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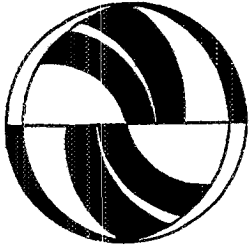
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The University of California  
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**A Comparison of High Occupancy Vehicle,  
High Occupancy Toll, and Truck Only Lanes in the Sacramento Region**

A Report to the University of California Transportation Center

by

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## **ABSTRACT**

As the evidence mounts that HOV lanes will not produce expected reductions in congestion and emission, alternatives are being sought. High occupancy toll (HOT) lanes and truck only lanes are attractive alternatives. In this study, a region-wide system of new HOV lanes, HOT lanes, and truck only lanes in the Sacramento region are compared. The travel effects are simulated with the Sacramento regional travel demand model (SACMET96). The economic benefits for both personal travel and commercial vehicle travel are obtained from economic welfare models developed for use with the travel model. The DTIM2 model is used for the emissions results. The scenarios are evaluated against travel, emissions, total economic benefit, and equity criteria. With respect to travel and emissions, the results did not vary much among scenarios but the economic benefit results did have more significant variation. The scenarios that included HOT lanes produced economic benefits that were clearly superior to the other scenarios. As a result, it is concluded that the economic welfare models applied in this study can be useful tools in the analysis of transportation policies.

## INTRODUCTION

To date nearly 1,200 miles of high occupancy vehicle (HOV) lanes have been built in the U S. Federal and state policies currently promote HOV lane projects. In air quality non-attainment regions, HOV lanes are virtually the only roadway projects approved. The rationale behind these policies is that HOV lanes foster carpooling and transit use and thus will reduce congestion and emissions. However, increasingly the evidence has suggested that HOV lanes may not produce expected reductions in congestion and emissions (Dalgren, 1996, Johnston and Ceerla, 1996, Rodier and Johnston, 1997). As a result, alternatives to HOV lanes are being considered.

High occupancy toll (HOT) lanes are one attractive alternative. HOT lanes have been implemented on State Route 91 in Orange County, CA, I-15 in San Diego, CA, and I-10 (Katy) in Houston, TX. Many other regions are actively considering HOT facilities.

Truck Only lanes are another alternative to HOV lanes in corridors with high volumes of truck travel. Truck freight travel is expected to grow rapidly within the next decade with the potential to increase congestion and emissions and heighten public concern over truck accidents that are disproportionately fatal. The Congestion Management Systems may favor the approval of projects that include Truck Only lanes (Martin and Coogan, 1995).

The Transportation Equity Act for the 21<sup>st</sup> Century (1998) or TEA-21 recognizes the importance of efficient movement of *both people and goods* and requires that transportation projects and plans be evaluated for *economic efficiency*. However, to date, there is a discrepancy between these requirements and the planning methods used by

metropolitan transportation organizations (MPOs) Coogan (1996) describes ad hoc performance measures currently used by MPOs to evaluate freight planning, which are not measures of economic efficiency and do not meet TEA-21's requirements. Efficiency measures based on the correct application of economic theory should be adopted by all MPOs to meet TEA-21's requirement and to facilitate a rational comparison and integration of information about freight and personal mobility across states and the U S.

In this study, a region-wide system of new HOV lanes in the Sacramento region is compared to a system of HOV lanes and Truck Only lanes for the year 2015. The travel effects are simulated with the Sacramento regional travel model (SACMET96). This model can be classified as representative of the state-of-the-practice travel demand model. Models to obtain the economic benefits for both personal travel and commercial vehicle travel are developed by us for use with the SACMET96 model. The DTIM2 model is used for the emissions results. The scenarios are evaluated against travel, emissions, total economic benefit, and equity criteria.

## **BACKGROUND**

Recent evidence has challenged the rationale behind the adoption of HOV lane projects, namely that HOV lanes foster carpooling and transit use and thus will reduce congestion and emissions. Rodier and Johnston (1997) simulate an extensive system of HOV lanes in the Sacramento region for the year 2015. They find, compared to a no-build scenario, only a modest reduction in congestion, an increase in emissions, and a loss in economic benefits when the unobserved private cost of additional auto travel is considered.

Johnston and Ceerla (1996) also find that new HOV lanes may increase vehicle miles traveled (VMT) and thus emissions compared to a no-build scenario. Joy Dalgren (1996) develops a model to estimate person-delay and emissions for a number of HOV and general purpose lane alternatives. She finds that HOV lanes will only be more effective in reducing congestion and emissions than general purpose lanes when there is a high level of congestion and a high proportion of HOVs in the general purpose lanes. Alan Pisarski (1996) finds that nationwide carpooling to work has declined by 19% during the 1980s and that average vehicle occupancy has declined from 1.17 in 1970 to 1.09 in 1990, despite the increase in HOV lanes.

