PRIORITY TECHNIQUES FOR HIGH OCCUPANCY VEHICLES

Technology Sharing

STATE-OF-THE-ART OVERVIEW
NOVEMBER 1975

DEPARTMENT OF TRANSPORTATION ★ UNITED STATES OF AMERICA ★

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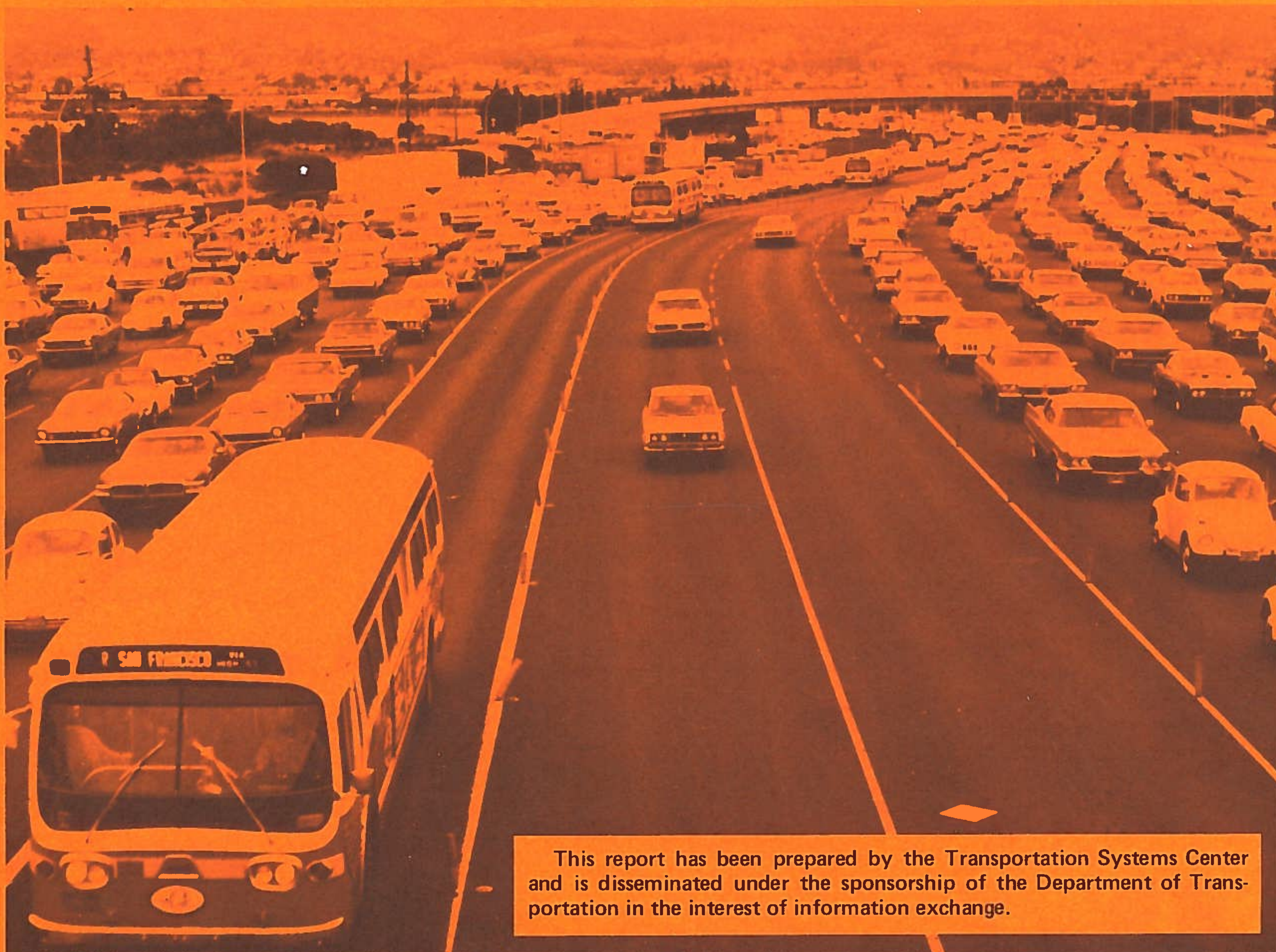

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16. Abstract

This report, part of a series of publications based on research and development efforts sponsored by the Department of Transportation, is a concise state-of-the-art overview of priority techniques for high occupancy vehicles (buses, carpools, and vanpools). The report identifies and summarizes selected characteristics of 17 freeway-related and 37 arterial-city street priority techniques. The document also provides a perspective on planning and implementation guidelines, and legal, financial, and institutional considerations associated with priority techniques. Supplementary material includes a listing of current sources of information, a directory of referenced transit authorities, operating agencies, and governmental units, and a glossary of terms used in the report.

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FOREWORD

As part of its ongoing commitment to the principle of technology-sharing, the U.S. Department of Transportation has initiated a series of publications based on research and development efforts sponsored by the Department. The series comprises technical reports, state-of-the-art documents, newsletters and bulletins, manuals and handbooks, bibliographies, and other special publications. All share a primary objective: to contribute to a better base of knowledge and understanding throughout the transportation community, and, thereby, to an improvement in the basis for decision-making within the community.

This title in the series presents an overview of priority techniques for high occupancy vehicles, an innovative approach that may help fill the need for flexibility in public transportation. The report is designed to make more accessible the body of knowledge that now constitutes the state-of-the-art in priority techniques for high occupancy vehicles. A special feature is the inclusion of supplementary material to serve as a sourcebook for further information.

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- OFFICE OF THE SECRETARY
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San Bernardino Freeway Busway in Los Angeles

I ROLE OF PRIORITY TECHNIQUES IN URBAN TRANSPORTATION

overview

IN RECENT DECADES, the automobile has dominated urban transportation development. In consequence, it has been instrumental in the shaping of our current urban form and way of life—particularly in the dispersal of urban area populations. Predictably, this dispersed populace has become increasingly auto-dependent in the absence of competitive transportation alternatives.

The emergence of the major problems of congestion, pollution and energy consumption, and the conflicting claims on urban land and fiscal resources—all highly correlated with auto-intensiveness—make the development of competitive alternatives to the automobile imperative. Such alternatives, however, while reducing urban auto use, must continue to provide increasing mobility for urban area populations.

A number of approaches are possible. The development or expansion of conventional rapid rail and fixed-route bus systems have been undertaken in several localities. In other instances, more recently developed demand-responsive transportation services have been implemented to combine the economic efficiencies of line-haul mass transportation with the point-to-point flexibility of private taxis.

Reflecting the same shift in emphasis, another alternative is to make more efficient use of existing vehicle and highway capacities by diverting a significant segment of auto users to buses and increasing the occupancy levels of the remaining automobiles beyond the national average occupancy of approximately 1.3 persons per vehicle during peak hours (reference 74). A long-standing consensus exists within the transportation community on the desirability of effecting such use-efficiency improvements. Generally, however, positive incentives are necessary to induce auto users to become users of high occupancy vehicles—to become bus passengers, or to join carpools and vanpools.

To provide these incentives, various transportation organizations throughout the nation have developed and implemented programs providing priority of movement to high occupancy vehicles. These techniques appear feasible and meet the following transportation objectives without heavy consumption of transportation resources:

- Better collection and distribution in suburbs. Priority techniques are not directly applicable here, but the location of suburban terminal points on line-haul trips allows for a rational system of feeder buses, park-n-ride and kiss-n-ride, as well as pedestrian and bicycle access in suburban areas.
- Better line-haul systems. Bus and carpool/vanpool priority techniques have great applicability in allowing fast and safe travel on highways and arterials, while reducing automobile traffic congestion.
- Better internal circulation in high-density urban areas (e.g., the Central Business District). Priority techniques have great applicability in enabling high occupancy vehicles to move more quickly through heavy street traffic.

advantages

Among the advantages which can be realized by the institution of priority techniques for high occupancy vehicles, *in contrast to several of the other possible alternatives,* are:

- The previously-noted increased efficiency in the use of existing vehicles and highways.
- Relatively low capital investment requirements.
- Short lead time in the planning and implementation of projects.
- Flexibility in adapting or terminating unsuccessful projects.

historical development

Providing priority treatment for high occupancy vehicles is not a new or revolutionary concept. During earlier periods of transit growth, transit companies were frequently allowed special operating privileges to compensate for the public service they provided and the regulated fare constraints under which they were obliged to operate. For example, trolley lines were allowed to be constructed in the center of the roadway or in the median of wide streets to minimize interference by other traffic. Similarly, where physical obstacle problems existed (e.g., a river), exclusive rights-of-way were often constructed. Moreover, when bus service replaced streetcar service, and competition for roadway space emerged between buses, autos and trucks, various traffic engineering techniques were applied to assist bus mobility, including:

- Curb parking regulations
- Traffic signal modifications
- Reservation of curb or median bus lanes.

Figure 1 shows a chronology of selected priority techniques in the United States and a geographical distribution is presented in Figure 2.

Figure 1. Chronology of Selected Priority Techniques in the United States

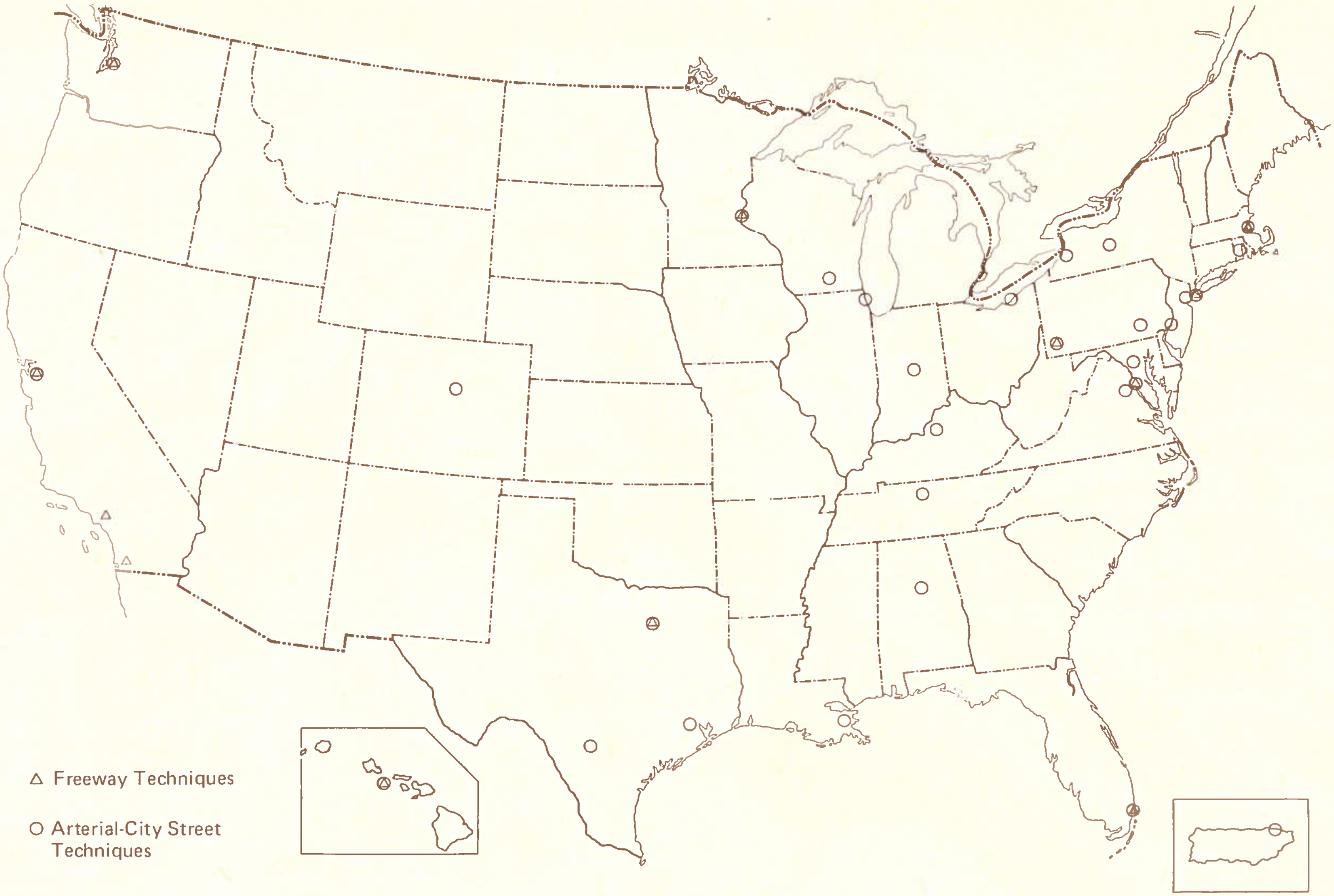
YEAR OPEN*	LOCATION**	TYPE OF TECHNIQUE: FREEWAY	TYPE OF TECHNIQUE: ARTERIAL-CITY STREET
1939	N. Sheridan Rd., Chicago, IL		Contra-flow bus lane
1948	East Side Tunnel, Providence, RI		Exclusive bus tunnel
1956	Market St., Newark, NJ		Curb bus lane
1958	Elm and Commerce Sts., Dallas, TX		Curb bus lanes
	Harvard Square, Cambridge, MA		Exclusive bus tunnel
	Market St., Harrisburg, PA		Contra-flow bus lane
1963	New York, NY		Curb bus lanes
1968	Nicollet Mall, Minneapolis, MN		Exclusive bus street
	Alamo Plaza, San Antonio, TX		Contra-flow bus lane
1969	Shirley Highway, Washington, DC	Exclusive right-of-way for buses (carpools - 1973)	
	College Ave., Indianapolis, IN		Contra-flow bus lane
1970	I-5 Freeway Ramp, Seattle, WA	Exclusive bus ramp	
	I-495/Lincoln Tunnel, New York, NY	Contra-flow bus lane	
	San Francisco-Oakland Bay Bridge, San Francisco, CA	Normal flow reserved bus lane at toll plaza area (carpools - 1971)	
1971	Kalakaua Ave., Honolulu, HI		Contra-flow bus lane
	Main St., Houston, TX		Curb bus lane
	Los Angeles, CA	Bus and carpool bypass lanes at metered ramps	
	San Juan, PR		Contra-flow bus lanes
	Long Island Expressway, New York, NY	Contra-flow bus lane	
1972	Louisville, KY		Bus pre-emption of traffic signals
	U.S. 101 (Marin County), San Francisco, CA	Contra-flow and normal flow bus lane	
1973	San Bernardino Freeway Busway, Los Angeles, CA	Exclusive right-of-way for buses	
1974	N.W. 7th Avenue, Miami, FL		Median bus lane and traffic signal modifications
	S. Dixie Highway, Miami, FL		Contra-flow bus lane and normal flow reserved carpool lane
	Denver, CO		Curb bus lanes and carpool lanes
	Moanalua Freeway, Honolulu, HI	Normal flow reserved bus and carpool lane	
	I-35W Ramps, Minneapolis, MN	Bus bypass lanes at metered ramps	

*Many projects were opened in stages, therefore the year open is the first segment or project at the selected site.

**City designation is the metropolitan area most often associated with the project.

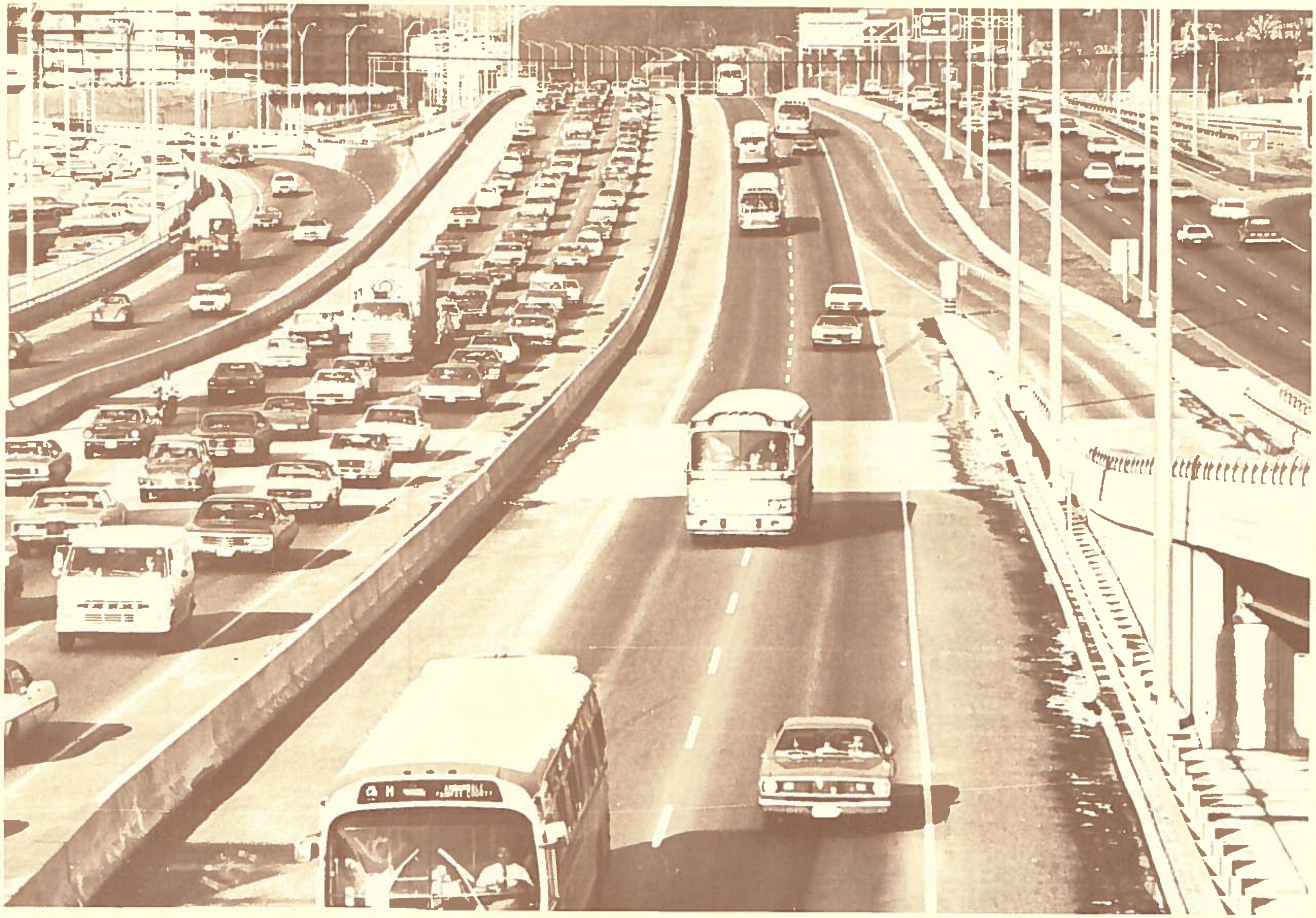
Source: Appendices A and B

Figure 2. Geographical Distribution of Priority Techniques in the United States, June 1, 1975



