High-Occupancy-Vehicle Treatments, Impacts, and Parameters: Procedures and Conclusions

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This paper contains the first part of a report that details the findings of 256 past and present high-occupancy-vehicle (HOV) treatments. The procedures followed and the major conclusions found concerning the 19 specific HOV treatment types studied are presented. Some of these conclusions are that only four treatments (park-and-ride lots, separate roadways, contraflow freeway and arterial lanes, and preferential bypasses at metered ramps) produced the impacts that were expected. Another seven treatments either produced mixed results or had no effect, and for the remaining six treatments either no reportable data had been collected or they had never been implemented. Findings concerning specific HOV treatments were as follows: transit malls and automobile-restricted zones must have an operating transit system in the street and a major pedestrian generator to be effective; reserved-lane operations must not affect reverse-flow traffic and should be physically separated from peak-direction traffic to be effective; contraflow lanes usually have safety problems during off-peak hours or where major turning movements or pedestrian activity exists; concurrent-flow lanes usually need major transit use or a large increase in occupancy to be effective; and finally, a much greater effort must be made by traffic engineers, planners, and researchers to obtain pertinent information about HOV preferential treatments. Volume 2 of this report (available from the New Jersey Department of Transportation) contains a comprehensive bibliography along with a listing of each HOV treatment cited, including the year implemented, size, priority cutoff, hours of operation, current status, and any before-and-after data concerning the impacts that the treatments may have had.

More and more emphasis has been put on the use of mass transit and carpooling in recent years, mainly because of such factors as the trend away from construction of new highways caused by fiscal constraints, limited rights-of-way, and the ever-present, although not always prevalent, energy problems. However, the American love affair with the automobile continues, and the habit of driving alone to work is difficult to change.

One way of enticing people to form a carpool or use mass transit is to give carpools and buses some type of preferential treatment. Preferential treatments for high-occupancy vehicles (HOVs) have therefore become popular transportation system management (TSM) tools for reaching certain objectives such as conserving natural resources or increasing the person-carrying capacity of a roadway at low cost. Examples of such treatments are reserving a lane on a freeway for HOVs, preferential toll charges for HOVs, and special park-and-ride facilities.

In the past, a location was studied for a specific HOV treatment because no systematic approach was available to determine which HOV treatment was best suited for the location. Lack of a systematic approach, in turn, was due partly to the lack of understanding of how well different preferential treatments compared in terms of meeting specific objectives. Therefore, an expensive and detailed feasibility study was necessary to determine whether a specific HOV preferential treatment had the possibility of meeting the proposed objectives for the location.

For example, during the past several years, three different feasibility studies were performed in New Jersey for a preferential HOV lane at three different locations. At one of these locations, Route 444 in Middlesex and Union counties, it was determined that a preferential lane was feasible within 12 mi of the 39-mi study area. After that study, the preferential lane was implemented and subsequently discontinued because it did not meet the objectives. At another location (17 mi of Routes 80 and 95 in Bergen and Passaic counties), it was determined that a preferential HOV lane of 1 mi was feasible for bypassing congestion associated with the George Washington Bridge toll plaza. Steps are currently under way to achieve implementation. However, a preferential lane was not recommended for the remaining 16 mi of the study area. At the third location (6 mi of Route 3 in Passaic, Bergen, and Hudson counties), it was determined that a preferential HOV lane was not feasible.

Because each location was studied independently, large amounts of time and money were expended before it was determined whether the particular preferential treatment should be recommended for implementation. Also, because only one specific preferential HOV treatment was studied at a time, another study was necessary to determine the feasibility of other HOV treatments.

Many preferential HOV treatments have been studied and implemented in other parts of the country. Tremendous amounts of data have been provided by these studies,

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which can be used in identifying the potential of the different treatments in meeting certain objectives. However, no one has compiled these data by each particular parameter associated with the objectives of the HOV treatment.

Therefore, this study had two main objectives: first, to identify the objectives associated with each HOV preferential treatment and from the data of past research, to determine how the parameters associated with these objectives were affected by both successful and unsuccessful HOV treatments; and second, to put this information into an easily accessible manual for project engineers to use in assessing how a specific objective might be affected by implementing a specific preferential treatment.

PROCEDURE

The project was set up in three steps. First an extensive literature review of past work concerning HOV preferential treatments was conducted to compile the material available on the objectives associated with each HOV treatment. Also considered were the parameters used to measure whether the objectives were being reached. Examples of these parameters are travel time, automobile occupancy, transit ridership, and accident rates. These preferential treatments, objectives, and parameters were then grouped in tabular form.

After these groupings had been made, the next step was to determine the opinions of New Jersey's local and state officials on these HOV preferential treatments. In the past, HOV treatments were studied taking only engineering concerns into consideration. Later it was found that the officials were not as enthusiastic as the engineers about the treatment and its attributes. Thus, the main goal during this step of the project was to determine which objectives the respondents thought were the most important for their jurisdiction, whether the respondents thought HOV preferential treatments or more conventional transportation methods best addressed these objectives, and which HOV treatments were supported by the respondents and should be studied for implementation in the future.

Initially, a mailout questionnaire was prepared to obtain these data. However, because most of the local officials were unfamiliar with HOV preferential treatments, it was decided that personal interviews would be more appropriate. HOV treatments, which are relatively new techniques in traffic management, could be better explained and understood in face-to-face meetings. But the list of local officials had grown to over 700, which caused another problem, that is, the large amount of time needed to conduct these interviews. Therefore, plans were again changed and it was decided to interview representatives of the metropolitan planning organizations (MPOs) within the state. In this way, the number of interviews could be greatly reduced and the local point of view could still be obtained because these organizations deal regularly with elected officials. Also, these representatives were more familiar with the use of preferential treatments.

