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Baltimore Feeder Bus Planning Study

September 1986

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Final Report
September 1986

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FOREWORD

Planning effective feeder bus services is an important task in the design of a rapid transit line. Many passengers can only access the rail system by bus because many passengers do not live within convenient walking distances and parking is often limited at the stations. The success of the rapid transit line may thus depend on an effective feeder bus network.

The process that was used by the Maryland Mass Transit Administration to design feeder bus services in Baltimore is described in this report. An evaluation of the methods used is made through a comparison of projected and actual results. This type of "before-after" evaluation is rare in transit planning; few transit systems critically evaluate the planning approach that they have used "after-the fact."

This report was funded through the UMTA Section 8 Special Studies Program. It is a good example of current feeder bus planning practices at large transit systems. The type of planning evaluation presented in the report is suggestive of approaches that other systems might consider adopting.

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CHAPTER I

INTRODUCTION

One important task in the planning of a rapid transit line is the design of a feeder bus network which will transport transit riders to the new rail stations. A feeder bus system is a network of buses which collect and carry passengers to, or distribute them from, a specified place where they transfer with another transit vehicle. This hub or transfer point is served by several feeder routes, which all feed into a typically faster transit mode. The success of a rail system depends, to a certain extent, on the ability of the feeder buses to provide an easy method for accessing the rail, since not everyone can walk, and parking spaces are often limited.

One aim of some feeder systems, besides serving existing transit patrons, is to be attractive to auto users such that they will prefer to leave their cars at home, rather than fight the traffic and pay high parking fees at their destination. Such behavior saves money for the commuter, and provides benefits to the community. The individual pays less for gas and auto operation, as well as eliminates parking charges. The community gains by potentially conserving fuel, and reducing road congestion and air pollution. In Baltimore, however, this was not a goal, since the corridor described in this report has transit dependent riders who generally have no choice.

Accompanying the increase in new rail starts throughout the country, is the need to know how to design successful feeder systems to transport riders to the rail stations. To aid other cities interested in developing a feeder bus network, this document outlines the process undertaken by the MTA in designing its system. The Planning Research and Evaluation Division of the Urban Mass Transportation Division (UMTA), U.S. Department of Transportation, is funding this work through a special Section 8 grant. In addition to documenting Baltimore's actions, this report evaluates the success of the planning methods used, by comparing projected and actual results, and makes recommendations for improving the process of planning feeder service.

The following chapters discuss the planning process, evaluate it, and recommend changes. Chapter 2 describes the Baltimore transit system and the Mass Transit Administration (MTA) which operates it. Chapter 3 provides background on the areas served by the feeder bus, explains the planning process, and presents a framework for evaluating the planning results. Chapter 4 evaluates each phase of the planning process, with recommendations for improvements. Chapter 5 summarizes this report's major conclusions on how to improve the feeder bus planning process.

CHAPTER II

PROJECT SETTING

The area involved in the Baltimore Feeder Bus Planning Study is located in the northwest corridor of the city and adjacent Baltimore County (Figure 1). The Mass Transit Administration (MTA), which is responsible for providing transit services to three jurisdictions, Baltimore City, Baltimore County, and Anne Arundel County, managed this project.

These three jurisdictions have a combined population of 1,813,165 and 1,096 square miles of land area (Table 1). Baltimore City has the largest population, 786,775 (43 percent), with the smallest area, 80 square miles. Persons employed in Baltimore City, Baltimore County, and Anne Arundel County total 921,600, with 50 percent of the jobs located in Baltimore City. Of the 458,000 working in the city, 127,000, or 28 percent, are based downtown, the largest employment center in the region. The service area of the four outer rail stations included in the feeder bus planning study has a population of 140,369 and employment of 42,390 on 15.3 square miles of land (Table 1). This area has 18 percent of Baltimore City's population and 9 percent of its employment.[1]

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[1]The city and county statistics are from the 1980 Census, while study area population and employment statistics are based on the RPC Round II Socioeconomic Data (1983). Study area square miles are based on the RPC Technical Memo No. 1 on the Baltimore Region Transportation zones (revised 1981).

FIGURE 1
STUDY AREA MAP

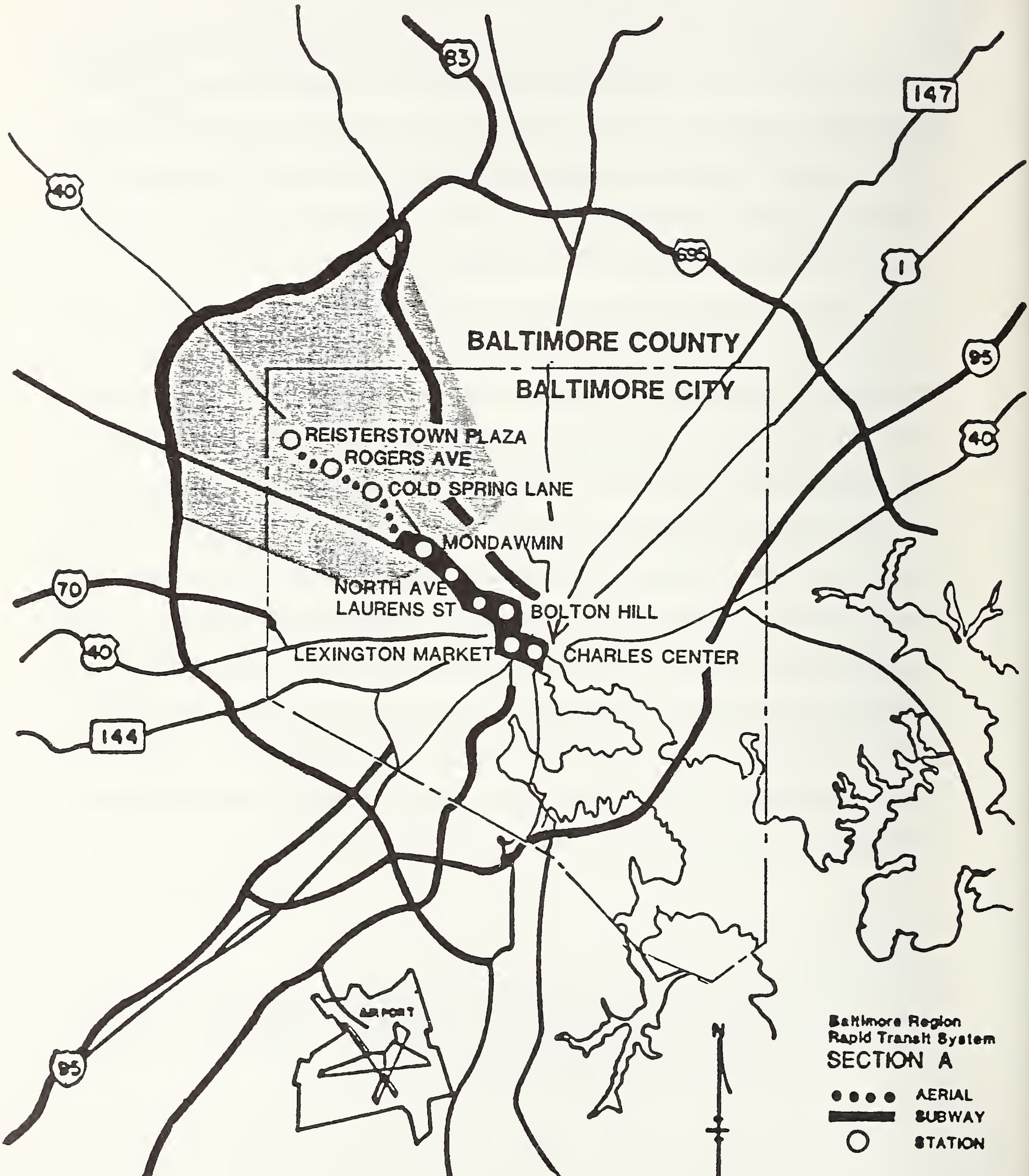

TABLE 1

SOCIOECONOMIC CHARACTERISTICS OF JURISDICTIONS

SERVED BY MTA AND STUDY SERVICE AREA

	Population	Employment	Square Miles
Baltimore City	786,775	458,600	80.34
Baltimore County	655,615	316,300	597.6
Anne Arundel County	370,775	146,700	418.37
TOTAL MTA SERVICE AREA	1,813,165	921,600	1096.31
STUDY SERVICE AREA	140,369	42,390	15.3

Source: 1980 Census

Unlike most other transit authorities, the MTA is part of a State agency, the Maryland Department of Transportation (MDOT). The MTA has responsibility for planning, scheduling, and operating transit service in the Baltimore metropolitan area.

The Planning and Program Development Division within the MTA managed the Feeder Bus Study. Other divisions of MTA which contributed to the study include the Transit Operating Division (TOD), and the Community Relations Department. The TOD analyzes bus operational requirements in terms of vehicles, hours, and drivers, and determines bus schedules. The Community Relations Department coordinates between the MTA and the community. It organized the extensive public participation effort for the Bus Feeder Study.

The Regional Planning Council (RPC), the Metropolitan Planning Organization for the Baltimore region, also participated in the study. Its major role involved development of the mode choice access model used to estimate the percentage of rail patrons who would ride the feeder buses.

During the fiscal year ending in June 1983, MTA carried 74,128,881 annual bus passengers and provided 24,186,999 bus-miles of service. This included a fixed-route demand-responsive van for the elderly. As of August 1983, the MTA employed 1,349 bus and rail operators, 69 street supervisors, and 1,202 administrative and support staff, including employees in planning, engineering, and accounting. The MTA operates a 47 route bus system, plus an eight mile rail rapid transit line with nine stations. The next section of rail to open, will extend the northwest line by six miles and add three stations. The possibility of a two mile, two station rail segment in the northeast part of the city is presently being studied.

