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RESERVED LANES FOR BUSES: THE SHIRLEY HIGHWAY EXPERIMENT

Jean G. Taylor

April 1970

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URBAN MASS TRANSPORTATION PROJECT
400 Army-Navy Drive, Arlington, Virginia 22202

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ABSTRACT

Under its contract with The Office of Research of the Urban Mass Transportation Administration (UMTA) of The Department of Transportation, IDA has been investigating and analyzing transportation system concepts. This paper reports the results of a several man-month effort examining one such concept, that of reserved lanes for buses on freeways and specifically the application of this concept in the Shirley Highway corridor of Northern Virginia adjacent to Washington, D.C.

There is an increasing interest in the concept of busways and reserved lanes on freeways for buses, or a combination of buses, and car pools, to help solve both the bus transit problems and the commutation from suburb to Central Business District (CBD) problem. The first place in the country where buses have the exclusive use of a freeway lane is on the permanent reversible lanes of Shirley Highway (Interstate Route I-95) in Northern Virginia from Edsall Road north to Shirlington. The service was inaugurated in September 1969 during the 3-hr AM peak period. However, until completion of the proposed interim roadway in late 1971, extending the last 4.5 miles to the new Potomac River bridge, a true test of the concept cannot be made.

The inauguration of an exclusive bus roadway in the Shirley Highway corridor during the next year can have far-reaching implications on busway or reserved lane projects across the country. If it is "successful," it is reasonable to predict that many cities will be encouraged to institute similar services. The requests to the Department of Transportation (DOT) for planning and implementation money--for roadways and equipment--may increase significantly. In order to evaluate the potential "success" of future projects, DOT should obtain, to the greatest extent possible, information on the Shirley Highway experiment which will be useful in

considering future proposals. In order for this information to be available, careful planning, implementation and evaluation of the Shirley Highway experience is necessary.

This paper provides an initial examination of the Shirley Highway experiment and addresses specific aspects of the bus project. In the short time available for the study, experiments, measurements and evaluations were outlined and described in the detail possible. These mainly concern (1) potential reaction of automobile occupants to what will be an apparent sparse use of the reserved lanes by buses only, (2) measures of success and the associated data collection requirements before and during the experiment, (3) improvements in bus utilization during the project, (4) means to reduce car attractiveness which in turn would increase the relative attractiveness of buses, (5) utilization of excess bus lane capacity by car pools and (6) circulation systems.

A systematic and exhaustive survey of bus demonstration projects is recommended to assist in planning the Shirley Highway experiment as well as to provide a single source for guidelines to Federal and local agencies concerned with the development of bus programs. An important aspect of this study would be to examine the current status of the bus projects considered "successful" during the demonstration period.

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I. INTRODUCTION

Recent efforts to increase the vehicle carrying capacity of existing urban freeways have involved the use of roadway and ramp surveillance and control techniques. Ramp controls during peak periods have been used successfully to reduce congestion and decrease overall travel time on freeways; however, these are usually accompanied by increased travel and delay on arterial streets (Refs. 1, 2). Such approaches are primarily designed to increase the volume of vehicle rather than person throughput. To realize maximum use of highways for the purpose of moving people, other approaches are needed.

An especially attractive solution to increasing person throughput of a freeway is to decrease the number of people using personal cars by attracting them to increase their use of bus transit systems. Introducing high speed long haul bus commuter service on freeways has several potential advantages: it is more economical and more flexible than rail transit systems for lower density suburban areas; it is capable of fairly rapid implementation where rights-of-way already exist; it offers a way to initiate a change in commuter habits in areas that have long range rapid rail transit plans; and it provides a means for making more efficient use of highways, thereby reducing the need for additional lanes at the expense of public taxes.

For several years, the Federal Highway Administration (FHA) has encouraged the examination of highways as a means of moving people rather than vehicles. FHA has recommended that consideration be given to reserving a freeway lane for the exclusive use of buses during peak hours when more people will be accommodated than would be in cars and when the headways between buses would not be "unreasonably long" (Ref. 3). To date the concept has not been implemented in any urban area.

Two important reasons for this lack of implementation are (1) "the lack of corridors where anything close to 120* or more buses per hour would be traveling in one direction, and (2) the consequences of taking one lane away from automobile and truck traffic when there presently are not enough lanes to handle it" (Ref. 4).

A number of concepts for increasing the attractiveness of buses for commuters, by reducing travel time below both current bus and automobile travel time, have been proposed. Generally they fall into the following categories: exclusive bus lanes or busways, reserved bus lanes, and metering/preferential entry. Express buses, fringe parking and car pools may be combined with any one of these systems.

The following is a brief summary of the concepts together with examples of feasibility studies and proposed implementation plans.** Although the concept of reserving freeway lanes for the exclusive use of buses has been discussed for nearly 10 years (Ref. 5), its actual implementation was not tried until 1969 when the reversible lanes of Shirley Highway were opened for buses only. The Shirley Highway experiment over the next several years will provide an opportunity to develop guidelines and standards for application of the concept in other areas; therefore, the design of the experiment and evaluation procedures are the principal subjects of this paper and are addressed specifically in Chapter II. The remainder of the present Chapter is a summary of the efforts to provide preferential use of freeways by buses and a general description of the Shirley Highway experiment.

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*The statement appears to imply that 30 second headways meet the criterion of not being "unreasonably long."

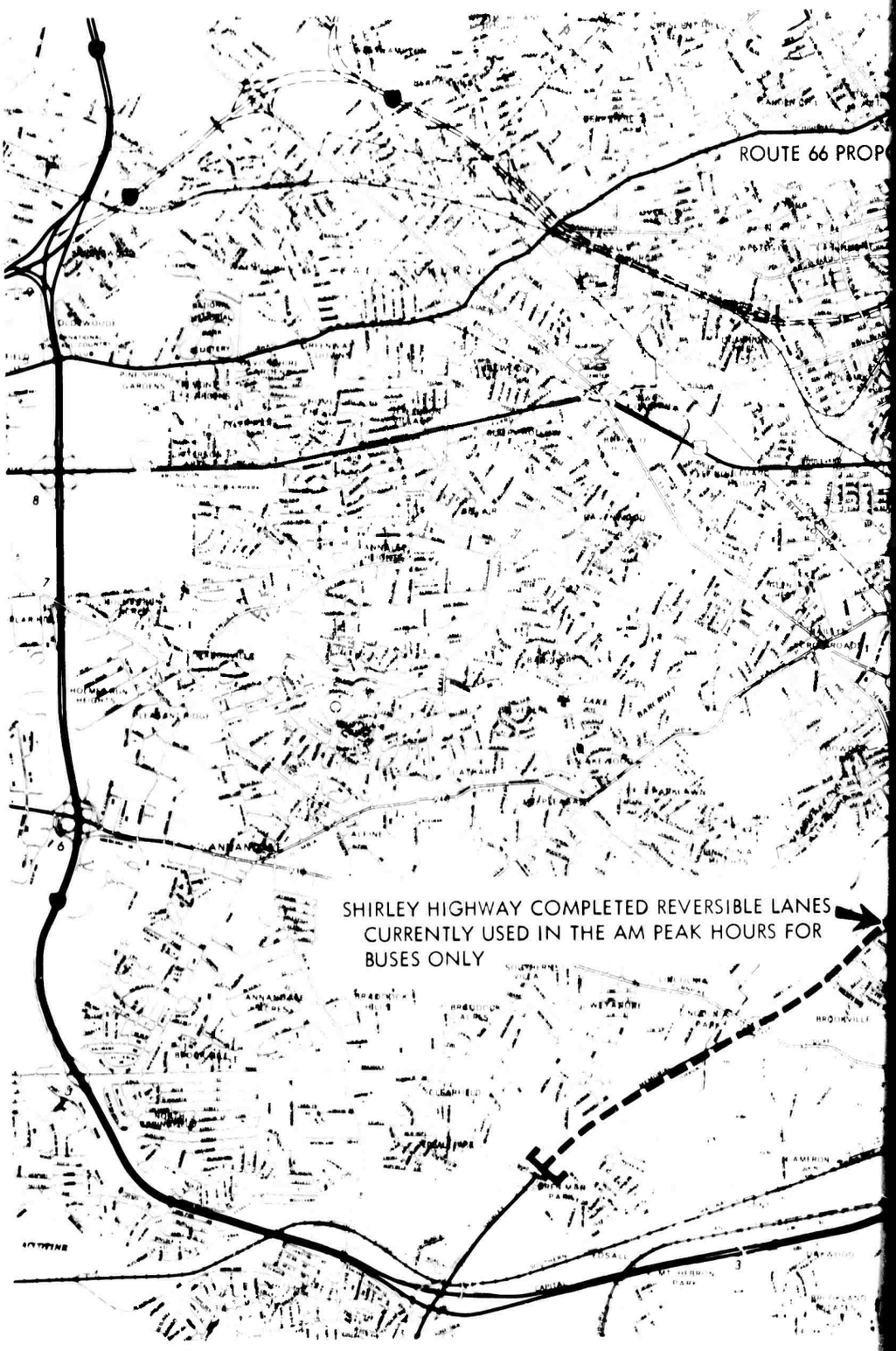
**Summaries of bus rapid transit using busways, reserved lanes or preferential access are available in Refs. 7, 8, 9, 11, 29, and 43.

A. EXCLUSIVE BUS LANES AND BUSWAYS

Exclusive bus lanes and busways comprise "special lanes either on or immediately adjacent to a freeway or on other special rights-of-way that are permanently set aside for the exclusive use of buses. These bus lanes have the advantage of providing an exclusive right-of-way for buses 100 percent of the time, comparable to a rapid rail facility" (Ref. 6). An exclusive bus roadway that would be constructed partly in the median and partly adjacent to the San Bernardino Freeway in Los Angeles is currently under consideration by the Federal Highway Administration (Ref. 7). A bus roadway has been proposed in Milwaukee County, Wisconsin, and preliminary designs for the roadway are being developed (Refs. 7, 8, 9).