The final step in this study was the preparation of a user's manual detailing experience with HOV preferential treatments. From the earlier literature search, an association was determined among the preferential treatments, the impacts of each treatment, and the parameters used to measure whether the objectives were being met. The information on the effect of HOV preferential treatments on these parameters had not previously been gathered and compiled for easy reference. The resulting manual enables an engineer proposing a preferential treatment to take the parameters associated with the specific location and compare them with both successful and unsuccessful treatments of the past. The comparison will help the engineer in determining the feasibility and possible success of the proposed preferential treatment.

RESULTS

Treatments, Impacts, and Parameters

The first item to be determined was the nature of an HOV preferential treatment. Such treatments were generally considered to be any improvement designed to give those who carpool, vanpool, or use public transportation preference during their trip over those who do not. These treatments are generally installed for use during the peak periods of the day, when congestion exists, and require only minimal cost outlay and a relatively short time to implement. Use of this definition identified 19 preferential treatments, which were then grouped by the four types of preference they provided:

1. Economy: treatments that primarily make a specific trip less expensive for the HOV user,
2. Convenience: treatments that primarily make a specific trip more convenient for the HOV user,
3. Space: treatments that primarily reserve an area for HOV users and require low-occupancy-vehicle users to change their route, and
4. Time: treatments that primarily reduce the travel time for HOV users for a specific trip without requiring non-HOV users to change their route.

The 19 preferential treatments studied, by type, are defined as folows:

1. Economic-preferential treatments
   a. Preferential toll charge: increased toll on a facility for low-occupancy-vehicle users or reduced toll for HOV users;
   b. Preferential freeway congestion price: fee charged to low-occupancy-vehicle users for travel on a congested section of freeway that previously was free (HOV users would continue to travel free);
   c. Preferential parking price: increased fee for low-occupancy-vehicle users to park off the street or reduced parking fee for HOV users;

2. Convenience-preferential treatments
a. Park-and-ride lot: centralized parking lot for HOV users, accessible by transit;
b. Preferential parking: reserved parking in the most desirable spaces for HOV users (applicable to large employers, transit station parking areas, and shopping malls);
3. Space-preferential treatments
a. Exclusive freeway ramp: existing freeway ramp reserved for HOV users;
b. Transit mall: street reserved for transit and HOV vehicles, principally used within a central business district (CBD) shopping area or a heavy transit transfer area;
c. Automobile-restricted zone: area of a city in which all automobile traffic is restricted, except sometimes HOV vehicles and public transit (much larger restricted area than a transit mall);
d. Reduced parking with priority: reduced availability of parking spaces, with priority given to HOV users;
e. Turning movement restriction: turning movement restricted to HOV users;
4. Time-preferential treatments
a. Separate roadway: roadway for the exclusive use of HOV users, usually in the median of an existing freeway;
b. Contraflow freeway preferential lane: freeway traffic lane in the off-peak direction reserved for HOV users;
c. Contraflow arterial preferential lane: same as the preceding treatment except on an arterial street;
d. Concurrent-flow freeway preferential lane: freeway traffic lane in the peak direction reserved for HOV users;
e. Concurrent-flow arterial preferential lane: same as the preceding treatment except on an arterial street;
f. Exclusive bypass ramp: ramp built exclusively for HOV users to bypass a congested ramp, usually in conjunction with a preferential lane;
g. Preferential bypass at metered ramp: bypass on the shoulder of a ramp that meters traffic onto a freeway so that HOV users can avoid the queue on the ramp;
h. Toll-facility preferential lane: reserved toll booth so that HOV users can bypass the queue at the toll plaza;
i. Signal preemption: traffic signal control, actuated by transmitters located on transit vehicles, that extends the green phase for transit vehicles, thus reducing their delay.

Once the HOV preferential treatments had been determined, the impacts associated with these treatments needed to be determined. In a study (*1*) performed by JHK and Associates and Peat, Marwick, Mitchell and Company for the Federal Highway Administration, a list of goals and impacts was compiled that could be used for all TSM strategies. This list was very helpful in the determination of the final list of objectives, for which 18 positive impacts were chosen.

After the literature review, however, it was found that although some HOV preferential treatments met their stated objectives, they were still determined to be unsuccessful for other reasons. Because of this, a list of 17 negative impacts of these preferential treatments was compiled. These negative impacts are very detrimental to the successful presentation of the treatments to the public.

The next step was the determination of which preferential treatments and which impacts should be grouped, that is, which preferential treatments can be used to meet the positive objectives or to cause the negative impacts to occur. After a review of the literature, a matrix was constructed showing these relationships.

Finally, the parameters that are used to monitor whether the impacts are being affected had to be selected. Thus, Table 1 was compiled, which gives parameters for each of the 35 impacts. The effect that an HOV preferential treatment has on these parameters was used in the third part of this study to determine its success or failure in meeting its objectives.

Questionnaire and Personal Interviews

As detailed in the section headed Procedure, representatives from 12 MPOs were interviewed. Each representative was asked five questions, dealing with (*a*) the objectives associated with the organization itself and with the HOV treatments, (*b*) whether priority should be given and which treatments are applicable in the organization's area, and (*c*) what negative impacts are associated with HOV treatments. Most of the responses to these questions are summarized in Tables 2–4.