CHAPTER III

THE FEEDER BUS PLANNING PROCESS

The planning process conducted by the Mass Transit Administration (MTA) in developing a feeder bus system, is discussed in this chapter. The chapter begins with a statement on the study's purpose and is followed by a description of the study area. In the next section the details of the planning process are explained, including methods used, assumptions, and conclusions.

STUDY PURPOSE

The main purpose of the Feeder Bus Planning Study was to develop a feeder bus network that oriented bus service in the northwest corridor to the new rail stations. In realigning the bus routes, the new system was to be designed so that it met the needs of the community and encouraged ridership. This meant that the level of service (i.e., coverage and trip time) provided to most individuals would be improved or maintained at existing levels. Although an attempt was made to minimize trip time, some riders did experience longer trips with the feeder system.

STUDY AREA

The Feeder Bus Planning Study covers a corridor within the northwest section of Baltimore and adjacent Baltimore County. The first section of the rail system to begin operation extends for eight miles, from downtown Baltimore northwest to just before the Baltimore City/County line. Of the nine stations along this rail line, six are underground and three are above ground. The underground stations are the ones closest to downtown. Extensions are expected to be added to the system in the future.

The goal of the Feeder Bus Study was to develop a feeder network to transport riders to and from the four stations farthest from downtown Baltimore, since the routes in the vicinity of the five inner stations already traveled close enough to the stations so that they could easily be diverted there to drop off and pick up passengers. The Feeder Bus Study therefore involved 24 (out of a system total of 47) existing bus routes which operated in the vicinity of the outer four stations.

Three of the four outer stations serve primarily residential areas. Reisterstown Plaza Station, the station farthest from downtown Baltimore, has surrounding residential neighborhoods with high income and auto ownership, plus a few sections with low income and elderly residents (Table 2). The Rogers Avenue Station, which follows Reisterstown Plaza when heading south towards downtown, also has surrounding residential neighborhoods with high auto ownership and concentrations of low income and elderly persons. The West Cold Spring Lane Station, the next station heading downtown, serves neighborhoods which are primarily medium to high density residential, with some commercial strips and light industry. This area also has a large number of low income and elderly residents. The fourth station, Mondawmin, is the only station which is underground. Its service area includes a mixture of commercial, institutional, parkland, and high-density residential land uses.

TABLE 2

SOCIOECONOMIC SUMMARY

	Reisterstown Plaza	Rogers Ave.	Cold Spring Lane	Mondawmin
Population*	77,000	72,490	43,120	43,790
Elderly**	9,770	7,760	2,610	3,150
Poor**	3,450	7,240	7,460	7,630
Households*	28,400	23,850	13,700	17,960
Automobiles*	44,100	27,960	11,740	15,920
Autos per Household*	1.55	1.17	.86	.89
Labor Force*	38,400	34,180	18,850	20,460
Employment*	24,050	14,470	5,960	10,650
Median Income***	$23,400	$15,530	$13,830	$13,830
Approximate Service Area Size	Up to 6 miles from station	Up to 3 miles from station	Up to 3 miles from station	Up to 3 miles from station

Source: Mass Transit Administration, Planning and Program Development Division, Services Planning Department, Feeder Bus Study Task Report No. 4, <u>Project Patronage Process and Develop Cost Model</u>, June 1981, p. 32.

* Regional Planning Council Round 9 <u>Socioeconomic Data by Transportation Zone</u>, Technical Memo 36, 1975.

** 1970 Census.

***Census Tract Update, 1970-1976.

THE PLANNING PROCESS

A seven-step process was used to design a feeder network that would transport riders to the rail stations, as well as satisfy intra-route travel needs. First a transit patronage survey was conducted to determine ridership, travel patterns, and access modes. Then, a feeder bus service connecting to an express bus route was implemented to test operational concepts and to identify community attitudes. Next, an access mode choice model was developed to estimate the percent of rail riders expected to transfer to or from the bus. The results of the mode choice model and previous rail and bus ridership estimates were used to project feeder bus patronage. After developing models to project patronage and cost, alternative feeder bus routes were evaluated. Then, an alternative was chosen and later revised based on citizen input. The remainder of this chapter will discuss in more detail each step of the planning process.

TRANSIT PATRONAGE STUDY

The Transit Patronage Survey was conducted during May through August of 1978. This planning phase consisted of passenger surveys and ridership counts. The purpose of the survey was to determine existing ridership, and identify travel patterns and socioeconomic characteristics of current transit riders in the northwest corridor. Information learned about ridership, travel patterns, and socioeconomic characteristics was used at a later stage in the planning process to calibrate and validate the patronage model.

Before implementing the survey, four pilot surveys were conducted, to test the wording of the survey questions and passenger willingness to respond to the questions. Each pilot survey differed in wording, questions, layout, the number of surveyors, the option of mailing the survey, the survey hours, and the incentive of a free bus token for returning the survey (Table 3). The MTA did not maintain detailed records of the response rate for each pilot test, but do know that pre-tests without an incentive for survey completion averaged a 40 percent response rate, while availability of an incentive increased the response rate to 55 percent. The final survey questionnaire did not offer an incentive.

The pilot questionnaire chosen for use in the actual survey (Figure 2), was the survey in which respondents best seemed to understand the questions, and were willing to answer them, with the exception of certain socioeconomic questions, such as income. The MTA wanted a survey which encouraged responses to the travel questions, even if a respondent did not wish to answer the more personal socioeconomic questions.

The pilot surveys were a valuable tool in designing the actual survey. The testing of the surveys helped reduce costs and produced more accurate responses. By testing the wording, respondent misinterpretation of questions became evident and revisions made. The pilot surveys also demonstrated the need for two surveyors on each surveyed vehicle, one to pass out questionnaires and the other to count riders. The mailback option and

TABLE 3

SUMMARY OF THE PILOT TESTS

DATE	5/18/78	7/13/78	7/20/78	7/26/78
LINE	#1	#7	#10	#20
SURVEY FORM	Form A	1/2 Form A 1/2 Form B	Form C	Form C
NUMBER OF SURVEYORS	1 per bus	2 per bus	2 per bus	2 per bus
MAILBACK OPTION	yes	yes	no	no
TIME OF DAY	6 AM to 6 PM	6 AM to 9 AM	6 AM to 6 PM	6 AM to 1 PM
DIRECTION	Inbound & Outbound	Inbound	Inbound	Inbound & Outbound
INCENTIVE	No	No	No	1/2 Yes 1/2 No

Source: Mass Transit Administration, Planning and Program Development Division, Services Planning Department, Feeder Bus Study Technical Report No. 1, Transit Patronage Survey, June 1979, p. 3-2.

FIGURE 2

FINAL ON-BOARD SURVEY

MTA BUS SURVEY

1. Where did you come FROM? (check one)

1☐ Your home
2☐ Your workplace
3☐ Your school
4☐ Other (shopping, social, doctor, bank, etc.)

2. What is the address (or building name)?

number ______ street ______ zipcode ______

OR ______
name of building or factory

3. How did you get to this bus? (check one)

1☐ Transferred from Bus Route ______ (fill in number)
2☐ Walked only
3☐ Drove car
4☐ Rode in car
5☐ Other (taxi, bike, etc.)

4. What is your destination?

1☐ Your home
2☐ Your workplace
3☐ Your school
4☐ Other (shopping, social, doctor, bank, etc.)

5. What is the address (OR building name)?

number ______ street ______ zipcode ______

OR ______
name of building or factory

6. How will you get to your destination from this bus?

1☐ Transfer to Bus Route ______ (fill in number)
2☐ Walk only
3☐ Drive car
4☐ Ride in car
5☐ Other (taxi, bike, etc.)

7. What time did you leave home today? 1☐ (time) ☐AM ☐PM

What time will you arrive home today? 2☐ (time) ☐AM ☐PM

TELL US SOMETHING ABOUT YOURSELF... Your response will help us determine if others will use new bus services.

8. How many times a week do you make this trip? (check one)

☐Seldom ☐1 ☐2-4 ☐5 ☐More than 5

9. Was a car available to you for this trip? 1☐YES 2☐NO

10. Do you have a driver's license? 1☐YES 2☐NO

11. How did you pay your bus fare?

1☐ CASH in farebox
2☐ Ordinary MTA TOKEN
3☐ Special Senior Citizen or Handicapped TOKEN
4☐ MTA Monthly PASS
5☐ Student Ticket

12. In what YEAR were you born? 19__

13. Are you: 1☐Female 2☐Male

14. What is your total family income? (check one)

1☐ below $3,000
2☐ between $3,001 & $6,000
3☐ between $6,001 & $10,000
4☐ between $10,001 & $15,000
5☐ between $15,001 & $20,000
6☐ between $20,001 & $25,000
7☐ over $25,000

Source: Mass Transit Administration, Planning and Program Development Division, Services Planning Department, Feeder Bus Study Technical Report No Transit Patronage Survey, Jun 1979, p. 3-3.

the incentive of a free bus token did not significantly increase the survey response rate, and therefore were not included in the actual survey.

The actual survey occurred during 10 days of August 1978. Passengers on 14 routes between the hours of 6 a.m. to 1 p.m. received printed survey questionnaires while on board the bus. MTA would have preferred to survey for an entire day, but were restricted to a half day due to cost. Out of approximately 1,160 MTA daily bus trips during the survey hours, about 860 trips were surveyed, or 74 percent. Approximately 13,600 usable surveys were returned from the 38,300 patrons who boarded the surveyed buses, a 36 percent response rate. MTA estimates that this equaled 28 percent of all daily transit passengers traveling in the northwest corridor between 6 a.m. and 1 p.m. For each trip not selected, at least one scheduled trip with similar characteristics, such as direction of service, time of trip, type of service (regular or express), and similarity in location was identified. Then the survey results from the similar surveyed trip were also attributed to the non-surveyed trip.

