The Shirley Highway Express-Bus-on Freeway Demonstration Project/ Second Year Results

November 1973
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This report contains:

a) A review of the performance of the Shirley Highway Express-Bus-On-Freeway Demonstration Project between 1969 and 1973.

b) A description of the methodology and data use to estimate project measures of effectiveness.

c) A discussion of factors considered in commuter mode choice decision making.

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THE SHIRLEY HIGHWAY EXPRESS-BUS-ON FREEWAY DEMONSTRATION PROJECT - SECOND YEAR RESULTS

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National Bureau of Standards
U.S. Department of Commerce

November, 1973
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Prepared for
URBAN MASS TRANSPORTATION ADMINISTRATION
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PREFACE

The authors wish to acknowledge the major technical and editorial contributions of Mr. Ralph E. Schofer of the Technical Analysis Division. His guidance and patience were invaluable in this effort. Major credit goes to Mrs. Carol Harrison who coordinated the preparation of the final draft. She was ably assisted by Mrs. Janet Stamper in the production of the report.

ABSTRACT

The purpose of the Shirley Highway Express Bus on Exclusive Freeway Lane Demonstration Project is to determine the effectiveness of this technology in easing urban traffic congestion and improving the urban environment. This project, jointly sponsored by the Urban Mass Transportation Administration (UMTA) and the Federal Highway Administration of the Department of Transportation, is comprised of three elements: exclusive bus lanes, new feature buses, and fringe parking lots coordinated with the express bus service.

As compared with the situation in 1969 prior to implementation, this demonstration project in the Shirley Highway Corridor has resulted in:

1. A shift of approximately 8300 auto commuters to the bus service.
2. An improvement in vehicle utilization which has reduced by 17 the number of buses required to maintain the March 1973 headways.
3. A diversion of approximately 5000 autos from daily peak period Corridor traffic streams and the removal of all buses from the auto lanes of the Shirley Highway.
4. A substantial improvement in the people moving efficiency of the Shirley Highway.
5. A reduction in peak period auto emissions and gasoline usage.
6. A reduction in travel times for motorists and bus riders.
7. An improvement in the reliability of the transit system.

The Technical Analysis Division of the National Bureau of Standards is evaluating this demonstration project for UMTA by monitoring performance in terms of attaining the project objectives, and by determining the contributions of particular project features to increases in the percentage of commuter trips by bus.

This report presents the results of the evaluation at the end of June 1973, highlighting the period between July 1972 and June 1973 of the multi-year demonstration project which is scheduled for completion in 1975.

Other reports on the evaluation of the Shirley Express-Bus-on-Freeway Demonstration Project are listed below:

1. "The Shirley Highway Express Bus-on-Freeway Demonstration Project-Project Description, Interim Report 1" (Report DOT/UMTA 1), August 1971. Available from Technical Analysis Division, National Bureau of Standards, Washington, D.C. 20234
2. "The Shirley Highway Express Bus-on-Freeway Demonstration Project/First Year Results, Interim Report 2" (Report DOT/UMTA 2), November 1972. Available from NTIS, Springfield, Virginia, PB-214333.
3. "The Shirley Highway Express-Bus-on-Freeway Demonstration Project-Users' Reactions to Innovative Features, Interim Report 3," prepared for Urban Mass Transportation Administration, U.S. Department of Transportation, June 1973. Available from NTIS, Springfield, Virginia, COM 73-11453.

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SECTION 1. EXECUTIVE SUMMARY

1.1. Introduction

The Shirley Highway Express Bus-on-Freeway Demonstration Project, scheduled for completion in December 1974, entered its fourth year of service as of July 1973. This report documents project achievements up to that date, with primary emphasis on activity between July 1972 and June 1973.

Evaluation of the demonstration project is aimed at measuring performance in terms of attaining project objectives, and at estimating the contributions of particular features to increases in the percentage of commuter trips by bus. This latter information will subsequently facilitate the evaluation of future bus-on-freeway projects.

Objectives of the demonstration project are: (1) to divert auto commuters to the bus service; (2) to promote the economic viability of transit operations; (3) to reduce traffic congestion during peak periods; (4) to increase the people-moving efficiency of Shirley Highway; (5) to reduce auto air pollution emissions and gasoline consumption; (6) to reduce travel time for motorists and transit users; and (7) to improve the reliability of bus service.

The preliminary achievements discussed in this report have not as yet been related to the costs of providing the service. Determining who benefits, in what ways, and by how much, and relating these benefits to the costs of providing them is an on-going evaluation task, the results of which will be described in a final report.

1.2. Attainment of Objectives

The Corridor-wide percentage of person-trips which are potentially bus trips and which are made by bus has been designated the primary measure of project effectiveness; this percentage is called the bus market share and is directly related to the achievement of Objectives 1, 3, 4, 5, and 6. The June 1973 peak period Corridor bus market share estimate (based on 1971 commuter surveys and 1973 traffic and bus passenger data) of 40 percent is essentially unchanged since October of 1972; however, an additional 6900 persons are using Corridor transportation facilities, and Corridor bus service attracted 2800 additional bus riders between June 1972 and June 1973. Since the inauguration of the project in 1969, daily bus ridership has increased by 7500 passengers (to 20,000) and bus market share increased from 27 percent (prior to project implementation) to the present 40 percent.

A concern of the evaluation is whether the increase in bus passengers was at the expense of Corridor auto occupancy. Between July 1972 and June 1973 peak period Corridor auto occupancy averaged about 1.34 persons/auto, not significantly different from 1.36 persons/auto during the previous 12 month period; Corridor auto occupancy averaged 1.44 persons/auto between April 1970 and December 1970 (initial Corridor traffic data collections). This decline, however, cannot properly be attributed to the demonstration project, since (1) auto occupancy in the Corridor (and in the whole Washington Metropolitan area as well) had been declining prior to the implementation of the project and has continued to decline at only a slightly higher rate during the life of the demonstration project; and (2) a majority of the former auto users had driven alone prior to riding the bus.

Former auto users riding the demonstration project buses have indicated that service and comfort features (as opposed to interior bus features) have been the primary determinants of their decisions to change from automobile to bus. The service features include the reliability of bus service and the convenience of bus arrival and departure times; adequate air conditioning and heating were the most important of the comfort features (Objective 1).

As a consequence of the shift of automobile commuters to the bus service, approximately 5000 automobiles were removed from the daily peak period traffic streams on the major Corridor highways, with approximately 800 autos being removed since October 1972; however, it appears that newly opened portions of the reconstructed Shirley Highway have been more responsible for reducing congestion and automobile travel times than the diverted automobiles. Nonetheless, had these large numbers of express bus riders not been diverted from auto travel, the highway system would have been more congested and all auto users would have been subjected to additional delays and longer travel times (Objective 3).

Other consequences of the removal of automobiles from Corridor highways are reductions in automobile air pollution and gasoline consumption. Between October 1972 and June 1973, the reduction in auto air pollution emissions was approximately 700 tons of carbon monoxide, 100 tons of hydrocarbons and 50 tons of nitrogen oxides; during the same period approximately

850,000 gallons of gasoline were saved. The estimated total reduction in air pollution emissions since June 1969 was 1950 tons of carbon monoxide, 300 tons of hydrocarbons and 150 tons of nitrogen oxides; total gasoline conservation was approximately 2 million gallons (Objective 5).

During the A.M. peak period in June 1973, the Shirley Highway (with three auto lanes) was carrying approximately 28,100 persons (11,900 bus riders and 16,200 auto persons). This is 11,600 persons more than in April 1970 when the Shirley Highway had two auto lanes. During the June 1973 peak hour (the hour with the maximum observed person trip volume), 7700 bus passengers were observed on the buslane and 7100 auto person trips were observed on the three auto lanes of the Shirley Highway (Objective 4).

The busway continues to contribute to the reduction of bus travel time and the improvement of bus schedule reliability by providing a high speed, congestion-free line haul route. Unfortunately, the extent to which the downtown bus-priority lanes have been effective in reducing bus travel times and improving scheudle reliability has been difficult to measure because of interference from the construction of the Washington (Metro) subway system (Objective 7).

The busway has had a generally positive impact on the bus operation. Utilization of vehicles and labor has improved on routes that use the busway. Time savings on these routes allow the same number of buses and drivers to make more trips than would be possible without a busway. Increased utilization, however, has not been enough to accommodate growth in patronage, and additional buses have been put into service. To maintain present bus headways if the busway did not exist, would require approximately 17 additional buses and would cost the operator an estimated additional $26,000 per month (Objective 2).

Although peak period service was expanded substantially during the last half of 1972, net operating revenues for peak period service exceeded those of the corresponding period in 1971. In addition, during the last half of 1972, net project operating revenue (peak and off-peak) was positive for the first time ever.

Many of the elements of this demonstration project have been implemented in the past with varying results. This demonstration project is different in the simultaneous implementation of project elements, the aggressive expansion of bus service (as opposed to the reduction of service as with most transit operations) by the project administrator, and the continued provision of timely and highly reliable bus service.

SECTION 2. PROJECT DESCRIPTION AND EVALUATION PROGRAM

2.1. Introduction

The Shirley Highway Express Bus-on-Freeway Demonstration Project began in April 1969, and the Technical Analysis Division (TAD) of the National Bureau of Standards began monitoring the project's performance in January 1971. This multi-year demonstration, scheduled for completion in December 1974, is a joint effort of the Federal Highway Administration (FHWA) and the Urban Mass Transportation Administration (UMTA) and involves the cooperation of many participating state, regional and local agencies.[1]

The current state of project development, with emphasis on performance from July 1972 through June 1973, is the subject of this report. Section 2 will acquaint the reader with the purpose and organization of the report, and describe the demonstration project and the travel corridor which it impacts.

2.1.1. Background of Report

Since 1971, three interim reports have been published describing various results of the UMTA evaluation program for the Shirley Express Bus-on-Freeway Demonstration Project. The first report described the project in detail, including its background and location as well as major elements and their operation.[2] The second report presented interim results from monitoring the seven project objectives through July 1972, and included bus and auto commuter profiles based upon the 1971 surveys.[3]

Interim Report 3 presented the results of a survey of user reactions to the special interior bus features.[4] Other reports to be published in this series include (1) an analysis of the results of a survey of commuters at project park-and-ride lots; (2) an analysis of project benefits and costs; and (3) a documentation of commuter mode choice behavior based upon results from the 1971 survey of auto and bus commuters (including modal choice models for allocating Corridor peak-period travel demand).

2.1.2. Purpose of Report

The purpose of this report is to document the monitoring and evaluation results and describe project developments during the period July 1972 to July 1973. Specifically written for urban transportation planning professionals with an interest in the application of bus-on-freeway technology, this report should be of value to transportation administrators as an indication of the impact of various project elements. In addition, our procedures for data collection and analysis, and parameter estimation might also be of interest to transportation analysts.

2.1.3. Scope of Report

Each objective within the UMTA evaluation plan was investigated, and (as in Interim Report 2) project performance is discussed. The investigations were based primarily upon the Corridor travel information obtained from roadside observations and commuter surveys. While the roadside observations have been continued since the project began in 1969, commuter surveys were only conducted in 1971; however, two special surveys were conducted

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[1] Participating agencies include the Metropolitan Washington Council of Governments, Virginia Department of Highways, District of Columbia Department of Highways and Traffic, Washington Metropolitan Area Transit Authority and the Northern Virginia Transportation Commission.

[2] "The Shirley Highway Express Bus-on-Freeway Demosntration Project - Project Description, Interim Report 1" (Report DOT/UMTA 1), August 1971. Available from the Technical Analysis Division, National Bureau of Standards, Washington, D.C. 20234.

[3] "The Shirley Highway Express Bus-on-Freeway Demonstraion Project/First Year Results, Interim Report 2" (Report DOT/UMTA 2), November 1972. Available from NTIS, Springfield, Virginia, PB 214333.

[4] "The Shirley Highway Express-Bus-on-Freeway Demonstration Project-Users' Reactions to Innovative Features, Interim Report 3", prepared for Urban Mass Transportation Administration, U.S. Department of Transportation, June 1973. Available from NTIS, Springfield, Virginia, COM 73-11453.

during 1972. One focused on bus commuter responses to the special bus interior features of the project buses, and the other on bus commuters using the fringe park-and-ride lots. the other on bus commuters using the fringe park-and-ride lots.

An extensive analysis of commuter mode choice behavior based on the 1971 surveys was also undertaken. The detailed analyses and findings will be presented in Interim Report 5.

2.1.4. Report Contents

The report is divided into four sections. An executive summary of the entire report is found in the first section. The remainder of Section 2 reviews the evaluation program, and describes the project elements and the travel Corridor. The third section presents information pertaining to the attainment or status of each major project objective. The fourth section summarizes the analyses of commuter mode choice behavior based on results of a park-and-ride survey and a survey of users' reactions to special interior bus features.

2.2. Evaluation Plan

The purpose of the UMTA evaluation program for the Shirley Highway Express-Bus-on-Freeway Demonstration Project is to assess the degree to which the project's objectives are being attained, i.e., to estimate measures of effectiveness for each of the project's objectives. There are seven major objectives of the evaulation program:

1. Determine the magnitude of the modal shift (auto-to-bus) in the Shirley Highway Corridor. Determine the relative influence of the following transit service features or characteristics on mode choice decisions:

    a. the exclusive busway (time advantage)
    b. the fare
    c. the access convenience (e.g., the time and effort required to go from one's door to the bus stop)
    d. the egress convenience
    e. the number of transfers required
    f. the park-and-ride facilities
    g. the qualities and characteristics of vehicles (e.g., air conditioning, rider comfort, seat width)
    h. the non-fare costs (e.g., parking fees).

2. Determine the impact of the improved and additional peak-period service on the bus operator.

3. Determine the reduction in peak-period auto volumes due to the mode changes (auto to bus).

4. Measure the increase in the volume of people moved on the freeway during the peak period.

5. Determine gasoline savings and the reduction in vehicle air pollution emissions.

6. Determine the reduction in total trip time for both bus and auto users in the Corridor.

7. Determine the improvement in schedule reliability of peak-period transit service.

The evaluative information should be useful from two perspectives, the national view and the regional one. In the national interest, UMTA seeks to make the results and forecasting procedures developed in conjunction with the Shirley Project available to those considering, designing, or implementing similar systems in other cities. Information related to the attainment of project objectives will permit better-informed, more judicious implementation of similar concepts elsewhere. Where possible, the various features of the Shirley bus system will be characterized with respect to their contributions to patronage. Knowledge concerning the effects of the enlarged market share on the bus operator, Corridor highway congestion, trip or travel times, efficiency of freeway lane utilization, air pollution, gasoline usage and bus schedule reliability will be useful for making decisions about bus-on-freeway operations in other cities.

The regional perspective concerns relating project achievements to local bus and auto travelers, bus operators, and the local communities. It is hoped that many corridor groups will benefit from the public transportation improvements engendered by this demonstration project. (For example, reductions in auto traffic volumes and commuter times are of value to both auto and bus users.) These benefits will be identified, related to the incident group or groups, and considered jointly with costs in a benefit-cost evaluation to be performed at the conclusion of the project. Such assessments will aid the regional agencies as they evaluate the impact of the demonstration project on their respective constituencies.

2.2.1. First and Second Year Evaluation Activities

In the first year of the project evaluation, July 1971 to June 1972, the busway and the priority lanes in downtown Washington were put into service, sixty new-feature buses were placed into operation, and two fringe parking lots in shopping centers were opened. During this period, the major thrust of the evaluation effort was to develop the evaluation plan, to test various data-gathering procedures, and to aid the regional agencies in implementing the project. Basic measurements of traffic volumes, travel times, and bus patronage were made before the entire busway opened in April 1971, and have been repeated during 1971, 1972, and 1973. These data, together with surveys of bus and auto users conducted in October 1971, provided the primary information used in assessing project Objectives 1 through 7 for the period June 1969 to July 1972. The results are presented in the First Year Results Report (Interim Report 2).

The evaluation activities from July 1972 to June 1973 consisted of two major tasks: (1) refinement of existing analytical procedures for estimating project measures of effectiveness (e.g., bus market share, peak-period automobile reduction, etc.), and (2) data collection activities for providing information on peak-period travel conditions within the corridor. Parameters derived from the resultant analytical procedures were applied to the appropriate data to estimate project measures of effectiveness. Project measures of effectiveness will be summarized as benefits and costs at the end of the demonstration.

The analytical procedures used in estimating project measures of effectiveness are described in Section 3. An overview of data collection activities is presented in paragraph 2.2.2., and an in-depth discussion of the primary project evaluation data is presented in paragraph 3.1.

2.2.2. Data Collection Activities

Measurement of the attainment of project objectives is being accomplished by the monitoring of several types of data. The two primary types are: (1) periodic counts of vehicles and persons in vehicles (both buses and autos) crossing an eight-station screenline which intercepts the main arterials emanating from Washington, D.C. into the Corridor (see discussion in paragraph 3.1), and (2) in-depth mailback surveys of auto and bus commuters crossing the screenline. The screenline counts began in April 1970, and have been continued during the second year of project evaluation. A survey of bus and auto commuters was conducted in October 1971. Since that time, there have been no major commuter surveys (a major bus commuter survey was conducted in November 1973; unfortunately, the processing of those data will not be completed until January 1974); however, two special surveys of bus commuters were conducted during this second year: (1) a survey of users' reactions to special bus interior features and (2) a survey of factors influencing the use of bus service at park-and-ride lots.

The traveler interviews were held in October 1971. Bus questionnaires were distributed by bus drivers to approximately 25 percent of the riders. Over 2,400 completed forms were returned by mail (a 55 percent response rate). Surveying auto travelers was a more complex process. A sample (1 in 5) of licenses was taken from all autos crossing the screenline. The Virginia license numbers were matched with Virginia Motor Vehicle registration files, and owners' addresses were retrieved. Mail-back survey forms were then sent to about 4,900 addresses of registered owners. A driver's form and three passenger forms, for car pool passengers, were included. Over 3,100 complete forms were returned. (This represented 55 percent and 45 percent response rates for auto drivers and auto passengers respectively.)

Other data are utilized in monitoring the project objectives. The Washington Metropolitan Transit makes monthly visual roadside counts of all passengers on buses using

the busway during the two daily peak periods.[5] Tabulations of aggregate system costs, revenues, and operating statistics are prepared quarterly (some statistics are available on a monthly basis). Bus and auto travel time measurements (time checks between points) and bus schedule adherence data are collected periodically.

2.3. Project and Corridor Descriptions

The Shirley Highway-Express-Bus-on-Freeway Demonstration Project was designed to provide Corridor commuters with fast and reliable peak-period bus service to three major employment centers: (1) Downtown Washington, D.C., and (2) Pentagon and (3) Crystal City Complex in the Northern Virginia suburbs.[6] Bus travel times have been reduced by the following project features: (1) more direct routing in suburban and downtown collection and distribution; (2) expanded and more frequent bus service; and (3) preferential treatment on streets in downtown Washington, D.C., and the exclusive use of the busway with its high operating speeds Bus schedule reliability has also been improved by this preferential treatment accorded the buses because the buses have been removed from the primary flow of traffic and are less vulnerable to delays caused by automobile congestion and accidents.

The demonstration project is being operated in the Shirley Highway Corridor of the Northern Virginia suburbs of Washington, D.C., one of the most affluent areas in the Country. In 1970 the median family income in the area was about $15,000 per year, about 28 percent more than the national median for suburban areas and about 15 percent more than the median income of the Washington, D.C. SMSA. (The SMSA median family income of $12,993 was the third highest in the nation[7].)

2.3.1. Major Project Elements

Three major elements comprise the project: (1) the busway, including the exclusive lane on Shirley Highway and the bus-priority lanes in Washington, D.C.; (2) a bus transit operation, involving new buses (with special features) operating on new routes and schedules; and (3) residential fringe parking facilities for bus riders, located in shopping centers and newly constructed lots.

The busway (first project element) is provided as a part of the reconstruction of Shirley Highway into an eight lane road (two three-lane directional roadways separated by a two-lane reversible express roadway). Figure 1 depicts the Shirley Highway, showing both the temporary and the completed permanent portions of the busway. Also shown are the permanent and temporary bus access points. The completed busway will be approximately 11 miles long and will end at the southern end of the 14th Street Bridge on the Potomac River.

After traveling on the busway, inbound buses cross the Potomac River on the 14th Street Center Bridge and merge with regular District of Columbia traffic. Within the District, peak period bus lanes and turn advantages give the buses some priority over autos.

Bus transit operations (second project element) include the transit service operated by the Alexandria Division of the Washington Metropolitan Area Transit Authority (WMATA) prior to the demonstration project and the new service which WMATA operates for the Northern Virginia Transportation Commission (NVTC) as a part of this demonstration project.[8] WMATA vehicles served the pre-existent bus routes; however, the new project service is being provided with 90 new-feature buses purchased by NVTC with a part of the demonstration grant funding.

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[5] Transit vehicles and patrons are not tallied for the busway as part of the screenline counting program; special busway counts are used as estimates of buses and bus passengers in place of the screenline counts for the Shirley Highway.

[6] The Northern Virginia Suburbs are defined as the cities of Alexandria, Falls Church and Fairfax; and Arlington and Fairfax Counties.

[7] U.S. Department of Commerce, Bureau of the Census, U.S. Statistical Abstract, 1972.

[8] WMATA acquired the AB&W Transit Company, a private firm, on February 4, 1973, as part of the regional bus system. It now operates the former AB&W buses as well as the NVTC service. The service offered by the Alexandria Division of WMATA is substantially the same as that of its predecessor.

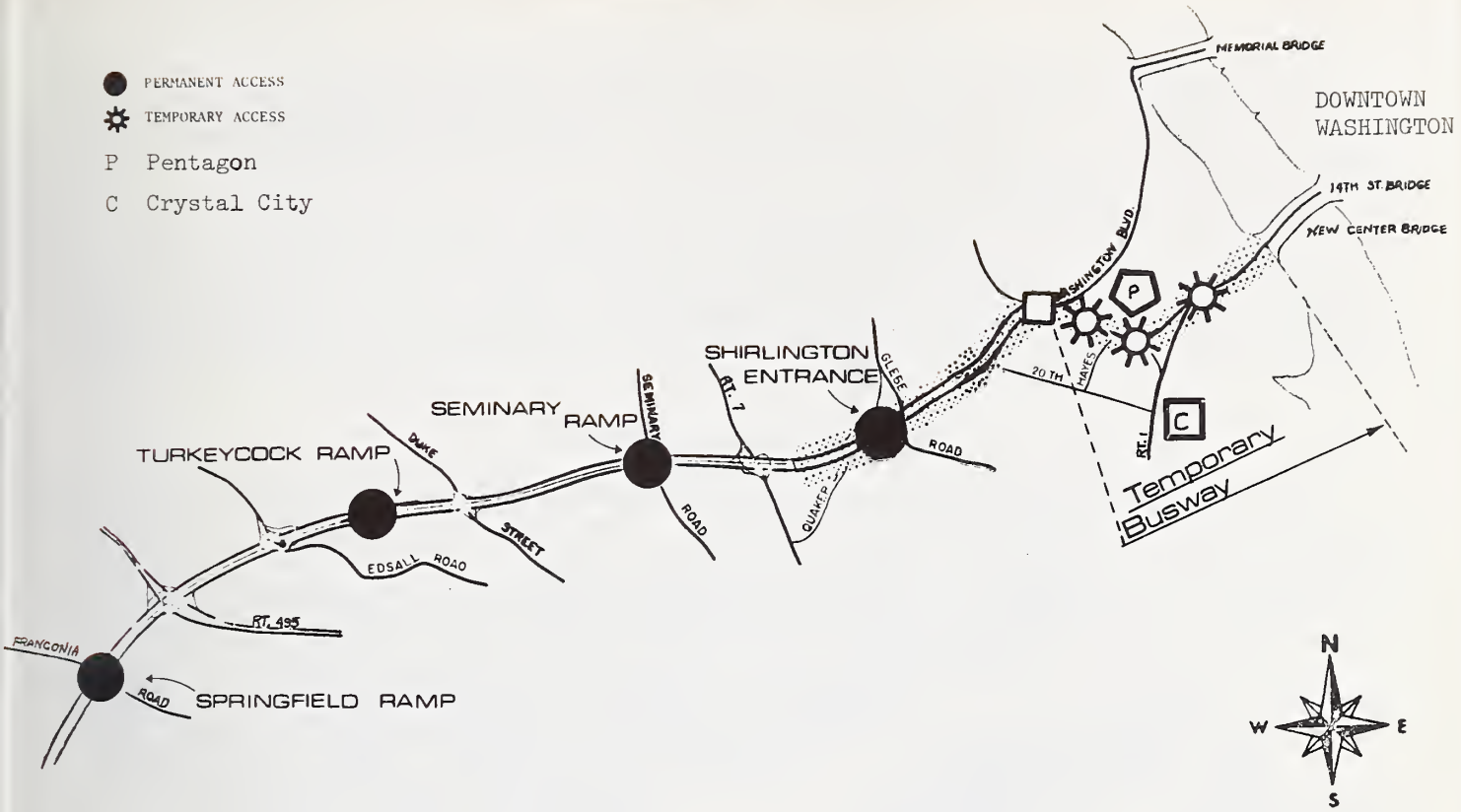

Figure 1. Shirley Highway Busway Entrances

The 90 new-feature project buses were purchased incrementally. The first 30 were placed into service in June 1971; the second 20 began operation in February 1972. Ten more were in operation in June 1972. Sixteen buses were placed into service in September 1972 and the final 14 began operation in February 1973. The last 30 buses were not used to expand the project service area by developing new routes; rather, they were added to established routes to relieve overcrowding and to improve the level of service by reducing headways (time between bus departures) on established routes (see paragraph 3.6 for detailed travel time and distance descriptions for each of the project routes). In addition, three reverse commuter routes (from downtown to the residential portion of the Corridor) were initiated in February 1973. These routes will be examined in a subsequent report.

The new buses have special features (relative to typical urban transit buses) which enhance passenger comfort and increase service reliability. Special bus features designed to increase passenger comfort include: air conditioning, wider seats and aisles, and smooth line interiors (no advertising racks) with colorful plastic wall coverings. Two-way radios have been provided to enable dispatchers to communicate with drivers in the event of breakdowns or accidents, and to direct route changes where warranted by traffic conditions. In addition to the above features, all of the buses are equipped with anit-pollution devices to reduce exhaust emissions, and some are powered by more powerful eight-cylinder engines (typical urban transit buses have six-cylinder engines).

The third project element (the fringe parking lots) is coordinated with the new bus service for park-and-ride patrons. In June 1971 the NVTC obtained permission from two shopping centers (Springfield Plaza and Shirlington Plaza) to designate portions of their lots for all-day free parking for bus riders. Other shopping centers are also used for parking by daily bus riders, but are not officially part of this demonstration project.

A permanent fringe park-and-ride lot was opened in October 1972 at Backlick Road near the Capital Beltway. This lot, the location of a future subway station, was leased by the NVTC for the duration of the demonstration project. The five acre, lighted lot has 400 parking spaces, an area for passenger boarding and alighting, and a kiss-and-ride staging zone as well as a bike rack.

As separate entities, each of the three demonstration project elements has been attempted in the past with varying degrees of success; however, this project is significant in that a coordinated attempt is being made to improve transit service at several levels simultaneously. Herein lies much of the reason for the increases in bus ridership at a time when bus patronage is declining throughout both the Metropolitan area and the Nation (see paragraph 3.2).

2.3.2. Corridor Definition

The Corridor was defined according to the expected influence of the demonstration project on urban radially oriented (as differentiated from inter-city) travel in the Northern Virginia suburbs. If travelers from a particular area might use the project buses, the area was included as a part of the Corridor. After analyzing the 1971 commuter survey data, the Corridor area indicated in Figure 2 was selected. Some commuter travel highlights are listed below:

a. Approximately 550,000 people live within this 150 square-mile area. At the northeast end of the Corridor are major employment centers including the Pentagon, the rapidly growing Crystal City Complex in Virginia, and Downtown Washington, D.C. (See Figure 2.)

b. Corridor motorists commuting into the three employment centers travel on the Shirley Highway and six radial arterials: (1) Arlington Boulevard, (2) Columbia Pike, (3) Army-Navy Drive, (4) Jefferson Davis Highway, (5) George Washington Memorial Parkway and (6) Mount Vernon Drive. (See Figure 3, page 14.) All are congested during peak commuting periods.

c. Corridor bus commuters use the more than twenty bus routes (pre-existent and project routes) which enter the three employment centers.

