

A SIMPLE DEFINITIVE EXPERIMENT TO DETERMINE HOV LANE EFFECTIVENESS.

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AJM Engineering
August 23, 1998

Introduction

The issue of HOV effectiveness is far from resolved. While most transportation planners feel they are effective, this is based almost entirely on peripheral evidence or plausibility indicators, none of which directly addresses the fundamental question of whether HOV or Mixed Flow operation of the lane would result in greater reduction of congestion, travel-time, emissions or energy consumption. Looked at in detail, the issue is one of some complexity and subtleness. An HOV lane produces both beneficial and adverse effects and the overall result can only be inferred from a comprehensive quantitative analysis accounting for both. This is a problem well beyond anyone's simple intuitive judgments.

On the other side of the issue, a number of recent comprehensive traffic modeling studies have found the Mixed Flow (MF) alternative to afford more reduction of congestion and emissions (Ref. 1). However, these results seem not to have had much impact on transportation planners. Undoubtedly part of the reason for this is that the model methodology is so complex and its database so vast that planners may not fully comprehend or trust results that run counter to their prior notions. The best ultimate proof of the issue may be a carefully planned and conducted test-demonstration, the results of which are *both* obvious and technically valid. This note sets forth some of the necessary conditions for such an experiment. It concludes that, with appropriate planning and controls, such a test demonstration could be conducted simply within a period of about two months. It would provide results that are both unmistakably obvious and comprehensible, and with appropriate data reduction, technically valid comparisons of HOV vs. Mixed-Flow lane performance in terms of total vehicle-hours, total person-hours, total emissions, and total fuel consumption.

Why Haven't Such Tests Been Done?

Real data performance comparison or A-B testing (HOV vs. MF operational alternatives) has mostly proven to be difficult or impossible for two reasons.

The first reason is political/perceptual. The first HOV lane in California, the infamous Santa Monica Diamond lane experiment, was implemented just that way, by

converting a regular unrestricted freeway lane to HOV operation. The consequences were instantaneous and disastrous. What was formerly a slightly congested freeway became a parking lot nightmare. Accident rates skyrocketed. Drivers were furious. After several months of damaging newspaper revelations and a lawsuit, the lanes were restored to mixed-flow by court order. HOV lane establishment was set back about ten years thereafter in California.

Ignoring the more fundamental lesson of relative effectiveness, the lesson taken from this experience by most transportation planners was *never establish an HOV lane by taking away a lane*. In other words, never create an opportunity for an A-B performance comparison. Since that time, that policy has been adhered to absolutely in California. Now, HOV lanes are established only bundled with the *creation* of a new lane, which of course can only improve congestion; and the question of whether a mixed-flow lane might have afforded more improvement remains unaddressed and unanswered. Authorities generally oppose conducting an A-B comparison test for the same reason, saying, *if we ever converted an HOV lane to mixed flow for such a test, we would never get it back*. This begs the question *if it were that much better, why would anyone want to "get it back"*. So while one should not underestimate the strength of this opposition, the self-defeating nature of that main argument against the test should be obvious.

The second reason this experiment may not have been done is the technically valid objection that a short-term measurement of relative pre- and post- conversion performance may mislead by failing to capture the fundamental benefit of an HOV lane, that is, the new "benefit" carpools or ridesharing attributable to the lane incentive. Such motivated new carpool formation has a rather long time-constant, possibly several years to fully develop. And during that time, other traffic influences, such as general growth might well mask the beneficial effect of such *benefit* carpooling. So over a several weeks test, only a very small fraction of the ultimate benefit carpooling would be expected to appear (or disappear). So ignoring this effect would be misleading and prejudicial to the HOV lane benefit assessment. Typically for our Orange County HOV lanes it turns out to be a fraction, typically less than 20%, of the total *ambient* carpooling (1-3% of all vehicles). By far the major effect of HOV lane operation is the traffic redistribution, or *diversion* that occurs immediately because of the lane. Relative to the diversion effects which are immediately obvious and measurable in such an A-B experiment, the benefit carpooling effect could usually be ignored with a small, but perhaps not negligible error.

However, it is easy to compensate for even that small error. Having measured the HOV time saving in the experiment, the ultimate amount of *benefit* carpool formation can be estimated with the same modal choice models with adequate accuracy. This compensation is developed and illustrated in Ref. 2.

Such a “compensated” A-B comparison experiment remains as possibly the most directly indicative measure of HOV effectiveness but has not been done. While the political difficulties should not be underestimated, it may be of value to briefly consider the design criteria for such a test.

Test Design

The test will be described as applied to the opening of a new HOV lane. It can equally well be applied by converting a mixed flow lane temporarily to HOV or vice-versa.

Venue

A priori, the freeway should be in well established traffic equilibrium, that is, no significant change in operational mode, demographics, or traffic factors within the last year.

At least 10 miles in length with no outstanding downstream bottlenecks.

Not more than one or two prominent parallel (alternative) arterials within ± 2 mi.

Decide whether one or two directions will be measured. The following discussion will be in terms of one direction since it is less expensive.