As the evidence mounts that HOV lanes may not deliver expected reductions in congestion and emissions, HOT lanes are increasingly becoming an attractive alternative. HOT lanes allow non-carpools and some carpools to use HOV lanes by paying a toll. HOT lanes have been implemented on State Route 91 in Orange County, CA, I-15 in San Diego, CA, and I-10 (Katy) in Houston, TX. Since the State Route 91 Express Lanes opened in December 1995, there has been a reduction in peak period congestion on adjacent non-toll lanes (ARDFA, 1997). However, this reduction in congestion was due to the combination of the opening of the express lanes as well as the opening of Metrolink rail lines which serves the same corridors. These two improvements essentially doubled the person-carrying capacity of the corridor. In San Diego, the HOT lanes on I-15 have been open since December 1996. There has been considerable demand for use of these HOT lanes (ITE Task Force, 1998) as well as an 11% increase in carpooling (Hamberg, 1998). An express bus service in the corridor has been launched with the HOT revenues (Hamberg, 1998). The I-10 HOT lanes in Houston have only



recently been opened, but demand is expected to be significant (ITE Task Force, 1998) Areas throughout the U S are considering HOT lanes including Dallas, TX, Sonoma County, CA, Contra Costa County, CA, Alameda County, CA, Maryland, Milwaukee, WI, Portland, OR, Phoenix, AR, Denver, CO, Hampton Roads, VA, Los Angeles, CA, and Minneapolis, MN

An alternative to the conversion of HOV lanes to HOT lanes may be Truck Only lanes, with or without tolls in corridors with a high volume of truck travel Truck Only lanes for truck freight could potentially provide large benefits to the freight industry (even with tolls) because of the high value this industry places on fast and reliable arrival times (due in part to the trend toward just-in-time delivery) Truck Only lanes may also benefit the general public through reduced congestion and emissions and increased safety Moreover, the Congestion Management System calls for consideration of freight movement in proposed regional highway projects and could favor projects with exclusive truck lanes (Martin and Coogan, 1995) Truck Only lanes are being examined in the Los Angeles, CA region

Nationwide, a very large volume of freight is transported across the country and truck transport of freight dominates the market In 1991, 6.5 billion tons of freight traveled about 3 billion ton-miles and created freight revenues on the order of 350 billion dollars Trucks transported 41% of the freight tons, traveled 25% of the ton miles, and received 79% of freight revenues (Martin and Coogan, 1995) Freight trucking contributes significantly to the U S economy In the 1991 trucking industry freight revenues accounted for 5% of the Gross Domestic Product (GDP), while all

transportation services revenues accounted for 6.4% of the GDP (Martin and Coogan, 1995)

In the U.S. and the world, growth in freight transport is expected to increase rapidly in the future. Some estimate that a doubling of freight transport is possible within the next 10 years because of increased economic activity, more specialization and centralization, just-in-time delivery, development of Eastern European and Third World countries, and rising global populations (Clarke, 1993). In recent years, France has experienced growth in freight traffic double that of car traffic (Blosseville, 1996)

Within the next ten years, the U.S. trucking industry is expected to lose some of its share of domestic freight tonnage (by 0.05%) to air freight and intermodal rail freight (Martin and Coogan, 1995). However, the limited capacity of railroad mainlines and terminals sharply restrict the shift of freight from truck to rail within metropolitan areas (Martin and Coogan, 1995)

Meeting future increases in freight transport with current trucking technologies could have several negative consequences for metropolitan areas, including increased congestion, heightened public concern over truck accidents (which are disproportionately fatal), and worsening air quality (Clarke, 1993, Vandersteel et al. 1997). National air quality standards and the lack of funding for highway expansion point to the need for policy alternatives for truck freight travel.

Paul Roberts states that "any expansion in highway capacity will immediately be filled with more single-occupancy vehicles and increases in vehicle-miles traveled are typically associated with further degradation of air quality. Unless a substantial portion of the added capacity can be preserved for freight movements, the efficiency of the

freight delivery system will not be improved ” (*TR News*, Jan-Feb, 1996) (Dr Roberts directed the freight programs at Harvard and MIT in the 1960s and 70s and is now President of Transmode Consultants )

In recent years, the increase in truck traffic on U S highways has raised concerns about the number of truck-involved fatal accidents and the significant congestion and delay resulting from major truck accidents In Virginia, Vindunas and Hoel (1997) report that, partly in response to these concerns, motorists and truckers have been receptive to the idea of exclusive truck facilities on the Washington beltway They conducted a benefit-cost analysis and found that exclusive truck facilities would be economically beneficial due to travel time saving, vehicle operating cost savings, and injury and property damage savings