From the results of these interviews, the following conclusions can be drawn:

1. Keeping costs down, decreasing congestion, improving the productivity (capacity) of the transportation system, and improving safety are the main objectives and pose the largest problems to the planning organizations.
2. It is generally agreed that HOVs should be given preference, but the specific situation should determine the definition of the HOV.
3. All but one of the 19 HOV preferential treatments were judged to be applicable by at least one planning organization. The two larger metropolitan areas have much more use for these treatments because these are the areas where congestion is greatest.
4. Even though there seems to be support for HOV preferential treatments, very few are being considered for implementation. Preferential treatments are not given top priority in the development of the overall transportation system.
5. The determination of exactly what an HOV treatment is and where and when to implement it is still very abstract. More work needs to be done to determine how to successfully implement an HOV treatment.

TABLE 1 PARAMETERS USED TO MEASURE EFFECTIVENESS OF HOV TREATMENT IMPACTS

Impact	Parameter	Impact	Parameter
Increase person-carrying capacity of roadway	Persons carried, volume-to-capacity comparison	Increase non-HOV operational costs	Parking costs, point-to-point travel costs
Increase bus transit use	Transit passengers, transit passenger-miles of travel	Increase delays for non-HOVs	Person-hours of travel, vehicle-hours of travel, vehicle delay, point-to-point travel time, person delay
Increase bus transit reliability	Schedule adherence, bus breakdowns, travel-time variance	Increase transit operating costs	Operating costs, revenues, deficits
Increase carpooling and vanpooling	Number of carpools and vanpools, automobile occupancy	Increase governmental operating costs	Operating and maintenance cost
Increase safety	Number of accidents, accident rates both per vehicle-miles and per passenger-miles traveled	Increase amount of weaving on roadway	Weaving maneuvers, accidents, accident rates both per vehicle-miles and passenger-miles traveled
Reduce need for future expansion of roadway	Difference between person-moving capability with and without improvement	Increase enforcement costs	Enforcement costs
Reduce congestion on roadway	Total vehicle and person delay	Increase parking needs	Parking reductions, parking needs, parking accumulations
Reduce future capital costs for new construction	Costs saved from sixth objective	Increase energy use initially	Energy consumption
Reduce automobile use on roadway	Number of vehicles, vehicle-miles traveled, automobile occupancy, person-miles of travel	Increase accidents initially	Number of accidents, accident rates both per vehicle-miles and per passenger-miles traveled
Reduce travel time for HOV users and overall	Person-hours of travel, vehicle-hours of travel, point-to-point travel times, vehicle delay	Decrease comfort and convenience for non-HOV users	Perceived comfort and convenience
Reduce travel costs for HOV users	Parking cost, point-to-point travel cost, point-to-point transit fare	Decrease air quality initially	Concentration of pollutants, tons of emissions
Reduce energy use	Energy consumption	Decrease noise quality initially	Noise levels
Improve air quality	Tons of emissions, concentrations of pollutants	Diversion to other routes	Traffic volumes
Improve noise quality	Noise levels	Inconvenience to residents of affected area	Parking needs, walking distance from parking location to destination
Improve comfort and convenience for HOVs	Perceived comfort and convenience, transit load factor, walking distance from parking location to destination	Hamper commercial deliveries	Business owners' complaints
Increase pedestrian and bicycles traffic	Bicycle and pedestrian counts	Negative media coverage	Press articles, editorials
Enhance local commercial access and activity	Dollar sales, employment	Court actions initiated against priority treatment	Court cases
Minimize operating costs for roadway administration	Operating and maintenance costs, operating revenue, operating deficits		

TABLE 2 IMPORTANCE OF EACH IMPACT TO INTERVIEWED PLANNERS

	No. of Responses by Degree of Importance		
Impact	Absolute	Great	Some, Little, or None
Reduced capital costs	9	2	1
Reduced congestion	9	1	2
Increased safety[a]	7	4	1
Increased governmental operational costs	7	2	3
Increased transit use	5	6	1
Increased roadway capacity	6	2	4
Reduced user travel time	3	6	3
Reduced future need to expand roadway	4	3	5
Improved comfort and convenience for HOVs	2	7	3
Increased carpool use	3	4	5
Increased bus reliability	3	3	6
Enhanced local commercial activity	3	3	6
Reduced user travel costs	0	8	4
Reduced automobile use	1	6	5
Improved air quality	1	3	8
Increased pedestrian and bicycle travel	1	2	9
Reduced energy use	0	3	9
Noise impacts	0	0	12

[a] The possibility of increased accidents was mentioned as a negative impact, but the results for 7 of 10 treatments showed no increase in accidents.

This last conclusion leads into the final step of the project, which was to determine whether there is a common link among the successful HOV preferential treatments in the past.

Implemented HOV Treatments and Data

An extensive telephone survey was performed in which state and city transportation agencies across the country were contacted to determine which HOV treatments had been implemented and where, and also to obtain any before-and-after implementation data that might have been collected. Through this survey, 256 specific applications of preferential treatments were pinpointed. Before-and-after data were collected for only about half of these treatments to determine their effectiveness, and only about a fourth had substantial data. All the collected data as well as the entire bibliography are included in Volume 2 (*2*) of this report, which can be obtained by contacting the author.

As shown in Table 5, the format includes the specific locations, year implemented, and other general information for each preferential treatment. Then, as shown in Table 6, for this type of preferential treatment, any before-and-after data for each specific impact are given.

