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HOV Lanes

Are they the best way to reduce congestion and air pollution?

By Joy Dahlgren

Joy Dahlgren is a postdoctoral researcher at ITS who received her Ph D in transportation engineering in 1994 It was her fourth degree from UC Berkeley She earned a bachelor's degree in 1956, a master's in public policy in 1977 and a master's in transportation engineering in 1992 She has worked as a researcher analyst and transportation planner This article was adapted from her dissertation

High occupancy vehicle (HOV) lanes are being promoted as a way to reduce congestion and air pollution on urban freeways While constructing new general purpose lanes is often seen as environmentally destructive, constructing new HOV lanes is seen as good for the environment and effective in reducing congestion The reality, however, is that although both are effective in reducing emissions and congestion, construction of a general purpose lane will be more effective in a wide range of typical conditions

Current Policy Promotes HOV Lanes

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 specifies that federal funds designated for congestion mitigation and air quality (CMAQ) may be used for HOV lanes but not for general purpose lanes. In areas that have not attained federal air quality standards, federal funds may not be used for projects that increase capacity for single occupant vehicles unless the projects are part of an approved congestion management system.

In California, state law requires urban counties where congestion exceeds certain levels to prepare congestion management plans to correct the situation. Air quality agencies decide what types of projects are acceptable. In the San Francisco Bay area, the air quality agency lists HOV lanes as one of the measures that can be included in deficiency plans; new general purpose lanes are not included.

It seems to me that public policy should promote construction of HOV lanes only in situations where their benefits are greater than their costs and where HOV lanes compare favorably to alternatives, such as adding general purpose lanes Of course, one can argue that HOV lanes should be built to anticipate future growth, regardless of whether they are the best choice now However, such an approach trades known current benefits for uncertain future benefits If a new technology such as electric cars or automated highways should become commonplace, the anticipated future benefits of HOV lanes might never materialize

Focus on Delay and Emissions

A review of the most cited objectives of HOV lanes leads to the conclusion that the intended benefits are reduced person-delay, reduced air pollution, reduced fuel consumption and increased bus service operating efficiency My research focuses on person-delay and emissions

A curious thing about an HOV lane is that in order to motivate a shift to HOVs, the HOV lane traffic must move faster than the traffic on the other freeway lanes This means that delay must *continue* on the other lanes – but HOV lanes are supposed to *reduce* delay Furthermore, as people shift to HOVs to take advantage of the time savings, they erode the time difference Given these limitations, I became curious about how an HOV lane could provide greater benefits than an added general purpose lane

Need for a New Model

The primary benefits of HOV lanes derive from reductions in vehicle delay and vehicle trips Yet current planning methods generally treat the highway system as if it were constant during the peak period, providing only peak hour travel times and volumes The translation of peak hour travel times and volumes into total peak period delay and trips requires many assumptions that are highly uncertain, such as the distribution of trips, mode shift, and vehicle occupancy over time The detailed data used in the current methods gives a false sense of accuracy which masks a high level of internal uncertainty

Traffic simulation models, such as the FREQ computer program which has been used to evaluate HOV lanes in Houston, are dynamic and can model delay for freeways with or without HOV lanes or a parallel arterial However, their extensive data requirements make them expensive to use and provide many opportunities for data error

Consequently, I developed a new model that is dynamic, yet requires a minimal amount of data, and used it to estimate the relative benefits of constructing an HOV lane, constructing a general purpose lane, converting a general purpose lane to an HOV lane, and doing nothing For each alternative, I did not attempt to estimate absolute benefits, but only to estimate relative benefits in terms of person-delay and air quality Given the current availability of data regarding the effects of HOV lanes, a well founded theoretical model based on a limited amount of accurate data can provide a better estimate of the potential benefits of HOV lanes than models based on incomplete observations of the effects of existing HOV lanes

The model calculates the number of vehicle and person-trips and total vehicle and person-delay, along with the final proportion of HOVs The proportion of people who will use HOVs during any time increment is estimated with a logit discrete choice model

Adding a high occupancy vehicle (HOV) lane is more effective than building a general purpose lane only when a freeway has very long delays (around 35 minutes) and the percentage of HOVs using the route is high (about 20% of all vehicles).

The only factor affecting the choice of HOV versus single occupant vehicle that changes when an HOV lane is constructed is the travel time via each mode. Therefore, given the difference in these travel times and the initial proportion of people using HOVs, all that is needed to estimate the proportion who will use HOVs is the coefficient to apply to this travel time differential. Because data from which to estimate this coefficient were not available, I used a range of values found in the choice literature (-0.01 to -.05 per minute of in-vehicle travel time) to establish a range of reasonable results and to determine the sensitivity of these results to this uncertain value. *(The model is described in detail in the author's dissertation, UCB-ITS-DS-94-2.)*

The model contains a number of assumptions. The net effect of these assumptions is to overstate the benefits of HOV lanes relative to general purpose lanes.

