ALTERNATIVE METHODS FOR MAINTAINING FREEFLOW CONDITIONS ON HOV FACILITIES

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SUMMARY

Traffic congestion has become a major issue of concern in many urban areas throughout the United States. The preferential treatment of high occupancy vehicles (HOVs) on freeways is one strategy that has been implemented to relieve some of this congestion. Interest in HOV projects has grown significantly over the past several years and currently over 340 HOV miles are in operation.

One of the guidelines for a successful HOV project requires that volumes be kept below capacity so that significant delay and congestion do not develop on the high speed priority lane. Several HOV projects across the country, however, have either reached or are approaching capacity. Actions must be taken to relieve this congestion and maintain acceptable levels of service on these facilities.

This paper presents several alternative methods for maintaining acceptable levels of service on HOV facilities. These alternatives are: Do Nothing, Raise Occupancy Requirements, Entry Metering, Limit Use to Authorized Vehicles, Congestion Pricing, Provide Additional Bus Service, Alter Commute Patterns, Close Off Some Access Points, Add More Lanes to the HOV Facility, and Add an HOV Facility in a Nearby Corridor. Each alternative is discussed in terms of facility operation, implementation, facility design, and public response/reaction. Alternatives that are recommended for implementation where feasible include the addition of more lanes to the facility, the provision of additional bus service, the limitation of facility use to authorized vehicles, and the metering of vehicles into the facility. The alternatives involving raised occupancy requirements and congestion pricing are recommended conditionally. The remaining alternatives are not recommended.

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INTRODUCTION

Traffic congestion has become a major issue of concern in many urban areas throughout the United States. Public hearings held in every state to determine local transportation concerns identified present and future congestion as the top problem. Delays on urban freeways are expected to increase by 360% between 1985 and 2005 in central cities (1). Congestion of this magnitude frustrates drivers, reduces productivity, and incurs billions of dollars of delay costs per year.

In an effort to relieve some of this congestion, transportation systems management (TSM) techniques and strategies have been developed to improve urban mobility. One such strategy is the preferential treatment on freeways for high occupancy vehicles (HOVs). Preferential treatment for HOVs have proven to be flexible, cost effective alternatives for increasing the capability of congested urban transportation systems to move people (2). Various HOV facilities yield different degrees of success, a typical project like the Route 55 HOV lanes in Orange County, California, will move about 4000 persons per hour in a single direction in 1700 vehicles. At level of service "F", a congested freeway lane may only move 1500 persons per hour in 1200 vehicles (3).

THE ROLE OF HOV FACILITIES IN RELIEVING URBAN CONGESTION ON FREEWAYS

Due to the success of several early HOV projects, interest in HOV lanes as a means of increasing the person movement capacity of a freeway without increasing vehicle movement has grown significantly in the past several years. At present, over 20 urban areas throughout the U.S. are either operating or are in the process of actively developing HOV lanes. The number of miles of operating HOV lanes has risen from 180 miles in 1985 (4) to approximately 340 in 1990. It is estimated that 850 miles of HOV lanes will be in operation by the year 2000 and that 1500 miles will be in operation by the year 2010 (2).

While HOV lanes are not appropriate in all situations, a role does exist for HOV projects. The general thinking of transportation engineers and planners is that HOV lanes are effective in increasing person throughput when:

1. The general purpose lanes are congested at least during the peak hour.

2. The HOV facility expedites the flow of HOVs without negatively affecting the operation of the mixed flow traffic.

3. The facility appears adequately utilized, approximately 400 to 800 vph.

4. Time savings to HOVs exceeds 1 minute per mile with a total time savings of at least 5 to 10 minutes per trip.

5. Enforcement is integrated into the design of the project.

6. The HOV facility is implemented in conjunction with other strategies to increase vehicle occupancy, i.e., park-and-ride lots, transfer centers, etc. (5)

To insure continued success of an HOV project, it is essential that volumes in the transitway be kept below capacity so that significant delay and congestion do not develop on the high speed priority lane (6) and travel times remain consistent.

Several HOV lanes across the country have either reached or are approaching capacity. The resulting congestion causes considerable delay on the HOV lane and travel time savings are no longer realized on those facilities. Since these two measures of effectiveness are critical to the success of a facility, actions must be taken to relieve the congestion and maintain acceptable levels of service.