Table 7 presents the impacts that each preferential treatment is expected to have. The amount given in the first column after the name of each treatment is the total number of treatments found in the United States. The shaded blocks represent the expected impact areas. The number

TABLE 3 APPLICABILITY OF HOV TREATMENTS IN AREA REPRESENTED BY MPO

Treatment	No. of Positive Responses
Park-and-ride lot	10 (4)
Preferential toll charge	7 (2)
Preferential parking	7 (1)
Toll-facility preferential lane	6 (1)
Automobile-restricted zone	6 (1)
Concurrent-flow arterial preferential lane	6 (3)
Preferential parking price	5
Contraflow arterial preferential lane	5
Transit mall	5
Exclusive bypass ramp	4
Contraflow freeway preferential lane	3
Signal preemption	3
Reduced parking with priority	2
Turning movement restriction	2
Separate roadway	2
Concurrent-flow freeway preferential lane	2 (2)
Preferential freeway congestion price	2
Exclusive freeway ramp	1
Preferential bypass at metered ramp	0

NOTE: Numbers shown in parentheses indicate responses where preferential treatments are now or have been in operation.

TABLE 4 NEGATIVE IMPACTS THAT MAY CAUSE PROJECT TO BE DROPPED FROM CONSIDERATION

Impact	No. of Responses
Increase accidents initially	6
Inconvenience to residents of affected area	6
Increase governmental operating costs	6
Increase delays for non-HOVs	5
Increase amount of weaving on roadway	4
Increase transit operating costs	4
Diversion to other routes	3
Hamper commercial deliveries	3
Decrease comfort and convenience for non-HOV users	2
Negative media coverage	2
Increase parking needs	1
Decrease air quality initially	1
Court actions initiated against priority treatment	1
Increase non-HOV operational costs	0
Increase enforcement costs	0
Increase energy use initially	0
Decrease noise quality initially	0

TABLE 5 REPORT GIVING GENERAL INFORMATION ON HOV TREATMENTS: TREATMENT L—CONTRAFLOW FREEWAY PREFERENTIAL LANE

	Treatment No.		
Item	L-1	L-2	L-3
Location	Southeast Expressway, Boston, Mass.	I-45N, Houston, Tex.	U.S.-101, San Francisco, Calif.
Year implemented	1971	1979	1972
Length/size	8.5 mi	9.6 mi	4 mi
Number of lanes	1 of 4	1 of 3	1 of 5
Priority cutoff	Bus only	Buses and 8+ vanpools	Buses only
Hours of operation	NB: 7:00–9:30 a.m. SB: 4:00–7:00 p.m.	SB: 6:00–8:30 a.m. NB: 4:00–6:30 p.m.	NB: 4:00–6:00 p.m.
Current status	SB operation suspended in 1971, NB operation suspended in 1976	Operation suspended in 1984	Operational
Violations		10–15 violations per month	No violation problems
Comments	Southbound operation closed after 1971 demonstration because of small benefit; northbound closed in 1976 because operating costs were too high. Lane was only operated during the summer because of safety problems when setting up and removing cones during darkness	Operation was replaced by a separate roadway (K-8)	Connects with concurrent-flow freeway lane (N-2)

in each shaded block indicates the number of treatments that had before-and-after data for that impact. Table 7 shows that the type of data most often collected or calculable deal with congestion reduction, travel-time improvement, increased capacity, capital cost reduction, and safety. Data not usually collected deal with energy, air and noise quality, comfort and convenience, and commercial activity. This closely matches the results of interviews with the state's planning and transit organizations about which impacts are considered important and which are not.

Number and Results of Treatment

In the following paragraphs each preferential treatment will be briefly reviewed, giving the number of treatments, whether the expected impacts occurred, and why they did or did not occur, if possible.

Preferential Toll Charge

Seven cases of preferential toll charges were cited, all of which are still operational. From the data available (seven sites), this preferential treatment really has no effect on increasing the number of carpools and thus improving capacity. However, it does not increase operating costs or cause court actions, either. Therefore, it seems to simply be a way to reward HOV users.

Preferential Freeway Congestion Price

No present or past implementations of this treatment have been found in the United States.

Preferential Parking Price

Two cases of the use of preferential parking prices were cited; one has been suspended because a construction project has removed the parking area. No real data were collected; therefore, no conclusions can be drawn.

Park-and-Ride Lot

In a New Jersey study, the 50 states were surveyed for before-and-after data concerning the use of park-and-ride lots. The results of this study have been published (*3*) and are used as the data base for this treatment. Ten sites were evaluated. Very little in the way of concrete data was available, but a few assumptions can be made. Park-and-ride lots do decrease energy use, vehicle miles traveled, and operating costs, but probably also create additional travel time for the commuter.

Preferential Parking

Five instances of preferential parking treatments were cited; one has been suspended because a construction project has removed the parking area. No data were collected; therefore, no conclusions can be made.