A proposal to use 3½ miles of the Interstate Route 66 right-of-way (see Fig. 1) for an exclusive bus-only roadway was prepared in July 1969 by the Metropolitan Washington Council of Governments (Ref. 10). The idea was received favorably within the Department of Transportation (Ref. 11), and stimulated interest of the Virginia Highway Department to the extent that Federal funds were requested to help build the busway (Ref. 12). On March 2, 1970, however, the Virginia Department of Highways announced its decision to advance by 2 years the construction of Interstate Route 66, thereby making the busway project impractical. Furthermore, it was stated that the busway study "led directly to the state's reprogramming of the road, by focusing attention on highway congestion on its inner section" (Ref. 13).

Perhaps the most extensive busway system proposed to date is for Atlanta. In June 1967, the Atlanta Transit System announced a plan for "Rapid Busways" that generally followed railroad rights-of-way and was to be a "possible and practical interim relief for Atlanta's worsening traffic congestion of the present until the introduction of rail rapid transit (MARTA) several years hence" (Ref. 14). The plan for metropolitan Atlanta had 32 miles of busway made up of five trunk lines that were selected on the basis of available rights-of-way, density of population, present and projected origin-destination patterns and costs of construction. The Metropolitan Atlantic Transportation Authority (MARTA) reviewed the plan and disapproved


ROUTE 66 PROP
SHIRLEY HIGHWAY COMPLETED REVERSIBLE LANES
CURRENTLY USED IN THE AM PEAK HOURS FOR
BUSES ONLY

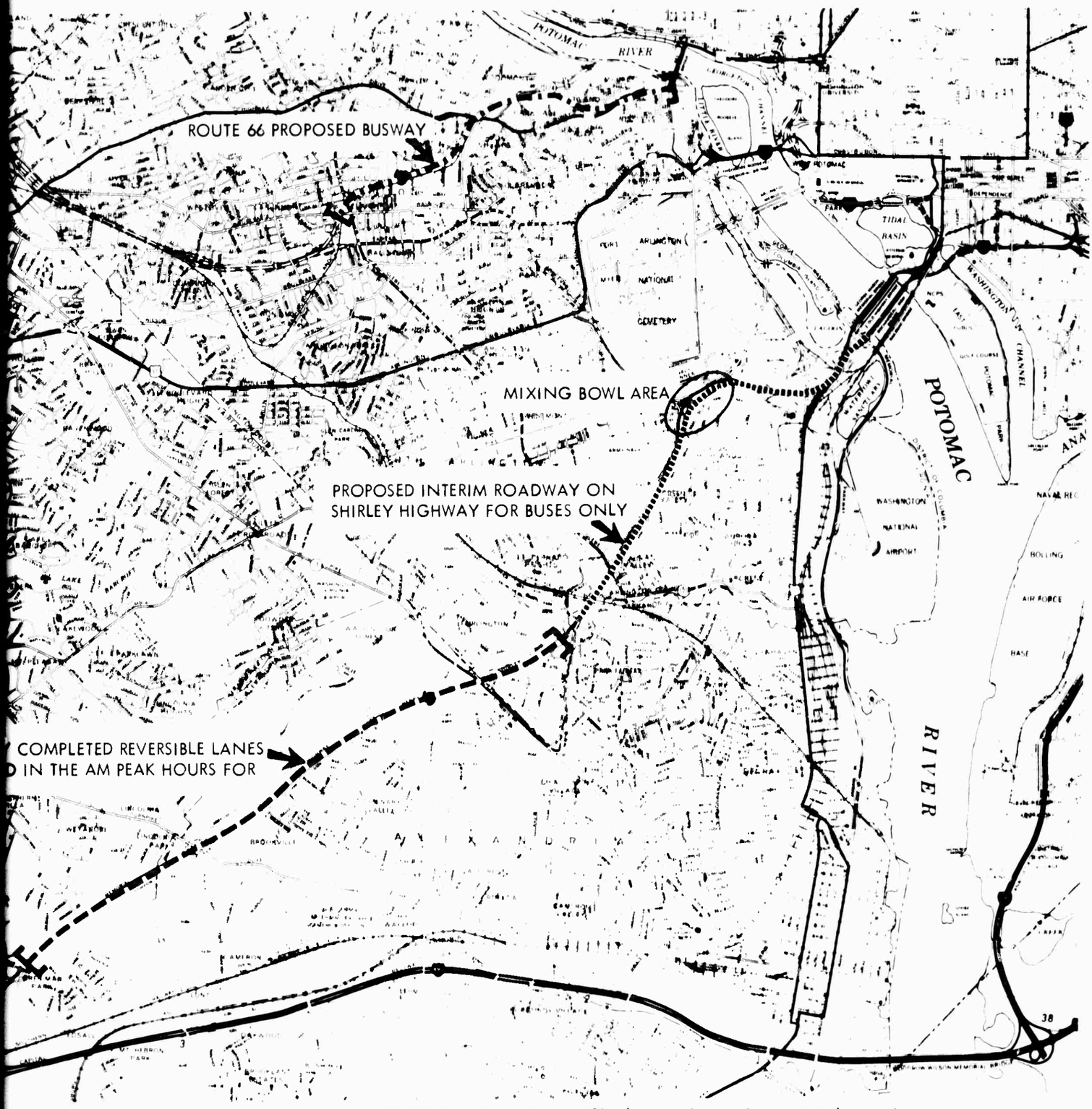


FIGURE 1. Location of Shirley Highway (Virginia) and Route 66 Proposed Bus Project

of busways "as a permanent solution and recommended against its implementation as an interim measure" (Ref. 14, App. B). Subsequently, however, MARTA agreed to share the cost of an in-depth engineering study of busways by an outside consulting firm "related to the possibility of including express busways in the city's overall transit program" (Ref. 15). The resulting study (Ref. 15a) compared busways with rapid rail on a relative cost basis. The results confirm the high capital costs for rail and the high operating costs for buses; however, the determining factors are passenger volume and percent of subway versus surface construction. The systems were comparable in line length, passenger volume, percent of subway, nature of comfort and convenience to passengers. In general, there were insignificant cost differentials for the cases tested. For example, there is not a large cost advantage of one mode over another if one assumes no subways are required and that traffic volumes equal 12,000 passengers per hour. When volumes drop to 4,000 per hour, the use of buses saves about 20 percent of the total cost. The authors point out that the results must be viewed with caution because the bus system assumed in this study has never been implemented anywhere whereas there are empirical data available for rail.

In addition to the examples cited above, there have been studies of busways in the Boston Metropolitan area (connecting the South Shore communities with the Boston CBD); in Memphis, and in the Portland (Oregon) Vancouver (Washington) area (Ref. 16). A variation on the exclusive busway concept is the demonstration project in the final stages of planning in Seattle, Washington. The project termed the "Blue Streak Special" involves buses operating from "park-and-ride" lots in mixed traffic on the reversible lanes of I-5. The buses utilize exclusive access and egress ramps connecting the reversible lanes with the CBD (Ref. 17).

The only exclusive busway operation already in being is in suburban Philadelphia. Several miles of an intra-urban trolley right-of-way were paved. Because there are no grade separated crossings of local streets, crossing gates are used and these require that the buses stop at intersections (Ref. 8).

B. METERING/PREFERENTIAL ENTRY

The "Metering/Preferential Entry" system involves the controlling or "metering" of the flow of vehicles onto a freeway to prevent or reduce congestion and the attendant reduced travel speeds. Applied to the bus transit problem, preferential entry onto the freeway for buses and car pools can be provided thereby permitting these vehicles to bypass the queue of vehicles waiting to enter the freeway.

A recent study for UMTA undertaken by the Texas Transportation Institute concluded that freeway surveillance and control techniques to facilitate bus rapid transit operations were technically feasible and cost effective (Ref. 21). The control techniques used to improve freeway flow were applied to achieve a desirable speed for buses operating in mixed traffic. They provide priority access to the freeway by using exclusive ramps for buses and ramp controls for metering automobiles on the freeway. Capital costs (ramp construction and/or modification and the surveillance and control system) were estimated to be about $650 thousand for a 12-15 mile freeway. Annual operating costs for surveillance and control were estimated to be approximately $250 thousand. With such a system, if 50 buses per lane per hour were mixed with a total of 1,920 autos the passenger movement per hour would be 4,810 or 1.7 times that of 2,000 autos alone.* The study outlines a demonstration project for a bus-freeway system which would require a period of 5 to 6 years to complete at a cost of between 12 to 15 million dollars.**

C. RESERVED BUS LANES

Reserved bus lanes are freeway lanes reserved for the exclusive use of buses only during peak hours. The lane reserved may be one of the directional lanes or all or part of the reversible section of a freeway. In January 1967 the

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*Assumes 1.4 passengers/auto, 42 passengers/bus.

**A large portion of these costs are for the conducting of the demonstration project and analysis of the data (Ref. 21, p. 95).

Port of New York Authority recommended the exclusive use of the median outbound lane of I-495 by inbound buses during the AM peak period. This route connects the New Jersey Turnpike with the Lincoln Tunnel (Ref. 9).

During reconstruction work in 1962 on the tunnel portion of the bridge across San Francisco Bay, a lane on the lower deck of the bridge was set aside for the exclusive use of buses (Ref. 18). A major problem on the Bay Bridge was a bottleneck at the tunnel; the buses could bypass the queues of cars because a lane was reserved for them at the approach to the bottleneck. This exclusive lane gave the buses a 4 to 9 minute advantage over the automobiles but failed to produce a measurable modal shift. Auto occupants using the Bridge increased more than the bus passengers during the experiment (Ref. 19), probably because the Bridge is just one segment of the commuters' trip and the amount of time saved by using the bus on the Bridge is insignificant compared to the losses incurred on the whole trip.

The feasibility of establishing an exclusive bus lane on the San Francisco-Oakland Bay Bridge was reexamined in 1969, when it appeared that the number of buses using the Bridge, namely approximately 340, would satisfy the Federal Highway criteria for dedication of a lane. The study concluded that the increased delay to automobile users would far exceed the 2-4 minute savings to bus users and therefore implementation was not recommended (Ref. 20).