ALTERNATIVES FOR MAINTAINING ACCEPTABLE LEVELS OF SERVICE ON HOV FACILITIES

In this section, several alternatives that can be applied to congested HOV facilities to manage demand are presented. Each alternative is discussed in terms of facility operation, implementation, facility design, and public response/reaction.

Do Nothing

Facility Operation

If nothing is done to manage vehicular demand on a congested HOV facility, the volumes will continue to increase until benefits are no longer realized by using the facility over the general purpose lanes. Once this equilibrium is reached, facility volumes will remain virtually constant and the level of service on the HOV lane will be only slightly better than the level of service on the mainlanes. This alternative fails to provide two of the conditions considered necessary for a successful HOV project. These conditions are (1) the flow of HOVs is expedited and (2) a travel time savings is provided by the facility.

Implementation

No implementation is required by this alternative.

Facility Design

This alternative is independent of the facility design.

Public Response/Reaction

Commuters would not use the HOV facility if there were not benefits to be derived from it. Consequently, once the capacity of the facility was reached and delays, travel times, and travel speeds became comparable to the general purpose lanes, new facility users would no longer be attracted. Once the travel time savings became unavailable on the HOV facility, many existing users would revert back to the mainlanes and possibly break up.

Unfavorable reactions could be expected from carpool and bus riders who use the facility. Carpool riders would press for demand management strategies other than increasing occupancy requirements. Bus riders would press for the removal of carpools from the facility.

Raise Occupancy Requirements

Facility Operation

Raising occupancy requirements is an appropriate way of addressing increasing demand (7) on an HOV facility. This strategy was successfully applied to the Katy Freeway in Houston in October 1988 when demand began to exceed the upper level volume that could be served with reasonably reliable travel speeds. An immediate elimination of the previous travel time delays was observed due to an initial drop in peak hour vehicular volume of about 64%. Person movement also dropped off significantly immediately after the change. By December 1989, however, daily person movement had increased to within 3% of the volume prior to the change (6). Because of the drastic reduction in vehicular volumes brought about by this alternative, it may be considered overkill in many cases.

Several operational factors need to be considered along with this alternative. First, due to the considerable peaking of commuter trips, an increase in occupancy requirements may only be necessary at certain times of the day. For this reason, a policy decision needs to be made regarding the hours the change will be in effect, i.e., a.m. and/or p.m. peak hour, a.m. and/or p.m. peak period, or 24 hour/day. Second, carpools that are no longer eligible to use the HOV facility are then cast back onto the mainlanes. The idea of casting vehicles back onto the general purpose lanes is in direct conflict with one of the primary guidelines for HOV success--expediting HOV flow without adversely affecting mixed flow traffic (7).

Implementation

Implementation of a raised occupancy alternative requires that signing along the facility be altered to accommodate the new conditions. Also, an extensive public awareness program defining the need for the action and the times the new requirement will be in effect is desirable. In the case of the Katy Freeway, however, only three days notice was given with very little marketing.

Facility Design

The design of the HOV facility is not a critical aspect of increasing the occupancy requirements. In other words, the level of occupancy can be enforced regardless of whether the facility is barrier separated, concurrent flow, or contraflow. Enforcement, however is likely to be more easily accomplished on the barrier separated and contraflow facilities due to the limited number of access points.

Public Response/Reaction

Surprisingly mild public reaction was experienced in response to the increased occupancy requirements on the Katy Freeway. Apparently, persons using the transitway recognized that the value of the facility was reduced by the high vehicle volumes (6). Many commuters switched to a higher occupancy mode as a result of the change. Some may have diverted to an HOV lane in a nearby corridor in order to take advantage of the lower occupancy requirements on that facility. It was felt that a few of the carpools placed back in the mainlanes may have broken up since the incentive of the HOV lane was no longer available to them (6).

Another concern to be addressed when considering this strategy is whether or not the HOV lane will appear to have sufficient utilization by persons on the mainlane after the change takes place. Since this approach can have a drastic effect on the vehicular volume in the HOV lane, commuters may question the level of operation even though the ultimate person volume may be comparable to that prior to the change.

