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# SHIRLEY HIGHWAY EXPRESS BUS ON FREEWAY DEMONSTRATION PROJECT

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This paper describes a series of improvements that have given buses preferential treatment leading to travel time savings of 5 to 30 minutes. These improvements have been implemented over the past 2 years along a 9-mile section of I-95 (Shirley Highway) linking Northern Virginia with downtown Washington, D.C. Bus routes experiencing these time savings have gained approximately 4,000 more riders, most of whom have a choice between taking a bus or driving an automobile. Over half of the increase has occurred in the past several months following the opening of the full length of exclusive roadway for buses in the median of the Shirley Highway and the implementation of eight new express bus routes. Results of two travel surveys in the corridor made at the beginning and end of this period are discussed, and early indicators of the modal choice shift are described. Additional surveys are scheduled at 4- to 6-month intervals over the next few years. The types of analyses and data that will be available for general use by urban transportation planners are presented in preliminary form. The cost and revenue associated with the increased commuter traffic is analyzed using a five-parameter cost allocation procedure to provide preliminary guidelines for the financial requirements of similar improvements designed to attract more commuters to bus service.

•IT IS commonly recognized that the congestion of traffic in the nation's major cities is unacceptable and can be relieved only if large numbers of motorists will abandon peak-hour travel in their private automobiles and make use of mass transit instead. The U.S. Department of Transportation, through the Urban Mass Transportation Administration (UMTA) and the Federal Highway Administration (FHWA), is demonstrating various methods to attract motorists into public buses. A very important inducement is the significant reduction in trip time from boarding point to destination. This can be achieved by giving the bus preference over the automobile. UMTA in partnership with FHWA has placed emphasis on this solution and is conducting demonstrations to prove its success and to measure the effects. The largest and most promising demonstration is the use of express buses on an exclusive bus lane that has been operating for over 2 years on Shirley Highway, a major artery between Washington, D.C., and its Northern Virginia suburbs.

Planning for the project began in 1964 with discussions by a group representing the District of Columbia, the Virginia Highway Department, two bus companies, the Regional Regulatory Authority for Transit, the Regional Rapid Transit Authority, and the FHWA. As a result of these discussions, proposals for express bus service were incorporated in the reconstruction plans for Shirley Highway.

The same agencies again met and agreed in early 1968 to proceed with a detailed study. A steering committee to guide the study was established, consisting of a member and an alternate from each of the following agencies: Washington Metropolitan Area Transit Commission, Washington Metropolitan Area Transit Authority, Washington Metropolitan Area Council of Governments, Virginia Department of Highways, Northern Virginia Transportation Commission, District of Columbia Department of Highways, AB&W Transit Company, and the WV&M Coach Company. The FHWA and UMTA are represented in an advisory, non-voting capacity.

This steering committee was assigned responsibility for the determination of overall policy. It also selected the consultant (Howard, Needles, Tammen and Bergendoff) to perform the work and approved their detailed study design.

The study evaluated all travel in the Shirley Highway Corridor to find out how bus rapid transit could best be provided and to determine its feasibility within two separate time periods. The first period covered the last stages of the Shirley Highway reconstruction (1969-1975). The second was the post-reconstruction period, when a new important factor had to be taken into consideration: the completion of the Metro rail rapid transit system, which will raise complicated questions of integrating bus and rail rapid transit service.

The steering committee has maintained a high level of active support and collaboration in top-level policy guidance. As a result, the plan for express bus operations recommended for the interim period while Shirley Highway is being reconstructed is now operational. The committee continues to function now that the project is under way and serves to resolve those problems that involve several of the operating partners in the project.

FHWA, through the Virginia Department of Highways, has constructed the exclusive bus lane in the median. With funds provided by UMTA, the Northern Virginia Transportation Commission (NVTC) has purchased the new buses needed for the demonstration, and the buses are operated under contract by the AB&W Transit Company. Other bus companies, notably Continental Trailways, Colonial, WV&M, and Greyhound, are also permitted use of the exclusive bus lane.

## LOCATION AND DESCRIPTION

The area influenced by the project is known as the Shirley Highway Corridor, a broad, wedge-shaped section of Northern Virginia extending from Washington, D.C., to Woodbridge, 25 miles to the south. Its area is approximately 160 square miles, with a population of approximately 600,000. It includes portions of Arlington and Fairfax Counties and the cities of Alexandria, Falls Church, and Fairfax, all major suburbs of the Nation's Capital. At the northeastern end of the corridor are the region's major employment centers: the Pentagon, the rapidly growing Crystal City complex, and the central business district of the District of Columbia, where there are three major terminal areas for the commuter buses. The three Washington terminals combined provide close access to over 270,000 jobs, a number predicted to be over 300,000 by 1975. Figure 1 shows the corridor area and Figure 2 the routes and terminals in the District of Columbia.

There are several major highway facilities in the corridor that handle commuter traffic radiating northward to downtown Washington. The principal facility is I-95, the Shirley Highway. It is in the median of this freeway that a roadway is now available for the exclusive use of buses. That roadway is composed of two 12-foot-wide reversible highway lanes for a little over half the distance and a single temporary 17-foot-wide highway lane for the remainder of the distance into Washington.

The median will eventually consist of two reversible lanes most of the distance from Springfield, Virginia, to downtown Washington—a distance of about 12 miles. At present, the last 4.5 miles of the roadway approaching Washington is being reconstructed (see "Temporary Busway" in Fig. 3). In approximately 2 years this lane will be replaced by two reversible lanes joining those now existing south of this temporary lane. The comparative travel times for buses and automobiles in both the morning and evening peak periods and on various sections of the roadway are also shown in Figure 3.

The pattern of bus routes collecting commuters in Northern Virginia and feeding into the busway is shown in Figure 4. Also shown are proposed locations for fringe parking that are now under development.