2.3.3. Corridor Demographic Characteristics

The 1970 Census data provide a demographic description of the Corridor before the entire busway opened in 1971. The 1970 Census tracts within the Corridor boundary were used for the tabulation of selected demographic characteristics.[9] Figure 2 indicates the Corridor boundaries and the enclosed Census tracts. (The tract numbers are also listed in Table 1.) The Corridor is divided into four groups of tracts. The first group consists of those tracts within one mile of the busway; the second is those between one and two miles (see Figure 2). The remaining groups are those tracts in the East and West regions along the outer Corridor boundaries.

Table 1

Corridor Census Tracts

1 MILE			2 MILE		WEST				EAST		
1029	4014	9005	1026	4021	1021	4032	4052	4073	2007	4002	4017
1030	4020	9006	1027	4033	1022	4037	4056	4074	2013	4003	4018
1031	4035	9007	1028	4034	1023	4038	4057	4075	2014	4004	4019
1038	4036		2005	4039	3108	4045	4058		2015	4005	4022
2001	4040		2006	4042	3109	4046	4059		2016	4006	4024
2002	4043		2008	4053	3110	4047	4060		2017	4007	4025
2003	9001		2009	4054	3111	4048	4061		2018	4008	4027
2004	9002		2012	4055	3112	4049	4062		2019	4009	
2010	9003		4015	4064	4030	4050	4063		2020	4010	
2011	9004		4016		4031	4051	4065		4001	4011	

[9] Source: U.S. Department of Commerce, Bureau of the Census, Census of Population and Housing: 1970 Census Tracts PHC (1)-226, Washington, D.C.-Md.-Va. SMSA, May 1972.

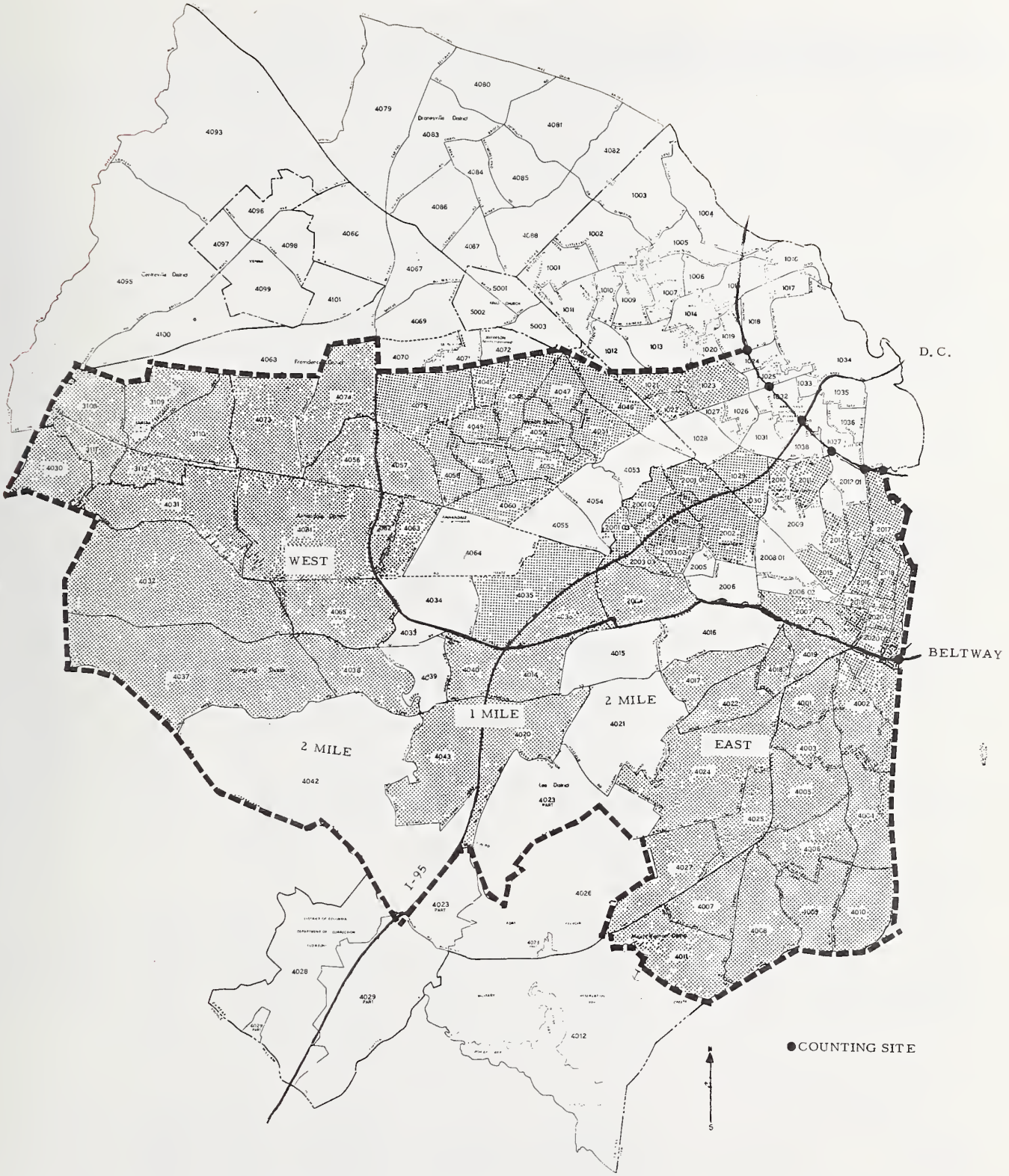

Figure 2. Shirley Highway Corridor Area.

Table 2

Selected Demographic Characteristics of
Shirley Highway Corridor and Washington, D.C. Md - Va. SMSA

1970 DEMOGRAPHIC CHARACTERISTICS	TOTAL CORRIDOR TOTAL	TOTAL CORRIDOR PERCENT	TOTAL SMSA TOTAL	TOTAL SMSA PERCENT	WASHINGTON, D.C. TOTAL	WASHINGTON, D.C. PERCENT
POPULATION						
Total	496,470		2,861,123		756,510	
Negro	32,379	7	763,445	25	537,712	71
Number Families	167,564		898,496		162,656	
AREA						
Square Miles	152.6		2,399		61	
Population Density per sq. mile	3,253		1,193		12,390	
YEAR MOVED INTO HOUSING						
1968 - 1970 (March)	73,871	47	367,995	41	96,118	37
1965 - 1967	35,147	22	206,136		59,743	23
1960 - 1964	24,117	15	139,366	15	40,229	15
1950 - 1959	17,922	11	128,366	14	41,226	15
1949 or earlier	5,764	4	62,059	7	25,222	10
1970 FAMILY INCOME[1]						
Median	$15,000		$12,993		$9,583	
CLASS OF WORKER						
Private	110,666	52	665,596	57	179,830	54
Government	95,080	44	460,779	39	141,163	42
Self-employed	6,788	3	50,419	4	13,510	4
Total	212,534		1,176,794		334,503	
AUTOS AVAILABLE						
1	74,497	44	405,179	45	113,671	70
2	60,004	36	277,330	31	28,380	17
3 or more	9,680	5	49,713	5	4,379	2
Total (Autos)	223,545		1,108,978		183,568	
Average (Autos/family	1.34		1.23		1.13	
None	25,179	15	166,274	19	16,226	10
MEANS TRANSPORTATION TO WORK						
Driver	147,958	69	748,801	60	125,415	37
Passenger	30,186	14	163,922	13	39,246	12
Total	178,144	83	912,723	73	164,661	49
Bus	21,906	10	190,187	15	119,021	36
Walked to Work	7,965	4	78,504	6	33,745	10
Worked at Home	3,352	2	24,019	2	6,880	2
Other	4,107	2	33,022	3	11,039	3
WORK PLACE						
D.C. Central Business District	20,095	9	128,453	12	48,467	18
D.C. Remainder	38,259	18	363,813	33	171,925	63
Arlington	40,114	19	103,655	10	11,590	4
Virginia	88,847	41	183,811	17	7,181	3
Other	28,241	13	308,948	28	34,298	12

[1]The Corridor median annual family income of $15,000 is an approximation based on the mean of the median family incomes of the jurisdictions within the Corridor. (75 percent of the Corridor commuters live in Fairfax County where the median annual family income was $15,700 in 1969.)

Source: U.S. Department of Commerce, Bureau of the Census, Census of Population and Housing: 1970 Census Tracts PHC (1)-226, Washington, D.C.-Md.-Va. SMSA, May 1972.

Table 3

Corridor Demographic Characteristics[a]

	TOTAL CORRIDOR		WITHIN 1 MILE		BETWEEN 1&2 MILES		WEST REMAINDER		EAST REMAINDER	
	TOTAL	PERCENT	TOTAL	PERCENT	TOTAL	PERCENT	TOTAL	PERCENT	TOTAL	PERCENT
POPULATION										
Total	496,470	100	132,945	26	93,861	18	149,607	30	120,057	24
Negro	32,379	7	10,919	8	5,536	5	1,916	2	14,008	12
Number Families	167,564		47,832		32,079		46,389		41,264	
AREA										
Square Miles	152.6		42.6		30.3		49.5		30.1	
Population Density per Sq. Mile	3,253		3,120		3,097		3,022		3,988	
YEAR MOVED INTO HOUSING										
1968-1970	73,871	47	24,725	56	13,392	45	19,668	45	16,086	42
1965-1967	35,147	22	9,786	22	6,687	22	10,178	23	8,496	22
1960-1964	24,117	15	5,575	13	4,320	14	7,933	18	6,287	16
1950-1959	17,922	11	3,378	7	4,201	14	5,171	12	5,172	14
1949 or earlier	5,764	4	1,011	2	1,304	4	1,145	2	2,304	6
CLASS OF WORKER										
Private	110,666	52	30,282	51	21,621	53	30,926	50	27,837	55
Government	78,708	37	23,260	39	15,038	37	23,139	38	17,271	34
Local Government	16,372	7	4,370	7	2,721	7	5,264	9	4,017	8
Self-employed	6,788	3	1,417	2	1,189	3	2,340	3	1,842	3
Total	212,534	100	59,329	28	40,569	19	61,669	29	50,967	24
AUTOS AVAILABLE										
1	74,497	44	25,000	53	14,327	44	17,569	37	17,601	41
2	60,004	36	14,488	30	10,963	34	21,261	46	13,292	32
3 or more	9,680	5	1,947	4	1,851	6	3,607	7	2,275	5
Total (Autos)	223,545		60,617		39,955		10,912		51,010	
Average (Autos/family)	1.34		1.27		1.25		1.53		1.24	
None	25,179	15	6,291	13	4,518	14	4,815	10	9,555	22
MEANS TRANSPORTATION TO WORK										
Driver	147,958	69	41,186	68	27,647	66	44,972	73	34,153	67
Passenger	30,186	14	8,763	14	6,155	15	8,164	13	7,104	14
Total Autos	178,144		49,949		33,802		53,136		41,257	
Bus	21,906	10	6,633	11	5,096	12	4,448	7	5,729	11
Walked to work	7,965	4	2,070	3	1,334	3	2,079	3	2,482	5
Worked at home	3,352	2	881	1	622	1	1,059	2	790	1
Other	4,107	2	1,092	2	844	2	1,113	2	1,018	2
WORK PLACE										
D.C.-Central Business District	20,095	9	5,973	10	3,967	10	5,920	9	4,235	8
D.C. Remainder	38,259	18	11,536	19	8,079	19	10,331	17	8,313	16
Arlington	40,114	19	11,569	19	8,844	21	13,168	21	6,533	13
Virginia Remainder	88,847	41	23,885	39	15,935	38	24,624	40	24,403	48
Other	28,241	13	7,688	13	4,924	12	7,812	13	7,817	15
Total	215,556	100	60,651	28	41,749	19	61,855	29	51,301	24

[a]Refer to Figure 2 in paragraph 2.3.3.

Source: U.S. Department of Commerce, Bureau of the Census, Census of Population and Housing: 1970 Census Tracts PHC (1)-226, Washington, D.C.-Md.-Va. SMSA, May 1972.

Table 2 compares the Corridor totals for selected 1970 demographic characteristics with data obtained for the District of Columbia and the entire Washington, D.C. SMSA. The same statistics for each of the four Corridor Segments are presented in Table 3.

From these tables, the following demographic statistics can be highlighted:

a. Seven percent of the Corridor population were Negro compared to 25 percent for the entire SMSA.

b. The mobility of the Corridor residents appears quite high, with 47 percent of the people moving into their homes within a 27 month period (March 1968 to 1970) compared to only 41 percent of the SMSA residents and 37 percent of the District residents having moved during this same period. Within the one mile segment, 56 percent of the residents moved into their homes during 1968-1970.

c. About 44 percent of the Corridor workers are government employees, compared to 39 and 42 percent for the SMSA and the District respectively.

d. On the average, 1.34 automobiles per family are available throughout the Corridor, and 41 percent have 2 or more cars. For the SMSA, the average number of cars per family is 1.23, with 36 percent having two or more cars. The District average is 1.13 with only 19 percent having two or more cars available.

e. In 1970 about 83 percent of all work trips originating inside the Corridor were made by auto; the corresponding figure for the SMSA was 73 percent; in the District, only 49 percent of the workers commuted by automobile.

f. Of all Corridor workers, 60 percent were employed in Virginia and 27 percent in the District; of this 27 percent, only one-third were employed in the central business district.

2.3.4. Population Growth

During the 1960-1970 decade the rate of population growth in the Northern Virginia suburbs was among the highest in the Nation. During this period, population in the area increased about 50 percent, from 523,700 to 783,000 persons. For the same period population in the Washington, D.C. SMSA and the Nation's suburban areas increased about 38 and 39 percent respectively.[10]

Since 1970, the rate of population growth in the Northern Virginia suburbs has declined substantially. Of the five jurisdictions in the area, only one, Fairfax County, did not experience a decline in population between 1970 and 1972. In Fairfax County, where three out of every five Corridor residents live, population increased about 5.9 percent between 1970 and 1972, from 455,070 to 482,100 persons.[11]

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[10] U.S. Department of Commerce, Bureau of Census, 1970 Census of Population and Housing, PHC(1)-226, Washington, D.C. -Md.-Va. SMSA, May 1972.

[11] U.S. Department of Commerce Current Population Reports: Federal-State Cooperative Program For Population Estimates Series P-26, No. 39 (Washington, D.C., Govt. Printing Office, June 1973).

SECTION 3. ATTAINMENT OF PROJECT OBJECTIVES

This section describes the degree of attainment of the seven major evaluation objectives disucssed in paragraph 2.1. The first part (paragraph 3.1) describes multiple purpose data collection activities and various types of information used to monitor and analyze the status of the project objectives, and the next seven major paragraphs (3.2-3.8) address each project objective individually. The second part of Objective 1, relating to the importance of transit features in mode choice decisions, is treated in Section 4. Since Section 3 primarily updates and revises earlier findings, its organization parallels that of the First Year Results report.[1]

3.1. Multiple Purpose Data

The monitoring of project objectives attainment has relied on various types of information collected prior to and since the project began, some of which form the basis for more than one project impact analysis. The screenline passenger and vehicle count data, the busway passenger count data, and the October 1971 auto and bus commuter survey results are used for a variety of purposes. This section identifies the different uses of these data, reports the statistics, and presents a general discussion of each data collection method. Other data used for singular purposes are presented in the appropriate sections.

3.1.1. Screenline Data

In 1970, the Metropolitan Washington Council of Governments (COG) began a monthly counting program to monitor person and vehicular volumes in the Shirley Highway Corridor. A screenline was established which intercepts the major radial traffic arteries in the Corridor. Counting stations were established on (1) Arlington Boulevard (Route 50) at Highland Street; (2) Columbia Pike (Route 244) at Walter Reed Drive; (3) Shirley Highway (I-95) just north of Glebe Road; (4) Army-Navy Drive at 28th Street; (5) Arlington Ridge Road just north of Glebe Road (Route 120); (6) Jefferson Davis Highway (Route 1) at Glebe Road; and (7) George Washington Parkway at Four Mile Run. An eighth station on the northbound ramp connecting the Woodrow Wilson Bridge with the Anacostia Freeway (I-295) was added in 1971. Figure 3 shows the locations of the counting stations.

Roadside counts of all inbound buses and passengers were made at each station from 6:30 to 9:00 A.M.[2]. During the same period, visual counts were made and recorded for auto vehicles and auto persons at 30 minute intervals. Each station's counts were made on the same day of the week, to minimize the effect of day-of-the-week variation; counts were not made during inclement weather or other unusual conditions (i.e., accidents, holidays, etc.). Counts (at each station) were made during one morning peak period of each month from March through November 1970. During 1971 counts were made for one morning peak period during March, June, and October. In 1972 and 1973 the counting schedules were identical to those for 1971.

Counts of all persons and vehicles crossing the screenline on the eight major highways within the Corridor provided data on travel volumes. A complete listing of all A.M. peak period traffic data for each screenline data is presented in Appendix A. For each count, the following data were collected: auto persons, autos, auto occupancy, bus passengers, and buses.

3.1.1.1. Traffic Flows Across the Screenline

By monitoring the traffic flows across the screenline, changes in mode utilization, auto traffic volumes, and auto occupancy, as well as variations in utilization of major Corridor roadways, can be observed. In April 1970, approximately 48,280 auto person trips

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[1] "The Shirley Highway Express-Bus-on-Freeway Demonstration Project/First Year Results, Interim Report 2."

[2] Bus passenger data for the Shirley Highway are gathered by the transit operator as part of the busway counting program, discussed later in 3.1; see page 18.

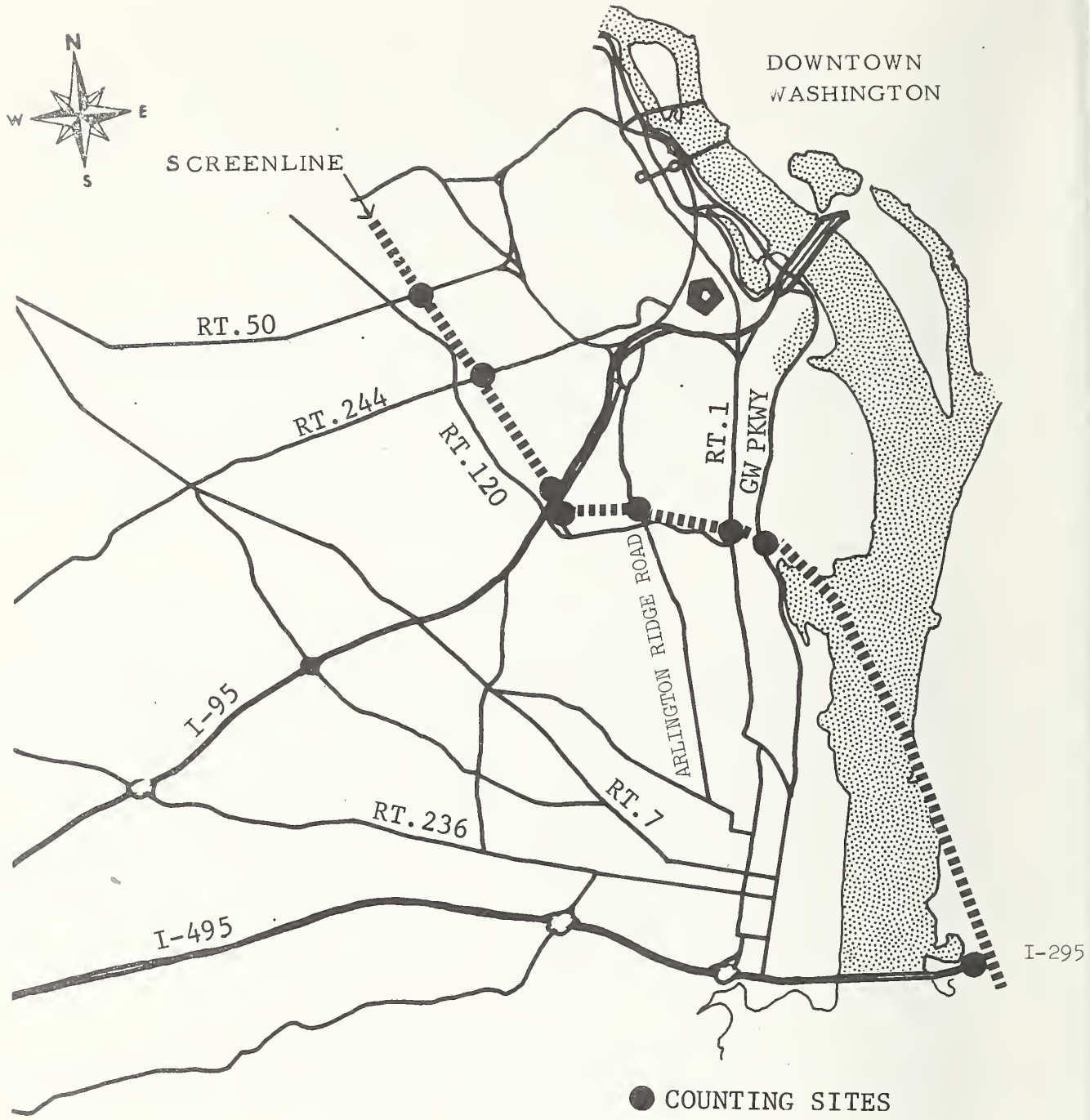

Figure 3. Screenline Location

crossed the seven-station screenline during the A.M. peak period. In October 1971, this volume had fallen to 42,900 trips. During June 1973, the number of auto person trips regained its earlier level of 48,250.

During the same period, Corridor bus person trips increased 44 percent, from 13,800 in April 1970 to 16,400 in October 1971, to 19,900 in June 1973. Also, the "bus percentage" of the total person trips crossing the screenline increased, rising from about 22 percent in April 1970 to over 29 percent in June 1973.

Since June 1972 the number of total person trips crossing the seven station screenline (I-295 not included) has shown steady growth. Highlighting this development is the June 1973 count, which shows the greatest number of persons (total) crossing the screenline since the counting program was initiated (68,200). Although the number of June 1973 auto person trips crossing the screenline was high, it was not the highest ever observed; however, the June 1973 bus and total person trips crossing the screenline were maximums.

While aggregate statistics disclose interesting developments, information for auto volumes on the Shirley Highway and six other major radial roadways (I-295 is not included) accents dramatic changes. The number of autos observed on the Shirley Highway from 6:30 - 9:00 A.M. (inbound) in June 1973 (11,400) had swelled to nearly twice the March 1973 figure (6,400) and was about 2,000 vehicles greater than ever before observed. This sharp increase was effected primarily by a sizeable shift of autos from the other six major arterials to the Shirley Highway, induced by the opening of a new section (with 3 to 4 lanes for autos) which prior to May 1973 was under construction (with 2 to 3 lanes open for autos). Attending this remarkable growth in auto volume on the Shirley Highway were record lows for auto volumes on Arlington Boulevard, Columbia Pike, and Mount Vernon Drive, and auto volumes on each of the three remaining routes were below those observed in March 1973.

As a result of this increase in auto volume, the once dominant person trips by bus on the busway assumed a subordinate position to Shirley Highway auto person trips in June 1973, after maintaining the lead for nearly 18 months as shown in Figure 4. Despite the decline in bus person trips relative to those by auto, the absolute number of bus persons on the Shirley Highway continues to mount.

3.1.1.2. Auto Occupancy Trends

Corridor-wide auto occupancy rates have shown a downward trend since 1970, going from an average of 1.44 between April 1970 and December 1970 (at the beginning of the screenline counts) to 1.34 persons/auto between July 1972 and June 1973. (Similar data for the 14th Street Bridge crossings (see Table 4) also show a decline in auto occupancy rates between 1970 and 1972 for District of Columbia bound Northern Virginia commuters.) In addition to annual auto occupancy rates (Corridor-wide averages), rates are also compared by season, since auto occupancy appears to be dependent on the time of the year. As shown in Figure 5, the seasonal auto occupancy rates (also Corridor averages) also show steady declines. Detailed seasonal auto occupancy data are also presented in Appendix A.

If the declines in auto occupancy rates had been caused primarily by auto passengers (as opposed to auto drivers) switching to the bus service, some of the benefits of the bus will be much less, particularly the reduction of auto air pollution emissions and the conservation of gasoline. This does not appear to be the case for the demonstration project, since 1) auto occupancy was already declining at the time the project began (the project began in April 1971 and the May 1971 occupancy rate of 1.53 represented a 4 percent decline from May of 1970); 2) as Table 5 shows, auto occupancy had been declining throughout the metropolitan area and not only in the Corridor where this major transit improvement was implemented (although the Corridor (Potomac) bridges had the largest decline in auto occupancy rates, going from 1.59 in May 1970 to 1.44 in May 1972); and 3) the October 1971 survey showed that of the bus passengers switching from auto, more than half had formerly driven alone.[3]

Table 4

A.M. Peak Period Auto Occupancy on 14th Street Bridge[a]

PASSENGERS PER AUTO	NO. OF AUTOS AT 7:00 A.M.			NO. OF AUTOS AT 8:00 A.M.		
	1970	1971	1972	1970	1971	1972
1	4,071	4,201	4,344	3,574	4,012	4,144
2	1,731	1,740	1,373	1,693	1,778	1,310
3	457	431	386	347	486	294
4	265	254	250	224	215	170
5	162	151	54	125	120	39
6	23	36	71	41	28	72
TOTALS	6,709	6,813	6,478	6,004	6,639	6,029
Occupants	10,912	10,961	9,944	9,768	10,654	8,953
Auto Occupancy	1.63	1.61	1.54	1.63	1.60	1.48

[a]Data were collected on a single day in May of each year. Source: D.C. Department of Highways and Traffic, "D.C. Cordon Traffic Survey, 1970, 1971 and 1972."

[3]"Shirley Highway Express Bus on Freeway Demonstration Project/First Year Results," page 70.

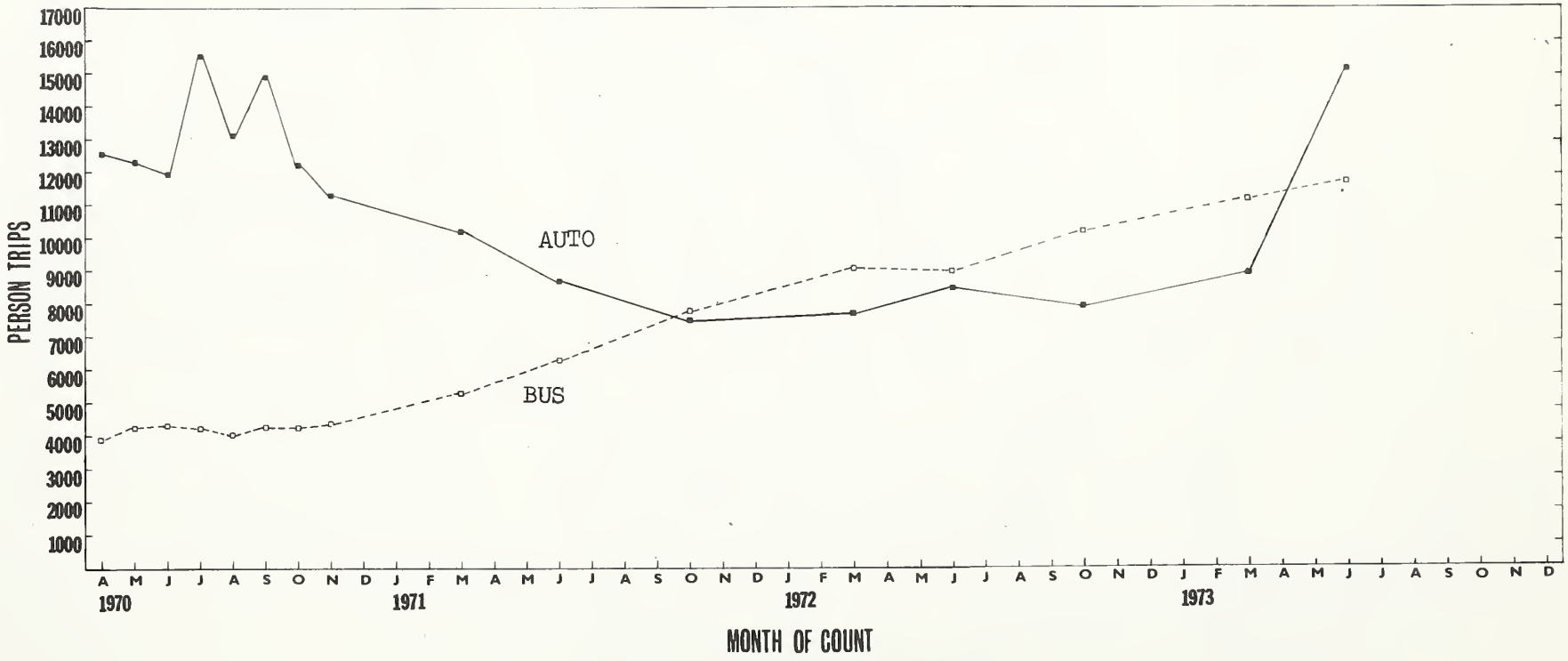

Figure 4. A.M. Peak Period (Inbound) Traffic Volumes on Shirley Highway.