Entry Metering

Facility Operation

By metering vehicles onto the HOV lanes, the facility may be operated at near maximum efficiency. The rate of entry can be adjusted to provide a fine tuning dial with which the volume on the facility can be controlled. This alternative allows for wasted space to be minimized.

Operational considerations that need to be addressed are the following. First, a significant travel time savings must still be attained despite the imposed stop at the meter and possible wait in line. Second, characteristics of the vehicles to be metered need to be determined. For example, a by-pass could be provided for buses and 3+ carpools while metering in 2+ carpools. This would provide for fewer vehicles to be placed back on the mainlanes than simply raising the occupancy requirements. Third, the metering process may only be necessary in the a.m. and/or p.m. peak hour or peak-period when congestion is most severe. Finally, the rate of metering at one location must take into account the entry volumes both upstream and downstream of the meter.

Implementation

Implementation of an entry metering alternative requires that existing signing be altered to accommodate the new conditions. Changeable message signs would be suitable since information may change on a daily basis. Entry metering hardware, including detectors, needs to be selected and installed. Also, an extensive public awareness program should be instigated prior to implementation to inform facility users of the changes.

Facility Design

An entry metering alternative is feasible for a limited range of facility designs. Due to the formation of queues behind the meter, a significant amount of storage capacity is required. Concurrent flow and contraflow lanes are thus excluded from this alternative as are some slip ramps on barrier separated facilities. Entry metering is, however, a viable option where access locations are grade separated (8).

Public Response/Reaction

The public may respond to entry metering in the following ways. First, some may opt to use a higher occupant mode in order to by-pass the meter if such an option is available. Second, some may enter the facility at a different ingress to avoid the metering process. Third, objections may be made in general to the imposed constraints. If, however, conditions prior to implementing a meter system were unacceptable to facility users, commuters may realize the need to reduce volumes in order to improve traffic operation.

Limit Use to Authorized Vehicles

Facility Operation

Under authorized vehicle requirements, the volume of vehicles using the facility could be strictly controlled by limiting the number of permits issued. The demand reduction implications of authorization is estimated to be 20% - 40% (8). Vehicles failing to obtain a permit, however, then become part of the mainlane volume thus increasing freeway congestion. The negative impact on the mixed-flow lanes can be minimized by enforcing the authorization requirement only when absolutely necessary, i.e., during the a.m. and/or p.m. peak hour or peak period.

Implementation

The following concerns should be addressed when implementing an authorization requirement. First, the signing along the facility needs to be altered to relay appropriate information to the facility riders. Changeable message signs are well suited to this application. Second, a public awareness program should be instigated in order to associate facility users with the reasons for the change and instructions for obtaining a permit. Finally, the operating agency will need to develop procedures and commit resources for authorizing large volumes of vehicles. The stringency of obtaining authorization can be adjusted depending on how much demand is to be eliminated.

Facility Design

The design of the HOV facility is not a critical factor of implementing an authorized vehicle permit alternative. Enforcement, however, would be more easily accomplished and more effective on barrier separated and contraflow lanes where ingress and egress is limited.

Public Response/Reaction

The public may oppose the constraints imposed and the confusion generated by an authorization requirement. This reaction may be eased by implementing marketing strategies to inform potential users of the requirements of obtaining authorization. Further reaction may be precluded by setting up authorization sites at the commute origins that remain open during non-work hours. Some commuters, however, may opt to take a bus in order to avoid the authorization process.

Congestion Pricing

Facility Operation

Congestion pricing is a transportation systems management technique that attempts to spread peak traffic demands to less congested segments of the network and to less congested periods of the day (9). This dispersion of peak traffic demands would improve the operation of the facility by removing excess volume from the peak hour(s). Congestion pricing allows some degree of flexibility in that, through the adjustment of price rates, minimum capacity is wasted. Some vehicles, however, will ultimately be placed back on the general purpose lanes and adversely affect mixed-flow traffic.