Figure 5 shows a bus operating on the completed reversible lanes of the exclusive bus roadway and passing the long queue of vehicles that back up on Shirley Highway during the morning peak travel period. The scene is approximately 5 miles from downtown Washington and the bus shown here will reach that destination in about 10 minutes. By contrast, the cars shown here will take over 30 minutes to travel the same distance.

Figure 1. Area of busway influence and major inbound destinations.

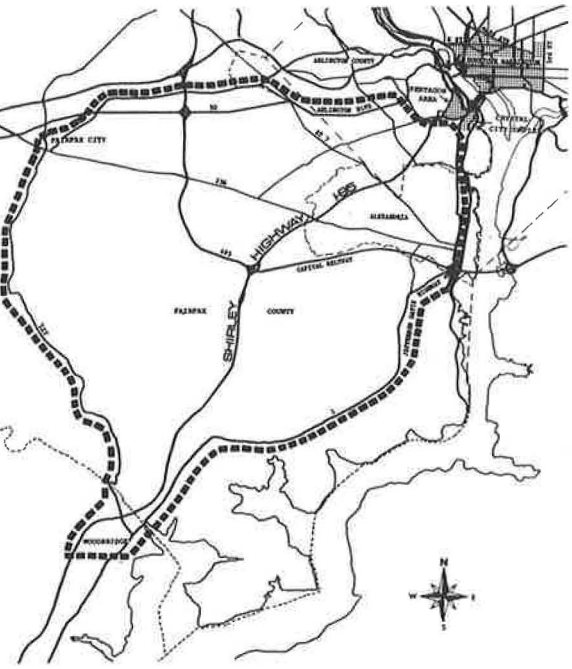



Figure 2. Peak-period bus routes to Washington terminals.


Figure 3. Auto and bus peak-hour travel times on Shirley Highway.

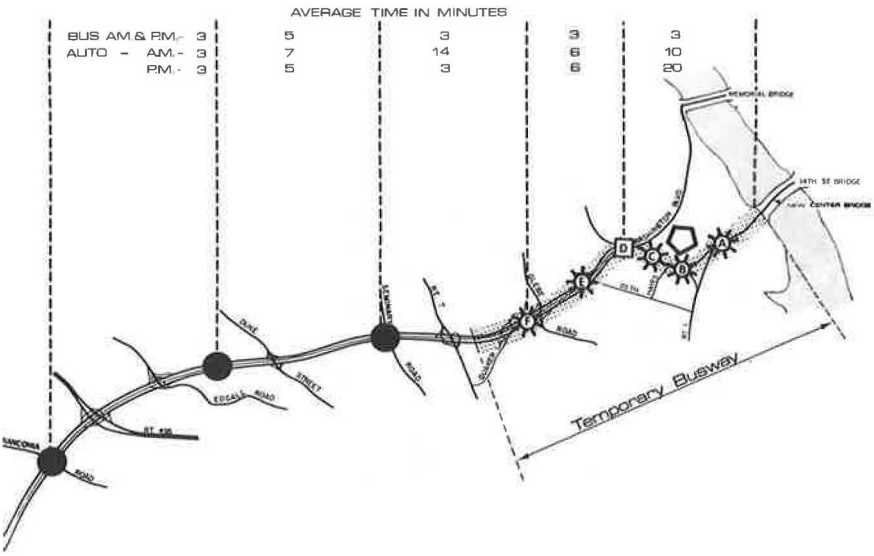


Figure 4. Peak-period bus routes and fringe parking locations.