In addition to the surveying effort, two types of ridership counts were made: on-off counts and point counts. On-off ridership counts track the number of passengers who get on and off the bus at each stop, as well as total number of passengers on the vehicle between stops. Point counts are a type of ridership count that records the number of passengers on each bus that passes by a particular point. While on-off counts were made by the surveyors physically in the bus, point counts were taken by individuals on the street, and had a dual purpose. First, they provided a check of the on-off counts at that point, and secondly, provided ridership estimates for those buses passing by which were not surveyed. These estimates of unsurveyed buses were used to project the ridership of unsurveyed trips.

The data from the on-off ridership counts were used to estimate the response rate. Survey cards were serialized, and the surveyors noted the serial numbers of the questionnaires distributed aboard each bus trip, in order to later determine the number of returns per bus trip.

Based on the proportion of surveys returned, the results of the survey questionnaires were factored to represent total transit travel in the northwest corridor during the period of the survey (6 a.m. to 1 p.m). The factoring accounted for both those riders who were on a surveyed trip but did not return a usable survey, and those who did not take a surveyed trip.

Attempts were made to reduce possible factoring biases. To this end, surveys were aggregated according to trip characteristics: bus route segment, type of service (regular or express), inbound or outbound, and time of day based on two hour intervals. An expansion factor for each ridership group was calculated from:

$$\frac{\text{number of patrons boarding}}{\text{number of usable surveys returned by these patrons}}$$

This group factor was applied to each questionnaire in the group, to estimate a trip table of passengers on surveyed trips.

An expansion factor was also derived for patrons on unsurveyed buses. Both surveyed and non-surveyed bus trips which operated during the survey time, between 6 a.m. and 1 p.m., were categorized by: bus route, type of service (regular or express), inbound or outbound, and time of day based on two hour intervals. The expansion factor was calculated by:

$$\frac{\text{total passenger loads observed for all bus trips}}{\text{total passenger loads observed for surveyed bus trips}}$$

Appropriate group factors were applied to each questionnaire, resulting in travel and socioeconomic characteristics for all riders in the northwest corridor from 6 a.m. to 1 p.m.

The information derived from the survey included: trip origin and destination, mode used to access and egress from the bus, trip purpose, trip frequency, travel time, and demographic information. The major characteristics of northwest corridor transit patrons as identified through the survey were:

- more than one-half were under 30 years old,
- 60 percent were female,
- more than 50 percent had family incomes below $10,000 per year,
- 57 percent did not have a driver's license, and
- 20 percent indicated that a car was available for the trip.

Furthermore, the key characteristics of morning peak period transit travel patterns in the corridor were identified:

- 86 percent of the trips were work-related,
- 60 percent of the riders walked to the bus,
- one-third of the riders transferred from another bus,

- 60 percent of the passengers paid the fare with cash; one-third used a monthly pass,

- 60 percent of trips were in the inbound direction, and

- 40 percent of the morning peak trips were on the three major radial lines serving the corridor, bus numbers 5,7, and 28.[2]

This survey also provided guidance for designing the alternative feeder bus systems. Major conclusions were:

- The feeder bus system should perform both collection and distribution functions.

- The number of existing riders who make short distance inbound trips and would have to transfer twice, from bus to rail to bus, should be minimized.

- To prevent additional transfers for crosstown bus passengers, crosstown routes should not be terminated at a station, but should continue past the station to the existing terminus.

FEEDER BUS DEMONSTRATION

The next step in the planning process was the conduct of a feeder bus demonstration project. The project involved implementing new feeder bus service that carried patrons from home or work, to a point where they could transfer to an express bus traveling directly downtown. Overall, this demonstration was unsuccessful, due to low feeder bus patronage which averaged less than one rider per trip. Since the MTA lacked experience in operating feeder services, the main objective of the feeder service demonstration was to gain experience and insights that

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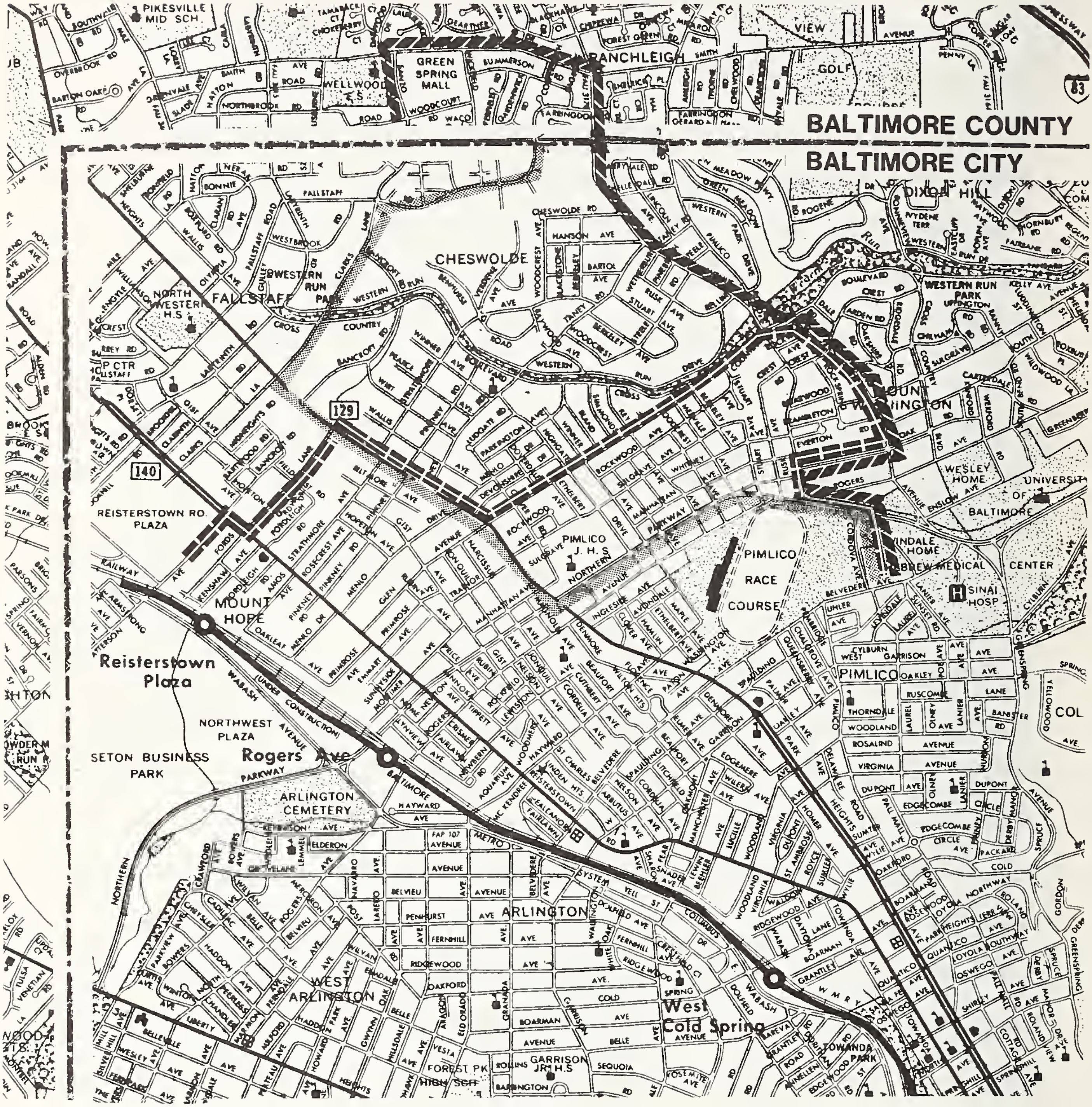
[2] Mass Transit Administration, Planning and Program Development Division, Services Planning Department, Feeder Bus Study Technical Report No. 1, Transit Patronage Survey, June 1979, p.1-1.

would be valuable to their later implementation of feeder bus service to rail stations. In addition, the MTA hoped to learn about the desirable characteristics of a feeder route, and user and community reaction to it.

Another purpose of the demonstration was to provide a data base to validate the patronage estimates from the travel demand forecasting models. The MTA wanted to compare the model results with the observed travel behavior from the feeder service demonstration to test reasonableness of the model estimates.

Since MTA wanted the feeder demonstration to replicate as closely as possible conditions of the future feeder bus service, sites considered for the demonstration were located in the same vicinity as the rail line. One existing express bus route, No. 24: The Pimlico Park and Ride Express, was chosen as the closest representation to the future rail line. Three new feeder routes, shown in Figure 3, were designed to carry passengers who would transfer to the express bus. All the feeder routes were within a three mile radius of one express bus stop, in order to limit feeder trips to 15 minutes or less. The fare for the feeder to express bus trip was identical to the fare paid for regular bus to express bus trips. Each of the three routes made 13 trips daily in the peak flow direction during the morning and afternoon rush hours through neighborhoods without existing bus service. To minimize wait time, feeder buses were scheduled

FIGURE 3
Three Feeder Bus Demonstration Routes



KEY:

- Reisterstown Road Plaza Route
- Ranchleigh Route
- Fallstaff Route
- Rail Station

to arrive within five minutes of an express bus departure. While the feeders arrived every 15 minutes, the express bus left every 5 to 15 minutes during the rush hours. In addition to the new feeder routes, a few existing bus routes also carried passengers to the same stop to transfer to this express bus.