Source: Appendices A and B

Shirley Highway Bus and Carpool Lanes



II FREEWAY PRIORITY TECHNIQUES

the role of freeway priority techniques

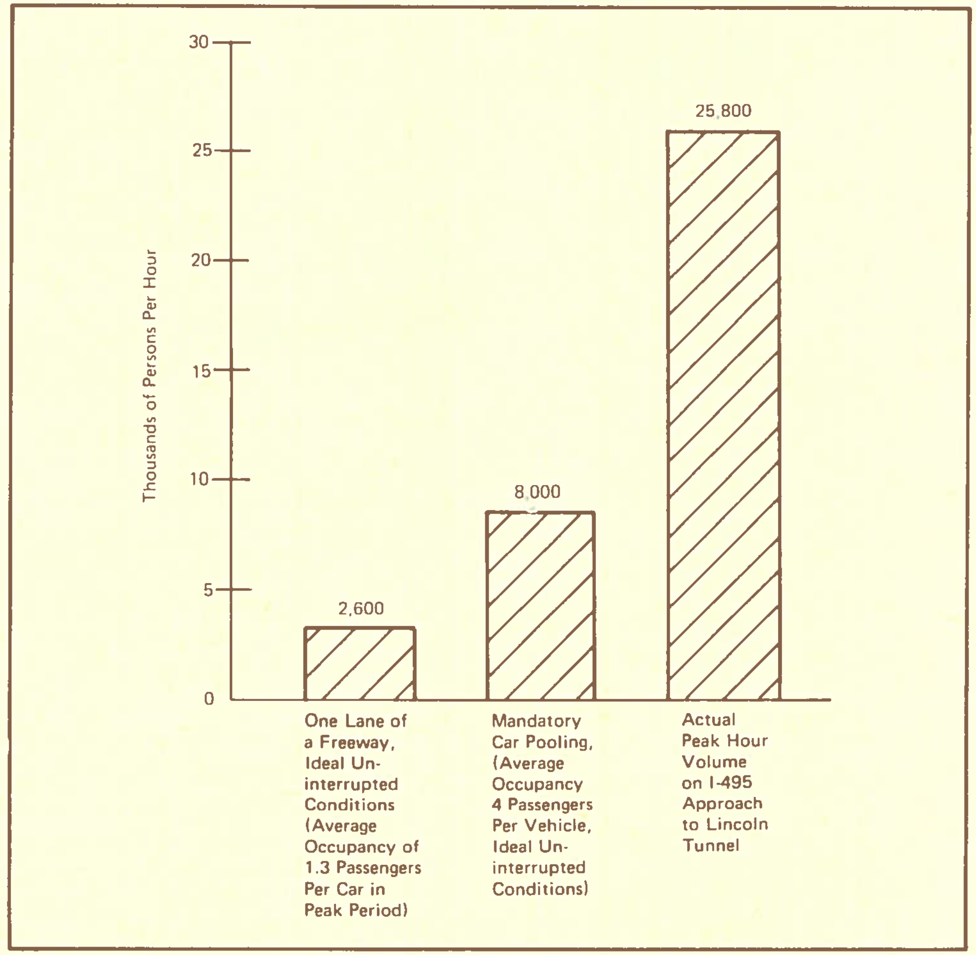
THE LAST TWO DECADES have seen a substantial population shift from the urban central core to suburban areas while maintaining economic dependence on the central city. In order to better serve the transportation needs of this growing commuter group there has been a great increase in "express bus" or "freeway flyer" services to major employment centers in the CBD. This type of service generally utilizes urban freeways for the line-haul portion of the trip.

Increased use of high occupancy vehicles such as carpools and buses on urban freeways has the potential to substantially increase the peak-hour person-throughput of urban freeways. The recognition of person-flow as opposed to vehicle-flow as a measure of freeway capacity is central to the understanding that freeway efficiency can be substantially increased by moving a greater proportion of people in higher occupancy vehicles.

The highest percentage of peak-hour bus use occurs in the New York City metropolitan area where more than 80% of the inbound commuters on the I-495 approach to the Lincoln Tunnel use buses. Buses also account for about one half of peak-hour person-trips on the San Francisco-Oakland Bay Bridge, the Shirley Highway in Virginia and the Ben Franklin Bridge in Philadelphia.

In a recent study completed for the U.S. Department of Transportation (reference 73), one notable conclusion is that the exclusive use of a highway lane by buses has the potential of increasing the passenger-carrying capacity of a highway lane by "several orders of magnitude." As indicated in Figure 3, actual peak-hour passenger volumes as high as 25,800 have been observed on a limited access highway lane with a bus terminal as the trip end.

Figure 3. Relative Peak-Hour Volumes of Normal Highway and Exclusive Busway Lanes



Source: Adapted from Reference 73

These figures contrast sharply with the 2600 persons per hour which is the maximum expected passenger volume of a traffic lane with no buses (assuming the current national average of 1.3 passengers per vehicle in the peak period). A recent report by the California Department of Transportation substantiates these figures (reference 31). The conclusions of this report are:

- Capacity of one exclusive lane is about 1200 buses per hour carrying 60,000 passengers for a lane length of less than 1/2 mile.
- Capacity for lane lengths greater than 1/2 mile average about 800 to 1000 buses.

Reduction in capacity as the length of the lane increases is due to gaps that tend to open up when buses "bunch-up" or platoon. Another noteworthy conclusion states that if carpools are allowed on an exclusive bus facility where capacity is not exceeded, the volume in terms of persons per hour would increase.

characteristics of existing freeway techniques

PHYSICAL FEATURES. There are many design factors involved in the establishment of priority techniques on existing freeways. Among these factors, are length, design speed, lane width and cross sections, stations, and median divisions. They are discussed below.

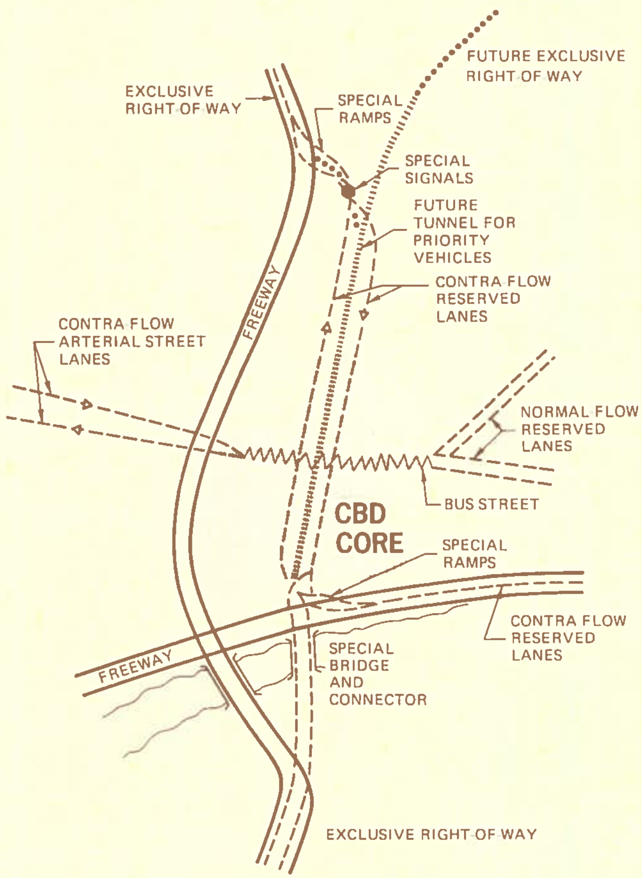
Length: The length of existing priority techniques ranges from several hundred feet to 11 miles. Most planned or proposed treatments are in the 8 - 12 mile range.

Design Speeds: The original design speeds were in the range of 50-70 mph. Operating experience, especially on high volume contra-flow facilities, has resulted in lower speeds. For example, buses using the contra-flow lane in Marin County, California are restricted to 40 mph while buses using normal lanes may travel at the posted speed limit of 55 mph. Buses approaching New York by way of the Lincoln Tunnel often find that the capacity of their contra-flow lane is saturated thus precluding higher speeds.

Lane Widths and Cross Sections: Lane widths on existing facilities range from 11 feet on the Long Island Expressway to 17 feet on the San Bernardino Busway. The total width of the priority facilities typically range from 30-50 feet but can be as narrow as the width of one lane. Primary considerations for variations in width is the need for passenger transfer in case of emergency and for violator apprehension by law enforcement personnel.

Stations: Location and the number of stations is largely dependent on the type of technique, the routing pattern, and the type of area serviced. Existing techniques on reserved freeway lanes do not have stations. However, proposed techniques in Chicago and Pittsburgh call for stations at intervals of about one mile and the San Bernardino Busway has three stations with varying distance between each station.

Figure 4. Coordination of Various Priority Techniques in a Metropolitan Area



Source: Adapted from Reference 83

Separation of Traffic: With the exception of some of the larger priority facilities, most techniques do not call for physical median barriers. Contra-flow projects such as those found in New York, Boston, Miami, and Marin County, California achieve separation of opposing flows by traffic posts, cones, signs, and signals. Separation on the Marin County project is accomplished by placing traffic posts in the center of the lane adjacent to the buses, thus creating a one-lane buffer.

COORDINATION CONSIDERATIONS. The fact that many of the freeway priority techniques exist, or are planned where rail rapid transit operates and/or is under construction, is not coincidental. Many treatments are located in corridors where rail rapid transit does not fully meet transportation requirements. This is particularly true of Boston and New York City. Washington, D.C.'s Shirley Busway is planned to connect with that city's rapid rail system and effectively eliminate a two mile, 15-minute trip through downtown streets. Priority proposals in Atlanta and Chicago are being designed for rail feeder and crosstown lines, respectively.

Many existing freeway techniques are part of a larger system which combines various techniques (see Figure 4). This larger, overall approach is in recognition of the benefits to be obtained from a system-wide traffic planning procedure. As a result, the Shirley Busway is complemented by peak-hour reserved lanes in downtown Washington, D.C. and by special ramps to the reversible roadway in Virginia.

Other examples are contra-flow lane operation in the Lincoln Tunnel to complement service on I-495 and a special downtown circulation loop for Blue Streak buses in Seattle. Complementary facilities such as terminals and outlying parking facilities discussed below also add to the enhancement of the system's performance.

OPERATIONAL EXPERIENCES. Operational experiences associated with existing priority techniques have shown that exploiting the full potential of these facilities is very important. The facility safety records have been excellent, despite the traffic engineering problems characterized by weaving among traffic lanes and conflicts in traffic movement.

Operational experiences and problems associated with existing priority techniques fall into three categories: 1) enforcement; 2) safety; and 3) traffic engineering.

Enforcement: Although the problems with enforcement of priority techniques have not, in general, been insurmountable, experience in some states indicates that violations can be a problem. Violators, those who are ineligible to use a priority facility, are either willfully or honestly confused. Unless rigid enforcement is provided, a large number of violations can counter the benefits expected from the priority techniques.

Experience in California reveals that there were 600 to 1500 violations during each three-hour morning peak period during the early stages of the reserved lanes project at the San Francisco-Oakland Bay Bridge. To combat this, both short-term intensive enforce-

San Bernardino Freeway Busway in Los Angeles Prior to Completion of Construction

ment and routine enforcement campaigns were necessary. In addition, a metering system was installed. As a result, the number of violations have decreased to about 150 in the peak period. The California experience shows that preferential carpool facilities have more violations than bus-only facilities. One possible reason is that violators may feel less conspicuous when in the company of other automobiles. In addition, an effective use of advertising campaigns in the media prior to the implementation of priority techniques could have prevented driver confusion.

Safety. A review of the safety of priority facilities shows that the number and severity of accidents has not increased to the point where safety is a problem. One example of this is the Lincoln Tunnel and I-495 in New York City. At this site, there has been no increase in accident rates since the implementation of contra-flow lanes. This is significant despite very high bus volumes and the use of minimum design. The same kind of favorable accident experience has been reported for the Long Island Expressway in New York City and Southeast Expressway in Boston.

Reports on contra-flow accidents state that although firm conclusions could not be drawn due to the unavailability of desired data, a number of positive statements could be made concerning contra-flow priority operations (reference 3). Among these are that when comparing normal lanes to priority lanes, accident rates have not been excessive in the latter facility. Therefore, priority techniques have not been viewed as hazardous by transit operators who, in fact, are openly enthusiastic about them.

Traffic Engineering: Reports from existing priority facilities regarding delays and conflicts indicate only minor operational problems. The operating conditions at critical locations of the freeway must be investigated in order to determine their effects on the safety, capacity, and the levels of service concerning priority techniques. A determination should also be made of these service levels as they relate to key points on each freeway so that bottlenecks will be minimized and traffic operations will not break down. Critical points on a freeway can be located where there are sudden increases in traffic demand, where inter-vehicular conflicts are created within the traffic stream, or where both occur.

Traffic demand on a freeway can change only at entrance and exit ramps. These demands create critical points upstream from an exit ramp or downstream of an entrance ramp. Operational experience with priority techniques has revealed problems on the exit ramps from the I-5 reversible lanes in Seattle. The exit ramps at this location are often so congested that queues form where buses leave the freeway. Plans are underway to reconstruct these ramps to correct this situation.

Another critical location associated with freeway priority techniques is the weaving section. When large volume weaving movements occur during peak hours, there will be an increase in traffic friction and a decrease in average vehicular speeds resulting in an increased safety problem.

Los Angeles Area Carpool Bypass Lane

Figure 5. Typical Sign for Priority Techniques

Source: Reference 16

Operational experience with the Shirley Highway Busway in Washington, D.C. has revealed problems of bus access at the Shirlington Circle interchange because these buses had to weave across two highway lanes. Overall traffic speeds decreased when highway traffic had to yield to buses entering on a special entry ramp. In addition, buses at the northern end of the Shirley Busway were required to weave across vehicular traffic lanes to get to the 14th Street curbside bus lanes. Construction of special ramps corrected this situation.

A key element in maintaining smooth operation of priority techniques and one which is of vital concern to traffic engineers is the provision of adequate signing and control devices. On freeway priority techniques, one major precaution is to alert the motorist to the changes in the usual traffic pattern. Where mixed traffic approaches the start of a priority facility, current experience indicates that it is necessary to warn motorists well in advance of the point of divergence. Similarly, signing is necessary at the merge point of these facilities with normal traffic flow. In the past, a number of State Highway Departments and local jurisdictions have established their own set of signs for designating priority bus and carpool lanes because of the lack of standard signs and markings. As a result, the Federal Highway Administration (FHWA) has recently issued a change to the Manual on Uniform Traffic Control Devices which establishes standard signs for priority facilities (reference 16). One such sign is illustrated in Figure 5.

PLANNING CRITERIA. The planning of priority techniques for high occupancy vehicles is ideally based on a careful examination of the complex factors involved in implementing this type of facility. This section will detail some of the costs and benefits of existing priority techniques. In addition, several non-quantifiable characteristics will be discussed. The planning criteria for 10 selected freeway projects is shown in Figure 6.

Costs: The cost for implementation of priority techniques on urban freeways varies greatly between the four major categories of a) exclusive rights-of-way, b) normal flow reserved lanes, c) contra-flow reserved lanes, and d) preferential treatment at ramps. Costs for 10 selected priority facilities are illustrated in Figure 6.

The cost for maintenance and operation of reserved freeway lanes can be much higher than the initial construction costs, if indeed there is any construction. Cost breakdowns for reserved freeway lanes are:

- I-495 (Lincoln Tunnel): Total costs for reversible-lane operation at this site was $700,000 of which $134,000 was for construction and the remainder for traffic controls (overhead directional lane signals, traffic posts, and traffic signs.) Annual costs are $200,000.
- Long Island Expressway: Implementation costs were approximately $44,000. In contrast, the annual maintenance costs are approximately $150,000.

Figure 6. Planning Criteria for Selected Freeway Priority Techniques

Technique	Length (miles)	Costs ($) Implementation	Costs ($) Operating	Use	Time Saved (min)
Exclusive Rights-of-Way					
Shirley Highway	11	Not Available	16,000/year	300 buses carrying 16,000 round-trip passengers daily	10-15
San Bernardino Freeway Busway	11	56,000,000	N.A.	7800 bus passengers in combined peak periods (5.5 hours)	10
Normal-Flow Reserved Lanes					
I-93, Boston	1	Nominal	Nominal	24 buses and 560 carpools in peak period	2-4
S.F.-Oakland Bay Bridge	.5	398,000[a]	30,000/year	500 buses and 1900 carpools in peak period	5
Contra-Flow Reserved Lanes					
Southeast Expressway	8.4	40,000	550/day	95 buses carrying 3000 passengers in the peak period	14
I-495 Lincoln Tunnel	2.5	700,000	200,000/year	950 buses carrying 40,000 passengers in the peak period	8-15
Long Island Expressway	2.0	44,000	150,000/year	200 buses carrying 10,000 passengers in the peak period	15
Freeway Ramps					
Lakewood Blvd./Route 405, Los Angeles	--	Nominal	Nominal	Increase in the number of carpools from 125 to 425 in the peak period	1-3
I-35W, Minneapolis	--	759,000[b]	Nominal	Bus ridership increased from 1100 to 8800 peak period passenger per day	Nominal
I-5 Ramp, Seattle	--	15,000	Nominal	50 buses carrying 2500 passenger in the peak hour	5-10

[a]includes traffic signal metering system

[b]includes nine bus ramps

Source: Appendix A

- Southeast Expressway: The total implementation cost was $97,000, of which nearly 2/3 consists of operating costs for the 106 days per year of operation. These figures do not include police assistance.
- San Francisco-Oakland Bay Bridge: Total implementation cost for the bus and carpool bypass lanes (including the metering system) was $398,000, while maintenance costs are about $30,000 per year.

The construction costs for exclusive rights-of-way priority facilities (ranging from $1 million per mile to $5 million per mile) are higher than for reserved freeway lanes. On the other hand, the operating and maintenance costs for exclusive rights-of-way are lower than reserved lanes.

Construction costs for exclusive rights-of-way vary depending on the type of construction and the desired level of service. Construction cost for at-grade projects were about $1 million per mile while costs for elevated or depressed roadways were about $3 million - $4 million per mile.

In the case of preferential treatment at freeway ramps, the implementation and operating costs in most cases have been quite modest. Where complex surveillance and control has also been implemented, the costs have been higher. Nonetheless, the provision of priority for buses and carpools at freeway ramps has been highly successful in terms of increasing their popularity at various sites (references 31 and 36).

Benefits. The two major quantifiable areas in which priority techniques have been found to be beneficial are in the increased use of high occupancy vehicles (which may be measured by increased bus patronage and increased automobile occupancy) and in commuter time savings.

The urban areas that generally have the highest bus passenger volumes are those with existing or proposed mass transit systems and that have a high density CBD employment, high parking costs, heavy mass transit use, and larger bus fleets. Examples of bus passenger volumes for these types of areas are:

- New Jersey I-495 - peak period volume of 40,000 passengers
- San Francisco - Oakland Bay Bridge - morning peak period volume of 13,000 passengers
- Shirley Highway - morning peak period volume of 16,000 passengers

Bus flows and carpool volumes during the peak period for existing priority treatments are illustrated in Figure 6.