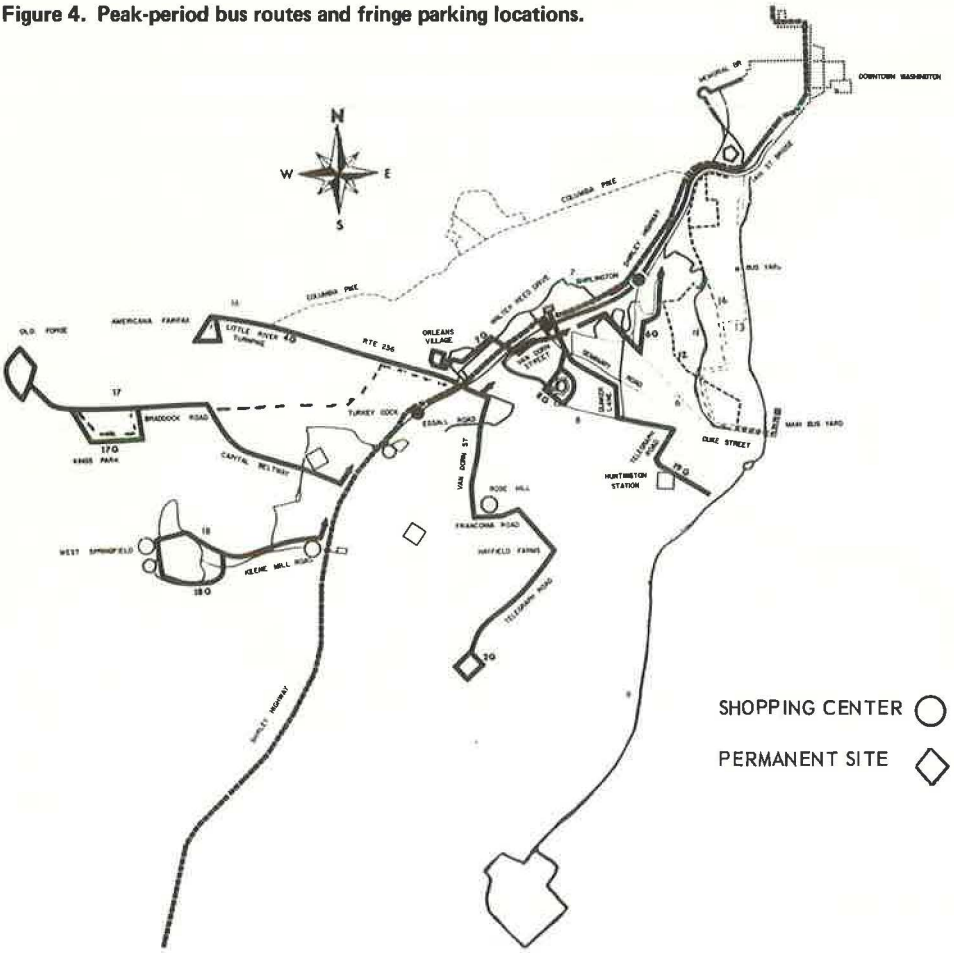
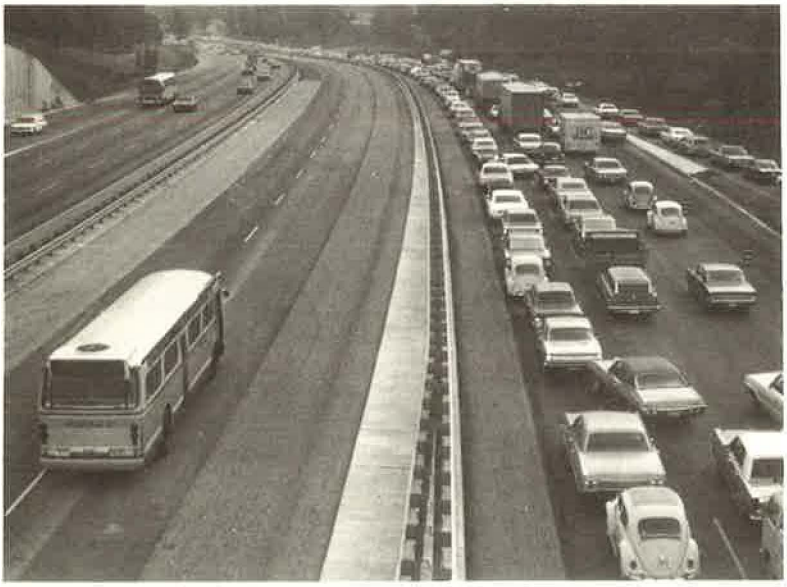



Figure 5. Shirley Express bus on reversible lanes.



As buses on the exclusive bus roadway approach Washington, they have a choice of two bridges over the Potomac. The great majority of buses use a new bridge built for the eventual reversible-lane operation (indicated by the heavy solid line in Fig. 2). As these buses exit from the bridge, they merge with regular traffic on 14th Street into downtown Washington. Buses may also leave the exclusive lane at point D in Figure 2 and proceed by Washington Boulevard to Memorial Bridge.

In Washington, curb lanes along the routes of the express buses are reserved for them and for right-turning automobile traffic. Ongoing construction of the Metro occasionally makes it necessary to make slight modifications in these plans (Fig. 6) to accomplish the most efficient bus circulation.

The flow of express bus traffic just described is reversed in the evening peak period, and the Shirley Highway median carries express buses in the opposite direction.

The three principal terminal points in Washington for the Shirley corridor service are shown in Figure 2 where they are marked with a T. The lower right terminal area in southwest Washington is convenient to about 60,000 jobs; the mid-terminal area (the Federal Triangle) is within walking distance of about 50,000 jobs; and the upper terminal area at Farragut Square is within walking distance of about 160,000 jobs.

## PROJECT EVALUATION

The evaluation of the project performance is based on a set of goals established in the planning stages and refined as the project became operational. An evaluation team undertook to study traffic on Shirley Highway, the characteristics of bus riders and motorists, travel times for both buses and automobiles, changes in commuters' modes of travel, and their attitudes toward the new system. Cost factors were also analyzed.

The major project goals and objectives are to (a) divert motorists to the Shirley bus service; (b) develop a viable service that will continue after the demonstration; (c) reduce travel time for all commuters; (d) reduce air pollution; (e) increase reliability of service; and (f) improve mobility for young, old, handicapped, and low-income travelers.

The object of the evaluation is to measure project performance in terms of progress toward meeting these goals. The evaluation team also collects data required for a better understanding of the phenomena underlying achievement of certain of the goals. For example, those variables that may affect modal shifts will be monitored throughout the project. Also, to better understand project costs, a chart of accounts for operating expenditures is being maintained; a preliminary analysis of these costs is given later in this paper.

A substantial number of bus passengers use the roadway, as indicated in Figure 7. The graph shows distinct incremental increases in bus passengers occurring in September 1970 and April 1971; each coincides in time with the opening of new sections of the exclusive bus roadway and the rerouting of buses that had up to those dates been operating in mixed traffic.

These incremental jumps in ridership should not, of course, be interpreted as traffic growth or diversions between bus routes. Most of the genuine passenger growth has been and continues to be on those routes serving the southern part of the corridor. A substantial increase in bus service for this area occurred in June 1971 through the addition of 30 new buses on new express routes. Service increased in February 1972 with the addition of 20 more new buses and will be expanded by at least two increments of 10 to 20 buses later in 1972.

Peak-period ridership in this southern sector has risen by more than 4,000 persons since September 1969. Taking into account all the AB&W buses operating over portions of the exclusive roadway, more than 12,000 passengers in each peak period are experiencing the benefit of time saving in commuting. Some 1,200 additional people traverse the exclusive bus roadway on other private carrier buses during each of the peak periods.

To evaluate demonstration projects of the magnitude of the Shirley project requires monitoring of numerous phenomena and the employment of several different techniques of data gathering. All of the following data-gathering efforts are under way by the evaluation team: postcard origin and destination (O&D) surveys; screen-line counts; bus passenger counts; travel time diaries; accounting summaries; schedule-adherence checks; and product-evaluation surveys. An attitude survey is also being planned.