The use of reserved lanes during peak hours was examined in the context of the projected total bus transit system for the metropolitan area of Baltimore in 1980. The study states that:

> "...Forced flow is the usual condition during the peak commuting periods. Under such circumstances, exclusive rights-of-way would be a distinct advantage for bus travel in maintaining its competitive position. Either 'busways' or preferential entry to metered/reserved freeway lanes during peak hours are recommended to speed bus transit around congested peak period traffic.
>
> "In view of the relatively light bus loads observed on the most densely traveled sections of typical urban freeways, it appears worthwhile to recommend that

> other special vehicles, such as high person occupancy autos, be allowed to use exclusive 'busway' or reserved freeway lanes during peak periods in order to take advantage of the available vehicle capacity" (Ref. 6, p. xii).

The Federal Highway Administration and the Urban Mass Transportation Agency are sponsoring a feasibility-evaluation study of reserved freeway lanes for buses and car pools in peak periods (Ref. 30). These agencies "recognize the limits on the number of highways wherein there would be anywhere near the number of buses necessary to consider reserving a lane for exclusive bus use." Should the results of the study indicate that the combined use of buses and car pools on reserved lanes is feasible during peak periods, then it is intended to proceed with an implementation and evaluation phase at specific sites (Ref. 11).

A study of the feasibility of using the newly constructed reversible roadway on the Shirley Highway for buses during the peak period was undertaken in 1968. In September 1969 the permanent reversible lanes between Edsall Road and Shirlington were opened for exclusive use by buses (see Fig. 1). An implementation study is currently under way at the Washington Metropolitan Council of Governments to provide an interim bus-only roadway between Shirlington and the new Potomac Bridge. The interim roadway would be used until such time as the remaining 4-mile section of the permanent reversible roadway is completed. The Shirley Highway experiment is the first of its kind in the U.S. and it is the main subject of this paper, therefore a more detailed description follows.

D. SHIRLEY HIGHWAY

Several organizations* in 1967 began to develop plans for exclusive bus use of the reversible lanes of Shirley Highway during the peak hours. Construction of

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*The Washington Metropolitan Area Transit Authority, Washington Metropolitan Area Transit Commission, Federal Highway Administration, District of Columbia and Virginia Highway Departments, local bus operators, UMTA, and the Transportation Planning Board of the Metropolitan Council of Governments.

the permanent reversible lanes was still under way and completion to within 4 miles of the Potomac River Bridge (14th Street Bridge) was scheduled for 1969. The Bureau of Public Roads began working on a plan to have only buses use these reversible lanes to Shirlington when they were completed with preferential access to the lanes north to this point (Ref. 9). The Metropolitan Washington Council of Governments (COG), with financial support from the Bureau of Public Roads, contracted in 1968 with Howard, Needles, Tammen and Bergendoff (HNTB) to provide a Feasibility Study for Bus Rapid Transit in the Shirley Highway Corridor. The study was to evaluate travel in the corridor during two phases: (1) the interim period between 1969 and the completion of the permanent reversible lanes and 3 directional lanes to the bridge (in the 1973-1975 time period); and, (2) over the long-range period, when reconstruction has been completed.

On September 22, 1969, as a result of the interim recommendation of the feasibility study, buses were permitted exclusive use in the morning peak hours (6:30 - 9:30) of that portion of the reversible roadway between Edsall Road and Route 7, a distance of 4½ miles. The next day this was extended to Shirlington for a total of 5½ miles (see Fig. 1). At this point the buses merge with 3 lanes of automobile traffic to a 2-lane directional roadway for the remaining 3 to 4 miles of the trip, depending on whether the destination is the Pentagon or Washington. By extending the bus only lanes from Route 7 to Shirlington a reported 10 minutes* was saved by the bus compared to previous bus travel times (Refs. 22, 23).

After one month of operation, the ridership on buses using the reversible lanes during the AM peak 3-hour period had increased about 15 percent (from approximately 1900 to 2200 passengers) and 4 buses were added (Ref. 7). By

*In March 1970, it is reported that "Travel time savings over previous conditions gained by morning peak-period commuters have been up to 20 minutes" (Ref. 24d). This saving is not experienced by all buses; only those merging when auto queue is long. This is discussed in the next chapter.

March 1970, the daily number of passengers during the AM peak period had reached 2,450--an increase of approximately 30 percent (Ref. 24d, page 34). No comparable data on car flow increases or decreases are available for the same period.

In November 1969, Howard, Needles, Tammen and Bergendoff recommended the construction of a separate 18-ft wide roadway extending the 4 miles from Shirlington to the New Potomac River Bridge for use by buses during the period of final construction of the permanent reversible and directional lanes (Ref. 24c). It is estimated that construction of the 18-ft roadway will cost $5.4 million (Ref. 24d). An extra 15 minute saving for the bus trip is projected and the saving would apply to both morning and afternoon peak periods. The Metropolitan Washington Council of Governments is currently making detailed plans for implementation of the interim roadway, conduct of the project, and acquisition of the necessary bus equipment.

The use of the permanent reversible lanes on Shirley Highway for buses only is the first time an Interstate highway lane has been used exclusively for buses. The implementation, perhaps by the end of 1971, of an interim roadway for buses only, between the end of the permanent reversible 2-lane highway at Shirlington and the nearly-completed 14th Street Bridge may very well be the first experience with buses-only on freeway lanes in the United States.* There is a growing interest in the concept of reserved lanes for buses, or for buses and car pools. It is important therefore that the Shirley Highway experiment produce,

*Although the Seattle "Blue Streak" may be implemented prior to that, the buses will travel in mixed traffic on the freeway, using an exclusive bus-only ramp in the CBD (Ref. 17).

to the greatest extent possible, carefully documented and transferable results.* The planning and conduct of the experiment have more far-reaching implications for the Department of Transportation than for the local agencies involved. The Metropolitan Washington Council of Governments' (COG) primary concern can justifiably be that of implementing the reserved bus lanes on Shirley to reduce congestion on the highway and develop transit habits which will benefit the rapid rail system. On the other hand, from the Federal point of view, the need for transferability suggests careful planning and conduct of the experiment in order to identify constraints, system characteristics and significant factors which strongly influence the results.

In the next chapter specific aspects of the bus project are addressed; experiments, measurements and evaluations are outlined and described. One of the concerns that has been voiced is the potential reaction of automobile occupants to what will be an apparent sparse use of the reserved lanes by buses only. This is discussed in some detail and the discussion contains some suggestions for avoiding or alleviating this potential problem area. The major thrust of the chapter concerns the operational aspects of the experiment: what are the measures of success of the bus project; what is the current peak-period situation in the Shirley corridor; what measures should be made during the bus experiment; how can bus utilization be improved during the project; how can attractiveness of autos be reduced to increase bus ridership; and what are the merits of car pools on the bus lanes?

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*The estimated cost for Shirley Highway bus roadway construction, supporting facilities, and additional buses is $9.24 million (Ref. 24d). In view of the fact that other more expensive busways may be designed it is especially important to evaluate the Shirley Highway project accomplishments. For example, the Southern California rapid transit district has proposed a 2-lane busway on I-10 from El Monte to Los Angeles--a distance of 12 miles. The total construction cost is estimated at $39 million; $7 million of this is for shifting rail tracks on one segment which would be used by an estimated 40 buses/hour.

II. THE SHIRLEY HIGHWAY EXPERIMENT

A. POSSIBLE DRIVER REACTION TO THE RESERVED BUS ROADWAY

The permanent reversible 2-lanes of Shirley Highway between Edsall Road and Shirlington, Virginia, were opened on September 22, 1969, to "buses only" during the morning 3-hour peak period. During the following month, the Steering Committee received two letters of complaint* and one of praise concerning the exclusive use of the roadway by buses. The directors of the project conclude, based on this minimal amount of negative response as well as on additional verbal responses and observations of motorists, that there appears to be no significant resentment of the project. Motorists apparently readily permit buses to merge from the reversible lanes into the car lanes of Shirley Highway just south of Shirlington.

The present circumstances do not permit one to draw the conclusion that there will be motorist acceptance of exclusive use of a roadway from Edsall Road to the new 14th Street Bridge. The present configuration is quite different from that which will exist when the interim roadway is completed. These differences, potential motorist reaction and suggested approaches to counter or avoid legal and political action are discussed in the following sections.

1. Current vs Proposed Busway

Currently Shirley Highway contains essentially 3-lanes north to Shirlington plus a 2-lane reversible median highway. At Shirlington it narrows to 2-lanes; the

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*The letters were received from a military officer and a congressman. There may have been additional letters to local newspapers and congressmen; the study has not investigated these additional sources.

3 lanes merge to 2 lanes and the buses merge at the head of the 2 lanes. If the 2-lane reversible median highway were opened at the present time to cars it would involve merging 5 lanes into 2 lanes. Clearly little or no advantage would accrue to the motorist. The number of buses that merge at the head of the 2 lanes of cars is not large--between 40 and 45 over approximately a 3-hour period. The time saving advantage for the buses occurs when the cars are backed up in the 2-lanes and the buses can merge at the head of the lanes--this appears to occur predominantly during a one-hour period, 7-8 AM. At that time car traffic is backed up about 1 mile and is slowed to approximately 4 miles an hour at the merge point. This accounts for the 15 minute reduction in bus travel time for those buses that arrive at the head of the queue during this period. An example of this is shown in the photograph in Fig. 2.