Increased bus patronage and automobile occupancy is only one of the wide range of benefits that have been reported. The most important user benefit is in terms of time savings. The time savings for several projects are found in Figure 6.

Reliability of operations is another extremely important benefit. Users of priority techniques have experienced significantly smaller variations in their total trip time, therefore increasing the probability that they can meet their time schedules. In addition, there are indications that commuters really appreciate the benefits of priority techniques. This is significant in a time when consideration is being given to absolute automobile restrictions.

Minor benefits have been reported after the introduction of priority techniques (reference 73). A particular example is in vehicle (especially bus) maintenance. There has been a reduction in vehicle wear and tear as manifested by fewer clutch and engine overhauls and more miles between brake repairs. In addition, there has been an increase in driver productivity due to the relative absence of congestion and delays.

summary of freeway priority techniques

Freeway bus service and automobile use provides the highest level of service on uncongested roadways. Unfortunately, most radially-oriented freeways are routinely congested during the peak hour. As a result, many cities have implemented, or are planning, freeway priority techniques for buses and carpools. These techniques can be classified into four major types: construction of exclusive rights-of-way; normal-flow reserved lanes; contra-flow reserved lanes; and preferential treatment at freeway ramps. These techniques are compared and contrasted in Figure 7, illustrating the results each change implies.

EXCLUSIVE RIGHTS-OF-WAY. The construction of exclusive rights-of-way for high occupancy vehicles offers the highest type of service. These roadways can be constructed on an existing freeway right-of-way or on its own right-of-way. In either case, these facilities assure the positive segregation of vehicle classes. Where separate rights-of-way are constructed, provision for intermediate stations and access ramps is facilitated and design standards for vehicle size, speeds, and hours of use can be tailored to each application. Abandoned rail lines may provide inexpensive rights-of-way and ready-made subgrades for these facilities. The construction of exclusive rights-of-way for high occupancy vehicles may evoke public opposition similar to that encountered during construction of new urban highways.

Preferential facilities which are located within an existing freeway right-of-way are generally located in the freeway median or along one side of the freeway. These facilities represent one stage in the development of a transportation corridor. California has plans to reserve the medians of several new freeways for possible future conversion for transit use (reference 31), a result of California Department of Transportation directives that freeway routing studies be done in the form of transportation corridor studies. Freeway priority facilities located in the median have a limiting influence on the number and size

Figure 7. Advantages and Disadvantages of Various Freeway Priority Techniques

Technique	Examples	Advantages	Disadvantages
I – Construction of Exclusive Rights-of-Way	Shirley Busway, Washington, D.C. San Bernardino Busway, Los Angeles, CA Pittsburgh, PATways (under construction)	1) Priority vehicles can operate at high speeds 2) Efficiency of existing highway not reduced 3) Operating costs are low 4) Easily enforceable	1) Major construction takes relatively long time for implementation 2) Capital costs are relatively high 3) Community opposition may develop
II – Normal-Flow Reserved Lanes	San Francisco-Oakland Bay Bridge, CA Marin County, San Francisco, CA Moanalua Freeway, Honolulu, HI	1) Involves minimum construction 2) Can be rapidly implemented	1) Weaving problems 2) Takes lanes away from peak direction 3) Enforcement may be more difficult
III – Contra-Flow Reserved Lanes	I-495, Lincoln Tunnel, NY/NJ Long Island Expressway, NY Southeast Expressway, Boston, MA Marin County, San Francisco, CA	1) Capacity in peak direction is increased 2) Capital outlay is low 3) Such lanes are rapidly implemented	1) Should not be implemented if congestion would occur in off-peak direction 2) Operating costs are relatively large 3) Bus speeds are relatively low
IV – Preferential Treatment at Freeway Ramps	I-5 Blue Streak, Seattle, WA Los Angeles Area Freeway Ramps I-35W, Minneapolis, MN	1) Low construction costs 2) Causes minimum delay to non-users 3) Problem of freeway under-utilization is avoided 4) Speed difference is diminished so safety is enhanced	1) Violations may be high 2) May not always be physically possible 3) Priority vehicles subject to delays once they are on freeways during days with accidents or incidents

Source: Reference 31 and Appendix A

San Francisco-Oakland Bay Bridge Toll Plaza

Marin County, California Contra-Flow Lane

of intermediate stations. For locations where patrons are likely to arrive by car, intermediate stations outside of medians are preferred.

NORMAL-FLOW RESERVED LANES. Establishment of normal-flow reserved lanes for high occupancy vehicles involves the traffic operations and control techniques necessary to allow only these designated vehicles to use these lanes. This procedure involves a minimum of physical construction, but the possibilities for intermediate stations is limited.

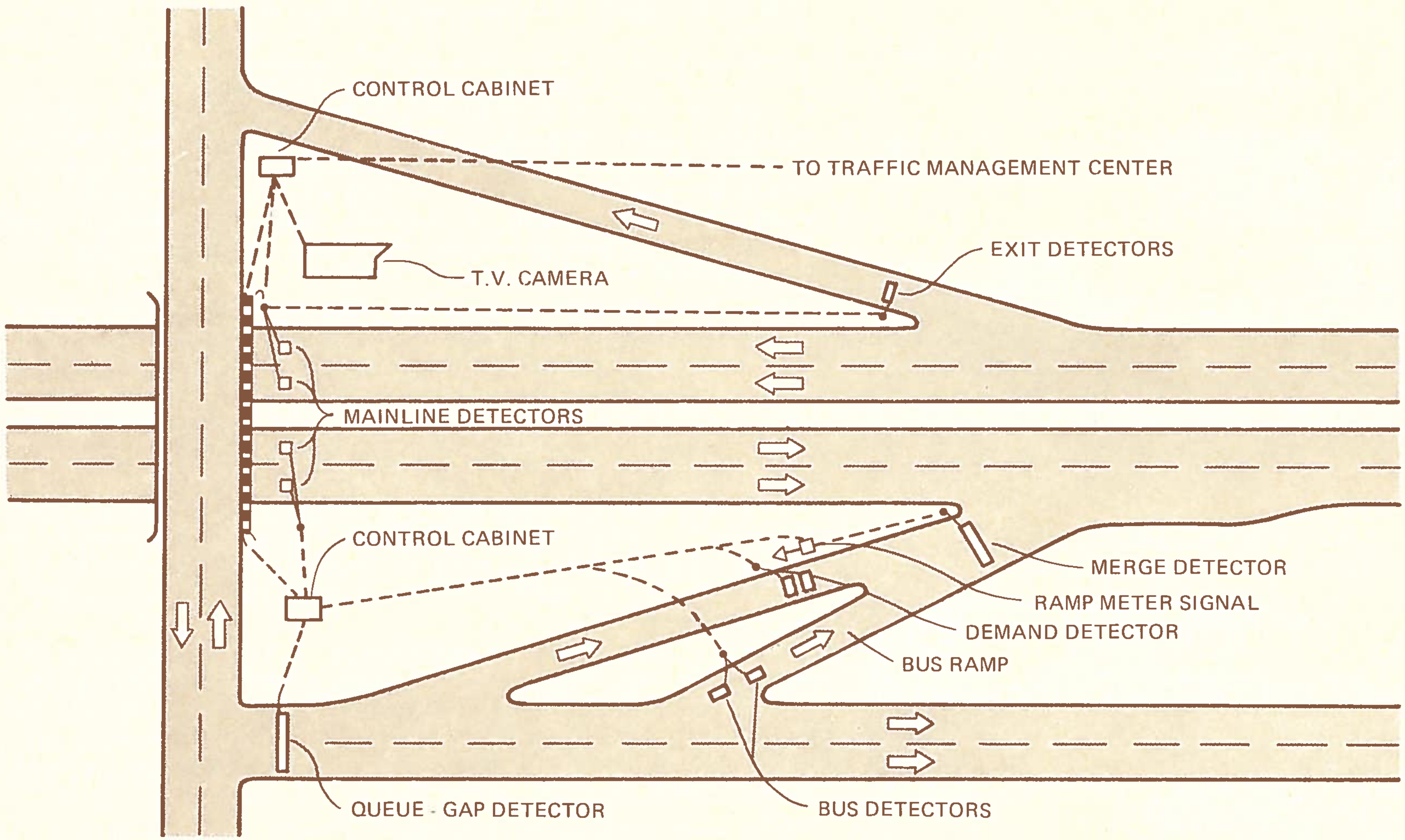
Implementation of normal-flow reserved lanes is complicated by the weaving problems associated with merging points. In addition, reservation of lanes in the normal flow of traffic can only be provided if there is a sufficient capacity reserve in the same direction or where roadways have been widened in order to provide additional lanes. Providing queue bypass lanes upstream from a traffic bottleneck involving high occupancy vehicles could result in significant benefits if these vehicles are metered back into the general traffic stream at the head of the queue. This technique has been used in California as well as other states.

CONTRA-FLOW RESERVED LANES. Implementation of contra-flow reserved lanes is an adaptation of the reversible-lane concept which has been applied for more than 30 years. These contra flow lanes use a portion of the roadway which serves under a relatively light opposing traffic flow and, therefore, will not reduce highway capacity in the peak direction. With this configuration, it is not possible to make provisions for intermediate stations or interim access by designated vehicles. Application of this technique is highly dependent on a large directional imbalance between opposing traffic movements. These requirements have resulted in existing contra-flow reserved lanes which operate only in the peak hours and only on freeways which are at least six lanes wide. In this way, provision can be made for at least two lanes in the off-peak direction.

PREFERENTIAL TREATMENT AT FREEWAY RAMPS. At many freeway locations it is possible to control vehicular volumes and thus decrease the amount of congestion. In this way, automobiles and buses move at a relatively high speed and the freeway operates at a higher level of service. This has been done at a number of locations by limiting the freeway on-ramp volumes to that which the freeway can absorb smoothly and still offer a high level of efficiency. This limiting of ramp volumes causes some vehicles to divert to other routes or to wait a few minutes at the ramp. State-of-the-art experience has shown that this method can significantly reduce overall delay in a transportation corridor.

In many locations where ramp metering is in effect, it is also possible to provide for bypass lanes so that high occupancy vehicles can avoid the delay to other vehicles. In this way, buses and carpools have convenient access to freeways which are operating at relatively high speeds. This technique has been applied at a number of freeway on-ramps in the Los Angeles area and on I-35W in Minneapolis.

Ramp Metering Technique Used on I-35W in Minneapolis



Source: Reference 95

Seattle, Washington Blue Streak Exclusive Freeway Ramp

El Monte Terminal and Fringe Parking for the San Bernardino Freeway Busway

It is also possible to provide for bypass lanes for high occupancy vehicles without ramp metering. This affords these vehicles easy access to freeways which is not open to other vehicles. This technique has been applied on I-5 in Seattle, the I-495 approach to the Lincoln Tunnel in New York City, and a number of other sites.

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complementary techniques and facilities

Several recent studies (references 54, 72 and 74) have found that the effectiveness and the attractiveness of priority techniques can be greatly enhanced by providing other complementary techniques and facilities. In order to make high occupancy vehicles such as buses and carpools an attractive alternative to the single occupant automobile, convenient access to these other modes is necessary. The proximity of these facilities to the user's origin and destination are essential.

Freeway priority techniques have benefited greatly from outlying transfer terminals such as park-n-ride and kiss-n-ride facilities located at convenient locations. These outlying transfer points serve as an interface between the neighborhood collection and line-haul functions. In areas where population densities are too low to rely on walk-in patronage, transfer facilities serve the auto and local bus distribution functions. Where local bus service is uneconomical, the automobile serves an important secondary distribution task. For this reason, parking at these outlying terminals is essential.

Most transfer facilities are simply designed and have free or low-cost parking for about 100 - 300 vehicles. The hours of operation are suited to a typical work trip. All-day service is restricted to larger facilities such as the Lincoln Tunnel (New York City) and Blue Streak (Seattle) services. The use of designated parking areas in regional shopping centers has also met with great success.

Establishment of these outlying transfer terminals, especially when supplemented by parking provisions have produced important benefits. It should be noted that lost time, due to transfer from low occupancy to high occupancy modes, must be made up by time gained from the use of a priority technique for the higher occupancy mode; that is, there must be a total trip time saving. In addition, the out-of-pocket costs must be competitive with the costs for driving and parking in the CBD.

Recent reports (references 12, 66, and 89) cite a number of other techniques which encourage the formation of carpools and vanpools. These incentives are offered by a wide variety of agencies, employers, groups, and individuals. They can be devised for carpool and vanpool riders, drivers, organizers, or combinations of all three.

State-of-the-art experience indicates that there are at least three major areas, other than travel time savings and reliability of time schedules (usually associated with priority facilities), which have been used as incentives for carpooling.

— Travel cost measures are very powerful factors. Examples are reduced parking costs for carpoolers and vanpoolers, reduced tolls at bridges and tunnels, and provision for company vehicles to be used exclusively by carpoolers on their work trip.

— Convenience measures can also be used to great advantage. Examples of this are closed-in or weather protected parking facilities for carpoolers and vanpoolers or dial-in carpool matching services.

— Intangible factors such as the image for carpoolers reflecting the importance and desirabliity of this activity can also be very important.

Washington, DC Reserved Bus Lanes

III ARTERIAL - CITY STREET PRIORITY TECHNIQUES

THIS CHAPTER DISCUSSES existing priority techniques on arterials and city streets. *Because of the difficulties that occur when defining these roadways due to the variety of identification schemes adopted by different states, divergent arterial and city street techniques have been incorporated. Wherever appropriate, differences in planning and implementation will be discussed and the distinction made.* Although the majority of priority techniques on arterials and city streets have been implemented for bus use only, some are now permitting use by other high occupancy vehicles.

magnitude of urban bus use

The majority of bus service in this country takes place within urban boundaries either on arterials or city streets. Freeway bus service is generally limited to some of the larger metropolitan areas. An improvement in bus service on downtown streets and radial arterial roads will benefit those cities which have a wide range of population densities. During the peak hours, bus routes typically converge on a handful of downtown streets where priority techniques can expedite flow. The use of buses on arterial streets leading to the downtown area and distribution within that area is greater than the use of buses on freeways. The fact that buses carry more than half the peak hour travelers on many arterial and city streets in metropolitan areas underscores the importance of bus use and the magnitude of benefits that priority techniques can have in downtown areas.

characteristics of existing arterial—city street priority techniques

Most priority techniques on arterials and city streets traditionally have been implemented in heavily congested areas, typically in the CBD, in order to alleviate spot traffic problems. These techniques are short in length, many not longer than a few blocks. The most common priority technique in the United States is the reservation of the normal-flow curb lane while European treatments are mostly contra-flow lanes on one-way streets.

PHYSICAL FEATURES. The geometric relationship between reserved lanes and other lanes of traffic have generally reflected the available street width. Most priority lanes are approximately the same width as normal traffic lanes, that is, 10-12 feet wide. Very wide streets are potential candidates for median bus lanes. Bus streets are commonly about 24 ft. wide in order to have the widest possible walkways for pedestrians. Designation of more downtown streets as bus-only streets is generally hampered by vehicular access requirements and previous traffic patterns assigned for a different point in time.

COORDINATION CONSIDERATIONS. Existing arterial and city street priority techniques largely reflect combinations of treatments. Bus use on arterials and city streets is frequently preceded by routing over freeways where similar priority techniques may have been utilized.

Differences in coordination requirements have been found between arterial and city street priority techniques. These have been primarily in the areas of traffic engineering and enforcement.

- City street priority techniques generally consist of a greater number of intersections than arterial techniques, thus resulting in more potential traffic conflicts. Traffic engineering requirements may, therefore, be more complex for city street applications.
- The problem of enforcement of city street priority techniques may also be more difficult. This is due primarily to the greater number of individual areas where violators may not feel conspicuous.

OPERATIONAL EXPERIENCES. State-of-the-art experience indicates that arterial and city street priority techniques will achieve their purposes only if there is vigorous enforcement. Violations are generally infrequent on contra-flow lanes and bus streets. However, normal-flow bus lanes are often violated by either the confused driver or the willful violator. One of the most effective methods of controlling the errant driver is an adequate program of signing and pavement marking.

Many transportation officials are reluctant to implement priority techniques on curb lanes, primarily because many CBD land uses make easy access a requirement. In addition many older buildings have provisions for shipping and receiving only through front entrances, thus precluding implementation of curb bus lanes and bus streets. Some transit officials believe that an effective alternative to reserved curb lanes is strict enforcement of curb parking regulations, especially during peak hours. In locations where curb lane parking takes up a needed traffic lane, restriction of parking in that lane may be a good alternative.

PLANNING CRITERIA. With the current state-of-the-art it is often difficult to assess the effects of arterial-city street priority techniques on bus patronage. In general, bus ridership has declined in recent years in most American cities. The effects of operational improvements on patronage in specific traffic congested spots may be hidden in overall bus ridership statistics.

The costs of a majority of the city street priority techniques are largely absorbed in the overall traffic engineering and improvement budget. In most cases it is so small and the changes were made so long ago that it is hard to identify. Operating costs in most cases are also nominal. This is particularly true of techniques which consist of only signing and striping.

Benefits to bus patrons and carpoolers using priority facilities have been reported in a number of cities:

- New York City's Fifth and Madison Avenues bus zones reduced midday travel times by nearly a half from 11 minutes to 6.5 minutes.
- Chicago's Washington St. bus lane has saved the bus operator one bus run during the peak period, corresponding to an annual saving of $25,000.
- Louisville's bus pre-emption scheme has decreased bus travel time by 10-20 percent.
- Miami's South Dixie Highway reserved carpool lane is saving users six minutes.
- San Juan's contra-flow bus lanes have cut transit travel time for commuters by 35 percent.

summary of arterial—city street priority techniques

The primary motivation for the establishment of priority techniques in downtown areas is to provide preferential treatment for high occupancy vehicles such as buses, carpools, and vanpools by physically separating these vehicles from single occupant vehicles. In this way, it is hoped that there will be sufficient incentive to increase vehicle occupancy so that the total person-capacity will increase. There are a number of ways to achieve this

Denver, CO, Normal-Flow Reserved Curb Bus Lane

Seattle, Washington Contra-Flow Reserved Bus Lane

separation of vehicles. The most common method is to establish reserved lanes for exclusive use of high occupancy vehicles (bus-only or buses and carpools) or shared with taxis and vehicles turning right. These lanes can be located along the curb, either normal-flow or contra-flow, or in the median strip of a roadway. In order to achieve a lane reservation, traffic engineering measures in the form of curb parking prohibitions and/or one way street designations are required. The five most common priority techniques on arterials and city streets are: normal-flow reserved lanes; median strip reserved lanes; contra-flow reserved lanes; bus streets; and traffic signal pre-emption.

NORMAL-FLOW RESERVED LANES. The most common type of priority technique on arterials and city streets is a reserved curb lane in the normal flow of traffic. Most of the major cities in the United States, Canada, and Europe have provisions for this type of a facility. Due to the bi-modal distribution of daily traffic, these reserved lanes are generally in effect for only peak periods, although some are in effect continuously. The costs and implementation times are low, typically involving only pavement marking and street signs. The only significant traffic engineering problem is that vehicles turning right conflict with buses so that right turns may need to be restricted or prohibited.