The factors considered in choosing the selected site included: parking availability, the size of the "choice" rider market (those who have cars available), ease of implementation, travel time between the site and downtown Baltimore, number of bus shelters on the site, site access points suitable for buses, proximity to rail stations, and area land use. The MTA sought community input on the selection of the feeder demonstration routes. Community groups and elected officials were contacted. Community reaction was limited, but on the whole, favorable.

Two media campaigns were conducted to inform the community about the feeder service and to encourage their patronage. The initial campaign, which began just before service initiation in October 1979, consisted of mailing brochures to 12,300 homes and businesses within the feeder service area, inserting full-page newspaper advertisements, placing brochures on the 300 cars in the express bus parking lot, and distributing brochures to the existing express bus passengers. Four months later, in February 1979, the second media campaign was conducted. A newly designed postcard was mailed to the same households and businesses as previously, and again left on cars parked in the express bus parking lot. In addition, advertisements were placed in different newspapers than previously.

The effectiveness of these marketing strategies was tested by the responses to a community survey. A random survey of households in the service area was conducted by telephone, resulting in 262 interviews (10 percent of those contacted) with adults who commute either downtown or to the Hopkins Hospital area. The following conclusions on community awareness of the feeder service were derived from the survey:

- About 40 to 45 percent of the market had heard of the feeder bus service, compared with about 95 percent who had heard of the No. 24 line (the Pimlico Park and Ride express).

- Only one out of every three auto users had heard of the feeder service.

- Of the forms of publicity used to promote the service, the brochure mailed to residences was recalled most often as a source of knowledge; about 20 percent of the target group mentioned learning about the service from the brochure.

- A very small proportion of the market, about 10 percent, recalled any knowledge of the routes. Even fewer recalled the schedules.

Additional information was collected through another community survey, a passenger survey, and patronage counts to determine community reaction to the feeder bus service, and ways to improve it. MTA conducted the second random community survey by phone of commuters to the downtown area who live within a quarter mile of the feeder routes, to learn why they do or do not use feeder service. From the 2,490 households contacted, 212 interviews resulted (9 percent response rate).

A survey of feeder bus patrons was conducted to learn their travel behavior, their reason for riding the feeder bus, and their perceptions of the service. The names and telephone numbers of riders were collected while they transferred between buses, so that a surveyor could contact them at home. Seventy-six names were collected, resulting in 61 interviews. This method was successfully pre-tested before actual use.

The community and patronage surveys indicated that feeder bus users were:

- more likely than non-users to be women, employed in clerical professions, and members of households with one or no cars;
- valued convenience, such as proximity to the bus route, more than non-users; and
- valued time less than non-users.

The MTA counted ridership on the feeder buses approximately twice a week. During the demonstration, ridership was low, ranging from a total of 15 to 50 daily passengers on 36 bus trips. By the end, approximately 20 patrons daily were using the service, averaging less than one rider per bus trip. Due to such low ridership levels, the service was terminated after six months.

The insights gained from all facets of the feeder bus demonstration indicate that the desirable service characteristics for feeder service are the same as those for line-haul service. These service characteristics are:

- <u>Coverage</u> - A key factor in selecting feeder service was residential or employment proximity to the route. In designing alternative feeder plans, coverage should be maximized.

- Service Reliability - Service reliability is one of the most important factors influencing the acceptance of feeder service.

- Frequency - The frequency of service does not appear to influence the decision to use feeder service as long as the service is reliable. When designing feeder alternatives, resources (i.e., vehicles and operators) which might have been used to increase frequency should be assigned instead to maximize coverage and assure service reliability.

- All Day Service - Flexibility in arrival and departure times is an important determinant in the selection of a mode. Therefore, all-day service should be scheduled.

- Fare - The cost of the trip was not considered an important factor, as long as it remained within reasonable bounds.

- Fare Payment Method - Patrons are interested in having an easy method of fare payment, such as the monthly pass program.

- Communication - One problem during the demonstration involved the communication of route and schedule information to potential users. Dissemination of service information becomes particularly important if the recommendation for low frequency and high coverage service is implemented. In developing the routes and operating plan, consideration must be given to reducing the complexity of routes and schedules.

- Auto Disincentives - The results of the demonstration indicate that the implementation of disincentives for using the automobile, such as limiting the number of downtown parking spaces used for all-day parking, may be necessary for feeder service patronage to reach desired levels.[3]

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[3]Mass Transit Administration, Planning and Program Development Division, Services Planning Department, Feeder Bus Study Technical Report No.2, Bus Feeder Demonstration, June 1979, p.iii.

ACCESS MODE CHOICE MODEL

The next stage in the study involved the development of a station access mode choice model. This model estimates the percentage of rail riders who will walk, drive, be driven, or take the feeder bus, to get to or from the rail station. The Regional Planning Council (RPC) developed the access mode choice model for MTA use in this study.

The scope of this effort was limited by two factors. First, the timing and the budget of the study did not allow development of an original, comprehensive model. As a result, the methodology developed does not specifically address the issues of station choice or the impact of feeder services on line-haul patronage. Second, a local data base representing actual use of feeder services was not available. Although data were available from the demonstration feeder service, patronage was too low to be useful for model calibration purposes.

After reviewing available models, three were studied more closely for their applicability in estimating mode choice to and from Baltimore rail stations: the Baltimore model, the Cleveland model, and the Chicago model. Tables 4 through 6 present the purpose, coefficients estimated, and access modes included, for each of these models. RPC chose to use the Cleveland model with adjustments (Table 7), to determine the distribution of access modes used to get to the Baltimore rail stations.

TABLE 4

CLEVELAND MODEL

Application Purpose: Sub-model within overall mode split model chain

Structure: Logit (multinomial)

Modes: Walk, Park/Ride, Kiss/Ride, Bus

$$P_i = \frac{e^{G(x)_i}}{\sum_{j=1}^{n} e^{G(x)_j}}$$

where,

P_i = probability of choosing mode i (walk, bus, park/ride, kiss/ride)

$G(x)_{walk}$ = -.2 (WDIST/WSPEED)

WDIST = distance to station (miles)
WSPEED = walking speed (3 mph)

$G(x)_{bus}$ = -.2 (WDIST/WSPEED) -.2 (WAITB) -.08 (BIVT) - .026 (FARE)

WDIST = distance to station (miles)
WSPEED = walking speed (3 mph)
WAITB = wait time for bus
BIVT = in-vehicle time on bus
FARE = bus fare

$G(x)_{P/R}$ = -2.42 - .2 (WDIST/WSPEED) - .026 (1/2*PCOST + OCOST) - .08 (PRIVT)

WDIST = distance from parking lot to station (miles)
WSPEED = walking speed (3 mph)
PCOST = parking cost
OCOST = operating costs (cents/mile)
PRIVT = in-vehicle time

$G(x)_{K/R}$ = -2.32 - .026 (OCOST) - .08 (KRIVT)

OCOST = round trip operating costs (cents/mile)
KRIVT = in-vehicle time including the one-way trip for the passenger and one-way trip of the driver

Source: Regional Planning Council Report, Transportation Technical Memorandum 38, Development of a Station Access Mode Choice Model, January 1980, p. 7 and p. Al.

TABLE 5

ILLINOIS MODEL

Application Purpose: Chicago area feeder bus model

Structure: Logit (binary)

Modes: Auto Composite, Bus

$$P_{bus} = \frac{e^{G(x)}}{1 + e^{G(x)}}$$

$$P_{auto} = 1 - P_{bus}$$

where,

P_{bus}, P_{auto} = probability of choosing bus or auto access mode

$$G(x) = 2.5 - .0012\ (TIMDIF) - .0317\ (CSTDIF) - .0455\ (DTSTOP) - .0006\ (BSFREQ)$$

TIMDIF = total origin to station travel time difference between modes (bus minus auto in seconds)

CSTDIF = bus fare minus auto operating cost including parking (cents)

DTSTOP = distance from trip origin to nearest feeder bus stop (hundred feed)

BSFREQ = headway between feeder buses (seconds)

Source: Regional Planning Council Report, Transportation Technical Memorandum 38, Development of a Station Access Mode Choice Model January 1980, p. 7 and p. A2.

TABLE 6

BALTIMORE MODEL

Application Purpose: Zone-level line-haul mode split model (peak work)

Structure: Disutility curves stratified by purpose, income, and parking cost.

Modes: Auto, bus

$P_{transit}$ = f(Equivalent Time Difference, Out of Pocket Cost, Purpose, Income, Parking Cost)

$P_{auto} = 1 - P_{transit}$

where,

Equivalent Time Difference = (Transit Run Time - Highway Run Time) + 2.12 (Transit Excess Time - Highway Excess Time) + 20

Transit Run Time = time spent riding on transit vehicle

Highway Run Time = time spent driving or riding in auto

Transit Excess Time = time spent walking to bus stop; waiting; and transferring, if necessary

Highway Excess Time = time spent walking to vehicle and parking time at destination

Out of Pocket Cost = Transit Fare - Auto Operating Cost

Source: Regional Planning Council Report, Transportation Technical Memorandum 38, Development of a Station Access Mode Choice Model. January 1980, p. 7 and p. A3.