Findings

The model was used to calculate the difference in average person-delay with construction of an HOV lane versus a general purpose lane in a wide range of typical situations:

◆ initial proportion of HOVs: 5%, 10%, 15% and 20% of vehicles

◆ initial maximum delay. 15, 25, and 35 minutes

◆ initial number of lanes 3 and 4

◆ average HOV occupancy 2.15 (a typical occupancy without regular bus service) and 4 (a typical occupancy with good bus service)

◆ sensitivity of mode choice to travel time differential (travel time coefficients per minute of round-trip in-vehicle time). -.01, -.02, -.03, -.04, and -.05

Person-Delay

The result was that an HOV lane outperforms a general purpose lane only when the initial delay is great (about 35 minutes) and when the initial proportion of HOVs is high (20% of vehicles on the freeway). Where the initial proportion of HOVs is 5% (or less), a general purpose lane is much more effective, regardless of the initial delay.

The results for a case when a lane is added to a three-lane freeway are shown in the figures below. The figure shows the cases where the initial delay is 15, 25 and 35 minutes. The vertical axis indicates the difference in person-delay with an added HOV lane versus an added general purpose lane. Positive values, shown by the portion of each plane above the horizontal axis, indicate less delay with the general purpose lane. Lines indicate that delay will be eliminated with construction of either type of lane, except in the case when the initial delay is 35 minutes and the initial proportion of HOVs is 25%. Here the proportion of HOVs is equal to the capacity allocated to HOVs, so the HOV lane functions much like a general purpose lane.

Effects on Emissions

Although adding an HOV lane has been promoted as a means of improving air quality, in most of the cases shown, adding an HOV lane will have a less positive effect than adding a general purpose lane. Nitrogen oxide emissions will be less if an HOV lane is constructed because there will be fewer vehicle trips and miles. But because the reduction in trips is small, the reduction in nitrogen oxide emissions will also be small. On the other hand, the reduction in delay, and thus vehicle hours, with construction of either an HOV or general purpose lane will be large, and the resulting reduction in emissions of pollutants that increase with vehicle hours – carbon monoxide and hydrocarbons – will also be large. In general, whichever type of lane would most reduce delay will also most reduce overall emissions.

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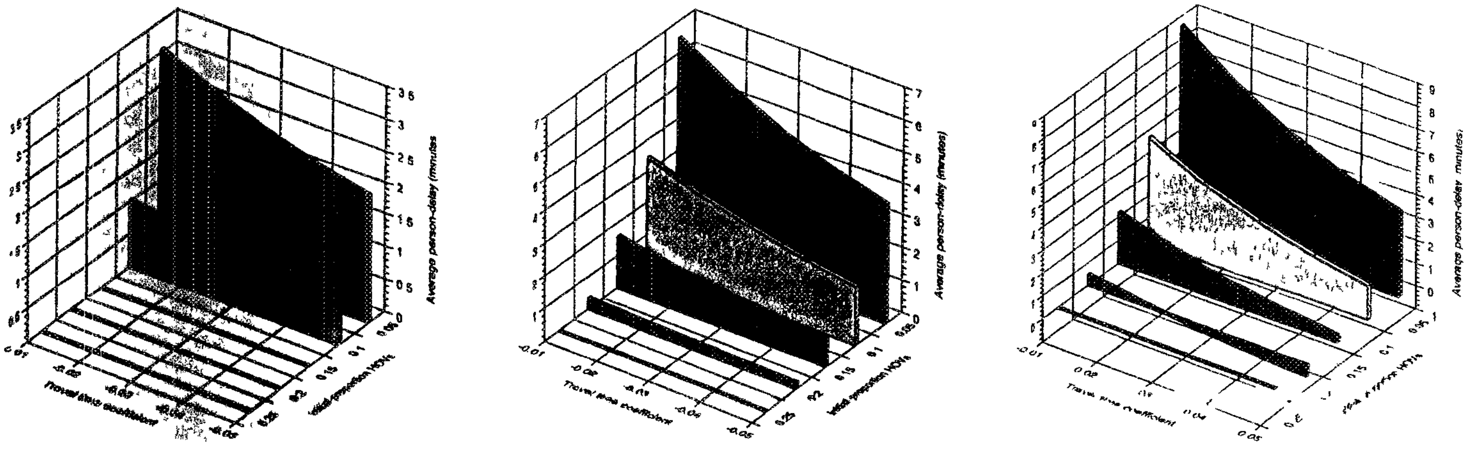

Initial maximum delay of 15 minutes   *Initial maximum delay of 25 minutes*   *Initial maximum delay of 35 minutes*

Difference in average peak period person-delay with an added HOV lane versus an added general purpose lane

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HOV Lanes *(Continued from page 5)*

Why These Results?