The O&D survey is the major part of the effort and the most costly. This type of inquiry is essential, however, for obtaining empirical data on the modal shifts that the project is causing.

Checkpoints have been established at appropriate locations on the major arteries in the corridor and approximately 2 miles from Washington. At these counting sites, shown in Figure 8, a sample of passing motorists is periodically surveyed. Drivers are identified by their license plates and mailed questionnaires to be answered and mailed back. Screen-line counts are conducted in the spring, summer, and fall of each year. Two O&D surveys have been completed—in April and October 1971—and a third is scheduled for the fall of 1972. At least one or two more O&D surveys will be conducted in 1973 or 1974.

A computer file of all the data collected is being compiled. Very detailed bus and highway networks are being coded to simulate the comparative travel times and costs for each O&D survey respondent. The actual mode choice decision is of course available on the completed survey form. Data on the independent variables that may affect this decision will be placed in the record for each survey respondent; these independent variables are given in Table 1. The evaluation team will analyze these data and describe the influence the variables have on mode choice in future project reports. It is hoped that this reporting will be helpful to transportation planners in other parts of the country who must estimate the impact of a similar type of transportation improvement for their area.

## EVALUATION RESULTS: PRELIMINARY DATA

Firm statistics concerning the project cannot be reported until about 1974. However, preliminary data indicating the general trends are presented here. No doubt there will be adjustments of the results reported here as more data and more analyses become available.

The statistics compiled over the longest period of time are derived from the screen-line counts that began in the spring of 1970. The percentage of person trips crossing the seven screen-line stations by bus is shown in Figure 9. It should be noted that an eighth station has been added for Beltway traffic and may be included in the screen-line statistics pending further analysis. The percentage of person trips by bus stayed at about 21 percent during 1970 but increased in 1971 to a little over 27 percent. Absolute screen-line counts are given in Table 2.

It cannot, of course, be assumed that everyone counted is a potential bus user. A gross comparison of auto and bus person trips across the screenline does not properly indicate how well the bus service in the corridor is competing with the automobile. Motorists making through trips, for example, crossed the screenline but could not possibly use the Shirley bus service. These are trips that neither started nor ended in the corridor or in downtown Washington. Also, trips may start in the corridor but have destinations in areas not served by bus.

Accordingly, the evaluation team adjusted the statistics, and the preliminary estimate is that two-thirds of automobile person trips crossing the screenline are actual potential express bus riders. These are designated as the "market". Those who use the buses are placed in a category designated the "market share". The growth of this group is shown in Figure 10, which indicates that the percentage of all potential bus-using motorists who graduated to actual bus riding increased from 29 percent in October 1970 to 32 percent in April 1971 and to an estimated 36 percent in October 1971.

During the same period the absolute number of bus passengers increased from 14,200 to 16,300. Very significantly, simultaneously the number of automobile person trips declined by an even more substantial number—from over 50,000 in October 1970 to 43,000 in October 1971.

The greatest change occurred on Shirley Highway itself where, as shown in Figure 11, the number of automobile person trips declined from a little over 12,000 in October 1970 to about 7,500 automobile person trips a year later. By contrast, bus passengers increased from 4,300 people to 7,800 people during the same period. Not all of this increase, however, represents growth in overall bus use because in that period existing

Figure 6. Peak-period priority lanes in downtown Washington.

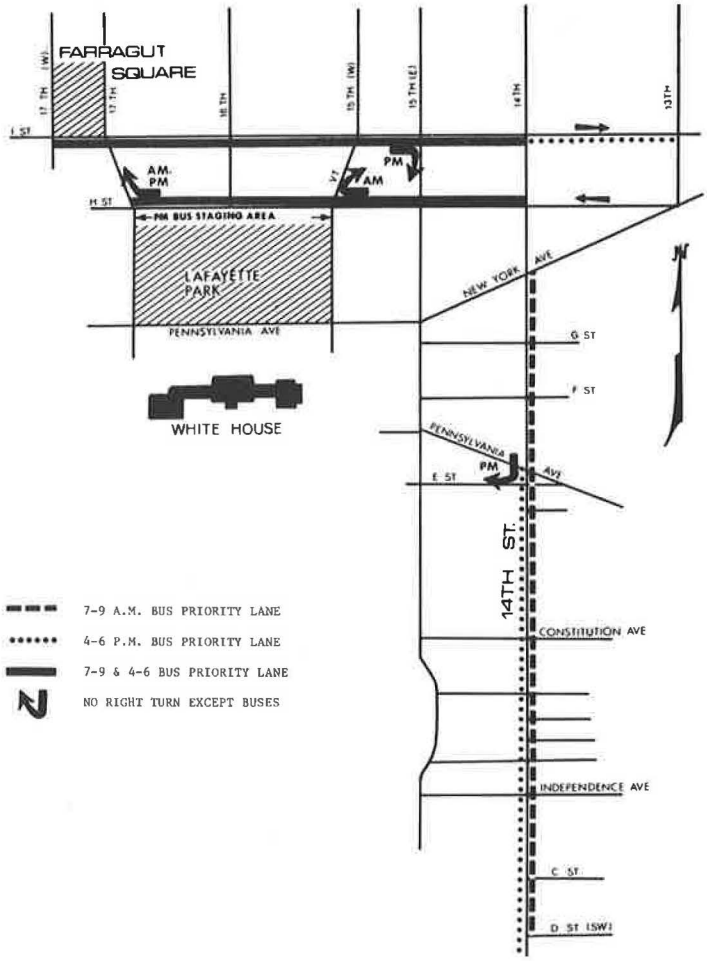



Figure 7. Total passengers using busway during 6:30-9:00 a.m. period.