TABLE 7

MODIFIED CLEVELAND MODEL

$$P_i = \frac{e^{G(x)i}}{\sum_{j=1}^{n} e^{G(x)j}}$$

where,

P_i = probability of choosing mode i (walk, bus, park/ride, kiss/ride)

$G(x)_{walk}$ = -1-.2 (WDIST/WSPEED)

WDIST = distance to station (miles)
WSPEED = walking speed (3 mph)

$G(x)_{bus}$ = -1-.2 (WDIST/WSPEED) - .2 (WAITB) -.08 (BIVT) - .026 (FARE)

WDIST = distance to stop (miles)
WSPEED = walking speed (3 mph)
WAITB = wait time for bus
BIVT = in-vehicle time on bus
FARE = bus fare

$G(x)_{P/R}$ = -2.42 - .2 (WDIST/WSPEED) - .026 (1/2*PCOST + OCOST) -.08 (PRIVT)

WDIST =distance from parking lot to station (miles)
WSPEED = walking speed (3 mph)
PCOST = parking cost
OCOST = operating costs (cents/mile)
PRIVT = in-vehicle time

$G(x)_{K/R}$ = -3.6 - .026 (OCOST) - .08 (KRIVT)

OCOST = round trip operating costs (cents/mile)
KRIVT = in-vehicle time including the one way trip for the passenger and the two-way trip of the driver

Source: Regional Planning Council Report, Transportation Technical Memorandum 38, Development of a Station Access Mode Choice Model, January 1980, p. 20.

Of the three models, the Cleveland model presented the best choice, since it provides the largest differentiation of modes: walk, park and ride, kiss and ride, and bus. The other models combine the two auto modes, park and ride, and kiss and ride, and do not include a walk mode.

The following assumptions are implicit in the use of the Cleveland model:

- o the relative value of the coefficients hold for Baltimore's northwest corridor, and
- o the distribution of socioeconomic characteristics in the Cleveland sample is similar to the area around each rail station.

RPC made adjustments to the Cleveland model in an attempt to produce a more accurate measure of future access mode behavior. The adjustments were based on three sources of local information:

- o the northwest corridor patronage survey previously undertaken as part of the Feeder Bus Planning Study,
- o a survey of Baltimore area park and ride lot patrons, and
- o the Baltimore access mode choice model which was considered, but not chosen for use in this study.

Data from the northwest corridor patronage survey were used to make adjustments, since it included information on passenger access modes. The parking lot survey of six MTA park and ride lots was conducted to determine the distribution between those who drove and parked, versus those who were dropped off. The results were compared to those of the Cleveland model, resulting in changes to the model parameters to reflect Baltimore circumstances. It was determined that kiss and ride and walk trips were overestimated under the Cleveland model, based on actual Baltimore survey results, necessitating an adjustment in these parameters. In addition, the mode split between auto and bus was compared between the Baltimore and Cleveland models. Since the Baltimore model had an income variable, adjustments based on the comparison reflect mode choice as influenced by socio-economic characteristics of Baltimore residents. Table 7 presents the equation from the modified Cleveland model used to estimate access mode choice.

To test this equation, the model was used to estimate the distribution of access modes for one of the Baltimore rail stations. The results seemed reasonable, and thereby inspired confidence in the model.

PATRONAGE ESTIMATION MODEL

The next planning phase involved the development of a model to estimate patronage. The inputs to the model included:

- socioeconomic estimates developed by RPC in conjunction with local jurisdictions,
- a transit network and fare structure comparable to that existing in 1978 with the addition of the rail line, and
- a highway network which included all road improvements scheduled to be completed by 1982.

A three step process was used to construct the patronage model. First, two transit trip tables (showing trip origins and destinations) were developed to project 1982 trips, based on 1978 conditions, one for bus patrons transferring to or from the rail, and the other for bus-only passengers. The Regional Planning Council's (RPC) computer models produced the travel simulations for the trip tables. To produce travel simulations for 1982 (the year the feeder bus system was expected to begin operation at the time of the analysis), model inputs included socioeconomic data, the highway network, and the transit network for 1978 and 1982. A different transit network was used for each feeder bus network alternative.

Then, an estimate was made of the percentage of rail passengers expected to use feeder bus from each transportation zone. The percentages derived from the RPC access mode choice model developed in the last phase, were applied to the trip table to project rail patrons using feeder bus by zone.

The final step in the process was the allocation of estimated trips to specific bus routes. Two types of transit passenger trips were assigned to routes:

- o trips in which both a bus and a rail line are used, and
- o trips in which the bus only is used.

For the bus-rail trips, the allocation to routes was a detailed, manual procedure using the modified Cleveland model. The MTA estimated by zone the proportion of trips which a route was likely to attract. Once the proportions were determined for each route, and the total number of projected feeder bus patrons was estimated by zone, individual route ridership could be calculated. The bus-only trips were allocated among routes by an Urban Transportation Planning Systems (UTPS) computer program called ULOAD, which assigns zone to zone transit trips to alternative transit routes. It was not possible to use ULOAD or any other computerized program to allocate bus-rail trips, because it could not provide the required detail on mode of access--the number who would walk, park/ride, kiss/ride, or take the bus to access the feeder routes. This type of information was not needed for the bus only trips, which used ULOAD in order to minimize the time and cost of the procedure.

To validate the model developed to estimate bus ridership, the 1978 transit simulation was compared with the Northwest Corridor Patronage Survey results, one of the first tasks undertaken in the Feeder Bus Planning Study. Although the comparison indicated that the model projected the number of regional transit trips fairly well (overestimated by 11 percent), the comparison of the number of trip origins and destinations by zone showed a large range of discrepancy (from none to 600 percent). To adjust the model to reflect actual conditions better, factors were developed for each zone and were applied to work and non-work trips, and origins and destinations separately. The adjustment factors were calculated by taking the ratio of survey to model simulated trips by zone for work origins, non-work origins, work destinations and non-work destinations. This resulted in a model compatible with the northwest corridor survey results.

COST MODEL

The next task in the Feeder Bus Planning Study involved construction of a cost model to be used to compare the operating costs of the different alternatives. The cost model estimated the number of vehicles and the hours of operation which would be required to operate each alternative system in the weekday morning three-hour peak period.

Because the service could not be scheduled at that time, upper and lower bounds were estimated to give a range of the likely vehicle and hour requirements. Cost estimates were then obtained by applying the current system average cost per vehicle hour to the estimates of total vehicle hours for each alternative.

The cost model made the following assumptions:

- o the passenger arrival rate at the peak-of-the-peak was 1.5 times the average peak arrival rate, and lasted one-half hour;
- o the maximum headway (interval between buses) was 30 minutes;
- o standard-sized buses with a 51 passenger seating capacity were used;
- o average operating speeds are 12, 15, or 18 miles per hour, depending on the location;
- o all morning peak routes would spend deadhead time traveling from the northwest Bus Maintenance Center to the rail stations, where they would begin passenger service;
- o costs were estimated for two types of scheduling situations: complete interlining of trips (a driver and vehicle cover a combination of routes in order to reduce layover time to a minimum) and no interlining of trips (resulting in longer layover times and therefore a need for more vehicles); and
- o total operating costs were proportional to vehicle hours of operation.

ALTERNATIVE FEEDER NETWORK

The next step in the planning process of the Baltimore Feeder Bus Study was to develop alternative feeder networks to the four outer rail stations. After constructing each set of bus routes, the MTA compared the alternatives in terms of patronage, productivity (passengers per route mile), and cost. Then, based on the comparisons, one alternative was chosen for presentation to the MTA Executive Committee and community groups. Community comments on the selected alternative resulted in a revised recommended alternative (Alternative D-1).

Initially three bus alternatives were constructed. Of the three, Alternative A provided the lowest level of service, slightly less service than what was then being provided. Alternative B restructured routes to the rail line, and added service in some areas. Alternative C provided a higher level of service than the other two, by extending coverage so that most residents would have no more than an 1/8th mile walk, which would take the average person approximately 2 1/2 minutes. After initial analysis of the alternatives, some adjustments were made to overcome perceived shortcomings, resulting in Alternative D. It provided more coverage than Alternative A, but less than B or C. After formulation of Alternative D, all four sets of bus routes were evaluated and compared to determine which had the superior performance measures. Alternative D was selected as the best alternative. A description of each alternative is provided in more detail in the following paragraphs.

In Alternative A, existing bus service was realigned to serve stations close to the route. A bus line was diverted to serve a station only when its route was within a short distance of the station, and it could be diverted with minimum impact on the functioning of the line. The routes continued to serve the same area as previously, and operation of buses was primarily limited to those streets currently served. Passenger trip times were expected to increase slightly, because of the additional time required to serve the stations.

In Alternative B, route configurations were altered to maximize the use of the rail line. Bus routes which paralleled the rail line were eliminated so that the route structure assumed the form of circumferential, or feeder, service.

Alternative C extended coverage, where physically feasible, to provide service within an one-eighth mile walk of most households. The policy to increase coverage was based on the experience of other systems, and the results of the feeder bus demonstration which showed that, in order to maximize patronage, more preference in bus route design should be given to area coverage than frequency of service. To provide this denser coverage, the use of smaller vehicles was assumed for narrow residential streets.

Alternative D evolved after preliminary analysis of the first three alternatives. With this alternative, 75% of the service area population was within 1/4 mile of bus service, and the routes were situated only on streets which were capable of accommodating a full-sized bus.

After the four networks were developed and the alternative feeder bus routes were specified for testing, the alternatives were evaluated. To evaluate how each feeder bus route performed, two basic criteria were established:

Rail Patronage:	The estimated number of rail patrons expected to use feeder bus routes during the morning peak period to travel to or from a rail station in the corridor.
Productivity:	The ratio of the estimated number of peak period inbound rail patrons using a particular feeder route to the number of route miles covered by that route.

Patronage for each alternative was derived using the modified Cleveland access mode choice model. The MTA based ridership estimates on a.m. peak period inbound (toward rail) patronage, and then assumed the p.m. peak was the exact reverse.