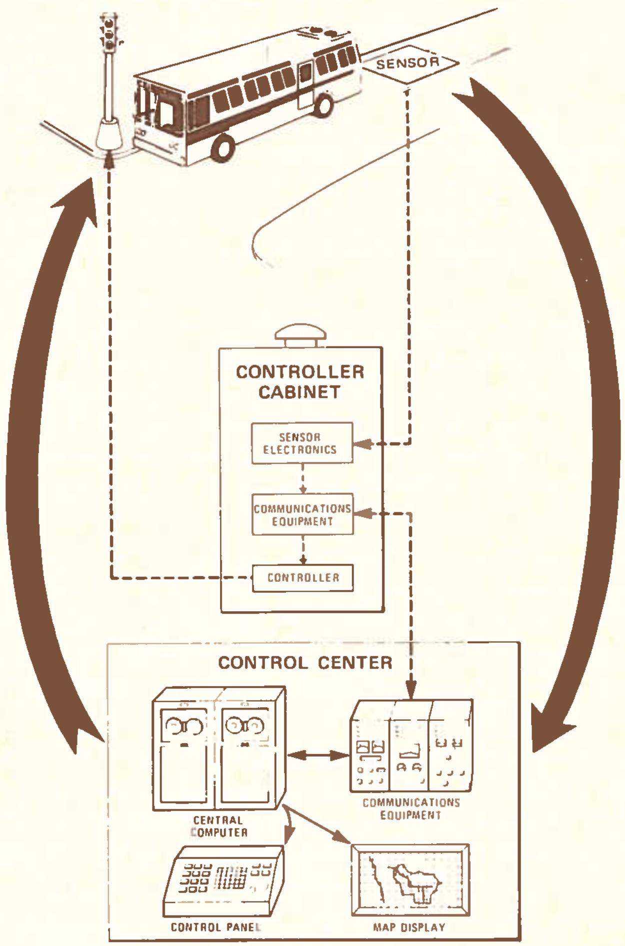
Implementation of reserved lanes should be limited to areas where there is a genuine need, otherwise violations increase and enforcement becomes difficult. In addition, there will be only marginal benefits to average bus speeds if priority techniques are implemented where there is no real need for them. A recent study shows that a decrease in the number of bus stops and traffic pre-emption techniques may be more beneficial in expediting bus flows (reference 64).

MEDIAN STRIP RESERVED LANES. U.S. cities which have had a history of street car operations often convert these facilities to reserved median lanes for high occupancy vehicles. The locations of these facilities in the middle of a roadway results in a removal of traffic conflicts in the curb lanes and for traffic making right turns. Establishment of median reserved lanes also requires wide streets and provision for passenger shelter in the median. However, bus stop placement requires passengers to cross busy streets in order to reach them. The alleviation of the right turn traffic problem is replaced by the control or prohibition of left turns in order to minimize the interference from users of the median lane priority facility.

CONTRA-FLOW RESERVED LANES. Implementation of contra-flow reserved lanes as a means of providing preferential treatment for high occupancy vehicles is growing in number. In the United States, contra-flow lanes can be found in Chicago, Madison, Miami, Honolulu, Harrisburg, and Seattle. They may be found in at least 10 British cities and in major cities of France, Italy, Germany, and Sweden. Implementation of contra-flow lanes is typically accomplished by reserving one lane of a multilane, one-way arterial

Washington, DC Bus Street

Example of Bus Pre-emption of Traffic Signal



for high occupancy vehicles traveling in the opposite direction. The contra-flow technique is largely self-enforcing since the violators are conspicuous by their presence. These lanes can play an important part in downtown circulation.

One of the longest contra-flow projects is in the heavily congested city of San Juan, Puerto Rico, along two parallel one-way arterials, each ten miles in length. Three lanes of each arterial are for regular traffic while the fourth is permanently reserved for buses. Pavement striping and marking are used to alert motorists traveling in the normal flow of traffic. This project has resulted in a 35% reduction in transit time for bus commuters along this corridor while maintaining an excellent safety record.

BUS STREETS. A higher level of service can be achieved by the reservation of all the lanes of a city street for only buses, commonly known as *bus streets*. Pedestrian access is greatly facilitated. Implementation is difficult because this type of preferential treatment must be limited to streets where access to local business by regular traffic is not required. Another potential problem area is created when parking garages are present in a candidate location.

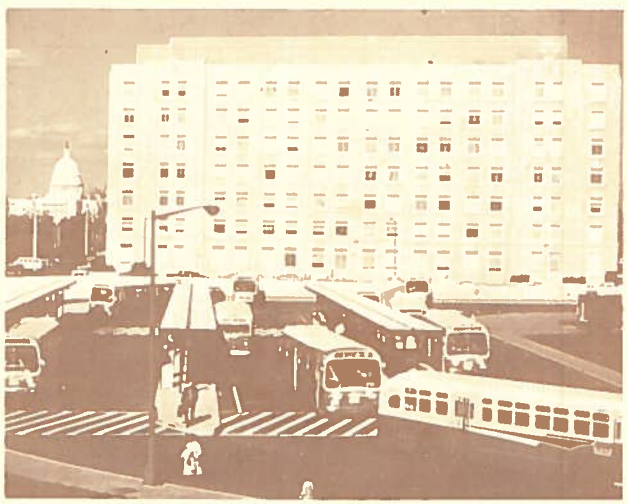
Bus streets can make a significant contribution to downtown transit and development. Two examples are Nicollet Mall in Minneapolis and 63rd and Halsted Streets in Chicago. In Washington, D.C. a one block section of a downtown street is reserved for buses and serves as a terminal area for several major bus routes. There are a number of bus streets in various European cities.

When a single bus street is expanded to include a series of streets or major portions of a downtown area, it is generally referred to as a traffic-restricted zone. Widespread implementation of these traffic restricted zones has not taken place in the United States, although they exist in several major European cities.

TRAFFIC SIGNAL PRE-EMPTION. Time delays to buses due to traffic signals can be substantially reduced by adjustment to these signals, since they can account for 10%-20% of overall trip time (reference 51). The provision for priority traffic signal pre-emption for buses is predominatly found in European cities, although they are becoming more popular in the United States. Their aim is to improve bus travel times by extending the green time on fixed or variable time signal cycles (commonly called a priority system) or by advancing to green from any part of the cycle (pre-emption system), or combinations of both types. Detection of the bus can be achieved by signal detectors and an optical emitter on the bus, radio antennae and a transmitter in the bus, or loop detectors in the street and transponders in the bus.

The most ambitious project to date is in Washington, D.C. where 111 downtown intersections are controlled by a computerized traffic system. Part of the total traffic control system is the implementation of a bus priority system enabling some 500 buses to exercise traffic control on a cycle-to-cycle basis. These buses are equipped with transmitters

Washington, DC Downtown Bus Terminal



which are used for detection purposes at selected intersections. When a bus is detected, the traffic control system makes a decision regarding a possible extension or advancement of green time. This decision is based on:

- Arrival time of the bus
- Vehicular queues in the vicinity
- Passenger volumes

The provision for bus priority is a part of the overall goal of the Washington, D.C. project, which is to develop and evaluate a variety of traffic control strategies.

Traffic signal pre-emption is also being used in Louisville and Miami. Their systems have been quite successful in reducing bus travel times. This technique has been used in the past in a number of cities to provide pre-emption for fire and other emergency vehicles.

complementary techniques and facilities

A variety of other techniques can also be used to provide priority for high occupancy vehicles. These techniques will result in varying levels of effectiveness and some may require vigorous enforcement.

One such technique involves restricting vehicular parking, standing, or stopping on established transit routes in the CBD. These restrictions eliminate maneuvering by transit vehicles around parked cars, vehicles loading or unloading passengers, or trucks making deliveries. Peak hour restrictions are typically put into effect at least a half hour in advance of the peak period so that enforcement can take place to clear these lanes. The success of these lane restriction techniques is highly dependent on the enforcement and control of these lanes.

A number of traffic and transit operational improvements can also be employed to increase speeds of high occupancy vehicles. These can include the revision of bus stops to shift near side stops to far side locations, lengthening bus stops so that buses can pull in all the way, and making small changes in traffic signal timing to accommodate buses. The utilization of special turn permits, allowing buses and carpools to make left turns where other vehicles are not allowed in the CBD, can also minimize travel times.

Bus priority programs which expedite the movement of buses into the CBD must also recognize the need to distribute the riders throughout the downtown area. This distribution need can be met in two ways: by routing the line-haul buses throughout the CBD streets; or by directing the line-haul buses to a central terminal area, and accomplishing the distribution from a terminal by a transfer to another mode.

It must be noted that total travel time for the transit rider includes the CBD distribution time. In most small cities the CBD is sufficiently compact and free of congestion that the line-haul bus can bring the rider close to their destination in a reasonable time. But in the largest cities, the spatial structure of the CBD and high traffic volumes usually make separate distribution facilities more efficient. However, the time spent in transferring to another vehicle must be considered.

Studies have shown that non-terminal use of buses is the most efficient in almost all cities. However, in the larger cities, the volume of transit buses and riders may be great enough to require off-street loading. In addition, inter-city buses usually require terminal facilities because of the time needed to load baggage and parcels and because of layover time built into their schedules.

The bus terminals in the largest cities have a number of common features. Many have direct or convenient connection to expressways. They sometimes have contiguous local distribution transportation facilities. They are usually removed from the areas of highest land values, except where air rights can reduce land costs. However, they are generally close enough to the CBD to permit walking to most major employment concentrations (including a transfer).

Further, city transit and interurban bus docks are separated since they have different requirements. For example, transit bus lines use linear docks to maximize capacity because, on the average, each berth handles 8 to 10 buses per hour and loading and unloading areas are frequency separated. Intercity buses on the other hand use sawtooth docks with single berths to simplify baggage loading and each berth handles one to two buses per hour.

Terminal patronage relates to CBD employment density and to the tributary areas served. In New York City, the Port Authority Bus Terminal serves more than 100,000 daily riders during the peak period; the George Washington Bridge Terminal 20,000; the San Francisco Transbay Terminal, 44,000; and the Cincinnati Dixie Terminal, 5,000.

Contra-Flow Bus Lane on I-495 Approach to Lincoln Tunnel

IV EVALUATIVE OVERVIEW OF PRIORITY TECHNIQUES

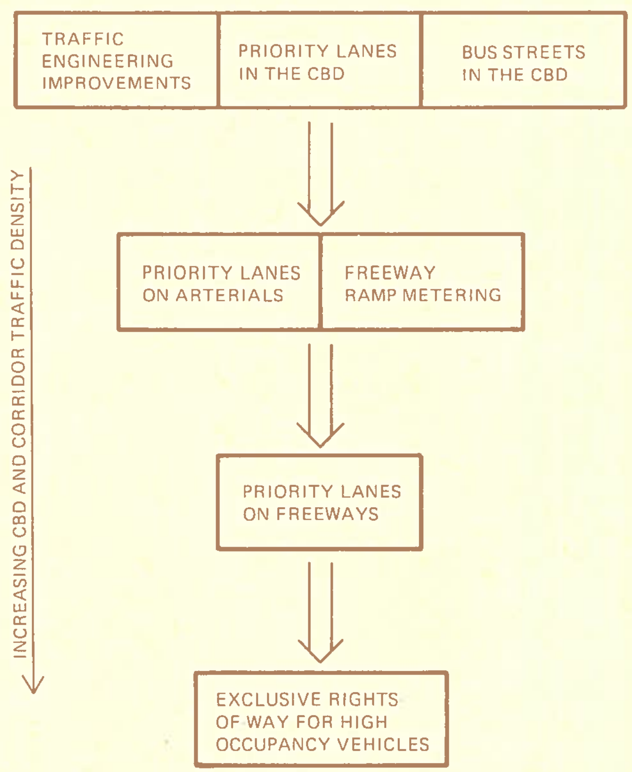
THE REQUIREMENTS, IMPACTS, AND COSTS of alternative transportation strategies demand in-depth analyses if the planning and implementation of priority techniques are to be successfully carried out. The unique transportation needs and attitudes of practically every urban profile makes this an absolute necessity. Therefore, this chapter discusses guidelines, decision making criteria, impacts, and future research relative to such implementation as identified by the state-of-the-art survey.

implementation guidelines

VOLUME REQUIREMENTS. Emphasis of priority techniques should be placed on operational changes rather than on physical construction whenever possible. This should be done because a review of the state-of-the-art indicates it is a more successful procedure than if the physical considerations are developed first. A hierarchy of transportation improvements and priority techniques is illustrated in Figure 8.

Several "rules of thumb" were used in the past to justify the implementation of priority techniques. One such rule was that when the number of people carried in a high occupancy vehicle lane exceeds the number of passengers carried in a normal traffic lane, then there is ample justification for reserving one lane for buses and carpools. However, this rule did not differentiate among the various techniques which are available, such as exclusive rights-of-way, normal flow reserved lanes, contra-flow reserved lanes, and

Figure 8. Hierarchy of Priority Techniques



preferential treatment at on-ramps. The traffic volume criteria for implementing any one of these techniques should not, in general, be the same for all of them. Existing criteria should be altered to more accurately reflect the role of high occupancy vehicles in meeting the peak-hour demand in transportation corridors. In addition, these criteria should complement energy and environmental objectives to: reduce congestion, reduce vehicle emissions, and reduce energy requirements.

A set of generalized applicability criteria, or warrants, for the implementation of various priority techniques has recently been developed on the basis of a review of priority techniques for high occupancy vehicles (reference 52). These criteria are presented only as an illustration of the types of relationships to be further developed by a more complete study. These warrants, presented in Figure 9, are expressed in peak hour buses and passengers. In addition, a number of related planning and transportation factors are identified. The authors suggest that a "bivariate" approach be taken in the application of these warrants. Transportation demands for a future design year as well as the base-year conditions should be used as the bases for implementation decisions, in the following manner:

- Warrants should apply to design year conditions.
- Seventy-five percent of the warrants should apply to the current, or base year, conditions.

This procedure will safeguard against unrealistic demand requirements while allowing for a certain degree of flexibility in meeting future transportation needs.

RESTRICTIONS ON USE. Prior to the implementation of a priority technique, decisions must be made on a project-by-project basis as to what constitutes a high occupancy vehicle. Should the facility be restricted to only buses, or should carpools, vanpools, and perhaps even taxicabs, be allowed to benefit from its use? If carpools are allowed, what is the minimum occupancy to qualify for this status?

It should be kept in mind that buses and carpools are two separate types of transportation. Travelers perceive each of these types to have different levels of comfort, convenience, reliability, cost, speed, safety, and availability. The characteristics of each mode will also affect the type of technique which can be offered. To some extent, buses and carpools are competitive modes. Allowing carpools to use a priority facility may, as a side effect, reduce the number of bus riders. Conversely, provisions for bus only priority techniques may discourage the use of carpools.

Early thinking on this subject was to restrict preferential techniques to only buses. However, it was soon realized that, except for cases where lane capacity was near saturation from high traffic volumes of buses, bus-only techniques could be very inefficient and could actually increase overall person-delay (reference 63). This realization led to the

Figure 9. Example of Applicability Criteria for Various Priority Techniques

Type of treatment (1)	Local bus service (2)	Limited express bus service (3)	Planning period, in years (4)	Ranges in peak hour one-way bus volumes (5)	Ranges in peak hour one-way bus passenger volumes (6)	Related land use and transportation factors (7)
General Applicability			Design Year Conditions			
(a) Freeway Related						
Busways on speical right-of-way	X	X	10-20	40-60	1,600-2,400	Urban population—750,000 CBD employment—50,000 20,000,000 sq ft (2,000,000m²) floor space
Busways within freeway right-of-way		X	10-20	40-60	1,600-2,400	Freeways in corridor congested in peak hour
Busways on railroad right-of-way	X	X	5-10	40-60	1,600-2,400	Not well located in relation to service area, stations required
Freeway bus lanes normal-flow		X	5	60-90	2,400-3,600	Applicable upstream from lane drop, bus passenger time saving should exceed other road user delays
Freeway bus lanes contra-flow		X	5	40-60	1,600-2,400	Freeways six or more lanes, where imbalance in traffic volumes permits level of service D in off-peak travel directions
Bus lane bypass at toll plaza		X	5	20-30	800-1,200	Adequate reservoir on approach to toll station
Exclusive bus access ramp to nonreserved freeway or arterial lane	X	X	5	10-15	400-600	
Bus bypass lane at metered freeway ramp		X	5	10-15	400-600	Alternate surface route available for metered traffic, express buses leave freeways to make intermediate stops
Bus stops along freeways		X	5	5-10	50-100 boarding or alighting passengers in peak hour	Generally provide at surface level in conjunction with metered ramp
(b) Arterial Related						
Bus streets	X	X	5-10	20-30	800-1,200	Commercially oriented frontage
CBD curb bus lanes—main street	X		5	20-30	800-1,200	Commercially oriented frontage
Curb bus lanes	X		5	30-40	1,200-1,600	At least two lanes available for other traffic in same direction
Median bus lanes	X	X	5	60-90	2,400-3,600	At least two lanes available for other traffic in same direction, ability to separate vehicular turn conflicts from buses
Contra-flow bus lanes short segments	X		5	20-30	800-1,200	
Contra-flow bus lanes extended	X	X	5	40-60	1,000-2,400	At least two lanes available for other traffic in opposite direction. Signal spacing greater than 500 ft (150 m) intervals
Bus turnouts	X		5	10-15	400-600	Points of major passenger loadings on streets with more than 500 peak-hour autos using curb lane
Bus pre-emption of traffic signals	X		1-5	10-15	400-600	Wherever not constrained by pedestrian clearance or signal network constraints
Special bus signals and bus actuated signal phases	X		1-5	5-10	200-400	At access points to bus lanes, busways, or terminals or where special bus turning movements must be accommodated
Special bus turn provisions	X		1-5	5-10	200-400	Wherever vehicular turn prohibitions are located along bus routes

Source: Adapted from Reference 52

Shirley Highway, Washington, DC, Temporary Busway During Construction

concept of allowing carpools to fill the gaps between buses. There is a growing awareness that priority techniques for carpools are an efficient method to move people. However, implementation may be more difficult because the traffic volume of automobiles is much greater than buses. In addition, safety problems may emerge because automobile drivers are generally considered not as skillful as professional bus drivers.

CHARACTERISTICS OF WELL-PLANNED PRIORITY TECHNIQUES. Priority techniques generally reflect two basic operating strategies, as illustrated in Figure 10.

One such strategy involves the development of a new facility through a high travel intensity transportation corridor. Examples of this type of technique are the San Bernardino Freeway Busway and the Shirley Highway priority lanes for buses and carpools. Arterial street priority lanes, found in a number of cities, also reflect this basic strategy. Although the costs for this type of facility can be substantial, it generally produces a strong sense of identity for high occupancy vehicles.

The other basic strategy is the development of a priority technique circumventing a bottleneck area. Many reserved lanes and special bypass ramps reflect this concept. Examples are the contra-flow lanes on approaches to the Midtown and Lincoln Tunnels in New York and the special reversible bus ramp in Seattle. This type of technique usually provides for a relatively high level of efficiency while requiring fairly low capital investments.