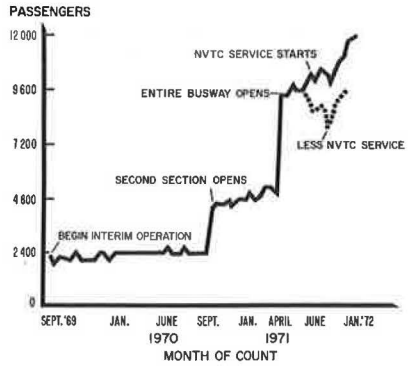



Table 1. Data file.

System Characteristics:
- Differential commute time
- Differential commute cost
- Out-of-vehicle time
- Transit fare
- Special advertising
- Transfers
- Park-ride availability
- Project vehicle

Zone Characteristics:
- Residential density
- Parking cost

Traveler Characteristics:
- Household income
- Sex
- Age
- Auto available

Trip Characteristics:
- Auto needed on job
- Distance to CBD

Figure 8. Corridor person movement counting sites.

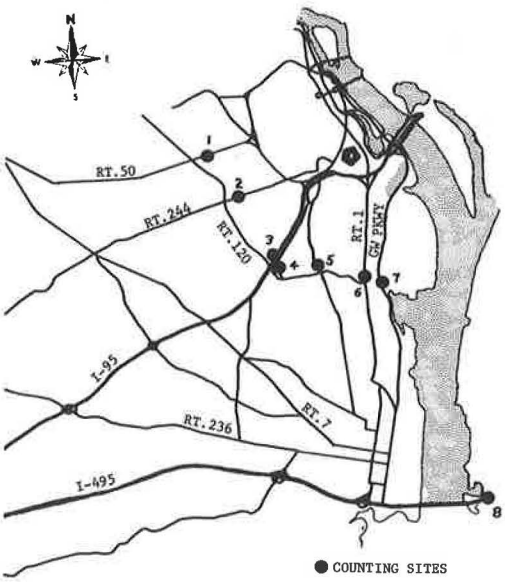
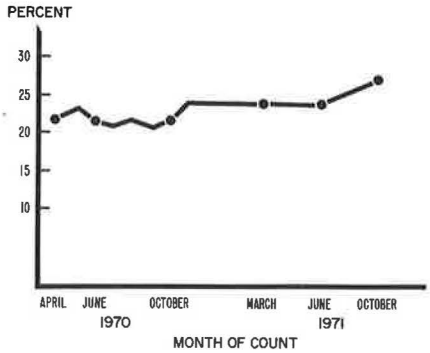



Figure 9. Percent person trips by bus crossing screenline during 6:30-9:00 a.m. period.



bus routes were diverted to the Shirley Highway to take advantage of newly completed sections of the exclusive busway.

This modal shift has caused a historic change in the balance of traffic being carried by public and private modes on Shirley Highway. The volume of morning peak-period person trips carried by buses on Shirley Highway exceeded the volume carried by automobiles for the first time in October 1971. The absolute numbers and percentages are given in Table 2. The car occupancy figures, also appearing in Table 2, have declined both for Shirley Highway and overall, but the change was slight: from 1.37 to 1.34 persons per car on Shirley Highway and from 1.41 to 1.35 persons per car in the combined sample from all screenline stations for the year between October 1970 and October 1971. The evaluation team is investigating the variation that occurs in these figures by screenline station and by season and the effect the project bus service has on reducing car pools.

## COMMUTER PROFILES

Characteristics of commuters in the corridor and their attitudes toward modes of travel are, of course, extremely important factors for the evaluation study. Information has been developed from both the April and October 1971 surveys.

The October survey contained an open-ended query designed to elicit from motorists unguided attitudes toward the concept of an exclusive roadway for buses now being demonstrated on Shirley Highway. Although there were some very lengthy negative comments, three-quarters of the motorists commented favorably about the concept. A substantial negative reaction was expected from motorists using Shirley Highway who experience the daily frustration of seeing buses speeding by on the wide-open bus roadway while they are caught in heavily congested bumper-to-bumper traffic. Surprisingly, even two-thirds of these motorists commented favorably on the concept.

A profile of the bus commuter and the automobile commuter emerges from the data given in Table 3. Here, too, attitudes are measured, although this time both bus users and motorists were queried. The scale used for the measurement of attitude needs some explanation: a score of 1 signifies a very positive attitude about transit, and 4 signifies a very negative attitude. As might be expected, bus users were found to have more positive feelings about transit than automobile users. Both groups appear to be more positive about transit in the October survey than they were in the initial survey in April.

The profile data reveal that nearly three-quarters of the automobile commuters are male whereas the bus commuters are about evenly divided between the sexes. The automobile commuters also have higher incomes, as expected, but the bus commuters are not too poor and their average income increased between the two surveys by nearly $1,000. This rise in average income implies that a substantial number of well-to-do motorists became bus riders between April and October.

The bus users have been further subdivided in Table 4 into Shirley and non-Shirley subpopulations. The Shirley bus users are defined as those riding buses that enter the busway at Shirlington Circle or further south. In other words, they make substantial use of the busway, using it for 4 miles for more. All the other bus users are in the category of non-Shirley bus users.