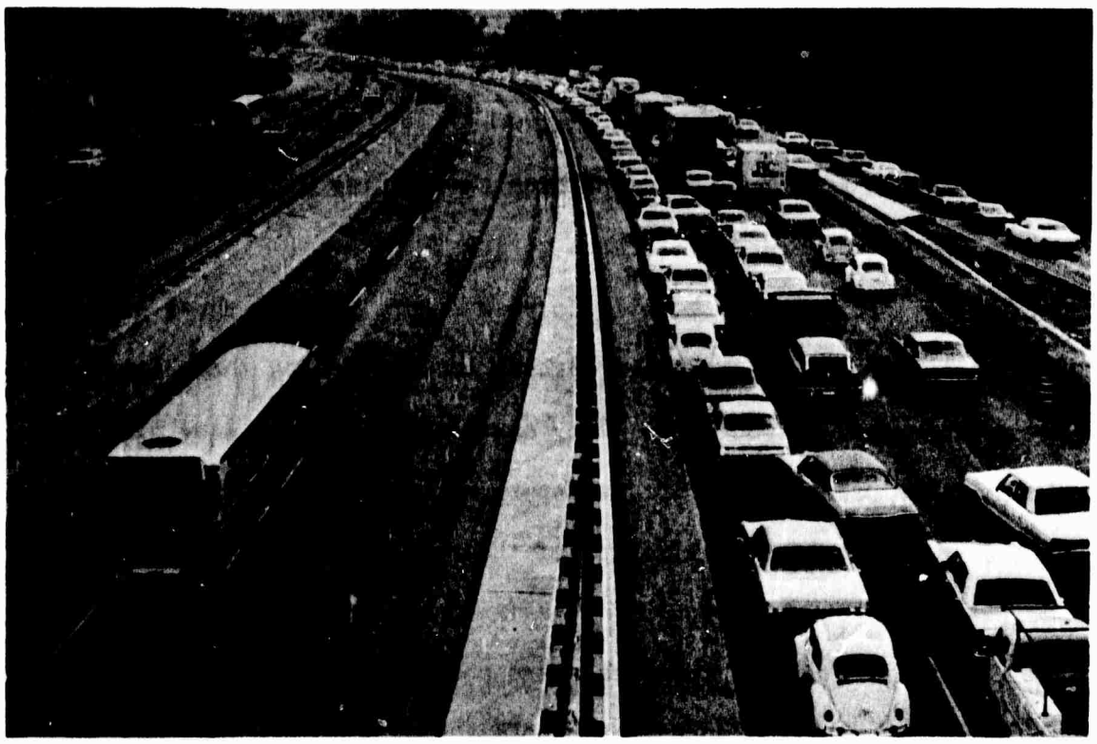

FIGURE 2. Bus Traveling on Exclusive Lanes Bypassing Traffic on Shirley Highway

Following the merger at Shirlington no time advantages currently accrue to buses. The construction of an interim roadway extending the median lanes for buses from Shirlington to and across the 14th Street Bridge would change the situation radically. Then instead of approximately 20 buses merging with the cars at Shirlington during the peak hour of the 3-hour peak period (the equivalent of 32 cars/hour using the factor of 1.6 car equivalents/bus), these buses would continue to travel northward the remaining 4.5 miles to the 14th Street Bridge at speeds approaching 40 mph. The car situation will not improve for at least 3 years (Ref. 25)--until the 3-lane permanent segment is completed to the "mixing bowl"* and perhaps not until it is later extended to the 14th Street Bridge. Furthermore, the current exclusive bus lane between Edsall Road and Shirlington is only used during the AM hours. With the construction of an interim roadway for buses, the use in the evening peak hours by buses will mean that the motorist will then twice a day see a 2-lane roadway traversed by buses with headways of more than one minute. The Howard, Needles, Tammen and Bergendoff (HNTB) report (Ref. 24d) projects 362 bus trips by 1975 on the Shirley Highway interim roadway.** These buses will be distributed along the 10-mile, 2-lane roadway during the 3-hour peak period approximately as shown in Fig. 3. The number of bus trips on the initial 5.5 miles of reversible roadway would reach a peak of 186 during the 3-hour period at Shirlington. Other buses would enter at Washington Boulevard, Hayes Street, and Route 1 thereby increasing the total number of buses to 362. However, 187 of the current 267 buses that use Shirley Highway at some point, cross either Memorial Bridge or terminate at the Pentagon or the Navy Annex. The number of buses after these exits that cross the 14th Street Bridge drops to less than 100 during the 3 hours. If

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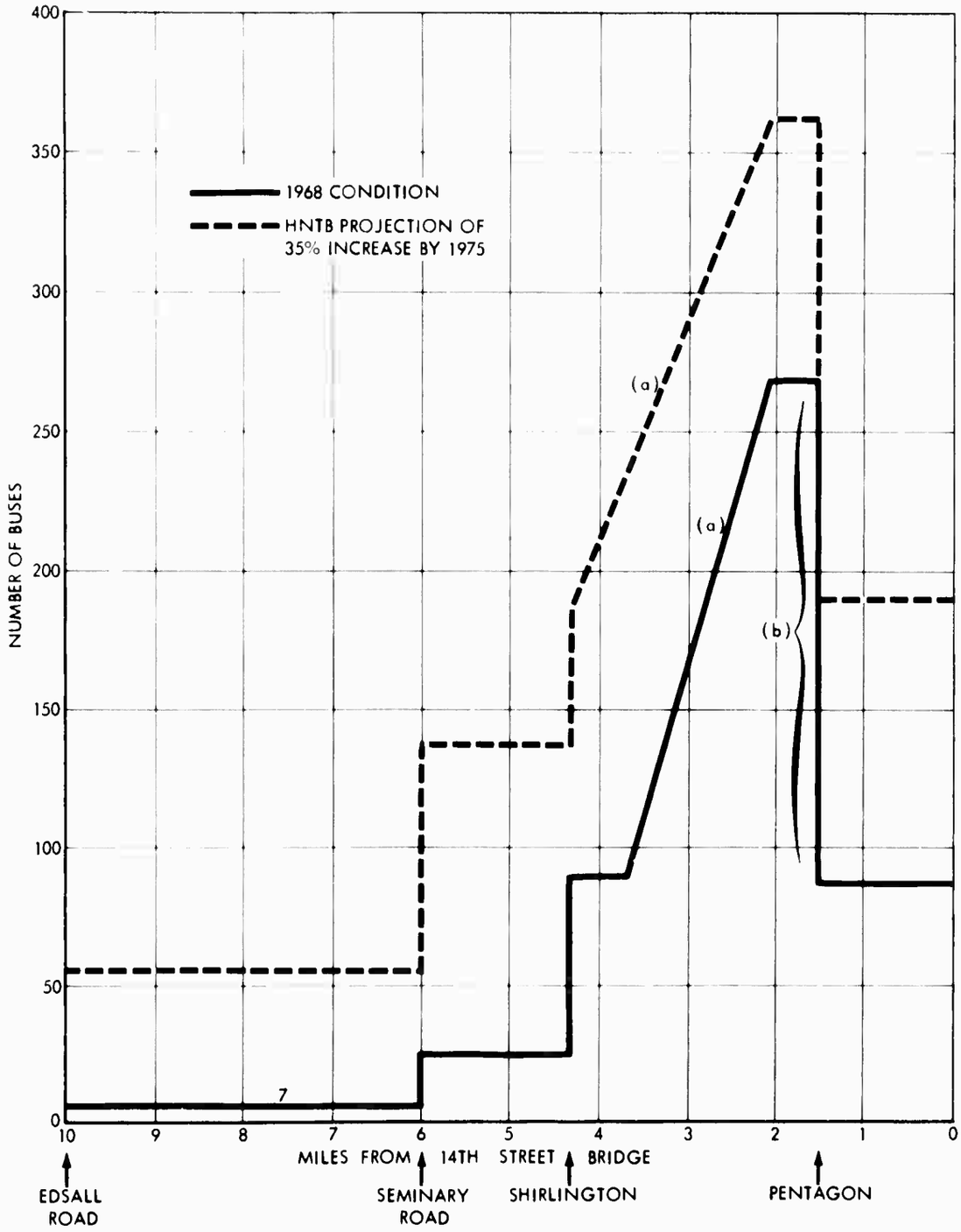
*See Fig. 1. Several roads merge in this area and lane cross-over is required to gain access to major roads in the northbound direction.

**This projection is based on 64 percent of the person trips to the Pentagon and Sector Zero (the major downtown Washington area) by transit as opposed to the current 52 percent.



(a) BUILDUP OF BUSES AFTER SHIRLINGTON.
(b) 178 CURRENTLY CROSS MEMORIAL BRIDGE OR TERMINATE AT THE PENTAGON.

H5-8-70-3

FIGURE 3. Distribution of Current (1968) and Projected (1975) Buses on Shirley Highway During AM Peak Hours

one assumes that 50 percent of the bus trips occur during 1-hour of the 3-hour peak period, then the number of buses per lane passing over segments of the interim roadway with their associated headways would be as follows:

	Buses/Hr/Lane	Headway, Min
Edsall Road to Seminary Road	14	4.3
Seminary Road to Shirlington	34	1.75
Shirlington to Pentagon Exit	90*	0.67 (40 sec)
Pentagon Exit to 14th Street Bridge	50*	1.2 (72 sec)

Except for the Shirlington to Pentagon section of the roadway, the times between buses would be relatively lengthy even in the peak hour period. North of Shirlington, the motorist encounters the greatest congestion on Shirley Highway with what is apparently a daily peak-hour back-up from approximately Washington Boulevard to the 14th Street Bridge--a segment of approximately 1.5 mile.

Assuming that this general picture of the future situation is accurate, what will be the probable reactions of the motorists who use this roadway? How can potentially negative or non-adaptive reactions be avoided or countered?

2. Possible Motorist Reactions and Countermeasures

Based on the projected estimates made by HNTB, it is clear that the number of cars on Shirley Highway will not decrease by 1975. In fact, the projected increase in bus ridership only absorbs the projected increase in work trips for the 1969-1975 period.** Thus, until a 3-lane permanent roadway is completed between Shirlington and the 14th Street Bridge, current congested conditions will persist.*** One may

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* Assumes a 2-lane interim roadway. If the interim 18-ft roadway provides only one lane, the number of buses per hour per lane double and headways are halved.

** This is discussed in a later section.

*** The congestion picture may be even gloomier when construction begins on the permanent 3-lanes and the capacity of the current 2-lanes is reduced below that currently experienced due to the disruption. This may result, of course, in increased incentive to use the bus.

anticipate that the motorist will raise objections to the apparent underuse of the interim roadway for "buses only" and that these objections will take the form of complaint letters, organizational pressure, legal action or political pressures. Carefully worded explanations of the nature of the experiment, noting that the temporary nature of the roadway makes it unsafe for cars, etc., should suffice to counter the objections registered in the individual complaint letters. When the objections become more formalized through organizational pressure (e.g., AAA), legal action or political pressure, however, different types of response may be required.