## **METHODS**

### **Travel Demand Modeling**

This study uses the SACMET96 travel demand model (DKS & Associates, 1994) The model was developed with a 1991 travel behavior survey conducted in the Sacramento region This model is an example of a state-of-the-practice regional travel demand model Some of the key features of this model include (1) model feedback of assigned travel impedances to the trip distribution step, (2) auto ownership and trip generation steps with accessibility variables, (3) a joint destination and mode choice model for work trips, (4) a mode choice model with separate walk and bike modes, walk and drive access modes, and two carpool modes (two and three or more occupants), (5) land use, travel time and monetary costs, and household attribute variables included in the mode choice

models, (6) all mode choice equations in logit form, and (7) a trip assignment step that assigns separate A M , P M , and off-peak periods

### **Economic Welfare Models**

Kenneth Small and Harvey Rosen (1981) show how a consumer welfare measure known as compensating variation (CV) can be obtained from discrete choice models

$$CV = 1/\lambda \left\{ \left[ \ln \sum_{m \in M} e^{V_m(p^f)} \right] - \left[ \ln \sum_{m \in M} e^{V_m(p^0)} \right] \right\} \quad (1)$$

where  $\lambda$  is the individual's marginal utility of income,  $V_m$  is the individual's indirect utility of all  $m$  choices,  $p^0$  indicates the initial point (i.e., before the policy change), and  $p^f$  indicates the final point (i.e., after the policy change). The change in indirect utility is converted to dollars by the factor,  $1/\lambda$ , or the inverse of the individual's marginal utility of income. Small and Rosen show how marginal utility of income can be obtained from the coefficient of the cost variable in discrete choice models.

The compensating variation formula (1) from above was adapted to suit the specifications of the SACMET96 mode choice models. In the home-based work, shop, and other mode choice models, households are segmented into income/worker categories, and person trips are generated for those categories. To obtain compensating variation for each income/worker category  $h$ , the following formula was applied for all modes  $m$  and for all trips  $Q$  between all origins  $i$  and all destinations  $j$ .

$$CV_h = 1/\lambda_h \left\{ \sum_{i \in I} \sum_{j \in J} \left[ \left( \ln \sum_{m \in M} e^{V_{ymh}(p^j)} * Q_{yh} \right) - \left( \ln \sum_{m \in M} e^{V_{ymh}(p^0)} * Q_{yh} \right) \right] \right\} \quad (2)$$

where  $\lambda$  is provided by the coefficient of the cost variable in the mode choice equations

Total compensating variation was obtained by summing the compensating variation obtained from each income/worker group Compensating variation was also obtained from the non-home-based mode choice models, however, these models are not stratified by household/income classes Based on a review of the literature (e g , Small, 1996), it is assumed that total operating costs are \$0.40 per mile Capital and operation and maintenance (O&M) costs of the new facilities were estimated based on cost figures provided in the Sacramento region's 1996 metropolitan transportation plan (SACOG, 1996) Change in revenues for gas taxes and transit fares are also included in the analysis It is assumed that tolls from the HOT lane scenarios are used to offset the capital and O&M costs of the scenarios (i e , not only the HOT lanes but also costs of the base case scenario)

Economic benefits to commercial vehicle travel resulting from transportation policies were obtained from the trip distribution model in SACMET96, which distributes commercial vehicle trips as a function of zone-to-zone travel times The following formula was applied

$$\text{Commercial Vehicle Benefits} = \sum_{i \in I} \sum_{j \in J} \left[ \left( B_v^{(p^j)} * Q_v \right) - \left( B_v^{(p^0)} * Q_v \right) \right] \quad (3)$$

where B is equal to the net benefits to commercial vehicle travel. These include travel time costs, O&M costs, and revenue benefits. Travel time is obtained from the model and converted to dollars with the average wage rate of truck drivers in the region (\$12 per hour). VMT for commercial vehicles is also obtained from the model for each scenario. Total O&M (excluding wages) costs and revenue benefits for the scenarios are obtained by multiplying the average per mile costs for the region (\$0.90 for O&M and \$0.95 for revenues) by VMT. Truck wages, O&M costs, and revenues were developed based on national data and in consultation with the California Trucking Association. Very little local data was available. Values used correspond to low estimates for the state of California, which are reasonable for the Sacramento region. While the modeling of truck travel in SACMET96 is not sophisticated, like most MPO models, the method used in this study can be applied to more sophisticated freight models as they are developed.