The evaluation of the four alternatives indicated that B and C would carry the most riders, followed by Alternative D, and then Alternative A with the fewest rail passengers (Table 8). However, in terms of productivity, rail patrons per bus mile, Alternatives B and D exceeded Alternatives A and C. Alternative D was selected over Alternative B, despite its higher patronage, because Alternative B required that MTA obtain smaller buses to maneuver the side streets. Since Alternative D only included major thoroughfares, it was not necessary to purchase a new type of bus.

When Alternative D was presented to the public at numerous community meetings, those attending suggested minor improvements to the plan, which were then incorporated into a fifth alternative called D-1 (Alternative D with adjustments suggested by the community). Table 8 shows Alternative D-1 (Figure 4) to be the most productive of the five alternatives, approximately 1,000 more a.m. riders with the least extensive system in terms of one-

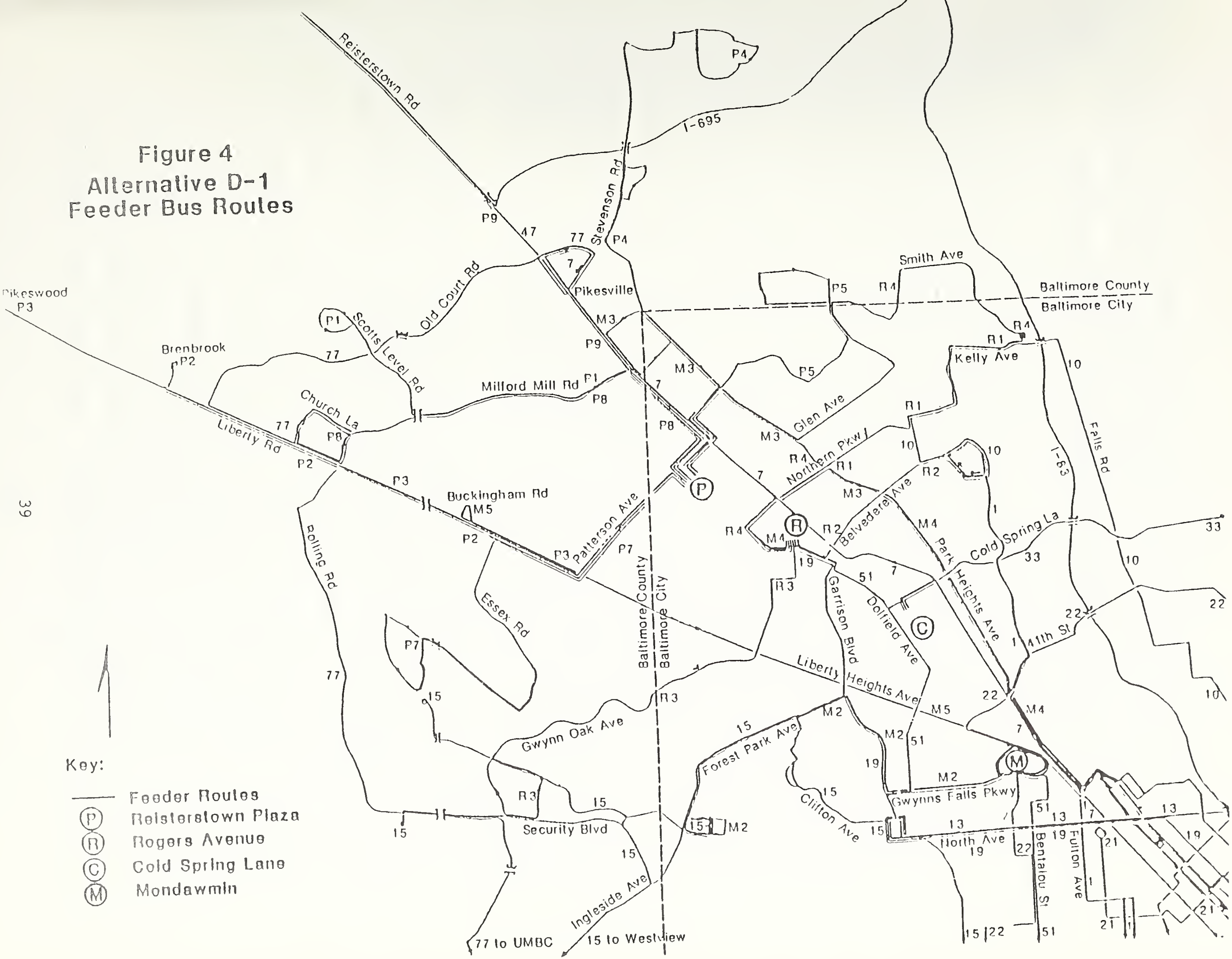
TABLE 8

ALTERNATIVE FEEDER BUS SYSTEMS

	One-Way Route Miles	Bus To Rail Passengers (Inbound)	Passengers Per Route Mile (Inbound)
Alternative A*	142	3115	22
Alternative B*	128	3702	29
Alternative C*	157	3761	24
Alternative D*	127	3444	27
Alternative D1**	126	4427	35

*Estimates based on 1978 data.
**Estimates based on 1982 data.

Figure 4
Alternative D-1
Feeder Bus Routes



Key:

- Feeder Routes
- (P) Reisterstown Plaza
- (R) Rogers Avenue
- (C) Cold Spring Lane
- (M) Mondawmin

way route miles. This may be partly attributable to the recommendations received at the public meetings, and partly due to the availability of more recent data for the projections.

COMMUNITY MEETINGS

After MTA staff selection of Alternative D, and its acceptance by the Executive Committee, MTA held community meetings to present this alternative and receive community feedback. Based on comments received from the community, MTA made minor adjustments to Alternative D, and called the modified feeder system Alternative D-1. In September 1982, the MTA Executive Committee approved Alternative D-1 as the planned feeder bus system. Alternative D-1 was expected to maintain or improve the level of service (coverage and travel time) presently provided in the corridor, while adding coverage in some areas. Buses paralleling the rail route would be eliminated, including the express buses, while some crosstown routes would remain unchanged.

Extensive community involvement had occurred throughout the process of route development. At the beginning of the planning process, MTA invited representatives of approximately 20 of the largest community umbrella organizations to attend a meeting concerning the planning of feeder bus routes. Approximately 25 community leaders from within the feeder service area chose to attend. Following this meeting, MTA developed four community Feeder Bus Task Forces, each headed by a community chairperson. The task force chairperson mediated between the community and the MTA Community Relations Department. In turn, the Community

Relations Department coordinated between the Task Force Chairpersons and MTA technical staff.

The Task Force Committees and the MTA Community Relations Department jointly selected sites for community meetings. Over 67 public meetings occurred, involving over 300 community organizations, with the task force chairpersons, community leaders, conducting the meetings. MTA staff attended the meetings to make presentations, provide necessary support, and note community concerns and suggestions. In addition to holding meetings, MTA mailed periodic newsletters to over a thousand individuals, predominantly those who had attended meetings, to keep them informed of the status of the feeder bus planning process.

The first of the meetings took place in the Fall of 1981, and continued until the Summer of 1983. Three meetings, during different stages of the planning process, were held at each site. The first two meetings involved community input of ideas, while the third one discussed the alternative selected by MTA, alternative D. As a result of the latter set of meetings, Alternative D was revised, resulting in Alternative D-1. Public hearings on Alternative D-1 were conducted during the Fall of 1983.

CHAPTER IV

EVALUATION OF THE FEEDER BUS PLANNING PROCESS

INTRODUCTION

This chapter begins by comparing the planned feeder bus system (Alternative D-1) with what was actually implemented. Then it evaluates the accuracy of the 1982 patronage, cost, and revenue projections with actual observations in May 1985, after sufficient time had passed for the system to build up its ridership levels. The remainder of the chapter evaluates the seven planning phases described in Chapter III, including approximate staff time spent to complete each task and recommendations on how to improve the process. The entire planning process cost the MTA approximately $200,000.

COMPARISON BETWEEN THE PLANNED AND IMPLEMENTED SYSTEM

The Baltimore feeder bus planning process concluded in December 1983. In June 1984, when the feeder bus system was implemented, the actual system was slightly different from Alternative D-1 (Figure 5). However, the implemented system and Alternative D-1 are similar in terms of coverage and the level of service provided (Table 9). The implemented system is 1.2 one-way route miles shorter (less than 1 percent) than the planned system, 127.2 versus 128.4 one-way route miles, with approximately 17 percent fewer vehicle miles of travel during the three-hour a.m. peak than the estimated system.