Exclusive Freeway Ramp

Four treatments used exclusive freeway ramps; one has been suspended because of the opening of a separate roadway for buses. From the small amount of data available

TABLE 6 REPORT GIVING BEFORE-AND-AFTER DATA ON HOV TREATMENTS: TREATMENT L—CONTRAFLOW FREEWAY PREFERENTIAL LANE

Treatment No.	Description of Impact
Increase person-carrying capacity of roadway	
L-1	Before implementation there were 5,054 vehicles, including buses, carrying 8,898 people for an average occupancy of 1.76; after implementation there were 5,068 vehicles, including buses, carrying 9,058 people for an average occupancy of 1.79
L-2	During the first week of operation 57 buses carried 804 passengers and 164 vanpools carried 1,539 passengers; after 1 year, 125 buses carried 5,140 passengers and 412 vanpools carried 3,584 passengers, an increase of 6,381 passengers and 316 vehicles
L-3	Very small increase in bus users
Increase bus transit use	
L-1	Before implementation buses carried 2,152 passengers; 3 months after implementation 65 buses carried 2,454 passengers
L-2	During the first week 57 buses carried 804 passengers; 1 year later, 125 buses carried 5,140 passengers
L-3	Currently, 150 buses carry 6,000 passengers, a very small increase in bus patronage.
Reduce need for future expansion of roadway	
L-1	Because approximately 100 vehicle trips were eliminated, it is estimated that it would take an additional year for the roadway to reach capacity
L-2	During both peak periods, 5,000 vehicle trips were eliminated; if one-fourth of these were eliminated during the peak hour, it is estimated that it would take an additional 7 or 8 years for the roadway to reach capacity
L-3	Because of a small increase in occupancy, no reduction is needed

(three sites), this treatment appears to have had no effect on increasing carpools or bus use, but it does afford a travel-time savings to those who use it.

Transit Mall and Automobile-Restricted Zone

Eighteen treatments were found in which transit malls or automobile-restricted zones were used. One has been suspended because it was in a wholesale commercial district and did not attract bus riders and pedestrians. From the small amount of data collected (three sites), it was found that most of the expected impacts did occur. However, some data were contradictory. For example, air and noise quality, pedestrian activity, commercial activity, and transit costs showed a change in the expected direction for one treatment, whereas they stayed the same or changed in the other direction for another. No explanation for this was found. Another facet of this treatment is that it usually reduces the travel time for transit.

Reduced Parking with Priority

One of these treatments was found and is still operational. No data were collected; therefore, no conclusions could be drawn.

Turning Movement Restriction

In five cases, turning movements were restricted, but they were all in conjunction with another preferential treatment, usually a preferential lane. Therefore, the effects of this treatment could not be separated from the effects of the other, more influential treatment.

Separate Roadway

Fifteen instances of the use of separate roadways were found, and all are still operational. From the available data (nine sites), these treatments performed exactly as expected. They increased both bus and carpool use, thereby reducing congestion and the need to expand the roadway. They increased bus reliability by reducing travel time and also reduced emissions and energy use. Media coverage was generally good, and no court challenges were found. This treatment did increase the transit company's operating costs because of the additional service that was usually needed to satisfy demand.

Contraflow Freeway Preferential Lane

Four treatments involving freeway contraflow lanes were found. One was suspended because a separate roadway was opened for HOVs, whereas another was closed in the evening peak because the operating costs outweighed the benefits. From the available data (three sites), these treatments also performed as expected. Bus ridership increased, reducing congestion and the need to expand the roadway. Travel time and cost for HOV users as well as energy use and emissions were reduced. The operating costs for this treatment are high. However, accidents, a major concern with this treatment, showed no signs of increasing during the peak period. During the off peak, accidents increased; it is thought that this occurred because traffic was light and vehicles mistook the priority lane for a general-use lane.

Contraflow Arterial Preferential Lane

In 26 instances, contraflow lanes were used on arterials. Eight have been suspended for the following reasons: high

TABLE 7 HOV PREFERENTIAL TREATMENTS AND IMPACTS: AVAILABLE BEFORE-AND-AFTER DATA

		Incr. Person Carry. Cap. of Rdwy.	Incr. Bus Use	Incr. Bus Reliability	Incr. Car and Vanpools	Incr. Safety	Red. Future Road Needs	Red. Congestion	Red. Capital Costs	Red. Auto Use	Red. Travel Time	Red. Travel Cost	Red. Energy Use	Imp. Air Quality	Imp. Noise Quality	Imp. HOV Comfort and Conv.	Imp. Ped. and Bicycle Traffic	Enh. Comm. Activity	Min. Oper. Costs	Incr. Non-HOV Oper. Costs	Incr. Non-HOV Delays	Incr. Transit Oper. Costs	Incr. Gov. Oper. Costs	Incr. Weaving Movements	Incr. Enforcement Costs	Incr. Parking Needs	Incr. Energy Use Initially	Incr. Acc. Init.	Decr. Non-HOV Comfort and Conv.	Decr. Air Quality Init.	Decr. Noise Quality Init.	Div. to Other Routes	Inconv. Area's Residents	Hamper Comm. Deliveries	Neg. Media Cov.	Court Actions Initiated
Pref. Toll Charges	7	1			1		1		1	1		7											2													3
Pref. Fwy. Cong. Pricing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					0	0	0	0		0		0			0	0	0			0	0
Pref. Parking Costs	2				0					0		2								0			0													0
Park-and-Ride Lots	10		0		0						1	9	4	0	0	0						0	1													
Pref. Parking	5				0					0	0					0			0										0							0
Exclusive Fwy. Ramps	4			0	1	0	1		1	0	3	0	0	0	0	0				0	0		0		0		0		0	0	0	0			0	0
Transit Malls Auto Restr. Zones	16		2	0						2			0	2	2	3	2	2	1	1	0	2				3	0		0	1	1	2	0	3	0	0
Red. Parking w/Prior.	1		0		0					0	0					0			0	0	0	0				0	0		0	0	0	0	0			0
Turning Movement Restr.	5			0	0	0					0								0	0	0						0		0	0	0	0	0			0
Separate Roadway	15	7	4	4	1		7	9	7	7	9	0	3	3	0							3	0	0											3	4
Contraflow Fwy. Pref. Lane	4	3	3	0			3	3	3		3	2	1	1	0							0	3	0				3								0
Contraflow Art. Pref. Lane	26	2	3	4			2	9	2		9	2	0	0	0							4	3	0		0		7								2
Concur. Flow Fwy. Pref. Lane	18	8	6	2	9		8	10	8	8	10	2	4	3	0							1	1	1	5		0	9		0	0				5	2
Concur. Flow Art. Pref. Lane	95	19	20	5	7		19	30	19	19	30	2	1	1	0							1	0	0	14	3	0	10		0	0				15	15
Exclusive Bypass Ramp	8			0	0		0		0	0	1	0	0	0	0	0			0						0										0	0
Pref. Bypass at a Metered Ramp	17	7		0	7		7		7	7	8	0	0	0	0	0			0					0	1			1								2
Toll Fac. Pref. Lane	5	4	2	1	1		4		4	4	4	0	0	0	0				0		1	0	3	0	0		0	1		0	0					0
Signal Preemption	16		3	4							7	0								0	5	2	2													