Several operational considerations should be addressed prior to implementation of a congestion pricing strategy. First, a policy decision should be made regarding the vehicles to be charged. For example, tolls could be imposed on all vehicles, carpools only, or lower occupant carpools only. This decision should be based on the necessary demand reduction and the volumes of each occupancy level using the facility. Second, the tolls may only be necessary to reduce demand during certain times of the day when congestion is most severe. These times would most likely be the a.m. and/or p.m. peak hours or a.m. and/or p.m. peak periods. Third, the facility must still provide a travel time savings to all users despite the toll collection procedures. This may be especially difficult if vehicles are required to stop. Finally, the method of enforcement most suitable to the toll collection system must be determined.

Implementation

The implementation of a congestion pricing alternative should include a study to determine the volume of each vehicle occupancy level desiring to use the facility and how much demand needs to be reduced. A second study should also be completed to determined the toll levels necessary to achieve this reduction in demand. An appropriate toll collection system must be selected that will complement the operational and design specifics of the facility as well as provide the most efficient throughput of vehicles given financial constraints of the operating agency. This system may consist of a traditional toll booth or employ advanced Automatic Vehicle Identification (AVI) capabilities or both. The revenue generated from the toll collection process may be used to pay off bonds together with legal and finance council as well as to operate the toll collection facility.

In addition to the actual collection of tolls, there are many TSM measures that can be considered a form of congestion pricing. One TSM alternative would be to lower bus fares during the peak hour or peak period to encourage commuters to take a bus rather than a private vehicle. A second measure would be to raise the occupancy requirement necessary to obtain free parking at the destination. This would persuade some commuters to form higher occupant carpools in order to avoid parking costs.

Facility Design

The design of the HOV facility should incorporate adequate space to construct the toll collection system at the appropriate ingress location. Depending on the collection system implemented, space may also be needed to store vehicles until they can be processed.

The HOV facility should be barrier separated with limited access to avoid excessive violation rates. With buffer separated facilities and on facilities with frequent access locations, many commuters would simply by-pass the toll collection system and enter the facility at a point downstream. Also, unless the collection system was a continuous AVI system from one end of the facility to the other, a congestion pricing strategy would favor a line haul trip since the charge is the same regardless of where the facility is exited. The design is not critical if TSM measures such as reduced bus fares and free parking are to be implemented.

Public Response/Reaction

The issue of congestion pricing is often a controversial one. Political opposition may be encountered in some cases with the major concern being double-taxation, the payment of a toll on top of federal and state gas taxes which are collected to build and maintain the highway system. Also, considerable debate is often generated by congestion pricing on the grounds that a facility is being provided for the rich. These oppositions can be addressed by defining the congestion pricing implementation as a means of demand management rather than a means to obtain revenue and reinforcing that the facility is available to everyone if the occupancy requirements are met.

Commuters may object to the toll collection system itself. For example, facility users may resent having to stop if a traditional toll booth is used and hold an aversion to having individual trips tracked if AVI is used. However, one study on the attitude of the public towards toll roads indicates that the public puts a high value on convenience and is not opposed to a user-tax if properly administered (10).

Provide Additional Bus Service (Create More Demand if Necessary)

Facility Operation

The addition of new bus service would improve the operation of the facility providing a significant number of carpool riders opted to shift their mode of travel to a bus. The volume of buses would increase but the volume of cars would decrease. Obviously, for the improved operations to be realized, the volume of private vehicles removed from the facility would have to greatly exceed the volume of buses added. Under these circumstances, the facility would move the same number of people in fewer vehicles. This alternative may also benefit the operation of the general purpose lanes by providing those commuters, in addition to transitway commuters, with a service that was either previously unavailable to them or was over-utilized.

Implementation

Along with the addition of bus service it is necessary to provide additional support services as well. The presence of park-and-ride lots and transit transfer centers enhances the performance of HOV facilities (11). Also, strategies to create more bus demand should be developed and instigated. A list of such strategies might include: increased parking prices, reduced bus fares, signal pre-emption for buses once the CBD is reached, and express and fixed route bus service. Fleet, drivers, subsidies, and maintenance facilities need to be obtained to accommodate the additional buses. A public awareness program to inform commuters of the new service may cause a switch to be observed sooner.

Facility Design

Additional bus service may be provided regardless of the design of the HOV facility.

Public Response/ Reaction

Some commuters may respond by taking a bus instead of driving. This response is more likely if the new bus service was not previously available to them or if the old service was over-utilized.

