of-pocket expense associated with the transit trip. Price, on the other hand, is an inclusive term, best defined as the generalized cost of the transit trip.* Because the price of the trip is a complex function which varies depending on the tastes of the individual, it is very difficult, if not impossible, to evaluate equity based on the total price paid. Therefore, the fare will be used as a measure of payment.

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* The generalized cost is equal to the weighted sum of the transit fare, the out-of-pocket expense associated with access to and egress from the system, and the value of the time required to make the trip. The weights associated with each component are a function of the traveler's value of time and, therefore, differ for different individuals. The final component of price is the amount paid for the transit system in taxes and/or forgone municipal services other than transit.

The second issue concerns the definition of equal service. Service may be defined in terms of distance travelled, speed, frequency of service, schedule convenience, route and station convenience, and ride comfort. Again, the relative importance of each service attribute varies based on the tastes of the individual. Hence, it is impossible to derive a universal definition of service. Service will therefore be measured in terms of distance and speed.

Using fare as a measure of payment and distance and speed as a measure of service, we can make some general determination of the equity impacts of each fare system. Under the graduated-fare system, a base fare is paid and additional charges are paid on a zonal basis. In contrast, under the flat-fare system, the same fare is paid for all rail trips. While the graduated-fare system does not always require equal fare for equal distances due to the use of zone boundaries rather than per-mile charges, it conforms more closely to a proportional fare-distance relationship. Under the flat-fare system, short trips pay a much higher price per unit of service than do longer trips. The graduated-fare system, therefore, results in a much more equitable pricing schedule.

The second definition of equity, that payment be related to ability to pay and that individuals with equal ability make equal payment, also introduces some complexities. As before, payment will be defined as the fare. Ability to pay may be defined in a number of ways, e.g., household income, per capita income, total disposable income, disposable income available for transportation, income plus wealth. Due to data limitations, household income will be used as an indicator of ability to pay.

The SCRTD Planning Department provided data on line-haul trip times for different income groups based on Metro Rail ridership simulations.* Assuming trip time is proportional to trip distance, these data may be used to determine whether higher income groups are more likely to travel greater distances than lower income groups.

Because we might expect a different distribution of trip times for non-work and work trips, separate data were provided for each trip purpose. Table 3-9 presents the mean and variance for non-work trip times for each income quintile. A series of difference of means tests was used to determine whether the mean trip time for each income quintile is greater than the mean trip time for the next lower income quintile. The results of the tests indicated that the mean trip time for each quintile was indeed significantly greater than the mean for the next lower quintile.** Hence, we may conclude that higher income travelers make longer non-work trips than lower income travelers.

In the case of work trips, trips involving a walk, feeder bus and kiss'n'ride access modes are considered separately from trips using park'n'ride access. This is because only a limited number of stations have parking available, suggesting that the trip length distribution for park'n'ride trips may be significantly different from the distribution for remaining trips. Table 3-10 presents the mean and variance of trip times for work trips accessed by walk, feeder bus and kiss'n'ride.

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* In the RTD simulation models income is calibrated in 1967 dollars.

** In the case of these and subsequent difference of means tests, significant differences were observed at the 99 percent level of significance.

A series of difference of means tests was again used to determine whether mean trip times were significantly different. The mean trip time for each quintile was found to be significantly greater than the mean for the next lower income group with one exception. The mean for the highest quintile was found to be lower than the mean for the next highest. This result may be due to the relatively high-income residential area in the vicinity of the Crenshaw Station. The mean for the highest quintile was, however, significantly greater than the remaining lower quintiles. Given the small size of the highest income quintile, we may conclude that travelers' income is proportional to trip length for work trips using walk, feeder bus and kiss'n' ride access modes.

Table 3-11 presents trips for park'n'ride work trips for each income quintile. A series of difference of means tests was used to determine significant differences between mean trip times. The mean trip time for each quintile was again found to be significantly greater than the mean for the next lower income group the four lowest quintiles. The mean for the highest quintile, however, was not significantly greater than either the third or fourth income quintile. Because this group represents a relatively small proportion of total trips, we may still conclude that higher income travelers in general make longer trips than lower income travelers.

Under the graduated-fare system, travelers making longer trips pay higher fares than travelers riding short distances. Therefore, the graduated-fare system results in higher income travelers paying higher fares. Under the flat-fare system, travelers of all incomes pay the same fare. Hence, the graduated-fare system is more equitable in terms of payment being related to ability to pay.

TABLE 3-9
METRO RAIL TRIP TIMES BY INCOME GROUP FOR
NON-WORK TRIPS

Income Quintile (annual household income range in 1967 dollars)	Number of Trips	Trip Time (minutes)	
		Mean	Variance
3,957 - 5,305	76,951	6.02	18.59
5,308 - 7,552	49,258	7.32	26.83
7,554 - 8,942	18,842	11.56	63.04
8,953 - 11,306	11,998	12.96	76.78
11,317 - 37,002	12,132	14.73	70.18

TABLE 3-10
METRO RAIL TRIP TIMES BY INCOME GROUP FOR WORK TRIPS USING WALK, FEEDER BUS AND KISS'N'RIDE ACCESS MODES

Income Quintile (annual household income range in 1967 dollars)	Number of Trips	Trip Time (minutes) Mean	Trip Time (minutes) Variance
1,215 - 5,658	51,189	6.37	27.61
5,644 - 7,714	30,290	8.21	49.04
7,720 - 9,427	14,175	10.98	72.87
9,440 - 11,803	8,029	13.19	91.74
11,824 - 37,002	7,736	12.13	85.49

CHAPTER 4

CONCLUSIONS

A barrier fare collection system that is designed to accommodate a flat fare has many cost and operational advantages over a system to accommodate a graduated fare.* The flat-fare system would result in:

- Capital cost savings of 47 percent
- O&M cost savings of 18 percent
- Almost 70 percent fewer failures per day
- Greater convenience to the patron
- Slightly reduced administrative requirements
- Additional annual revenues of $2.0 million for Metro Rail and $17.7 million for the combined bus and rail systems.

The flat-fare structure, however, is less equitable than the graduated-fare structure. The latter system provides for higher payment for greater service as well as higher payment by travelers with greater incomes. The importance of a more equitable fare structure and the value of equity to society is dependent on the goals and objectives of the service provider. Policy-makers should decide how highly equity is valued and how best to achieve this goal. It may be, for example, that inequities associated with a given fare system are better rectified through instruments more directly related to ability to

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* As noted earlier, this analysis relates to the purchase and operation of the initial equipment. If retrofitting the flat-fare system is required, the total cost may be greater than the cost of the graduated-fare system.

pay, such as user subsidies. Therefore, in order to make a final determination of the costs and benefits of the flat-fare and graduated-fare structures, the importance of equity in transit pricing and how to best achieve a standard for equity must first be addressed.