LOW COST URBAN TRANSPORTATION ALTERNATIVES

A Study of Ways to Increase the Effectiveness of Existing Transportation Facilities

EXECUTIVE SUMMARY

Prepared by

R.H. Pratt Associates, Inc.
Kensington, Maryland

January 1973

Prepared for
Office of Urban Transportation Systems
Assistant Secretary for Policy, Plans, and International Affairs
U.S. Department of Transportation
Washington, D.C.

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UNITED STATES GOVERNMENT

DEPARTMENT OF TRANSPORTATION

OFFICE OF THE SECRETARY

Memorandum

DATE: June 7, 1973

SUBJECT: Pratt Study

In reply refer to:

FROM : Acting Assistant Secretary for Policy, Plans, and International Affairs

TO : The Secretary

I am pleased to transmit a report on "Low-Cost Urban Transportation Alternatives," the culmination of a research contract directed toward more efficient utilization of existing transportation facilities, a subject of considerable interest to the Department and the Secretary's Urban Transportation Advisory Council.

The study was initiated by the Office of Urban Transportation Systems and supported by the Urban Transportation Advisory Council, whose recommendations on low- and non-capital alternatives were consistent with those of the study and led to Secretary Volpe's endorsement of the concept. Moreover, you have supported the application of a number of these approaches to the transportation problems in some of our largest cities. The study was designed to evaluate in a systematic manner a number of low- and non-capital approaches to the improvement of urban transportation systems. In addition, one of the most promising of these approaches--busway applications--was given an in-depth treatment to document the experience of a number of existing operations.

The principal investigator, John Dupree of R.H. Pratt Associates, Inc., received valuable assistance from John Lundin, Carl Rappaport, Charles Hedges, and Raymond Weil, all of the Office of the Secretary, Edward Fleischman of the Federal Highway Administration and others throughout the Department, in turning out what should prove to be a useful and practical study.

The Department believes that this study is a step toward the more efficient utilization of the current extensive investment in urban transportation facilities.

Robert Henri Binder

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16. Abstract This Study was designed to survey and report on a variety of techniques for improving the utilization of the existing investment in transportation capital facilities. Concepts receiving primary attention were those directed toward reducing peak period transportation demand and/or increasing the carrying capacity of existing facilities. The idea was to identify and explore such low cost techniques, technologies, or management strategies with the hope that some would be found to serve as alternatives to increased investment in transportation capital facilities. The Study proceeded in two phases. First, a survey and analysis of twenty-one candidate techniques was performed to provide a balanced assessment of the promise of low cost alternatives (Volume I). Second, case study analyses of selected promising concepts were performed in order to provide more information about the application potential of the more highly rated techniques (Volume II). The concepts selected for case studies were those related to use of traffic lanes or roadways for fully or partially exclusive use by public transit busses.

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PREFACE

This is a summary of a broad investigation into the concept of using certain inexpensive transportation techniques or technologies as alternatives to high cost conventional transportation facilities.

The underlying premise investigated by these studies is that so-called low cost alternatives will improve the operating efficiency of the present transportation system. In this way, construction of new highways, airports, and urban rail facilities may be, in some circumstances, postponed or perhaps indefinitely curtailed.

As will be seen, the actual investigations and analyses were carefully structured to touch on a wide variety of decision issues, ranging from the economic to the non-economic, from the technical to the institutional.

This summary, along with the two main reports of the study, is designed to provide an effective knowledge of the investigations undertaken. Hopefully, these reports will serve as a useful reference to both the professional and lay transportation decision-maker providing substantial clarification of the promise of low cost alternatives.

TABLE OF CONTENTS

BACKGROUND

The dominant feature of urban transportation development over recent decades has been the continuous rapid growth in demand for urban transportation services which has frequently outstripped growth in the nation's transportation supply. As a result congestion too often clogs the nation's urban highways, airports, and even certain rail transit facilities. Delay and crowding accompanies many peak hour trips while the concomitant environmental impacts of prevailing patterns of transportation useage has only served to further degrade the quality of urban life.

Historically the most frequent response to increases in transportation demand has been development of new capital intensive facilities such as highways, rail facilities, and airports. This response to transportation congestion and delay is characterized chiefly by high cost and slow implementation attributable to the extensive amounts of time required to fund, plan, and actually build such facilities. Too often as a result such facilities are completed long after they are needed and, when finally opened, demand may well overwhelm capacity with crowding and congestion soon reoccurring. The impetus to reinitiate the capital facility cycle thus begins anew. Finally it should be noted there has been a not insignificant amount of Congressional support for capital intensive approaches in the form of legislation, making technical assistance and Federal funds available to local governments for capital facility planning and construction.

In recent years however, a re-examination of transportation planning and urban priorities has raised serious questions about such traditional responses. The cost of such facilities has accelerated significantly, often to the point where development costs may exceed benefits. The resulting neighborhood and environmental disruption has generated substantial public concern and occasionally, active resistance. Thus, due to these and other reasons, serious questions have been raised about the wisdom and effectiveness of conventional capital and land intensive solutions directed principally to meeting apparently insatiable rush hour demands.

THE CONCEPT OF LOW COST ALTERNATIVES

The objective of the study was to critically appraise the potential of less expensive approaches to urban transportation service improvements in the area of congestion relief. Implicit in this concept of low cost alternatives is the idea that such techniques would develop more effective ways of utilizing the existing extensive investment in transportation facilities through revisions in operation procedures, technologies, or management.

As the study progressed, it became apparent that the basic criterion for achieving these systems efficiency improvements was to improve processing efficiency. More specifically this included two basic elements:

1. Reducing travel time for users of existing capital facilities

2. Increasing volumes of people carried by existing facilities

Thus the investigations in this study were oriented towards techniques to increase the effective <u>processing efficiency</u> of existing facilities.

PRINCIPLE FINDINGS

Three broad and general findings emerged from the survey of low cost techniques.

(1) Low cost alternatives provide a wide range of utility. Benefits related to increases in processing efficiency range from very marginal to order of magnitude improvements.

Some techniques were found to be extremely useful. Those ranked as "most favorable" may have sufficient benefits, under the right circumstances, to serve as effective substitutes for capital intensive convention solutions while costing relatively little. It was found that such techniques may prove useful both as short term solutions to vexing transportation problems and as components in long range planning to accomodate increased demand.

Most of the techniques reviewed were classified in a middle group exhibiting modest potential. While the cost of these techniques may be very little, their impact will typically not be sufficient to absorb normal growth in travel demand. They thus do not generally provide significant alternatives to more capital intensive approaches such as building new transit systems or, where acceptable, highway facilities. Many of these techniques had moderate to marginal benefits but also had important counterbalancing limitations. Of course in any given application circumstance the generalized drawbacks may not be relevant obstacles, while the benefits may be underestimated for the particular local transportation need.

When viewed in terms of the study context, namely concern with the effectiveness of low cost alternatives for alleviating capacity-related urban transportation problems, a few techniques were not found to be useful at all. Again, even these techniques may find application to a specific community's unique requirements.

(2) A second general finding was that as a group, mass transit oriented improvements would have the greatest impact. This is understandable since the potential to put 50 passengers into one transit vehicle represents a space economy of perhaps 20 to 1 over such individual modes as the automobile. A good example of this efficiency was the case study finding detailed in Volume II that a single lane of highway used exclusively by buses would provide passenger carrying capacity in excess of almost any known corridor's level of demand.

(3) By and large, little or no serious research has been directed at low capital alternatives. As a result communities are basically uninformed about the concept _per se_ and implications for planning and community finances are not well understood. Perhaps by default then, capital intensive solutions are likely to be proposed as solutions to transportation crises that might be equally or better resolved through application of less expensive techniques.

STUDY LIMITATIONS

Funding and project timing necessitated focusing the study on a limited set of investigations. Chief omissions as a result of these limitations were:

- Any examination of combinations of low cost alternatives into systems either in conjunction with capital facilities development or in combination with other low cost elements. There is reason to believe that further urban transportation efficiencies may result from such systematic treatment of low cost alternatives.

- Comprehensive study of the airport and urban rail service components of the urban transportation system.

- Examination of travel patterns and needs not directly related to radial corridor peak hour requirements.

SCOPE OF THIS SUMMARY:

The intention of this executive summary is to provide a brief overview of the study's methodology and to highlight the most significant of the findings.

Chapter I provides a brief summary of the approach used in preparing the analyses of the twenty-one low cost alternatives selected for review. Included is an explanation of how the study arrived at conclusions regarding the relative merit of each studied alternative. Further and more specific details on each of the twenty-one concepts is provided in the appendix to the executive summary. Here will be found brief summaries of the findings for each low cost concept analyzed.

Chapters two through five highlight findings of the case study investigations into various applications of busways. Busways were studied in great detail in the latter stages of the project after selection as perhaps the most promising of the low cost techniques reviewed. In addition, special attention is given to this phase of the investigation because of the desire to stress the relevancy of busways to the resolution of current and pressing urban transportation needs.

Readers are necessarily cautioned that greater detail and more complete information on the topics touched on in this executive summary is to be found in Volume I and II of this report.

CHAPTER I

SUMMARY OF STUDY METHODOLOGY AND FINDINGS OF PRELIMINARY INVESTIGATIONS

The study was initiated when twenty-one candidate "low cost alternatives" were selected after mutual consultations between the study staff and the United States Department of Transportation.

Initial activities were concerned with obtaining comprehensive literature on each candidate concept. Data and findings from the literature were used in developing a balanced profile of each concept. The resulting findings were assembled into a brief paper on each alternative with discussion of findings regarding thirteen critical implementation issues accompanying an operating description and summary critique. The thirteen implementation issues or evaluation criteria were selected deliberately to encompass a wide range of decision making criteria ranging from the technical to the political, from the economic to the non-economic. The resulting discussion of each technique is therefore designed to objectively answer questions raised by a wide variety of interests, ranging from city planners to local citizen's groups. These thirteen critical evaluation criteria are as follows:

- User price impacts
- Implementation costs
- Operating costs
- Other costs
- Indirect Economic Effects (for example, degree to which technique serves as an alternative to capital facilities development).
- Effects on Disadvantaged
- Environmental Impact
- Safety Impact
- Speed or Time

- Volume

- State-of-the Art

- Institutional Background

- Traveler Response

These criteria are further defined in Volume I.

EVALUATION AND RANKING

Each of the twenty-one concepts were rated according to a simple scale on their degree of impact as measured by the above thirteen criteria. Concepts were then ranked according to their cumulative ratings. The twenty-one techniques comprising the initial group of low cost alternatives surveyed are listed below in the three groups which resulted from the ranking exercise. Techniques are not listed in any order of preference within groups.

Group I <u>All Around Most Promising Techniques</u>

- Exclusive Bus Lanes on Urban Arterials (Existing Facilities)

- Exclusive Reserved Lanes on Freeways for Mass Transit (Existing Facilities)

- Exclusive Busways on Specially Constructed Rights-of-Way

- Work Scheduling Changes

- Highway Traffic Engineering Systems Improvements

Group II <u>Less Generally Promising Techniques</u>

- Paved Railroad Rights-of-Way

- High Capacity Transit Buses

- Organized Commuter Car and Bus Pools

- Freeway Metering, Monitoring, and Control Systems

- Free or Heavily Subsidized Transit

- Line Haul Feeder Systems
- Airport Access Improvements
- Automation of Bus Scheduling
- Economic Penalties and/or Incentives
- Urban Goods Movement Improvements
- Para Transit (Jitney's, Taxis, and Limousines)

Group III <u>Least Useful to Achieve Project Objectives</u>

- The Rail Bus
- Demand Actuated Bus Services
- Bus Traffic Signal Preference Systems
- Auto Driver Aids and Direction Systems
- The Minicar

It should be noted that the purpose of the ratings was to provide a simple screening technique for sifting out the techniques relatively more acceptable and technically practicable and promising. As a result, the resulting groupings reflect specific project objectives. Certain of the techniques would be rated higher if, for example, the objective of improved mobility for the disadvantaged was a major study goal. More details, qualifications and limits on the rating scheme, evaluation critera and related material can be found in Volume I.

In the appendix a short form review and technical summary of eighteen low cost alternatives is provided as a guide to the more completely detailed investigation reported in Volume I.

As can be noted, three types of busway applications were among those techniques rated most highly. After review with Department of Transportation officials it was decided that busways were especially suitable topics for case study investigation in the second phase of the study. The results of these case study investigations are briefly summarized in the following chapters and more completely detailed in Volume II.

These three concepts are therefore excluded from the appendix of the executive summary.