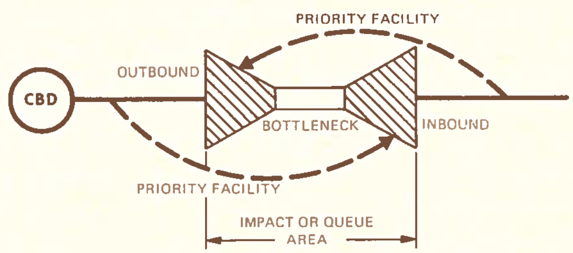
Another way in which many priority techniques can be differentiated is between those which add a lane to the existing highway capacity and those which pre-empt an existing lane for exclusive use by high occupancy vehicles (see Figure 11). A number of freeway priority techniques apply the former while arterial and city street priority techniques will often use the latter. Current experience indicates that it is generally difficult to remove a lane from the heavy flow direction of travel on freeways because of anticipated public resentment.

Priority techniques which have served genuine, demonstrated needs have generally been the most successful in terms of providing transportation service. Implementation of priority techniques where they are not warranted will encourage violations and eventually become unenforceable. Travel time savings during the peak period for users of successful techniques have been in the range of 5 to 30 minutes, which is a substantial percentage of the total work trip. The costs of implementation and operation were relatively low in comparison to more capital-intensive transportation alternatives. Major benefits to users of arterial and city street priority techniques, as yet, have not materialized. This is primarily due to the fact that most of these treatments have been very localized in physical length and very sensitive to enforcement policies.

The principal aim of most priority techniques has been to attract more bus riders and

Figure 10. Operational Strategies for Priority Techniques

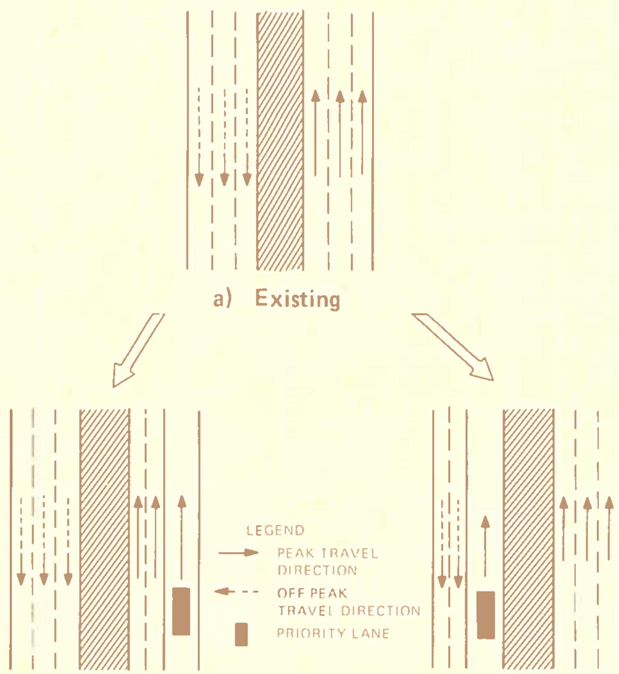
a) Priority Facility Through High Travel Density Corridor



b) Priority Facility Bypassing Traffic Congested Area

Source: Reference 51

Figure 11. Priority Lane Options



Source: Reference 51

to encourage carpooling and vanpooling. Complementing the implementation of many of the successful priority techniques has been a comprehensive marketing and public relations campaign. The primary purpose of these activities is to apprise the public about the advantages which can be gained by using buses and forming carpools.

A host of techniques have been used in the publicity effort. Among these are flyers mailed out or handed out at key locations, special displays at shopping areas, news coverage, public service announcements, and favorable radio and television editorials. In addition, follow-up questionnaires have been distributed and analyzed to determine public attitudes and future possibilities.

decision-making criteria

The decision-making process to implement a priority technique is a complex process. It includes the participation of a number of individuals and organizations, as illustrated in Figure 12. A number of professional disciplines are represented in these groups e.g., traffic engineers, transportation planners, environmentalists. It is the interplay between these groups which will ultimately result in any implementation decision.

INSTITUTIONAL CONSIDERATIONS. A review of the background of a number of priority techniques reveals the existence of several professional groups or agencies that played key roles in the planning and implementation of these techniques.

The state or local organization that controls highway traffic operations, and is responsible for traffic engineering on these roadways, generally plays the critical role in the implementation of a priority technique. Even though the cooperation of this agency is essential, its support has sometimes been the most difficult to obtain. Cautious elements will sometimes oppose the proponents of priority techniques, even if the original idea was conceived by individuals within the agency. Resistance to implementation of these techniques generally results from a natural reluctance to give preferential treatment to any one class of vehicles over another (be it bus-only or buses and carpools). This reluctance stems from the view that emphasis should be placed on the maximum movement of vehicles, a goal which the aforementioned individuals believe sometimes conflicts with maximizing total person-throughput (a goal generally associated with priority techniques). In addition, there exists a genuine professional skepticism about the safety of operational plans for some of these techniques, especially contra-flow techniques.

Another key agency involved in the implementation decision of priority techniques is the one charged with law enforcement. This can be at the local, county or state level. Too often traffic engineers and transportation planners design and subsequently present to the public concepts such as priority techniques without the significant input which can be obtained from law enforcement personnel. Once the traffic control techniques asso-

Figure 12. Principal Groups Involved in the Transportation Decision Making Process

Source: *Adapted from Reference 24*

ciated with priority techniques are in place, it is this agency's responsibility to enforce a control program to keep violators out of exclusive lanes. This responsibility will often entail the movement of equipment and personnel, thus requiring a sufficient lead time for the planning and budgeting of these moves. In addition, law enforcement personnel are very concerned about the safety of priority techniques. It is felt that safety must be an important consideration in the development of concepts for moving vehicles and people. Therefore, many law enforcement agencies advocate that they be included from the very beginning of the planning phase through the implementation and evaluation phases of projects involving priority techniques (reference 80).

Another essential agency involved in the implementation of priority techniques is the Metropolitan Planning Organization which is responsible for transportation planning functions. This agency is responsible for coordinating the transportation planning throughout affected metropolitan areas. It also plays an important role whenever state and/or federal funding is involved. Under those circumstances, the function of the planning agency is to prepare the appropriate applications and to administer the related funds.

The fourth group which has been identified as important in an implementation decision are the transit operators. Operators are generally more than willing to use priority techniques, since these techniques offer a significant advantage to their operation. In addition, the implementation of most priority techniques corresponded very well with the natural routing and scheduling of buses. As has been mentioned previously, transit operators report that utilization of priority techniques has given them at least two additional benefits. These are in the form of improved driver and vehicle productivity and reduced vehicle maintenance costs.

A review of the institutional background of various priority projects reveals another interesting relationship. Whenever the planning and implementation of priority projects requires the involvement of a number of agencies and authorities, especially in the case of autonomous jurisdictions or between neighboring states, progress can be slow and the ultimate implementation decisions may reflect political trade-offs and concessions. However, when a single authority is empowered to make decisions concerning traffic operations and there is a positive concensus, the implementation of priority techniques can take place in less time with fewer political concessions.

A single authority and shared authority approach is illustrated in the case of the Long Island Expressway and the I-495 (Lincoln Tunnel) priority projects, respectively. These projects are approximately the same length and both involve a contra-flow bus-only lane in the morning peak period on major urban highways leading to tunnels in the New York City metropolitan area. Despite their physical similarities, the institutional environment surrounding the implementation of these priority projects, as discussed below, was different.

The Long Island Expressway contra-flow bus lane is an example of the single authority project because it is entirely within one jurisdiction. The agency which controls operations on highway facilities is the New York City Transportation Administration. Within this agency, the Department of Traffic is responsible for managing traffic operations on the city's street system and the Department of Highways is responsible for street maintenance. These component divisions of the New York City Transportation Administration all worked together so that when the decision was made to establish the contra-flow bus lane, decisions on subsequent matters came from within the one agency.

Since Federal funding was not involved and the entire project is located within city limits, coordination with other jurisdictions or states was not necessary. The planning for the project was done by the New York City Transportation Administration and coordinated with New York State and the Federal Highway Administration. When informed about the availability of this facility, bus operators were eager to take advantage of the time saving, although some prior negotiations with operators was necessary to revise franchised routes.

An example of the shared authority project is the contra-flow bus lane on the I-495 approach to the Lincoln Tunnel. The four principal agencies involved in the planning, implementation, and the operation of this project are:

- Port of New York Authority (now the Port Authority of New York and New Jersey)
- Tri-State Transportation Commission (now the Tri-State Regional Planning Commission)
- New Jersey Department of Transportation
- New Jersey Turnpike Authority

Four authorities were involved in the implementation of this project because the highway crosses a number of jurisdictional and state lines.

Although the applied I-495 priority technique was successful once the project was underway, it was one of the most difficult to implement (reference 73). The beginning of the project can be traced to 1963 when several studies reported on the feasibility of various priority schemes. Field tests were conducted in 1964 and 1965 resulting in a January 1967 report strongly recommending the bus priority scheme. At this point, institutional problems arose in the form of opposition to the bus priority plan by one of the key agencies, the New Jersey Department of Transportation. Their opposition was based on their skepticism about the safety of the plan. In addition, the financing for the implementation and operation of the facility had not been secured.

Three years passed and in early 1970 a new Commissioner of the New Jersey Department of Transportation was named. He requested that a special study be done, entirely within his agency, on the feasibility of the bus lane concept. This in-house report was favorable to the priority technique and shortly thereafter the New Jersey Department of Transportation gave its approval. Subsequent to this approval, Federal funding was approved.

Two committees were responsible for the supervision of the project, the technical committee and the policy committee. The technical committee, composed of key technical personnel from each of the agencies, was charged with establishing the operating procedures and safety rules for the project. The work of the technical committee was reviewed and supervised by a policy committee composed of top level agency representatives. The function of the policy committee was to negotiate contracts, review material submitted to Tri-State and the Federal Department of Transportation and review operating recommendations submitted by the technical committee.

The responsibilities for planning and administration of the project were divided among the four agencies listed above. The grant by the U.S. Department of Transportation for the general administration of the project was made to Tri-State. Planning and day-to-day operation of the project (including both the enforcement and maintenance) was delegated by Tri-State to the Port Authority. The New Jersey Department of Transportation reimbursed the Port Authority for 2/3 of the operating costs. The New Jersey Turnpike Authority was responsible for building the access road and maintaining the roadway within its jurisdiction.

The complexity of the Lincoln Tunnel project demonstrates that to induce the needed changes in modal preference to higher occupancy modes, a well thought-out plan and a large amount of interagency cooperation is required. While the original idea and catalyst for some techniques can sometimes be traced back to an individual or a small group, implementation of many of the major projects requires the involvement of several public agencies at all levels of government and the private bus operator. Unless the participants in these various organizations understand the interactive nature of their roles, the chances for a successful priority technique will be greatly diminished.

LEGAL CONSIDERATIONS. To date, only one court case has questioned the legality of establishing priority techniques. The Wisconsin State Supreme Court ruled that without specific state-enabling legislation, cities could not discriminate in the use of a public street (reference 54). This case stemmed from a serious pedestrian accident which occurred shortly after the establishment of a contra-flow bus lane in Madison, Wisconsin. As a result, the city changed the designation of the facility from a "bus-only" lane to a "limited-use" lane. Signs and markings now dictate that all vehicles using the lane must enter it at the beginning and traverse its entire length to the terminus.

State-of-the-art experience indicates that for local authorities to establish, administer, and maintain priority techniques, appropriate state government authorities must pass enabling legislation which would then be subject to judicial review. Traffic management procedures such as the establishment of priority techniques for one class (high occupancy) of vehicles should show that these techniques are in the public interest.

The question of liability, especially for contra-flow bus lanes, is an area of significant concern. In general, a determination of liability responsibility for injuries and property damage due to accidents on the priority facility is agreed upon by highway authorities and transit operators prior to the implementation of any priority techniques (reference 57). Only one of the contra-flow bus lane operators, the Port Authority of New York and New Jersey, has increased its liability insurance. The additional cost for this coverage is included as an eligible item in the operating agreement for this project.

In another example, the liability for the daily operation, signing, and delineation devices for the Marin County contra-flow bus lane rests with the Golden Gate Bridge, Highway, and Transportation District, although the California Department of Transportation is still liable for the highway design. Experience has shown that it is desirable to settle questions of liability before the implementation of priority techniques.

FUNDING CONSIDERATIONS. Congress has sought to overcome the arbitrary divisions in responsibility between state and local governments and their respective agencies. Federal laws stress "coordination" and "cooperation." Recent changes in national policy have become much more specific as to how coordination and cooperation are to be achieved.

Local groups must take the initiative in devising feasible transit-oriented plans and in developing these plans for funding. The local group seeking to implement a public transportation-related idea should begin with the Metropolitan Planning Organization. The State Departments of Transportation, or Departments of Highways, which administer highway funds, must also be contacted. The FHWA and UMTA Regional Offices can also assist. (See Appendix G)

The percentage of the budget of a transportation project funded by the Department varies with the project type and with the cost element within the project. Figure 13 sets forth the funding split for the most commonly encountered project categories. The U.S. Department of Transportation (DOT) provides the Federal funding for a large number of priority projects, the two agencies within the Department which provide this funding assistance are the Federal Highway Administration and the Urban Mass Transportation Administration.

Figure 13. Federal-State Matching Ratios for Various Transportation Categories

PROGRAM	FEDERAL-STATE RATIO
FHWA	
Interstate System	90:10
Most other Systems	70:30
High hazard location & roadside obstacle removal	90:10
Bridge replacement	75:25
UMTA	
Technical Studies	80:20
Capital facilities	80:20
Service & Methods Demonstration	Up to 100 Federal
Operating subsidies	50:50

Figure 14. Effect of Bus Use on Auto Traffic[a]

Condition	PM Peak-Hour Outbound Movement[b]	Maximum Accumulation[c]
1. Existing condition:		
People	54,000	65,000
By transit	15,000	18,000
By car	39,000	47,000
Cars (1.5 persons/car)	26,000	31,300
2. 50 percent increase in transit use:		
People	54,000	65,000
By transit	22,500	27,000
By car	31,500	38,000
Cars (1.5 persons/car)	21,000	25,300
Percent change in cars	−19	−19
3. 50 percent decrease in transit use:		
People	54,000	65,000
By transit	7,500	9,000
By car	46,500	56,000
Cars	31,000	37,300
Percent change in cars	+19	+19

[a]Arterial street lanes (500 cars per lane per hour): 50 percent increase in transit, +10 lanes; 50 percent decrease in transit, −10 lanes. Parking space change; 50 percent increase in transit, +6,000 spaces; 50 percent decrease in transit, −6,000 spaces.

[b]Hourly rate based on highest peak half hour.

[c]About noon.

Source: Reference 54

Federal Highway Administration (FHWA) Programs: Many types of projects related to priority techniques and public transportation are supported by present legislation and by the administrative regulations and guidelines of the FHWA, (see reference 84).

Few restrictions exist when using Federal-Aid highway projects to develop urban highway public transportation since urban highway public transportation-related projects are viewed as highway projects. Exclusive and/or preferential lanes for high occupancy vehicles, highway traffic control systems, bus loading installations, and both fringe and corridor parking facilities all fall within the broad highway project definition.

Urban Mass Transportation (UMTA) Programs: The major funded programs of the Urban Mass Transportation Administration are all potential sources of support for priority project planning and implementation efforts.

– Technical Studies grants are made to provide funds for planning efforts related to bus priority projects and other public transportation efforts. These studies may include engineering, management, economic, financial, and operational tasks.

– Capital Facilities grants are made to provide capital funds for the initiation or improvement of bus priority and other public transportation projects. Capital grant funds may be used for acquisition, construction, reconstruction, and/or improvement of facilities, buses and other rolling stock, and other real and personal property.

– Service & Methods Demonstration grants are made to develop, demonstrate, and evaluate innovative methods, using current generation equipment, to provide significant improvement in transit services and to disseminate information concerning the results.

– Transit Management assistance is available from the Office of Transit Management, both through grants and contracts for management improvement studies as well as technical assistance.

– Operating Subsidy grants are available under the National Mass Transportation Act of 1974, under guidelines available from UMTA.

impacts

HIGHWAY CAPACITY. In several locations where priority techniques have been implemented, peak-hour bus and carpool ridership has increased without an accompanying increase in total vehicular travel. This is largely due to the fact that a saturation of existing road networks has discouraged use by additional single-occupant vehicles. On the other hand, bus ridership is rarely at capacity and there is generally ample reserve, subject to the availability of buses. Implementation of priority techniques for high occupancy vehicles is an effective means for achieving capacity reserves on urban high-

Figure 15. Comparative Fuel Consumption Rates of Various Forms of Commuter Transportation

MODE	PASSENGER-MILES/GALLON
Walk-in/Rapid Rail (NYC)	109.0
Local Bus (3 million pop.)	93.1
Small Auto (4 occupants)	71.8
Van Pool	70.0
Walk-in/CTA Rail (Chicago)	70.0
Small Auto (3 occupants)	55.1
Local Bus (300,000 pop.)	46.6
Standard Auto (5 occupants)	44.9
Park-Ride/Raid Rapid (NYC)	41.7
Dial-a-Bus/Express Bus	39.8
Park-Ride/BART (San Francisco)	38.8
Small Auto (2 occupants)	37.8
Standard Auto (4 occupants)	36.7
Park-Ride/CTA Rail (Chicago)	35.6
Park-Ride/Express Bus	34.6
Park-Ride/Commuter Rail	30.6
Standard Auto (3 occupants)	28.2
Kiss-Ride/Rapid Rail (NYC)	24.6
Kiss-Ride/BART (San Francisco)	23.6
Kiss-Ride/CTA Rail (Chicago)	22.3
Kiss-Ride/Commuter Rail	20.3
Kiss-Ride/Express Bus	21.9
Small Auto (1 occupant)	19.3
Standard Auto (2 occupants)	19.3
Standard Auto (1 occupant)	9.9

Source: Reference 10

ways (see Figure 14).

TRANSIT COSTS. Changes in bus routing patterns and the associated costs of increased bus service must be evaluated during the planning stage for establishment of priority techniques. The labor costs involved in increased bus service may very well increase the total costs of bus operations, although unit costs may be lower. The rationalization of priority techniques when total transit costs are increased is usually made by a comparison to the alternate cost impacts associated with providing comparable highway capacity for low occupancy vehicles.

COMMUNITY DEVELOPMENT. Two major stimuli for community development are population growth and new levels of increased accessibility. At the present state-of-the-art, the effects of priority techniques on urban development are difficult to assess. However, it appears that incorporation of priority treatments into existing highway facilities would have a minimal impact on land use patterns.

Also, the construction of exclusive rights-of-way for high occupancy vehicles may have a social impact similar to those encountered during construction of new urban highways. These concerns were voiced in Milwaukee and New Haven where construction of exclusive rights-of-way were proposed.