The advantage of constructing an HOV lane is that it motivates a shift to HOVs, thus reducing the number of vehicles and delay However, because its use is limited to HOVs, it increases highway capacity less than construction of a general purpose lane In most of the cases depicted in the figure on page five the difference in capacity between the two types of lane is greater than the reduction in the number of vehicles As a result, there will be less delay with the general purpose lane

Only when there is a long initial delay and a high initial proportion of HOVs is the reduction in vehicles greater than the difference in capacity The long initial delay provides the delay differential necessary to motivate a substantial shift to HOVs Furthermore, having a proportion of HOVs (20%) that is close to the amount of capacity allocated for HOVs (25%) means that little capacity is lost by reserving a lane for HOVs However if the initial proportion of HOVs were 25% or more there would be no travel time benefit from using the HOV lane and an additional HOV lane would function much like an additional general purpose lane

Converting a Lane

Converting an existing lane to an HOV lane is a risky strategy unless the initial proportion of HOVs is very high Either the percentage of people in HOVs should be close to the proportion of freeway capacity devoted to HOVs (33% when dedicating one lane of a three-lane freeway and 25% when dedicating one lane of a four-lane freeway), or other data should indicate that a large shift to HOVs is likely

Even in these circumstances, conversion will tend to be politically unpopular because it initially causes greater delay for the people in general purpose lanes The conversion strategy was tried in 1976 on a 12-mile stretch of the Santa Monica Freeway at the same time bus service was dramatically increased Although the project succeeded in increasing ridership of carpools with 3 or more persons by 65% and bus ridership more than tripled, energy and air quality improvements were insignificant, accidents increased significantly, and non-carpoolers lost far more time than carpoolers gained The HOV lanes

(Continued on back page)

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HOT Lanes *(Continued from page 3)*

Construction of HOT lanes currently is underway in the median of State Route 91, the primary link between Orange and Riverside counties which is severely congested for about five hours each day A private group (the California Private Transportation Corporation) has been granted the right to plan, construct and operate four tolled lanes for 35 years. Vehicles with three or more passengers are to travel free at first and at a discount later, should carpoolers' use hamper profitability. Vehicles with one or two occupants will be permitted to buy in

Adding toll lanes was considered because the California Department of Transportation determined that an HOV lane in each direction should be built, but funding was not available. By making excess HOV lane capacity available to toll-paying vehicles, it became possible to add two lanes in each direction rather than just one. Gordon J Fielding conducted traffic simulations for the variations of the SR91 facility, comparing the benefits of two new HOT lanes to one added HOV lane. The results were as follows congestion on the conventional lanes is reduced, the HOT lanes are uncongested at peak periods, and the number of travelers participating in ridesharing is increased

HOT-Lane Conversion

An innovative project in San Diego indicates that there can be strong public support for HOT-lane conversion when HOV lanes are underutilized. In 1988, Caltrans opened an eight-mile, two-lane, reversible HOV expressway in the median of Interstate 15 to buses, vanpools, and two-person carpools. In 1991, with only about 50% of the two HOV lanes' capacity being used during the morning peak, the San Diego Association of Governments developed a plan to permit SOV buy-ins Although SANDAG's HOT lane project was initially denied funding under ISTEA, the project secured a transit development grant from the Federal Transit Administration and it may win ISTEA funding this year

Visible Benefits

The chief problem with introducing highway pricing is that the public opposes it But the San Diego experience shows that there is support for permitting SOV buy-ins where HOV lanes are not being fully utilized

The chief argument against HOT lanes is that they will harm ridesharing It's true that converting an existing HOV lane to a HOT lane may encourage some ridesharers to take the fast lane as an SOV buy-in, and the SOV buy-ins may reduce the time saved by using the HOT lane

However, there are other good reasons to convert an HOV lane into a HOT lane It would introduce a more efficient method of financing highways, and the funds could be used for upgrading and maintaining the road Nearly every motorist will find a benefit in being able to take the speedier lane when time is precious Finally, improved utilization of the reserved lane will help to relieve congestion in the conventional lanes

In the case of new construction, the revenue from SOV buy-ins may make it possible to build highway lanes that otherwise would not be built. Here there are only benefits The public has access to differential service – permitting everyone to avoid costly delays when time is especially precious As for ridesharing, the opportunity to use the new HOT lanes for free or at a reduced cost should encourage people to form carpools

HOV Lanes *(Continued from page 7)*

were reopened to all traffic after 21 weeks when a court ruled that an environmental impact report should have been filed Since then the only HOV lane conversions in California have been for construction staging and emergencies However, a seven-mile section of Interstate 90 in Seattle has been successfully converted to an HOV lane

Conversion is worth considering as an interim measure or when the costs of adding a lane are higher than the benefits

If the goal is reducing delay and emissions, converting an existing lane to an HOV lane is never more beneficial than adding an HOV lane, only more beneficial than doing nothing

Conclusion

When there is congestion, adding either an HOV lane or a general purpose lane will increase capacity and reduce delay and emissions However, because an HOV lane has the potential to motivate people to switch modes, it can be the more effective choice if the initial delay experienced on a route is very long and the initial use of HOVs is enough to ensure high utilization of the HOV lane but not so much that it exceeds the proportion of capacity allocated to HOVs Other than in these limited circumstances, construction of a general purpose lane will be more effective

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