CHAPTER II

BUSWAY APPLICATIONS: A VERY PROMISING LOW COST ALTERNATIVE

Busways in all forms were found to be among the most promising of the low cost techniques reviewed. Some exclusive bus lanes and similar applications are not unknown to transportation planners, having been in existence for a number of years. Yet after visits and discussions with traffic engineers and planners in many cities, it is evident that much confusion and misinformation exists about busways. Before turning to a summary of benefits, operating and technical information, this chapter describes and clarifies what is meant by busway applications.

PRINCIPLE OPERATING CHARACTERISTICS

The term "busway" covers many applications which provide some degree of priority for buses over other vehicles and examples range from simple freeway ramps to lengthy stretches of limited access roadways dedicated to the exclusive use of buses. The most useful busway applications have these operational characteristics in common:

- Only buses and in some special cases, taxis, carpools, and emergency vehicles, may use the facility when it is in operation. Prohibitions against general use of such lanes are strictly enforced.

- Busways are primarily oriented towards relief of congestion. Exclusive bus lanes are designed to effectively circumvent congestion delays, and frequently these facilities are in operation only during peak hours. In some cases twenty-four hour operation reflects more extensive round the clock congestion experienced in that particular environment.

- The busway facility is usually designed to provide the bus rider with a transportation advantage over commuting by auto.

While most busways have the above characteristics in common, the ubiquitous nature of buses combined with a diversity of urban planning constraints have resulted in a wide variety of actual applications.

As a result several distinctive operating patterns have developed in response to different resources and needs. These major operating distinctions are summarized below.

- Use of Specially Constructed Rights-of-Way vs. Existing Roadways

  A major point of differentiation between busways relates to the nature of the roadway used. A separate, specially constructed and dedicated roadway adjacent to, in the median of, or otherwise related to an existing highway is one solution. In the case of power line or abandoned railway rights-of-way, paving the right-of-way is an effective way of establishing a dedicated busway. Construction of dedicated separate lanes of pavement for the exclusive use of buses is a high priority item in the planning of transportation improvements in a number of cities. These facilities cost about the same as a single lane automobile facility although passenger carrying capacity is much less. In some cases special exit and entrance ramps are planned.

  Contrasted with such specially constructed rights-of-way are line haul busway facilities which use existing roadways. Two examples predominate in applications to date:

  1. Reversal of a freeway lane which normally carries traffic in the opposite direction.

  2. Reversal of one lane on a typical arterial one-way street.

  Other possibilities include reservation of a lane on a multi-lane arterial either with or against the flow of traffic for use of mass transit vehicles or reservation of a complete street.

  Costs are much higher and lengthy periods of construction are involved when a bus lane is newly constructed. A busway using an existing facility can be established at very low cost and be operational in a matter of weeks.

  An important subsidiary finding of this study was that few cities or transportation planners were able to recognize the extent to which existing roadways are both under-utilized and suitable for establishing exclusive busways.

With Flow vs. Contraflow

A second major operating distinction relates to the manner in which buses may interact with other traffic. Bus lanes can operate as a separate lane with the normal flow of traffic or operate against the flow of traffic in a separate lane. Under conditions of mixed traffic and in the absence of physical separation, the more successful line haul applications appear to be those where the bus operates contraflow.

The success of a contraflow lane is largely due to its intrinsic self-enforcing nature which keeps the lane exclusive and uncongested. Motorists are reluctant to drive or park even briefly in exclusive lanes carrying traffic in the opposite direction. Some intimidation can undoubtedly be attributed to the size and weight of buses using the contraflow lanes. Contraflow lanes on arterials have not required excessive enforcement.

Freeways, Arterials, One-Ways

Busways have been implemented on all types of existing roadways. Busways on freeways provide uninterrupted line haul trips, frequently under free flow conditions. Such facilities are rarely subject to delays on the bus lane portion of the trip and are therefore likely to save the most trip time for users. They are often designed to bypass the queues which frequently develop around freeway bottle-necks during peak hours, such as where lanes converge and demand remains unchanged or where tunnels or bridges are encountered. Various techniques, not all of them satisfactory, have been devised to assist buses in maneuvering to and from bus lanes when separate entrance and exit facilities are not available. Fringe parking lots have been used successfully in conjunction with exclusive bus lanes on freeways.

Arterials can also be converted to busway use when conditions are appropriate. While the time savings of arterial facilities may be significant, savings are usually less than for freeways since the bus in most cases is subject to delays occasioned by stops to discharge and pick-up passengers as well as to respond to traffic lights.

As will be detailed later, one-way street systems are among the best candidates for use as arterial contraflow bus lanes. However, the findings of this study suggest that nearly any type of arterial street may be converted to busways. A complete discussion of roadway geometrics and application possibilities is found in Volume II.

In summary, busways are facilities designed to enable the transit trip to have a speed advantage over normal mixed traffic. This is accomplished through the separation of bus traffic from normal traffic.

A variety of techniques reflecting the adaptability of busways to diverse urban environments may be used to achieve this transportation advantage.

CHAPTER III

BUSWAYS: A SUMMARY OF MAJOR FINDINGS

It is not possible to present in this brief summary the complete results of the investigations and analyses of busways undertaken throughout this study. That material is presented in more complete form in Volume II of the main report. Instead, highlights from the study's findings are presented here to illustrate the potential for busway applications and the major advantages as evidenced from actual implementation experience.

At the same time this summary should serve to demonstrate why busways ranked so high in the survey of twenty-one low cost alternatives.

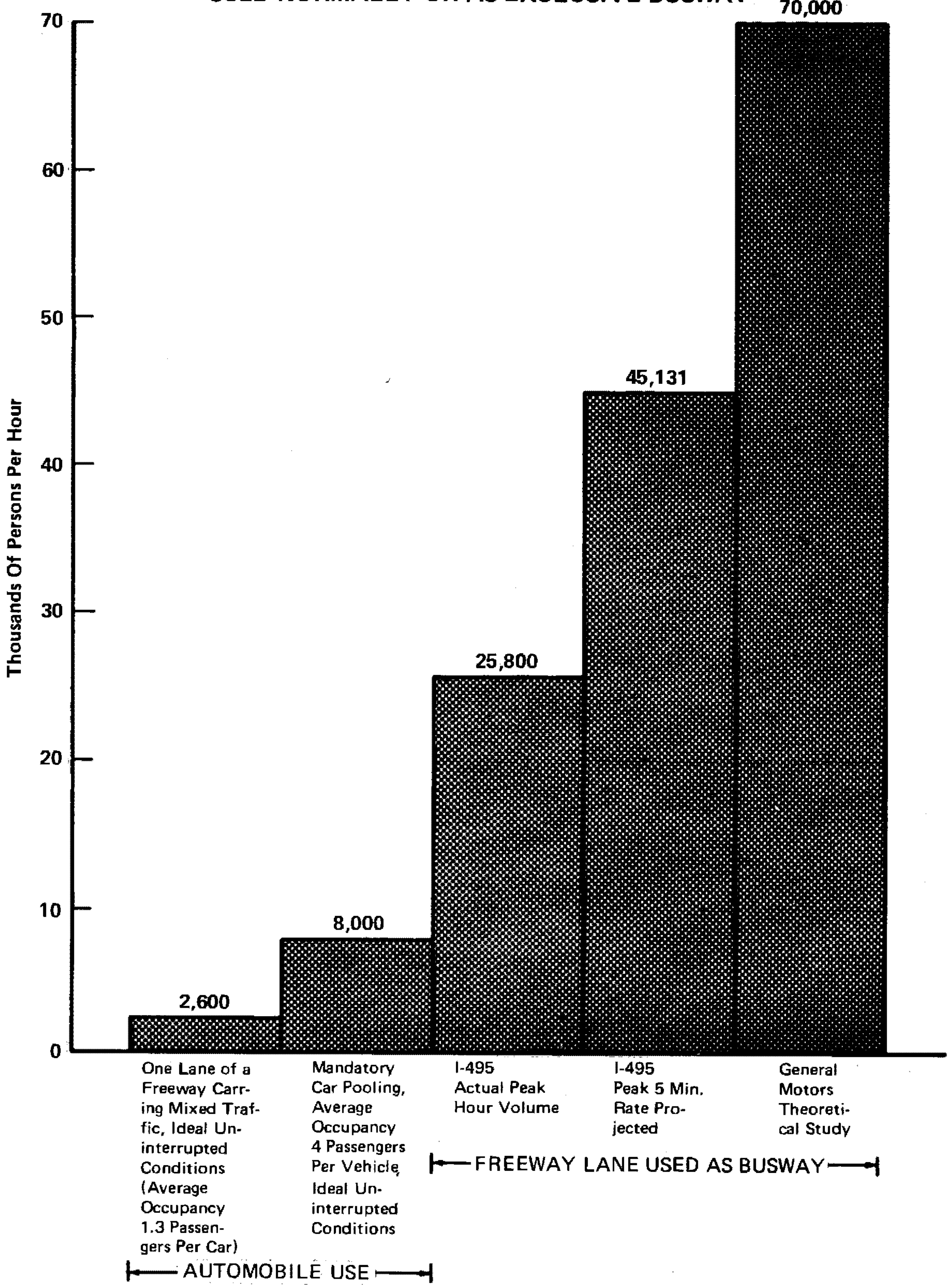
1. ORDER OF MAGNITUDE CAPACITY IMPROVEMENTS

Unlike most concepts studied, busways offer opportunties to increase the volume of persons carried on a lane of highway by several orders of magnitude. Figure 1 illustrates the difference between potential passenger carrying capacity of a traffic lane used as a busway and maximum levels under normal circumstances. As indicated, peak hour passenger volumes as high as 25,800 have been observed on a limited access busway lane. Theoretical studies indicate that it may be possible to carry as many as 70,000 passengers per hour. In contrast 2,600 persons per hour is the normal maximum passenger volume expected on a mixed traffic, limited access highway lane with few or no buses. (If average occupancy of a predominantly auto-oriented lane were increased to four passengers per vehicle through compulsory carpooling then potential volumes would be on the order of 8,000 people per hour.)

The potential passenger volume which can be accomodated by a bus-only lane is so great that few known corridors could generate sufficient demand to exceed this theoretical capacity. In addition, a survey of existing busways quickly reveals that these facilities are nowhere near maximum utilization.

The substantial increases in capacity available from busways are theoretically available from any wholesale substitution of bus mass transportation for private automobile use. A key problem with bus mass transportation to date is that is has not been possible to attract riders in the volumes necessary to capitalize on potential capacity. Unlike almost all other bus transportation improvements, service on busways can prove more

Figure 1
RELATIVE HOURLY VOLUMES IF HIGHWAY LANE USED NORMALLY OR AS EXCLUSIVE BUSWAY



See Text of Chapter 5 For More Detail and Sources.

attractive than private automobiles mainly due to increase in speed and therefore offer definite opportunities to more fully realize the capacity potential of bus mass transit.

The substantial volumes that can be processed on busways are chiefly responsible for the major ability of busways to improve the productivity of existing capital facilities. In five of the seven case study cities there is evidence to indicate that busways serve as direct substitutes for more traditional capital intensive auto or rail facilities. In several cases they represented alternatives to highway construction which the community refused to permit. In other cases traditional approaches were too expensive when compared with available funds.

2. SUBSTANTIAL COMMUTER TIME SAVINGS

Unlike most transportation improvements studied during this investigation and others that are often recommended, busways do generate substantial savings in travel time during peak periods. In the outstanding example, patrons of buses using the Long Island Expressway are reported to save as much as fifteen minutes over parallel congested traffic. This savings amounts to about eighty-five percent of total auto travel time over the distance of the exclusive bus lane. Savings reported for other successful busways are summarized in Table 1.

Unfortunately there are no thorough studies of changes in door-to-door trip time; however, there is some evidence to indicate that travelers can reduce their total travel time commitments each morning and evening. Time savings are a major factor in inducing commuters to use mass transit.

Both substantial travel time savings and high volumes of passengers carried can be achieved when buses operate at an average speed of thirty-three miles per hour. Thus, the substantial advantages of busway operations do not accrue from the attainment of unrealistically high operating speeds.

3. AN INEXPENSIVE SOLUTION

Busways provide an inexpensive way of avoiding peak period congestion and the attendant inconvenience and frustration. While a number of planned or proposed busways utilize separate specially constructed capital intensive facilities, a major finding of this study is that substantial capacity for busways is available on existing roadway systems. In a great many cases there are elements of existing systems which are under utilized during times of peak period travel and are quite acceptable for busway use.

Even when a full lane of excess capacity does not exist, it may be more cost efficient and socially desirable to subject mixed traffic to marginal penalties in order to obtain the substantial advantages of an exclusive busway than to further endure present conditions. In such cases, the capital facility is available at no capital cost of any consequence.