ENERGY AND ENVIRONMENTAL CONCERNS. The implementation of priority techniques for high occupancy vehicles has lead to benefits in both the energy and environmental areas. Increased use of high occupancy vehicles is rated very favorably in terms of energy efficiency (see Figure 15). In addition, the overall reduction in the number of private automobiles on urban freeways has had a positive impact on reducing total pollution levels and reducing highway congestion.

future research requirements

A review of existing research in the field of priority techniques has revealed several areas where significant contributions can be achieved by future research. Some of the areas to be addressed are:

- A need for more accurate information on peak-hour bus and passenger volume data for future priority proposals, as consistent peak-hour bus and carpool volume data are lacking.
- A need for greater clarity on downtown distribution proposals, as they will have an important bearing on the overall success of line-haul priority techniques.
- Additional research in demand forecasting and potential user motivational studies is essential in future freeway-related priority treatments. Much of the

existing research has been theoretical because actual data on usage was not readily available.

- Additional field testing and design studies should take place so as to determine some optimal physical parameters; i.e., cross section, lane width, types of separation barriers. Driver reaction and behavior on various types of facilities should also be examined.
- Development of guidelines for the selection of one type of priority technique over another. If there are methods of selecting the optimal priority technique in a given area, these should be developed and tested.
- Cost analyses of various elements of priority techniques, e.g., enforcement, maintenance, operation.
- There is a need for developing evaluation guidelines before the implementation of priority techniques. These guidelines should then be used to obtain data so that conclusions can be drawn about the effectiveness of the project.

SUPPLEMENTARY MATERIAL

APPENDIX A

SUMMARY OF SELECTED CHARACTERISTICS OF 17 FREEWAY-RELATED PRIORITY TECHNIQUES

		BOSTON, MA		DALLAS, TX
		SOUTHEAST EXPRESSWAY	ROUTE I-93	NORTH CENTRAL EXPRESSWAY
TYPE OF TECHNIQUE		Contra-flow bus lane on six-lane divided freeway	Normal flow reserved lane for buses and carpools (3 or more occupants) at the junction of two freeways	Total of six special freeway ramp entry gates and one bypass ramp for bus use only
DATE STARTED		May 1971	February 1974	Under construction
PROJECT LENGTH		8.4 miles	1 mile	12 miles
HOURS OF OPERATION		6:30 - 9:30 A.M. between April - October	6:30 - 9:30 A.M.	A.M. and P.M. peak periods
MAJOR AGENCIES INVOLVED		Massachusetts Department of Public Works	Massachusetts Department of Public Works	Dallas Department of Traffic Control, Dallas Transit System, Texas Highway Department
COSTS	IMPLEMENTING	$40,000	Nominal (Actual costs not determined at the time of this report)	$135,000
	OPERATING	$550 per day	Nominal (Actual costs not determined at the time of this report)	$16,000 per year (estimated)
RESULTS	USE	95 buses carrying 3000 passengers in the peak period	24 buses and 560 carpools in the peak period	Not available
	TIME SAVINGS	14 minutes	2-4 minutes	Not available
COMMENTS		Used only in good weather for safety considerations	Increase in mean passengers per vehicle from 1.35 to 1.44. Portable barriers, lane prohibition marking, and signs mark the special lane.	Scheduled to be completed in late 1975. Part of Urban Corridor Demonstration Program.

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Southeast Expressway

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Dallas, TX:

North Central Expressway

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SUMMARY OF SELECTED CHARACTERISTICS OF 17 FREEWAY-RELATED PRIORITY TECHNIQUES (CONT.)

		HONOLULU, HI	LOS ANGELES, CA	
		MOANALUA FREEWAY	FREEWAY RAMPS	SAN BERNARDINO FREEWAY BUSWAY
TYPE OF TECHNIQUE		Normal flow reserved lane for buses and carpools (3 or more occupants), one lane in each direction	Total of 10 ramp priority techniques for buses and carpools (2 or more persons) on five different freeways	Two-lane exclusive busway in center and alongside of freeway, one lane in each direction
DATE STARTED		October 1974	December 1971	January 1973
PROJECT LENGTH		Inbound - 2.7 miles Outbound - 1.4 miles	Varies, longest is 7 miles (5 ramps)	11 miles
HOURS OF OPERATION		24 hours	Typically in A.M. and P.M. peak periods	24 hours
MAJOR AGENCIES INVOLVED		Hawaii Department of Transportation, FHWA	California Department of Transportation, Southern California RTD	California Department of Transportation, Southern California RTD, Southern Pacific Transportation Co., City and County of Los Angeles, City of El Monte, Southern California Association of Governments, FHWA, UMTA
COSTS	IMPLEMENTING	$36,500	Nominal (Actual costs not determined at the time of this report)	$56,000,000
	OPERATING	Nominal (Actual costs not determined at the time of this report)	Nominal (Actual costs not determined at the time of this report)	Not available
RESULTS	USE	11 buses and 1500 carpools in the 2-hour morning peak period	Large increases in new carpools (sometimes doubling and tripling) and in vehicle occupancy	7800 bus passengers in combined morning and evening (5.5 hours) peak periods. 18 months of uninterrupted growth in bus patronage.
	TIME SAVINGS	10 minutes for inbound portion	1-3 minutes	10 minutes
COMMENTS		Some enforcement problems. Marked by signs and striping.	Occasional enforcement necessary. Few operational problems. Projects have been quite successful.	Special bus ramps for access. Three stations, including the park-n-ride terminal in El Monte.

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Honolulu, HI:

Moanalua Freeway

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Freeway Ramps

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SUMMARY OF SELECTED CHARACTERISTICS OF 17 FREEWAY-RELATED PRIORITY TECHNIQUES (CONT.)

		MIAMI, FL I-95	MINNEAPOLIS, MN I-35W FREEWAY RAMPS	NEW YORK, NY I-495 APPROACH TO LINCOLN TUNNEL
TYPE OF TECHNIQUE		Normal flow bus and carpool (3 or more occupants) reserved lane, 1 lane in each direction and one exclusive access ramp	Bus bypass lanes at nine metered freeway entry ramps	Contra-flow bus lane on six-lane divided freeway
DATE STARTED		Under construction	April 1974	December 1970
PROJECT LENGTH		7.5 miles	Each ramp is several hundred feet long	2.5 miles
HOURS OF OPERATION		6 - 10 A.M. 3 - 7 P.M.	6:30 - 9:00 A.M. 3:00 - 6:00 P.M.	7:00 - 10:00 A.M.
MAJOR AGENCIES INVOLVED		Florida Department of Transportation, Metropolitan Dade County, FHWA, UMTA	Minnesota Highway Department, Metropolitan Transit Commission, Metropolitan Council of Twin Cities, UMTA, FHWA	Port Authority of New York and New Jersey, Tri-State Regional Planning Commission, New Jersey Department of Transportation, New Jersey Turnpike Authority
COSTS	IMPLEMENTING	$18,500,000	$759,000	$700,000
	OPERATING	Not available	Nominal (Actual costs not determined at the time of this report)	$200,000 per year
RESULTS	USE	Not available	Bus ridership increased from 1100 to 8800 peak period passengers per day	950 buses carrying 40,000 passengers in the peak period
	TIME SAVINGS	Not available	Not available	8-15 minutes
COMMENTS		Priority lanes will be Phase II of a project in the I-95/N.W. 7th Ave. corridor (See Appendix B)	One-half of new bus passengers are former auto users. Extenisve traffic surveillance and control on freeway. No bus priority on freeway.	Exclusive entry ramp at New Jersey Turnpike; direct entry to terminal in New York City.

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SUMMARY OF SELECTED CHARACTERISTICS OF 17 FREEWAY-RELATED PRIORITY TECHNIQUES (CONT.)

		NEW YORK, NY	PITTSBURGH, PA	
		LONG ISLAND EXPRESSWAY	PATWAYS	BRADDOCK AVE. - PARKWAY EAST
TYPE OF TECHNIQUE		Contra-flow bus lane on six-lane divided freeway	Two-lane exclusive busways	Exclusive bus ramp
DATE STARTED		October 1971	Under construction	1971
PROJECT LENGTH		2 miles	East PATWAY - 8 miles South PATWAY - 4 miles	600 - 700 feet
HOURS OF OPERATION		7:00 - 9:00 A.M.	24 hours	A.M. peak period
MAJOR AGENCIES INVOLVED		New York City Transportation Administration	Port Authority of Allegheny County, Pennsylvania Department of Transportation, County of Allegheny, UMTA	Port Authority of Allegheny County, Pittsburgh Traffic Planning Department
COSTS	IMPLEMENTING	$44,000	Not available	Nominal (Actual costs not determined at the time of this report)
	OPERATING	$150,000 per year	Not available	Nominal (Actual costs not determined at the time of this report)
RESULTS	USE	200 buses carrying 10,000 passengers in the peak period	Not available	10 buses in the peak hour
	TIME SAVINGS	15 minutes	Not available	15 minutes
COMMENTS		Project implemented in a short time period. Public response favorable with growing demand for the type of service.	South PATWAY will open late 1975. East PATWAY in final design stage.	One-way ramp to inbound direction on Parkway East.

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Long Island Expressway

Same as I-495 Project

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PATWAYS

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SUMMARY OF SELECTED CHARACTERISTICS OF 17 FREEWAY-RELATED PRIORITY TECHNIQUES (CONT.)

		SAN DIEGO, CA	SAN FRANCISCO, CA	
		ROUTE 163	U.S. 101 (MARIN COUNTY)	SAN FRANCISCO - OAKLAND BAY BRIDGE
TYPE OF TECHNIQUE		Normal flow bus lane and special access ramp for buses and carpools, partially in CBD	Contra-flow (1 direction) and normal flow (both directions) bus lanes, in two separate segments on eight-lane divided freeway	Normal flow reserved lanes for buses and carpools (3 or more occupants) complemented by traffic signal system at the toll plaza area
DATE STARTED		Fall 1974	Contra-flow - September 1972 Normal flow - December 1974	Buses - April 1970 Carpools - December 1971
PROJECT LENGTH		0.5 miles on freeway 0.4 miles on arterial	Contra-flow - 5 miles Normal flow - 3.5 miles	0.5 miles
HOURS OF OPERATION		3:00 - 6:00 P.M.	Contra-flow - 4:30 - 6:15 P.M. Normal flow - 6:00 - 9:00 A.M. 4:00 - 7:00 P.M.	6:00 - 9:00 A.M. 3:00 - 6:00 P.M.
MAJOR AGENCIES INVOLVED		California Department of Transportation	California Department of Transportation, Golden Gate Bridge, Highway, and Transportation District, Marin County	California Department of Transportation, Alameda-Contra Costa Transit District
COSTS	IMPLEMENTING	$1,800	$250,000	$398,000
	OPERATING	Nominal (Actual costs not determined at the time of this report)	$5000 per month	$2300 per month
RESULTS	USE	22 buses per peak period	150 buses carrying 6000 passengers in the evening peak period	Negligible effect on bus patronage. Significant increase in number of carpools to 1900 in the morning peak period
	TIME SAVINGS	2-3 minutes	Up to 10 minutes	5 minutes
COMMENTS		No significant problems have arisen in enforcement, safety, or operations.	Small increase in bus patronage due to contra-flow lane. Buses limited to 40 M.P.H. Negligible violation and safety problems.	1 bus and 2 carpool lanes move through toll plaza with minimum delay. Occupancy (exclusive of buses) increased from 1.33 to 1.43 persons per vehicle.

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Zell, Charles E., "San Francisco - Oakland Bay Bridge Trans-Bay Bus Riders Survey," Highway Research Record No. 114 1966, pp. 169-182.

Phone conversation with Gerry Ducey, Ramp Control Engineer, California Department of Transportation, (415) 557-3992. 6/16/75.

SUMMARY OF SELECTED CHARACTERISTICS OF 17 FREEWAY-RELATED PRIORITY TECHNIQUES (CONT.)

		SEATTLE, WA I-5 FREEWAY RAMP	WASHINGTON, D.C. SHIRLEY HIGHWAY
TYPE OF TECHNIQUE		Exclusive reversible bus ramp leading into special downtown circulation loop	Reversible two-lane exclusive right-of-way for buses and carpools (4 or more occupants)
DATE STARTED		September 1970	Buses - September 1969 Carpools - December 1973
PROJECT LENGTH		Several hundred feet	11 miles
HOURS OF OPERATION		All day	6:00 - 9:00 A.M. 4:00 - 7:00 P.M.
MAJOR AGENCIES INVOLVED		Seattle Traffic Engineering Depart ment, Washington State Highway Commission, Metro Transit, FHWA, UMTA	Virginia Department of Highways and Transportation, Northern Virginia Transportation Commission, Washington Metropolitan Area Transit Authority, District of Columbia Department of Highways and Traffic, FHWA, UMTA
COSTS	IMPLEMENTING	$15,000	Not available
	OPERATING	Nominal (Actual costs not determined at the time of this report)	$300 per week
RESULTS	USE	50 buses carrying 2500 passengers in the peak hour	300 buses carrying 16,000 round-trip passengers daily
	TIME SAVINGS	5-10 minutes	10-15 minutes
COMMENTS		Buses mix with regular traffic on the reversible express lanes of I-5.	Implemented in stages from 1969-1975. Complemented by reserved peak hour lanes on major arterials in Washington, D.C.

References/Sources for further information:

Seattle, WA:
I-5 Freeway Ramp

Levinson, Herbert S., State-of-the-Art: Bus and Carpool Priorities, Presented at the Workshop on Priority Techniques for High Occupancy Vehicles by the U.S. Department of Transportation, Miami, April 29, 1975.

Preferential Treatment for High Occupancy Vehicles, U.S. Department of Transportation, Federal Highway Administration, April 1974.

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Shirley Highway

Avery, George A., and James C. Echols, "The Shirley Highway Project: Achieving Effective Intergovernmental Cooperation," Traffic Quarterly, July 1972, pp. 373-390.

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APPENDIX B

SUMMARY OF SELECTED CHARACTERISTICS OF 37 ARTERIAL-CITY STREET PRIORITY TECHNIQUES

		ARLINGTON, VA	BALTIMORE, MD	BIRMINGHAM, AL
TYPE OF TECHNIQUE		Normal flow curb bus lanes on two arterials (Wilson and Arlington Blvd.)	Normal flow curb bus lanes on 11 CBD streets and one radial arterial (York Rd.)	Normal flow curb bus lane on one street (19th St. North)
DATE STARTED		January 1974	May 1958	October 1973
PROJECT LENGTH		a) Wilson - 3.5 miles b) Arlington - 4.5 miles	CBD streets - varies from 2-16 blocks, total of 5 miles. Arterial - 6.5 miles, one lane in each direction	5 blocks (2200 ft.)
HOURS OF OPERATION		A.M. and P.M peak periods	A.M. and P.M. peak periods	7:00 - 9:00 A.M. 4:00 - 6:00 P.M.
MAJOR AGENCIES INVOLVED		a) Virginia Department of Highways and Transportation b) Arlington County	Baltimore Department of Transit and Traffic, Maryland Mass Transit Administration, EPA	Birmingham Traffic Engineering Department, Birminham-Jefferson County Transit Authority
COSTS	IMPLEMENTING	a) $135,000 b) $1,316,000	Not available	Nominal (Actual costs not determined at the time of this report)
	OPERATING	Nominal (Actual costs not determined at the time of this report)	Not available	Nominal (Actual costs not determined at the time of this report)
RESULTS	USE	40 buses per peak period for both projects	Varies for CBD streets, 20 buses in peak hour on arterial	65 buses in afternoon peak
	TIME SAVINGS	5 minutes	17% - 21% on CBD bus lanes, small saving on arterial bus lanes	Not available
COMMENTS		Wilson Blvd. has signal pre-emption at one site. Both sites have fixed message signs. Right turns allowed from bus lane.	Limited enforcement and roadway width (especially on arterial) has diminished effectiveness of bus lanes. Right turns allowed from bus lane.	Right turns allowed from bus lane. Marked by signs and striping.

References/Sources for further information:

Arlington, VA:	Coming Your Way, Washington Metropolitan Area Transit Authority, Office of Community Services, May 1974.
	Goodman, J.M., Presentation at Workshop on Priority Techniques for High Occupancy Vehicles, San Francisco, February 5, 1975, and subsequent phone conversation (202) 426-2360, 6/26/75.
Baltimore, MD:	Exclusive Bus Lane Study, Joint report by Baltimore Department of Transit and Traffic and Maryland Mass Transit Administration, April 1975.
	Pratt, R.H., Associates, A Study of Low Cost Alternatives to Increase the Effectiveness of Existing Transportation Facilities: Volume II - Results of Case Studies and Analysis of Busway Applications in the United States, U.S. Department of Transportation, Office of the Secretary, January 1973.
	Phone conversation with Mr. J. Erdman, Assistant Commissioner, Baltimore Department of Transit and Traffic, (301) 396-3029. 6/19/75.
Birmingham, AL:	Phone conversations with Mr. R. Higginbotham, Birminghan Traffic Engineering Department, (205) 254-2450 and with Mr. Burleson, Birmingham-Jefferson County Transit Authority, (205) 322-7701. 6/19/75.

SUMMARY OF SELECTED CHARACTERISTICS OF 37 ARTERIAL-CITY STREET PRIORITY TECHNIQUES (CONT.)

		BUFFALO, NY	CAMBRIDGE, MA	CHICAGO, IL
TYPE OF TECHNIQUE		Normal flow curb bus lane on one arterial (Church St.) and one city street (Main St.)	Two-level exclusive trackless trolley and diesel bus tunnel	Two reserved bus streets (63rd and Halsted) in Englewood Shopping Center
DATE STARTED		a) Church St. - 1969 b) Main St. - 1964	1958	Not available
PROJECT LENGTH		a) 0.11 miles b) 4 blocks	0.5 mile	63rd - 990 feet Halsted - 1320 feet
HOURS OF OPERATION		a) 24 hours b) 4:00 - 6:00 P.M.	24 hours	24 hours
MAJOR AGENCIES INVOLVED		Buffalo Department of Transportation, Niagara Frontier Transit Metro System, New York Department of Transportation	City of Cambridge, Massachusetts Bay Transportation Authority	Chicago Department of Streets, Chicago Department of Public Works, Chicago Transit Authority
COSTS	IMPLEMENTING	Not available	Not available	Not available
	OPERATING	Not available	Not available	Not available
RESULTS	USE	100 buses in peak period on Main St.	207 diesel buses and 306 trackless trolleys per day	40 buses in peak hour (total, both directions)
	TIME SAVINGS	Not available	Not available	Not available
COMMENTS		Church St. bus lane is protected by raised concrete curb, one of the few examples of a physically separated curb bus lane in the United States.	Bus patrons have direct access to subway.	Bus streets are 22-feet wide to allow for maximum sidewalk width.

References/Sources for further information:

Buffalo, NY:

Levinson, Herbert S., et al., Bus Use of Highways: State-of-the-Art, National Cooperative Highway Research Program Report 143, Highway Research Board, 1973.

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Cambridge, MA:

Levinson, Herbert S., State of the Art – Bus and Carpool Priorities, Presented at the Workshop on Priority Techniques for High Occupancy Vehicles, Miami, April 29, 1975.