It can been seen in Table 4 that the profile of the Shirley user resembles that of the automobile commuter. He is richer, has more cars per household, and has more choice than the non-Shirley bus user. The Shirley bus rider has a more favorable attitude about transit, and again both Shirley and non-Shirley bus users are more favorable toward transit in the October than in the April survey. A substantial portion of Shirley users previously drove alone, about one out of five. A smaller portion, nearly one out of eight, came from car pools. About half of the bus users did not make the trip before, and half the Shirley bus users reported in October that they began using the bus only since June 1971. Even a quarter of the non-Shirley users reported that they started using the bus after June 1971. There is undoubtedly a lot of shifting between modes as well as between home and job locations. Washington probably has above-average job mobility, and the evaluation team is analyzing this factor in more

**Table 2. Screen-line counts.**

| Statistic | Auto Persons | Total Vehicles | Auto Occupancy | Bus Passenger | Total Persons | Bus Percent |
|---|---|---|---|---|---|---|
| Shirley Highway Screenline Station | | | | | | |
| October 1970 | 12,210 | 8,906 | 1.37 | 4,353 | 16,563 | 26.28 |
| October 1971 | 7,564 | 5,662 | 1.34 | 7,824 | 15,388 | 50.84 |
| Difference | -4,646 | -3,244 | -0.03 | +3,471 | -1.175 | +24.56 |
| Total Screenline | | | | | | |
| October 1970 | 50,508 | 35,724 | 1.41 | 14,248 | 64,756 | 22.0 |
| October 1971 | 42,937 | 31,740 | 1.35 | 16,308 | 59,245 | 27.5 |
| Difference | -7,571 | -3,984 | -0.06 | +2,060 | -5,511 | +5.5 |

**Figure 10. Portion of potential bus market using transit "market share".**

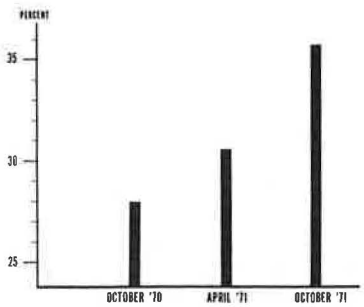



**Figure 11. Auto and bus person trips during 6:30-9:00 a.m. period.**

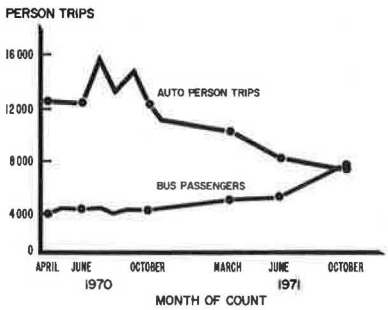



**Table 3. Bus and auto commuter profiles.**

| Characteristic | Bus April | Bus October | Auto April | Auto October |
|---|---|---|---|---|
| Percent male | 49 | 54 | 73 | 74 |
| Household income (dollars) | 15,500 | 16,400 | 19,500 | 19,100 |
| Cars per household | 1.1 | 1.3 | 1.7 | 1.7 |
| Attitude score (1.0 very positive) | 1.9 | 1.6 | 2.7 | 2.4 |
| Percent captive (no auto) | 33 | 24 | | |
| Percent choice (auto available) | 52 | 57 | | |
| Percent auto available but hardship[1] | 14 | 16 | | |

[1]The person had an auto available for his trip but at some inconvenience to others.

**Table 4. Bus survey results.**

| Characteristic | Shirley April | Shirley October | Non-Shirley April | Non-Shirley October | Shirley Passenger Description |
|---|---|---|---|---|---|
| Household income (dollars) | 16,300 | 16,900 | 15,200 | 16,100 | Richer |
| Attitude score (1.0 very positive) | 1.7 | 1.5 | 1.9 | 1.8 | Favorable to bus |
| Cars per household | 1.2 | 1.3 | 1.1 | 1.2 | More cars per household |
| Percent choice | 59 | 62 | 44 | 48 | More choice |
| Percent captive | 24 | 21 | 37 | 36 | Less captive |
| Percent park-ride | 8 | 16 | 7 | 9 | More park-ride |
| Previous mode (percent): | | | | | |
| Drove alone | 23 | 18 | 16 | 12 | |
| Car pool | 12 | 13 | 11 | 11 | |
| Another bus | 17 | 20 | 13 | 14 | |
| No trip | 48 | 49 | 60 | 62 | |
| Began bus after June 1971 (percent) | | 52 | | 26 | |

detail. This dynamic situation provides an opportunity to gain new riders for transit because commuting habits are frequently changing. It also represents a challenge to keep potential and existing transit users informed about available transit service.

The automobile user profiles are as given in Table 5. The most striking finding is the high percentage of those paying no parking costs—over half. Those who pay are charged, on the average, over $1 per day, which is about three-quarters of the average round-trip transit fare. Also, about one in five automobile users indicate that they need their car during the day, which reduces the possibility that they could be attracted to transit. Finally, about a quarter of the automobile users in the October survey said they have tried transit; 19 percent answered this question affirmatively in the April survey.

## REASONS FOR SWITCHING BETWEEN MODES

Among the most important findings of the October survey were the principal reasons stated for switching travel modes. The listing given in Table 6 of the major reasons cited by former automobile users for becoming bus users is divided into the two subpopulations defined earlier: Shirely and non-Shirley bus users. The categories are self-explanatory except possibly the "traffic" category, which represents comments pertaining to driving discomfort, traffic congestion, and other related adverse conditions. Automobile costs and parking costs are stated as major reasons for changing to the bus, especially by the non-Shirley users, who do not have the higher speed service to attract them.

In Table 7 are the reasons given by automobile users who have tried the bus but did not stay with it. The weight given to the first four categories is about evenly divided. Three categories relate to the service. Speed and convenience of the service can be improved with routing and schedule changes, although often at increased cost. The fares charged for the service definitely cannot be reduced without compromising the project objective of developing a viable service. It is noteworthy that half the people who responded that the buses were too expensive had free parking. Automobile comfort and privacy were also important reasons stated for changing back to the automobile mode. UMTA is attempting to counter the first of these objections by making the bus interior more spacious and attractive. The seating capacity has been reduced from 51 to 47, providing more leg room. The seats have been widened by 1 inch to 18 inches in the new buses and reached what is considered the optimum width of 19 inches for the buses put into service in February 1972. The importance of inclement weather cited in Table 7 may be diminished with the provision of bus shelters that will be built at key locations in the corridor during 1972. The effect of these various efforts in winning back bus riders as well as in attracting new customers will continue to be monitored. The successes and failures in dealing with these reasons for shifting back to the automobile will be analyzed and reported in the future.