Preparation of the facility for bus land use has proved quite inexpensive, usually involving only striping and signing. Normally it can be accomodated within the operating budget of the local highway agency. In one admittedly undercontrolled case the cost of preparing the roadway was so minor that no separate budgeting was necessary. More elaborate preparations in several instances included extensive signing, striping, cone barriers, minor construction, and public relations yet costs were still held to less than $50,000. Daily operating costs on facilities which are switched during the day to accomodate other uses may require extra budgeting, however. In this regard a choice exists between low capital cost equipment requiring manual operation and equipment which is more automated but costs more initially.

TABLE 1: Summary of Travel Time Savings on Seven Case Study Busways.

Site	Length of Exclusive Facility (miles)	Bus Time Saving Over Auto		Bus Time Saving Over Former Bus Time	
		Mins.	%	Mins.	%
Freeway Facilities					
• I-495, New Jersey	2.5	Not Available		10	Not Available (a)
• Long Island Expressway Long Island	2	15	85	N.A.	N.A.
• Southeast Expressway Boston	8.4	7.5	42	14	58
Specially Constructed					
• Shirley Highway Washington, D.C.					
AM	9	13	33	N.A.	N.A.
PM	9	20	54	N.A.	N.A.
Arterial					
• Third St., Louisville (b)	2	Slower		5.5 to 12	13 to 28
• College Ave., Indianapolis	-------- No Data --------				
• Fernandez Juncos, Ponce de Leon, San Juan	10.4	N.A.	N.A.	30	38

(a) Increases in speeds were noted for all eastbound traffic whether traveling the bus lane or not.

(b) Times shown for Louisville are for total bus route; data are not available for the portion of the trip on the exclusive bus lane.

4. IMMEDIATE IMPLEMENTATION

If existing roadways are utilized, busways can be operable in a matter of weeks. As a result, no time consuming design or construction lead times need be anticipated. Planning lead time can be further minimized if existing bus service does not need to be rerouted. In addition the non-permanent, flexible nature of busways will allow changes in demand and traffic conditions to be accomodated easily and quickly with new patterns of transportation service.

5. UNIVERSAL APPLICATION

Almost any existing street type, design configuration, or traffic system can be adapted to busway use. The primary concern in deciding whether an existing roadway should be developed into a busway is not a question of design but instead, of whether it is feasible and desirable

TABLE 2: Survey of Exclusive Lane Implementation and Operating Costs in Seven Case Study Cities

Site	Miles	Implementation Costs	Operating Costs Attributable to Exclusive lane
Converted Freeway Facilities			
. I-495 New Jersey	2.5	$750,000 [a]	$171,000 Annual
. Long Island Expressway, Long Island	2	$ 50,000 (Est.)	$ 500 Day (Est.)
. Southeast Expressway, Boston	8.4	$ 50,000 (Est.)	$ 500 Day (Est.)
Specially Constructed			
. Shirley Highway	9	$620,000 mile	Insignificant from prior costs
Converted Arterial Facilities			
. Third St., Louisville, Ky.	2	$ 30,000 (Est.)	Insignificant from prior costs
. College Ave., Indianapolis	2.9	Very Low	Insignificant from prior costs
. Ponce de Leon Fernandes Juncos	21.6	$100,000 Plus Staff Time	Insignificant from prior costs

(a) Costs here are not representative due to several factors explained in Volume II.

to remove a lane from general traffic use. It is clear from this study which briefly investigated the potential for busways in twelve representative cities that all but the smallest city has some potential for busway applications. Figure 2 illustrates typical roadway designs converted to bus lane use.

The chief reason for this universal potential is that all cities have an extensive urban highway network. By virtue of both design and the nature of urban usage patterns these highway networks may be well suited to adaptation as busways.

6. AN ATTRACTIVE MODE

Unlike most inexpensive transportation improvements which involve mass transportation service, indications are that commuters genuinely appreciate the benefits of mass transportation as provided by an effective exclusive busway. This has resulted in documented changes of travel mode both from other mass transit service as well as from private automobiles. For example, 59% of new riders on buses using the I-495 exclusive bus lane from New Jersey to Manhattan gave the exclusive bus lane service as their reason for switching from auto or other mass transit service to their present bus route. The Park-n-Ride lot at the outbound terminus of the I-495 exclusive bus lane has shown a dramatic increase in usage. Similar evidence though less well documented is available from the other effective exclusive bus lanes.

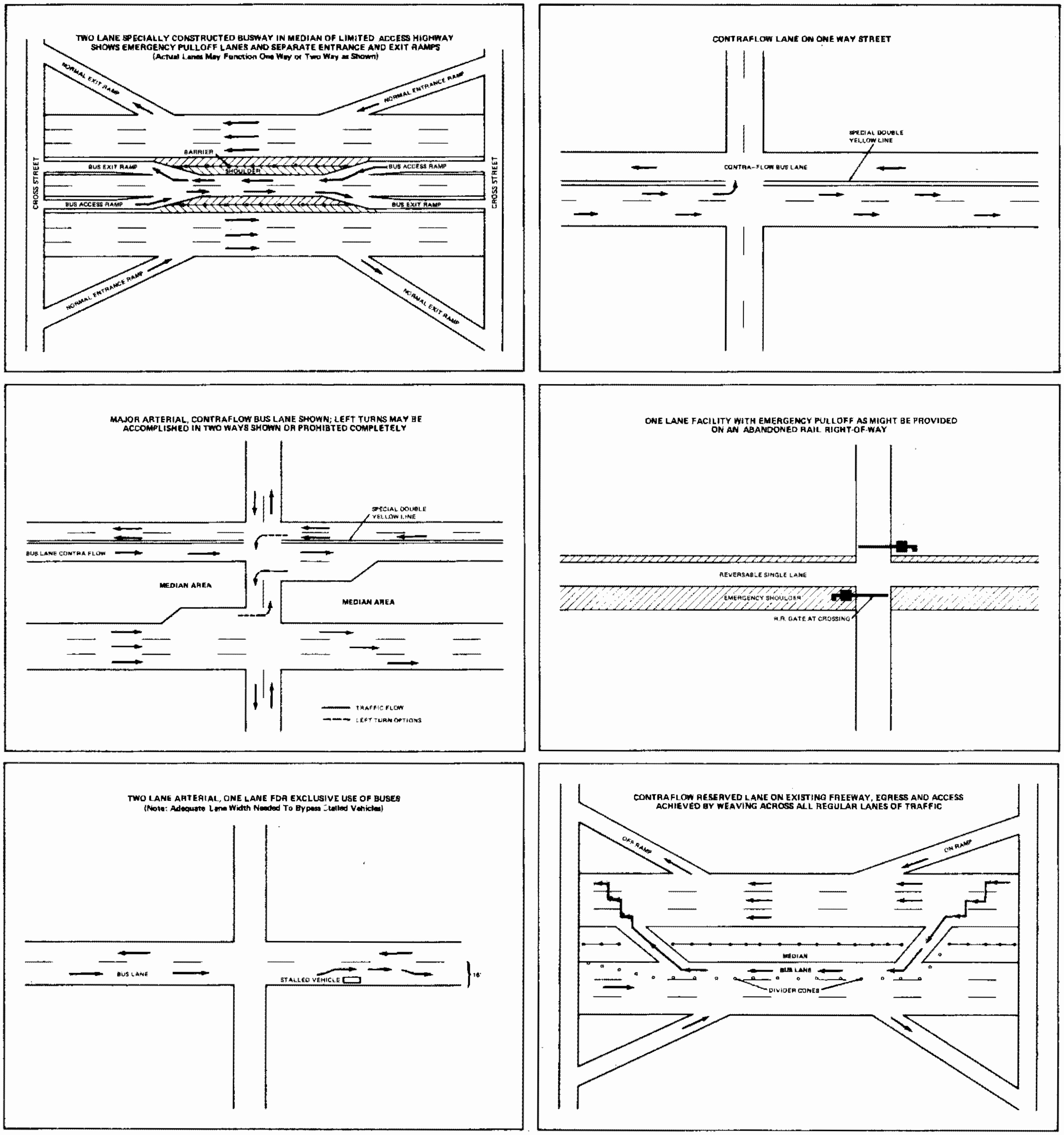
These mode choice influences appear to be directly related to the trip time advantage for commuters using buses on exclusive rights-of-way. This is further discussed below in the review of conditions under which busways might be expected to be successful; however, it is important to note here that these mode choice changes are induced and not forced. At a time when consideration is being given to various schemes which would reduce automobile use through absolute prohibitions, it is useful to point out that there are measures available which need not be so drastic or politically and socially unpopular.

7. OTHER BENEFITS

A number of minor benefits should be mentioned:

- Improved vehicle and driver productivity due to the absence of congestion delay
- Reduction in vehicle wear and tear as evidenced by more miles between brake, clutch, and engine overhauls

Figure 2


TWO LANE SPECIALLY CONSTRUCTED BUSWAY IN MEDIAN OF LIMITED ACCESS HIGHWAY SHOWS EMERGENCY PULLOFF LANES AND SEPARATE ENTRANCE AND EXIT RAMPS
(Actual Lanes May Function One Way or Two Way as Shown)
NORMAL EXIT RAMP
NORMAL ENTRANCE RAMP
BARRIER
SHOULDER
BUS EXIT RAMP
BUS ACCESS RAMP
BUS ACCESS RAMP
BUS EXIT RAMP
CROSS STREET
CROSS STREET
NORMAL ENTRANCE RAMP
NORMAL EXIT RAMP
CONTRAFLOW LANE ON ONE WAY STREET
SPECIAL DOUBLE YELLOW LINE
CONTRA-FLOW BUS LANE
MAJOR ARTERIAL, CONTRAFLOW BUS LANE SHOWN; LEFT TURNS MAY BE ACCOMPLISHED IN TWO WAYS SHOWN OR PROHIBTED COMPLETELY
SPECIAL DOUBLE YELLOW LINE
BUS LANE CONTRA FLOW
MEDIAN AREA
MEDIAN AREA
TRAFFIC FLOW
LEFT TURN OPTIONS
ONE LANE FACILITY WITH EMERGENCY PULLOFF AS MIGHT BE PROVIDED ON AN ABANDONED RAIL RIGHT-OF-WAY
REVERSABLE SINGLE LANE
EMERGENCY SHOULDER
R.R. GATE AT CROSSING
TWO LANE ARTERIAL, ONE LANE FOR EXCLUSIVE USE OF BUSES
(Note: Adequate Lane Width Needed To Bypass Stalled Vehicles)
BUS LANE
STALLED VEHICLE
16'
CONTRAFLOW RESERVED LANE ON EXISTING FREEWAY, EGRESS AND ACCESS ACHIEVED BY WEAVING ACROSS ALL REGULAR LANES OF TRAFFIC
OFF RAMP
ON RAMP
MEDIAN
BUS LANE
DIVIDER CONES

Substantial collective user time savings which may be valued in the millions of dollars annually

8. SAFE OPERATION

Despite the unusual and often seemingly dangerous operating patterns that have been developed, safety is not jeopardized after installation of exclusive bus lanes. The Long Island Expressway and Boston AM contraflow freeway bus lane along with the Shirley Highway facility have reported no accidents. In New Jersey police report that accident rates on I-495 have declined since the facility was placed in operation. Studies of contraflow arterial application also indicate that safety in some instances has been improved after installation of the exclusive bus lane.

CHAPTER IV

SUMMARY OF IMPLEMENTATION EXPERIENCE

Seven operating busways were selected for case study investigation in Phase II of this project. These seven busway examples were selected on the basis of being noteworthy representatives of various operating configurations. Volume II presents an in-depth examination of the technical, operational, and institutional characteristics of each studied busway. A brief description and summary of each case study busway is presented in this Chapter. The seven examples were grouped into the following classifications:

Peak Period Contraflow Lanes on Freeways:

- New Jersey - I-495 Approach to the Lincoln Tunnel
- New York City - Long Island Expressway
- Boston - Southeast Expressway

Contraflow Lanes on Arterials

- Louisville - Second and Third Streets, a one-way pair
- Indianapolis - College Avenue, a one-way street
- San Juan - Fernandez Juncos and Ponce de Leon Blvds.

Specially Constructed Busway Facility:

- Washington, D.C.- (Northern Virginia Suburbs) - Shirley Highway

The following paragraphs briefly describe and present a few key findings from each case study example.

PEAK HOUR CONTRAFLOW LANES ON FREEWAYS:

CASE STUDY 1: New Jersey, I-495; Approach to the Lincoln Tunnel

I-495 is a 2.5 mile long, six lane limited access highway leading from suburban New Jersey to the Lincoln Tunnel approach to mid-Manhattan.