Legal action might take one of two forms. One is based on the claim that public tax money was used to finance a roadway for a private bus company and the consequent claim of legal rights to drive on the roadway by the motoring public. The legal implications of "bus-only" roadways has not yet been faced mainly because the bus-only situation thus far has not arisen. A current study "Feasibility and Evaluation Study of Reserved Freeway Lanes for Buses and Car Pools in Peak Hour Periods" jointly supported by BPR and UMTA has as part of its purpose an examination of various legal problems. One of the questions this study should address is whether the exclusion of autos from a publicly financed roadway reserved for use by privately-owned bus companies is like exacting a toll. Although Federal funds by law cannot be used for toll roads this particular variant of the Federal funding provision has not been tested in the courts. It is not known, for example, whether a valid precedent is set by the exclusion of trucks from high speed lanes or particular highways. The only place where trucks have been excluded from lanes, according to the American Trucking Association (ATA), is in New Jersey where recently trucks have been prohibited from the inside passing lane on 3-lane highways. The ATA views this as merely a technique for regulating traffic and therefore considers it a reasonable ruling (Ref. 26). Tractor-trailer traffic represents less than one percent of the traffic on the road; the ATA realizes this and finds that the use of 2 lanes is sufficient; in fact they probably would be willing to accept the use of only one lane. The restriction is thus seen as a reasonable one. The other

situation where trucks are prohibited is on park roads operated by the Department of Interior. Not being allowed to use park roads is again considered reasonable because the roads are not the type that trucks ordinarily use--they are not strong enough for truck use. Trucks are not allowed on the Baltimore-Washington Parkway between Washington and Laurel for example, because this part of the Parkway is not strong enough for truck use.

A second type of legal action that might be instituted would be against the Virginia Commissioner of Highways who made the final decision to use the currently completed reversible lanes exclusively for buses and who will be the approving authority for the interim roadway. The suit would have to show that the Commissioner acted outside the powers of the Commission, with fraud, or in a capricious and frivilous manner. The Commissioner holds that he has acted within the powers of the Commission and that the action is by "choice" to take a number of vehicles off the road which in turn operates to the benefit of all by reducing congestion. Virginia takes the same position as the Federal Government, namely that the roads are for moving people, not vehicles, and moving 2,700 persons per hour on buses which is the equivalent of 1,800 cars x 1.5 passengers per car justifies the dedication of a lane exclusively to buses. In summary, the Commissioner of Highways believes that he has a defendable position but even so there is a movement underway to introduce legislation (none has been drafted to date) that would cover the exclusive bus lane situation in Virginia. At present the Commission is operating without supporting legislation except for that which establishes the powers of the Commission (Ref. 27).*

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*In a report (Ref. 28) on January 14, 1970, to the Governor and General Assembly of Virginia, the Virginia Metropolitan Area Transportation Study Commission suggested "the freeing of a limited amount of highway funds to initiate a program of transit-related highway construction for such projects as fringe parking facilities and exclusive bus lanes. These are construction projects which will permit the State to assist transit and simultaneously benefit highway travel by relieving motor vehicle congestion on our roads." Appended to the Report was a draft bill to establish a second Virginia Metropolitan Area Transportation Commission to conduct a thorough study of, among other things, "the State's highway program in relation to mass transit."

A potentially more expeditious method for the motorist to oppose the exclusive use of highway lanes for buses is to bring political pressures to bear through special interest and lobbying groups (e.g., auto clubs, auto trade associations) and members of Congress. The case for the exclusive bus use of the interim roadway should immediately be made to these groups and their public endorsement should be obtained now. To date they have not been involved in the planning or the evaluation of the projected plans. The steering committee for the Shirley Highway bus experiment has had representatives from local government agencies, transit authority, bus companies, and cooperating federal government agencies. Coincident with the decision to implement the interim busway, serious consideration should be given to the inclusion of community groups, special interest groups and political representatives of the area affected at least to the extent that they are made to understand the rationale for the implementation decision. Obtaining the public endorsement and support of these groups may obviate the necessity to expend a great deal of time, money and energy on countering legal or political actions later.

In addition to obtaining these endorsements, consideration should also be given to means of assuaging motorists' objections should this become necessary. There are several possibilities:

1. Permit car pools of 3 or more persons to use the interim roadway. Although the 18-foot 2-lane interim roadway* will not be up to the Federal standard of 12 ft/lane for cars, reduction of the speed

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*If the plans are to make the 18-foot roadway a 1-lane interim roadway, the question arises as why the necessity for 18-feet--why not 12 feet? Meyer, Kain and Wohl (Ref. 41, p. 315) in discussing the economies associated with smaller commuting automobiles point out that: "at present, urban interstate highways have 12-foot lanes (in large part, of course, to accommodate buses and trucks). If a highway were restricted to use by smaller cars, 8- or 9-foot lanes would be feasible, which alone could increase highway capacity and reduce highway costs by 30 to 40 percent." They note that Boston's 2-lane Sumner Tunnel operated with 2-way traffic at high volumes (of mixed car and truck traffic) even though the lanes were only 10½ feet wide and not divided. The Shirley Highway interim roadway would be operating with one-way traffic which is clearly an easier and safer situation for drivers.

limit to perhaps 40 mph and the introduction of other safety precautions (e.g., screening of, and special permits for, drivers) could perhaps be introduced to make its use feasible by cars.

2. Divert a lane of traffic from Shirley Highway across the new 14th Street Bridge, reserving one lane for buses. Since a major point of congestion is just south of the 14th Street Bridge, the possibility of building a temporary connecting roadway from the current Shirley Highway to the new 14th Street Bridge should be investigated in light of the following facts: (a) many buses terminate at the Pentagon or cross via Memorial Bridge thus reducing bus use of the new 14th Street Bridge; (b) the argument that the temporary interim roadway is not up to Federal standards for car use is not applicable to the new 14th Street Bridge; and (c) the current queue encountered at the 14th Street Bridge would be reduced. Reversing the flow in the evening probably would be of no benefit because the cars would have to merge into congested lanes just south of the current 14th Street Bridge.

3. Summary

The projected exclusive bus use of the interim roadway will present quite a different problem vis-a-vis the motorist than the current exclusive bus use of the permanent reversible 2-lanes. Therefore future motorist reaction should not be predicted on the basis of the current situation. The legal problems have not been addressed except in a very cursory manner, and it is clear that the trucking experience does not provide a valid precedent. Special interest groups and congressional representatives have not been included in the planning. Potential pressures from these groups suggest that steps be taken to obtain their endorsement by including them in the planning and implementation process, by presenting them with the results of studies that support the decision to construct the exclusive bus interim roadway and by otherwise actively seeking their support and endorsement.

B. BEFORE AND AFTER MEASURES

The Shirley Highway experiment provides a unique opportunity to examine the concept of buses on reserved lanes of an expressway during peak hours. The contractor (HNTB) estimates capital costs of $22.77 million for the project. This includes $5.4 million to prepare the temporary reserved bus roadway and $3.84 million for bus equipment and supporting facilities. The major costs are for fringe parking and access improvements ($13.53 million).* Additional operating costs of the project have not been estimated, e.g., planning, evaluation, publicity, operation and maintenance of fringe parking areas, etc.

A great deal can be learned from the Shirley Highway bus experience that will be valuable in the conduct of similar bus projects and can be useful to other localities in deciding whether or not to implement the concept. In order to realize the benefits, however, an organized research effort is required to determine the state of the transportation system before changes, to monitor, measure and analyze the results during the experiment, and to identify those areas of "success" or effectiveness of the changes. Plans and implementation procedures should be made concurrently with the construction of the roadway during the next 18 months.

The time series design seems especially appropriate to the type of data that should be collected. The time series design demands measurement both before and after an intervention: in this case the intervention would be the reserved lane from Shirlington to 14th Street Bridge. The figure below illustrates the data collection process:

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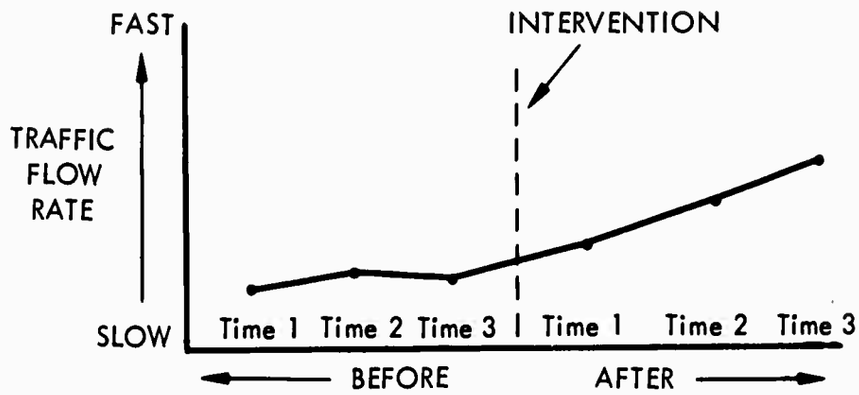
*The contractor (HNTB) recommended preparation of 5 fringe parking facilities in addition to potential space available at 10 shopping centers in the area. Three of the fringe parking sites have been designated as future rail transit stations in WMATA plans for Regional Rail Transit System. Since these parking facilities may not be available before 1980 under current WMATA plans for the rail system, HNTB recommended that they be prepared for the Shirley Highway bus project at a cost of approximately $9 million.



Hypothetical Data from Shirley Highway Experiment

Note that data are gathered several times before the intervention to obtain a measure of the stability of traffic flow (or other variable) before the intervention (a change). The measures after the intervention allow the researcher to make statements regarding the growth of improvement among the different measures. There are statistical tests that have been developed for time series data.

The contractor reports (Refs. 24a-d), provide detailed descriptions of the current and proposed physical system (roadway, access, egress, bridges, etc.). Potential fringe parking lots are identified. Current and projected traffic volumes, modal splits,* travel times, bus requirements and related items have been calculated. The inputs for these calculations in many instances are not complete and in

*Term used to indicate the division among the various modes of transportation.

large measure outdated. For a feasibility study to assist the decisionmaker these data are probably adequate. However, in order to evaluate the system in operation, to measure its "success," more timely and complete data are needed to describe the vehicle and passenger situation in the Shirley Highway corridor prior to the opening of the interim roadway for the exclusive use of buses on the entire length of 10 miles from Edsall Road to the Potomac Bridge.