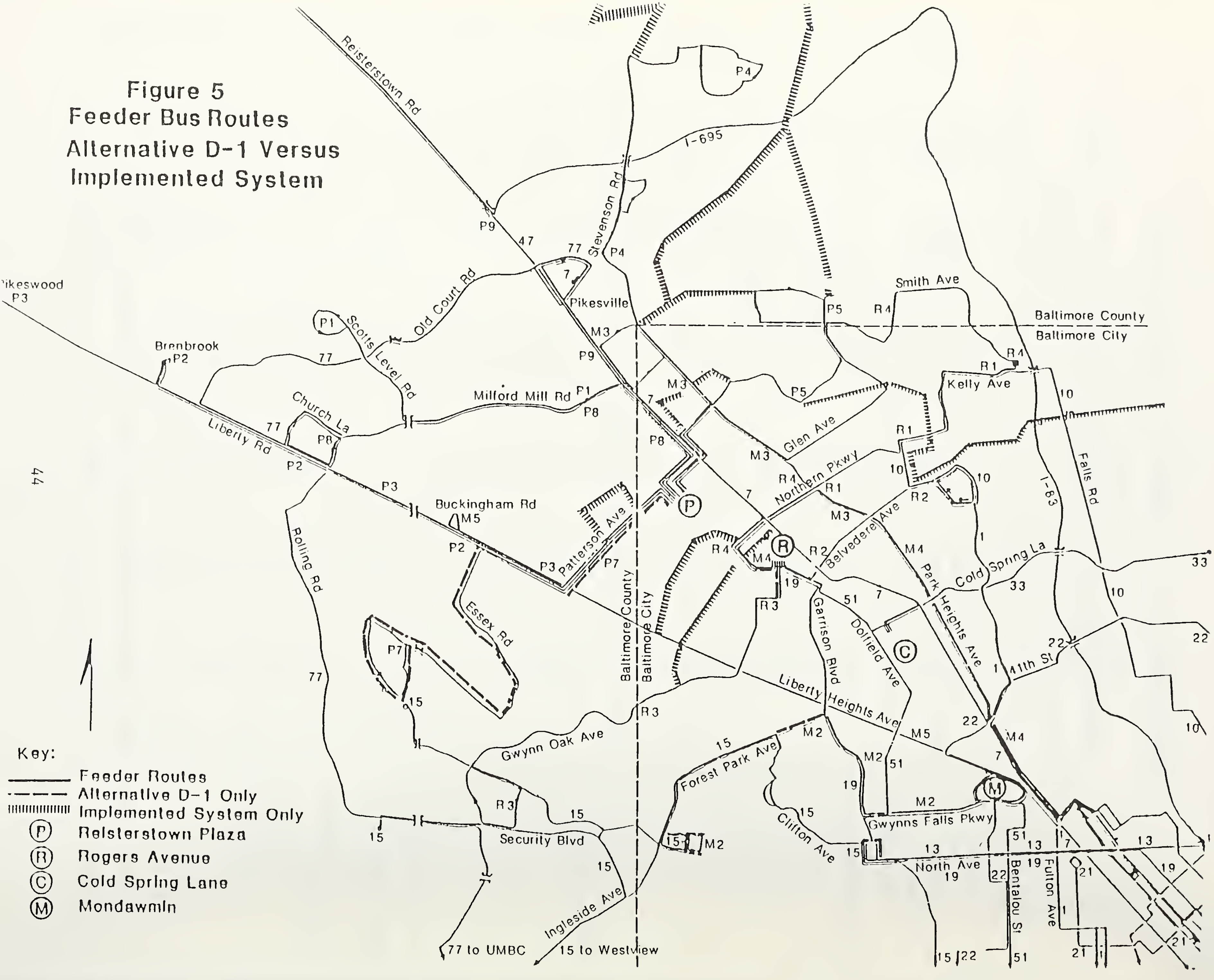
The difference in headways between the two systems are less than eight minutes for each route segment, with one exception. This does not apply to the six Alternative D-1 routes eliminated

TABLE 9

COMPARISON OF PLANNED VERSUS ACTUAL
ONE-WAY ROUTE MILES, HEADWAYS, AND IN-SERVICE
VEHICLE MILES OF TRAVEL BY ROUTE

Rail Station Served	ALTERNATIVE (D-1) Route #	One-Way Route Miles	AM Peak Head-Ways	6-9 AM VMT	ACTUAL Route #	One-Way Route Miles	AM Peak Head-Ways	6-9 AM VMT
Reisterstown Plaza	P-1	4.9	30	59	P-6	4.6	36	46
	P-2	5.3	30	64	ELIMINATED		--	--
	P-3	6.8	15	163	(SEE R-4)		--	--
	P-4	6.4	40	58	P-5	6.4	40	58
	P-5	4.5	30	54	P-7	4.7	23	74
	P-6	6.4	30	77	(SEE R-2)		--	--
	P-7	6.4	30	77	ELIMINATED		--	--
	P-8	5.3	30	64	P-6	4.8	36	48
	P-9	12.5	15	300	P-1	13.0	14	334
	--	--	--	--	P-2	10.3	>90	21
	--	--	--	--	P-3	8.1	90	32
	--	--	--	53	44	5.9	40	53
Rogers Avenue	R-1	3.6	20	65	27	3.6	20	65
	R-2	2.5	40	23	R-2	5.9	36	59
	R-3	5.2	10	187	R-3	6.1	11	200
	19	4.5	20	45	ELIMINATED		--	--
	--	--	--	105	33	4.1	14	105
	--	--	--	--	R-4	8.9	16	200
	51	4.4	13	122	51	4.4	13	94
	--	--	--	110	44	5.5	18	110
West Cold Spring Lane	--	--	--	--	51	(SEE	13	--
	33	3.1	20	--	33	ABOVE)	14	--
Mondawmin	M-2	5.7	15	137	ELIMINATED		--	--
	M-3	6.9	15	166	M-3	5.9	11	193
	M-4	5.7	20	103	ELIMINATED		--	--
	M-5	7.7	15	185	M-1	7.2	13	199
	22	4.3	14	111	22	4.3	14	111
	7	12.2	15	293	M-2	6.5	12	195
	--	--	7.5	58	5	1.2	7.5	58
	--	--	15	17	7	0.7	20	13
	--	--	7.5	48	28	1.0	15	24
	1	4.1	30	49	1	4.1	60	25
TOTAL		128.4		2793		127.2		2317

Figure 5
Feeder Bus Routes Alternative D-1 Versus Implemented System



from the implemented system or the seven routes added to the implemented system. Of those route segments included in both systems, six have more frequent service, while three have less frequent service. The actual system varies from Alternative D-1, the system originally recommended by MTA, due to continued community input to the feeder design and changes necessitated by system operational requirements.

ACCURACY OF FEEDER BUS PLANNING PROJECTIONS

Overall, MTA was pleased with the process used to estimate feeder bus ridership. Some estimates, such as feeder bus patronage and feeder bus revenue were considered reasonable (Table 10). Other estimates, such as bus to rail ridership, mode split (percent who use feeder bus), and average cost, were not as close to actual conditions.

A major cause of the inaccurate bus to rail ridership projections were overestimated rail system patronage estimates made outside the feeder bus planning process. Rail patronage projections* were overestimated by almost 50 percent. This may have been a result of overestimated rail headways, and transit fare and gas price assumptions which did not occur. The over-estimate of rail riders, used as a given in the feeder bus planning process, contributed to the 36 percent overestimate of the number of bus to rail transfers.

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*Includes rail passengers accessing and exiting the four outer stations of the first phase of the Baltimore rail system, the section under study in the feeder bus planning process.

TABLE 10

EVALUATION TABLE FOR THE BALTIMORE NORTHEAST CORRIDOR FEEDER BUS PLANNING STUDY*

Evaluation Criterion	Estimated (1982)	Actual (1985)	Percent Difference
TOTAL RAIL PASSENGERS ON FEEDER BUS (INBOUND)			
Number of Rail Passengers Using Feeder Bus	4,427	2,850	-36%
Percent of Rail Passengers Who Use Feeder Bus	36%	59%	+64%
RAIL PASSENGERS ON FEEDER BUS BY STATION			
Rail Passengers By Station Who Access The Rail By Bus:			
Reisterstown Plaza	1,889	460	-76%
Rogers Avenue	896	880	-2%
West Cold Spring Lane	324	120	-63%
Mondawmin	1,009	1,390	+38%
Percent of Rail Passengers By Station Who Access The Rail By Bus:			
Reisterstown Plaza	35%	23%	-34%
Rogers Avenue	38%	59%	+55%
West Cold Spring Lane	13%	11%	-15%
Mondawmin	68%	90%	+32%
TOTAL BUS PASSENGERS			
Total Bus Passengers (Both Directions)	14,745	13,752**	-7%
OTHER FEEDER BUS CHARACTERISTICS			
Average Cost of Feeder Bus Operation Per Hour	$29.60	$40.04	+35%
Feeder Bus Revenue	$7,000	$7,601**	+9%
One-Way Route Miles	128.4	127.2	-1%

*All values represent a daily three hour (6 a.m.-9 a.m.) morning peak period except where stated otherwise.

**Values for some routes are not available.

On the other hand, the access mode choice model developed for this study underestimated by 64 percent the percentage of rail passengers who would use feeder bus to access the rail system. A 45 percent underestimate or less, within a 25 percent margin of error, would have been considered reasonable by MTA due to time and budgetary constraints imposed on the development of the model.

Therefore, the number of bus to rail transfers was over-estimated because the overestimate of rail trips was larger than the underestimate of the percent who would access the rail system by feeder bus. This combination produced a 36 percent under-estimate of those using feeder bus to access the rail system.

With the exception of one station, individual station ridership was not closely estimated. Ridership estimates for two stations, Reisterstown Plaza and West Cold Spring Lane, were overestimated by approximately three-quarters and two-thirds, respectively, while Mondawmin station was underestimated by approximately one-third, and Rogers Avenue station was reasonably projected with a 2 percent overestimate.

Overall, the access mode choice model produced slightly better estimates for individual stations than those for the number of bus to rail transfers. Estimates of the percent of rail riders who transfer from feeder bus was underestimated by approximately one-half for the Rogers Avenue station and one-third for the Mondawmin station, while the percent was overestimated by approximately one-third for the Reisterstown Plaza station, and 15 percent for the West Cold Spring Lane station.

Despite the unreliability of the projection on the number of bus to rail transfers, the total feeder bus projection was close, with a seven percent overestimate.

The average cost of feeder bus operation per hour was underestimated by 35 percent. This was the result of three years of inflation and labor cost of living increases between the time of cost model development and implementation.

Revenue estimates were fairly accurate, underestimated by nine percent*, with revenue higher than expected, due to unanticipated fare increases.

SEVEN PLANNING PHASES

The remainder of this chapter will evaluate each of the seven phases of the planning process. Strengths and weaknesses of each phase will be discussed, in addition to MTA's thoughts on how it would conduct the process differently next time.