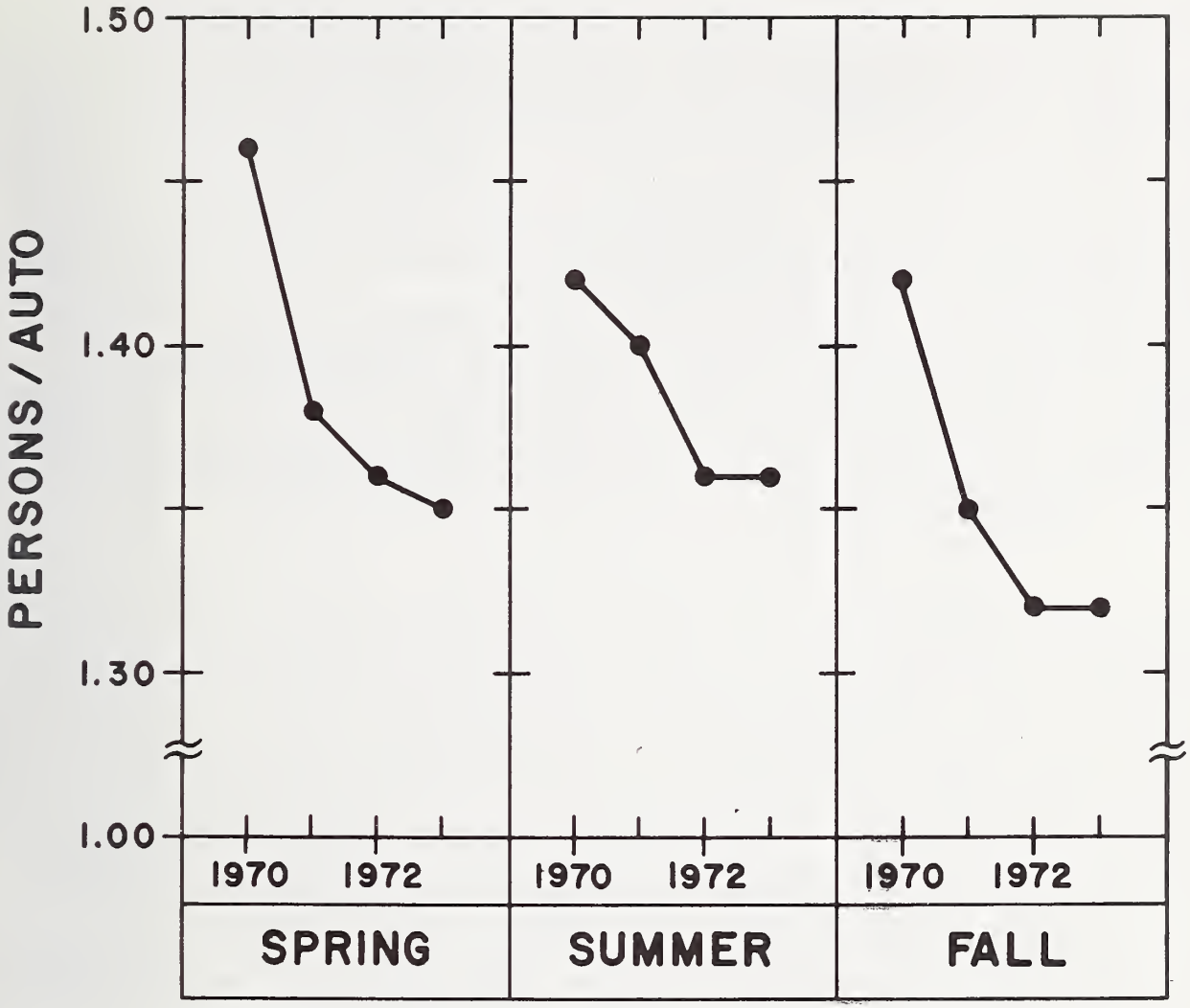

Figure 5. Trends in Corridor Auto Occupancy (Inbound A.M. Peak Period).

Table 5

A.M. Peak Period Auto Occupancy Rates for the District of Columbia[a] (Inbound A.M. Peak Period)

	May 1970	May 1971	May 1972
Potomac River Bridge	1.59	1.53	1.44
Western Avenue	1.42	1.37	1.35
Eastern Avenue	1.49	1.43	1.39
Southern Avenue	1.46	1.39	1.41

[a]Data were collected on a single day in May of each year. Source: See Table 4.

3.1.1.3. Screenline Bus and Auto Volume Variability

As noted earlier, screenline bus and auto volume counts are ordinarily made three times a year (one day in March, June and September or October) at each of the eight sites. To examine the reliability of these single counts, observations were performed one day in three successive weeks at the four major stations (Columbia Pike, Shirley Highway (auto traffic only), Jefferson Davis Highway, and George Washington Parkway) for the October 1972 and March 1973 counting periods. Appendix A shows these observations and presents a variability analysis.

The analysis for October 1972 (Table 30, Appendix A) indicates stability for the multiple counts recorded at Columbia Pike (all statistics -- auto persons, vehicles and occupancy rate, and bus passengers), the Shirley Highway (all statistics except auto occupancy) and Jefferson Davis Highway (all statistics). The observed levels of auto passengers and vehicles, bus passengers, and total persons for each of the stations ranges within 5 percent of the mean value.

The data taken at the George Washington Parkway site indicate wide deviation from the means (of the multiple observations), especially with respect to auto persons and vehicles, auto occupancy, and total persons. Two of these counts show auto persons varying in excess of 10 percent from the average figure. A fourth count taken at this site in November 1972 indicated continued fluctuation in traffic on the Parkway.

As Table 30 indicates, the March multiple count auto passenger and vehicle statistics on each of these major arterials exhibited a greater stability; for each of the three counts, deviation from the mean is less than 5 percent (including the George Washington Parkway). Unfortunately auto occupancy continues to vary on all routes except the Jefferson Davis Highway.

The mean of the multiple counts at the respective screenline sites will be used as estimates for October 1972 and March 1973 in all subsequent analyses. The mean of the four counts will be used as the October 1972 estimate on the George Washington Parkway, although statistics for that date will be regarded as less reliable than those for other stations.

3.1.1.4. Potential Screenline "Leaks"

As described earlier, there are eight screenline counting stations on the major radial traffic arteries in the Northern Virginia Corridor (see Figure 3, Page 14). These sites were established to intercept the Corridor-wide A.M. peak period bus and auto person, and vehicle volumes. All of the buses are counted at these locations, but there are a few secondary streets which represent potential "leaks" for auto trips through the screenline. An inspection revealed that there are eight such streets, but that each is unlikely as a portion of Corridor commute trips. All are narrow and wind through residential areas with frequent stops at intersections; also some are routed over hills.

In March 1972, vehicle counts were made at four of the major "leak" locations: Second and Eighth Streets between screenline stations 1 and 2; Ridge Road extending to Glebe Road between stations 4 and 5; and Eads Street between stations 5 and 6. There were about 2500 auto vehicles observed at these four sites. It is likely that most commuters will be unwilling to include these circuitous routes as parts of their commuting trips, and that most of the 2500 autos are for trips destined for internal locations and as such are properly excluded from the screenline count total. Nonetheless, even if <u>all</u> of these autos were involved in Corridor commuting trips (see paragraph 2.3), they would represent only about 9 percent of the potentially affected autos crossing the screenline (George Washington Parkway is not likely to be affected).

3.1.2. Busway Passenger Counts

One of the most important aspects of the Shirley Highway Demonstration Project is the improvement of bus transit service with an exclusive busway. In order to monitor the impact of this innovation on patronage, visual roadside counts of passengers riding on the Shirley busway during the A.M. peak period were begun in September, 1969 (at the opening of the first section of busway).[4] P.M. counts were initiated in September 1970.

The busway became operational incrementally, beginning with the southern portions and proceeding northward to the 14th Street Bridge. The counting program developed in a parallel manner. The first A.M. peak period counts (in September 1969) were taken at entrances south of Shirlington (routes entering here were the first to offer busway service). While monthly counts continued for points south of Shirlington, a new leg of the busway was opened, offering access to Shirlington Circle area buses, and corresponding counts were instituted.[5] Counts on routes which enter the busway in the Pentagon region began in April 1971 (both A. M. and P. M. peak period operations) to accompany the opening of the

[4] Because of the many counting locations, the passenger counts are made over a two or three day period with no specific days for any location. They are, however, summarized and presented as if collected on one day.

[5] Both A.M. and P.M. peak period counts were initiated for Shirlington Area buses in September 1970. P.M. counts for the south of Shirlington routes were also begun at this time.

last temporary section of the busway.[6] Milestones in the development of the demonstration project are presented in Figure 6, along with corresponding trends in patronage development.

Appendix B summarizes the A.M. peak period passenger and bus assignment trends for WMATA and NVTC bus operations over the entire busway,[7] and stratified into three main classifications: buses entering the busway south of Shirlington Circle, at Shirlington Circle, and north of Shirlington Circle in the vicinity of the Pentagon. "Passengers-per-bus" statistics are also included.

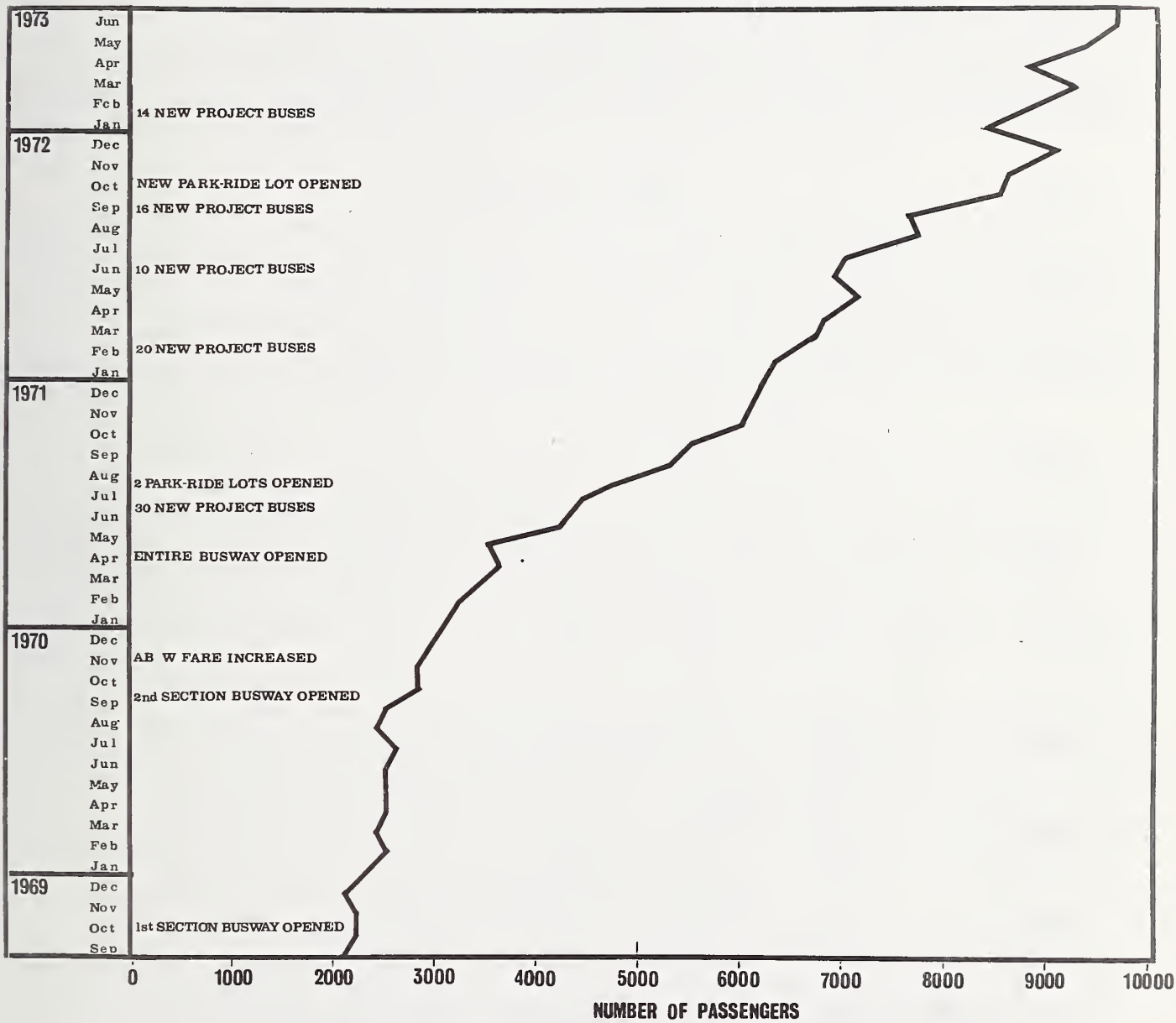

Figure 6. Project Development and Trends in Patronage Growth (Routes Entering Busway South of Shirlington).

[6] After September 1971 these counts have not been made regularly; however, routes entering the busway here experience only a nominal time savings and patronage has remained at or below, the April 1971 level.

[7] Information for the P.M. peak period passengers and buses is available, but for simplicity is omitted from this report since the A.M. and P.M. peak period data reflect the same trends.

Figure 7 highlights the passenger trends, showing that all of the busway patronage growth since April 1971 is attributable to the routes which enter south of Shirlington [8] in contrast with the relatively static conditions of the other busway routes. (The large increases in September 1970 and April 1971 do not indicate growth, but rather signify the incorporation of Shirlington and Pentagon area buses, respectively, into the total busway figure.) The total A.M. rush period busway patronage has peaked at slightly over 14,000 persons (April 1973), and patronage for the Shirlington and south of Shirlington area routes combined was nearly 12,000 persons for the 2-1/2 hour morning rush period during June 1973.[9] Most of this growth has occurred since September 1970, when the second section of busway, which bypassed a highly congested area on the Shirley Highway, was opened.

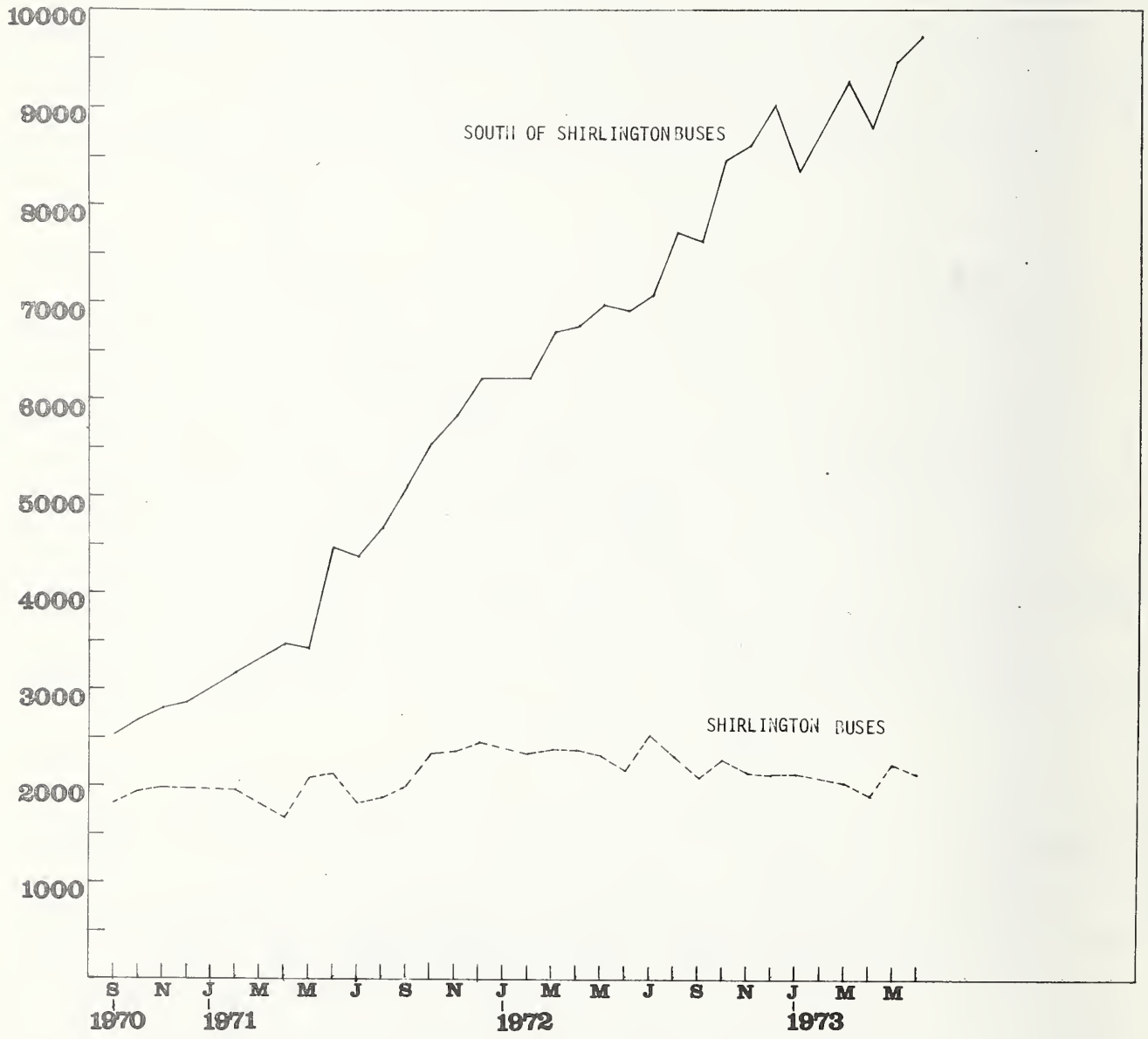

Figure 7. Trends in Busway Patronage (Inbound A.M. Peak Period).

[8] The greatest time savings are experienced by persons using these routes.

[9] Total figures are not available for months when Pentagon area counts were omitted. This includes October 1971, March and April 1972, June through November 1972, January through March 1973, and May and June 1973; also, the busway passenger counts do not include patronage on "Other" buses; see paragraph 3.2.

3.2. Increase in Bus Market Share

A primary measure of effectiveness of the Shirley Highway Bus-on-Freeway Project is bus market share, the percentage of total project trips that are made by bus. A "project trip" is defined as a person trip by auto or bus, beginning and ending in the project area and crossing the screenline during the A.M. peak period, 6:30 to 9:00 A.M. The project area corresponds to the region where commuters represent potential users of buses. This area has a residential portion where trips originate, and an employment portion where the trips end. Hence, in order to estimate bus market share, estimates both of potential bus trips (i.e., the bus market) and of trips actually made by bus are required.

The bus trips include persons on all buses originating in the Corridor, specifically NVTC ("project buses") and all WMATA (non-project) buses operating on the busway; buses within the Corridor but not on the busway; and "other buses," commuter buses operated on the busway by companies such as Greyhound, Colonial Transit, and Trailways. "Bus market share" is defined as the share determined by all of these buses.

3.2.1. Estimating Bus Market Share

The percent of person trips by bus crossing the seven station screenline increased from about 22% in April 1970 to over 29% in June 1973.[10] If all the auto and bus person trips counted at the screenline actually began in the Corridor and ended in the destination areas, these percentages would equal the respective bus market shares. The person trips crossing the screenline do not, however, all begin and end within the project areas. Removing from the screenline counts those auto trips that could not possibly have been made by bus assures that the remaining auto flow represents the potential additional market for bus. (However, this ignores the need of some persons for a car during their work day.)

3.2.2. Adjusting Screenline Counts Using the October 1971 Commuter Survey Results

Some persons crossing the screenline do not begin their trips in the Corridor. These are primarily automobile through-trips beginning in the southern counties of Virginia or Maryland, or in other states; also, some bus person trips originate outside the Corridor. Primarily these are bus commuters living in the vicinity of the Crystal City and Pentagon employment centers, both outside of the residential portion of the Corridor. In order to estimate the number of project person (automobile and bus) trips, it is necessary to remove those trips which originate outside of the residential portion of the Corridor (i.e. the non-project trips).

Since detailed data on Corridor commuting patterns for 1972 and 1973 were not available, estimates of non-project trips for these years were obtained by assuming a percentage for "through-trips" for (1) automobiles based on the license plate sample of auto screenline crossings in the October 1971 auto commuter survey; and (2) bus riders based on residences as reported in the October 1971 bus commuter survey. The percentages were then applied to the 1972 and 1973 screenline counts to obtain estimates of non-project trips. Obtaining the bus percentage was quite straightforward since it is the ratio of the number of bus commuters whose destinations lie outside the three employment centers to the number of bus commuters; however, obtaining the auto percentage was much more involved.

To estimate the percentage of autos with Virginia tags that represent trips beginning in the Corridor, a sample of all Virginia tags crossing the screenline were recorded and these tag numbers were matched against the Virginia Department of Motor Vehicles records of registered owners' addresses in the counties of Fairfax, Arlington, and Prince William, and in the cities of Fairfax, Alexandria, and Falls Church. The percentage of licenses that did not match the addresses in these nearby counties and cities is an estimate of the Virginia trips that do not begin in the area influenced by the busway. In general, such trips originated in the southern and western portions of the state.

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[10] "Other buses" are not counted at the screenline.

3.2.3. Bus Market Share Estimates

A relationship was established between the screenline person trip counts and the estimated number of project trips. The October 1971 commuter survey indicated that, of the trips crossing the screenline, approximately 54.7 percent of the auto person trips and 88.8 percent of the bus person trips were project trips. Estimates of project trips in October 1972 and June 1973 were developed from their respective screenline counts and adjusted using the October 1971 ratios. (The stability of these ratios will be investigated after analyzing the data from Fall 1973 Bus Survey.)

Table 6, Columns 2 and 4, presents the screenline person trip totals for October 1971, October 1972 and June 1973. Columns 3 and 5 present estimates of the project trips based upon the non-project trip percentages obtained from the October 1971 counts. The resultant market-share estimates are shown in column 6. Figure 8 illustrates (estimated) bus market share trends since 1968.[11]

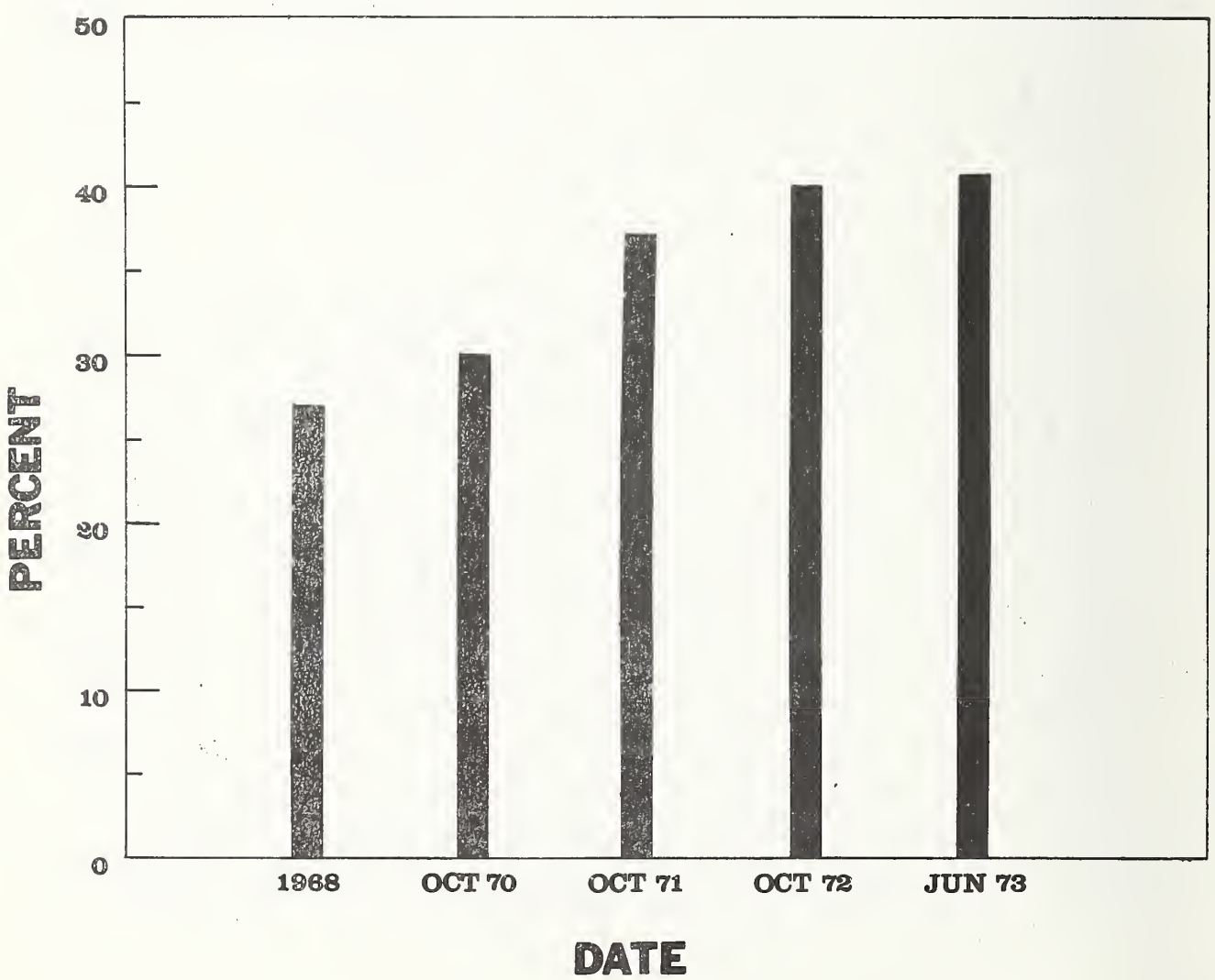

Figure 8. Trends in Corridor Bus Market Share (Inbound A.M. Peak Period).

[11] The computations for the 1968 and October 1970 bus market share estimates appear in the First Year Results Report, pages 21 and 22.

Table 6

Estimates of Corridor Bus Market Share for October 1971, October 1972, June 1973

DATE	AUTO PERSONS AT SCREENLINE	PROJECT AUTO PERSON TRIPS	BUS PERSONS AT SCREENLINE	PROJECT BUS PERSON TRIPS	TOTAL PROJECT PERSON TRIPS	BUS MARKET SHARE ESTIMATES (PERCENT)
Oct 1971 8 Stations	48,008	26,260	17,567[1]	15,599	41,859	37.3
Oct 1972 8 Stations	48,336	26,440	20,050[1]	17,804	44,244	40.2
Jun 1973 8 Stations	52,671	28,811	22,144[1]	19,664	48,475	40.6

[1]Includes estimates of patronage on the "Other" buses.

The slight increase in bus market share from October 1972 (40.2%) to June 1973 (40.6%) masks the substantial growth in the number of persons observed crossing the screenline by bus in June 1973. While the number of bus persons continued to mount, the large increase in auto persons more than offset the June increase in bus passengers.

The effects on market share estimates of assuming the stability of the percentage ratios of project trips to screenline counts can be examined by varying both the auto and bus total screenline ratios (in October 1971 these were 54.7% for auto persons and 88.8% for bus persons). Varying both of these ratios by ± 5% or ± 10% produces the market share estimates displayed in Table 7.[12] Estimates of market share for the Fall of 1973 will utilize the November 1973 commuter survey responses.

Table 7

Sensitivity Analysis of Bus Market Share Estimates

RATIOS VARY BY	OCT 72 (PERCENT)	JUN 73 (PERCENT)
0% Auto 0% Bus	40.2	40.6
- 5% Auto + 5% Bus	43.9	44.2
+ 5% Auto - 5% Bus	36.8	37.1
-10% Auto +10% Bus	47.8	48.2
+10% Auto -10% Bus	33.6	33.9

[12]Screenline counts variations were within a 5 percent range (see paragraph 3.1.1.2).