The measure or measures of success to use is in itself worthy of considerable discussion and consideration. The following is a suggested list.

(a) The speed of travel for all persons during the peak hours; e.g., distribution of decreases and increases in travel time both by buses and cars.

(b) The number of persons using the system: buses, carpools, diverted travel from other roads or means of travel.

(c) Changes in modal choice and the rate at which this takes place.

(d) Changes in route choice, e.g., diversion from arterial streets to the main freeway.

(e) Changes in auto occupancy.

(f) Level of, and length of, congestion in time and distance on the route and in the CBD.

(g) Car driver acceptance of the lanes used exclusively by buses during the peak hours. (This was discussed above in Section A of this chapter.)

In addition various financial measures need to be maintained--including the costs of the project in equipment, operation and management, the income of the bus company as a function of ridership and by route.

Other potential measures are not as central to the issue of success yet they do contribute to the overall operation of the system and should be considered in any overall evaluation. Some of these are:

(a) Development of ridership patterns that will be useful for the future rapid rail transit system in Washington.

(b) Changes in auto accident and breakdown rates.

(c) Effect on the economic condition of the bus transit industry.

(d) Requirements for additional highways.

Each of the above measures requires a knowledge of what the system looks like prior to the experiment in order to determine what changes occur and the magnitude of these changes as well as to relate these changes in quantitative terms when feasible to changes in service, cost and other measures of effort that are required for the system. In brief, what changes result from the use of exclusive bus lane and how do these changes relate to the costs involved in implementing the changes?

The data collection needs for evaluating the experiment in terms of the measures suggested are outlined below. Clearly costs of data collection should be a consideration; however, since the Shirley Highway experiment is a first of its kind, its evaluation should not be jeopardized by narrow budgetary constraints.

1. Peak Period Travel in the Shirley Highway Corridor

An up-to-date ramp survey covering the full 10-miles of Shirley Highway is needed prior to the opening of the interim roadway for buses. The 1968 entrance ramp survey used in the contractor's feasibility study is neither up-to-date nor complete. The survey covered only that portion of Shirley Highway between Springfield and Columbia Pike during the AM peak 3-hour period. The count was by ramp, vehicle and auto occupants. Not included in this ramp survey are those vehicles entering Shirley Highway at Hayes Street, Route 110, Route 1 and the George Washington Memorial Parkway. Destinations for the ramp survey population included the Pentagon and Sector Zero (downtown Washington) which account for 56.8 percent of the 16,135 vehicles. The other 43.2 percent of the vehicles (6,962) go to "remaining D.C. areas" (2,154), Rosslyn (439), other Virginia areas (3,785), and Maryland areas (584).

The modal split analysis reported in the HNTB reports (Refs. 24a-c) treats just Sector Zero and Pentagon destinations and certain Transportation Planning Board (TPB) districts of origin. As a result, the total number of autos used for the base 1968 condition is less than the actual number that travel Shirley Highway because (1) all the origins are not included, and (2) all the destinations are not considered as can be seen in the following:

Total Autos (1968 Ramp Survey between Springfield and Columbia Pike)			16,135
Destination Pentagon or Sector Zero	N = 9,173	56.8%	
Other Destination	N = 6,962	43.2%	
HNTB 1968 Base Data on Autos to Pentagon & Sector Zero (Based on 12,683 auto person trips from selected origins with 1.5 persons/auto)			8,455
Difference: Ramp - HNTB			7,680

Using a base of 22,500 auto person work trips in 1968, it was projected that without improved transit service the auto person work trips in the Shirley Highway corridor would increase by 42.5% to 32,100 or at 1.5 passengers/car, from 15,000 to 21,400 cars during the AM peak period. By 1975, if improved transit service is provided in the interim, the percentage increase in work trips would be 16.5 or 17,465 total autos for work trips.

Even the number 17,500--which is about 1,000 more cars than shown in the ramp survey does not take account of cars entering after Columbia Pike. Clearly, not all the autos will be on the total length of the road (some enter, others exit at about 11 places in the 10-mile length) and these will be spread over 3 hours; however, according to HNTB, 40 percent is used as the average peak-hour/peak-period relationship.

In addition to having a count of the traffic on Shirley Highway during the peak hours these measures should include the following:

a. Traffic Counts on Shirley Highway as a Function of Time. The total peak period count is not adequate for an analysis that would provide a measure of shifts

in travel pattern. For example, a change in congestion on Shirley Highway may not be perceptible during the peak hour because some travelers may switch from early commuting times to later times as a result of the bus experiment. The distribution of traffic over time during the 3-hour AM and PM peak periods before and during the experiment should be obtained in order to determine what changes in vehicular traffic are occuring during what periods. For example, there still may be congestion, but this may be confined to a shorter period of time and/or the travel during the before and after peak time may be lighter. On the other hand, total vehicular traffic on the Shirley Highway may in fact remain unchanged or even increase. This could occur if travel on other roads in the corridor switches to Shirley Highway as Shirley Highway "choice" riders switch to buses. It is therefore recommended that measures of the traffic in the corridor be made.

b. Traffic Measures in the Shirley Highway Corridor as a Function of Time. In order to measure the impact of the exclusive bus lanes on travel in the Shirley Highway corridor, examination of peak period traffic conditions should not be confined to the Shirley Highway. Although there are no well defined parallel routes and D.C. bound traffic must cross 14th Street or Memorial Bridges, there are some partial routes (e.g., Army-Navy Drive) in the 10 mile area leading to the 14th Street Bridge that carry heavy traffic loads. These should be included in the overall evaluation of the project. This could be done by traffic courts or periodic aerial photos, again as a function of time.

c. Measures of Truck Traffic. The traffic counts reported in the HNTB reports do not distinguish between type of vehicle, e.g., auto, bus and truck. If the 1968 ramp survey includes only autos, then clearly total vehicle count is higher than that reported. Commercial vehicles are generally larger and have less versatile operating characteristics and therefore require more space than an automobile. When the grade level of the highway is less than 1 percent, a truck is the equivalent of 2 cars; this increases with grade level increase, e.g., a truck is the equivalent of 4 to 5 cars on a 2 percent grade one quarter mile long (Ref. 21).

Observation of Shirley Highway during the peak hours indicates that there is truck traffic on the highway, and counts of this should be made. (Also see Fig. 1.) This is especially important if there has been any self-regulating activity of commercial vehicles to avoid the peak hour congested condition. A reduction in this congestion may result in a change in truck usage of Shirley Highway.

2. Auto Occupancy

Data on the average auto occupancy are available from the survey cited. These figures should be updated when vehicle counts are made and the frequency of varying number of occupants prepared. Such information is needed in the event that consideration is given to permitting car pools on the interim roadway (this is discussed in a later section). Although these data would not in themselves be sufficient to predict the usage of the roadway by high-occupancy vehicles they would provide a baseline to aid in deciding what occupancy level to permit on the roadway. For example, if the number of cars with 4 occupants was well below the number of cars that could use the excess capacity of the interim roadway but permitting cars with 3 occupants would exceed the capacity, only 4 occupant cars should be permitted on the roadway. In all probability some of the 3 occupant cars would then gain another occupant and thus meet the criterion.

3. Travel Time in the Corridor

As inputs to the modal split analyses for the feasibility study, travel times by auto and bus between all Shirley Highway zones and the Pentagon, downtown Washington and Rosslyn were computed. The travel times were obtained by using a computer highway network. These times were compared with drivers' estimates indicated in the auto origin-destination survey. Computer network times were generally about 5 minutes longer than that estimated by the drivers. (It is interesting to note in this regard that an average of 6 minutes per trip is estimated as the time

saved by auto riders remaining on Shirley Highway if the interim roadway for buses is implemented and the modal split predicted realized.*)

Travel time measures by mode of travel, peak period portion, origin and destination and segments of the work trip can be obtained in a variety of ways. Bus drivers can maintain a log for each trip recording times for the various segments of the trip in addition to ridership figures. Bus riders can be enlisted to maintain logs that record door-to-door times according to segments of walk, wait and ride. In addition to the studies of speed on the Shirley Highway conducted by floating car study teams at various times during the peak period, car drivers and passengers can be enlisted to maintain logs in the same manner as bus passengers. There are agencies, Federal and local, whose employees use the Shirley Highway corridor and are either bus or car riders. These persons could be categorized according to origin-destination, hours of work, type of transportation, and parking availability. From these, a sample could be selected to maintain logs according to a schedule, e.g., selected days of the week, or weeks of the year. Such data would provide not only a means for monitoring of the system continuously but also means to evaluate the effects of changes in the system that may be instituted during the progress of the experiment.

A major criticism of utilizing users of the system as opposed to independent data collectors to record data on the system is the incentive and motivation for maintaining accurate records. Methods can be devised to provide the incentive and do spot checks for biases in the records. First of all personnel employed in agencies directly involved in transportation problems--DOT, COG, WMATA--could be used to advantage in such a program. Additional incentives in the form of free transit rides or payment for the reports should be investigated.

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*In the year 1975, an economic benefit of $0.86 million would accrue to Shirley Highway auto users if time is valued at $0.05 a minute. Assuming 250 yearly AM trips by the projected 10,790 auto commuters, an average of $0.30 or 6 minutes per trip is saved.

4. Monitoring Ridership Characteristics

An additional advantage to using the approach suggested above will be information on shifts in travel mode and route. The data collection plan should provide the flexibility of shifting from car to car pool or to bus to assist in determining the reasons for changes in work trip habits. Thus one can monitor the bus as well as car riders to gain insight into behavior patterns and the impact of changes in the system, e.g., opening a new fringe parking lot, improving collection and distribution systems, and changes in cost or availability of parking.

Monitoring of bus ridership and car use should provide measures of trip time and the major associated variables as well as continual counts of ridership on the various routes. In addition there should be continuing sample surveys of the bus riders to determine reasons for switching to bus--the impact of various changes made in the system, and the characteristics of the riders. Although there is a reported 30 percent increase in AM peak period ridership on the current partial roadway,* the riders have not been surveyed to determine whether they have switched from cars, from other buses, from car pools, nor have they been surveyed to determine car ownership characteristics, origin-destination information, etc.