TRANSIT PATRONAGE STUDY

This planning phase consisted of passenger surveys and ridership counts, and took approximately one and a half calendar-years to complete. The purpose of the survey was to determine existing ridership, and identify travel patterns and socio-economic characteristics of current transit riders in the northwest corridor, where the four metrorail stations which connect with feeder buses are located.

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*Data on some routes are unavailable.

Before implementing the passenger surveys, four pilot surveys were conducted, to test the wording of the survey questions and passenger willingness to respond to the questions. The pilot survey was found to be a useful device to test the survey format and questions. The types of responses received helped refine the language of the travel and socioeconomic questions for the final survey, in terms of clarity and passenger willingness to respond.

The MTA used the survey results on ridership characteristics as inputs into the mode choice, patronage estimation, and cost models. The inputs included income, trip purpose, access/ egress mode, and the distribution of trip origins and destinations. Other characteristics which provided general information useful for feeder planning were auto availability, availability of a driver's license, transfer rate and fare payment. In addition, major conclusions derived from the survey proved useful in the planning process by emphasizing the importance of limiting the number of passengers required to transfer twice (from bus to rail to bus), particularly on short trips. Because of this, some crosstown routes were not eliminated from the final bus network. Two socioeconomic characteristics questioned on the survey--passenger age and sex--were found to be unimportant for planning purposes.

In retrospect, after having conducted four different pilot surveys, MTA believes that one pre-test of the survey would have been sufficient. Instead of conducting additional pilot tests, MTA believes that staff time would be more productively spent researching the surveying experiences of other transit properties.

FEEDER BUS DEMONSTRATION

The next step in the planning process was a feeder bus demonstration project, accompanied by additional user and market surveys, which took approximately eight calendar-months to complete. The demonstration consisted of a feeder bus service that carried passengers from home or work, to a point where they could transfer to an express bus traveling directly downtown. The objective of this demonstration was for MTA to gain experience with feeder route operation, as well as collect data to use in estimating access mode demand.

In retrospect, the MTA believes that the feeder demonstration was not a necessary component of the planning process. The information learned from the demonstration could have been acquired from available transit planning literature. The demonstration confirmed what is stated in the literature, that reliable on-time performance is more important to transit riders than cost and travel time. In addition, the demonstration was not successful in collecting sufficient data to use as an input into the access mode choice model, the next planning step, due to low ridership levels (averaged less than one rider per trip).

ACCESS MODE CHOICE MODEL

The station access mode choice model was developed to estimate the percentage of rail riders who would walk, drive, be driven, or take the feeder bus, to get to or from the rail station, and took approximately eleven calendar-months to complete. Due to budgetary and time constraints, the model was borrowed from the City of Cleveland, with appropriate adjustments made to reflect Baltimore socioeconomic characteristics. The Cleveland model was selected because it incorporated the access/egress modes which would be available in Baltimore. This was important to the MTA because it had no prior experience, except the failed feeder bus demonstration, from which to model transfers between bus and rail.

The MTA was pleased with the results of this approach, despite the large underestimate of the percent of riders who use feeder bus to access the rail system, and would not hesitate to use it again if the resources to create an entirely new one were not available. The model allowed the testing of the impact of alternative feeder bus service levels and policy decisions on the proportion of rail riders who would access/egress by feeder bus.

The estimated mode split of total feeder bus riders for the final selected alternative (D-1) was underestimated by a 64 percent difference (Table 10). MTA had not expected to produce a highly reliable model because it was their first experience in developing an access model with more than one transit mode (rail and feeder bus), in addition to their budgetary and time constraints. Therefore, they would have considered results within a 25 percent margin of error, which is a 45 percent underestimate, to be reasonable.

PATRONAGE ESTIMATION MODEL

The development of the patronage estimation model for each feeder bus route and the number of bus to rail transfers, involved a combination of the results of the access mode choice model and total feeder bus patronage estimates. Overall, MTA was pleased with the results of this process, and would not change the procedures used in future planning efforts. This phase took approximately four calendar-months to complete. As discussed in the previous section, MTA was generally happy with the access mode choice model. Of course, the results of the model are affected by changes to rail and bus fares and auto gasoline prices. A major part of developing the patronage estimation model involved the development of transit trip tables to project 1982 trips, based on 1978 conditions, and the allocation of trips to bus routes. To validate the patronage model, the transit simulation was compared with the Patronage Survey results undertaken as the first planning activity in this process. Based on the comparison, appropriate adjustments were made to reflect actual conditions.

COST MODEL

The next planning task involved construction of a cost model to be used to compare the operating costs of alternative feeder systems, and took about about five calendar-months to complete, due to low staff availability at the time. Overall, MTA was pleased with the model and would not make significant changes for future use. MTA was successful in developing a model highly reflective of local conditions and current operating characteristics. It estimated the cost implications of operating each alternative system, based on number of vehicles and hours of operation required. The initial costs produced by the model for each alternative, were used as a basis for re-evaluating the alternatives to meet budget limitations.

Despite MTA's belief in the general reliability of the cost model, the estimated costs produced from the model underestimated actual operating costs by 35 percent. MTA attributed the size of the error to inflation and increased labor costs which occurred between the time of model development and model implementation, a period of three years.

ALTERNATIVE FEEDER NETWORKS

In this phase, four alternative feeder networks to the four outer rail stations were developed, and took about four calendar-years to complete. To select the recommended feeder bus network for presentation to the community, the MTA compared the alternatives in terms of patronage, productivity (passengers per route mile), and cost.

The MTA believes that less time should have been spent on this phase. Although the MTA developed four feeder bus alternatives, it now believes it would have been more cost-effective to have concentrated on only one or two well conceived alternatives, since the significant amount of time and cost required to develop additional alternatives was not worth the benefits derived.

COMMUNITY MEETINGS

The last phase of the feeder bus planning process consisted of community meetings, which took approximately two calendar-years to complete. After MTA selected the preferred alternative, it presented it to the community at numerous meetings. Even though the MTA had initially prepared four alternative systems, only one recommended system was presented to the public. Then, based on community comments and reactions, MTA modified the recommended alternative, which was eventually implemented. This procedure, presenting one alternative to the community and then adjusting it according to public suggestions, operated smoothly and was acceptable to both the MTA and the community.

First the MTA met with umbrella groups who were expected to disseminate the information to smaller neighborhood groups. However, many neighborhood groups requested MTA presentation of the proposed feeder bus system. The MTA was responsive to all requests for presentations, resulting in a total of 67. Despite the large number, these public meetings were perceived by the MTA as being a worthwhile effort. The meetings provided MTA with community feedback, as well as creating community acceptance of the final system. In retrospect, however, the MTA staff now believes it would have been more efficient to have limited the period over which staff presentations would have been made, instead of allowing it to extend for one and a half years.

The MTA staff also believes that it should have better informed all politicians about the selected feeder bus alternative prior to the initiation of community meetings. Although some had been approached by the MTA, others had not. This latter group occasionally raised issues and questions at the meetings which the MTA would have preferred to have discussed with them beforehand.

CHAPTER V

CONCLUSION

The MTA was generally pleased with the process that was used in the Baltimore Feeder Bus Planning Study. The MTA believes that overall reasonable cost and revenue estimates were produced that helped guide the development of the feeder bus network. Furthermore, community input was encouraged and solicited which was invaluable in the modifications that were made to the feeder network.

Although the process was successful, the MTA learned a number of lessons which it would incorporate in future feeder bus planning activities. These lessons are:

- When surveying existing bus patronage to determine trip and socioeconomic characteristics, one pilot study that tests for passenger understanding of wording and willingness to respond prior to the actual survey is sufficient. The MTA undertook several pilot tests with distinct variations, and determined that the additional information gained was not worth the added time and cost.

- The MTA asked age and sex related questions in the socioeconomic section of its patronage survey of existing riders. It was determined that these questions were unimportant for planning purposes, and therefore should be eliminated from future planning surveys.

- The feeder bus demonstration, which operated shuttle service to an express bus stop, proved unsuccessful in producing information useful to the planning process, in part due to low patronage. It was implemented to provide MTA with knowledge of what feeder characteristics were necessary for a successful feeder operation, and it was hoped that this knowledge would be transferable to the planned feeder bus system. In retrospect, the MTA determined that the information gained from this experiment could have been derived more easily and less costly from the available planning literature.

- The MTA was satisfied with the access mode choice model which they borrowed from Cleveland and then adjusted where necessary to reflect local conditions. Although a locally created model should produce a more reliable estimate of local conditions, the MTA believes that borrowing a model is a satisfactory alternative when time or cost constraints exist.

- In the Baltimore planning study, four alternative feeder bus networks were developed and evaluated. In retrospect, the MTA feels it would have been preferable to have concentrated on two well thought out alternatives only. It felt the added time and cost of developing four alternatives was not worth the additional gain.

- The MTA presented its recommended alternative to the affected community for its input, and then made modifications based on community comments. Since this citizen involvement process also proved successful in encouraging community support for the feeder system, it had value both constructively and politically. While the MTA recognizes that extensive community meetings are valuable, the MTA believes the time-frame of community participation should be limited to a reasonable period.

- MTA believes that all politicians with constituents in the affected area be informed about the recommended plan prior to the community participation process in order to assure their cooperation at community meetings.

- Finally, the MTA found that the most important factors in designing a feeder bus system are: service reliability, coverage maximization, a minimum number of double transfers, continuation of crosstown service, flexibility in arrival and departure times, and uncomplicated routes and schedules. Service frequency and fare cost appear to be less important elements, as long as service is reliable and the fare is reasonable.

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