On this facility a normally westbound lane next to the median has been reversed for use by eastbound buses. (See Figure 3) The lane is physically separated from the remaining westbound lanes by cylindrical plastic traffic posts set into inconspicuously drilled holes in the roadway. Additional control is obtained from overhead electronically operated directional signals as well as roadside signs with manually changeable messages. The lane operates only in the morning peak period on weekdays. In the evening the so-called "reverse funnel" effect eliminates the need for reserved lanes westbound. That is, the bottleneck at the eastern entrance to the tunnel limits the rate at which cars enter New Jersey. The buses escape this bottleneck through special ramps from a bus terminal to the tunnel and once on I-495 operate essentially under free flow conditions due to the lighter resulting volumes on I-495.

The facility serves as an alternative to building additional roadway facilities and reflects a reluctance on the part of New York City to build additional freeways into Manhattan.

Perhaps the most important finding of this case study relates to the tremendous capacity potential of busways revealed by this demonstration. Daily peak period bus volumes in excess of 700 vehicles have been observed. For the peak hour, 400 plus buses use the lane. In certain peak five minute periods between sixty-two and sixty-eight buses were reported. This rate of flow projects to an hourly volume of between 745 and 817 buses. Translated into passengers per hour, the existing peak hour maximum volume recorded was 25,800. If sustained for an hour, peak five minute volumes would result in 42,484 bus passengers per hour. In the latter case no operational problems are anticipated if demand were sufficient to generate this volume of bus traffic (See Figure 1).

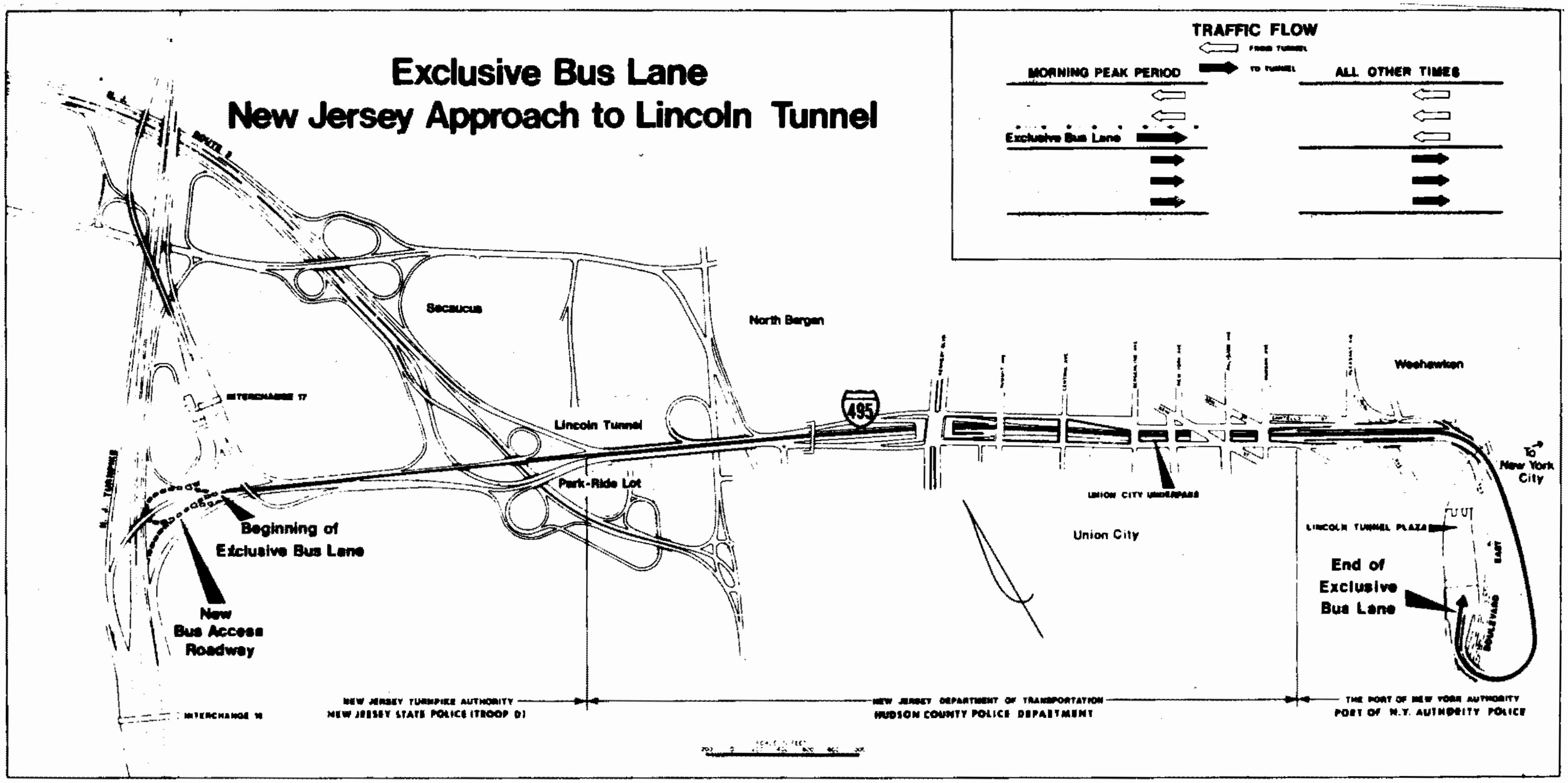
It was also noted that total vehicle flow (volume) eastbound improved forty percent after the segregation of buses, a rate higher than might be expected if an additional lane has been opened for mixed traffic.

Buses using the facility during the peak hour save an average of more than ten minutes. Greater time savings were recorded whenever normal eastbound traffic incurred substantial delays due to heavy congestion or breakdowns, a frequent experience. Time savings were also reported for the three lanes of mixed eastbound traffic.

While a vast majority of commuters already are using transit in this corridor, it was interesting to note that a survey of new riders on the I-495 service indicated that 59% choose the new route because of the express bus lane.

Figure 3

MAP OF EXCLUSIVE BUS LANE ON I-495 APPROACH TO LINCOLN TUNNEL



Buses use the exclusive lane on the Interstate Route 495 approach to the Lincoln Tunnel during the morning peak period of each work day. The additional eastbound lane, for buses only, is one of the three lanes which ordinarily carry traffic in the westbound direction. These lanes have light use during the period of 7:30 to 9:30 a.m. on weekdays when the exclusive bus lane is in operation. This change provides four lanes for New York-bound traffic. Jurisdictional limits of maintenance and police agencies are shown at bottom.

SOURCE: Tri-State Regional Planning Commission, Exclusive Bus Lane, I-495, Interim Report No. 2, Jan.-Sept., 1971.

Other important survey findings were that bus driver overtime declined (due to avoidance of time consuming traffic delays); ninety-five percent of surveyed patrons judged the service more reliable; and eighty-five percent indicated the trip was more enjoyable. So popular in fact was the innovation that it was reported that first morning patrons applauded as they pulled into the Manhattan terminal after passing the long queue of congestion-delayed eastbound vehicles.

The I-495 project was funded under a $500,000 grant from the United States Department of Transportation's Urban Corridor Program with local agencies contributing additional staff and materials. The higher than average cost of this facility is chiefly attributed to the costs of building a special bus access roadway and undertaking extensive planning, signing, training, and a public relations program in this pioneering effort.

Operating costs for the full year 1971 were about $176,000. It is expected that these costs may decline after remote control signs are placed in operation.

Police reports indicate that accident rates for the entire I-495 roadway have declined since implementation. Only four minor bus lane accidents were reported in the first eighteen months of operation.

<u>CASE STUDY 2</u>: Long Island, New York: Long Island Expressway

On the Long Island Expressway, the westbound approach to the Queens-Midtown tunnel and Manhattan, a 2.2 mile exclusive bus lane has been established similar to the I-495 facility. The bus lane operates contraflow and is separated from other traffic by traffic posts and cones. The facility operates only in the AM peak period.

The bus lane was created for the same reasons as the I-495 facility and also serves as an alternative to new capital facility construction.

Current volumes of vehicles using the facility range daily from 130 to 180 buses with a peak hour maximum of 102 buses.

The 35 to 45 MPH average bus lane speeds have saved riders as much as fifteen minutes or eighty-five percent of previous travel time for that part of their trip taken along parallel routes.

The earlier expensive implementation experience on I-495 was avoided in this project. Total start-up costs were less than $50,000. Daily operating costs (in house) are about $500.

Public response has been favorable and demand for express bus service into Manhattan continues to grow despite high fares ($1.15 to $1.25 vs. 35¢ on local buses and subway).

There were no reported accidents in the first six months of operation.

CASE STUDY 3: Boston, Massachusetts; Southeast Expressway

The Massachusetts Department of Public Works has established a busway on the Southeast Expressway running from the circumferential highway southeast of Boston to the Central Business District. The 8.4 mile facility operates essentially as in the above two examples. The facility currently operates only in the AM peak hours. It does not operate in the winter due to short daylight hours and unfavorable weather.Created in response to heavy peak hour congestion, the exclusive bus lane also serves as an alternative to construction of new highway facilities into Boston.

About 80 buses carrying 3500 passengers daily are using the facility. It is reported that the number of buses and passengers carried on this facility has increased 14% the first year. Travel time for bus passengers has been reduced from an estimated 22-24 minutes to about ten minutes.

Start-up costs were under $50,000 and operating costs are about $500 a day.

No accidents have been reported on the AM service, though one accident was reported on an earlier PM exclusive lane. Evening bus lanes were later deemed unnecessary and cancelled because of the reverse funnel effect.

CONTRAFLOW LANES ON ARTERIALS

CASE STUDY 4: Louisville, Kentucky; Third Street

Three different bus routes in Louisville, Kentucky collect passengers in suburban areas and then proceed to an approximately two mile long express bus lane on Third Street which is designed to speed up the trip to the business district. The exclusive bus lane itself is a single right hand lane operating contraflow to the normal one-way street traffic pattern on Third Street. At other hours of the day the bus lane is used as a parking lane.

Originally, a similar contraflow bus lane operated in the evening on an adjacent one-way street, but the travel time on the evening exclusive bus lane was longer than when the bus did not use a separate contraflow exclusive lane. This was due to the fact that the bus had to go out of its way to gain access to the busway facility. Any time savings resulting from the use of the exclusive bus lane were negated by the access time penalty. As a result, the evening service was rerouted to a normal mixed traffic street, providing a more direct route.

The bus using the AM exclusive bus lane is between six and ten minutes faster than former bus service but between four and ten minutes slower than comparative automobile travel. This can be attributed primarily to the fact that there is an absence of congestion in this corridor. While the bus must stop to load and unload passengers, the automobile in this instance can proceed with few delays. Lacking the incentive of travel time savings, Louisville commuters have not responded as enthusiastically to the bus service as would be desirable.

One pertinent finding of this study is that without some congestion, which is the principal source of delay for automobile commuters, buses are not able to gain a time advantage even with the use of an exclusive land. Without travel time advantages the exclusive bus lane service alone will divert few passengers from other modes. Thus the lack of substantial congestion in Louisville reduces the potential for large benefits accruing from bus lane use.

Start-up costs for striping, signing, paving a park-n-ride lot, and providing traffic signal pre-emptive devices were minor and are estimated at less than $30,000. Operating costs in Louisville are low; a policeman precedes the first vehicle and follows the last. These costs are absorbed in normal operating budgets.

Two minor accidents occurred in the opening weeks due to auto drivers backing out and failing to look in the opposite direction. These "learning curve" accidents have not been repeated.

CASE STUDY 5: Indianapolis, Indiana; College Avenue

The Indianapolis exclusive bus lane is a 2.9 mile lane facility which operates contraflow on College Avenue, a one-way street serving the near north side of Indianapolis. The facility is permanent and operates twenty-four days a month.

The facility was created as a compromise to allow the continuation of transit service on College Avenue. Community pressures for the safer operation associated with a one-way street convinced highway officials that all two-way traffic should be banned. The bus operator, however, responded by threatening to terminate south bound service completely in this important transit corridor as there were no other acceptable streets located nearby. The resulting compromise allowed buses only to use the the one remaining southbound lane.

From a safety viewpoint the operating modification may be termed a success. Between 1968 and 1971 the southbound lane accident rate declined 65%. However, the poorly marked lanes and inadequate signing on College Avenue and side streets has confused unfamiliar motorists and resulted in a slight rise in bus involved accidents.

Start-up costs were extremely low as only lane markings and a few overhead signs were involved. There are no extraordinary day-to-day operative costs associated with the exclusive bus lane.

No studies of bus travel times or volumes of passengers carried have been made. It appears that like Louisville, there is too little congestion for the bus service to provide a travel time advantage over other modes. As a result, the service did not appear to divert passengers from automobile modes.

The Indianapolis example serves primarily to illustrate that even with minimal safety and operating requirements, no catastrophic degeneration in safety need be expected.

CASE STUDY 6: San Juan, Puerto Rico; Fernandez Juncos and Ponce de Leon Blvds.

The most significant arterial exclusive bus lane is in operation on an important one-way street pair in San Juan.