### **Emission Modeling**

The California Department of Transportation's Direct Travel Impact Model 2 (DTIM2) and the California Air Resources Board's EMFAC7F model were used in the emissions analysis. The outputs from the travel demand model used in the emissions analysis included the results of assignment for each trip purpose by each time period (A.M. peak, P.M. peak, and off-peak). The Sacramento Area Council of Governments (SACOG) provided regional coldstart and hotstart coefficients for each hour in a twenty-four hour summer period.

## LIMITATIONS TO THE METHODS OF ANALYSIS

SACMET96 cannot capture the effect of changes in the transportation system (i.e., travel time and cost) on the location of activities. Such effects would likely be significant for large regional transportation projects or policy changes, like the ones examined in this study. As a result, SACMET96 would tend to underestimate trips, VMT, emissions, and economic benefits for the alternative policy scenarios examined in this study.

System equilibrium is assumed in model operation with full feedback from trip assignment to earlier steps until convergence using the method of successive averages. This implies an elasticity of demand with respect to capacity of about 1.0. If the actual transportation system does not attain complete equilibrium (as some research suggests), SACMET96 would tend to exaggerate the trip length in the new roadway capacity scenarios and overestimate VMT.

The inclusion of time and cost variables (composite impedance) is advised throughout the hierarchy of travel demand models in order to strengthen its theoretical basis and to increase its policy sensitivity. In SACMET96, the auto ownership step indirectly includes travel time variables through the retail employment and transit accessibility variables. In the trip distribution step, work trips are sensitive to travel time and cost variables and non-work trips are sensitive to travel time. In the mode choice model, time and cost variables are represented for all trip purposes. Time-of-day factors are applied after mode choice and, as a result, only the work trip purposes use peak or congested travel times during the trip distribution and mode choice steps. Trip assignment is only sensitive to travel times on roadways. As a result, the model's sensitivity to the HOT scenarios is somewhat limited. Because the trip assignment step is

not directly sensitive to travel cost and only the home-based work trips use congested times, toll modes were included only in the home-based work mode choice model as a separate mode. In addition, the home-based work mode choice model only uses three income groups, which restricts the sensitivity of the simulation within income groups. Thus, this simulation would tend to generally underestimate vehicle hours of delay, VMT, and economic benefits that may result from this scenario.

A model's sophistication in modeling travel time and congestion play an important role in the accuracy of the estimated travel, emissions, and economic benefits. Savings in travel time comprise a large portion of consumer benefits created by new transportation policies and projects. SACMET96 uses the user-equilibrium traffic assignment method (capacity restrained) and models separate peak (1 hour and 3 hours) and off-peak periods. SACMET96 does not include a time-of-day choice model and cannot simulate the phenomenon known as peak spreading. Thus, the volume of travel during peak hours may be overestimated in very congested scenarios because the propensity of travelers to move off the peak is not represented.

The assumption of constant VMT per vehicle per year may result in an overestimation of private costs for policy scenarios that increase VMT (e.g., scenarios that include expanded roadway capacity). However, travel reductions may be underestimated for the HOT scenarios because the auto ownership step is not sensitive to travel costs.

The propensity for auto drivers to switch to HOV lanes in the presence of higher auto travel time and cost is likely underestimated in the SACMET96 model. This is an artifact of the cross-sectional data used to estimate the model. Sacramento currently has



one relatively short HOV facility and thus cross-sectional data on travel behavior collected in this area would contain little variation in HOV mode choice

SACMET also assumes that a fixed percentage of shared ride vehicles will use an HOV lane if they are on that facility. It does not include an HOV lane use model for the entire network (although one is available for one corridor) that estimates the number of shared ride vehicles that will use the HOV lanes based on variables such as time savings and difficulty of changing lanes. As a result, HOV lane usage may be underestimated in the model.

In the simulation of the HOT and Truck Only scenario, the analysis may be limited because of the model's inability to capture the potential aversion of auto users to sharing HOT lanes with trucks. As a result, we may have overestimated the use of the HOT lane by autos.

Commercial vehicle trips are represented as a single purpose (and not by weight class) in SACMET96. At the time the model was developed, no local data was available to estimate commercial vehicle submodels and thus data from relatively current regional surveys of commercial vehicle travel in Phoenix and Chicago were used. Local surveys have now been conducted but a new truck model has not yet been developed for SACMET96. A better commercial vehicle model would be disaggregated by vehicle type and use local data. A better economic analysis would also use local cost and revenue data disaggregated by vehicle type as well as injury and property damage savings from scenarios. We found such data to be largely unavailable.