Phone conversation with Mr. Waelde, Massachusetts Bay Transportation Authority, (617) 722-5768. 6/18/75.

Chicago, IL:

Levinson, Herbert S., et al., Bus Use of Highways: State-of-the-Art, National Cooperative Highway Research Program Report 143, Highway Research Board, 1973.

SUMMARY OF SELECTED CHARACTERISTICS OF 37 ARTERIAL-CITY STREET PRIORITY TECHNIQUES (CONT.)

		CHICAGO, IL	CLEVELAND, OH	DALLAS, TX
TYPE OF TECHNIQUE		Normal flow, contra-flow, and median bus lanes	Contra-flow bus zone at major transfer and terminal point (Public Square)	Normal flow curb bus lanes on one-way couplet (Elm-Commerce Sts).
DATE STARTED		1939	Not available	July 1958
PROJECT LENGTH		Varies, up to 0.7 miles	0.5 mile	Each 0.55 miles
HOURS OF OPERATION		Mostly 24 hours	24 hours	7:00 - 9:00 A.M. 4:30 - 6:00 P.M.
MAJOR AGENCIES INVOLVED		Chicago Department of Streets, Chicago Department of Public Works, Chicago Transit Authority	Cleveland Traffic Engineering Department, Cleveland Transit System	Dallas Department of Traffic Control, Dallas Transit System
COSTS	IMPLEMENTING	Not available	Nominal (Actual costs not determined at the time of this report)	Nominal (Actual costs not determined at the time of this report)
	OPERATING	Not available	Nominal (Actual costs not determined at the time of this report)	Nominal (Actual costs not determined at the time of this report)
RESULTS	USE	Varies, up to 110 buses in peak hour	Not available	70-75 buses in peak
	TIME SAVINGS	Several minutes	Not available	Improvement in bus speed of over 23%
COMMENTS		Includes Washington St. median lane, contra-flow lanes on Canal St., Lake Shore Drive, and N. Sheridan Rd., and the State St. bus lanes.	Used primarily as layover area for a great number of buses.	Right turns allowed from bus lane. Signs mark the bus lane.

References/Sources for further information:

Chicago, IL:

Levinson, Herbert S., et al., Bus Use of Highways: State-of-the-Art, National Cooperative Highway Research Program Report 143, Highway Research Board, 1973.

Pratt, R.H., Associates, A Study of Low Cost Alternatives to Increase the Effectiveness of Existing Transportation Facilities: Volume II - Results of Case Studies and Analysis of Busway Applications in the United States, U.S. Department of Transportation, January 1973.

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Phone conversation with Mr. W.C. Franklin, Director of Planning and Intergovernmental Relations, Dallas Transit System, (214) 827-3400. 6/19/75.

SUMMARY OF SELECTED CHARACTERISTICS OF 37 ARTERIAL-CITY STREET PRIORITY TECHNIQUES (CONT.)

		DALLAS, TX	DENVER, CO	HARRISBURG, PA
TYPE OF TECHNIQUE		Bus signal pre-emption at 42 intersections in urban corridor (North Central Expressway)	Normal flow curb bus lanes on two city streets (16th and 17th) and reserved lanes for carpools (2 or more occupants) on two other streets (Lawrence and Larimer)	Contra-flow bus lane (Market St.)
DATE STARTED		Under construction	December 1974	1958
PROJECT LENGTH		12 miles (corridor length)	Varies, up to 24 blocks	0.3 miles
HOURS OF OPERATION		A.M. and P.M. peak periods	Peak periods	24 hours
MAJOR AGENCIES INVOLVED		Dallas Department of Traffic Control, Dallas Transit System, Texas Highway Department	City and County of Denver, Regional Transportation District, Denver Regional Council of Governments, Colorado State Highway Commission, Colorado Air Pollution Control Commission, EPA, FHWA	City of Harrisburg, Capitol Area Transportation Authority
COSTS	IMPLEMENTING	$563,000	Not available	Nominal (Actual costs not determined at the time of this report)
	OPERATING	$50,000 per year (estimated)	Not available	Nominal (Actual costs not determined at the time of this report)
RESULTS	USE	Not available	Approximately 110 buses in peak periods on bus lanes	37 buses in peak hour
	TIME SAVINGS	Not available	General improvement in bus travel times, nominal effect on carpool times	Not available
COMMENTS		Part of Urban Corridor Demonstration Program. Total of 70 intersections will be linked with a central control computer to provide overall traffic signal system coordination.	Nominal increase in bus ridership due to bus lanes. Right turns permitted from bus lanes. Carpool lanes are in left curb lane of streets.	Violation rate is very low. No turn prohibitions.

References/Sources for further information:

Dallas, TX:

Dallas, Texas: Urban Corridor Demonstration Program, City of Dallas, Traffic Control Department, December 3, 1971.

Voorhees (Alan M.), and Assoc., Status of the Urban Corridor Demonstration Program, Prepared for the U.S. Department of Transportation, Report DOT P6500.2, July 1974.

Phone conversation with Ken Miller, Administrative Assistant, Dallas Department of Traffic Control, (214) 748-9711. 4/15/75.

Denver, CO:

"Exclusive Bus Lanes are Opened in Denver," Passenger Transport, December 13, 1974. p.1.

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Phone conversation with James Graebner, Denver Regional Transportation District, (303) 759-1000. 6/75.

Harrisburg, PA:

Phone conversations with Ron Jones, Harrisburg Traffic Engineering Department, (717) 238-7101 and Harry James, Capitol Area Transportation Authority, (717) 238-8304. 6/18/75.

SUMMARY OF SELECTED CHARACTERISTICS OF 37 ARTERIAL-CITY STREET PRIORITY TECHNIQUES (CONT.)

		HONOLULU, HI	HOUSTON, TX	INDIANAPOLIS, IN
TYPE OF TECHNIQUE		Contra-flow bus lanes on two streets (Kalakaua and Kalanianaole)	Normal flow curb bus lane on down-town street (Main St.)	Contra-flow bus lane on four-lane arterial (College Ave.)
DATE STARTED		a) Kalakaua - June 1971 b) Kalanianaole - August 1973	October 1971	1969
PROJECT LENGTH		a) 2 segments of 5 blocks and 4 blocks b) 2.3 miles	14 blocks	2.9 miles
HOURS OF OPERATION		a) A.M. peak period b) All day	7:00 A.M. - 6:00 P.M.	24 hours
MAJOR AGENCIES INVOLVED		City and County of Honolulu Department of Transportation Services, Hawaii Department of Transportation	Houston Department of Traffic and Transportation, Houston Rapid Transit Lines	Indianapolis Department of Transportation, Bureau of Traffic Engineering
COSTS	IMPLEMENTING	Not available	Nominal (Actual costs not determined at the time of this report)	Nominal (Actual costs not determined at the time of this report)
	OPERATING	Not available	Nominal (Actual costs not determined at the time of this report)	Not available
RESULTS	USE	a) 30 buses in peak hour b) 15-17 buses in peak hour	1270 daily bus trips	10 buses in peak hour
	TIME SAVINGS	a) Not available b) 20 minutes	Not available	Not available
COMMENTS		Marked by signs and cones. Some enforcement problems.	Right and left turns prohibited, resulting in decreased vehicular volumes and higher bus speeds. Enforcement has been good.	Minimal enforcement although violations are high. Signs and striping mark bus lane.

References/Sources for further information:

Honolulu, HI:	Phone conversation with Roy Parker, Deputy Director, Honolulu Department of Transportation Services, (808) 523-4581. 6/75.
Houston, TX:	Levinson, Herbert S., et al., Bus Use of Highways: State-of-the-Art, National Cooperative Highway Research Program Report 143, Highway Research Board, 1973.
	Phone conversation with Mr. Lynch, Traffic Engineer, Houston Department of Traffic and Transportation, (713) 222-4485. 6/19/75.
Indianapolis, IN:	Pratt, R.H. Associates, A Study of Low Cost Alternatives to Increase the Effectiveness of Existing Transportation Facilities: Volume II - Results of Case Studies and Analysis of Busway Applications in the United States, Prepared for the U.S. Department of Transportation, January 1973.

SUMMARY OF SELECTED CHARACTERISTICS OF 37 ARTERIAL-CITY STREET PRIORITY TECHNIQUES (CONT.)

		LOUISVILLE, KY	MADISON, WI	MIAMI, FL
TYPE OF TECHNIQUE		Bus pre-emption of traffic signals at 8 intersections	Contra-flow limited use lane (University Ave.)	Express bus operation on reversible reserved median lane, with benefit of bus signal pre-emption (N.W. 7th Ave.)
DATE STARTED		May 1972	1970 (Began as bus-only lane in October 1966)	August 1974
PROJECT LENGTH		3 miles	0.9 miles	9.9 miles
HOURS OF OPERATION		6:30 - 8:30 A.M. 3:30 - 5:30 P.M.	24 hours	6:00 - 9:30 A.M. 3:00 - 6:30 P.M.
MAJOR AGENCIES INVOLVED		Louisville Traffic Engineering Department, Louisville Transit, FHWA	City of Madison Transportation Department	Metropolitan Dade County, Florida Department of Transportation, UMTA, FHWA
COSTS	IMPLEMENTING	$10,700	$50,000	$1,350,000
	OPERATING	Nominal (Actual costs not determined at the time of this report)	Nominal (Actual costs not determined at the time of this report)	$2400 per month
RESULTS	USE	Not available	23 buses in peak hour	42% increase in bus ridership to 1650 daily passengers on 52 buses
	TIME SAVINGS	10%-20% decrease in bus travel time	Up to 6 minutes	6 minutes
COMMENTS		Part of Urban Corridor Demonstration Program. Two express bus routes use pre-emption technique.	Legal problems resulted in change of status. All vehicles using lane must traverse its entire length. Used by many bicyclists.	Phase I of I-95/N.W. 7th Ave. project. Various traffic signal strategies are being evaluated.

References/Sources for further information:

Louisville, KY:

Voorhees, (Alan M.) and Assoc., Status of the Urban Corridor Demonstration Program, Prepared for U.S. Department of Transportation, Report DOT P6500.2, July 1974.

Phone conversation with Mr. Stockton, Louisville Traffic Engineering Department, (502) 587-3241. 6/19/75.

Madison, WI:

Levinson, Herbert S., et al., Bus Use of Highways: State-of-the-Art, National Cooperative Highway Research Program Report 143, Highway Research Board, 1973.

Phone conversation with Messrs. Jones and McLary, Madison Transportation Department, (608) 266-4761. 6/24/75.

Miami, FL:

Goodman, J.M., Presentation at Workshop on Priority Techniques for High Occupancy Vehicles, San Francisco, February 5, 1975.

"Lights Turn Green for Miami Buses," The American City, April 1974. p.100.

Orange Streaker, Project fact sheet prepared by Florida Department of Transportation.

Phone conversation with Bob Deuser, Project Engineer, Florida Department of Transportation, (305) 871-4480. 6/10/75.

SUMMARY OF SELECTED CHARACTERISTICS OF 37 ARTERIAL-CITY STREET PRIORITY TECHNIQUES (CONT.)

		MIAMI, FL	MINNEAPOLIS, MN	
TYPE OF TECHNIQUE		Contra-flow bus lane and reserved carpool lane (2 or more occupants) on major arterial (South Dixie Highway)	Bus street through shopping area (Nicollet Mall) in CBD	Contra-flow bus lanes on one-way couplet. (Marquette - 2nd Aves.)
DATE STARTED		July 1974	April 1968	September 1974
PROJECT LENGTH		5.5 miles	8 blocks	13 blocks
HOURS OF OPERATION		7:00 - 9:00 A.M. 4:00 - 6:00 P.M.	24 hours	24 hours
MAJOR AGENCIES INVOLVED		Florida Department of Transportation, Metropolitan Dade County	Minneapolis Traffic Engineering Department, Twin Cities Area Metropolitan Transit Commission	Minneapolis Traffic Engineering Department, Twin Cities Area Metropolitan Transit Commission
COSTS	IMPLEMENTING	$500,000	Not available	$30,000
	OPERATING	$62,000 per month	Not available	$100 per month
RESULTS	USE	54 buses carrying 1800 passengers in bus lane, and 3062 carpools carrying 6614 people in carpool lane, in combined peak periods.	Total of 75 buses both ways in peak hour	Marquette - 131 buses in 2-hour P.M. peak period. 2nd Ave - 139 buses in 2-hour A.M peak period
	TIME SAVINGS	Buses - 8 - 9 minutes Carpools - 6 minutes	Not available	Not available
COMMENTS		Violations are very low. Excellent enforcement. No left turns along total project length.	Cross streets open to all traffic. Taxis allowed.	Contra-flow lanes are currently in experimental stage.

References/Sources for further information:

Miami, FL:

Blue Dash, Project fact sheet prepared by Florida Department of Transportation.

Goodman, J.M., Presentation at Workshop on Priority Techniques for High Occupancy Vehicles, San Francisco, February 5, 1975.

Phone conversation with Marc Lopatin, Project Engineer, Florida Department of Transportation, (305) 871-4480. 6/24/75.

Minneapolis, MN:

Phone conversations with Dick Smith, Minneapolis Department of Public Works, (612) 348-2411 and Mr. Nietzel, Twin Cities Area Metropolitan Transit Commission, (612) 827-4071. 6/20/75.

Muzyka, Ann, Bus Priority Strategies and Traffic Simulation, Working Paper WP-SA-U, 3.0-40, U.S. Department of Transportation, Transportation Systems Center, August 1974.

Phone conversation with John Fantasia, Transportation Systems Center, (617) 494-2672. 6/25/75.

SUMMARY OF SELECTED CHARACTERISTICS OF 37 ARTERIAL-CITY STREET PRIORITY TECHNIQUES (CONT.)

		NASHVILLE, TN	NEW ORLEANS, LA	NEW YORK, NY
TYPE OF TECHNIQUE		Normal flow curb bus lane (4th Ave.)	Bus lane in median of major artery (Canal St.)	Normal flow curb bus lanes and bus zones at numerous locations
DATE STARTED		1956	1964	1963
PROJECT LENGTH		0.36 miles	1.5 miles	15 miles on 11 streets
HOURS OF OPERATION		7:00 - 9:00 A.M. 4:00 - 6:00 P.M.	24 hours	Bus lanes - peak periods Bus zones - 7:00 A.M. to 7:00 P.M.
MAJOR AGENCIES INVOLVED		Nashville Traffic and Parking Commission	New Orleans Public Service, City of New Orleans	New York City Transportation Administration, New York City Transit Authority
COSTS	IMPLEMENTING	Nominal (Actual costs not determined at the time of this report)	$1,450,000	Not available
	OPERATING	Nominal (Actual costs not determined at the time of this report)	Not available	Not available
RESULTS	USE	Up to 60 buses per hour	350 bus round trips on weekdays	Varies from 60-170 buses in peak hour
	TIME SAVINGS	Not available	Not available	Travel time reductions of 22-42%
COMMENTS		Right turns prohibited. Marked by signs and striping.	Former streetcar line, repaved as a 24-foot road for bus-use only.	Success depends on strict enforcement. Most bus lanes are in midtown Manhattan.

References/Sources for further information:

Nashville, TN: Phone conversation with Mr. May, Nashville Traffic and Parking Commission, (615) 259-5361. 6/19/75.

New Orleans, LA: Phone conversation with Mr. Schultz, Manager - Public Information Division, New Orleans Public Service, (504) 586-2412. 6/23/75.

New York, NY: Levinson, Herbert S., et al., Bus Use of Highways: State-of-the-Art, National Cooperative Highway Research Program Report 143, Highway Research Board, 1973.

Phone conversation with Messrs. Hollander and Shoumacher, New York City Transportation Administration, (212) 566-2890. 6/24/75.

SUMMARY OF SELECTED CHARACTERISTICS OF 37 ARTERIAL-CITY STREET PRIORITY TECHNIQUES (CONT.)

		NEWARK, NJ	PHILADELPHIA, PA	
TYPE OF TECHNIQUE		Normal flow curb bus lane (Market St.)	Normal flow curb and median bus lane at major transit hub (Market St.)	Normal flow curb bus lane (Benjamin Franklin Bridge)
DATE STARTED		December 1956	1956	1971
PROJECT LENGTH		0.3 miles	3500 feet	0.75 miles
HOURS OF OPERATION		4:00 - 6:00 P.M.	24 hours	A.M. and P.M. peak periods
MAJOR AGENCIES INVOLVED		Public Service Coordinated Transit, Transport of New Jersey, City of Newark	City of Philadelphia, SEPTA, Transport of New Jersey	Transport of New Jersey, Delaware River Port Authority
COSTS	IMPLEMENTING	Nominal (Actual costs not determined at the time of this report)	Not available	Not available
	OPERATING	Nominal (Actual costs not determined at the time of this report)	Nominal (Actual costs not determined at the time of this report)	Not available
RESULTS	USE	200 buses carrying 10000 passengers in peak period	160 buses in peak hour	125 buses in peak hour
	TIME SAVINGS	Not available	1.5 minutes	Not available
COMMENTS		Primarily used as loading area. Second lane for bypass.	Median lane has 5-foot wide concrete loading island.	Used primarily for channelization purpose. Trucks are allowed to use lane.

References/Sources for further information:

Newark, NJ:	Phone conversation with Mr. Palumbo, Newark Department of Public Works, (201) 733-8515. 6/24/75.
Philadelphia, PA:	Phone conversation with Frank Berdan, Manager - Operational Planning, SEPTA, (215) 627-8200. 6/24/75.

SUMMARY OF SELECTED CHARACTERISTICS OF 37 ARTERIAL-CITY STREET PRIORITY TECHNIQUES (CONT.)

		PITTSBURGH, PA	PROVIDENCE, RI	
TYPE OF TECHNIQUE		Normal flow curb bus lanes, median bus lane, contra-flow bus lanes and bus street	Normal flow curb bus lanes on one-way couplet. (Washington - Weybosset Sts.)	Exclusive bus use of tunnel (East Side tunnel)
DATE STARTED		1967	April 1964	1948
PROJECT LENGTH		Varies from 400 feet to 4100 feet	0.5 mile each	2160 feet
HOURS OF OPERATION		Most 24 hours	Washington - 8:00 A.M. - 6:00 P.M. Weybosset - 7:00 - 10:00 A.M. 1:00 - 10:00 P.M.	24 hours
MAJOR AGENCIES INVOLVED		Port Authority of Allegheny County, City of Pittsburgh Traffic Planning Department	Providence Traffic Engineering Department, Rhode Island Public Transit Authority	Rhode Island Public Transit Authority, City of Providence
COSTS	IMPLEMENTING	Not available	Nominal (Actual costs not determined at the time of this report)	Not available
	OPERATING	Nominal (Actual costs not determined at the time of this report)	Nominal (Actual costs not determined at the time of this report)	Nominal (Actual costs not determined at the time of this report)
RESULTS	USE	Not available	60 buses in peak hour	18 buses in peak hour
	TIME SAVINGS	Not available	Not available	2-3 minutes
COMMENTS			Inadequate enforcement has diminished effectiveness of bus lane	Tunnel is self ventilating, about 25 feet wide, and 17.5 feet high

References/Sources for further information:

Pittsburgh, PA:

Geissenheimer, Harold H., Summary of Exclusive Transit Lanes Presently in Operation in Pittsburgh, Pennsylvania, Port Authority of Allegheny County, November 12, 1974.