Ponce de Leon and Fernandez Juncos are four lane major arterials running the length of the San Juan business district. Each street operates as a one-way in each direction with three lanes for normal traffic. The fourth lane on each street, operating in the opposite direction contraflow for about 10 miles is reserved for buses.

The bus lane operates twenty-four hours a day and handl between 1,300 and 1,500 bus trips per day.

The bus lane was established as an emergency measure to provide better transportation service in this extremely congested corridor. Relief of this congestion through capital intensive facilities such as rail or highways is not practical due to severe capital shortages and the difficulty of locating such facilities in a overcrowded urban environment.

While good data is lacking, it is reported that bus trip times scheduled at 55 minutes but previously taking as long as one hour and twenty minutes now have been shortened to fifty minutes, a saving of 35% of former travel time.

The San Juan facility serves as an effective alternative to automobile modes principally because it circumvents heavy congestion. There is some evidence to indicate that ridership on the exclusive bus lane service has increased. Unfortunately there are no ridership studies of bus service using the exclusive bus lanes which might specifically isolate the mode choice impact of this service.

It appears from rough data that after an initial "learning curve" experience, the accident rates for the two streets have begun to decline. Specific statistics isolating the impact of the bus lane are not available.

Costs associated with establishing some 22 miles of exclusive bus lanes were an estimated $70,000 for signing, some right-of-way acquisitions, minor construction, and striping. An additional estimated $30,000 was spent on planning, administration, and engineering. Some $50,000 in added staff time was also charged to this project.

Interestingly, despite some capital facility construction this elaborate busway system was placed into operation within twelve weeks after the order to implement was passed down from the governor's office.

SPECIALLY CONSTRUCTED FACILITIES

CASE STUDY 7: Washington, D.C.; Shirley Highway (Northern Virginia Suburbs)

The only operational example of a so-called specially constructed exclusive bus lane facility is located on the Shirley Highway running from Springfield, Virginia to Washington, D.C., a distance of about nine miles.

The busway consists both of permanent and (for the moment) temporary roadways in the median of the multi-lane highway. The roadway is separated from other traffic by permanent barrier rails except at special entrance and exit points. Several interchanges provide separate, exclusive access ramps to the bus lane.

The facility was created after planners realized that for at least several years the median lanes could not be opened to other traffic due to the limited ability of roads and bridges entering the central business district to absorb the volumes of vehicles processed by five lanes on the outbound segments of Shirley Highway. In the meantime, the lack of adequate transit service and severe traffic congestion induced Federal, State, and local officials to suggest the exclusive bus lane experiment.

Volumes of passengers and buses using the facility have increased dramatically over time, partly in response to additions in bus service and partly from the attractiveness of transit service due to the exclusive lane. Currently officials estimate that about 15,000 passengers are carried daily by busses in the AM peak representing over 50% of AM peak period inbound commuters on this route. Approximately 3,500 private vehicles are estimated to have been removed due to the service.

Savings of between 58% and 55% of former trip times are reported respectively, for the AM and PM operations. Not unexpectedly, 35% of new bus riders gave time savings as the chief reason for switching from auto to bus.

The cost of constructing the special, but temporary facility averaged about $620,000 a mile, but there are no daily operating costs outside of normal roadway maintenance due to the nature of the roadway.

There have been no accidents reported for normal operations.

CHAPTER V

IMPLEMENTING SUCCESSFUL BUS LANES

The field visits and other studies of bus lanes in various urban environments enabled the project staff to appreciate the practical implications of bus lane implementation. This chapter briefly summarizes some of the lessons learned from this experience.

(1) TIME ADVANTAGE CRITICAL:

Bus lanes provide opportunities to develop transit service that is more attractive than other modes of commuting.

Studies of travel choice indicate that three basic variables are chiefly responsible for determining work trip modes: convenience, time, and cost. Of these, cost appears to be far less important than the first two variables.

Properly established bus lanes are an ideal means for improving travel times at little or no increase in operating cost. Evidence from bus lanes that actually provide commuters with a time advantage over competitive modes indicates that growth in ridership will occur at the expense of private auto and other transit modes.

In order for travel time to be saved, the exclusive bus lane must by-pass congestion which delays other vehicles on parallel routes. In addition, the congestion delay must be substantial enough so that the transit vehicle despite the necessity to stop for pick-up and discharge of passengers will still be able to operate with a net travel time advantage. Usually exclusive bus lane service will provide a net travel time advantage when existing capital facilities are not adequate to speedily process other demand. When congestion does not exist, as was noted in several operating examples, a free flowing bus lane will not provide a net travel advantage and therefore will not prove more attractive than normal bus service. In a situation where serious congestion does not exist capital facilities are probably adequate to meet most demands. Finally it should be noted that some so-called bus lanes do not themselves prove any faster than normal traffic. Bus service on such facilities is not likely to become much more attractive than normal bus service.

(2) GOOD ROUTE AND SERVICE PLANS NECESSARY:

As was mentioned earlier, convenience is a very important factor in determining mode choice. Bus lane routes which are not convenient cannot be expected to prove more attractive than other modes. More specifically this means routes must collect within close proximity to passenger homes and apartments and distribute patrons close to their eventual destinations with little or no transferring. Similarly park-n-ride lots provided at convenient outlying terminals have been successful in attracting riders to <u>FAST</u> bus service such as is provided by busways.

(3) TERMINAL NEEDS:

In certain cases where high volumes of passengers are processed, it becomes more efficient to establish terminals where passengers change from line haul vehicles to internal circulation and distribution systems. This was observed in New York City with the Port Authority bus terminal being used as the terminus of Manhattan bound bus lane trips and the subway used as the internal circulation mode.

In other cases heavy volumes may be carried without the need for a terminal. In San Juan lineal development facilitates this operating pattern. Heavy volumes of passengers are picked up at the beginning of the routes, and in the latter portions of the routes passengers are discharged at their respective destinations.

Buses in Boston, on Long Island, and in Washington, D.C. (Shirley Highway) collect from specific collection points or circulate in neighborhoods and distribute passengers in the business district with only limited use of terminals. It appears likely that most busway applications will be modelled on these last examples.

Two important points should be noted in such cases. First, the greater the volume of bus service and bus demand, the greater the probability that one bus can be filled quickly with patrons from a compact neighborhood all going to destinations in close proximity. The resulting reduction in travel times would further enhance bus attractiveness. Second, the greater the volume of bus traffic on an exclusive bus lane, the more likelihood that complementary traffic engineering is needed to protect the bus lane service. For example, buses arriving at CBD destinations may need curb lanes reserved for loading and unloading, special reserved streets for distribution and pick-up, perhaps traffic signal preference controls as well as other complementary services.

(4) CITY SIZE RELATIONSHIPS:

The smaller the city, the shorter will be average commuting times and the greater the proportion of commuting time that will need to be saved in order for the bus service to prove mode attractive. Studies have shown that small amounts of time savings are not valued as highly as larger amounts.

(5) DESIGN TYPES:

Operation on a specially constructed and permanently reserved roadway is perhaps the most desirable operating circumstance, but such an approach is capital intensive (although far less expensive than facilities to carry the same volumes of auto commuters) and may not be economically justifiable or practical.

When operation on an existing roadway is considered, it appears that contraflow operations are more desirable. This is due to two basic advantages:

- The contraflow lane is effectively self-enforcing.
- Peak hour traffic in many cases is heavily directional; removal of a lane from the non-peak directional flow laneage may not be missed and adds to the capacity of directional lanes.

Exclusive bus lanes operating on arterials are ideally suited to one way streets. One-way street basic operational advantages are:

- One-way streets are often set up in pairs with one of the pair heavily used in each peak and the other street often under-utilized during the same time period.
- Loading and unloading is safe in that passengers are discharged directly onto the sidewalk as in normal operations rather than onto a more dangerous median strip.
- Establishment of a bus lane is essentially converting the street back to a modified version of two-way operation.
- Normal traffic has less difficulty making turns.
- Signal timing is often easier to effect.

Two-way streets may be converted to busways and a number of techniques and possibilities are discussed in Chapter Six of Volume II.

(6) INSTITUTIONAL ENVIRONMENT:

In general there is substantial support for the concept of bus lane operations from the public, local governments, bus operators, and Federal agencies. In some cases inertia and/or caution has slowed implementation. When displayed, resistance is primarily traceable to three justifications:

- Fears of reduced roadway safety despite substantial evidence to the contrary
- Reluctance to penalize automobiles (where this is the case) and/or grant buses priority use of street space
- The basic unconventionality of certain operating patterns and the concept itself.

In general, the group most critical to achieving implementation is the local highway operating agency.

APPENDIX

EIGHTEEN LOW COST ALTERNATIVES: SUMMARY OF INDIVIDUAL STUDIES

CONCEPT: HIGHWAY TRAFFIC ENGINEERING SYSTEMS IMPROVEMENTS

Operating Description and Summary of Findings

A brief review and summary of five types of techniques for improved street system utilization is undertaken to acquaint readers with the documented benefits and results of extensive previous work in this area. The five techniques reviewed are:

1. Traffic Lane Use and Directional Control
2. Curb Lane (Parking) Controls
3. Traffic Channelization
4. Signal Control
5. Bus and Large Vehicle Operation

A key observation in almost all traffic engineering studies is that effective law enforcement of traffic regulations is essential to success and will result in maximum gain from any traffic engineering improvement. It has also been observed that poor regulation may negate a traffic improvement program.

In general it can be said that the potential to improve traffic movement through the use of traffic engineering represents achievement of important marginal efficiencies.

TECHNICAL BACKGROUND

(Data quality indicated by letter at right*)

User Price Impacts: Not likely to be affected	A
Implementation Costs: Traffic signal installation costs are in the range of $2000 to $35000 per intersection. Most other costs are relatively minor.	A
Operating Costs: Traffic painting costs range from thirty to eighty cents per capita. Sign and signal maintenance costs are comparable.	A
Other Costs: Minimal	A
Indirect Economic Effects: Value of time saved may range from two to 20 cents per trip. Potential for moderate reduction in need for new facilities.	C
Effects on Disadvantaged: Very minor; primary benefit is to motorists	A
Environmental Impact: Reducing stop and start driving conditions through traffic engineering will minimize vehicular pollution.	C
Safety Impact: The potential gains in safety are substantial.	A
Speed or Time: Initial improvements may result in up to a forty percent time saving where present conditions are very bad. Successive improvements give diminishing returns.	B
Volume: Moderate incremental gains in capacity may be achieved; sometime larger gains with major curb parking restriction.	A
State-of-the-Art: Fairly well developed.	A
Institutional Background: Easy acceptance of most techniques. Resistance will likely be encountered in instituting one-way streets and parking restrictions.	A

*Data Quality: A = strong empirical documentation, B = data which appears valid but which should be subject to further analysis, C = hypothetical data only, or data suspect, requires further verification.

CONCEPT: WORK SCHEDULING CHANGES

Operating Description and Summary of Findings

Work hours or days worked are shifted from familiar patterns so that employees of cooperating firms distribute demand for transportation facilities. The resulting reduction in peak period transportation demand would alleviate pressures for new facilities designed solely to serve existing heavy peak period demands.

The limited evidence now available suggests that important efficiencies might be realized at little or no cost.

Unfortunately, there has been a great deal of resistance, especially from employers, and as a result only limited success with introducing this concept has been achieved.

TECHNICAL BACKGROUND
(Data quality indicated by letter at right*)

User Price Impacts: All other things being equal, the individual's commuting cost would decline under a four day work week. Changes in work hours for others may require a change of mode, i.e., carpools and public transportation may not be adaptable - in such cases costs would change.	B
Implementation Costs: Most expensive effort to date cost $50,000 (Manhattan) and involved staffing and publicity. In some instances, little cost need be incurred. Transit operators may have some start-up costs associated with changing of schedules.	B
Operating Costs: Only significant cost likely to be those incurred by transit operators;not certain if these will be favorable or unfavorable.	C
Other Costs: Major factors are those associated with communications between enterprises plus any changes in worker productivity. Limited evidence on latter is favorable, to date. There do not appear to be any important transportation related costs.	C
Indirect Economic Effects: Some evidence that 10-20% decrease in demand might be realized during absolute peak periods, thus substantially relieve existing congestion. In addition, workers report absent and tardy less frequently.	C
Effects on Disadvantaged: Possible problem in that transit schedules must be shifted to accommodate new hours. Captives, including disadvantaged, must be able to use transit.	C
Environmental Impact: In some cases positive but highly dependent upon plan adopted.	C
Safety Impact: Uncertain and possibly negative due to increased leisure time.	C
Speed or Time: Slight savings. New York data estimates impact at one hour per month.	C
Volume: As mentioned above, volumes handled in subways, elevators, and on streets are reduced during absolute peak period.	B
State-of-the-Art: No problems anticipated.	A
Institutional: Severe problems in gaining employer and employee cooperation. The more diffuse the area of implementation, the less chance for implementation.	B
Traveler Response: Employees in projects to date have generally been enthusiastic about staggered work hours and work days.	B

*Data Quality: A = strong empirical documentation, B = data which appears valid but which should be subject to further analysis, C = hypothetical data only, or data suspect, requires further verification.