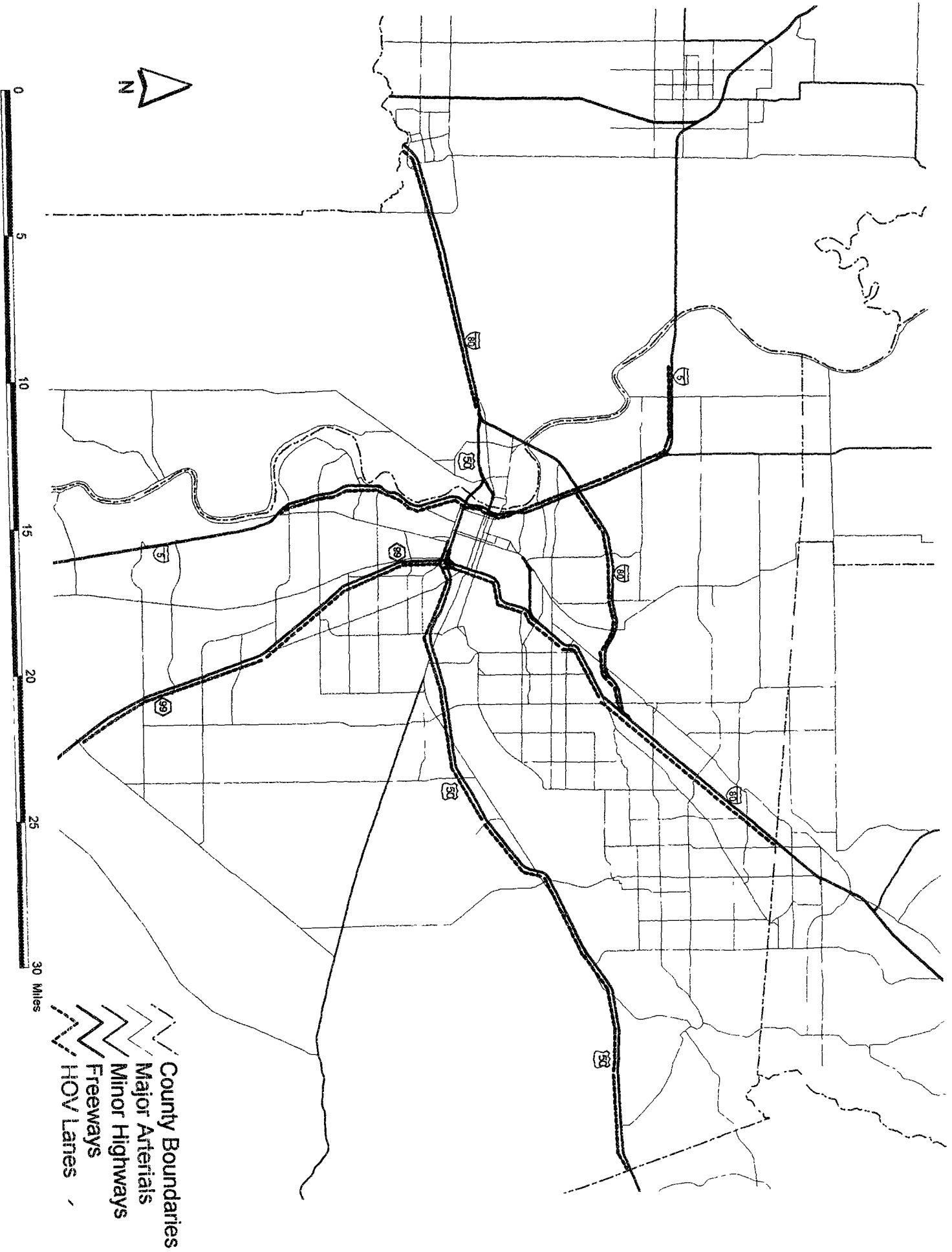
## 2015 SCENARIOS IN THE SACRAMENTO REGION

*Base Case* The base case scenario represents a financially conservative expansion of the Sacramento region's transportation system and serves as a point of comparison for the other scenarios examined in this study. This scenario includes a relatively modest number of road-widening projects, new major roads, one freeway HOV lane segment, and a limited extension of light rail (east to Mather Field Road).

*High Occupancy Vehicle (HOVs) Lanes.* The HOV lane scenario represents an extensive expansion of the Sacramento region's HOV lane system to encourage the use of carpools and reduce traffic congestion and emissions. The HOV lane system is expanded east on SR-50 past Folsom near the El Dorado County line, northeast on I-80 to Douglas in Roseville, northwest on I-5 to the Sacramento International Airport, and west on I-80 to Davis. See Figure 1. In this scenario, HOV lanes are increased from 26 lane miles in the base case scenario to 179 lane miles. Mixed-flow freeway lanes are increased by 6% over the base case scenarios. Express bus service that takes advantage of the HOV lanes is also added to the transit network. HOV lanes are separately coded in the highway network used in SACMET96.