operating costs, low utilization, conversion to a bicycle lane, construction along the roadway, and safety problems. Two others will be suspended in the near future because of safety problems. For the number of treatments, very few data were obtainable. What is available (11 sites) does show an increase in bus use, which reduces congestion and the need to expand the roadway. Travel time and costs are reduced for HOV users. Because of the travel-time reduction, one transit company reported a reduction in operating costs. This treatment has two major drawbacks: government operating costs are high and safety is a major problem.

Concurrent-Flow Freeway Preferential Lane

Eighteen sites of concurrent-flow freeway lanes were found. One has been suspended because of the construction of a light rail system, whereas three others and the operation of another in one direction were suspended because of low utilization of the lane. From the available data (10 sites), most of the expected impacts occurred. Travel time and costs were reduced and bus reliability was improved. However, at a few sites, very little or no increase in carpool use occurred. This was the reason for the closing of two sites where there was also no bus use. Accidents were expected to be a problem for this treatment, but in no case was an extensive increase in accidents reported.

Concurrent-Flow Arterial Preferential Lane

Concurrent-flow lanes on arterials were found in 95 cases, which makes them by far the most popular treatment. However, 22 of these have been suspended for the following reasons: opening of concurrent-flow freeway lane (one case), safety problems (one case), transit strike (one case), high operating costs (one case), opening of light rail system (two cases), enforcement problems (four cases), reconstruction of the roadway (five cases), and low utilization (six cases); one was suspended for an unknown reason. In 11 other cases it has been stated that lack of enforcement or inability to enforce the restrictions may cause the suspension of these lanes. However, for none of the treatments that were suspended for low utilization were there any before-and-after lane use data, and violation rates were reported for almost none of the treatments with enforcement problems. It is therefore impossible to determine how these treatments differ from those that succeeded.

Data were available for 33 sites; the results were somewhat mixed. Most treatments increased carpool and transit use, thus reducing congestion and the need to expand the

roadway. Travel time and costs were reduced for HOV users, thus improving bus reliability. The biggest problems with the use of this treatment are enforcement and the possibility of increased accidents, although 7 of 10 treatments showed no increase in accidents. Two aspects that were thought to be problems, negative media coverage and court actions, proved not to be.

Exclusive Bypass Ramp

Eight exclusive bypass ramps were found; one was suspended because of the opening of a light rail line. No real data were collected, so no conclusions could be drawn.

Preferential Bypass at Metered Ramp

Seventeen locations with 294 bypasses were found. Only three bypasses have been suspended, two because of volume problems on the roadway and one because of lack of storage on the ramp. From the available data (for 9 sites and 81 bypasses), most of the expected impacts occurred. Carpool and bus use increased, causing reduced congestion and reduced need to expand the roadway. But at a few sites, the other ramps without bypasses were not studied to determine whether new HOV trips were being generated or whether they were being diverted from the other ramps. Travel times were reduced, and the expected problems, increased accidents and court actions, did not occur. The largest problem that surfaced was that of violation, which was reported as high as 50 percent at some locations. The inability to enforce without being too visible was also stated as a problem.

Toll-Facility Preferential Lane

Preferential lanes on toll facilities were found in five instances, and all are still operational. From the data available (four sites), this treatment does not appear to increase bus ridership, but is merely another way of giving HOV users a time savings, which improves bus reliability without adversely affecting the general traffic. When the lane is operated as a contraflow lane, the operating costs are quite high, but no increase in accidents occurs.

Signal Preemption

In 16 sites signal preemption was the treatment used. At 9 sites these were suspended for the following reasons: new signal system (one case), long delays for buses caused by congestion and an ineffective system (one case), opening of freeway preferential lane (one case), suspension of bus service (one case), high maintenance costs (one case), and long delays for side-street traffic (four cases). Again, for these treatments no before-and-after data were presented to justify the suspensions. From the small amount of available data (nine sites), the treatment appeared to have no effect on ridership but did improve travel time and therefore improved reliability and lowered the transit company's operating costs. It had mixed effects on non-HOV travel times, not affecting them at all at some locations and increasing them, causing delays for both side-street and preemptive-street traffic, at others. Government operating costs appeared to increase.

Summary of Treatment Effects

The number of applications of each treatment and the reasons for suspension of any of them are given in Table 8. In Table 9 the effects of each preferential treatment are summarized. For each type of treatment, the total for each row equals the number of impacts (shaded blocks in Table 7) expected for that treatment.