CONCEPT: FREEWAY METERING, MONITORING, AND CONTROL SYSTEMS

Operating Description and Summary of Findings

In order to avoid unstable freeway traffic flows with attendant delay and congestion, methods have been proposed for regulating the volume of vehicles attempting to utilize a freeway. Metering techniques are designed to regulate the number of vehicles entering the freeway through an electronic assessment of the available capacity. Monitoring and control techniques are designed to warn controllers of accidents or other conditions which may warrant restrictions on vehicle admittance and may also facilitate the quick removal of the impedance.

A successful metering, monitoring and control system requires a nearby parallel route to absorb unwanted traffic. Few freeways operate under these conditions. Metering does not increase theoretical capacity or speed; rather it permits highways to operate at design levels by preventing overloading. As a result only minor impact on growth in demand for new facilities can be expected.

TECHNICAL BACKGROUND
(Data quality indicated by letter at right*)

User Price Impacts: No direct user price impacts.	A
Implementation Costs: Moderate: Estimated at $6,000 per interchange, about $9,000 if bus preference approach is used (exclusive of any roadway or right-of-way costs). Admin. & lease costs are variable.	B
Operating Costs: Moderate: Necessary to staff and maintain a centralized facility for monitoring traffic and reacting to real time conditions. $200,000 per community per year is rough estimate.	C
Other Costs: While studies to date indicate that traffic as a whole will flow faster and more efficiently with use of metering and control systems, individual autos may suffer heavy time penalties. Lack of adequate alternate routes would also penalize these drivers whose access to the freeway is delayed.	B
Indirect Economic Effects: Principle impact likely to be some user time savings. Not likely to moderate new demand.	C
Effects on Disadvantaged: Slight, if any.	C
Environmental Impact: A slight reduction in total emissions may result from traffic flowing more smoothly.	C
Safety Impact: One study showed a 16.8% reduced accident rate.	B
Speed or Time: Substantial travel time improvements reported.	A
Volume: Slight to moderate increase in vehicle miles where freeways were severely overcrowed previously.	A
State-of-the-Art: Satisfactory, except for versions which would provide preference to buses.	A
Institutional Background: Inertia and reluctance to offend the public seem to be the chief institutional considerations.	B
Traveler Response: Implementation of metering and control systems is not expected to reduce overall demand for freeways. Apparently most users are willing to queue up to use metered ramps.	B

*Data Quality: A = strong empirical documentation, B = data which appears valid but which should be subject to further analysis, C = hypothetical data only, or data suspect, requires further verification.

CONCEPT: FREE OR HEAVILY SUBSIDIZED TRANSIT

Operating Description and Summary of Findings

Proponents of "free" or heavily subsidized transit contend that lowering the price will divert commuters from inefficient auto modes to more desirable transit modes. As a result congestion on existing facilities will be alleviated and demand for new facilities abated.

Unfortunately there is little reliable data at this point to substantiate these claims. What little theoretical and empirical data available suggests that mode choice is only moderately sensitive to the single factor of price. It is observed, however, that more transit trips are made when the price goes down, perhaps reflecting the increased attractiveness of transit for short trips or marginally necessary travel.

TECHNICAL BACKGROUND
(Data quality indicated by letter at right*)

User Price Impacts: Savings expected to be substantial.	A
Implementation Costs: No change unless demand for service necessitates adding schedules. Some start-up advertising and public relations needed.	B
Operating Costs: 1. Little to slight savings from eliminating fare collection under plans of free transit. 2. Substantial costs to the community to support the subsidy.	B
Other Costs: Several. 1.Discrimination against non-transit users, 2. Excessive trips by youngsters who may or may not be a nuisance. 3. Changes in travel patterns affecting shopping and employment patterns, etc., as a result of more frequent transit use.	C
Indirect Economic Effects: Inconclusive indication at this time that demand for capital facilities would be abated.	C
Effects on Disadvantaged: Great boon to transportation captives and low income citizens.	A
Environmental Impact: Slight but expected positive impact resulting from decreases in auto travel.	C
Safety Impact: No change unless substantial congestion reduction occurs.	C
Speed or Time: Completely dependant upon the number of automobiles removed through mode shifts. Not expected to show immediate gains of any significance.	A
Volume: No change except as demand leads to gradual expansion of transit system capacity.	A
State-of-the-Art: No problems except developing screening techniques to avoid abuse of the privilege.	A
Institutional Background: Strong support from unions, principal opponents would be community factions generally opposed to public subsidy.	C
Traveler Response: Mixed data. Apparently more people will ride, however, not certain how many of these are new riders.	C

*Data Quality: A = strong empirical documentation, B = data which appears valid but which should be subject to further analysis, C = hypothetical data only, or data suspect, requires further verification.

CONCEPT: ORGANIZED COMMUTER CAR AND BUS POOLS

Operating Description and Summary of Findings

Organizing commuters into bus and car pools as a substitute for individual modes would, theoretically, remove large numbers of automobiles from the highway and thus increase the carrying capacity of existing facilities.

Subscription bus service refers to a concept of organizing the bus riders of a neighborhood so that each has a guaranteed transit seat and each receives close to door-to-door service as a result of previous knowledge of demand by the bus operator.

"Pooling" has substantial theoretical and real benefits. At this time there is little evidence to indicate that these benefits can be achieved through voluntary efforts. A substantial organized effort is needed to coordinate "pools" and to provide effective incentives for their use.

TECHNICAL BACKGROUND
(Data quality indicated by letter at right*)

User Price Impacts: Most cases very inexpensive: Carpool $.025 - .029 van pool $.01 - .015 mile, buspools $.055/mile (fares), subscription service $.15 - .25/mile.	B
Implementation Costs: Hard to estimate, purchase of vans $5,100-5,700 or .021 - .023/mile (amortized)	C
Operating Costs: Very low to moderate; van pool .013 - .0158/mile, per passenger (full occupancy) buspool .014 - .0207 mile, per passenger (53 passengers per bus).	B
Other Costs: The primary other cost associated with car-pooling is loss of privacy and convenience normally associated with one's personal automobile.	A
Indirect Economic Effects: Reduced demand for highways and parking lots if widespread.	C
Effects on Disadvantaged: Fair social impact possible through greater mobility for disadvantaged workers.	C
Environmental Impact: Not known.	C
Safety Impact: Improved.	C
Speed or Time: Slower than all other conventional modes except fixed route bus service.	C
Volume: Substantial increases in volume that can be carried on existing facilities if pooling became widespread.	B
State-of-the-Art: Not expected to present problems	B
Institutional Background: Substantial resistance to carpooling among autodrivers; no benefits other than cost savings would be available to users until a great many pools had been set up.	B
Traveler Response: Apparently, demand for these modes would have to be organized. This purpose is served by centralizing and computerizing the formation and possibly the operation of such pools. Other incentives might also be needed to maximize carpooling: reserving parking spaces for carpools at little or no cost, and/or letting carpools use bus exclusive lanes, etc. Carpools do not form in sufficient numbers on a voluntary basis to achieve the widespread impacts desired.	B

***Data Quality:** A = strong empirical documentation, B = data which appears valid but which should be subject to further analysis, C = hypothetical data only, or data suspect, requires further verification.

CONCEPT: HIGH CAPACITY TRANSIT BUSES

Operating Description and Summary of Findings

The high capacity transit bus either an articulated or double-deck model, carries from 50% to 100% more seated passengers than conventional transit vehicles. The increased driver productivity can improve the economics of transit operations by cutting the extra costs associated with serving heavy peak hour demands.

Improved passenger comfort and increased schedule reliability are also likely to be realized from the use of such vehicles.

This technique shows some promise for increasing the efficiency and processing capacity of transit services but the extent is not known. It seems likely that the most effective use would be on routes where headways are short and crowding is severe. It is not known to what extent the high capacity bus could be substituted for other service, nor what union response would be. At present high capacity vehicles are all produced abroad. This concept appears to offer minor advantages with few if any serious drawbacks.

TECHNICAL BACKGROUND
(Data quality indicated by letter at right*)

User Price Impacts: Not expected to change.	A
Implementation Costs: In production quantities, it is estimated that each vehicle would cost about $75,000, last 12 years or 750,000 miles.	C
Operating Costs: Vehicle operating costs are expected to increase about 16¢ a mile including depreciation and added maintenance. This would range between 12% and 21% of existing operating costs.	C
Other Costs: High capacity buses may not be able to operate on some streets. Unknowns about union response and vandalism require answers.	C
Indirect Economic Effects: More seats and less numbers of buses on streets indicate, respectively, increased attractiveness of transit to non-transit users and less overall congestion. Attractiveness may be counterbalanced by reduction in scheduled service frequency.	C
Effects on Disadvantaged: Slight, except as improved transit service generally tends to work to advantage of transit captives.	C
Environmental Impact: Probably slight, dependent on the substitutability of one transit trip for many auto trips.	C
Safety Impact: Slight, larger vehicles may have difficulty in traffic at least at first.	C
Speed or Time: Main advantage, loading area can hold passengers prior to payment of fares, thus buses move away from curbs more quickly (minor advantage).	B
Volume: Between 50% and 100% more seated passengers per vehicle.	A
State-of-the-Art: European technology demonstrated and proved; likely to require some adaption for American service.	A
Institutional Background: State and local laws regulate weights and size of vehicles; these apparently are not serious barriers. Unknown how labor unions would react.	C
Traveler Response: It may be that as the convenience and attractiveness of transit service is improved through the use of high capacity vehicles, that increased ridership will be noted.	C

*Data Quality: A = strong empirical documentation, B = data which appears valid but which should be subject to further analysis, C = hypothetical data only, or data suspect, requires further verification.

CONCEPT: PAVED RAILROAD RIGHTS-OF-WAY

Operating Description and Summary of Findings

Abandoned or little used railroad rights-of-way may be paved over at moderate cost to provide an exclusive, narrow, roadway for buses. Grade crossings may revert to signalized intersections or continue to operate with railway crossing controls activated well in advance by the bus.

In many cases one lane is adequate to handle directional peak hour flows, although pull-offs for emergencies are advisable.

Major obstacle to extensive usage is the limited number of abandoned or abandonable rail rights-of-way which correspond to areas of high transportation demand. Without good correspondence the paved right-of-way routing may be slower and more congested than direct routes because of the necessity to detour to obtain access and egress.

TECHNICAL BACKGROUND
(Data quality indicated by letter at right*)

User Price Impacts: May not change from present transit fares; however, if right-of-way and start up costs are born by the carrier it may result in fare surcharges to cover these extra costs.	C
Implementation Costs: While right-of-way purchase is costly (if necessary), paving is somewhat less expensive than a highway facility at $175-200,000 a mile including signals; landscaping, etc.	B
Operating Costs: Normal bus operating costs; probably usual roadway maintenance costs.	B
Other Costs: Fairly permanent change in usage under most plans.	B
Indirect Economic Effects: May alleviate need for new facilities because of high volume capacity potential.Under advantageous routing circumstances would save substantial travel time with attendant economic benefits.	C
Effects on Disadvantaged: Routes may or may not serve travel needs of disadvantaged.	C
Environmental Impact: Insignificant impact unless large numbers of vehicles removed from highways.	A
Safety Impact: Uncontested right-of-way safer, grade crossings may be more hazardous.	B
Speed or Time: 35 MPH average speed expected as opposed to approximately 12-25 MPH average speed on congested street. Time advantage occurs when long distances involved or severe bottleneck bypassed. Egress and access, collection and distribution time must be compensated for by time savings on exclusive right-of-way.	B
Volume: Same as other busways, theoretical studies indicate as high as 70,000 passengers per hour can be carried.	B
State-of-the-Art: Very well established.	A
Institutional Background: Railroads probably only obstacles	C
Traveler Response: Substantial time savings with considerable comfort will generate demand.	B

***Data Quality:** A = strong empirical documentation, B = data which appears valid but which should be subject to further analysis, C = hypothetical data only, or data suspect, requires further verification.

CONCEPT: LINE HAUL FEEDER SYSTEM

Operating Description and Summary of Findings

Systematic efforts at organizing the collection and distribution of demand around fast line haul transit facilities are designed to (a) replace automobiles carrying out this function and (b) improve the convenience of the line haul facility itself. The resulting increase in use of mass transit may be expected to alleviate certain demand for highway facilities.