*High Occupancy Tolled (HOT) Lanes.* In this scenario, the HOV lanes in the HOV lane scenarios are converted to HOT lanes. HOT trips are assigned to the separately coded HOT lanes. A \$0.05 per mile toll is charged for using the HOT lanes. Tolls are charged to single occupant vehicles (SOVs) and two occupant vehicles but no tolls are charged to vehicles with three or more people. Where congestion is not eliminated on the HOT lanes with the \$0.05 toll, a \$0.50 per mile toll is imposed in order to achieve non-congested conditions on those roadway segments. This toll level was selected after

Figure 1: Sacramento Region 2015 HOV Lane Network



numerous other tolls were tried to obtain the lowest toll level that would eliminate congestion on the HOT links. To simulate the use of HOT lanes in SACMET96, the mode choice model for the home-based work trip purpose was expanded to include the HOT mode (using variable coefficients specific to the drive alone mode) and shared-ride two occupancy toll mode (using variable coefficients specific to the shared-ride mode).

*Truck Only Lanes* In this scenario, the HOV lanes in the HOV lane scenarios are converted to Truck Only lanes. This Truck Only network was selected based on poor level of service ratings on parallel freeway facilities and in consultation with SACOG officials. In the assignment step, only commercial vehicles are allowed on the Truck Only lanes.

*HOT/Truck (HOTT) Lanes* The HOT lanes in the HOT lane scenario allow commercial vehicle travel in this scenario and commercial vehicles that use these lanes do not pay a toll.

## **RESULTS**

### **Travel**

The results of the travel model simulations of the alternative scenarios for vehicle trips, VMT, and vehicle hours of delay (VHD), which is a measure of congestion, are presented in Table 1. All the alternative scenarios increase VMT and decrease VHD compared to the base case scenario. The HOT scenario provides the greatest increase in VMT compared to the base case scenario (with a 2.2 percentage change), followed by the HOV and HOTT scenario (both with a 1.9 percentage change), and then the Truck Only scenario (1.5 percentage change). The HOTT scenario provides the greatest reduction in

VHD compared to the base case (14.7 percentage change), followed by the HOT lane scenario (7.7 percentage change), and then the HOV and the Truck Only scenario (5.20 and 5.17 percentage change, respectively). Among the scenarios there is little variation in the number of vehicle trips made, however, all the alternative scenarios increase vehicle trips somewhat.

**Table 1. Daily Vehicle Travel Projections  
2015 Policy Scenarios for the Sacramento Region**

	Trips (millions)	Vehicle Miles Traveled (millions)	Hours of Travel Delay (thousands) <sup>a</sup>
<b>Base Case</b>	<b>6.8</b>	<b>62.2</b>	<b>243.3</b>
HOV	6.8 (0.2%)	63.3 (1.9%)	230.7 (-5.20%)
HOT	6.8 (0.3%)	63.5 (2.2%)	224.5 (-7.7%)
Truck Only	6.8 (0.1%)	63.1 (1.5%)	230.7 (-5.17%)
HOTT	6.8 (0.3%)	63.3 (1.9%)	207.6 (-14.7%)

<sup>a</sup> Vehicle hours of delay are vehicle hours traveled under congested speeds minus vehicle hours of travel under free flow speeds on the same facility.

<sup>b</sup> Figures in parentheses are percentage change from the base case scenario.

In general, the increased highway capacity in the alternative scenarios results in an increase in VMT and a decrease in VHD. In the HOV scenario, carpool vehicles are diverted to the HOV lanes to take advantage of faster travel times in those lanes, VHD is reduced in the adjacent multipurpose lanes or other parallel facilities, and vehicle trip lengths and VMT are increased.

In the HOT scenario, carpools (3+ occupants), tolled carpools (2 occupants), and tolled SOVs are allowed to use the HOV lanes. Given the congestion levels on the

parallel facilities, many drivers are willing to pay the toll to use this facility. As a result, HOT lanes attract more vehicles than the HOV lanes and VHD is reduced and VMT is increased compared to the HOV lane scenario.

In the Truck Only scenario, only commercial vehicles are allowed to use the new highway lanes. This scenario performed almost as well as the HOV scenario with respect to reduction of VHD but not as well as the HOT scenario. This is most likely because the heaviest volume of truck travel occurs during the off-peak period when there is not a lot of congestion in the region.

In the HOTT scenario, HOT lanes are opened up to commercial vehicles. This scenario produces the greatest reduction in VHD compared to all the other scenarios. As noted previously, this result may be overestimated somewhat because the model was not able to represent potential aversions that some drivers may have to sharing lanes with commercial vehicles. The higher levels of congestion reduction in this scenario suggest that the new lanes are underutilized in the other scenarios. In the base case scenario, congestion is present on almost all the facilities where the new lanes are added. It appears that the level of congestion is not high enough to encourage more carpooling or to entice more SOVs to pay a toll to use a faster facility. However, as mentioned previously, it is also possible that use of the HOT lanes by tolled SOVs is underestimated in this study because only home-based work trips are charged a toll and only three income groups are represented in the mode choice model.