This continual surveying is necessary to measure the effect by means other than ridership of certain features of the system. For example, some studies have indicated that it is not time-savings but rather greater convenience (e.g., expanded service and no parking worry) that is the most frequently given reason for changing from auto to bus. The situations where these surveys have been made (e.g., express buses in mixed traffic) in general do not involve time-savings to the bus rider as compared to the car such as projected for the Shirley Highway. An important question to answer, therefore, is what impact will time-savings have on ridership as compared with convenience factors (increased schedule, fringe parking, etc.) and the decreasing availability of parking spaces in some downtown areas. Also important to assess is

*This increase is reported despite complaints of a lack of seating on the buses, which reflects less than optimal service in the present situation.

rider reaction to seating availability. Not surprisingly, some demonstration projects indicate that this has a significant impact on ridership. For example the Metro Flyer demonstration between Towson and Baltimore, Maryland (a half-hour one-way trip) considered availability of seating of major importance, i.e., "Throughout the demonstration period, riding continued to increase whenever seating space was available. When passengers were required to stand, the riding leveled off; and a substantial turnover in passengers was observed" (Ref. 31).

5. Summary

The Shirley Highway experiment represents a unique opportunity to obtain measures for evaluating the concept of exclusive lanes for buses during peak traffic hours. During the next 18 months, while the interim roadway between Shirlington and the 14th Street Bridge is being constructed, plans and implementation procedures should be formulated to measure the current conditions in the corridor before any changes are made and to monitor and measure effects during the experiment. The analyses to determine "success" are dependent upon timely and adequate data. Some of the major ones have been discussed--peak period travel in the corridor, auto occupancy, travel time and ridership characteristics--various suggestions as to methods that might be employed in the conduct of these analyses have also been made.

The next sections treat briefly several factors that deserve consideration in the planning and implementation of the Shirley Highway experiment.

C. CAR POOLS ON THE EXCLUSIVE BUS LANES

Studies (Refs. 32, 33) have shown that taking a lane away from automobile and truck traffic and using it exclusively for buses does not reduce average person delay to those in automobiles under reasonable demand assumptions even at a 50 percent modal split. On the other hand, permitting car pools to use the reserved lane does reduce total delay significantly. Although the experiment on Shirley Highway is different--a lane is not being taken away from normal traffic but rather 2 are being added for exclusive bus use--it does not appear that congestion will be reduced

even at the modal splits forecast by the contractor. In fact more cars will be using Shirley Highway in 1975 than are currently using it as described previously in Section B.*

Based on the projections in the HNTB reports, it seems evident that the congested auto condition on Shirley Highway will not improve over what it is today. One or more of several changes would have to occur:

(a) The three lane directional highway is constructed in the near future.

(b) The "choice" modal split for Sector Zero and the Pentagon increases above that projected by HNTB.** Their projection of an increase of 25.1 percent over today's 20.8 percent for a total of 45.9 percent just about equals the additional auto person trips one could expect without the interim roadway.

(c) Bus service comparable to that planned for Sector Zero and the Pentagon is provided to other destinations--such as remaining D.C. areas (13.3% of the present autos), and other Virginia areas (26.1% of the present autos) e.g., Crystal City, Rosslyn, etc. to decrease

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* It should be noted, of course, that without the interim roadway for buses, auto person work trips would increase by 42 percent in 1975.

** The question of the validity of modal split analyses performed for the Shirley Highway bus project has not been examined in this study. However, the results of the projections that are presented in Ref. 24d raise questions of the prediction accuracy. For example, the plot of "percent of total auto available person trips using bus transit" vs "equivalent cost savings" between the Shirley Highway corridor TPB Analyses Districts and Sector Zero (Fig. A-4, Ref. 24d) shows a wide scatter of points. The curves that were drawn for downtown areas according to ratios of employees per parking spaces do not fit the data. These data are very sensitive to time estimates for driving (see comment supra p. 27); walk and bus; drive, park and bus. How the latter two estimates were obtained is not described. Further, modal splits are assumed to be sensitive to parking availability--spaces and fees--as these change so do the modal splits. Modal split analyses in general need an in depth examination to establish their validity and usefulness and to determine means for improving predictability.

use of personal autos to those destinations. To do so will, of course, increase the bus requirements and consequently the number of buses to be purchased. It may be that parking in the Virginia areas is less of a problem and less incentive may exist to switch from cars to buses for these destinations.

(d) The interim roadway is opened to car pools. The total number of bus trips projected for 1975 on the interim roadway is 362. These are distributed approximately as previously shown in Fig. 3. For example, assuming that 50 percent of the buses travel during one hour of the 3 hour peak period the buses/lane/hour range from 14 to 90 on various segments of the roadway with headways that vary between 4 minutes and 40 seconds. Assuming that a bus is the equivalent of 2 cars and using 5 seconds for safety sake on the temporary roadway, then 2 x 90 or 180 car equivalent buses per lane, plus 540 cars per lane or 1,080 cars on the two lanes, could be accommodated on the interim roadway during peak hour. If only car pools of 3 or more persons per car are permitted on the interim roadway, then an additional 3,200 persons would be diverted from the 2-lane Shirley Highway during peak hour. At the current 1.5 person per car occupancy rate this would take approximately 2,150 cars off of Shirley Highway during this peak hour.*

Currently no consideration is being given to car pools on the interim roadway because of the temporary nature of the 18-foot planned roadway.** This does not

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*Where there are currently car pools of 3 or more persons that would be diverted to the reserved lanes, then clearly less than 2,100 cars based on a 1.5 occupancy rate would be removed from the 2-lane Shirley Highway.

**The contractor's final report (Ref. 24d) examines bus and car pools as one alternative when the permanent roadway has been completed circa 1975.

appear an insurmountable problem if safety precautions are taken. It seems appropriate to consider car pools for several reasons: (a) utilization of the interim roadway would be increased; (b) congestion on the 2-lane Shirley Highway would be reduced. This is especially significant when the construction of the permanent 3-lanes from Shirlington to the bridge begins. If car pools are permitted on the roadway then congestion may be kept to present day levels; (c) an incentive would be provided for car pooling especially if this were tied to government agency restrictions on parking; (d) driver objection to the exclusive and clearly visible low utilization of the roadway by buses may be obviated.

The experiment might begin with bus-only use with public announcements that car pools will be phased in when safety features have been installed. This would permit comparative measures of roadway use and congestion on Shirley Highway under two different conditions: buses only, and buses and car pools combined. An alternative would be to issue car-pool permits 2-weeks in advance of opening the roadway as a potential way to avoid adverse reactions of car drivers.

A suggested alternative to car pools is to permit commercial vehicles on the interim roadway, thereby removing them from the stream of car traffic. In all probability this would aggravate the public acceptability of the exclusive lanes. The other question concerns the safety and strength of the temporary roadway for truck use. It is contempated that the 18-foot roadway would be available for construction and emergency vehicle use during off peak hours (Ref. 24d); however, these vehicles will, in general, weigh less than tractor trailer vehicles.

D. REDUCE ATTRACTIVENESS OF CAR USE

Increasing the attractiveness of bus service by improved schedules and time-savings over current bus trips may not be sufficient to attract substantial numbers of drivers from their cars. For example, the 15 to 20 minute time savings currently experienced by the buses on the reversible lane is believed to compensate for loading and unloading times of the buses, thereby making it

comparable to a car from origin to destination (Ref. 34). However, this does not cover walking distances to and from boarding and unloading points, nor time spent waiting for the bus. Furthermore, this savings is only experienced during the period when there is a queue of cars approximately a mile in length at the merge point near Shirlington--approximately a 1-hour period during the AM. Even when the interim roadway is completed to the new 14th Street Bridge, time savings to those buses entering north of Shirlington may be more than offset, when compared to car usage, by the time taken to traverse the collection and distribution routes.

Time savings, although an important factor, should not completely dominate the planning for the Shirley Highway experiment. The car represents a convenient mode of transportation and as long as this remains true, no matter how attractive the bus may seem in other respects, inducing people to leave their cars may depend on reducing this convenience factor. One way to make car use comparatively unattractive is to make parking at the destination difficult and costly. Currently parking cost is not a major deterrent to auto use in D.C. For example, the results of a survey of 1,055 auto passengers traveling on Shirley Highway between a TPB district and Sector Zero show daily parking cost per auto-person trip as follows (Ref. 24a):

Daily Person Trip Parking Cost, $	% of Person Trips	Cumulative %
0	45	45
0-0.25	10	55
0.25-0.50	14	69
0.50-0.75	9	78
0.75-1.00	7	85
> 1.00	15	100

Over half of those persons arriving by auto pay 25 cents or less; by far the largest percentage of these park free. Three-quarters pay less than 75 cents.

Furthermore, parking availability has not been a limiting factor on car use. Where new office building construction is taking place (e.g., Connecticut Avenue

area) the availability of parking is increasing. Whereas in 1960 there were 42,627 parking spaces available in the area bounded by Massachusetts Avenue, 2nd Street, Constitution Avenue and 23rd Street, in 1968 this had increased to 56,854 or a one-third increase. During this period the employee per space ratio has declined from 4.3 to 3.7 (Ref. 35). The office building increase has been a major contributor to this improvement in parking facilities since the D.C. regulations require one parking space for each 600 square feet of gross floor area.* Under this regulation the trend is toward an employee per parking space ratio of 3.0 using 200 square feet of gross office space per employee. The Southwest area on the other hand is projected to go from the 3.9 employee per space ratio in 1968 to 5.1 in 1970 and 6.3 in 1973 when the employment in that area will exceed 82,000.** This shortage of parking space in Southwest could become a major factor in inducing car drivers to become bus riders to this area.

Parking costs and availability are doubtless important factors in the decision to drive downtown. An examination of fringe parking in the Washington area several years ago concluded that the main motivation for those using the lots was the avoidance of downtown parking costs, the secondary motivation was the dislike of driving in congested traffic (Ref. 38). An examination of alternatives to reduce availability and increase cost would be useful to both the Shirley Highway experiment and other

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* Garage space has increased 47 percent; lot space has declined approximately 1 percent (Ref. 35).