3.3. Impact of the Demonstration Project on the Transit Operator

3.3.1. Introduction

One of the most important incentives for providing transit system improvements, such as a busway, is to promote the economic viability of the operator. Since World War II most bus transit operations have engaged in a continuing reduction of bus service in hopes of reducing costs and increasing net income; however, these reductions have contributed to accelerated patronage losses and have not brought about increased financial solvency among bus transit operations.[13] The busway and other project elements represent attempts to reverse this trend by attracting new bus passengers through an upgrading and expansion of transit service, and by increasing the efficiency of transit operations.

This section focuses on three areas of impact of the Shirley experiment on the Alexandria Division of WMATA (formerly the AB&W Transit Company):

1. Patronage - The increase in bus passengers attributable to the busway is highlighted.
2. Productivity - Operating cost savings attributable to the busway are estimated.
3. Financial status - Operating costs and revenues for project bus operations are explored and the demand response to bus service expansion is investigated.

The following distinctions were made in Corridor bus operations for the analysis of the impacts of the demonstration project on the Alexandria Division of WMATA: 1) Buses used in WMATA busway operations which are administered by NVTC are referred to as "project" or NVTC buses; 2) Other buses used in WMATA managed busway operations are referred to as "non-project" or WMATA buses; 3) Buses used in WMATA non-busway operations which are administered by NVTC are referred to as NVTC base day buses; and 4) Buses used in WMATA managed non-busway peak-period operations are referred to as non-busway buses.

3.3.2. Impact on Patronage

The Alexandria Division of WMATA provides bus service during three general time periods each weekday: (1) A.M. and P.M. peak periods, (2) mid-day period, and (3) evening period. Although an increase in bus ridership during any period would be welcomed, the demonstration project focuses on peak periods because of mounting problems of congestion and air pollution.

3.3.2.1. Peak Period Patronage

While patronage remains stable or declines on all non-busway routes, an increasing number of peak period commuters are switching from autos to buses using the busway. (The evolution of busway operations and attendant patronage gains are presented in paragraph 3.1, page 13.) These increases for the busway routes have offset passenger losses for the remainder of the system and established a positive patronage trend for the entire WMATA Alexandria Division. This is occurring primarily because the reserved lanes guarantee speedy, reliable trips for bus users by allowing higher operating speeds and improving schedule adherence during the A.M. and P.M. peak periods,[14] while in contrast, autos may experience major delays due to congestion effects on the regular lanes of the Shirley Highway and the other major Northern Virginia arterials radiating from Downtown Washington, D.C.

Periodic (busway) passenger counts, discussed in paragraph 3.1, indicate substantial peak period patronage increases on those WMATA routes which benefit most by the use of the

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[13] "Historical Overview of the Decline of the Transit Industry" by A. Saltzman and R.J. Solomon, Highway Research Record #417, Highway Research Board, Washington, D.C., 1972; "Economic Characteristics of the Urban Public Transportation Industry," Institute for Defense Analyses, done for the Department of Transportation, Washington, D.C., February 1972, Chapter II, part B and Chapter III.

[14] Travel time changes resultant from the busway are analyzed by a "before" and "after" comparison in the First Year Results Report, section 3.6 , pages 55 and 56. Recent results of travel time field checks for the line haul portion of the bus trip (from the last stop before a bus enters the busway to 14th & C Streets, to the first stop after buses exit from the busway) are summarized in paragraph 3.7 of this report. Paragraph 3.8 summarizes the results of schedule adherence checks.

busway. Some of this growth began with the opening of the initial portion of the busway prior to the introduction of project service in June 1971, and the rate has accelerated since then. During the same period, transit patronage was declining throughout the Washington Metropolitan area.[15]

Buses entering the busway south of Shirlington experience the greatest time advantage and have yielded the largest increases in patronage. Table 8 presents the history of growth on these routes. Patronage declines for Routes 7, 8 and 17 from December 1972 to March 1973 reflect a smaller number of buses counted for these routes on those dates. The large increases in June 1971 attend the initiation of project service and the incorporation of 30 additional buses. Passenger statistics for Route 6, and those variants of Routes 7 and 8 which enter the busway at Shirlington Circle are available; but, as Figure 7, page 21 reveals, these routes exhibit stable patronage and so are not spotlighted. (A detailed discussion of routes using the busway is presented in Appendix F.)

Average bus occupancy is highlighted in Figures 9 and 10. Note that although bus service has been continuously expanded, buses operate at, or above, seated capacity (the dotted horizontal line represents the seated capacity of these buses). The dip in passengers per bus around June 1971 signifies the lag in market adjustment to the increased capacity afforded by the 30 additional buses being placed into service. Thus, it appears that the number of buses in service in a particular time has acted as a constraint on patronage, and as bus fleet size has been expanded peak period patronage has increased.

Although peak period patronage has grown quite rapidly, off-peak patronage has not. Special passenger counts for NVTC off-peak operations conducted during 1972 revealed low stable patronage levels for all routes except the 17's and 18's (see table 9). Routes 17 and 18 exhibit gradual growth trends, but are operating at levels far below capacity. (Service was initiated on Route 4 on September 5, 1972, and Route 26G was discontinued September 5, 1972, because of low ridership.) Reliable patronage information by route for non-NVTC operations is not available.[16]

3.3.2.2. Peak Relative to Total Daily Patronage

Peak period bus riders are a subset of total daily ridership. A large peak period ridership relative to total daily ridership is important because it impacts heavily on resource inventory and allocation. Most transit operations experience sharp peak demands which are of limited duration. Therefore recovery of operating and capital costs is difficult because the operator is forced to hire drivers and purchase equipment for the peak periods in numbers which greatly exceed his needs for the remainder of the day.

NVTC administered operations include mid-day (base day) service as well as peak period service. In December 1972, daily peak period riders represented approximately 91.5 percent of NVTC daily ridership, 10075 of 10981 riders. The 906 base day ridership figure was taken from passenger counts on NVTC base day bus service (see Table 9).

Because of this sharp peaking phenomenon, two developments would have extremely beneficial impacts on the bus operator: (1) increased off-peak patronage, and (2) more efficient utilization of drivers (and vehicles) during the peak period. Increased off-peak patronage would result in increased revenue at low marginal costs. Strategies for increasing off-peak patronage (and revenues) are being sought in an on-going investigation by NVTC. Increases in productivity resultant from the use of the busway have permitted the bus operator to perform additional trips during the peak periods without a corresponding increase in resources.

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[15] See Appendix C, p. 38 and Appendix D, p. 39 Eleventh and Twelfth Annual Reports of the Washington Metropolitan Area Transit Commission for the periods July 1, 1970 to June 30, 1971 and July 1, 1971 to June 30, 1972, respectively.

[16] Statistics for these operations were presented in the First Year Results Report for May and October of 1970 and 1971, based upon driver manifest counts. A follow-up investigation of these procedures revealed the unreliability of driver manifests for estimates of passengers carried.

Table 8

Trends in Patronage for Routes Entering Busway South of Shirlington Circle (Inbound A.M. Peak Period)

MONTH OF COUNT	PASSENGERS				
	Rt.7	Rt. 8	Rt. 17	Rt. 18	Rts.19,27, 28 &29
Sep 69	720	789	218	368	
Oct	801	784	228	351	
Nov	875	825	214	321	
Dec	745	762	250	301	
Jan 70	865	847	233	344	
Feb	879	881	240	364	
Mar	890	883	246	355	
Apr	1031	841	243	340	
May	994	825	228	365	
Jun	972	922	248	361	
Jul	992	859	264	352	
Aug	914	848	269	376	
Sep	981	843	276	406	
Oct	1015	922	336	414	
Nov	1072	967	336	443	
Dec	1098	967	343	447	
Feb 71	1257	1034	379	506	
Apr	1374	1105	420	582	
May	1328	1125	393	575	
Jun	1703	1214	530	729	297
Jul	1620	1134	525	723	396
Aug	1587	1125	594	857	515
Sep	1659	1218	696	964	581
Oct	1783	1248	735	1086	699
Nov	1901	1279	823	1132	714
Jan 72	1896	1441	896	1189	801
Feb	1906	1341	850	1262	878
Mar	1964	1415	876	1366	1103
Apr	1926	1367	939	1364	1164
May	2028	1432	944	1412	1176
Jun	1942	1407	921	1369	1298
Jul	1938	1407	850	1436	1443
Aug	1994	1554	1019	1552	1603
Sep	1981	1357	1185	1540	1578
Oct	2081	1485	1332	1868	1731
Nov	2042	1442	1363	1898	1885
Dec	2137	1510	1483	1911	1988
Jan 73	1843	1309	1360	1912	1954
Mar	1800	1392	1393	2210	2464
Apr	1695	1195	1301	2246	2377
May	1806	1338	1581	2265	2483
Jun	1914	1407	1583	2278	2547

Source: Unpublished busway patronage data from the Washington Metropolitan Transit Authority.

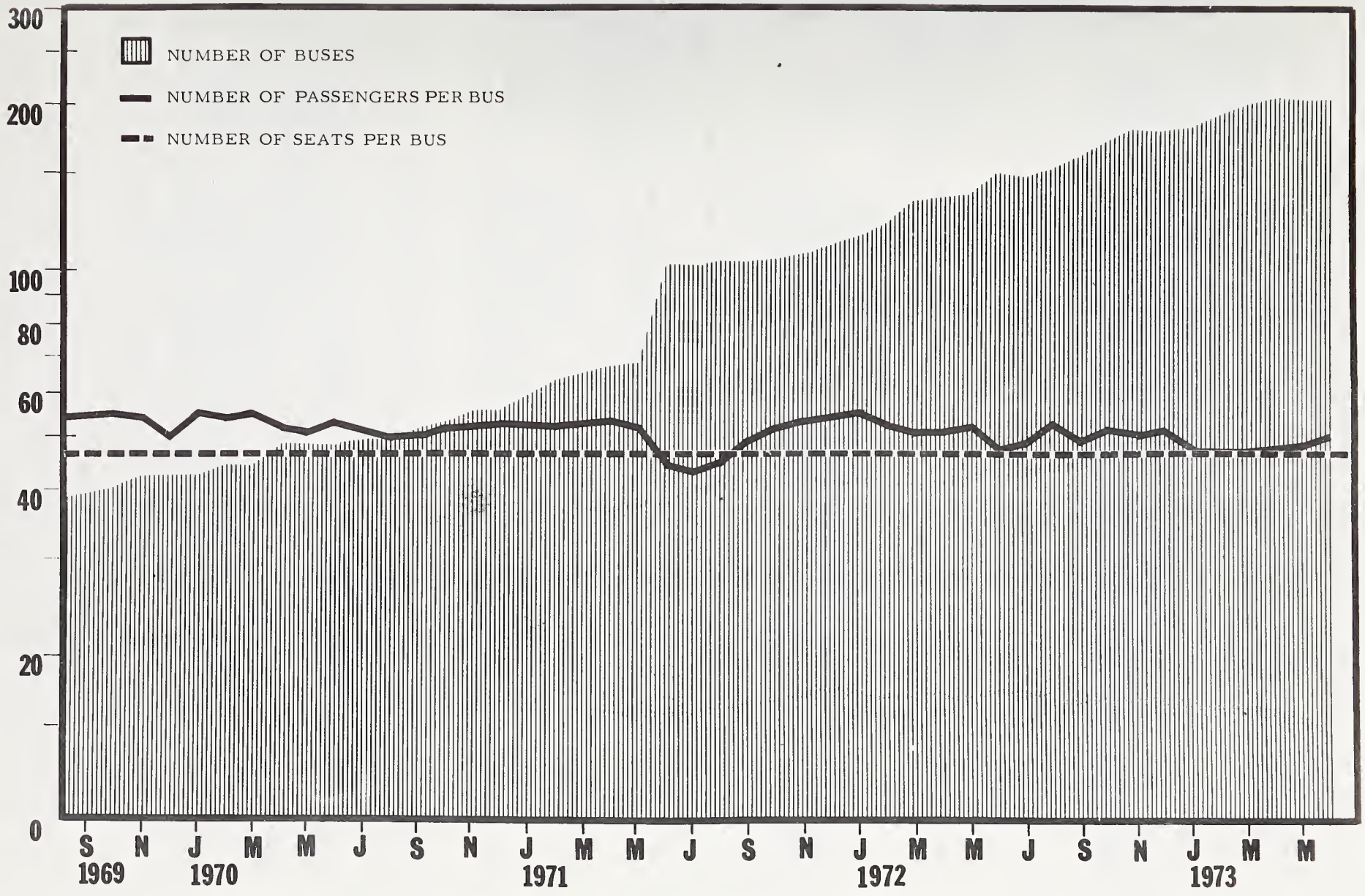

Figure 9. Trends in Busway Passengers Per Bus (Inbound A.M. Peak Period).

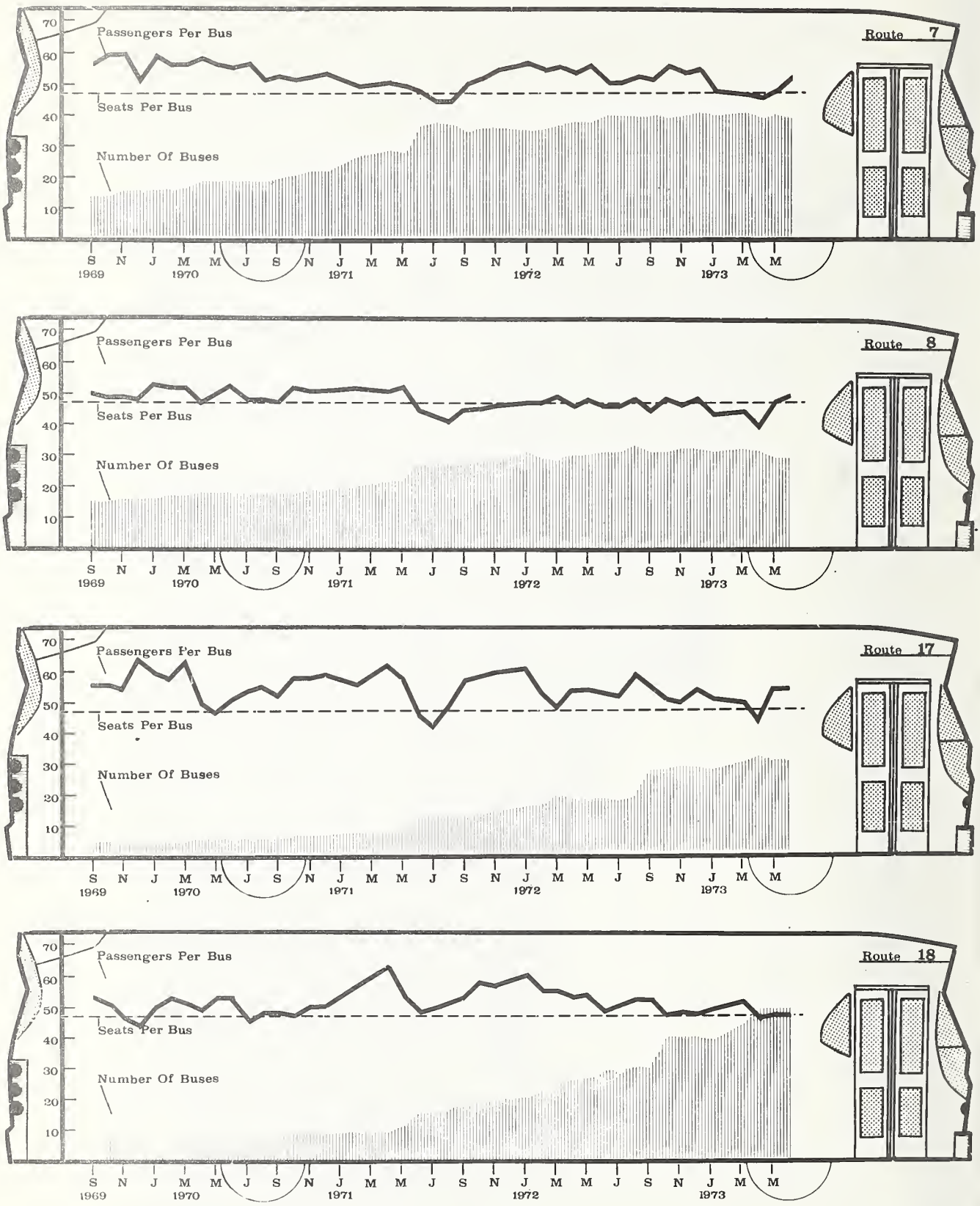

Figure 10. Trends in Passengers Per Bus for Routes 7, 8, 17 and 18. (Inbound A.M. Peak Period).

Table 9

Trends in Base Day Patronage During 1972

ROUTE	FEBRUARY		APRIL		AUGUST		DECEMBER	
	PASSENGERS	PASSENGERS PER BUS	PASSENGERS	PASSENGERS PER BUS	PASSENGERS	PASSENGERS PER BUS	PASSENGERS	PASSENGERS PER BUS
1A,B	97	6	233	15	213	13	233	15
3A	69	9	58	7	63	8	79	10
4L							108	6
17G,H	68	3	139	5	175	6	226	7
18G,H	113	4	171	6	251	9	260	9
26G	30	1	39	1	20	1		
Total	367	5	640	7	722	7	906	9

3.3.3. Impact on Operator Productivity

Operator productivity concerns the utilization of resouces in providing Corridor bus service. Information used to gauge operator productivity should be stratified by route and by peak and off-peak operations, and should include the following statistics: (1) operating hours, (2) vehicle miles, (3) required vehicles and (4) frequency of service. With these statistics, changes in productivity can be estimated for various changes in transit operations, in this case the introduction of the busway.

The data required for comparison of busway and non-busway- operations were not available, and therefore a direct analysis of operator productivity was not possible; however, the staff at WMATA was able to provide estimates of required vehicles with and without the higher operating speeds possible with the busway.

To maintain the March 1973 peak period headways without the busway would require approximately 17 additional buses. This represents monthly savings of approximately $26,600 in both capital and operating costs. (It should be noted that without the busway time advantage, these headways would probably not be required since the passenger demand would not require this capacity.)

3.3.4. Impact on Financial Status: Results of the Cost Allocation Study

In order to explore in more detail the economic impacts of the project service, monthly operating costs and revenues were allocated by line and by type of service (peak or off-peak).[17] The procedures used to allocate costs are discussed in Appendix C. Note that this algorithm weights peak-period operations more than off-peak operations due to the higher peak-period vehicle and operator requirements. About 40 percent of the total operating cost is allocated to peak period service alone; the remaining 60 percent is distributed between peak and off-peak operations so that approximately 80 percent of total costs are attributed to peak period service.

Estimated costs of providing project bus service by line and by peak and off-peak periods are summarized in Table 10. Costs are provided for the second half of 1971, the first half of 1972, and the second half of 1972. Corresponding estimates of revenues and net income are also included. Revenues by line were estimated using average peak and off-peak fares developed by the NVTC.

[17] The term "line", as used here, is equivalent to major route designation (e.g. Route 7,8, etc.). Hereafter, these terms will be used interchangeably.

Table 10

Project Operating Expenses and Revenue by Route[a]

ROUTES	LAST HALF 1971			FIRST HALF 1972			LAST HALF 1972		
	EXPENSES	REVENUES	INCOME	EXPENSES	REVENUES	INCOME	EXPENSES	REVENUES	INCOME
Peak									
2G	40,199.	30,654.	(9,545.)	50,317.	45,526.	(4,791.)	60,039.	68,653.	8,614.
3G				2,389.	1,644.	(745.)	27,185.	18,267.	(8,918.)
4	34,651.	43,276.	8,625.	91,319.	90,723	(596.)	137,132.	148,297.	11,165.
6	24,595.	26,431.	1,836.	29,901.	30,515.	614.	27,316.	32,674.	5,358.
7	49,306.	63,747.	14,441.	63,233.	79,161.	15,928.	70,511.	95,290.	24,779.
8	29,338.	25,507.	(3,831.)	37,794.	33,682.	(4,112)	36,237.	44,464.	8,227.
17	42,908.	48,554.	5,646.	80,601.	77,789.	(2,812.)	121,479.	138,140.	16,661.
18	47,684.	64,740.	17,056.	101,524.	110,149.	8,625.	152,184.	170,240.	18,056.
19	23,189.	21,163.	(2,026.)	32,513.	31,238.	(1,275.)	35,737.	40,294.	4,557.
S Total	291,870.	324,072.	32,202.	489,591.	500,427.	10,836.	667,820.	756,319.	88,499.
Base									
1A	28,183.	3,971.	(24,212.)	32,728.	10,267.	(22,461.)	31,046.	11,788.	(19,258.
3A				6,418.	3,755.	2,663.)	7,831.	3,625.	(4,206.)
4L							15,647.	5,545.	(10,102.)
17	20,731.	5,954.	(14,777.)	30,485.	9,608.	(20,877.)	36,697.	14,064.	(22,633.)
18	21,364.	11,196.	(10,168.)	37,959	12,743.	(25,216.)	39,524.	19,790.	(19,752.)
26				16,561.	2,016.	(14,545.)	8,430.	1,322.	(7,108.)
S Total	70,279.	21,123.	(49,157.)	124,151.	38,389.	(85,762.)	139,193.	56,134.	(83,059.)
G Total	362,149.		(16,955.)	613,742.	538,816.	(74,926.)	807,013.	812,453.	5,440.

[a]Revenue figures were computed using a weighted average of fares based on the fare zones and the passengers boarding in each zone.

Source: Unpublished data from the Northern Virginia Transportation Commission, 1971 and 1972.

As bus service was expanded during the 18 month period (July 1971 through December 1972), operating costs increased accordingly. Total peak period miles traveled increased 145 percent, and peak period revenue trips increased 127 percent. During the same period, peak period operating costs increased 129 percent.

Route 4, which experienced a 330 percent increase in vehicle miles traveled during this period, had a 303 percent increase in operating costs; and Routes 17 and 18, which experienced increases in vehicle miles traveled of 200 and 212 percent respectively, had operating cost increases of 182 and 223 percent respectively.

Table 11

Project Operating Statistics - Last Half 1971 (30 Bus Fleet)

ROUTES	TOTAL DAILY MILES[1]	REVENUE TRIP DISTANCE (MILES)[2]	DAILY REVENUE TRIPS[3]	DAILY PASSENGERS	RUNNING SPEED (MPH)[4]	PASSENGERS PER MILE[1]	PASSENGERS PER TRIP	REVENUE PER PASSENGER	REVENUE PER MILE[1]	COST PER MILE[1]
Peak										
2G	338	18.8	11.0	340	17.31	1.00	30.9	$ .73	$ .73	$ .95
4G, H	258	15.4	8.6	494	19.30	1.91	57.1	.70	1.34	1.07
6G	153	10.4	8.6	352	14.58	2.30	40.7	.60	1.38	1.29
7G	344	11.9	15.8	784	16.68	2.27	49.5	.62	1.48	1.14
8G	203	11.5	10.0	340	15.56	1.67	34.0	.60	1.00	1.15
17G, H, Y	420	20.8	10.6	491	20.97	1.17	46.1	.80	.92	.82
18G, M, X	469	19.7	13.5	647	19.75	1.39	47.9	.80	1.11	.82
19G	132	13.8	6.0	260	13.88	1.97	43.4	.65	1.28	1.40
	2312[T]		84.1[T]	3708[T]	17.4[M]	1.60[M]	44.14[M]	.70[M]	1.12[M]	1.01[M]
Base										
1A, B	431	26.1	16.0	75	12.97	.17	4.73	.41	.07	.52
17G, H	365	23.2	15.0	68	16.21	.18	4.54	.72	.13	.45
18G	362	22.1	15.0	127	15.56	.35	8.53	.71	.25	.47
	1159[T]		46.0[T]	270[T]	14.6[M]	.23[M]	5.86[M]	.61[M]	.15[M]	.48[M]

T - total
M - mean

Source: Unpublished data from the Northern Virginia Transportation Commission 1971 and 1972.

[1]Sum of revenue and non-revenue bus miles on the route.

[2]Miles between the first and last bus stops on a route.

[3]A revenue trip is made whenever a bus traverses a route to pick up passengers.

[4]Travel time between first and last stop on the route divided by route distance.

Table 12
Project Operating Statistics - First Half 1972 (56 Bus Fleet)

ROUTES	TOTAL DAILY MILES[1]	REVENUE TRIP DISTANCE (MILES)[2]	DAILY REVENUE TRIPS[3]	DAILY PASSENGERS	RUNNING SPEED (MPH)[4]	PASSENGERS PER MILE[1]	PASSENGERS PER TRIP	REVENUE PER PASSENGER	REVENUE PER MILE[1]	COST PER MILE[1]
Peak										
2G	350	17.4	11.8	512	17.63	1.46	43.3	$ .70	$1.02	$1.12
4G, H	661	16.6	21.3	1006	19.24	1.52	47.2	.70	1.07	1.08
6G	158	9.7	9.0	400	14.27	2.52	44.5	.60	1.51	1.48
7G	422	11.1	18.6	944	16.79	2.23	50.6	.66	1.47	1.17
8G	232	9.9	12.0	442	14.73	1.90	36.8	.60	1.14	1.27
17G, H, Y	685	20.2	18.0	805	21.37	1.17	44.8	.76	0.89	.92
18G, M, X	833	20.5	24.0	1172	20.10	1.40	48.8	.74	1.04	.95
19G	176	13.5	7.6	367	14.67	2.08	47.9	.67	1.39	1.45
	3517[T]		122.3[T]	5648[T]	18.4[M]	1.60[M]	46.29[M]	.69[M]	1.11[M]	1.09[M]
Base										
1A, B	410	24.3	16.0	188	12.16	.45	11.7	.42	.19	.62
3A	71	8.6	6.6	65	16.19	.92	9.9	.45	.41	.71
17G, H	479	18.3	25.8	114	16.62	.24	4.4	.63	.15	.50
18G	573	20.2	26.6	147	15.85	.25	5.5	.68	.17	.52
26G	244	7.3	23.0	31	14.72	.13	1.4	.46	.06	.53
	1777[T]		98.0[T]	545[T]	15.1[T]	.31[M]	5.56[M]	.52[M]	.16[M]	.55[M]

T - total
M - mean

Source: Unpublished data from the Northern Virginia Transportation Commission 1971 and 1972.

[1]Sum of revenue and non-revenue bus miles on the route.

[2]Miles between the first and last bus stops on a route.

[3]A revenue trip is made whenever a bus traverses a route to pick up passengers.

[4]Travel time between first and last stop on the route divided by route distance.

Table 13

Project Operating Statistics - Last Half 1972 (76 Bus Fleet)

ROUTES	TOTAL DAILY MILES[1]	REVENUE TRIP DISTANCE (MILES)[2]	DAILY REVENUE TRIPS[3]	DAILY PASSENGERS	RUNNING SPEED[4] (MPH)	PASSENGERS PER MILE[1]	PASSENGERS PER TRIP	REVENUE PER PASSENGER	REVENUE PER MILE[1]	COST PER MILE[1]
Peak										
2G	460	17.0	15.6	797	18.00	1.73	50.9	$ .70	$1.21	$1.05
3G	182	9.2	10.0	256	15.28	1.40	25.6	.58	.81	1.21
4G, H	1117	16.3	34.6	1698	19.26	1.51	49.0	.71	1.07	.99
6G	156	9.6	9.0	442	14.27	2.83	49.2	.60	1.69	1.41
7G	542	10.9	23.0	1173	16.68	2.16	51.0	.66	1.42	1.05
8G	282	9.5	14.3	602	14.71	2.13	42.0	.60	1.27	1.04
17G, H, Y	1271	20.6	32.3	1477	22.52	1.16	45.7	.76	.88	.77
18G, M, Y	1449	19.1	41.8	1870	21.68	1.29	44.7	.74	.95	.85
19G	223	13.4	9.8	488	14.69	2.18	49.7	.67	1.46	1.29
	5682[T]		190[T]	8803[T]	19.77[M]	1.55[M]	46.08[M]	.70[M]	1.08[M]	.95[M]
Base										
1A, B	399	23.9	16.0	222	11.92	.55	13.93	.42	.23	.63
3A	92	10.4	8.0	65	10.63	.71	8.19	.44	.31	.69
4L	285	16.1	11.3	69	18.07	.24	6.12	.63	.15	.44
17G, H	665	21.8	29.3	173	18.67	.26	5.91	.65	.17	.44
18G	696	21.6	29.6	236	18.28	.33	7.98	.70	.23	.46
26G*	104	.7	26.0	21	14.13	.22	2.48	.45	.10	.65
	2241[T]		120[T]	786[T]	16.67[M]	.35[M]	6.52[M]	.62[M]	.23[M]	.56[M]

T - total
M - mean
*Only operated months of July and August during last half of 1972.