## **Emissions**

All of the alternative scenarios increase emissions over the base case alternative. The HOV lane scenario provided the lowest overall increase, followed by the HOT lane

scenario, then the Truck Only scenario, and finally the HOTT scenario. The higher emissions for the scenarios with the Truck lanes can be explained by an increase in VMT for commercial vehicle travel in those scenarios. Commercial vehicles tend to have higher emission rates than personal vehicles. Generally, however, the results do not vary much across scenarios.

**Table 2. Daily Emission Projections  
2015 Policy Scenarios for the Sacramento Region**

	TOG (ton)	CO (ton)	NOx (ton)	PM (ton)
<b>Base Case</b>	<b>33.10</b>	<b>222.26</b>	<b>78.57</b>	<b>19.13</b>
HOV	33.46 (1.09%) <sup>a</sup>	227.25 (2.25%)	81.10 (3.22%)	19.50 (1.93%)
HOT	33.45 (1.06%)	227.43 (2.33%)	81.41 (3.61%)	19.55 (2.20%)
Truck Only	33.44 (1.03%)	227.93 (2.55%)	81.6 (3.86%)	19.44 (1.62%)
HOTT	33.39 (0.88%)	227.93 (2.55%)	82.04 (4.42%)	19.53 (2.09%)

<sup>a</sup> Figures in parentheses are percentage change from the base case scenario.

### **Economic Benefits**

The change in total economic benefits from the base case for both personal and commercial vehicle travel for alternative scenarios is presented in Table 3. With respect to economic benefits, the HOT lane scenarios are clearly superior to the HOV and Truck Only scenarios. For personal travel, the HOV and Truck Only scenario result in a small total economic loss (\$0.01 per trip) when the full, unobserved cost of additional travel is included in the analysis. Both scenarios produce similar reductions in VDH and increases in VMT. For commercial vehicle travel, both scenarios produce a small

economic benefit resulting from cost savings due to avoided delays and increased revenues for more potential travel. Commercial vehicle benefits were not much greater in the Truck Only scenario than in the HOV lane scenario. However, benefits from Truck Only lanes may be underestimated in this analysis because avoided costs from injury and property damage are not included in the analysis.

**Table 3. 1995 Present Value of the Change in Economic Benefits<sup>a</sup> from the Base Case Scenario 2015 Policy Scenarios for the Sacramento Region**

	<i>Total without Commercial Vehicle Travel</i>		<i>Total Commercial Vehicle Travel</i>		<i>Total with Commercial Vehicle Travel</i>	
	Total	Per Trip	Total	Per Trip	Total	Per Trip
HOV	-\$56,201.67	-\$0.01	\$1,168.65	\$0.00	-\$55,033.02	-\$0.01
HOT	\$281,832.45	\$0.03	\$15,645.32	\$0.02	\$297,477.77	\$0.03
Truck Only	-\$64,902.34	\$0.01	\$1,339.79	\$0.00	-\$63,562.56	-\$0.01
HOTT	\$494,627.84	\$0.06	\$19,773.11	\$0.03	\$514,400.95	\$0.06

<sup>a</sup> Includes Capital and O&M Costs

As discussed in the previous section, most commercial vehicle travel occurs during the off-peak period when there is much less congestion than during the peak period and the potential benefits to commercial vehicles in this scenario are limited. As a result, a tolled Truck Only lane does not appear to be feasible based on this analysis. Tolls would be low and would not be great enough to cover the capital and O&M costs of the new Truck Only facility.

The HOT scenario results in an economic benefit of \$0.03 cents per trip for personal travel because of travel time saving to travelers with high values of time, which



more than offsets the unobserved cost of additional travel. Economic benefits to commercial vehicles are also significant because of the greater reduction in VHD in this scenario compared to the HOV and Truck Only scenarios. As discussed in the methods section, it is assumed that revenues from the HOT lanes are used to offset the capital and O&M costs of the HOT lanes and the new transportation facilities included in the base case scenario. This approach is similar to the I-15 HOT lanes in San Diego.

The HOTT scenario provides the greatest economic benefits to both personal and commercial vehicle travel. The HOTT scenario results in an economic benefit of \$0.06 cents per trip for personal travel because of travel time saving to travelers with high values of time, which more than offset the unobserved cost of additional travel. In addition, the increase in VMT (and thus the increase in the unobserved cost of additional travel) for this scenario is smaller than the HOT scenario. Economic benefits to commercial vehicles are larger than those obtained for the HOT scenario, again, because of the greater reduction in VHD in this scenario compared to the HOT scenario.