For six treatments (B, C, E, I, J, P) either no data were available or no applications had been implemented. Therefore, nothing could be said about the 84 possible effects of these treatments. For the remaining 13 treatments, 79 of 210 impacts could not be discussed because no data were available. Data were available for the 131 remaining impacts, 71 of which were affected as expected whereas 24 had a mixture of effects. Finally, for 36 impacts the effects were the exact opposite of what had been expected or they did not occur at all. Most of the latter were negative impacts that did not materialize.

Table 10 is the matrix of preferential treatments and impacts again, this time showing the types of impact for each specific treatment. The results in Tables 8–10 and a review of the data on preferential treatment as a whole may be summarized as follows:

1. A much larger effort must be made to collect the pertinent data when HOV treatments are implemented. It is hard enough to justify reserving a lane or roadway when supporting data are at hand, much less when data are not even available on whether the number of carpools increased. Also, the collection and comparison of more data will help in determining why certain negative impacts occur and how they might be reduced.
2. Nothing can be said about six of the treatments (B, C, E, I, J, P), because no data were available.
3. Four treatments (A, F, R, S) did not appear to increase bus and carpool ridership but were simply a good way of giving HOV users a time or cost reduction. The first two cost the governing agency relatively little, whereas the last two are somewhat expensive. Only Treatment S (signal preemption) could have a negative effect on non-HOV users.
4. Five treatments (D, K, L, M, Q) produced the impacts that were expected of them.
5. Four treatments (G, H, N, O) produced a mixture of impacts.
6. Transit malls and automobile-restricted zones must have an operating transit system in the street and a major

TABLE 8 HOV TREATMENTS: NUMBER IMPLEMENTED AND REASONS FOR SUSPENSION

Treatment	No. Implemented	Reason for Suspension: New Construction	Enforcement Problem	Low Utilization	Caused Delay	Other Preferential Treatment Opened or Rail Service Initiated	High Operating Costs	Other	Safety Problem
Preferential toll charge	7								
Preferential freeway congestion price	0								
Preferential parking price	2	1							
Park-and-ride lot	Numerous								
Preferential parking	5	1							
Exclusive freeway ramp	4					1			
Transit mall/ automobile-restricted zone	18			1					
Reduced parking with priority	1								
Turning movement restriction	5								
Separate roadway	15								
Contraflow freeway preferential lane	4					1			
Contraflow arterial preferential lane	26	2		1		1	1		3
Concurrent-flow freeway preferential lane	18			4		1			
Concurrent-flow arterial preferential lane	95	5	4	6		3	1	2	1
Exclusive bypass ramp	8					1			
Preferential bypass at metered ramp	17 (294)								
Toll-facility preferential lane	5								
Signal preemption	16				4	2	1	2	

TABLE 9 SUMMARY OF EFFECTS

Type of Treatment	No Data	Type of Impact: Expected	Mixed	Opposite or None
A: Preferential toll charge		1		7
B: Preferential freeway congestion price	25			
C: Preferential parking price	6			
D: Park-and-ride lot	6	3		1
E: Preferential parking	7			
F: Exclusive freeway ramp	19	1		3
G, H: Transit mall/ automobile-restricted zone	8	6	6	3
I: Reduced parking with priority	17			
J: Turning movement restriction	14			
K: Separate roadway	4	12	1	1
L: Contraflow freeway preferential lane	5	10		1
M: Contraflow arterial preferential lane	5	9	1	2
N: Concurrent-flow freeway preferential lane	4	8	8	3
O: Concurrent-flow freeway preferential lane	6	8	8	4
P: Exclusive bypass ramp	15			
Q: Preferential bypass at metered ramp	8	5	1	3
R: Toll-facility preferential lane	12	5		6
S: Signal preemption	2	3	1	2
Total	163	71	24	36

pedestrian generator, such as a commercial business area or a college, for them to be effective.

7. For reserved-lane operations to be effective, the treatment usually should not affect the reverse-flow traffic and at the same time should be physically separated from the peak-direction traffic.

8. Contraflow lanes usually have safety problems during off-peak hours or where major turning movements or pedestrian activity exists.

9. Concurrent-flow lanes must usually have either major transit use or a large increase in general use for them to be successful.