Source: Unpublished data from the Northern Virginia Transportation Commission 1971 and 1972

[1]Sum of revenue and non-revenue bus miles on the route.

[2]Miles between the first and last bus stops on a route.

[3]A revenue trip is made whenever a bus traverses a route to pick up passengers.

[4]Travel time between first and last stop on the route divided by route distance.

Operating cost increases were accompanied by revenue increases. Although total project (NVTC) revenues exceeded project operating costs for the last six months of 1972, total project operating costs exceeded project revenues by $70,000 for all of 1972. Off-peak service with a net loss of $169,000 (for the year) was the reason for the deficit.

Costs and revenues for project service on a per mile basis, and other statistics computed using the financial and operating characteristic data, are presented for the last half of 1971, the first half of 1972, and last half of 1972 in Tables, 11, 12 and 13, respectively. During the last half of 1972, peak period operating costs averaged $.95 per mile, down from $1.01 per mile for the corresponding period in 1971;[18] for the same two time periods, base day costs averaged $.56 per mile and $.48 per mile respectively. Net operating income for peak period project service averaged $.13 per mile during the last half of 1972, as compared with $.11 per mile during the last half of 1971. Also during the same six month period in 1972, only one peak period route had a negative net operating income (Route 3G, with a deficit of $.30 per mile, began operating in June 1972; since that time patronage has grown steadily) as compared with three with negative net incomes during the last half of 1971.

3.3.5. Demand Response to Bus Service Expansion

Increases in bus patronage, highlighted in paragraph 3.3.1, represented demand responses to bus service expansion. During 1972, bus service (in terms of vehicle miles traveled) and patronage expanded at approximately equal rates (see Table 14); during the same period operating costs of the expanded service were exceeded by the increased passenger revenues. Similar responses to service expansion on some individual routes can also be detected. During the 18 month period from July 1971 to December 1972, scheduled miles more than tripled on Routes 17 and 18. Nonetheless on both routes, the passengers per bus and passengers per mile statistics were only slightly lower during the last half of 1972 than they were during the last half of 1971 prior to the expansion of service.

Table 14

Expansion of Peak Period Project Bus Service

	LAST HALF 1971	FIRST HALF 1972		LAST HALF 1972	
	NUMBER	NUMBER	PERCENT CHANGE FROM LH 1971	NUMBER	PERCENT CHANGE FROM FH 1972
Daily Passengers	3708	5648	52	8803	56
Daily Vehicle Miles	2312	3517	53	5682	61
Daily Revenue Trips	84	122	45	190	56

Source: Unpublished NVTC passenger and operations data, 1971 and 1972.

Base day service has also been expanded during the 18 month period from July 1971 to December 1972, and although it remains quite low, base day ridership increased during this period. Base day service was expanded from 46 daily revenue trips during the last half of 1971 to 120 daily revenue trips during the last half of 1972, and from 1159 to 2241 total daily operating miles during the same periods. Base day passengers per mile and passengers per bus statistics were slightly higher during the last half of 1972 then they were during the last half of 1971, .36 versus .23 passengers per mile and 6.5 versus 5.9 passengers per bus.

Collectively, these statistics depict the interaction of service expansion and demand adjustment. The effect of the demonstration project in this area has been to foster a healthy environment of service enlargement with subsequent and commensurate increases in patronage. It also appears to have improved the financial position of the transit operator.

[18] Because the timings of some indirect operating expenditures vary, only like time periods are compared.

Net operator income was positive for the first time since the project began during the last half of 1972.

3.3.6. Summary of Findings on Project Impact on the Transit Operator

(1) The busway has stimulated substantial patronage growth (almost 8,000 persons for the A.M. peak-period, since September 1969) for those routes experiencing the greatest time savings. The number of persons per bus for these routes meets or exceeds seated capacity despite substantial increases in the number of buses being utilized.

(2) The percentage of the daily ridership served during the peak period is extremely high for both NVTC and WMATA routes, 80 percent for WMATA routes and 91 percent for NVTC routes. This peaking translates into labor costs for the operator which are difficult to offset.

(3) Preliminary estimates by the WMATA staff indicate a more efficient utilization of resources during the peak periods. To maintain present headways without the busway would require approximately 17 additional buses and drivers during the peak periods. This is equivalent to a monthly cost saving of approximately $26,000.

(4) From July 1971 to December 1972 peak period service operated in the black. Peak period income was low in the first half of 1972, corresponding to additional expenses accompanying the expansion of service but without compensating increases in revenue. By the latter half of 1972 patronage grew to absorb the increased capacity and peak-period revenue reached a record high. Off-peak service continues to lose money, but in the last half of 1972 for the first time (half year interval), peak-period income more than offset off-peak loses.

(5) The Demonstration Project has effected a departure from the historical transit service cutback-fare hike syndrome by providing an expanding and attractive service which generates complementary increases in patronage, and stimulates an improved financial situation for the operator.

3.4. Reduction in A.M. Peak Period Auto Volumes

3.4.1. Introduction

An investigation of the assumptions underlying each of the methods used to estimate auto volume reduction in Interim Report 2, led to a modification of the procedure.[19] As a result of that investigation, the screenline count approach to estimating auto usage reduction was replaced by an approach using the October 1971 bus commuter survey responses and the busway passenger counts.

Interim Report 2 presents auto reduction estimates based on screenline data. The critical assumption of this analysis was that auto occupancy on the Shirley Highway and other Northern Virginia arterials would have remained constant if no busway existed; however, paragraph 3.1 , Auto Occupancy Trends, substantiates that auto occupancy has not been constant, but rather has exhibited slight but steady declines since 1970. Since the assumption is not valid for traffic in the Corridor, the method based on screenline data has been abandoned.

3.4.2. Estimating Reduction in Autos Using Bus Survey Data and Busway Counts[20]

For this report, the estimate of auto usage reduction attributable to the demonstration project was obtained by adjusting the latest screenline counts with information about commuting modes prior to using bus extracted from October 1971 bus commuter survey. This information coupled with data on increased bus ridership from the busway counts (see paragraph 3.1 , Busway Counts) was used to produce auto reduction estimates.

The bus riders surveyed in October 1971 included persons (1) who formerly had not made the trip (from their present home to present job), (2) who had commuted by auto, or (3) who had commuted on a bus which did not use the busway. Those persons who previously

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[19] "The Shirley Highway Express Bus on Freeway Demonstration Project First Year Results, Interim Report 2," paragraph 3.3.

[20] Busway data collection procedures are reviewed in paragraph 3.1.1 of this report.

commuted by bus may have done so on WMATA Alexandria buses which were routed on the Shirley Highway (now part of the busway buses)[21], on WMATA Alexandria buses which used other Northern Virginia arterials (non-busway buses)[22] or on "Other" buses which traveled via the Shirley highway (i.e., Colonial Transit, Continental Trailways, Greyhound, or WMATA Arlington Division) and now use the busway.

Most of the growth on the busway routes has been the result of persons transferring from the auto to the bus mode, although some portion was attributable to the diversion of non-busway bus passengers to the busway routes. An analysis of bus riders' responses to the "previous mode" question in the 1971 bus commuter survey yielded estimates of diversion of riders from non-busway routes and of auto commuters diverted onto busway buses.

Of the riders on busway routes since April 1969, it is estimated that a) 4370 (3920 on NVTC and WMATA buses and 450 on "Other" buses) were riders on bus routes which had used the Shirley Highway prior to the opening of the busway and b) 1070 have diverted from WMATA non-busway routes. The remainder have diverted from auto, and for every five auto commuters diverting to the busway service, it is estimated that three autos are no longer used for daily commuting. (For the derivation of these estimates, see Appendix D.)

Estimates for the number of autos not using the highways due to the demonstration project were computed for October 1971, October 1972, and June 1973. To obtain an estimate of auto diversion using the busway counts, it was necessary to remove from the counts all riders who had commuted by bus prior to using the busway buses. This was accomplished by subtracting diverted non-Shirley Highway bus users (1070 riders) and former Shirley Highway bus users (4370 riders) from each busway count. The estimate of autos removed from the highways was obtained by multiplying the the resultant estimates of former auto users from each busway count by .6 (the ratio of auto diversion to auto person diversion). The computations and estimates are summarized in Table 15.

Table 15

Summary of Auto Reduction Estimates and Computations

	OCTOBER 1971		OCTOBER 1972		JUNE 1973	
	WMATA	OTHER	WMATA	OTHER	WMATA	OTHER
Total Daily Busway Users	7,980	1,250	10,770	1,700	11,870	1,900
Users Diverted from Non-Shirley Highway Buses	1,070		1,070		1,070	
Users of Shirley Highway Buses Prior to Busway Opening	3,920	450	3,920	450	3,920	450
Former Auto Users	2,990	800	5,780	1,250	6,880	1,450
Diverted Autos	1,794	480	3,468	750	4,128	870

3.4.3. Increase in Bus Ridership Attributable to the Demonstration Project

Two of the assumptions employed in estimating the reduction in auto volumes are used in estimating the increase in bus ridership attributable to the demonstration project. One, the sample (October 1971 survey) former mode characteristics can be imputed to the entire

[21] Prior to February 1973 WMATA Alexandria buses were operated by the AB&W Transit Company. The service provided by the new authority (WMATA) is substantially the same as that of its predecessor. For simplicity, sole reference will be made to WMATA

[22] Some of these buses were admitted to the busway in the Pentagon area beginning in April 1971 (e.g., Routes 12 and 16). Because they achieve only a nominal time saving and their patronage has remained about constant (see paragraph 3.1., Busway Counts), they are included here with the non-busway buses.

Corridor bus population, and two, bus patronage would have remained static if the transit service improvements had not been implemented.[23]

Under these assumptions the estimated increases in bus persons spurred by the demonstration project are shown in Table 15 as estimated former auto users. Including WMATA buses and "other" buses, these increases are 3700, 7030, and 8330 passengers for October 1971, October 1972 and June 1973, respectively.

3.4.4. Future Surveys

At this time, it is believed that the best possible estimate for auto usage reduction induced by the demonstration project would be obtained by surveying a sample of new bus users and ascribing their former mode behavior to the entire bus population.[24] Unfortunately, the absence of information pertaining to the users of the busway service since October 1971 forces reliance on the results of the earlier survey to assess their former mode characteristics. Hence, the estimates for auto volume reduction presented in this section are tentative, pending confirmation by figures based on a bus commuter survey conducted in November 1973.

3.4.5. Summary

Since April 1969, bus ridership increases of 3700, 7030 and 8330 peak period passengers for October 1971, October 1972 and June 1973 respectively have resulted in estimated peak period auto diversions of 2274, 4218 and 4998 respectively (as compared to what they would have been without the demonstration project). These statistics will be verified or revised using new information to be developed from the November 1973 bus survey.

3.5. Increase in A.M. Peak Period People-Moving Productivity Per Lane on Shirley Highway

One of the impacts of the busway is an increase in the volume of person trips accommodated on the Shirley Highway. By monitoring the operations of the bus lane and auto roadway during the A.M. peak period, the people-moving productivity per lane can be determined.

Ideally, the busway and automobile lanes should be monitored without the interference of construction activities. Since completion of the improvements on the Shirley Highway is not scheduled until Spring 1974, this has not been possible. The findings presented are therefore preliminary in nature, and reflect the influence of the construction with its resultant capacity restraints for both bus and auto lanes.

As of June 1973, much of the Shirley Highway reconstruction has been completed (temporary lanes have been routed through the construction zones of the northern reaches), thereby furnishing a minimum of three lanes in each direction. The busway consists of two lanes (except in the construction area where it narrows to one lane); however, the buses will generally use only one lane during normal operations.

With the increase in the number of autos observed on the Shirley Highway in June 1973, the number of bus riders on the busway, although continuing to mount, fell behind the number of auto persons after maintaining the lead for 18 months. During the A.M. peak period in June 1973, nearly 12,000 busway passengers were observed while, in contrast, slightly more than 16,000 auto persons were observed in the three northbound lanes of the Shirley Highway.

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[23] This assumption is supported by the fact that ridership has declined on every transit operation in the Washington Metropolitan area except the busway service, and if anything, the assumption overstates what bus ridership would have been without the demonstration project. In addition, project bus control counts have been stable over the life of the project. Statistics taken from bus control counts for November 1971 (116 buses), October 1972 (112 buses) and June 1973 (114 buses) indicated stable ridership with 27.7 25 and 27 passengers per bus respectively.

[24] There still is a problem of estimating what the former mode would have been for new Northern Virginia residents who began commuting immediately via the busway. How they would have commuted if no busway existed has yet to be determined.

The volume of person trips on the bus lane is actually greater because this figure includes only people riding on WMATA and NVTC buses; people on the buses of Continental Trailways, Colonial Transit and other suburban commuter bus companies (i.e., "other buses") were not counted at the screenline. Information about these ridership levels is obtained from company records and estimates. The best estimate of daily A.M. peak period passenger levels for the "other" buses on the Shirley Highway is 1,250 during October 1971, 1,700 during October 1972, and 1,900 during June 1973. No information is available for ridership levels by time interval within the peak period for these buses.

During the peak hour (the single hour with the maximum observed person trip volume) in June 1973, 14,800 person trips (7100 by auto and 7700 by bus) were observed on the Shirley Highway. Figure 11 shows the number of persons per lane during the peak hour on the busway and the main roadway. The wide divergence of the curves for bus and auto person trips per lane per (peak) hour reflects the high productivity of the busway lane relative to that of the auto lanes. Peak hour person trips by auto per lane per hour averaged about 2,800 until November 1970. The ensuing decline, to a low of about 1,800 person trips per lane per (peak) hour in October 1971, and the gradual upswing, to nearly 2,400 person trips per lane per (peak) hour in June 1973, are attributable to changes in the construction zones along the highway. By contrast, since November 1970 peak hour bus person trips per lane have steadily increased, going from about 2800 in November 1970 to over 7700 in June 1973.

The busway continues to contribute to the increased people moving capability of the Shirley Highway. Although the June 1973 count of 16,000 auto person trips on the main roadway was the highest ever observed during the demonstration project, the single lane used by busway buses still carried more persons than all three lanes devoted to auto during that morning's peak hour.

3.6. Peak Period Reduction in Auto Generated Air Pollution and Auto Gasoline Consumption

The demonstration project has had an impact on the amount of automobile air pollution emissions and the amount of gasoline consumed by automobiles during the peak periods. In this section estimates for decreased vehicle air pollution emissions and gasoline usage are computed, based primarily on the auto vehicle trip reduction estimates obtained in paragraph 3.4.

3.6.1. Factors Affecting Air Pollution and Gas Consumption

Both air pollution emissions and gasoline usage are affected by several characteristics of highway operations. The most important factors are:

1) Volume of traffic (number of vehicles)
2) Composition of traffic stream (mix of autos, buses, trucks, etc.)
3) Age and condition of vehicle engines
4) Whether the vehicles are run from hot or cold starts[26]
5) Vehicle speeds

Changes in only three of these factors can be attributed to the demonstration project. One, the diversion of auto travelers to buses has altered the volume of traffic by diverting autos from peak period Corridor traffic streams. Two, the composition of peak period Corridor traffic streams has been altered by the diversion of autos and the removal of buses from the main roadway of the Shirley Highway.[27] Finally, attainable vehicle speeds have been increased because of changes in the two previous factors.

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[26] "Cold Start" refers to a vehicle that has not been operated for a number of hours prior to its current use. The Environmental Protection Agency (EPA) specifies 12 hours, but a car left overnight (or all day after the morning work trip) may be regarded as being driven from a cold start.

[27] Although autos left at home may be driven and thus contribute to air pollution and gasoline usage, except for noting such a possibility no further analyses were performed. Likewise, although buses consume some diesel fuel (they are fitted with emission reduction devices), this consumption is not included in the gasoline conservation estimates. It will be included in later project reports.

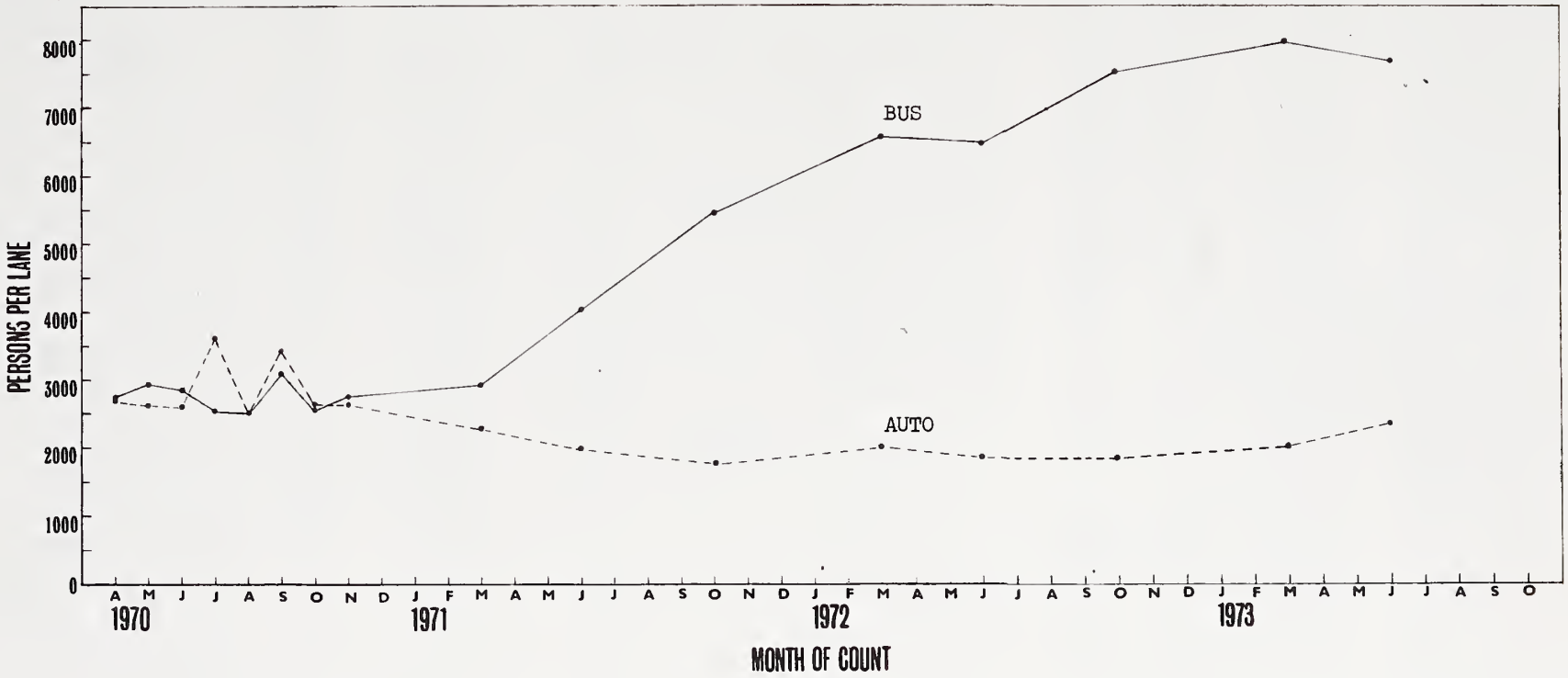

Figure 11. A.M. Peak Hour Person Throughput Per Lane on Shirley Highway (Inbound).

3.6.2. Air Pollution Analysis

Daily air pollution reduction estimates have been prepared for October 1971, October 1972, and June 1973. These results can be averaged to produce figures for total air pollution emissions abatement over the life of the demonstration project. Computation details of the analysis are presented in Appendix E, and the procedure is outlined below:

1) For each model year, estimates of auto exhaust emission rates of carbon monoxide (CO), hydrocarbons (HC), oxides of nitrogen (NO_X), and auto crankcase-evaporative hydrocarbons (HC^o) are presented in Table 37.

2) The effectiveness of CO, HC, and NO_X exhaust emission control devices diminishes over time, and deterioration factors for each pollutant type (listed in Table 38) are applied to the exhaust emission rates of each model year. "Adjusted" exhaust emission rates are presented in Table 39.

3) "Adjusted" emission factors for each model year are then weighted by the estimated percent of annual travel contributed by that model year's vehicles (distribution shown in Figure 12).

4) Air pollution emissions for the "typical" vehicle in use are obtained by summing the weighted emission factors (for CO, HC, NO_X, and HC^o) over the distribution of model years (see Table 40).

5) Auto carbon monoxide (CO), hydrocarbon (HC), and nitrogen oxide (NO_X) exhaust emissions are dependent on vehicle operating speed. It was assumed that the traffic volumes distribute themselves over the Shirley Highway and other Corridor arterials so that the average travel speeds on all of these roadways are approximately equal,[28] and speeds observed during half hour intervals from 6:30-9:00 A.M. (inbound) on the Shirley Highway (between Route 7 and the Virginia side of the 14th Street Bridge) are chosen as representative of rush period velocities for all project commuters.[29] Weighted by the percent volume of traffic observed during each half-hour interval within the 2-1/2 hour A.M. peak period, these vehicle speeds specify emissions adjustment factors applicable to the situation on the Shirley Highway.[30] CO, HC, and NO_X (exhaust) emissions for the "typical" auto are corrected for operating speed by using the adjustment factors suggested by the Shirley Highway data.

   By summing over the five half-hour intervals (the entire peak period), <u>average peak period</u> CO, HC and NO_X (exhaust) <u>emissions</u> for a "typical" vehicle are estimated (see Table 42). Average peak period HC^o (evaporative-crankcase) emissions for the "typical" auto are taken directly from Step 4, since they are relatively independent of speed.

6) The amount of air pollution reduction resulting from the demonstration project is obtained by assuming an average roundtrip commute distance of 19.8 miles[31] and auto vehicle reduction estimates of 2274 for October 1971, 4218 for October 1972, and 4998 for June 1973 (from paragraph 3.4.). The product of these figures and

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[28] In "Some Theoretical Aspects of Road Traffic Research," Institute of Civil Engineers Road Pager #36, London, England, 1952, Wardrop's first principle of flow distribution states that travel times on all paths used by traffic flow between a particular origin destination pair are equal.

[29] See Figure 1, paragraph 3.1; the Shirley Highway is I-95.

[30] The speeds and volumes used for October 1971, October 1972, and June 1973 are the averages of speeds and volumes presented in Table 40 for March 1971 and March 1972; and March 1972 and March 1973; and March 1973 and May 1973, respectively. Table 42 shows pollution estimates adjusted for speed and weighted by the auto volume distributions.

[31] "First Year Results Report," Appendix E, p. 116; this implicitly assumes that speed volume conditions prevalent during the A.M. peak-period also apply to the P.M. peak-period.

average peak period pollution emission rates for the "typical" auto represents the estimated (CO,NO, HC (exhaust), and HC° (evaporative-crankcase)) reduction in air pollution for one day during each of these months (presented in Table 16).[32]

7) The pollution reductions for the years October 1970 to October 1971, October 1971 to October 1972 and the period October 1972 to June 1973 (see Table 17) are obtained by averaging the estimates for a day in October 1970 (zero pollution reduction is assumed), October 1971, October 1972, and June 1973, based upon a 200 day working year.

Table 16

Estimates of Daily Reductions in Air Pollution Emissions (Pounds)[a]

DAILY	OCT 71	OCT 72	JUN 73
Carbon Monoxide	6895	12320	11765
Hydrocarbons (Exhaust)	715	1260	1111
Nitrogen Oxide	530	900	714
Hydrocarbons (Evaporative)	326	440	377

Table 17

Estimates of Yearly Reductions in Air Pollution Emissions (Tons)[a]

	OCT 70-OCT 71	OCT 71-OCT 72	OCT 72-JUN 73	OCT 70-JUN 73
Carbon Monoxide	380	986	738	2104
Hydrocarbons (Exhaust)	39	101	78	218
Nitrogen Oxide	27	81	54	152
Hydrocarbons (Evaporative)	16	38	27	81

[a]The estimates do not currently account for bus emissions or possible use of diverted autos.

3.6.3. Gasoline Consumption Analysis

Gasoline savings, estimated for October 1971, October 1972 and June 1973 are calculated as a function of 1) auto mix and associated gasoline consumption rates and 2) the average roundtrip distance of a project commuting trip (19.8 miles).[33] These estimates are then averaged to produce figures for total gasoline savings over the life of the demonstration project. The details of the approximation procedure are presented below:

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[32]Unpublished data from the Washington Council of Governments estimate 1972 daily peak period emissions at 867.8, 43.3 and 32 tons for carbon monoxide, hydrocarbons (HC° and HC) and nitrogen oxides respectively, for the entire Washington Metropolitan Area.

[33]Where traffic volumes are particularly high (equal to or approaching capacity), such as often occurs on high volume expressways near busy access-exit points, vehicles may be slowed to a stop or even to a series of stops of uncertain duration, with a corresponding increase in the running costs associated with stops and slowdowns, i.e., fuel and oil consumption, tire wear, and maintenance. The present techniques for estimating auto gasoline consumption do not adequately account for the effects of congestion, and therefore, they could not be used and speed could not be included as a variable in the calculation of auto gasoline savings. Sources consulted include: 1)EPA, "Fuel Economy and Emission Control," EPA, Office of Air and Water Programs, Washington, D.C., November 1972; 2) NCHRP Report 1, "Running Costs of Motor Vehicles as Affected by Road Design and Traffic," Highway Research Board, Washington, D.C., 1971; 3) NCHRP Report 133, "Procedures for Estimating Highway Use Costs, Air Pollution, and Noise Effects," Highway Research Board, Washington, D.C., 1972; 4) Winfrey, Robley, Economic Analyses for Highways, International Textbooks, Scranton, Penna., 1969.

1. Corridor autos are assumed to fall into two categories, small and large;[34] gasoline consumption rates of 20 and 13 miles per gallon are adopted for small and large auto categories respectively.[35]
2. Twenty-five percent of Corridor commuting miles were assigned to the small car category. (Unpublished data from the 1968 Washington Metropolitan Area Home Interview estimate that 11 percent of the vehicles in the area were small cars. In addition, a 1969 survey estimated that 10 percent of the autos in the U.S. were small cars, and that nationwide, small cars accounted for 25 percent of new car purchases in 1969). The use of a 25 percent share for small cars will produce a conservative estimate for gasoline savings.
3. The gasoline consumption rates are applied to the estimate of small and large car mileages to estimate daily gasoline savings. Estimates of daily gasoline savings attributable to the project are 3433 gallons for October 1971, 6209 gallons for October 1972 and 7350 gallons for June 1973.
4. Estimated gasoline savings for the years October 1970 to October 1971, October 1971 to October 1972, and the period October 1972 to June 1973 are 306,000; 892,000; and 856,000 gallons, respectively. Total gasoline savings between October 1970 and June 1973 are estimated at 2,054,000 gallons.

3.6.4. Summary of Findings on Air Pollution Reduction and Gasoline Consumption Attributable to the Demonstration Project

Based on the auto vehicle volume reductions of paragraph 3.4., the estimated air pollution abatement resulting from the demonstration project between October 1970 and June 1973, is as follows: 2103 tons of carbon monoxide, 218 tons of exhaust hydrocarbons, 151 tons of nitrogen oxides, and 81 tons of evaporative crank-case hydrocarbons. During the same period an estimated 2,054,000 gallons of gasoline were saved because of the reduction in Corridor auto vehicle volumes.

3.7. Changes in Peak Period Bus and Auto Travel Times

Several aspects of the demonstration project contribute to improved travel times and increased schedule reliability for bus users. These include: the use of an exclusive bus lane, the availability of bus priority lanes in downtown Washington, and the incorporation of project routes which feature a more direct routing than that of regular WMATA buses from the suburban collection and distribution points to the busway entrances.