Phone conversation with Mr. Norris, Superintendent - Rates and Service Planning, Port Authority of Allegheny County, (412) 237-7287. 6/24/75.

Providence, RI:

Phone conversation with Ms. Testa, Providence Traffic Engineering Department (401) 781-4044. 6/24/75.

Phone conversation with Mr. Wanson, Rhode Island Public Transit Authority, (401) 781-9400. 6/26/75.

SUMMARY OF SELECTED CHARACTERISTICS OF 37 ARTERIAL-CITY STREET PRIORITY TECHNIQUES (CONT.)

		ROCHESTER, NY	SAN ANTONIO, TX	SAN FRANCISCO, CA
TYPE OF TECHNIQUE		Normal flow curb bus lanes on two streets (Main St. and Lake Ave.)	Contra-flow bus lane (Alamo Plaza)	Normal flow curb bus lanes on two pairs of one-way streets (Geary - O'Farrell and Sutter - Post Sts.)
DATE STARTED		1957	1968	November 1971 (Revised on Sutter - Post in February 1975)
PROJECT LENGTH		a) Main St. - 1.5 miles b) Lake Ave. - 2.0 miles	0.25 miles	0.75 mile to 1 mile
HOURS OF OPERATION		a) 24 hours b) A.M. and P.M. peak periods	24 hours	A.M. and P.M. peak periods
MAJOR AGENCIES INVOLVED		County of Monroe Bureau of Traffic Engineering, Rochester Regional Transit Authority	San Antonio Transit System, San Antonio Traffic Department	San Francisco City Planning Department, San Francisco Department of Public Works, MUNI
COSTS	IMPLEMENTING	Nominal (Actual costs not determined at the time of this report)	Nominal (Actual costs not determined at the time of this report)	Nominal (Actual costs not determined at the time of this report)
	OPERATING	Nominal (Actual costs not determined at the time of this report)	Nominal (Actual costs not determined at the time of this report)	Nominal (Actual costs not determined at the time of this report)
RESULTS	USE	a) 100-150 buses in peak hour b) 8 buses in peak hour	30 buses in peak hour	Up to 90 buses in the peak hour on Sutter - Post Sts. 40 buses in peak hour on Geary - O'Farrell.
	TIME SAVINGS	Not available	2 minutes	Not available
COMMENTS		Right turns permitted from bus lane. Marked by signs.	Violations are low, excellent safety record.	Right turns permitted from bus lanes. Sutter - Post lanes are 18 feet wide while Geary - O'Farrell are 10-11 feet wide.

References/Sources for further information:

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SUMMARY OF SELECTED CHARACTERISTICS OF 37 ARTERIAL-CITY STREET PRIORITY TECHNIQUES (CONT.)

		SAN JUAN, PR	SEATTLE, WA	WASHINGTON, DC
TYPE OF TECHNIQUE		Contra-flow bus lanes on one-way arterial couplet. (Ponce De Leon and Fernandez Juncos)	Contra-flow bus lane	Normal flow curb lanes for buses, bicycles, motorcycles and taxis (at least two passengers)
DATE STARTED		May 1971	September 1970	1962
PROJECT LENGTH		11 miles	3 blocks	26 miles on 18 streets with 27 lanes
HOURS OF OPERATION		24 hours	24 hours	24 hours on two streets, rest are in effect in A.M. and P.M. peak periods
MAJOR AGENCIES INVOLVED		Puerto Rice Planning Board, P.R. Department of Public Works, P.R. Highway Authority, San Juan Police Department	Seattle Traffic Engineering Department, Metro Transit	Metropolitan Washington Council of Governments, WMATA, D.C. Department of Highways and Traffic
COSTS	IMPLEMENTING	$100,000	Nominal (Actual costs not determined at the time of this report)	Not available
	OPERATING	Nominal (Actual costs not determined at the time of this report)	Nominal (Actual costs not determined at the time of this report)	Not available
RESULTS	USE	40-70 buses in peak hour	50 buses carrying 2500 passengers in peak hour	3812 bus trips carrying 191,000 passengers during the entire period of oper ation of all bus lanes on all streets
	TIME SAVINGS	20-30 minutes	Not available	Not available
COMMENTS		Excellent safety record. Bus lanes have cut transit time by 35%.	Part of downtown circulation loop for Blue Streak buses which use exclusive bus ramp (see Appendix A).	Vehicles turning right and those stopping to pick up and discharge passengers are allowed in lanes.

References/Sources for further information:

San Juan, PR:

Goodman, J.M., Presentation at Workshop on Priority Techniques for High Occupancy Vehicles, San Francisco, February 5, 1975.

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Seattle, WA:

Phone conversation with Mr. Succo, Public Information Officer, Seattle Engineering Department, (206) 583-2860. 6/16/75.

Washington, DC:

Bus Priority Lanes: Fact Sheet, D.C. Department of Highways and Traffic, May 1, 1975.

Phone conversation with Jack Hartley, (202) 628-6000 and Mr. Schoene (202) 629-5788, both of D.C. Department of Highways and Traffic. 7/75.

SUMMARY OF SELECTED CHARACTERISTICS OF 37 ARTERIAL-CITY STREET PRIORITY TECHNIQUES (CONT.)

		WASHINGTON, DC
TYPE OF TECHNIQUE		Bus pre-emption of traffic signals
DATE STARTED		November 1972
PROJECT LENGTH		Network of 114 intersections, 31 with bus pre-emption capability
HOURS OF OPERATION		Not available
MAJOR AGENCIES INVOLVED		D.C. Department of Highways and Traffic, WMATA, FHWA
COSTS	IMPLEMENTING	Not available
	OPERATING	Not available
RESULTS	USE	450 transmitter-equipped buses
	TIME SAVINGS	Bus travel times reduced at least 10%
COMMENTS		Part of Urban Traffic Control System. Various traffic control strategies are being evaluated.

References/Sources for further information:

Washington, DC:

Tarnoff, Phillip J., "The Results of FHWA Urban Traffic Control Research: An Interim Report," Traffic Engineering, April 1975. pp. 27-35.

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APPENDIX C
OVERSEAS CITIES HAVING PRIORITY ACTIVITIES

AUSTRALIA	–	Sydney
BELGIUM	–	Brussels, Liege
FRANCE	–	Le Havre, Marseilles, Paris, Rouen, Strasbourg, Toulouse
GREAT BRITIAN	–	Berkshire, Birmingham, Chatham, Carlisle, Derby, Dundee, Exeter, Gateshead, Isle of Wight, Leeds, Leicester, Liverpool, London, Manchester, Newcastle-upon-Tyne, Northampton, Oxford, Reading, Redditch, Runcorn, St. Peter Port, Salford, Southampton, Stockton
IRELAND	–	Dublin
ITALY	–	Bologna, Catania, Firenze, Genoa, Milan, Naples, Rome, Turin
NETHERLANDS	–	Groningen, The Hague, Maastricht, Nijmagen, Rotterdam, Utrecht
REPUBLIC OF SOUTH AFRICA	–	Johannesburg
SPAIN	–	Barcelona, Madrid
SWEDEN	–	Gothenburg, Stockholm
SWITZERLAND	–	Basel, Bern, Geneva, Zurich
WEST GERMANY	–	Aachen, Bremen, Hamburg, Hanover, Wiesbaden

APPENDIX D

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APPENDIX E

SUGGESTED PERIODICALS AND OTHER SOURCES OF CURRENT INFORMATION

This list represents the more important trade journals and other periodical literature that are known to contain articles and information on priority techniques for high occupancy vehicles. These sources are available by subscription or at major public and university libraries.

The American City

Civil Engineering

Current Literature in Traffic and Transportation (bibliographic source)

Highway User Quarterly

Journal of Transportation Economics and Policy

Lea Transit Compendium

Mass Transit

Metropolitan

New Concepts in Urban Transportation

Passenger Transport

Public Works

Traffic Engineering

Traffic Engineering and Control

Traffic Quarterly

Traffic World

Transit Topics

Transitrends

Transport Central

Transportation Engineering Journal (ASCE)

Transportation Journal

Transportation Research

Transportation Research Board Publications (formerly Highway Research Board)

Transportation Science (ORSA)

APPENDIX F

DIRECTORY OF REFERENCED TRANSIT AUTHORITIES, OPERATING AGENCIES, AND GOVERNMENTAL UNITS

Birminghan-Jefferson County Transit Authority
3105 Eighth Ave., North
Birmingham, AL 35202
(205) 322-7701

AC Transit
508 16th Street
Oakland, CA 94612
(415) 654-7878

Golden Gate Bridge
Highway & Transportation District
P.O. Box 9000
Presidio Station
San Francisco, CA 94129
(415) 346-5858

Marin County Transit District
Civic Center, Room 304-C
San Raphael, CA 94903
(415) 479-1100

San Bernardino Municipal Transit System
183 South G,
San Bernardino, CA 92410
(714) 884-4735

San Francisco Bay Area Rapid
Transit District (BARTD)
800 Madison Street,
Oakland, CA 94607
(415) 465-4100

San Francisco Municipal Railway
949 Presidio Ave.
San Francisco, CA 94115
(415) 649-6864

Southern California Rapid Transit
District (RTD)
1060 S. Broadway
Los Angeles, CA 90015
(213) 749-6977

Washington Metropolitan Area Transit
Authority (WMATA)
600 Fifth Street, N.W.
Washington, DC 20001
(202) 637-1234

Metropolitan Dade County Transit Authority
3300 NW 32nd Avenue
P.O Box 887
Miami, FL 33152
(305) 633-3381

Metropolitan Atlanta Rapid Transit Authority (MARTA)
100 Peachtree Street NW
Suite 1300
Atlanta, GA 30303
(404) 522-4460

Chicago Transit Authority (CTA)
Merchandise Mart
Chicago, IL 60654
(312) 664-7200

Louisville Transit Corp.
318 W. Jefferson Street
Louisville, KY 40202
(502) 585-2301

New Orleans Public Service, Inc.
317 Baronne Street
New Orleans, LA 70160
(504) 529-4545

Mass Transit Administration of Maryland
1515 Washington Blvd
Baltimore, MD 21230
(301) 539-6281

Massachusetts Bay Transportation Authority (MBTA)
500 Arborway
Jamaica Plain, MA 02130
(617) 722-5000

Twin Cities Area Metropolitan Transit Commission
330 Metro Square Bldg
St. Paul, MN 55101
(612) 227-7343

Transport of New Jersey
180 Boyden Avenue
Maplewood, NJ 07040
(201) 622-7000

APPENDIX F (CONT.)

Metropolitan Transportation Authority
1700 Broadway
New York, NY 10019
(212) 757-4040

New York City Transit Authority (NYCTA)
370 Jay Street
Brooklyn, NY 11201
(212) 852-5000

Niagara Frontier Transit System, Inc.
855 Main Street
Buffalo, NY 14203
(716) 884-6800

Port Authority of New York & New Jersey
1 World Trade Center
New York, NY 10048
(212) 466-7000

Rochester-Genesee Regional
Transportation Authority
2 State Street
Rochester, NY 14614
(716) 546-7340

Cleveland Transit System
1404 E. 9th Street
Cleveland, OH 44114
(216) 781-5100

Capitol Area Transit
901 N. Cameron St.
Harrisburg, PA 17105
(717) 233-5657

Port Authority of Allegheny Co.
121 7th Street
P.O. Box 1981
Pittsburgh, PA 15230
(412) 471-7450

Southeastern Pennsylvania Transportation
Authority (SEPTA)
12 S. 12th Street
Philadelphia, PA 19107
(215) 627-8200

Metropolitan Bus Authority
Munoz Rivera Avenue & Ochoa Street
P.O. Box 1029
Hato Rey, PR 00919
(174) 764-8383

Rhode Island Public Transit Authority
265 Melrose Street
Providence, RI 02907
(401) 781-9400

Dallas Transit System
101 N. Peak Street
Dallas, TX 75226
(214) 827-3400

Rapid Transit Lines
Main Building, Room 210
1212 Main Street
Houston, TX 77002
(713) 223-7171

San Antonio Transit System
Tower Life Building
San Antonio, TX 78205
(512) 227-5371

Northern Virginia Transportation Commission
2009 N. 14th Street
Arlington, VA 22201
(703) 524-3322

Metropolitan Transit Corp.
802 S. Dearborn Street
Seattle, WA 98134
(206) 622-1313

Municipality of Metropolitan Seattle
410 W. Harrison Street
Seattle, WA 98119
(206) 284-5100

Madison Service Corp.
166 S. Fair Oaks Avenue
Madison, WI 53704
(608) 249-6455

APPENDIX G

FEDERAL HIGHWAY ADMINISTRATION REGIONAL OFFICES

REGION 1
FHWA Regional Administrator
O'Brien Federal Building
Albany, New York 12207
(518) 472-6476

REGION 3
FHWA Regional Administrator
Room 1633
George H. Fallon Federal Office Building
31 Hopkins Plaza
Baltimore, Maryland 21201
(301) 962-2361

REGION 4
FHWA Regional Administrator
Suite 200
1720 Peachtree Road, N.W.
Atlanta, Georgia 30309
(404) 526-5078

REGION 5
FHWA Regional Administrator
18209 Dixie Highway
Homewood, Illinois 60403
(312) 799-6300

REGION 6
FHWA Regional Administrator
819 Taylor Street
Fort Worth, Texas 76102
(817) 344-3232

REGION 7
FHWA Regional Administrator
P.O. Box 7186
Country Club Station
Kansas City, Missouri 64113

Street Address: 6301 Rockhill Road
Kansas City, Missouri 64131
(816) 961-7563

REGION 8
FHWA Regional Administrator
Box 25246, Room 230
Building 40, Denver Center
Denver, Colorado 80225
(303) 234-4051

REGION 9
FHWA Regional Administrator
Two Embarcadero Center
Suite 530
San Francisco, California 94111
(415) 556-3951

REGION 10
FHWA Regional Administrator
Room 412, Mohawk Building
222 S.W. Morrison St.
Portland, Oregon 97204
(503) 221-2065

URBAN MASS TRANSPORTATION ADMINISTRATION FIELD OFFICES

REGION I
UMTA Representative
Transportation Systems Center
Room 277, Technology Building
55 Broadway
Cambridge, MA 02141
(617) 494-2055

REGION II
UMTA Representative
Suite 507
26 Federal Plaza
New York, NY 10007
(212) 264-8162

REGION III
UMTA Representative
3535 Market Street
Philadelphia, PA 19104
(215) 597-1084

REGION IV
UMTA Representative
Suite 501
1720 Peachtree Road, N.W.
Atlanta, GA 30309
(404) 526-3948

REGION V
UMTA Representative
Suite 700
300 S. Wacker Drive
Chicago, IL 60606
(312) 353-6005

REGION VI
UMTA Representative
Suite 9E24, Federal Center
1100 Commerce Street
Dallas, TX 75202
(214) 749-7322

REGION VII
UMTA Representative
Suite 633
601 East 12th Street
Kansas City, MO 64106
(816) 374-5845

REGION VIII
UMTA Representative
Suite 1822, Prudential Plaza
1050 17th Street
Denver, CO 80202
(303) 837-3242

REGION IX
UMTA Representative
Suite 7061
450 Golden Gate Avenue
Box 36125
San Francisco, CA 94102
(415) 556-2884

REGION X
UMTA Representative
Suite 7004
909 First Avenue
Seattle, WA 98104
(206) 442-4210

APPENDIX H

GLOSSARY

arterial street
A major highway, primarily for through traffic, characterized by a high vehicular carrying capacity and its continuity to other adjacent local streets.

bus rapid transit
A bus operation generally characterized by operation on an exclusive right-of-way which enables high speeds to be maintained.

busway
A grade separated right-of-way with full access control used exclusively by buses.

capacity
The maximum number of vehicles or passengers which have a reasonable expectation of passing over a facility during a given time period under prevailing conditions.

carpool
A group of people who share their automobile transportation to designated destinations, usually alternating drivers and vehicles.

CBD
An acronym for Central Business District, usually the downtown retail trade area of a city, or generally an area of very high land valuation, traffic flow, and concentration of retail business offices, theaters, hotels, and service businesses.

contra-flow lane
A traffic lane in which vehicles move in the opposite direction to other vehicles.

express bus
A conventional bus operating in limited stop service on a busway or in mixed traffic on freeways or arterials.

expressway
A divided highway for through traffic with full or partial access control and generally with grade separations at major intersections.

freeway
A divided highway for through traffic with full access control and grade separation at all intersections.

fringe area
That portion of a municipality immediately outside the CBD which is noted by a variety of business, industrial, service, and some residential activity.

level of service
A term which denotes any one of an infinite number of differing combinations of operating conditions that may occur on a given facility when it is accommodating various traffic volumes.

local bus
A type of bus service whereby the bus picks up passengers and discharges them at frequent, designated stops.

local street
A street or roadway used primarily for access to adjacent land use.

OBD
An acronym for Outlying Business District and referring to that portion of a municipality normally separated from the CBD and Fringe Area and where the chief land use is business activity; also characterized by its own traffic circulation superimposed on some through traffic.

operating cost
Those recurring costs in transportation systems which include drivers' wages (if applicable), salaries of administrative officers, maintenance, fuel (power), supplies, taxes, insurance, and supplies, but not depreciation or interest payments.

operating speed
The highest overall speed at which a vehicle can be safely operated under prevailing traffic and environmental conditions.

APPENDIX H (CONT.)

rail rapid transit
A passenger-carrying rail system on an exclusive right-of-way and which generally serves one contiguous urban area.

reserved lane
A class of lanes on roadways to be used exclusively by designated vehicles ranging from lanes on freeways, to lanes on major arterial streets, to lanes on local streets.

roadway design speed
A speed selected for purposes of design and correlation of those physical features of a roadway such as curvature, super-elevation, sight distance, upon which the safe operation of vehicles is dependent.

route (bus)
A designated, specified path over which a bus or fleet of buses is assigned and which indicates stops for serving passengers.

service volume
The maximum number of vehicles that can pass a given point during a specified time period and while maintaining a desired level of service.

signal pre-emption
An electro-mechanical device usually placed in or on a vehicle where the driver can alter, within predetermined bounds, the signal cycle and thereby increase the length of green time permitting that vehicle to pass through without being subjected to signal delay.

station
An enclosed or partially covered area whose main function is to process large volumes of transit passengers efficiently. Stations are of two types: off-line and on-line. The former is a station in which the roadway on which the vehicle stops is not part of the main line. The latter is a station in which the vehicles stops along the main line.

transportation costs
That part of operating costs which includes the cost of conducting transportation: drivers' wages, supervision, fuel, and associated administrative costs directly related to operation.

uninterrupted flow
A condition in which a vehicle while on a right-of-way is not required to stop or slow down due to signals, signs, or opposing intersections.

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