** By June 1969 there were 46,000 employees (approximately 10,000 of these non-Federal) and an additional 16,000 were projected by the end of 1969 to be working in the area surrounding L'Enfant Plaza (Ref. 36).

transit plans.* Potential utilization of parking levels in buildings--for storage, recreation, shops, etc.--needs to be examined to compare benefits that would accrue to owners. Restrictions should be considered on parking permits in free government parking areas**--e.g., restrict to car pools. Since the effect of decreased parking in the downtown area would affect not only Shirley Highway corridor users, the practicality of implementing restricted parking would have to be coordinated with transit plans from other suburban areas. Furthermore, the impact on businesses and other organizations moving to the suburbs must be addressed.

E. BUS UTILIZATION

Availability of buses to meet the demand may well be a limiting factor in the Shirley Highway experiment as in other bus experiments.*** The time savings projected for the Shirley Highway bus experiment will accrue to buses as well as

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* Restriction on the amount of off-street parking and the price charged for its use was determined in June 1969 to be within the power of Washington's City Council by the Council's legal staff. The Council sees this power as a means of discouraging suburban commuters from arriving by car rather than bus. The major business organizations, on the other hand, support measures proposed by Congress to expand parking facilities, i.e., condemn land to provide sites if necessary (Ref. 37). A study contracted for by the D.C. Council in July 1969 to prove that the city had power to cope with the problem failed to show that the city had the necessary tools to regulate and control parking facilities (Ref. 39).

** Government provided parking spaces represented 14 percent of the spaces available in Ring Zero (Ring Zero is bounded by 23rd Street, Massachusetts Avenue, 2nd Street and Constitution Avenue) in 1968. Private parking accounted for 15.5 percent. The remaining 70.5 percent were public (Ref. 35).

*** Reluctance of bus companies to purchase and provide additional buses was experienced in both the Reston, Va. and Towson, Maryland bus projects (Refs. 40 and 31). After 15 months of successful operation the main unsolved problem of the Reston express bus service was the lack of suburban coaches for high-quality operation. The project director "repeatedly asked for such vehicles, but the bus company, which had already made available the only two that it possessed, was unwilling to purchase new equipment for a single daily round trip."

passengers, and with proper scheduling, increased utilization could result, thereby reducing total new bus, as well as bus driver requirements. For example, Howard, Needles, Tammen and Bergendoff (HNTB) project that 362 bus trips will be required to meet 1975 demands of 18,830 AM peak period transit riders (52 passengers per bus)* (Ref. 24d). This is 95 bus trips more than presently scheduled in the corridor (267 bus trips for 13,800 passengers trips). HNTB uses the present factor of 1.25 bus trips per bus and 7 percent for equipment down time and concludes that 82 new buses at $40,000 per bus are needed for a cost of $3.28 million. With time savings projected for the high speed, line haul trips, fringe parking availability and new terminal areas such as that in the Southwest area, this factor should increase. If one uses the present bus trip figure of 267 and the HNTB factors of 1.25 and 7 percent, the current bus needs are estimated to be 229. If the utilization rate increases to 1.5 in the Shirley Highway experiment, then for the projected 362 bus trips a total of 258 buses would be needed, representing an increase of 29 buses over the current 229. The cost would be $1.16 million, or $2.12 million less than the $3.28 million for new buses projected by HNTB.

A savings in time for the transit passenger is projected which results in an economic benefit each day of $15,376 summed for all 18,797 AM peak period passengers** (Ref. 24d, App A, Table 16). Time savings are valued at $.05/minute. The average AM peak period passenger therefore is projected to save 16 minutes and, of course, larger time savings during the more heavily congested one-hour of the 3-hour AM peak period. The same time savings accrue to the operation of the bus. This should improve the utilization rate over that experienced today. Clearly, the bus schedules and travel times by origin and destination would have to

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*This represents a load factor greater than 100%. Seating capacity on current buses ranges between 44 and 51.

**One can anticipate that car drivers may reasonably ask what the economic benefits would be if cars used the roadway.

be examined in detail to determine utilization and equipment needs. For example, 50 percent of the current peak 3-hour period bus needs appear to occur during the peak hour.

The HNTB Study does not establish equipment needs. This is a very critical part of the busway concept--especially in the D.C. Metropolitan area where the bus companies concerned are privately owned and one of the constraints in implementing the plan will be the availability of funds to provide the additional buses needed. Under current legislation, UMTA can only provide grant and demonstration funds to public agencies--these in turn may lease equipment to private companies. Under the currently pending legislation (S. 3154) this would be changed to permit grants to private transit companies. Even if the buses are provided to a public agency (c.g., COG), this is not a 100% grant; matching funds by the local agencies (under current law) or the private transit company (pending law) must be provided.

In view of previous experience with bus availability, a special effort should be made to examine and experiment with means of increasing bus utilization.*

F. COLLECTION AND DISTRIBUTION SYSTEMS

A major contributor to bus travel time in the Shirley Highway experiment will be the collection and distribution times at either end of the interim bus roadway. Fringe parking with express buses to the Pentagon or the Southwest Washington terminal will probably represent minimum times for bus riders. When the bus covers many miles prior to entering the busway--as for example the eight miles covered by a bus originating south of Alexandria and entering the expressway at Seminary Road--walking to the bus stop, waiting for the bus and additional passenger collection time may more than offset the time saved on the exclusive bus lane when compared to door-to-door car times.

The major increase in transit riders in the HNTB study comes from the "choice" group--namely, those with 2 or more cars. These are projected to increase

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*The maxi-bus concept should be examined for the Shirley Highway experiment and specifically for those trips where origin and destinations are confined to fringe parking lots and CBD terminals (Ref. 44).

from the current 3,300 person trips to the Pentagon and Sector Zero to 9,260 in 1975 when the interim roadway for exclusive bus use is contructed (Ref. 24d, p. 38).* Provision of fringe parking for these 2-car owners is being planned at suburban shopping centers. The experiment might include devising means to encourage car pooling to the fringe lots, varying the design of the reserved parking areas to minimize walking distances, and testing ways to provide shelter. In addition, systematic analyses of the beneficial effects on shopping centers should be made, e.g., economic advantages, in both sales and increased services on such businesses as car repair facilities.

Transferring is considered one of the detriments to bus use. However, an examination and possible experimentation with alternatives for passenger collection other than by the bus which travels on the exclusive bus lane should be considered. As mentioned above, car pooling to fringe parking would be especially attractive, but problems of coordination of timing may minimize this. The use of the mini buses such as the F Street variety might be used for collection of passengers and distribution in the suburbs in the morning and evening and then used during the 10 to 4 period in downtown Washington.** The economics of such operations need examination; however, one clear benefit would be the increased utilization of regular buses on high speed long-haul operations between fringe parking and downtown terminals.

G. SUMMARY AND RECOMMENDATION

Implementation of the Shirley Highway interim roadway for buses-only offers a unique opportunity to assess the concept of exclusive roadways for buses. To evaluate the concept and its operation and to obtain transferable results, attention

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* "Captive" transit riders show a 10 percent decline (from 10,530 to 9,565) between 1968 and the projected 1975 condition with interim bus reserved lanes (Ref. 24d).

** Congress is currently considering public acquisition and operation of all bus companies in the Washington Metropolitan area. The bill passed the Senate in April 1970 (Ref. 42). Jurisdictional problems that exist today for using the current F Street mini bus for collection and distribution would be removed by such legislation.

should be given to (1) obtaining a careful and detailed description of the current system; (2) developing a monitoring system of bus ridership and car drivers; (3) examining ways to increase bus utilization; (4) identifying means of reducing the attractiveness of car use; (5) considering the introduction of car pools on the busway, and (6) improving passenger collection and distribution systems.

A body of literature and experience is accumulating relative to bus demonstration projects and related aspects of bus travel designed to improve service and assist a dying industry. Some of these have been examined during the course of this study; however, it becomes readily apparent that the existing documentation is generally not complete nor up-to-date in that the post demonstration period is not covered. It is equally apparent that a great deal of useful information can be gained from these demonstrations that can be of assistance in planning the Shirley Highway experiment and other experiments. It is recommended that a complete survey be made of bus demonstration projects and related bus activities. The objective of such a study would be several-fold:

1. To identify the nature and causes of the successes and failures.
2. To develop general guidelines and standards to be used in related demonstrations or by localities that want to adopt the concept tested.
3. To determine what the operational history of the projects has been once the demonstrations have ended.
4. To analyze lessons learned applicable to busways and exclusive bus lanes.
5. To provide a collective source of data and knowledge on bus demonstrations that can be made readily available to interested agencies and localities.
6. To identify gaps in the bus program that may require future R&D attention.

The survey should include an examination of estimations, pre-project surveys and other tools used prior to the demonstration and an explanation of how

these results relate to the actual ridership experienced. The build-up as a function of time, service provided and socio-economic area served should be detailed where data are available. Emphasis should be placed on developing measures of success or effectiveness--e.g., ridership, revenue, reduced congestion, flexibility, reduced time--because this area has not been systematically examined and related to planning and length of demonstrations. To the extent possible the variables that affect the measures of success should be identified, such as amount and kind of publicity, schedules, types of buses, fare structure, parking availability, convenience and comfort.

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13. ABSTRACT
(U) This paper provides an initial examination of the Shirley Highway experiment and addresses specific aspects of the bus project. In the short time available for the study, experiments, measurements and evaluations were outlined and described in the detail possible. These mainly concern (1) potential reaction of automobile occupants to what will be an apparent sparse use of the reserved lanes by buses only, (2) measures of success and the associated data collection requirements before and during the experiment, (3) improvements in bus utilization during the project, (4) means to reduce car attractiveness which in turn would increase the relative attractiveness of busses, (5) utilization of excess bus lane capacity by car pools and (6) circulation systems.

(U) A systematic and exhaustive survey of bus demonstration projects is recommended to assist in planning the Shirley Highway experiment as well as to provide a single source for guidelines to Federal and local agencies concerned with the development of bus programs. An important aspect of this study would be to examine the current status of the bus projects considered "successful" during the demonstration period.

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