Alter Commute Patterns

Facility Operation

The operation of an HOV facility could be significantly enhanced by the alteration of commute patterns depending on the level of participation achieved. Staggered hours, compressed work weeks, and flex-time are all strategies with which commute patterns can be changed and travel demands spread over a wider period of time. The operational benefits of these strategies are: (1) peak hour congestion is relieved, (2) timing flexibility is provided to the commuter to meet bus schedules and arrange carpools more conveniently, and (3) more employees usually begin to carpool and use transit (12).

Implementation

Encouraging employers to allow or enforce alternate work hours is one Transportation Demand Management (TDM) technique to alter commute patterns. A large number of employers must be agreeable to this suggestion, in spite of the administrative costs incurred, for any positive benefits to be observed. If this method is used in conjunction with congestion pricing, some commute patterns could be altered by providing lower tolls for times outside the peak hour or peak period.

Facility Design

The facility design does not play an important role in this alternative.

Public Response/Reaction

The idea behind the alteration of commute patterns is that individual commuters will change the time of day that they use the facility. Reaction should be neutral since no constraints are being imposed and all actions are voluntary.

Close Off Some Access Points

Facility Operation

The operation of the HOV facility would be enhanced by restricting access at some location(s) due to the removal of that vehicular volume no longer able to access the facility. Closure could pertain to all vehicles, carpools only, or lower occupant carpools only. The latter two options would make enforcement extremely difficult, however, and the former may result in a excessive reduction in demand and person movement. The congestion on the facility may be such that the ingress closure is necessary only at certain times of the day:

namely, the a.m. and/or p.m. peak hour or the a.m. and/or p.m. peak period. This strategy would adversely affect the mixed flow traffic by the addition of the volume denied access to the HOV lane.

Implementation

Signing alterations along the facility and public awareness programs should be implemented in conjunction with the closing of the access points to inform commuters of the changes. Entry volumes and traffic characteristics would have to be studied on a site-to-site basis by the controlling authorities to determine which access points should be closed to yield the desired reduction in volume. Also, the operating authorities should decide whether the closure will pertain to all vehicles or only those below a certain occupancy level.

Facility Design

Only barrier separated facilities with relatively few access locations are suited to this alternative. Contraflow lanes typically have only one access point while concurrent flow lanes have unlimited access, consequently both designs are inappropriate.

Public Response/Reaction

Extreme opposition can be expected from current users of the access point (8). Bus riders as well as carpool riders will be negatively affected if the closure is applied to all vehicles. Also, a question of equity could be raised, as this action discriminates against shorter trips in favor of longer trips (8).

Add More Lanes to the HOV Facility

Facility Operation

The addition of more lanes to the HOV facility would increase capacity and thus decrease the volume-to-capacity ratio. In some instances, one lane HOV facilities are designed with space on either side of the lane and when demand reaches capacity on that facility, the cross section can be re-striped to provide two lanes. If excess space along the facility is not available, however, the additional lane will have to be constructed. Obviously, the addition of a new lane would contribute a great deal to the operational characteristics of the facility and allow for considerable growth in the utilization of the facility in the future.

Implementation

Implementation of this alternative would consist of re-striping or widening the existing facility if such means were feasible. For concurrent and contraflow lanes, implementation may involve delineating additional freeway lanes for HOV usage. Resources to cover incurred costs must be available.

Facility Design

To provide an additional lane to the HOV facility, adequate space must be available within the facility. Re-striping of barrier separated facilities would not present a major ordeal providing the two lanes fit between the existing barriers. Should the facility be located in the median and require widening, space must be available between the barriers and the freeway mainlanes. If the facility is raised and requires widening, construction costs would be extensive. Depending on the frequency of bottlenecks, however, the facility may only require two lanes over certain stretches.

On facilities such as certain concurrent flow and contraflow lanes, the design of the facility may be such that the addition of a new lane requires nothing more than marking off a second freeway lane for HOV use. However, if space is available on the shoulder side of the existing HOV lane, an additional lane could be striped there.

Public Response/Reaction

The addition of a new HOV lane within the existing facility would most likely meet with public approval provided a lane is not taken away from the freeway. If a lane is taken away, however, the public may react unfavorably.