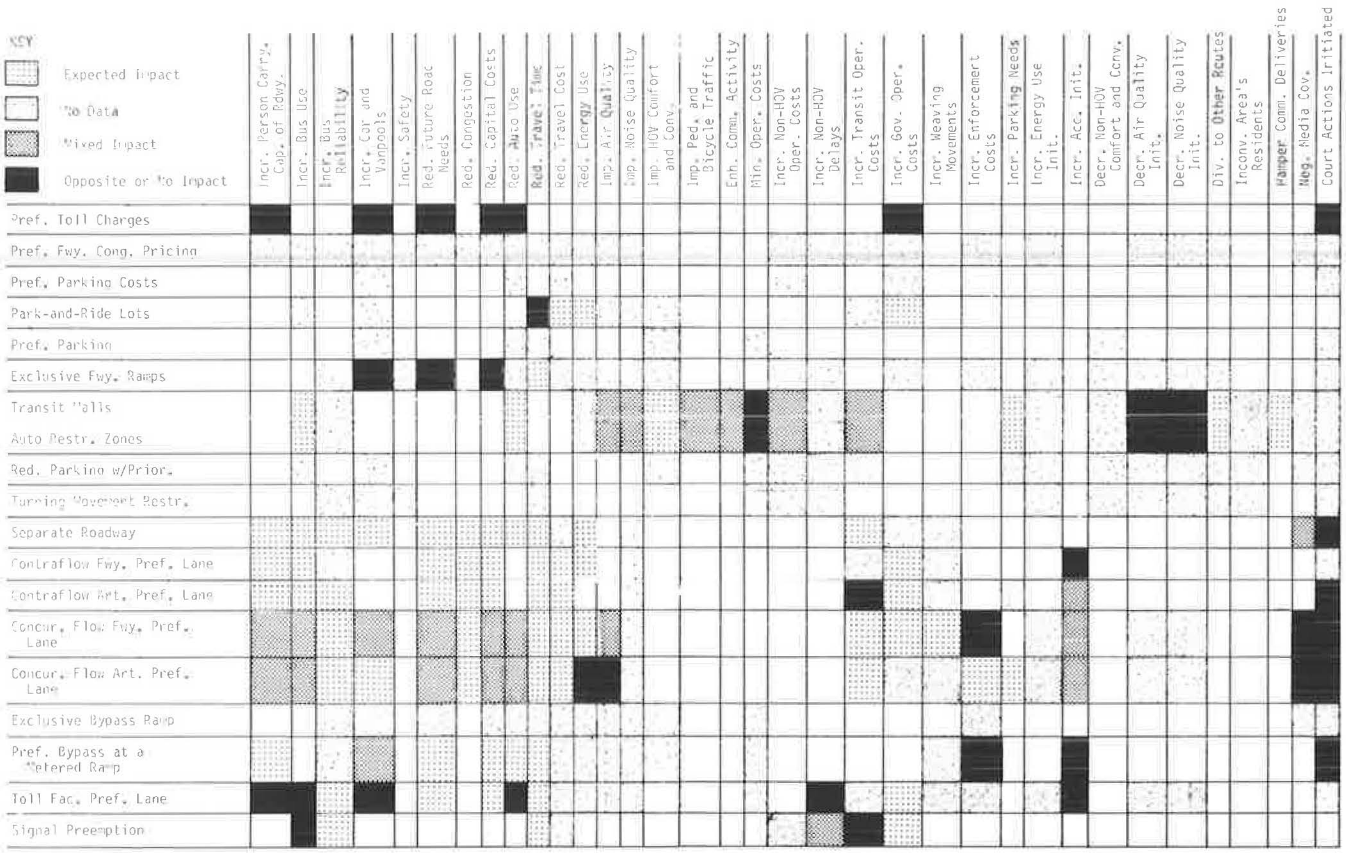
SUMMARY AND CONCLUSIONS

Because of such factors as competing funds for new highway construction, limited right-of-way, and the ever-present energy problems, mass transit and carpool use have received more emphasis in recent years. New ways of enticing commuters out of their cars and into a bus or carpool have been implemented, and this study has reviewed 19 of these HOV preferential treatments. First, the treatments were grouped by the type of preference they produce (economy, convenience, space, and time). Then the anticipated impacts (increased transit use, improved air quality, increased parking needs, etc.) were determined, and finally, the parameters used to measure these impacts (number of transit passengers, tons of emissions, number of parking spaces, etc.) were determined.

Initially, representatives of the MPOs and transit planning agencies in New Jersey were interviewed to determine their interests and views with regard to HOV treatments. From these interviews it was determined that costs, congestion, capacity, and safety are impact areas of major concern. Eighteen of the 19 HOV treatments were judged to be applicable in New Jersey, but very few are being considered. HOV treatments appear to be given low priority in the development of the overall transportation system. Exactly what an HOV treatment is and where and when to implement one are very unclear, and more work needs to be done on what makes a certain implementation a success.

Finally, contact was made with transportation agencies in the United States to determine the number of HOV treatments implemented, to obtain before-and-after data, and to obtain treatment analysis that could help determine why certain treatments are successful. Two hundred and fifty-six applications of the 19 HOV treatments were found,

TABLE 10 HOV PREFERENTIAL TREATMENTS AND IMPACTS: RESULTS



but only about half of them had any before-and-after data, and only about a fourth had substantial data.

One of the findings from the available data was that the information most often collected was that about which the MPOs were most concerned, namely, costs, congestion, capacity, and safety.

Five treatments (park-and-ride lots, separate roadways, contraflow freeway and arterial lanes, and preferential bypasses at metered ramps) produced the expected impacts, whereas four treatments (preferential toll charges, exclusive freeway ramps, toll-facility preferential lanes, and signal preemptions) did not produce the expected results but were simply a good way of giving HOV users a time or cost reduction. Four treatments (transit malls, automobile-restricted zones, concurrent-flow freeway preferential lanes, and concurrent-flow arterial preferential lanes) produced mixed results on the expected impacts, whereas for the final six treatments (preferential freeway congestion pricing, preferential parking costs, preferential parking with or without priority, turning movement restrictions, and exclusive bypass ramps) no reportable data had been collected or they have never been implemented.

It was generally found that, to be effective, transit malls and automobile-restricted zones must have an operating transit system in the street and a major pedestrian generator. Reserved-lane operations must not affect reverse-flow traffic and should be physically separated from peak-direction traffic to be effective. Contraflow lanes usually have safety problems during off-peak hours or where major turning movements or pedestrian activity exists. Concurrent-flow lanes usually need major transit use or a large increase in general use to be effective.

A much greater effort must be made by traffic engineers, planners, and researchers alike to obtain pertinent information about HOV preferential treatments. These data are needed not only to justify present and future treatments, but also to determine the reason for certain negative impacts. With this knowledge, these negative impacts might even be reduced, making preferential treatments even more attractive to decision makers.

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