The study found that a properly integrated feeder bus or similar service could be expected to improve the use of line haul facilities and thus alleviate demand for new auto related facilities. Costs associated with use of feeder bus appear to be less than for conventional transit operation.

Certain problems exist in (a) developing an intergrated service system especially on a regional basis and (b) in persuading auto oriented travelers to use feeder bus services.

TECHNICAL BACKGROUND
(Data quality indicated by letter at right*)

User Price Impacts: Probably higher: Most existing rapid transit operations charge the commuter a separate fare for feeder service. However, some feeder service provides free or low-cost transfers to line haul facilities.	A
Implementation Costs: Moderate: Cost of new rolling stock, storage facilities, possible one-time subsidy.	A
Operating Costs: Costs similar to those of conventional bus operation.	B
Other Costs: If auto access is replaced, riders may suffer some degree of inconvenience and delay. To enforce useage it may be necessary to prohibit station parking or to charge higher fares.	
Indirect Economic Effects: Potentially substantial, only partially quantifiable: Less congestion, less demand for new roads, fewer auto trips.	C
Effects on Disadvantaged: Potentially great: Even feeder bus service in suburbs should be helpful, improving access to suburban employment for low income groups.	C
Environmental Impact: Potentially substantial, depending on amount of diversion of auto drivers.	C
Safety Impact: Potentially substantial - transit safer than auto mode.	C
Speed or Time: Feeder bus trip time greater than auto trip time to line haul pickup points, but line haul speeds should help compensate.	C
Volume: Greater than auto and kiss-n-ride.	B
State-of-the-Art: Adequate - but further research on economic feasibility and routing procedures for feeder bus service is needed.	B
Institutional Background: Problems exist, particularly in coordinating feeder service with line haul systems which may be independently operated.	B
Traveler Response: Evidence is sketchy on the long range characteristics of demand for feeder transit service. In some instances growth in demand has been noticed. In general not expected that growth in demand would be overwhelming.	C

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CONCEPT: THE RAIL BUS

Operating Description and Summary of Findings

The rail bus is a standard transit or over-the-road bus which is equipped with an extra set of special wheels enabling it to travel on conventional railroad tracks.

The rail bus would operate on abandoned or lightly used railroad tracks much as a train. When not using the railroad tracks the bus would retract its wheels and operate conventionally on city streets. In this way the usual collection and distribution convenience of a bus could be combined with the line haul speed of a rail vehicle.

In order to permit rail bus operations the trackage must be extensively upgraded at a fairly high cost and each bus must be specially equipped to operate on railroad tracks.

The major justification for the rail bus approach to the utilization of rail rights-of-way is to permit conventional rail operations to continue. Except in this latter instance it appears that the best use of rail rights-of-way is to pave.

As in the case of Paved Railroad Rights-of-Way, the big question is whether available rail rights-of-way are located in areas that correspond to patterns of transportation demand.

TECHNICAL BACKGROUND
(Data quality indicated by letter at right*)

User Price Impacts: Unknown: Transit operating costs should rise between 30% and 80% which could be expected to be partly offset by higher fares.	C
Implementation Costs: Converting bus: $20,000 - $30,000 per vehicle. Roadbed rebuilding: $200-$225,000 per mile.	B
Operating Costs: Expected to rise 30% to 80% over standard bus operating costs.	C
Other Costs: A possible cost occurs if rail bus scheduling interferes with regular rail schedules. The ride quality of the railbus is expected to be inferior to most modes now in use, with excessive sway, bumping, and higher noise levels anticipated.	
Indirect Economic Effects: Moderate to substantial: If the service is successful in attracting large numbers of commuters to this service it may allay needs for more capital facilities.	C
Effects on Disadvantaged: Slight to negative: Negative if disadvantaged charged higher fares.	C
Environmental Impact: None, unless substantial numbers of autos are removed from the highway.	C
Safety Impact: Unknown: Grade crossing accident potential may be higher; greater braking requirements or rail tracks may prove dangerous.	C
Speed or Time: Would depend on application: Rule of thumb, average rail bus line haul speed 35 MPH, average street speed 12 MPH, with penalties for access and egress mileage, likely time advantage would accrue at greater distances.	C
Volume: Less than paved bus lane because of greater braking distance required. Estimate minimum headway at 90 seconds or about 40 buses per hour and approximately 2,000 passengers per hour maximum.	C
State-of-the-Art: It is said that there are no problems, but not all elements have been satisfactorily demonstrated.	B
Institutional Background: Numerous obstacles, but appear resolvable: Rail unions want full crews, FRA and Association of American Railroads have safety and signal codes to be met, railroads reluctant to share use of track. State and local laws may govern. Union problem solved in one instance and others appear resolvable.	B
Traveler Response: Demand for the railbus is dependent on the time savings the bus gives over driving or normal bus service.	C

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CONCEPT: PARA-TRANSIT (JITNEYS, TAXIS, AND LIMOUSINES)

Operating Description and Summary of Findings

Para transit service includes a number of less well known travel modes which fill a gap between the services provided by conventional transit and private automobiles. Included would be limousine and jitney services as well as taxi. All services are for hire. The chief advantage of para-transit lies in its ubiquitous nature which potentially, at least, allows it to serve any pattern of origins and destinations.

In general, the study found that the greater flexibility offered by these services was effectively counterbalanced by higher user costs. There is a real possibility that encouragement of para-transit would lead to abandonment of some forms of mass transit. Little evidence is available to indicate that demand for new facilities would be relieved through expansion of para-transit. It is expected that attempts to develop more para-transit service would be heavily resisted by powerful institutions.

TECHNICAL BACKGROUND
(Data quality indicated by letter at right*)

User Price Impacts: User charges vary. They are fixed by regulation or what the traffic will bear, since most operators earn a profit, user charges include total cost of operation. In general, jitneys, have the lowest fares (usually slightly higher than bus) and taxi the highest of all.	A
Implementation Costs: Variable for vehicles (several hundred dollars to $25,000). For entry permit 0-$20,000.	B
Operating Costs: Car-van type vehicle 8¢ mile plus labor; 1.5 to 8¢ mile should be added for administration. Jitneys and limousines run only slightly higher.	B
Other Costs: Added vehicles and congestion will result if para-transit diverts passengers from buses (higher capacity vehicles) or if additional trips not formerly taken (due to lack of usable mode) are generated by the availability of a good para-transit system and corresponding reductions in auto travel do not materialize.	
Indirect Economic Effects: Greater mobility than available from regular transit, non-subsidized public transit, reduction in high capital cost investment.	C
Effects on Disadvantaged: Greater mobility for disadvantaged, but probably at higher costs unless publicly subsidized.	C
Environmental Impact: Slight unless large numbers of automobiles displaced.	C
Safety Impact: Inconclusive data, highly dependent upon particular application.	C
Speed or Time: Slightly better than regular transit because of smaller loads (means fewer stops). Drivers learn routes, become adept at minimizing travel time.	B
Volume: Unknown. Improved volume processing efficiency of roadways if average vehicle occupancy improved, however it would increase vehicle congestion if transit riders attracted in any great numbers.	C
State-of-the-Art: Not a problem.	A
Institutional Background: Heavy resistance anticipated from taxi and transit operators, possibly unions. Higher prices mean disadvantaged can't use. Therefore perhaps governmental or other institutional sponsorship is needed.	A
Traveler Response: Demand is not likely to be generated easily from existing automobile users. Patrons using current transit service and non-auto users not making trips are likely to be more easily attracted depending on price and range of mobility.	B

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CONCEPT: ECONOMIC PENALTIES AND/OR INCENTIVES

Operating Description and Summary of Findings

Regulation of demand for transportation facilities through policies of charging users different fees for road useage and/or parking is one suggested technique for reducing congestion and promoting use of more efficient transportation modes such as mass transit. Two techniques were reviewed here: Road pricing (both electro-mechanical and a license approach) and parking charge schemes.

Policies of establishing actual prices reflect differing philosophies. Some contend that prices should reflect actual costs including the costs associated with delay and congestion. Others contend that pricing should reflect traffic management objectives and would be raised or lowered according to the achievement of traffic management goals.

It is clear that incentives and penalties could be effective in reducing vehicle miles traveled and thus the attendant urban evils.

There are substantive reasons why immediate implementation is not likely. First, the technology of administration, operation, and enforcement has not been satisfactorily described or demonstrated. And serious questions about implementation techniques remain to be resolved. Second, for those "priced out" there must be a satisfactory transportation alternative. In few if any cities does the transit system meet this criteria. Third, public resistance, including charges of discrimination against low income and inner city residents has been severe to date. Finally, there is a real danger that hard pressed urban decision-makers may look upon pricing as a technique for revenue generation rather than traffic regulation.

TECHNICAL BACKGROUND
(Data quality indicated by letter at right*)

User Price Impacts: While some authorities claim **in** some cases total costs would not rise, it seems more likely that private vehicle trip costs would show a substantial gain.	C
Implementation Costs: System implementation expenses vary. For some approaches, costs would be very low (license systems for example) for electro-mechanical types the cost would be moderately high.	C
Operating Costs: Administration and enforcement represents a sizable annual expenditure. It is difficult to pin point these costs at this time and they will vary with the type of system implementated.	B
Other Costs: The collection of extensive travel data with potential for invasion of privacy may be one danger.	
Indirect Economic Effects: It would be possible to postpone additional capital facility improvements indefinitely, if charges were raised high enough and good transit alternatives were available. A good road pricing system would also save substantial user time.	B
Effects on Disadvantaged: There is a high likelihood that pricing would be discriminatory to low income individuals. In the absence of adequate alternatives, this becomes a critical problem.	C
Environmental Impact: Substantial potential impact, since if fees raised sufficiently substantial numbers of vehicle miles will not be driven.	B
Safety Impact: Less congestion is likely to result in lower accident rates.	C
Speed or Time: Changes in speed or time will occur as a result of reductions in congestion, which in turn is a function of the level of road use charges. It is possible to achieve a definite improvement in operating speed through a pricing scheme.	B
Volume: Pricing *per se* will not improve capacity, however reducing congestion may make it possible for roads to operate at design capacity more frequently than is now possible.	C
State-of-the-Art: Some techniques involve simple and proven components, others have unproven technical, administrative, and enforcement elements. A substantial amount of design and testing is still needed before both an operational and effective system is developed.	B
Institutional Background: A great deal of resistance is expected from all groups involved in transportation decision making as well as from the citizenry as a whole.	B
Traveler Response: Incentives and penalties will not generate new demand, rather channel existing demand. The result would be more dispersal of demand. New demand is not likely to be generated and possibly the net effect is likely to be a drop in overall demand.	B

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CONCEPT: AUTOMATION OF BUS SCHEDULING

Operating Description and Summary of Findings:

Current manual bus scheduling procedures are extremely slow and inefficient. As a result of this archaic technology, it is almost impossible to make major route and schedule changes in the medium sized and larger bus systems. Assignment of men and vehicles is accomplished in an inefficient manner and route patterns are not easily changed in response to changes in the patterns of origins and destination.

It is thought that automation of this procedure, chiefly through computerization, would improve the frequency and thoroughness of schedule revision.

Major obstacles remain in the way of implementation of this technology. First, the computer programs and related techniques have not been perfected although current research promises near term results. Second, inertia within the transit industry and active resistance from unions means that implementation will not easily be achieved. While the implementation of this technique is moderately costly, if successful it could generate definite savings to transit operators. Its major advantages however, are more likely to accrue as the result of facilitating widespread reorganization of transit service necessary in any plan of providing faster and more convenient transit service to urban residents. This technique may well be essential to the success of any plan of reorganization or extension of transit service as alternatives to present pattern of private transportation.

TECHNICAL BACKGROUND
(Data quality indicated by letter at right*)

User Price Impacts: Not likely to be affected.	A
Implementation Costs: Costly: Expensive hardware systems needed, expensive software adaptation required. Would depend greatly on specific application	B
Operating Costs: Moderate to low depending on degree of extra burden facility would place on transit operators. Operational savings would be about 1.5 to 3% of total operating costs according to current tests.	B
Other Costs: Minor, if any	
Indirect Economic Effects: Hard to judge, ability to better serve changing community with transit may alleviate some needs for other more expensive facilities.	C
Effects on Disadvantaged: Strong to the extent schedule revisions better serve low income individuals with access to needed services and job.	C
Environmental Impact: Minimum	A
Safety Impact: Minimum	A
Speed or Time: No change.	A
Volume: Not likely to be affected, except that transit capacity can better serve new areas of need.	B
State-of-the-Art: Major breakthrough needed, may be achieved if current work is as successful as claimed.	B
Institutional Background: Not easily instituted because of inertia of industry and stronger, but general resistance of unions.	B
Traveler Response: Minor, if any.	B

*Data Quality: A = strong empirical documentation, B = data which appears valid but which should be subject to further analysis, C = hypothetical data only, or data suspect, requires further verification.