Timing

Ideally, avoid time-of-year for which there will be significant foreseeable weather, construction, or other change in traffic generation or carrying capability of the freeway or the two or three principal supporting parallel arterials defining its corridor for the 8 weeks duration of the test (e.g. Christmas, school-out, or daylight-saving transitions)

Pre-publicity

Announce and explain the purpose of the test for one month beforehand using all available means to communicate with the users.

Explain that the test involves *temporarily* opening the new lane first for use by all drivers for the first three weeks, after which it will be converted to HOV operation.

Measurement pre-planning

Define at least two transverse screen-lines two or three miles apart in the neighborhood of the peak congestion point along the freeway (per Caltrans “Highway Logs”) but not closer than 5 miles to the downstream end of the test lane and extending out at least as far as any parallel arterials liable to be affected by freeway overflow (probably at least ± 2 mi.)

Procure and install any required special sensors and terminals necessary for volume counts and speed for each parallel arterial and freeway lane in the test direction, at each screenline. Some of the arterial sensors should be well enough upstream from a stop light to measure multi-cycle queuing. The screenlines will presumably be drawn at the location of existing freeway lane sensors but if not these should also be installed. Insofar as possible these should be integrated as an extension of the PEMS system to take full advantage of the well developed PEMS hardware and software.

Complete any necessary calibrations or checks, particularly of speed.

Plan and procure HOV freeway signage with temporary covers giving notice that the lane is now open to (all users) / (HOV only).

Pre opening measurements

For two complete, 5 day x 24 hour work-weeks preceding conversion, record vehicle counts and average speed at intervals no more than 5 minutes (the “counting period”), for each lane of each arterial and freeway. Convert the data to convenient electronic format.

Complete all data reduction of this data as per “Data Reduction” below.

Lane Opening

Prepare and open the lane as mixed-flow.

MF Mode measurements

Allow one week for traffic diversions to reach new equilibrium distribution. Then repeat the pre-opening two-week test measurement series, including the new lane.

Lane Conversion

Carefully preplan the conversion to sand-blast, restripe, and remove sign covers to convert the lane to HOV, preferably over a weekend.

HOV Mode Measurements

Allow one week for traffic adjustment to new condition. Then repeat the two-week test measurement series.

Data Reduction

For each (pre-lane, MF, and HOV) condition, and counting period (not more than 5 minutes), and lane derive:

- average corridor vehicle count,
- total corridor vehicle-hours per mile,
- average speed.
- average inverse speed (hrs/mile)

From these and CARB emission factors and speed factors determine

- Lane vehicle-hours, emissions (ROG, NO_x, CO, CO₂) burden, and fuel consumption per mile per count period.
- Total corridor vehicle-hours, emissions per mile per counting period and totaled for the day.
- In the HOV condition, determine the HOV time saving from the speed data for HOV lane and MF lanes.

Using the best available modal choice model, determine the number of carpoolers that could logically be attributed to the HOV incentive. This may be of the simplified linearized form:

(benefit carpoolers) = (ambient carpoolers) * K* (Time saving, minutes)

with K a constant of about 0.02 to .03 per minute (TBD) (derived in Ref 2).

Using this as a basis, adjust all the above HOV condition quantities to reflect their ultimate values on the assumption that the total number of travelers stays the same but the number carpooling ultimately increases by the number given by the modal model as above.

Finally, compare pre- (HOV) and post- (mixed-flow) operation for every counting period and totaled for the day in terms of

- Total vehicle hours
- Total person hours
- Total emissions of each type.

This reduction procedure should be fully worked out, programmed, and tested before the opening and start of measurements, so that the final results above could be available within one week after the conclusion of the measurements.

CONCLUSION

A short, simple two-month test program is designed to give a definitive answer on HOV effectiveness for a particular freeway. A new HOV lane would be first opened temporarily as mixed-flow for a period of three weeks, then converted to final HOV operation. The freeway corridor would be instrumented with traffic count and speed sensors and data gathered for two-week periods in the pre-opening, MF, and HOV conditions.

The principal result will be obvious in terms of increase or decrease of congestion and is about 90% accurate. The final data analysis corrects for the residual 10% or so effect of benefit carpooling that may be anticipated to occur within the next several years as a result of the HOV time saving. The resulting data directly support valid determination of the ultimate increase or decrease in the three

most important bottom-line comparative performance measures, total corridor vehicle-hours, emissions, and fuel consumption.

The analysis assumes that the several-week period between phases of the test is sufficiently small that the amount of HOV preference motivated ridesharing developed (plus or minus) is negligible, and the full ultimate ridesharing as predicted by the modal is to be included as a correction to the data. To this extent the methodology is somewhat slanted in favor of the HOV alternative. My estimate, based on Rideshare data on carpool formation, is that the carpool development time-constant is of the order of two years and that the error in this procedure will be negligible.

This test procedure provides a definitive, and clearly comprehensible result applicable to one particular freeway. The test is probably not practical for widespread application but may well have very important impacts on the full understanding and application of simpler screening tests for HOV lane operation on other freeways.

REFERENCES

1. "The Best Evidence of HOV Lane Effectiveness", AJM Engineering, August 23, 1998. On-line at <www.hov-lanes.org>
2. "Carpool Lane Effectiveness", Jack Mallinckrodt, DHS, March 16, 1992. On-line at <www.hov-lanes.org>.