Paragraph 3.7 will present information regarding the status of travel times for autos and for buses on the line haul (busway) segment of their journey. Route distances and travel times, taken from published schedules, for each portion of the bus trip (suburban collection and distribution, line haul, and downtown collection and distribution) along several project routes are listed in Appendix F. Auto travel speed data collected on the Shirley Highway before and after the recent opening of the new lanes in the vicinity of the Pentagon are exhibited in Table 19.[37]

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[34] The small car category was defined to include cars with engine sizes of about 150 cubic inches or smaller, and large cars' engine sizes range from about 150 cubic inches to the largest engines made.

[35] A recent report to the U.S. Department of Transportation, "Highway Travel Forecasts Related to Energy Requirements" (Dec. 1972), reported fuel consumption rates of 22.2 and 13.14 miles per gallon for small and standard sizes respectively. In "Fuel Economy and Emission Control", the U.S. Environmental Protection Agency (Nov. 1972) reported fuel consumption rates ranging from 11.9 to 23.9 miles per gallon.

[36] Schedule reliability is discussed in paragraph 3.8 of this report.

[37] Changes in the Shirley Highway re-construction are identified in Section 2.

3.7.1. Line Haul Travel Times and Speeds

Table 18 displays the observed and scheduled line haul travel times and speeds for various Farragut Square bound project buses during a typical morning rush period in November 1972.[38] Also listed are estimated travel times for comparable trips without the use of the busway, extracted from Table 3.6-1 of the First Year Results Report.

Table 18

Comparison of Line Haul Travel Times With and Without the Busway For Selected Project Bus Routes

ROUTE	NUMBER[1] OF BUSES OBSERVED	MEAN TRAVEL TIME (MIN.)	OBSERVED TRAVEL TIME STANDARD DEVIATION (MIN.)	SCHEDULED TRAVEL TIME (MIN.)	ESTIMATED[2] TIME W/O BUSWAY (MIN.)	DISTANCE (MILES)
7G	12	12.6	1.3	14	32	6.5
19G	5	10.8	1.3	14	32[3]	6.5
4H	5	15.4	2.0	16	35[3]	7.1
4H	10	14.6	2.5	16	35[3]	8.5
18G	10	20.7	2.0	22	40	12.1
17G	5	22.8	2.3	25	37	14.0
17H	4	21.3	1.0	25	37	14.0

[1]Observations were made in November 1972.

[2]Taken from the First Year Results Report, Table 3.6-1. These buses now travel via 14th Street Bridge; in the absence of a busway they would use Memorial Bridge; times are estimated assuming Memorial Bridge crossings.

[3]Routes 19G and 4G,H were not included in Table 3.6-1 (First Year Results). The estimated time without the busway for Route 19G was assumed to be the same as for Route 7G which enters at the same point. Travel times for Routes 4G,H are taken to be equal to the average of times for Routes 17G,H and 7G since the entrance for Routes 4G,H is located midway between the access points for these routes.

On the average, observed travel times are less than scheduled travel times which, in turn, are significantly lower than estimated travel times before the busway. The standard deviations for the mean observed times reflect only a slight degree of variability among the buses whose times were recorded (all standard deviations are within 15 percent of the mean value).[39]

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[38]Measurements were taken by two observers, one stationed at the last stop before the bus enters the busway and the other at 14th & C Streets, S.W. (the first stop after the bus exits from the busway). Several routes differ in line haul times and speeds because they access the busway at different points.

[39]Schedule reliability is discussed in greater detail in section 3.8.

Table 19

A.M. Peak Period Auto Travel Times and Speeds on Shirley Highway (Inbound from Rt. 7 to the 14th Street Bridge)

15 MINUTE PERIODS BEGINNING	AVERAGE TIME (MINUTES)				SPACE MEAN SPEED (MPH)				NUMBER OF OBSERVATIONS[1]			
	MAR 71	MAR 72	MAR 73	MAY 73	MAR 71	MAR 72	MAR 73	MAY 73	MAR 71	MAR 72	MAR 73	MAY 73
6:30	7.3	8.1	10.2	6.5	35.3	32.0	25.1	39.3	3	10	9	6
6:45	10.9	12.3	13.0	6.5	23.7	21.0	19.7	39.3	8	11	10	22
7:00	14.7	18.0	16.4	7.8	17.5	14.4	15.6	32.8	6	6	7	23
7:15	18.7	19.4	20.6	8.9	13.8	13.3	12.4	28.7	6	8	8	19
7:30		20.1	22.0	9.0		12.9	11.6	28.4		7	6	22
7:45	23.3	21.5	27.3	8.5	11.1	12.0	9.4	30.1	3	6	9	16
8:00	19.0	20.4	21.5	8.7	13.6	12.6	11.9	29.4	1	5	6	18
8:15	20.0	19.4	22.2	6.0	12.9	13.4	11.5	42.6	1	5	6	13
8:30	8.5	10.9	13.9	5.2	30.3	23.6	18.4	49.2	2	7	8	19
8:45	6.0	7.2	9.5	4.9	43.0	36.0	26.9	52.2	7	8	8	4
AVERAGE[2]	14.2	15.7	17.7	7.2	22.3	19.1	16.3	37.2				
Total									37	73	77	162

[1]Time of arrival (at 14th Street bridge) of auto license numbers recorded at the two points on Tuesday, March 24, 1971; Thursday, March 23, 1972; Wednesday, March 28, 1973; and Thursday, May 24, 1973.

[2]Figures are computed as straight averages, not weighted for traffic volumes within the time interval.

3.7.2. Auto Vehicle Travel Times and Speeds on the Shirley Highway

Table 19 shows that auto travel times decreased radically from March 1973 to May 1973. This is the result of increased capacity on the Shirley Highway attending the opening of new lanes in the Pentagon region.[40] The March 1973 figures, which are consistent with the data for March 1971 and 1972, mirror conditions of construction-reduced capacity which predated this development.[41]

The May 1973 observations were conducted shortly after the new lanes were opened, and perhaps before Corridor-wide auto users adjusted to the additional capacity by shifting to the Shirley Highway from other Northern Virginia arterials.[42] Future auto speed checks will be performed to determine if this was the case.

3.8. Changes in Peak Period Bus Service Schedule Reliability

One of the anticipated impacts of an exclusive bus lane is improved bus schedule reliability during the peak period. That reliable bus service is an important aspect of increasing bus patronage is becoming more evident. The findings of a market survey for the "new look" buses, summarized in Section 4,[43] substantiate that commuters consider schedule reliability to be one of the most important factors in bus transit service.

In order to monitor schedule reliability, a data collection program was established whereby the arrival and departure times for the buses at the first and last bus stops in the District of Columbia were observed, and compared with the corresponding scheduled times (hereafter referred to as schedule adherence checks). These data indicate how well the buses are able to meet the published schedule times.

3.8.1. A.M. Peak Period Schedule Adherence

Tables 20 and 21 summarize results of schedule adherence checks for WMATA and NVTC buses as witnessed on 6 separate occasions.[44] Schedule reliability tests at the first stop (Table 20) seek to measure the effect of the busway on schedule adherence; tests at the second stop (Table 21) attempt to measure the effect of bus priority features within the District on schedule adherence. Arrival times were recorded at the first bus stop in the District (shortly after buses leave the busway) for each bus during the A.M. peak period (6:30-9:00 A.M.). The values in Table 20 show the percentage of buses out of the total number observed on a given day, which arrived early, on time, or late.

The late category is further subdivided into: a) 1-6 minutes late, b) 7-15 minutes late, and c) more than 15 minutes late. Similarly, the arrival times for buses at the last stop in the District during the A.M. rush period were noted and compared to scheduled times. Table 21 displays the findings in the format described above. Late or early at the last stop signifies observed versus scheduled performance in traveling from the first to the last stop, since minutes late or early at the first stop have been discounted in obtaining figures for the last stop.

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[40] Speed checks on Shirley Highway are taken from Virginia Route 7 to the 14th Street Bridge during the morning rush period (6:30-9:00 A.M.). The mixing bowl is located between these landmarks.

[41] Auto travel times indicate a slight increasing trend from March 1971 to March 1973.

[42] Auto volumes observed on the Shirley Highway and other Northern Virginia arterials are discussed in paragraph 3.1., Screenline Counts. A comparison of data for June 1973 with earlier screenline counts reveals a sizeable shift of autos to the Shirley Highway from the other roadways. A spot travel time check made on the Shirley Highway on the day (June 1973) screenline counts were conducted showed auto travel times much greater than those observed in May 1973.

[43] "The Shirley Highway Express-Bus-on-Freeway Demonstration Project - Users' Reactions to Innovative Features, Interim Report 3."

[44] Schedule adherence checks were conducted on two mornings during each of the Fall tests and one morning on each of the Spring tests. Consequently the Fall tests included about twice as many observations as the Spring tests.

Table 20

Schedule Adherence for A.M. Peak Period Busway
Bus Trips at First Stop in D.C.

WHEN OBSERVED	NUMBER OF OBSERVATIONS	PERCENT OF BUS TRIPS				
		EARLY	ON TIME	MINUTES LATE		
				1-6	7-15	OVER 15
Fall 71	216	36.3	7.5	35.3	15.5	5.4
Spring 72	91	41.7	13.2	41.8	3.3	0
Fall 72	296	40.5	11.5	41.5	6.2	.3
Spring 73	169	50.9	11.8	31.4	5.9	0

Table 21

Schedule Adherence for A.M. Peak Period Busway
Bus Trips at Last Stop in D.C.

WHEN OBSERVED	NUMBER OF OBSERVATIONS	PERCENT OF BUS TRIPS				
		EARLY	ON TIME	MINUTES LATE[a]		
				1-6	7-15	OVER 15
Fall 71	216	19.2	8.6	64.0	8.2	0.
Spring 72	91	4.4	5.5	64.8	25.3	0.
Fall 72	296	4.7	6.0	73.7	14.9	.7
Spring 73	169	4.5	8.9	58.6	24.8	7.1

[a]Minutes early (or late) are as compared to scheduled time to travel from first to last stop, not with respect to scheduled time for arrival at last stop. Thus, minutes early (or late) at first stop have been added to (deducted from) the difference between scheduled and observed arrival time at last stop.

3.8.2. Factors Affecting Schedule Reliability

Bus schedule reliability is affected by several factors, including (1) the busway (2) the bus priority lanes in downtown Washington and (3) the subway construction in downtown Washington. Some control can be exercised over the first two factors, but little can be done about the construction related problems.

The effects of the busway on schedule reliability can be seen in Table 20. Generally, buses arrive at the first stop within six minutes of the scheduled time. Although bus schedule adherence in 1973 continues well above that of 1971 just after the busway was opened, it is essentially unchanged since 1972.

The effects of bus priority lanes (see Table 21) in the District on schedule reliability are not as discernable as the effects of the busway. A primary reason for this is the disruptive effects of subway construction on traffic movements in downtown Washington.

SECTION 4. EXAMINATION OF COMMUTER MODE CHOICE DECISIONS

4.1. Introduction

Section 4 summarizes the results of two surveys of riders' reactions to selected bus features: 1) a survey of users' reactions to interior bus features is discussed in paragraph 4.2, and 2) a survey of park and rider lot users' reactions to bus service features is discussed in paragraph 4.3. Using the results of these surveys, the section presents evidence on the contribution of selected bus features to the increase in Corridor bus ridership.

Responses to queries on the importance of and satisfaction with each of the following selected bus features were assessed to determine their relative influence on riders' decisions to switch from auto to bus.

Service Features

a. Travel time and cost (door-to-door) differences
b. Bus shelters
c. Security of bus service
d. Reliability of bus service
e. Convenience of bus arrival and departure times
f. Access and egress convenience
g. Waiting time

Interior Features

a. Availability of a seat
b. Air-conditioning and heating
c. Seat size
d. Leg room
e. Noise level
f. Interior design
g. Lighting
h. Advertising
i. Floor covering

The first survey solicited commuter reactions to innovative approaches in interior vehicle design. The second survey solicited commuter perceptions of the bus features responsible for their switching to the park and ride bus service. With each survey, commuters were requested to rank the importance of each bus feature and also to evaluate the performance of the bus system with respect to each feature. Inferences for mode choice decision-making were drawn from summaries of the responses in the surveys. These summaries are the basis for the analysis found in this section.

4.2. Survey of Users' Reactions to Innovative Bus Features[1]

The objectives of the investigation of user reactions to innovative bus features were:

1. To determine commuters' relative satisfaction with the special interior bus features;
2. To determine the importance commuters place on the interior features relative to service features; and
3. To determine the relative influence of each of the features on commuter mode choice decisions.

4.2.1. Survey Approach

During the week of July 5, 1972, a survey was conducted on a sample from the twelve project peak period bus routes.[2]

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[1] Paragraph 4.2 is a summary of the report "The Shirley Highway Express Bus-on-Freeway Demonstration Project - Interim Report 3."

[2] The project routes are designated 2G, 3G, 4G, 4H, 6G, 7G, 8G, 17G, 17M, 18G, 18M, and 19G.

One bus on each route was selected, and the first 47 boarding passengers were given a questionnaire by a survey distributor.[3] The riders were requested to complete and return the form before getting off the bus. Of the 590 forms distributed, 551 were returned, a 95 percent response rate. The form consisted of a brief introductory segment which was followed by three main sections. Section 1 solicited users' perceived satisfaction with the various special interior bus features. This was accomplished by asking the bus patrons to complete the following for each of the 12 innovative interior comfort and aesthetic bus features listed:

CONSIDERING EACH FEATURE BY ITSELF, PLEASE RATE THE FOLLOWING FEATURES OF THIS BUS BY PLACING AN "X" IN THE APPROPRIATE BOX

	Very Poor	Poor	Fair	Good	Very Good
FEATURES	☐	☐	☐	☐	☐

The second section of the survey form (on the page opposite the above question) requested bus users to consider 15 bus interior and service related features and assign each of them an importance rating:

PLEASE RATE
THE IMPORTANCE OF EACH OF THE FOLLOWING FEATURES OF BUS TRANSIT BY PLACING AN "X" IN THE APPROPRIATE BOX

	Not At All	Only Slightly	Somewhat	Quite	Extremely	Would You Be Willing To Do Without This Feature For A 5 Cent Reduction In Fare? Yes	No
FEATURES	☐	☐	☐	☐	☐	☐	☐

The "Yes-No" questions, asking the respondent if he would do without the feature for a reduction in fare, were designed to provide another measure of importance to check for consistency. While the second section of the survey requested importance ratings for 15 service and interior features, section one asked for satisfaction ratings for only interior features.

4.2.2. Findings

Analysis of satisfaction and importance assessments reveals that bus commuters consider the innovative interior features satisfactory although less important than service oriented features. Table 22 presents the features ordered with respect to satisfaction. As can be seen in the last column, the overwhelming majority of the features (10 out of 12) were rated as "Very Good" or "Good" by 77 percent or more of those responding. In fact, no feature received less than 60 percent of the responses in one of these two categories.

In contrast to the satisfaction responses, bus riders' assessments of importance for the interior bus features do not all cluster in a single high rated group, but are stratified along several levels of perceived importance. Table 23 presents three general

[3] The seating capacity of the buses is 47; in some cases standees volunteered to complete the questionnaires and were allowed to do so, up to a limit of 3 per bus. Very few passengers refused to complete the questionnaire.

levels into which the importance responses are grouped.[4] All of the service oriented features ("Constant, Reliable Schedules; Assurance of Getting a Seat"; and "Less Time Between Buses") fall into the highest level (I). Also included in the high importance level are "Air Conditioning/Heating" and "Reduction in Exhaust Emissions".[5] It should be noted that even within Level I,"Constant, Reliable Schedules" was rated somewhat higher than the other features.

Of the features for which satisfaction and importance responses were solicited, only the air conditioning and heating feature was highly rated in both categories. The implication of the simultaneous consideration of user satisfaction and importance responses is examined in paragraph 4.4. Attention is also given to service features which users rated high in importance (no satisfaction responses were solicited for these features) and for which there were improvements in the level of service.

Table 22

Commuter Satisfaction Rankings for Bus Interior Features

FEATURES	PERCENT RATING FEATURE "Very Good"	RANK	PERCENT RATING FEATURE "Very Good" or "Good"
No Interior Advertising	64	1	90
Seat Comfort	49	2	92
Floor Covering	43	3	92
Total Interior Design	41	4-5*	90
Seat Width	41	4-5*	83
Leg Room	38	6	82
Interior Lighting Level	33	7-8*	92
Air Conditioning/Heating	33	7-8*	80
Interior Sound Level	25	9	77
Riding Stability	23	10	80
Aisle Width	21	11	71
Acceleration Ability	17	12	60

*Tie in ranking.

4.3. Survey of Reactions of Users of Park and Ride Service to Selected Bus Features

The objective of the survey of commuters using the bus service at the park and ride (PR) lots was to examine the factors which influenced auto and bus commuters to switch to bus service at the lots. Selected features of bus service at the PR lots are examined to determine their relative importance in the decision to use bus service at the lots and the extent to which commuters are satisfied with each of the features.

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[4] Based on a comparison of the overall responses patterns, as well as the rankings and other data (particularly the sums of the percentages), three groupings of features were defined and labeled Levels I, II and III. These groupings are intended to provide a general classification and means for discussion.

[5] The high importance placed on air conditioning is very understandable since the survey was conducted during the summer in the Washington Area where the weather is very hot and humid.

Table 23

Commuter Importance Rankings for Bus Interior & Service Related Features

FEATURES	PERCENT NOT WILLING TO DO WITHOUT THIS FEATURE FOR A 5¢ FARE REDUCTION	PERCENT OF RESPONSES "EXTREMELY" IMPORTANT
Level I		
Constant Reliable Schedule[1]	87	77
Air Conditioning/Heating	85	56
Assurance of Getting a Seat[1]	73	53
Reduction in Exhaust Emissions	68	43
Less Time Between Buses[1]	70	38
Level II		
Shelters at Bus Stops	42	21
Level III		
Leg Room	39	9
Seat Width	40	8
Interior Sound Level	36	9
Total Interior Design	37	6
Acceleration Ability	34	7
Aisle Width	28	7
Interior Lighting	30	5
No Interior Advertising	21	10
Floor Covering	24	4

[1]Service Feature

4.3.1. Survey Approach

During the week of January 28, 1973, a survey was conducted at two project PR lots. Within the morning peak periods, 344 commuters were contacted; 277 of those contacted returned their forms, for an 80 percent response rate.

The two PR lots are quite different in the quality of service which they provide. One (the Backlick lot) was designed as a park and ride lot. It is a secluded lot with a 400 auto capacity, a kiss and ride drop-off area, a bicycle rack and a telephone. By contrast, the other (the Springfield lot) is located in a shopping center (a designated portion for the bus service). Bus riders at the shopping center lot were at a disadvantage with respect to seat availability because the bus collected riders in the surrounding neighborhoods before stopping at the lot.

This survey of bus riders at the PR lots focused on a specific market, and therefore the results are not necessarily generalizable to all Corridor commuters. That is, features which attracted these former auto users to the bus service at the PR lots will not necessarily attract other auto commuters. Nonetheless, it is encouraging that the demographic characteristics of the former auto users at the PR lots are quite similar to those observed for Corridor-wide auto users during the October 1971 survey (Table 24). Former auto users at the PR lots had more autos per household than the 1971 auto commuters and more of them drove alone when commuting to work (56 and 54 percent respectively).

Except for the fact that all of the features considered in this survey concerned the quality of service of the bus system, the questionnaire and method of analysis were quite similar to the other. The questionnaire consisted of three sections. After an introductory segment, Section One solicited users' reactions on the importance of 12 features of

the bus service to their decision to use the bus service at the PR lots. Section 2 solicited bus riders' perceived satisfaction with the service features and Section 3 requested demographic information.

Table 24

Current Auto Users and Former Auto Users at Park and Ride Lots

DEMOGRAPHIC CHARACTERISTICS	AUTO USERS[a]	FORMER[b] AUTO USERS
Annual Household Income		
0 - 5,000	0.3	0
5,001 - 15,000	27.9	17
15,001 - 30,000	57.5	67
over 30,000	14.3	16
Total	100.0%	100%
Age (years)		
under 21	1.1	1
21-39	44.0	52
40-65	53.7	46
over 65	1.2	1
Total	100.0%	100%
Sex		
Males	73.1	75
Females	26.9	25
Total	100.0%	100%
Autos per Household		
0	1.5	0
1	37.4	20
2	50.4	67
3	8.9	10
4 or more	1.8	3
Total	100.0%	100%

[a]October 1971 Auto Commuter Survey

[b]January 1973 Park and Ride Survey

4.3.2. Survey Analysis

The survey analysis focuses on three groups of commuters: 1) former auto users at the Backlick and 2) Springfield lots, and 3) former bus users at the Backlick lot.[6] The results suggest that all commuters were generally satisfied with two of the three features ranked as most important in their mode choice decisions; however, they were less satisfied with the third, the convenience of arrival and departure times. Since that time nine

[6]Only three former bus riders were surveyed at the Springfield lot.

additional bus trips have been added in each peak period. It seems quite likely that the inclusion of these additional trips has increased the level of satisfaction with bus scheduled times. The remainder of paragraph 4.3.2 will examine the responses of each of the three individual groups of commuters.

4.3.2.1. Satisfaction

The satisfaction responses of the various commuter groups at the PR lots (see Table 25) exhibit materially different ratings. This is especially true of ratings for parking convenience, convenience of arrival and departure times, seat availability, and walking distance to the boarding point.

Table 25

Commuter Satisfaction Rankings for Bus Service Features

FEATURE	PERCENT RESPONDING "VERY SATISFIED"		
	BACKLICK		SPRINGFIELD
	FORMER AUTO USERS	FORMER BUS USERS	FORMER AUTO USERS
Stress and Frustration	68	47	46
Parking Convenience	50	28	65
Travel Time	50	37	38
Convenience of Bus Arrival and Departure Times	45	38	29
Schedule Reliability	44	38	47
Seat Availability	42	55	3
Evening Bus Service	30	30	34
Security at Lot	25	35	22
Commuting Cost	20	14	9
Walking Distance to Boarding	16	11	50
Bus Shelter	7	6	3

If differences in level of service at the PR lots and assumptions about user expectation based on previous commuting experiences are considered, some of the differences in user satisfaction rankings can be explained.

With regard to the differences in the satisfaction responses of former auto users at Backlick and Springfield, there is a distinct difference in the level of service provided at the two areas. Moreover, the level of service differences are consistent with the satisfaction rankings:

1. The buses collect riders in the surrounding neighborhoods before proceeding to the Springfield lot and at times there are no vacant seats when they arrive at Springfield.
2. Riders at Backlick must walk an average of about 60 yards to the boarding point, a longer distance than at Springfield.

With these facts in mind the differences in the satisfaction rating of the "seat availability" and "required walking distance to boarding point" features are more understandable.

Explanations of the differences in satisfaction ratings of the former bus and former auto users at Backlick are less definitive; however, a plausible explanation involves differences in expectations occasioned by different experiences with their past modes. Former bus users (accustomed to crowded buses) are likely to have lower expectations for seat availability and higher expectations for parking facilities. By similar reasoning, former auto users accustomed to crowded streets and scarce parking are likely to have lower expectations for parking facilities and higher expectations for seating after leaving the comfort of the private automobile. If these presumptions are valid the differences are rendered more understandable.

4.3.2.2. Importance

Unlike the satisfaction responses, the rankings of the group importance responses are similar. As Table 26 shows, the users generally indicated that the most important bus features in the decision to use bus service at the PR lots were the convenience of bus arrival and departure times, relief from the stress and frustration of commuting, and reliable and dependable bus service. Bus shelters, the walk from the lot to the boarding point and, to a lesser extent, cost were least important in the decision to use bus service at the PR lots.

Table 26

Commuter Importance Rankings for Bus Service Features

FEATURE	PERCENT RESPONDING "OF HIGHEST IMPORTANCES"		
	BACKLICK		SPRINGFIELD
	FORMER AUTO USERS	FORMER BUS USERS	FORMER AUTO USERS
Stress and Frustration	61	45	57
Schedule Reliability	46	42	29
Convenience of Arrival and Departure Times	40	45	34
Travel Time	34	27	23
Seat Availability	28	38	18
Parking Convenience	24	16	21
Security at Lot	20	10	21
Evening Bus Service	19	24	17
Commuting Cost	16	14	21
Walking Distance to Boarding	13	10	6
Bus Shelter	11	6	3

Of the features rated highly important, commuters were generally less satisfied with "convenience of bus arrival and departure times"; however, additional bus service has been added, and currently service is more frequent from the PR lots.

4.4. Findings

4.4.1. Conclusions

The results of these two surveys suggest that the service features of the buses have been primary factors in the diversion of auto commuters to the bus service. The reliability of bus service, reduction in the level of stress and frustration and the convenience of bus arrival and departure times (all service features) are identified as the bus features most likely to have been responsible for the large diversion of auto commuters to the bus system. By contrast, the analysis indicates that although the commuters are generally satisfied with the innovative interior features, the latter have not been very prominent in commuter mode choice decisions. Of all features considered, interior features (except for air conditioning and heating) were considered least important in commuter mode choice decision making. Air conditioning and heating, characterized as comfort features to distinguish them from appearance features, were considered only slightly less important than reliable bus service.

4.4.2. Implications of Survey Findings

The implications of these survey findings are many; however, two areas are of immediate concern - patronage predictions and marketing. To date, the method for predicting transit diversion from auto is the modal choice model. Previous models and the ones being developed in conjunction with this evaluation of the demonstration project include only the components of travel time and travel costs as transportation variables. Nonetheless, the survey results demonstrate that travel time and cost do not seem to be the primary factors in the mode choice decisions of these commuters; therefore, it will be difficult to accurately predict diversion using models which ignore convenience and stress and frustration conditions.

Likewise, if transit is to be successfully marketed to the public, the features to be highlighted are not just travel time and travel cost. According to the results of these surveys, it will be necessary to focus upon 1) reducing the frustration of commuting through transit usage, 2) eliminating the unreliability label often attributed to transit service and 3) providing operating schedules that are convenient for the riders, as well as providing travel times that are comparable with those of auto.