CONCEPT: URBAN GOODS MOVEMENT IMPROVEMENTS

Operating Description and Summary of Findings

Removal or redirection of truck traffic is one way in which additional roadway capacity may be made available in congested times or places. Three basic techniques were reviewed: (1) time of day restrictions (2) reducing the total number of trucks needed in urban areas and, (3) parking and movement regulations.

In general it was found that trucks did not constitute a significant enough portion of urban traffic such that removal, even allowing for greater size, would greatly improve other vehicle flow. It was observed however, that many of the techniques proposed for reduction of truck trips would improve the efficiency of shipping and receiving. Thus, while only slight traffic management benefits may be expected they may be achieved at little or no cost or may actually improve the economics of urban goods movement.

TECHNICAL BACKGROUND
(Data quality indicated by letter at right*)

User Price Impacts: No effect.	A
Implementation Costs: Moderate to expensive	B
Operating Costs: Moderate increase	C
Other Costs: Principally those disruptions and reschedulings associated with new patterns of delivery.	
Indirect Economic Effects: Minor	C
Effects on Disadvantaged: Minimal	B
Environmental Impact: Minimal	B
Safety Impact: Minimal	B
Speed or Time: Minor increase in speed possible	C
Volume: Small increase in capacity.	B
State-of-the-Art: Essentially proven and operational	B
Institutional Background: Stiff resistance expected from industry, expected to be some problem with those techniques requiring enforcement.	B
Traveler Response: To the extent roadways experience real reductions in levels of congestion, it can be expected that new demand will be generated.	B

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CONCEPT: AIRPORT ACCESS IMPROVEMENTS

<u>Operating Description and Summary of Findings</u>

Improved airport access techniques are needed as substitutes for extensive highway and parking facilities serving airports. Four possible approaches were summarized in this analysis: (1) organized limousine or bus service (2) demand bus service (3) minibus shuttles from close in lots (4) satellite parking facilities in remote locations.

The four techniques surveyed could reduce demand for land adjacent to airports. However, faster access is more likely to result from improvements in general traffic flow.

There are likely to be institutional barriers to implementation of several of the reviewed techniques.

TECHNICAL BACKGROUND
(Data quality indicated by letter at right*)

User Price Impacts: Mixed, in some cases lower than present modes.	B
Implementation Costs: Low: Vehicle and administrative costs would be the major components.	A
Operating Costs: Low but uncertain: Buses and mini-buses are not expensive to run per mile (labor is an important part of the cost), but concession charges may be assessed by the airport.	B
Other Costs: Mainly loss of convenience, comfort and privacy of present modes.	
Indirect Economic Effects: Potentially significant: Less need for airport land to be used for parking lot development, less need for capital intensive facilities to serve airports (highways, etc.).	B
Effects on Disadvantaged: Possible benefits for low income airport employees who would use a suitable access system as a commuting mode.	C
Environmental Impact: Minimal	A
Safety Impact: Minimal	A
Speed or Time: None or increased times: Dial-A-Bus, conventional bus, and satellite lots may be slower than taxis or private auto trip times.	B
Volume: Increased volume per vehicle, as compared to taxis or private car, would result from all these facilities except the minibus shuttle.	B
State-of-the-Art: Some developmental work still needed on disptaching and routing systems for Dial-A-Bus otherwise all proven technologies involved.	A
Institutional Background: Resistance from existing concessionaires (taxi operators and limousine) would probably be the major institutional barrier.	B
Traveler Response: The absence of positive incentives such as time savings, comfort, or convenience may outweigh personal economic advantage (if any) and require enforced usage of alternative airport access facilities.	B

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CONCEPT: DEMAND ACTUATED BUS SERVICE

Operating Description and Summary of Findings

Demand actuated transit has been presented in a number of operating configurations. In most cases buses, whether large or small, are routed according to passenger requests and feature door-to-door service. Most often mentioned applications are feeder bus service to rail lines and to provide extended mobility for the transportation disadvantaged.

At this time there is little evidence to indicate that demand actuated transit would alleviate demand for new facilities. The high operating cost and unresolved technical, institutional, and demand questions dictate a cautious approach to this concept.

TECHNICAL BACKGROUND
(Data quality indicated by letter at right*)

User Price Impacts: Heavily subsidized fares on existing experiments run between 25¢ and 50¢. It is unlikely that this fare level could be maintained in many applications.	B
Implementation Costs: A five vehicle manually dispatched system initially is estimated to cost about $42,000. A 100 vehicle, computer dispatched system would cost about $1.3 million to implement initially.	B
Operating Costs: Estimates, based on limited experiments, 53¢ to 91¢ a mile (no union wage paid). Probably much higher in more typical urban environments.	C
Other Costs: Demand transit, under some plans, may substitute many smaller transit vehicles for fewer large vehicles. Demand transit may also jeopardize the existance of taxi service, conventional mass transit, and jitneys.	B
Indirect Economic Effects: The advent of demand bus is not expected to alter personal travel habits to any great extent and hence would not be expected to reduce demand for new facilities.	C
Effects on Disadvantaged: Major advantage to low income and other captives in that a greater range of transit destinations are served (however, cost in time and money is high).	A
Environmental Impact: Slight	C
Safety Impact: Not likely to be affected	B
Speed or Time: Slower than comparable auto trip, rapid transit, and in some cases conventional buses.	B
Volume: Additional capacity on existing facilities would be a function of the number of automobiles replaced; anticipated that few autos would be replaced	B
State-of-the-Art: Manually dispatched system - adequately demonstrated. Computer dispatched system - operational capability exists	B
Institutional Background: Potential serious conflicts between taxi and transit operators, possibly with state laws. Union responses unpredictable, expect union wage rates to make service very costly (all applications to date non-union).	B
Traveler Response: It appears likely that a slight increase in total trips would result as the opportunity for travel to many new destinations is presented to the transportation disadvantaged.	C

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CONCEPT: BUS TRAFFIC SIGNAL PREFERENCE SYSTEMS

Operating Description and Summary of Findings

By controlling traffic signals to favor buses, it may be possible to decrease bus travel times. One version would permit buses to change lights to green or hold lights green whenever a bus approaches. Another would only change lights or hold a green when side street traffic queues were manageable and ample downstream capacity existed. The latter is felt to be the only practical large scale system application, although the former may prove useful in certain specific circumstances.

Under mixed traffic circumstances, the impact on bus travel time is expected to be too minor to warrant implementation. Further, without appropriate large scale schedule adjustments, this slight travel time advantage may not be fully realizable. However, this is one technique which may prove more valuable if implemented in conjunction with an exclusive bus lane. (See Volume II)

TECHNICAL BACKGROUND
(Data quality indicated by letter at right*)

User Price Impacts: No change expected for bus users; for automobile users, increased wait time may increase operating costs.	B
Implementation Costs: Estimated at $1,800 per intersection (from Washington, D.C. data); extra costs for leased lines, computer and administrative service center variable.	C
Operating Costs: Unknown, but expected to be slight.	C
Other Costs: Drivers in cars on non-bus routes may be penalized with extra wait times at lights. To some extent this is counter balanced by the extra speed of vehicles once they enter the same traffic stream as buses.	B
Indirect Economic Effects: Slight, unless bus time savings or appearance of faster ride attracts enough auto commuters to decrease demand for new facilities.	B
Effects on Disadvantaged: Slight benefits resulting from faster trips	B
Environmental Impact: Emphasis on people not vehicles may increase vehicle hours and hence total emission levels. Appears effect would be small.	C
Safety Impact: No change anticipated.	B
Speed or Time: Slight, estimate 3% of trip time saved.	B
Volume: Slight, any volume increases would result from transit ridership gains.	C
State-of-the-Art: Alleged that hardware and software easily produced but it appears that a demonstration is needed to verify hardware performance.	B
Institutional Background: Slight resistance might be expected from delayed motorists.	C
Traveler Response: Ridership demand formulas developed by transit planners and based on empirical evidence list speed as a major component affecting a person's decision on whether to ride a bus (assuming that a person is not a captive). If a bus priority system can noticeably decrease bus travel time, or perceived bus travel time (and this has not been conclusively demonstrated) then some new patrons may be attracted to transit.	B

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CONCEPT: AUTO DRIVER AIDS AND DIRECTION SYSTEMS

Operating Description and Summary of Findings

Systems of changeable roadside message signs are designed to warn motorists in advance of undesirable traffic conditions and to advise on more favorable alternative routes. As a result it is hoped net travel time delays would be reduced.

Studies of this technique have failed to indicate any substantial benefits from use to date. In addition, there remain serious questions about whether a workable and understandable message technology has been developed.

TECHNICAL BACKGROUND
(Data quality indicated by letter at right*)

User Price Impacts: No change anticipated.	A
Implementation Costs: Low to moderate costs. Signs $100-$250 each; surveillance and control facilities about $58,755 (also needed for ramp metering).	B
Operating Costs: Low to moderate	C
Other Costs: None of significance	
Indirect Economic Effects: Possibly achieve some individual travel time savings; not expected to reduce needs for new facilities.	C
Effects on Disadvantaged: None	B
Environmental Impact: Slight, if vehicle miles or hours are reduced as result of decrease in delay, then emission levels may drop somewhat.	B
Safety Impact: Some reduction in accident rates normally could be expected to accompany congestion reduction. (This may be more directly related to ramp metering.)	C
Speed or Time: Poorly documented, not expected to be large, but none-the-less positive.	C
Volume: Some volume increases due to reduction in instances of over-loading (this may be more directly achieved through ramp metering).	C
State-of-the-Art: Metering technology proven, signing and computer analysis needs much development.	C
Institutional Background: Requires highway agency to operate on daily basis; required justification of denial of roadway.	B
Traveler Response: This system may be expected to divert existing demand rather than generate new demand although some new demand may be generated by the improved efficiency of the system.	C

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CONCEPT: THE MINI-CAR

Operating Description and Summary of Findings

Small two to three passenger vehicles would be rented by urban residents for short trips within a particular urban area. Typically, vehicles would be powered by low emissions engines and consume small amounts of capital facility whether operating on the street or parked. Typical plans call for the vehicles to be available at many convenient locations around the city. Trips could be charged by the mile and payment by credit cards which would be available only to properly licensed drivers. The minicar would serve as an effective substitute for larger space consuming traditional vehicles.

The substantial initial investment required appears to be as great as more traditional capital intensive solutions. Major technical institutional and operational questions remain unresolved and near term applicability is therefore unlikely.

TECHNICAL BACKGROUND
(Data quality indicated by letter at right*)

User Price Impacts: Between 7.5¢ and 25¢ a mile, all inclusive, Figures are based on certain very questionable technical feasibility assumptions and are realized only with large scale applications.	C
Implementation Costs: High costs: A Contra Costa, California, estimate of $70 million in capital costs for 30,000 cars plus computer equipment. Another study says $13.5 million for initial financing.	C
Operating Costs: Moderate: Rough and questionable estimates indicate 20¢ a mile to be a minimum figure for occasional use service.	C
Other Costs: There may be substantial diversion of present mass transit users to the minicar and more overall congestion. Availability of the vehicle might stimulate additional trips not now being taken. Notice should be taken of possible inconvenience associated with locating a vehicle.	C
Indirect Economic Effects: Moderate potential: Will reduce need for parking facilities and possibly for road construction.	C
Effects on Disadvantaged: Potentially useful: minicars seen as ubiquitous mobility for low income groups - may help other traditional captives.	C
Environmental Impact: Unclear: minicar may be less polluting than standard cars; but if transit users are diverted to minicars or if new trips are generated, these effects may be negated.	C
Safety Impact: Unclear: While minicar design stresses safety features, there may be problems due to low speed capabilities and possible licensing policies.	C
Speed or Time: Unclear: with large concentration of minicars in congested areas, some time saving would result due to minicar's shorter length if a net reduction in space required were achieved.	C
Volume: Unclear: with minicars, number of vehicles processed might increase. However, passenger processing efficiency might decrease if diversion from carpools and mass transit is large.	C
State-of-the-Art: Redistribution of vehicles, operating vehicle, communications and coordination technology, billing, etc. require substantial development and demonstration before proven.	C
Institutional Background: Lack of concrete experience in this field: It appears that many labor, governmental, and consumer groups will take various positions on concept. No source of large capital investment known.	C
Traveler Response: It appears that actual use of the system is contingent upon assurance that it is a dependable mode, cheaper and almost as fast as a regular automobile, and possibly may require reinforcements in the form of higher priced, or eliminated parking for regular automobiles in the CBD.	C

*Data Quality: A = strong empirical documentation, B = data which appears valid but which should be subject to further analysis, C = hypothetical data only, or data suspect, requires further verification.