Add an HOV Facility in a Nearby Corridor

Facility Operation

The operation of the HOV facility would be enhanced by adding a second facility in a nearby corridor under certain specialized conditions. Given these conditions, volume would be taken from the congested facility and placed on the new one instead.

Implementation

To implement this alternative the following two conditions must exist. First, there must be a corridor near enough to service commuters with the same origin. Second, a demand for an HOV facility must exist in that corridor as well. A large capital outlay is required for this alternative as well as public support and interagency cooperation. Occupancy requirements on the new facility should be low in order to attract a meaningful volume of carpools from the congested facility.

Facility Design

The design of either HOV facility is not critical to the success of this alternative.

Public Response/Reaction

The situation described by this alternative existed in Houston. Carpool riders residing between the Katy and Northwest freeway corridors opted to take the Katy route because of the travel time savings realized on the Katy transitway. The subsequent implementation of an HOV lane on the Northwest freeway provided a travel time savings along this route as well. As a result, many carpool riders opted to switch routes to the Northwest transitway.

Other Methods

Many other techniques, besides those discussed, could be used to manage demand on HOV facilities. Restrictions may be applied to allow certain facility riders to use the facility only on certain days thus reducing daily demand. For example, on odd days of the month, vehicles with license plate numbers ending in odd digits would be allowed to use the facility. All other vehicles would be required to use the general purpose lanes. Another technique may involve improving traffic operations at the end of the line haul. An example of this would be improving signal timings.

RECOMMENDATIONS

The severe congestion plaguing urban areas in the United States is resulting in driver frustration, reduced productivity, and billions of dollars per year in delay costs. Many TSM measures have been conceived and implemented in an effort to relieve some of this congestion. One such measure is the preferential treatment of high occupancy vehicles. HOV lanes have met with considerable success in increasing the person movement of a freeway corridor without increasing the vehicle movement. Several HOV projects, however, have reached their operational capacity and are currently over-utilized. To preserve peak hour movement on these facilities, TDM techniques should be applied.

This paper discussed several alternatives for maintaining acceptable levels of service on HOV facilities. Several of these alternatives are more desirable than others from a practical standpoint. If space is available, the addition of an HOV lane by restriping would be the most effective means of improving the operation of the facility without incurring excessive implementation costs and negative public reactions. A second alternative that should be considered is the provision of more bus services. This alternative has the potential to significantly affect the operation of the HOV facility if inadequate services currently exist. Also, limiting the use of the facility to authorized vehicles and entry metering are appropriate alternatives for allowing the operating agency to have a control mechanism with which the demand can be adjusted.

Some of the alternatives may be beneficial from an operational standpoint and yet be undesirable for other reasons. The raised occupancy requirement, for example, would provide immediate restoration of freeflow conditions but would also result in an excessive waste of unused capacity. Congestion pricing would improve the operation of the facility without wasting capacity but would result in high implementation costs and much public reaction. These alternatives are recommended conditionally.

The remaining alternatives are not recommended by the author due to the negative factors associated with them. First, the 'do nothing' alternative would provide little operational benefit and still generate reactions from the users of the facility. Second, the alteration of commute patterns could provide benefits on a regional level; however, for a single corridor, the effect would be small. Third, although the closure of certain access points could improve the operation of the facility, this alternative is unfair to current users of those entrances. Finally, it is unlikely that the operational benefits to a congested HOV facility could economically justify the addition of an HOV facility in a nearby corridor.

The results of each alternative represent a wide range of reductions in the demand of a priority lane. Depending on the reduction needed, several of the alternatives presented may remove an excessive number of vehicles from the facility, while others may not remove enough. To achieve the necessary demand reduction, many of these alternatives can be applied at the same time. Careful consideration, study, and planning need to be executed prior to determining which alternative or set of alternatives is best suited to the HOV project in question. Factors to be addressed include the following:

1. Will the action(s) achieve the appropriate reduction in demand?

2. Are adequate resources available for implementation?

3. Is the action feasible for the given facility design?

4. What kind of public response will the action generate?

By evaluating each of these factors along with the alternatives discussed, the action most appropriate for a given facility and application can be determined.

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