APPENDIX A

APPENDIX A

Table 27

Summary of Corridor Screenline Counts (W/O I-295)
(Inbound A.M. Peak Period)

DATE OF SURVEY	TOTAL AUTOS	PERSON TRIPS			W/SHIRLEY HIGHWAY		W/O SHIRLEY HIGHWAY	
		AUTO	BUS	TOTAL	PERCENT BUS TRIPS	AUTO OCCUPANCY	PERCENT BUS TRIPS	AUTO OCCUPANCY
Apr 70	32,979	48,272	13,791	62,063	22.22	1.46	21.61	1.40
May 70	33,990	48,441	15,147	63,588	23.82	1.43	23.06	1.39
Jun 70	33,579	47,566	13,900	61,466	22.61	1.42	21.07	1.39
Jul 70	35,725	53,076	14,087	67,163	20.97	1.49	20.60	1.41
Aug 70	33,254	48,044	14,004	62,048	22.57	1.44	22.09	1.41
Sep 70	36,081	53,296	14,514	67,810	21.40	1.48	20.88	1.43
Oct 70	35,734	50,573	14,248	64,821	21.98	1.42	20.50	1.43
Nov 70	33,135	46,249	14,885	61,134	24.35	1.40	22.96	1.40
Mar 71	33,598	46,371	14,837	61,208	24.24	1.38	20.73	1.37
Jun 71	32,676	45,852	15,149	61,001	24.83	1.40	19.18	1.41
Oct 71	31,740	42,927	16,377	59,304	27.62	1.35	19.34	1.36
Mar 72	33,267	45,255	17,489	62,744	27.87	1.36	18.25	1.36
Jun 72	33,133	45,064	16,845	61,909	27.21	1.36	17.45	1.34
Oct 72	33,510	44,172	18,299	62,472	29.29	1.32	18.05	1.31
Mar 73	34,181	45,992	18,936	64,929	29.16	1.35	17.12	1.33
Jun 73	35,491	48,250	19,944	68,194	29.25	1.36	20.14	1.33

APPENDIX A

Table 28

Corridor Screenline Counts By Station (Inbound A.M. Peak Period 6:30-9:00)

SURVEY DATE	AUTO PERSONS	TOTAL AUTOS	AUTO OCCUPANCY	BUS PASSENGERS	TOTAL PERSONS	BUS PERCENT	PASSENGERS PER BUS
			ARLINGTON BLVD.				
Apr 70	7578	5720	1.32	1619	9197	17.6	34.4
May 70	7742	5843	1.33	1701	9443	18.0	36.2
Jun 70	7630	5711	1.34	1424	9054	15.7	31.0
Jul 70	7928	5870	1.35	1462	9390	15.6	31.8
Aug 70	7772	5784	1.34	1384	9156	15.1	30.1
Sep 70	7624	5739	1.33	1407	9031	15.6	30.6
Oct 70	7943	5878	1.35	1438	9381	15.3	33.4
Nov 70	7864	5862	1.34	1362	9226	14.8	31.7
Mar 71	8324	6335	1.31	1421	9745	14.6	34.7
Jun 71	8182	6057	1.35	1211	9393	12.9	36.7
Oct 71	7485	5761	1.30	1204	8689	13.9	34.4
Mar 72	7543	5935	1.27	1253	8796	14.2	36.9
Jun 72	7949	6021	1.32	1246	9195	13.6	35.6
Oct 72	7990	6320	1.26	1101	9091	12.1	32.4
Mar 73	8031	6302	1.27	1143	9174	12.5	32.7
Jun 73	6775	5532	1.22	1010	7785	13.0	28.9
			COLUMBIA PIKE				
Apr 70	4889	3687	1.33	3684	8573	43.0	38.4
May 70	5138	3856	1.33	4425	9563	46.3	46.1
Jun 70	5116	3799	1.35	3563	8673	41.1	36.4
Jul 70	5263	3893	1.35	3476	8739	39.8	35.5
Aug 70	5553	3993	1.39	3628	9181	39.5	37.0
Sep 70	5612	4053	1.38	3798	9410	40.4	38.8
Oct 70	6218	4421	1.41	3807	10025	38.0	39.2
Nov 70	5145	3830	1.34	3812	8957	42.6	40.1
Mar 71	4291	3207	1.34	3274	7565	43.3	40.9
Jun 71	4345	3139	1.38	3324	7669	43.3	38.2
Oct 71	4339	3187	1.36	2984	7323	40.7	36.8
Mar 72	4468	3233	1.38	2865	7333	39.1	36.3
Jun 72	4456	3383	1.32	2473	6929	35.7	30.5
Oct 72	4910	3762	1.31	2910	7820	37.2	34.4
Mar 73	4865	3781	1.29	2493	7358	33.9	30.7
Jun 73	4123	2916	1.41	3016	7139	42.2	36.8
			SHIRLEY HIGHWAY				
Apr 70	12529	7420	1.69	3937	16466	23.9	41.0
May 70	12261	7937	1.54	4304	16565	25.9	44.8
Jun 70	11942	8029	1.49	4392	16334	26.9	43.9
Jul 70	15327	8934	1.72	4293	19620	21.9	42.1
Aug 70	13121	8413	1.56	4104	17225	23.8	41.5
Sep 70	14941	9276	1.61	4390	19331	22.7	44.8
Oct 70	12210	8916	1.37	4353	16563	26.3	45.3
Nov 70	11356	8226	1.38	4483	15839	28.3	44.8
Mar 71	10260	7262	1.41	5394	15654	34.5	49.0
Jun 71	8778	6295	1.39	6348	15126	42.0	40.7
Oct 71	7554	5662	1.33	7893	15447	51.1	47.5
Mar 72	7768	5604	1.39	9121	16889	54.0	48.5
Jun 72	8539	5941	1.44	9126	17665	51.6	44.0
Oct 72	8100	5897	1.37	10355	18455	56.1	45.4
Mar 73	9054	6419	1.41	11305	20359	55.5	44.7
Jun 73	16223	11392	1.42	11869	28092	42.2	46.5
			ARMY-NAVY DRIVE				
Apr 70	1949	1337	1.46	490	2439	20.1	32.7
May 70	1243	962	1.29	452	1695	26.7	30.1
Jun 70	1356	1032	1.31	409	1765	23.2	29.2
Jul 70	1447	1064	1.36	502	1949	25.8	33.5
Aug 70	1449	1066	1.36	414	186	22.2	27.6
Sep 70	1508	1102	1.37	450	1958	23.0	30.0
Oct 70	1526	1121	1.36	390	1916	20.4	26.0
Nov 70	1630	1161	1.40	443	2073	21.4	31.6
Mar 71	1954	1295	1.51	394	2348	16.8	28.1
Jun 71	2549	1721	1.48	334	2883	11.6	23.9
Oct 71	2599	1757	1.48	386	2985	12.9	27.6
Mar 72	2593	1898	1.37	306	2899	10.6	21.9
Jun 72	2450	1805	1.36	303	2753	11.0	21.6
Oct 72	2660	1952	1.36	333	2993	11.1	22.2
Mar 73	2822	2145	1.32	373	3195	11.7	28.7
Jun 73	1827	1405	1.30	322	2149	15.0	24.8

Table 28 Continued

Corridor Screenline Counts By Station (Inbound A.M. Peak Period 6:30-9:00)

SURVEY DATE	AUTO PERSONS	TOTAL AUTOS	AUTO OCCUPANCY	BUS PASSENGERS	TOTAL PERSONS	BUS PERCENT	PASSENGERS PER BUS
			MT. VERNON DRIVE				
Apr 70	3628	2426	1.50	1633	5261	31.0	34.0
May 70	3468	2339	1.48	1617	5086	31.8	29.9
Jun 70	3505	2331	1.50	1560	5065	30.8	29.4
Jul 70	3596	2385	1.51	1636	5232	31.3	31.5
Aug 70	3723	2430	1.53	1616	5338	30.3	31.1
Sep 70	3584	2373	1.51	1763	5347	33.0	33.9
Oct 70	4104	2671	1.54	1708	5812	29.4	34.9
Nov 70	3484	2335	1.49	1697	5181	32.8	35.4
Mar 71	3678	2531	1.45	1429	5107	28.0	33.2
Jun 71	4265	2930	1.46	1291	5556	23.2	30.0
Oct 71	3658	2649	1.38	1274	4932	25.8	29.0
Mar 71	3655	2737	1.34	1360	5015	27.1	28.9
Jun 72	3494	2537	1.38	1127	4621	24.4	26.2
Oct 72	3832	2830	1.35	1156	4988	23.2	26.9
Mar 73	3696	2719	1.36	1181	4877	24.2	27.5
Jun 73	2647	2055	1.29	1034	3681	28.1	25.9
			JEFFERSON DAVIS HIGHWAY				
Apr 70	6868	4756	1.44	727	7595	9.6	23.5
May 70	6798	4796	1.42	750	7548	9.9	26.8
Jun 70	6923	4880	1.42	894	7817	11.4	34.4
Jul 70	7038	4941	1.42	970	8008	12.1	29.4
Aug 70	6719	4466	1.50	1101	7820	14.1	34.4
Sep 70	8539	5397	1.58	987	9526	10.4	31.8
Oct 70	7762	5039	1.54	1003	8765	11.4	33.4
Nov 70	6918	4545	1.52	1148	8066	14.2	37.0
Mar 71	7075	4986	1.42	911	7986	11.4	27.6
Jun 71	6821	4649	1.47	793	7614	10.4	29.4
Oct 71	6993	4971	1.41	930	7923	11.7	38.7
Mar 72	8179	5660	1.45	967	9146	10.6	31.2
Jun 72	7616	5385	1.41	951	8567	11.1	32.8
Oct 72	7644	5472	1.40	829	8473	9.7	28.0
Mar 73	6841	4898	1.40	801	7643	10.5	26.7
Jun 73	6279	4646	1.35	888	7167	12.4	29.6
			GEORGE WASHINGTON PARKWAY				
Apr 70	10831	7633	1.42	1701	12532	13.6	40.5
May 70	11791	8207	1.44	1898	13689	13.9	41.3
Jun 70	11094	7797	1.42	1658	12752	13.0	36.8
Jul 70	12477	8638	1.44	1748	14225	12.3	38.8
Aug 70	9708	7102	1.37	1757	11465	15.3	39.0
Sep 70	11488	8141	1.41	1719	13207	13.0	39.1
Oct 70	10810	7688	1.41	1549	12359	12.5	39.7
Nov 70	9853	7176	1.37	1940	11793	16.5	44.1
Mar 71	10789	7982	1.35	2014	12803	15.7	42.0
Jun 71	10912	7885	1.38	1848	12760	14.5	39.3
Oct 71	10299	7753	1.33	1706	12005	14.2	36.3
Mar 72	11049	8200	1.35	1617	12666	12.8	35.2
Jun 72	10560	8061	1.31	1619	12179	13.3	33.7
Oct 72	9035	7276	1.24	1615	10650	15.2	34.4
Mar 73	10682	7916	1.35	1639	12322	13.3	34.9
Jun 73	10376	7545	1.38	1805	12181	14.8	37.6
			I-295 (WILSON BRIDGE)				
Mar 71	5403	4396	1.23	0	5403	0	0
Jun 71	5481	4282	1.28	0	5481	0	0
Oct 71	5081	4274	1.19	0	5081	0	0
Mar 72	5039	4274	1.18	0	5039	0	0
Jun 72	4316	3679	1.17	0	4316	0	0
Oct 72	4163	3590	1.16	0	4163	0	0
Mar 73	4200	3649	1.15	0	4200	0	0
Jun 73	4421	3770	1.17	0	4421	0	0

Table 29

Distributions of Corridor Auto Occupancy

Percent of Autos Crossing Screenline

SCREENLINE	PASSENGERS PER AUTO 1	2	3	4+	AUTO OCCUPANCY	PASSENGERS PER AUTO 1	2	3	4+	AUTO OCCUPANCY	PASSENGERS PER AUTO 1	2	3	4+	AUTO OCCUPANCY	PASSENGERS PER AUTO 1	2	3	4+	AUTO OCCUPANCY
	Apr 70					Mar 71					Mar 72					Mar 73				
Arlington Blvd.	74	21	03	02	1.32	75	21	03	01	1.31	76	21	02	01	1.27	77	19	03	01	1.27
Columbia Pike	70	27	02	01	1.33	71	25	03	01	1.34	70	24	04	02	1.38	76	21	02	01	1.29
Shirley Highway	57	26	08	09	1.69	71	21	05	03	1.41	73	19	04	04	1.39	71	21	04	04	1.41
Army-Navy Drive	66	26	05	03	1.46	63	28	05	04	1.51	72	22	04	02	1.37	76	19	03	02	1.32
Mt. Vernon Drive	63	27	07	03	1.50	67	25	05	03	1.45	71	25	03	01	1.34	71	24	04	01	1.36
Jefferson Davis Highway	67	25	05	03	1.44	67	26	05	02	1.42	68	24	05	03	1.45	70	24	04	02	1.40
George Washington Highway	69	24	04	03	1.42	72	23	04	01	1.35	73	22	03	02	1.35	74	20	03	03	1.35
I-295						84	12	02	02	1.23	86	11	02	01	1.18	89	09	01	01	1.15
All Station (w/o I-295)					1.46					1.38					1.36					1.35
	Jun 70					Jun 71					Jun 72					Jun 73				
Arlington Blvd.	73	21	04	02	1.34	73	22	03	02	1.31	74	21	03	02	1.35	82	15	02	01	1.22
Columbia Pike	70	26	03	01	1.35	70	22	04	02	1.38	74	22	03	01	1.32	68	25	04	03	1.41
Shirley Highway	66	24	06	04	1.49	71	22	03	04	1.39	70	21	05	04	1.44	70	21	05	04	1.42
Army-Navy Drive	78	15	04	03	1.31	66	23	06	05	1.48	73	21	04	02	1.36	77	17	04	02	1.30
Mt. Vernon Drive	64	26	07	03	1.50	65	27	05	03	1.46	71	23	04	02	1.38	80	13	04	03	1.29
Jefferson Davis Highway	69	23	05	03	1.42	66	25	05	04	1.47	69	24	05	02	1.41	72	23	03	02	1.35
George Washington Highway	69	24	04	03	1.42	69	25	04	02	1.38	73	23	03	01	1.31	72	21	04	03	1.38
I-295						79	16	03	02	1.28	86	12	01	01	1.17	86	12	01	01	1.17
All Station (w/o I-295)					1.42					1.40					1.36					1.36
	Oct 70					Oct 71					Oct 72									
Arlington Blvd.	73	21	04	02	1.35	76	19	03	02	1.30	77	20	02	01	1.26					
Columbia Pike	67	27	04	02	1.41	72	22	04	02	1.36	75	21	02	02	1.31					
Shirley Highway	74	18	04	04	1.37	75	19	04	02	1.33	73	20	04	03	1.37					
Army-Navy Drive	76	16	05	03	1.36	65	25	06	04	1.48	72	22	04	02	1.36					
Mt. Vernon Drive	62	26	08	04	1.54	70	24	04	02	1.38	71	24	04	01	1.35					
Jefferson Davis Highway	63	25	07	05	1.54	70	23	05	02	1.41	70	22	05	03	1.40					
George Washington Highway	68	26	04	02	1.41	74	20	04	02	1.33	79	18	02	01	1.24					
I-295						85	13	01	01	1.19	87	11	01	01	1.16					
All Station (w/o I-295)					1.42					1.35					1.32					

Table 30

Summary of Screenline Count Variability Analysis

	AUTO PERSON TRIPS		AUTO VEHICLES		AUTO OCCUPANCY		BUS PASSENGERS		BUSES		PASSENGERS/BUS		TOTAL PERSON TRIPS		PERCENT BUS TRIPS	
	NUMBER	PERCENT DEVIATION	NUMBER	PERCENT DEVIATION	NUMBER	ACTUAL DEVIATION	NUMBER	PERCENT DEVIATION	NUMBER	ACTUAL DEVIATION	NUMBER	ACTUAL DEVIATION	NUMBER	PERCENT DEVIATION	NUMBER	ACTUAL DEVIATION
Columbia Pike																
20 Sep 72	4751	-3.2	3602	-4.3	1.32	+0.02	2833	-2.6	83	-2.0	34.1	-0.1	7584	-3.0	37.4	+0.2
27 Sep 72	5152	+4.9	3963	+5.3	1.30	0	3028	+4.0	85	0.0	35.6	+1.4	8180	+4.6	37.0	-0.2
10 Oct 72	4828	-1.7	3723	-1.0	1.30	0	2870	-1.4	86	+1.0	33.4	-0.8	7698	-1.6	37.3	+0.1
Mean	4910		3763		1.30		2910		85		34.2		7820		37.2	
7 Mar 73	4679	-3.8	3678	-2.7	1.27	-0.02	2356	-5.5	82	+1.0	28.7	-2.1	7035	-4.4	33.5	-0.4
14 Mar 73	4958	+1.9	3797	+0.4	1.31	+0.02	2610	+4.7	79	-2.0	33.0	+2.2	7568	+2.8	34.5	+0.6
21 Mar 73	4959	+1.9	3869	+2.3	1.28	-0.01	2514	+0.8	83	+2.0	30.2	-0.6	7473	+1.6	33.6	-0.3
Mean	4865		3781		1.29		2493		81		30.8		7359		33.9	
Shirley Highway																
21 Sep 72	7886	-2.6	5664	-4.0	1.39	+0.02										
5 Oct 72	8506	+5.0	6097	+3.3	1.40	+0.03										
12 Oct 72	7909	-2.4	5930	+0.7	1.33	-0.04										
Mean	8100		5897		1.37											
3 Mar 73	8274	-8.6	5878	-8.4	1.41	0.00										
15 Mar 73	9329	+3.0	6660	+3.7	1.40	-0.01										
22 Mar 73	9559	+5.6	6721	+4.7	1.42	+0.01										
Mean	9054		6420		1.41											
Jefferson Davis																
20 Sep 72	7626	-0.2	5454	-0.3	1.40	0.00	837	+0.9	30	0.0	27.9	0.0	8463	-0.1	9.9	+0.1
27 Sep 72	7607	-0.5	5478	+0.1	1.39	-0.01	846	+2.0	30	0.0	28.2	+0.3	8453	-0.2	10.0	+0.2
9 Oct 72	7700	+0.7	5484	+0.2	1.40	0.00	805	-2.9	29	-1.0	27.8	-0.1	8505	+0.3	9.5	-0.3
Mean	7644		5472		1.40		829		30		27.9		8473		9.8	
5 Mar 73	6661	-2.6	4794	+2.1	1.39	-0.01	814	+1.6	30	0.0	27.1	+0.4	7475	-2.2	10.9	+0.4
12 Mar 73	6998	+2.3	4983	-1.7	1.40	0.00	863	+7.7	30	0.0	28.8	+2.1	7861	+2.8	11.0	+0.5
19 Mar 73	6866	+0.3	4918	-0.4	1.40	0.00	727	-9.3	30	0.0	24.2	-2.5	7593	-0.6	9.6	-0.9
Mean	6842		4898		1.40		801		30		26.7		7643		10.5	
George Washington Pkwy																
21 Sep 72	9396	+10.2	7483	+6.2	1.26	+0.05	1555	-1.0	47	0.0	33.1	-0.3	10951	+8.5	14.2	-1.4
28 Sep 72	8557	+ 0.4	7095	+0.7	1.21	0.00	1556	-1.0	48	+1.0	32.4	-1.0	10113	+0.1	15.4	-0.2
5 Oct 72	7621	-10.6	6562	-6.9	1.16	-0.05	1603	+2.0	46	-1.0	34.8	+1.4	9224	-8.6	17.4	+1.8
Mean	8525		7047		1.21		1571		47		33.4		10096		15.6	
7 Mar 73	10744	+0.6	8003	+1.1	1.34	-0.01	1669	+1.8	47	0.0	35.5	+0.6	12413	+0.7	13.4	+0.1
14 Mar 73	10721	+0.3	7911	-0.1	1.36	+0.01	1633	-0.4	47	0.0	34.8	-0.1	12354	+0.3	13.2	-0.1
21 Mar 73	10583	-0.9	7834	-1.0	1.35	0.00	1617	-1.4	47	0.0	34.4	-0.5	12200	-1.0	13.2	-0.1
Mean	10683		7916		1.35		1640		47		34.9		12322		13.3	
George Washington Pkwy (4 Counts)																
21 Sep 72	9396	+ 4.0	7483	+2.8	1.26	+0.02	1555	-3.7	47	0.0	33.1	-1.1	10951	- 2.8	14.2	-1.1
28 Sep 72	8557	- 5.3	7095	-2.5	1.21	-0.03	1556	-3.7	48	+1.0	32.4	-2.0	10113	- 5.1	15.4	+0.1
5 Oct 72	7621	-15.7	6562	-9.8	1.16	-0.08	1603	-0.7	46	-1.0	34.8	+0.4	9224	-13.4	17.4	+2.1
15 Nov 72	10568	+17.0	7966	+9.5	1.33	+0.09	1746	+8.1	47	0.0	37.1	+2.7	12314	+15.6	14.2	-1.1
Mean	9036		7277		1.24		1615		47		34.4		10651		15.3	

APPENDIX B

APPENDIX B

Table 31

Trends in Busway Bus Assignments and Patronage Growth

	NUMBER OF BUSES					PASSENGERS			
MONTH OF COUNT	SOUTH OF SHIRLINGTON	SHIRLINGTON	PENTAGON	TOTAL	PASSENGERS PER BUS	SOUTH OF SHIRLINGTON	SHIRLINGTON	PENTAGON	TOTAL
Sep.	39			39	53	2,095			2,095
Oct.	40			40	54	2,166			2,166
Nov.	42			42	53	2,235			2,235
Dec.	42			42	59	2,058			2,058
Jan. 70	42			42	54	2,290			2,290
Feb.	44			44	53	2,364			2,364
Mar.	44			44	53	2,375			2,375
Apr.	48			48	51	2,456			2,456
May	48			48	50	2,412			2,412
June	48			48	52	2,504			2,504
July	49			49	50	2,469			2,469
Aug.	49			49	49	2,408			2,408
Sep.	51	49		100	43	2,507	1,816		4,323
Oct.	53	49		102	45	2,688	1,944		4,633
Nov.	55	48		103	46	2,818	1,987		4,805
Dec.	55	48		103	47	2,856	1,991		4,847
Feb. 71	62	48		110	46	3,177	1,976		5,154
Apr.	66	42	92	201	46	3,482	1,689	4,165	9,336
May	67	47	97	212	45	3,422	2,072	4,226	9,721
June	103	52	95	250	42	4,474	2,134	4,009	10,618
July	103	53	96	252	40	4,398	1,847	3,956	10,201
Aug.	106	51	89	247	41	4,679	1,889	3,699	10,267
Sep.	106	53	96	255	43	5,118	2,016	3,930	11,065
Oct.	109	57				5,551	2,342		
Nov.	111	55	93	260	46	5,850	2,363	3,819	12,033
Jan. 72	114	55	88	257	48	6,223	2,464	3,817	12,504
Feb.	121	56	93	270	46	6,237	2,344	3,894	12,476
Mar.	133	55				6,724	2,397		
Apr.	135	57				6,760	2,383		
May	136	57	93	286	46	6,994	2,320	4,088	13,403
June	149	58				6,937	2,189		
July	148	62				7,074	2,508		
Aug.	151	57				7,722	2,309		
Sep.	159	58				7,641	2,121		
Oct.	170	58				8,497	2,275		
Nov.	177	57				8,630	2,148		
Dec.	178	58	90	326	45	9,029	2,113	3,680	14,822
Jan. 73	180	58				8,379	2,144		
Mar.	199	54				9,259	2,046		
Apr.	204	55	90	349	40	8,814	1,921	3,441	14,176
May	202	55				9,473	2,233		
June	199	56				9,729	2,140		

APPENDIX C

Appendix C

Cost Allocation Study

In order to explore in more detail the economic impacts of the project service, monthly system costs and revenues were allocated by line and by type of service - peak and off-peak. The procedures utilized to allocate costs were developed by Mr. D.H. James, Transit Consultant, Reston, Virginia and are based upon his observations and experience. The procedure can be summarized as follows:

1. The bus company posts monthly expenses for the project service in accordance with a chart of accounts established by the Interstate Commerce Commission and the Washington Metropolitan Area Transit Commission (WMATC). A definition of each account is provided in Table 32.
2. The allocation procedure is used to distribute total monthly (or other period) expenses in these accounts among each line for peak and off-peak periods of the day. The allocation is made on the basis of five factors (or parameters):
   a. Total miles (revenue and non-revenue) - by line peak and off-peak
   b. Platform hours[1] - by line, peak and off-peak
   c. Passengers - by line, peak and off-peak
   d. Number of bus vehicles - by line, peak service only
   e. Number of operators - by line, peak service only.

The first three parameters are used to allocate certain variable costs; the last two parameters to allocate certain fixed or semi-fixed costs. Mr. James has established an allocation methodology which has been used herein to estimate the relative contribution to the accounts by each of the five parameters. For example, 58% of account 4110 (Supervision of Shops and Garage) is likely to be explained by route mileage, and 42% by the number of vehicles required to service the route. The percentage allocations developed by Mr. James are listed in Table 33.

Total expenses in each account have been distributed among the five parameters in accordance with these percentages. For each route, by peak period (and off-peak if applicable), total (revenue and non-revenue) miles, platform hours, number of operators (required for peak service), number of vehicles (required for peak service), and number of passengers have been determined and each has been expressed as a percentage of the total (Project system) level for that parameter. Those percentages are used to allocate the total expenses in each account which have been broken down by parameter type. Summaries of expenses allocated by each parameter are presented in Table 33.

Table 34 displays the changes in parameter values, costs allocated by each parameter, percent of total cost allocated by each parameter, and parameter unit costs from the last half of 1971 to the last half of 1972. In the latter half of 1972, 39.4% of the total costs were allocated to peak service alone (peak period vehicles and peak period operators) versus 41.4% for the last half of 1971. The net result is that in 1972 about 82% of the project service costs were allocated to peak operations versus 80% for the last half of 1971. Total costs do not include depreciation on project bus vehicles, diversion payments or management fees paid to the AB&W Transit Company.[2]

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[1] Platform hours include all running and layover time.

[2] Diversion payments were made to compensate the AB&W Transit company for passengers diverted from non-project to project routes. With the acquisition of AB&W by WMATA in February 1973 these payments and the management fees were discontinued.

Table 32

Operating and Maintenance Expense Accounts

ACCOUNT NUMBER	ACCOUNT TITLE
●	EQUIPMENT MAINTENANCE & GARAGE EXPENSES
4110	Supervision of Shop and Garage
4121	Repairs to Shop & Garage - Equipment
4122	Operation of Service Cars & Equipment
4128	Repairs to Shop & Garage - Buildings & Grounds
4131	Light, Heat, Power, & Water; Shop & Garage
4132	Other Shop & Garage Expenses
4140	Repairs to Revenue Equipment
4140-A	Repairs to Revenue Equipment
4145	Repairs to Revenue Equipment - Accidents Off Premises
4146	Repairs to Revenue Equipment - Accidents On Premises
4147	Recovery on Accidents
4150	Servicing of Revenue Equipment
4160	Tires & Tubes - Revenue Equipment
●	TRANSPORTATION EXPENSES
4210	Supervision of Transportation
4220	Drivers' Wages
4230	Fuel for Revenue Equipment
4240	Oil for Revenue Equipment
4261	Road Expense
4262	Bridge & Road Tolls
4264	Other Transportation Expense
●	STATION EXPENSES
4311	Station Expense - Salaries & Commissions
4314	Station Supplies & Expenses
4319	Repairs to Station Buildings & Equipment
4331	Commissions Paid
●	TRAFFIC SOLICITATION & ADVERTISING EXPENSES
4410	Traffic Solicitation-Advertising Salaries & Expenses
4410-SS	Traffic Solicitation-Sightseeing-Salaries & Expenses
4430	Tariffs & Schedules - Salaries & Expenses
4440	Tickets & Transfers
4470	Advertising
4470-E	Advertising (Escrow Expense)
●	INSURANCE AND SAFETY EXPENSES
4510	Insurance & Safety - Salaries & Expenses
4520	Public Liability & Property Damage Insurance
4530	Injuries & Damages
4541	Workman's Compensation Insurance
4570	Fire & Theft Insurance - Buses
4571	Fire & Theft Insurance - Property
4580	Other Insurance

ACCOUNT NUMBER	ACCOUNT TITLE
●	ADMINISTRATIVE & GENERAL EXPENSES
4611	Salaries of General Officers
4612	Expense of General Officers
4613	Salaries of General Office Employees
4614	General Office, specifically NVTC
4616	Expenses of General Office Employees
4620	Law Expense
4630	General Office - Supplies & Expenses
4640	Communication Expense
4651	Outside Auditing Expense
4652	Employees' Welfare Expense - Retirement
4652-1	Employees' Welfare Expense - Group Health & Sick
4652-2	Employees' Welfare Expense - Life Insurance
4655	Purchasing & Stores Expense
4655-1	Purchasing & Stores Expense - Cash Discounts (Credit)
4656	Other General Expenses
4656-A	Overage & Shortages (Cashiers - Ticket Agents)
4673	Regulatory Expenses
4674	NVTC Regulatory Expenses
4680	Uncollectable Revenues
●	DEPRECIATION EXPENSE
5011	Depreciation Structures
5021	Depreciation - Revenue Equipment
5031	Depreciation - Service Cars & Equipment
5041	Depreciation - Shop & Garage Equipment
5051	Depreciation - Office Equipment
5071	Depreciation - Improvements to Leasehold Property
5091	Depreciation Adjustment
●	OPERATING TAXES & LICENSES
5210	Gasoline, Other Fuel & Oil Taxes
5220	Licenses & Road Taxes
5230	Real Estate & Personal Property Taxes
5240	Payroll Taxes
5250	Other Taxes
●	OPERATING RENTS
5320	Other Operating Rents - Debit
5321	Operating Rents, NVTC, e.g., AB&W Bus Rental

Table 33

Percentage Contributions to Variations in Transit Expenses

ACCOUNT NUMBER	PARAMETERS					TOTAL AMOUNT		
	MILES	HOURS	OPERATORS	VEHICLES	PASSENGERS	LAST HALF 1971	FIRST HALF 1972	LAST HALF 1972
4110	58			42		5,202.	6,444.	7,625.
4121	58			42		169.	351.	419.
4122	90			10		249.	520.	723.
4128	50			50		118.	481.	1,380.
4131	58			42		2,428.	2,806.	3,678.
4132	50			50		9,280.	13,489.	20,048.
4140	100					11,076.	32,607.	36,806.
4145	100					791.	7,774.	4,848.
4146	100					100.	243.	(8,227.)
4147	100			100		(1,117.)	(6,303.)	(5,925.)
4150				100		27,569.	37,755.	53,678.
4160	100					3,692.	6,312.	10,738.
4210	80		20			11,267.	16,664.	22,450.
4211	80		20			6,320.	9,648.	11,953.
4220		67	33			167,517.	269,932.	415,809.
4230	100					12,076.	19,825.	29,877.
4240	100					494.	1,656.	1,597.
4264		25	75			3,717.	6,664.	7,950.
4311					100	3,244.	5,534.	8,533.
4314					100	30.	39.	57.
4319					100	0.	9.	0.
4410					100			
4430		95			5	8,948.	15,018.	13,992.
4440					100	117.	867.	1,137.
4470					100		743.	0.
4510	25		25		50	839.	1,623.	2,426.
4520	33				67	9,906.	17,001.	22,090.
4541	16	3	71	9	1	939.	1,461.	2,562.
4570				100		3,954.	692.	5,268.
4571	50			50		187.	338.	624.
4580				100		68.	234.	512.
4611					100	703.	1,468.	319.
4612					100	61.	43.	22.
4613	5		10	10	75	6,365.	10,221.	14,784.
4614	5		10	10	75	4,193.	4,708.	4,605.
4616	5		10	10	75	12.	14.	45.
4620	10				90	519.	524.	2,523.
4630	5		10	10	75	504.	1,260.	1,453.
4640					100	815.	1,210.	2,299.
4651	5		10	10	75	814.	1,971.	2,519.
4652	16	3	71	9	1	18,614.	37,410.	39,671.
4655	80			20		1,614.	2,538.	3,478.
4656	5		10	10	75	917.	1,628.	2,083.
4673					100	670.	1,479.	595.
4674	20	20	20	20	20	1,540.	5,807.	786.
5011	5		10	10	75	78.	588.	910.
5031	90			10		544.	833.	1,104.
5041	58			42		194.	231.	241.
5051	5		10	10	75	353.	506.	712.
5071	58			42		476.	622.	518.
5210	100					6,947.	9,033.	2,761.
5220	25			75		1,056.	10,554.	4,145.
5230				100		2,813.	12,812.	4,176.
5240			100			12,487.	23,754.	29,839.
5250					100	286.	415.	615.
4320				100		12,875.	13,053.	12,890.
5321				100		528.	433.	1,294.