## ALLOCATION OF PROJECT OPERATING EXPENSES

The expense of operating the new Shirley Express bus service is recorded in separate accounts kept by the AB&W Bus Company. These accounts are important in themselves as a management tool to control costs. Also, like many transit operations in other metropolitan areas, the Shirley service is heavily commuter-oriented, a situation that causes severe peak demands on labor and equipment. This circumstance has associated pricing implications that should be analyzed. A key part of the analysis involves determining the cost impacts of these peak commuter loads on the transit operation. These costs might also be contrasted with other means for meeting the demand, such as constructing additional highway lanes. It is therefore considered important to allocate these costs back to the basic transit operation in order to compare revenues and costs both by route and by time of day.

In an initial effort to allocate these costs, five operating parameters have been identified as explaining the variation in operating expense by route and by time of day (peak versus off-peak). The five parameters are as follows:

1. Vehicle-miles—assign certain variable costs;
2. Platform hours (the time the operator is on dispatch including deadheading to and from his run)—assign certain variable costs;
3. Transit passengers—assign certain variable costs;
4. Transit vehicles—assign certain fixed or semi-fixed costs; and
5. Vehicle operators—assign certain fixed or semi-fixed costs.

An analysis was made of each expense-account item, and a portion of each or the whole expense was assigned to one or more of these five parameters. For example, fuel costs vary by the amount of miles operated; therefore 100 percent of the fuel costs was assigned to the vehicle-miles parameter. Not all of the expense-account items are that straightforward. In some cases, considerable judgment is required. For example, all of the straight salary costs for vehicle operators have been assigned to the platform hours parameter, which in turn is measured by route for both the peak and off-peak operation. Some may argue that, because the bus driver is guaranteed 8 hours of pay regardless of whether or not he is needed in the off-peak, a portion of his straight salary costs should be assigned to the vehicle operator parameter, so that the semi-fixed nature of that salary cost could be reflected in the expense allocation to the peak-period operation. The evaluation team will continue to study this aspect of the problem.

The semi-fixed bus driver labor costs (overtime, retirement, vacation, and other benefits) are assigned to the vehicle operator parameter. Other fixed or semi-fixed costs such as insurance, taxes, and building maintenance are assigned to two parameters—transit vehicles and vehicle operators. In turn these two parameters are determined only for transit routes in the peak period. The logic underlying this allocation is derived from the scope of the transit operation; i.e., the number of vehicles and the size of maintenance and storage facilities are determined by the requirements to meet peak-period demand. The variable expenses are assigned to the other three parameters (miles, hours, passengers) that are determined by route in both the peak and off-peak periods. The results obtained for the off-peak operation are close to what one might term the marginal cost of that operation. In other words, one could actually realize a profit if the off-peak revenues exceeded those costs. If revenues are less than those costs, the value of the social benefit needed to justify the operation will be more accurately represented than is customary with conventional cost analyses.

The initial results of this approach to the cost analysis are shown in Table 8. A similar analysis is being made of the Blue Streak Express Bus Demonstration in Seattle, Washington, also being sponsored by UMTA, and the results will be reported in an interim report for that project. As shown in Table 8, about 60 percent of the operating expense is spread across all routes for both peak and off-peak operations. The remaining 40 percent of the expense is assigned only to the peak-period bus operation. After further analysis of the data the evaluation team may weigh the portions to further reduce the marginal cost of the off-peak service. Also, it should be noted that the depreciation expense for the buses has not been assigned. If these costs were assigned, it would be consistent with the logic of this cost analysis to assign all of the depreciation costs to the transit vehicle factor, which would increase peak-period costs by about 15 percent.

As the result of this initial cost analysis, it can be seen in Table 8 that the weighted unit cost per mile varies from $0.80 to $1.27 for peak-period routes. It is estimated to be considerably less costly to operate off-peak routes, which are within a range of only $0.43 to $0.50 per mile.

Table 9 gives the net result of this approach and reveals the estimated profitability by route with data based on project statistics for September and October 1971. It is noteworthy that there is a substantial surplus of revenues over expenses for the peak-period routes, great enough in October even to cover the off-peak loss.

Finally, in Figure 12 one major factor that affects profitability (speed) is plotted against the weighted unit operating cost for each route. There is a reasonably good straight-line relationship. Obviously, if the speed of the service is increased, there is more opportunity to get second trips in the peak period, thus raising driver and

**Table 5. Auto survey results.**

| Description | April | October |
|---|---|---|
| Submode: | | |
| Drive alone (percent) | 50 | 51 |
| Alternate driver (percent) | 14 | 13 |
| Driver with passengers (percent) | 13 | 12 |
| Passengers (percent) | 23 | 24 |
| Vehicle Parking Cost: | | |
| Zero (percent) | 55 | 55 |
| Paying average (dollars) | 1.15 | 1.10 |
| Need car during day (percent) | 19 | 17 |
| Have made trip by bus (percent) | 19 | 24 |

**Table 6. Reasons for switching from auto to bus.**

| Reason | Shirley (percent) | Non-Shirley (percent) |
|---|---|---|
| Traffic | 24 | 22 |
| Car pool dissolved | 9 | 25 |
| Bus faster | 35 | 6 |
| Moved, changed jobs | 16 | 20 |
| Auto cost | 9 | 8 |
| Parking cost | 7 | 19 |
| Total | 100 | 100 |

Note: Data are those given by choice riders—i.e., persons who had an automobile available for the trip.