Parentheses indicates refund for period, usually an adjustment.

Table 34

Comparison of Project Bus Cost Allocations - Last Half 1971 With Last Half 1972

BASIS OF ALLOCATION	TOTAL UNITS			TOTAL COST ALLOCATED			PERCENT OF TOTAL COST		UNIT COST			
	1971	1972	PERCENT CHANGE	1971	1972	PERCENT CHANGE	1971	1972	1971	1972		PERCENT CHANGE
Platform Hours	26,167	53,581	105	121,995.	$295,296.	142	33.7	36.6	$ 4.66	5.51	(Hour)	18
Revenue and Non-revenue Miles	434,340	975,422	124	68,076.	140,146.	105	18.8	17.4	0.16	0.14	(Mile)	(13)
Number of Peak Period Vehicles	31	65	110	60,830.	104,740.	72	16.8	13.0	15.88	13.03	(Day)	(18)
Number of Peak Period Operators	31	65	110	88,894.	213,356.	140	24.6	26.4	23.21	26.53	(Day)	14
Passengers	496,947	1,173,496	136	22,312.	53,477.	139	6.1	6.6	0.044	0.046	(Passenger)	5
Total Cost				362,107.	807,015.	122						

APPENDIX D

APPENDIX D

PROCEDURE FOR ESTIMATING REDUCTION IN AUTO USAGE

The basic elements of the auto reduction estimating procedure are 1) the busway passenger counts and 2) an analysis of the "previous mode" responses of the 1971 bus commuters survey. The analysis of the former mode responses of the 1971 bus rider survey provided parameter values which were applied to the busway passenger counts to estimate auto usage reduction. Elements of the procedure are discussed below.

Use of Busway Counts and "Other" Bus Patronage Estimates

In estimating auto reduction stimulated by the demonstration project, it was necessary to estimate the number of autos which would have used Corridor highways if the demonstration project had not been undertaken. To obtain this estimate of auto reduction required an estimate of what busway patronage would have been without the project. Bus patronage levels on Shirley Highway bus routes at the times of busway service initiation were taken as the estimate of what bus patronage would have been without the demonstration project.[1]

Busway service was first initiated in September 1969 when the established bus routes originating south of Shirlington Circle were rerouted onto the completed sections. The first busway count (taken in September 1969) is taken as an estimate of what bus patronage on south of Shirlington routes would have been in the absence of a busway. In September 1970 busway entrances at Shirlington Circle became operational and Shirlington area bus routes were admitted to the busway. The September 1970 busway count is taken as an estimate of what patronage for Shirlington area routes would have been if no busway existed. The sum of these Shirlington and south of Shirlington passenger counts represents the hypothetical patronage level for WMATA Shirley Highway buses without the demonstration project. "Other" buses also began busway service in September 1969; pre-busway patronage estimates for these buses, taken from the appropriate company records and dispatcher notes for 1969, are assumed to represent the hypothetical patronage of "Other" Shirley Highway buses without the project. (See Table 35 for pre-busway patronage estimates.)

Table 35

Bus Patronage on Shirley Highway Routes - September 1969,1970

	WMATA (PROJECT AND NON-PROJECT)	"OTHER" BUSES
September 1969 Busway Patronage south of Shirlington	2100	450
September 1970 Busway Patronage at Shirlington	1820	
Total	3920	450

Non-Busway and Auto Diversion

The additional bus riders on the busway routes have come from non-busway (non-Shirley Highway) routes and from autos. The diversion from non-busway bus routes to all busway routes is estimated using a sample of responses of commuters on NVTC buses to the October 1971 bus commuter survey "former mode choice" question.[2] Estimates for the number of autos

[1] This actually overstates the hypothetical patronage for the no busway condition since some of the persons counted on these routes in September 1969 (and September 1970) were attracted by the provision of a busway.

[2] Former mode choice refers to the means of transportation used by an individual prior to using busway service.

removed from the highways as a function of diverted auto users are based on an analysis of former mode responses of commuters on all busses surveyed.[3]

The survey form contained six responses to the former mode question:

1. did not make this trip (from my present home to my present job location)
2. drove my car (carried no passengers)
3. was a driver carrying passengers
4. was an alternate driver
5. was an auto passenger
6. used another bus (specify route and bus company)

Those who reported that they did not previously make the trip (which includes people who failed to respond to the former mode choice question) were assumed to have former mode characteristics similar to all others interviewed. Responses in Category (1) therefore will not be treated explicitly in this analysis, but rather attention will focus on replies which fell into categories (2) through (6).

There were 666 persons interviewed for former mode on NVTC buses; of those that responded in categories (2) through (6), 90 reported that they had previously used a non-Shirley Highway bus. This implies that in October 1971, 13.5 percent (90/666), of the project bus sample were diverted bus users.[4] This percentage was applied to the October 1971 busway patronage estimate to obtain an estimate of passengers diverted from non-Shirley Highway bus routes. This estimate of riders diverted from non-Shirley Highway routes was subtracted from the October 1971, October 1972 and June 1973 busway patronage counts.[5]

Auto reduction as a function of diverted auto users is estimated using the following interpretive scheme (for categories (2) through (6)). For every respondent in (2), one fewer vehicle is in use. One half of those persons who drove with passengers (3), and one out of every six alternate drivers (4) are presumed to represent diverted vehicles. Auto passengers (5) and former bus riders (6) have no effect on auto volumes since they did not previously drive autos. The sample of bus users interviewed for former mode whose responses are summarized in the aforementioned categories is represented in Table 36 (excluding those who did not previously make the trip (category 1), and those who used another bus (category 6)). Thus, given these assumptions, the 315 former auto users represent 190 diverted autos; or, for every 5 auto commuters attracted to the bus, 3 autos are diverted from the highways (190/315=60%). The ratio of diverted motorists to diverted autos was the same for riders on the "Other" buses (46/77=60%).

Table 36

Former Auto Users and Diverted Autos

CATEGORY	RESPONSES TO OCTOBER 71 SURVEY FORMER MODE QUESTION[1]		NUMBER OF AUTOS DIVERTED	
	WMATA BUSES	"OTHER" BUSES	WMATA BUSES	"OTHER" BUSES
Drove alone	167	39	167	39
Drove w/passengers	26	5	13	3
Alternate driver	57	22	10	4
Auto passenger	65	11	0	0
Total	315	77	190	46

[1]Excluding "did not make trip" and "used another bus" categories.

[3]Not each former auto user represents an auto removed from the highways, since he might have been an auto passenger, or a participant in a car pool.

[4]This does not include persons who were diverted from the other busway buses since shifts from one busway route to another have no effect on total busway patronage. Also, Colonial Transit, Continental Trailways, and Greyhound commuter buses serve regions outside the Corridor, and do not board passengers at stops in competition with non-busway routes. Only a few WMATA Arlington buses use the busway; thus their effect on diversion, if any, is slight.

[5]Implicit in this procedure is the assumption that maximum diversion over the life of the project occurred with the inauguration of busway bus service. This assumption will be tested during the Fall 1973 bus survey.

APPENDIX E

APPENDIX E

Details of Air Pollution Reduction Computations

The following series of 6 tables contain the statistics and computations leading to the estimates in paragraph 3.6 for reductions in air pollution due to the demonstration project.

Tables 37 through 42 and Figure 12 correspond to the air pollution reduction analysis outlined in 3.6, and are labeled accordingly. The total amount of air pollution reduction attributable to the demonstration project is an estimated 1962 tons of carbon monoxide, 194 tons of exhaust hydrocarbons, 136 yons of nitrogen oxides, and 75 tons of evaporative crankcase hydrocarbons.

Table 37

Unadjusted Air Pollution Emission Rates By Vehicle Model Year

MODEL YEAR	CARBON MONOXIDE gr/mile	HYDROCARBONS (EXHAUST) gr/mile	NITROGEN OXIDES gr/mile	HYDROCARBONS (EVAPORATIVE) gr/mile
1963 & earlier	87	8.8	3.6	3.8
1964	87	8.8	3.6	3.8
1965	87	8.8	3.6	3.8
1966	87	8.8	3.6	3.8
1967	87	8.8	3.6	3.8
1968	46	4.5	4.3	3.0
1969	39	4.4	5.5	3.0
1970	36	8.6	5.7	3.0
1971	34	2.9	4.8	0.5
1972	19	2.7	4.6	0.2
1973	19	2.7	4.6	0.2

Table 38

Deterioration Factors for Exhaust Pollution Control Devices

MODEL YEAR	CARBON MONOXIDE			HYDROCARBONS			NITROGEN OXIDES		
	Oct 71	Oct 72	Jun 73	Oct 71	Oct 72	Jun 73	Oct 71	Oct 72	Jun 73
1967 & earlier	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1968	1.47	1.53	1.58	1.23	1.26	1.28	1.00	1.00	1.00
1969	1.59	1.63	1.68	1.18	1.21	1.23	1.00	1.00	1.00
1970	1.32	1.38	1.40	1.10	1.13	1.15	1.00	1.00	1.00
1971	1.18	1.32	1.38	1.05	1.10	1.13	1.00	1.00	1.00
1972	1.00	1.18	1.32	1.00	1.05	1.10	1.00	1.00	1.00
1973		1.00	1.18		1.00	1.05		1.00	1.00

Table 39

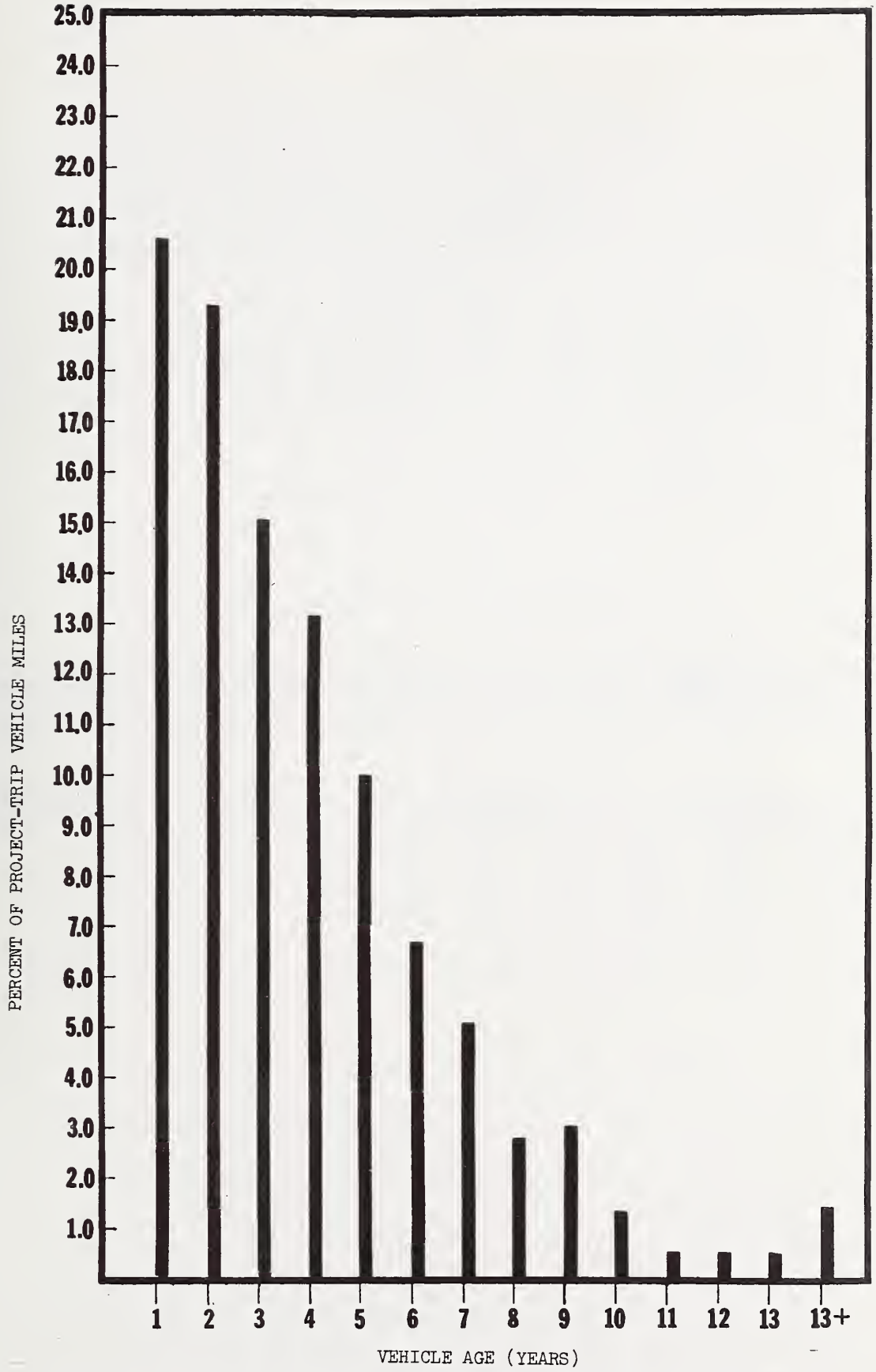
"Adjusted" Air Pollution Emission Rates

MODEL YEAR	CARBON MONOXIDE			HYDROCARBONS (EXHAUST)			NITROGEN OXIDE			HYDROCARBONS (EVAPORATIVE)		
	Oct 71	Oct 72	Jun 73	Oct 71	Oct 72	Jun 73	Oct 71	Oct 72	Jun 73	Oct 71	Oct 72	Jun 73
	(Grams/Mile)			(Grams/Mile)			(Grams/Mile)			(Grams/Mile)		
1963 & earlier	87.0	87.0	87.0	8.8	8.8	8.8	3.6	3.6	3.6	3.8	3.8	3.8
1964	87.0	87.0	87.0	8.8	8.8	8.8	3.6	3.6	3.6	3.8	3.8	3.8
1065	87.0	87.0	87.0	8.8	8.8	8.8	3.6	3.6	3.6	3.8	3.8	3.8
1966	87.0	87.0	87.0	8.8	8.8	8.8	3.6	3.6	3.6	3.8	3.8	3.8
1967	87.0	87.0	87.0	8.8	8.8	8.8	3.6	3.6	3.6	3.8	3.8	3.8
1968	67.6	70.4	72.7	5.5	5.7	5.8	4.3	4.3	4.3	3.0	3.0	3.0
1969	62.0	63.6	65.5	5.2	5.3	5.4	5.5	5.5	5.5	3.0	3.0	3.0
1970	47.5	49.7	50.4	9.5	9.7	9.9	5.7	5.7	5.7	3.0	3.0	3.0
1971	40.1	44.9	46.9	3.0	3.2	3.3	4.8	4.8	4.8	0.5	0.5	0.5
1972		22.4	25.1		2.8	3.0		4.6	4.6		0.2	0.2
1973			22.4			2.8			4.6			0.2

Table 40

"Typical" Vehicle (Weighted) Air Pollution Emission Rates

MODEL YEAR	CARBON MONOXIDE			HYDROCARBON (EXHAUST)			NITROGEN OXIDE			HYDROCARBONS (EVAPORATIVE)		
	Oct 71	Oct 72	Jun 73	Oct 71	Oct 72	Jun 73	Oct 71	Oct 72	Jun 73	Oct 71	Oct 72	Jun 73
	(Grams/Mile)			(Grams/Mile)			(Grams/Mile)			(Grams/Mile)		
1963 & earlier	6.3	3.7	2.5	0.6	0.4	0.3	0.3	0.2	0.1	0.3	0.2	0.1
1964	2.4	2.6	3.7	0.2	0.3	0.4	0.1	0.1	0.2	0.1	0.1	0.2
1965	4.4	2.4	2.6	0.4	0.2	0.3	0.2	0.1	0.1	0.2	0.1	0.1
1966	5.8	4.4	2.4	0.6	0.4	0.2	0.2	0.2	0.1	0.3	0.2	0.1
1967	8.7	5.8	4.4	0.9	0.6	0.4	0.4	0.2	0.2	0.4	0.3	0.2
1968	8.9	7.0	4.9	0.7	0.6	0.4	0.6	0.4	0.3	0.4	0.3	0.2
1969	9.4	8.4	6.6	0.8	0.7	0.5	0.8	0.7	0.6	0.5	0.4	0.3
1970	9.2	7.5	6.7	1.8	1.5	1.3	1.1	0.9	0.8	0.6	0.5	0.4
1971	8.3	8.7	7.1	0.6	0.6	0.5	1.0	0.9	0.7	0.1	0.1	0.1
1972		4.6	4.8		0.6	0.6		0.8	0.9		0.0	0.0
1973			4.6			0.6			0.9			0.0
Typical Vehicle	63.4	55.1	50.3	6.6	5.9	5.5	4.7	4.6	4.9	2.9	2.2	1.7



Source: Unpublished Data from the Metropolitan Washington Council of Governments.

Figure 12. Distribution By Vehicle Age of Vehicle Miles Traveled Within the Washington Metropolitan Area.

Table 41

Distributions of Corridor Peak Period Speeds and Volumes

30 MINUTE INTERVAL	AVERAGE SPEED				PERCENT OF TOTAL VOLUME[a]			
	Mar 71	Mar 72	Mar 73	Jun 73	Mar 71	Mar 72	Mar 73	Jun 73
6:31-7:00	29.23	26.17	22.36	39.32	22.0	27.5	25.1	21.9
7:01-7:30	15.53	13.69	13.99	30.75	20.5	21.4	19.4	21.2
7:31-8:00	11.57	12.30	10.49	29.23	19.5	17.5	17.7	20.8
8:01-8:30	13.12	12.85	11.70	35.99	18.6	15.8	17.0	20.0
8:31-9:00	36.33	29.48	22.64	50.66	19.6	17.8	20.8	16.1

[a]Columns may not total 100 percent because of rounding.

Table 42

Corridor Peak Period Auto Emission Rates

30 MINUTE INTERVAL	CARBON MONOXIDE			HYDROCARBONS (EXHAUST)			NITROGEN OXIDE			HYDROCARBONS (EVAPORATIVE)		
	Oct 71	Oct 72	Jun 73	Oct 71	Oct 72	Jun 73	Oct 71	Oct 72	Jun 73	Oct 71	Oct 72	Jun 73
	(Grams/Mile)			(Grams/Mile)			(Grams/Mile)			(Grams/Mile)		
6:31-7:00	11.2	13.6	7.8	1.2	1.5	0.9	1.2	1.4	1.2			
7:01-7:30	16.4	15.2	10.3	1.6	1.5	1.1	0.9	0.9	0.3			
7:31-8:00	17.1	13.5	11.0	1.7	1.3	1.2	0.8	0.7	0.3			
8:01-8:30	15.7	11.8	9.3	1.5	1.2	1.0	0.8	0.7	0.3			
8:31-9:00	8.1	8.3	4.7	0.9	0.9	0.6	1.1	0.9	1.0			
Typical Vehicle	68.5	62.4	43.1	6.9	6.4	4.8	4.8	4.6	3.1	2.9	2.2	1.7

APPENDIX F

APPENDIX F

Inventory of Project Route Mileages and Travel Times

Included in this appendix are definitions for the various bus route components [a) suburban collection and distribution, b) line haul, and c) downtown collection and distribution] for the different bus route destinations [1) Farragut Square (only), 2) Southwest Terminal, 3) Pentagon (only), and 4) Farragut Square via the Pentagon]. The route distances[1] (mileage) for each of the three portions of the four route types are displayed in Table 43. The associated times required to traverse the distance listed in the table are given in Table 44. The percent of the total route travel time required by each route component is also exhibited. Table 45 shows average travel speed for the entire route and each segment of the route for the four types of bus destinations.

Note that for most routes, barely one-third of the total travel time is spent in the line haul portion (on the busway). Thus, while busway speeds are high the contribution they make to the overall trip speed is slight; see Table 45.

Definition of Terms

I. Bus Route Destinations - A.M. Peak Period Operations
   a. Farragut Square - Bus routes serving only Farragut Square (see d)
   b. Southwest Terminal - Bus routes with Southwest Terminal destinations
   c. Pentagon - Bus routes serving only the Pentagon (see d)
   d. Farragut Square and Pentagon - Bus routes serving both the Pentagon and Farragut Square

II. Route Distance Components
   a. Suburban collection and distribution distance - for all destinations - the distance from the beginning of the route until the last stop (LS) before bus enters the Shirley Highway. (For route 17G buses, the last stop before bus enters route I-495 (Beltway).)
   b. Line haul distance
      1. For Farragut Square (only) and Southwest Terminal destinations - the distance from the LS to 14th and C streets, S.W. (Please note that this distance includes some arterial and residential street distance - from the LS until the entrance to Shirley Highway - as well as any distance traversed on the regular lanes of the Shirley Highway until buses can enter the reserved lane of the highway (busway).)
      2. For Pentagon (only) bus destinations - the distance from the LS to the Shirley Highway exit for Pentagon bound traffic.
      3. For Farragut Square and Pentagon destinations - the distance from the LS to the exit of the Shirley Highway for Pentagon bound traffic, plus the distance from the entrance of the Shirley Highway (for traffic coming <u>from</u> Pentagon) to 14th and C Streets, S.W.
   c. Downtown collection and distribution distance
      1. For Farragut Square (only) destinations - the distance from 14th and C Streets, S.W. to 17th and K Streets, N.W. (Please note that AB&W and NVTC published schedules give 20th and Eye Streets as the location of Farragut Square. The 17th and K Streets location was thought to be a more realistic description of the terminus for Farragut Square bound buses.)
      2. For Southwest Terminal destinations - the distance from 14th and C Streets, S.W. to the southwest terminal on D Street, near 9th St., S.W.
      3. For Pentagon (only) destinations - the distance from the exit of the Shirley Highway (for Pentagon bound traffic) to the Pentagon.
      4. For Farragut Square and Pentagon destinations - the distance from the exit of the Shirley Highway (for Pentagon bound traffic) to the Pentagon, and that from the Pentagon back to the entrance of the Shirley Highway, plus the distance from 14th and C Streets, S.W. to 17th and K Streets, N.W.

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[1] All distances were scaled from an AAA map of Northern Virginia.

III. Route Travel Time Components

a. Suburban collection and distribution time, line haul time, downtown collection and distribution time - For the distances defined in Section 2 , the travel time is the time required to travel those distances (from the published schedule of bus routes produced by AB&W). In those cases where the published schedule does not explicitly list the time the bus arrives at a given checkpoint (i.e., LS, 14th & C St., etc.), estimates were made from the available information in the schedule. Four minutes was assumed as the time requirement for buses to travel from 20th and Eye Streets to 17th and K Streets.

Table 43

Revenue Trip Distances for Project Bus Routes (Miles)

ROUTES	DESTINATION	SUBURBAN COLLECTION & DISTRIBUTION MILES	LINE HAUL MILES	DOWNTOWN COLLECTION & DISTRIBUTION MILES	TOTAL MILES
2G	Farragut Square	8.3	8.1	2.6	19.0
2G	Farragut Square & Pentagon	8.3	8.1	3.7	20.1
3G	Farragut Square & Pentagon	1.0	6.5	3.7	11.2
4G	Farragut Square	4.7	8.5	2.6	15.8
4H	Pentagon	9.7	7.1	0.8	17.6
6G	Farragut Square	3.2	4.8	2.6	10.6
7G	Farragut Square	3.1	6.5	2.6	12.2
8G	Farragut Square	2.2	6.5	2.6	11.3
17G	Farragut Square	5.3	14.0	2.6	21.9
17G	Pentagon	5.3	12.1	0.8	17.2
17M	S.W. Terminal	9.9	8.5	1.3	19.7
18G	Farragut Square	7.2	12.1	2.6	21.9
18M	S.W. Terminal	9.7	10.5	1.3	21.5
19G	Farragut Square	4.8	6.5	2.6	13.9

Table 44

Schedule Travel Times for Project Bus Routes

ROUTE	DESTINATION	SUBURBAN COLLECTION & DISTRIBUTION		LINE HAUL		DOWNTOWN COLLECTION & DISTRIBUTION		TOTAL MINUTES
		MINUTES	PERCENT[1/]	MINUTES	PERCENT[1/]	MINUTES	PERCENT[1/]	
2G	Farragut Square	26	45.0	16	27.5	16	27.5	58
2G	Farragut Square & Pentagon	26	42.0	16	25.8	20	32.2	62
3G	Farragut Square & Pentagon	5	13.2	13	34.2	20	52.6	38
4G	Farragut Square	16	33.3	16	33.3	16	33.3	48
4H	Pentagon	32	71.0	11	24.4	2	4.6	45
6G	Farragut Square	13	32.5	11	27.5	16	40.0	40
7G	Farragut Square	14	31.8	14	31.8	16	36.4	44
8G	Farragut Square	12	28.6	14	33.4	16	38.0	42
17G	Farragut Square	17	29.4	25	43.1	16	27.5	58
17G	Pentagon	17	43.5	20	51.3	2	5.2	39
17M	S.W. Terminal	33	57.9	16	28.1	8	14.0	57
18G	Farragut Square	23	37.8	22	36.2	16	26.0	61
18M	S.W. Terminal	30	50.8	21	35.6	8	13.6	59
19G	Farragut Square	20	40.0	14	28.0	16	32.0	50

1/ Percent of Total Trip Time

Table 45

Average Speeds for Project Bus Routes

ROUTE	DESTINATION	SUBURBAN COLLECTION & DISTRIBUTION M.P.H.	LINE HAUL M.P.H.	DOWNTOWN COLLECTION & DISTRIBUTION M.P.H.	TOTAL M.P.H.
2G	Farragut Square	19.2	30.4	9.8	19.7
2G	Farragut Square & Pentagon	19.2	30.4	11.1	19.4
3G	Farragut Square & Pentagon	12.0	30.0	11.1	17.7
4G	Farragut Square	17.6	31.8	9.8	19.7
4H	Pentagon	18.2	38.7	24.0	23.4
6G	Farragut Square	14.8	26.2	9.8	15.9
7G	Farragut Square	13.7	27.8	9.8	16.7
8G	Farragut Square	11.0	27.8	9.8	16.2
17G	Farragut Square	18.7	33.6	9.8	22.6
17G	Pentagon	18.7	36.3	24.0	26.4
17M	S.W. Terminal	18.0	31.8	9.8	20.5
18G	Farragut Square	18.8	33.0	9.8	21.5
18M	S.W. Terminal	19.4	30.0	9.8	21.9
19G	Farragut Square	14.4	27.8	9.8	16.7