**Table 7. Reasons for switching from bus to auto.**

| Reason | Percent |
|---|---|
| Inconvenient | 19 |
| Bus too expensive (50 percent have zero parking cost) | 18 |
| Bus slower | 17 |
| Car comfort, privacy | 16 |
| Weather | 8 |
| Irregular hours | 8 |
| Car pool formed | 6 |
| Evening service poor | 4 |
| Other | 4 |
| Total | 100 |

**Figure 12. Operating cost versus average speed of Shirley Express bus routes.**

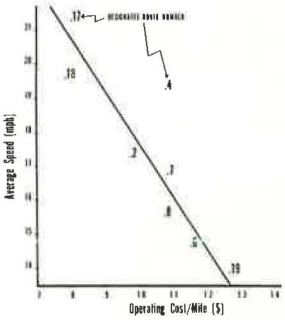



**Table 8. Preliminary unit results of expense allocation.**

| Factor | Percent of Expenses | Unit Cost |
|---|---|---|
| Miles | 17 | $0.13 per mile |
| Hours | 35 | $4.61 per hour |
| Operators | 25 | $23.20 per day |
| Vehicles | 16 | $14.52 per day |
| Passengers | 7 | $0.05 per passenger |
| Variation in weighted unit cost per mile: | | |
| Peak period | | $0.80 to $1.27 |
| Base day | | $0.43 to $0.50 |

**Table 9. Cost and revenue by route (dollars).**

| Route | | September Expense | September Revenue | September Net Revenue (Loss) | October Expense | October Revenue | October Net Revenue (Loss) |
|---|---|---|---|---|---|---|---|
| Peak Period | | | | | | | |
| 2G | Hayfield Farms | 7,009 | 4,822 | (2,187) | 6,041 | 5,006 | (1,035) |
| 4G | Heritage Mall | 5,715 | 6,903 | 1,188 | 5,729 | 7,678 | 1,949 |
| 6G | Parkfairfax | 4,552 | 4,486 | (66) | 3,478 | 4,372 | 894 |
| 7G | Lincolnia | 8,274 | 10,474 | 2,200 | 7,475 | 10,369 | 2,894 |
| 8G | Shirley Duke | 5,445 | 4,356 | (1,089) | 4,140 | 4,157 | 17 |
| 17G | Kings Park | 6,628 | 7,121 | 493 | 5,984 | 8,246 | 2,262 |
| 18G | Springfield | 8,411 | 10,171 | 2,060 | 7,338 | 10,657 | 3,319 |
| 19G | Huntington | 4,309 | 3,884 | (925) | 3,248 | 3,744 | 496 |
| | Subtotal | 50,343 | 52,017 | 1,674 | 43,433 | 54,229 | 10,796 |
| Base Day | | | | | | | |
| 1A&B | Northern Virginia Loop | 4,621 | 1,215 | (3,406) | 4,081 | 636 | (3,445) |
| 17G | Kings Park | 3,362 | 1,239 | (2,123) | 2,974 | 903 | (2,071) |
| 18G | Springfield | 3,452 | 2,025 | (1,427) | 3,107 | 1,788 | (1,319) |
| | Subtotal | 11,435 | 4,479 | (6,956) | 10,162 | 3,327 | (6,835) |
| | Grand total | 61,778 | 56,496 | (5,282) | 53,595 | 57,556 | 3,961 |

vehicle productivity. Unfortunately, other factors that cannot be simply represented in a graph of this nature must also be analyzed. The route length and the duration of the peak-period demand are especially important. The cost of operating Route No. 4 is plotted to the right of the straight-line relationship. It is a good example of the effects of the factors just mentioned. Demand is more peaked on this route, and, even though it has a relatively high average speed, second trips in the peak period cannot presently be scheduled within the demand period.

These figures give a very brief introduction to the cost analysis work under way; more detailed results will be reported in the future.

## CONCLUSION

The Shirley Express Bus Demonstration is a partnership of many agencies. There has been a substantial change in the mode choice for commuters in the corridor, and this phenomenon is being monitored closely. The overall project performance in meeting certain goals is being reported. Key independent variables that may explain the changes taking place are being analyzed and reported. In addition, the economic impact on transit operations of the largely commuter-oriented service is being analyzed using a unique approach. Reporting over the next 2 or 3 years should provide a valuable source of basic data and analysis results for transit operators and transportation planners. This paper is intended to be a preliminary outline of the type of reporting that can be expected.

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This project is a partnership at both federal and local levels. Two people primarily responsible for initiating the project were Don Morin of the Federal Highway Administration and James Echols of the Washington Metropolitan Area Council of Governments. As the project progressed toward implementation, James Bautz and Stan Price of the Urban Mass Transportation Administration made significant contributions to improve project operations and guide the development of a high-quality evaluation plan. John Crain, a private consultant, finalized the development of the project evaluation plan. The plan is being implemented under the leadership of Gerry Miller, Ralph Schofer, and Keith Goodman of the National Bureau of Standards under contract to UMTA.

Project operations (highway and transit) involve the close cooperation of several organizations. First, the local sponsor of the demonstration is the Northern Virginia Transportation Commission. Their project manager, Irving Smith, has kept the project on schedule and in the process has solved many problems. He is assisted by Dave Erion and Jack Crawford of the NVTC staff. Mike James, a private consultant, has been especially helpful in planning new routes and developing a procedure to analyze transit operating expenses. The AB&W Transit Company is under contract for the actual operation of the bus service; their general manager, Dick Lawson, and staff have been instrumental to the success of the transit operation. Finally, a major element of the project, the busway, was implemented and is being kept operational under the skillful guidance of Ken Wilkenson of the Virginia Department of Highways. In the District, Jack Hartly and his staff in the D.C. Department of Highways are responsible for the busway operation on the new center-span bridge and approaches as well as the operation of the priority bus lanes along District streets.