### **Equity**

The results of the equity analysis are presented in Table 4. For the HOV and Truck Only scenario, there is no significant difference among the benefits and losses for the different income classes on a per trip basis. However, the highest income class clearly benefits more from the HOT and the HOTT scenario. This is because of the time saving to travelers with a higher value of time. For the HOT and HOTT scenarios, benefits increase with level of income.

**Table 4. 1995 Present Value of the Change in Economic Benefits<sup>a</sup>  
from the Base Case by Income Class per Trip  
2015 Policy Scenarios for the Sacramento Region**

	Low Income	Middle Income	High Income
HOV	\$0.00	-\$0.01	\$0.00
HOT	\$0.00	\$0.01	\$0.08
Truck Only	-\$0.01	-\$0.01	\$0.00
HOTT	\$0.00	\$0.01	\$0.07

<sup>a</sup> Includes Capital and O&M Costs

## SUMMARY AND CONCLUSIONS

With respect to congestion reduction, several findings are suggested in this study of the Sacramento region. First, the travel results indicate that the HOT lane scenario may be somewhat better at reducing congestion than the HOV lane scenario. However, our simulation of the scenario may underestimate the demand for this facility and thus its efficacy at reducing congestion. Second, the Truck Only lane scenario produces reductions in congestion similar to that of the HOV lane scenario. Significant congestion reduction does not occur in this scenario because the heaviest volume of truck travel occurs during the off-peak period when there is not a lot of congestion. These results suggest that Truck Only lanes may be more appropriate in regions that experience congestion during both the peak and off-peak periods. Third, the HOTT lanes produce a more significant reduction in congestion than all the other policies. This result may be overestimated somewhat because the model was not able to represent potential aversions that some drivers may have to sharing lanes with commercial vehicles. However, this scenario does make more apparent that the HOT and Truck Only lanes are not fully

utilized in the other scenario. This region is not severely congested.

All of the scenarios increase vehicle trips, VMT, and emissions compared to the base case scenario. There is not a great deal of variation among the scenarios with respect to vehicle trips and VMT, however, the emissions results show a somewhat more pronounced difference and a difference that did not strictly rank with the ordering of vehicle trips and VMT for the scenarios. The HOT, Truck Only, and HOTT scenarios all produce higher overall emissions than the HOV lane scenario. The HOTT scenario has the highest overall emissions, followed by the Truck Only scenario, and then followed by the HOT scenario. The higher emissions for the scenarios with the Truck lanes can be explained by an increase in VMT for commercial vehicle travel in those scenarios. Commercial vehicles tend to have higher emission rates than personal vehicles.

With respect to economic benefits for the scenarios, the HOT lane scenarios (HOT only and HOTT) are clearly superior to the HOV and Truck Only scenario. The HOV and Truck Only scenarios each have a small total economic loss for personal travel when the full, unobserved cost of additional travel is included in the analysis. Both scenarios produce an economic benefit for commercial travel resulting from cost savings due to avoided delays and increase revenues for more potential travel, but benefits are not large because congestion reduction is not significant. A tolled Truck Only lane does not appear to be feasible based on this analysis because toll levels and revenues would be limited. The HOT scenario and HOTT scenario produce comparatively large economic benefits for personal travel because of travel time saving to travelers with high values of time, which more than offsets the unobserved cost of additional travel. Economic benefits to commercial vehicles are also significant because of the greater reduction in

VHD in this scenario compared to the HOV and Truck Only scenarios

The equity analysis indicates that the highest income class clearly benefits more (on a per trip basis) from the HOT and the HOT and Truck scenarios. This is because of the time saving to travelers with a higher value of time. However, there is no significant difference among the benefits and losses for the different income classes on a per trip basis for the HOV and Truck Only scenarios.

The ranking of the scenarios in this study with respect to VHD and economic benefits indicate that the HOTT is best followed by the HOT scenario. This is probably because this region is not severely congested. The rankings of the scenarios examined in this study will depend on the levels of congestion in a particular region.

This study shows little variation in the travel and emissions results across scenarios. However, more significant variation was found in the economic benefit results among the scenarios. The scenarios that included HOT lanes produced economic benefits that were clearly superior to the other scenarios. As a result, it is concluded that the economic welfare models applied in this study can be useful tools in the analysis of transportation policies.

While the results of this study did produce some interesting findings, its conclusions should be interpreted in the context of the described limits of the model. These limitations are not only present in the SACMET96 model but are present in almost all MPO models in the U.S. Most MPO models lack a land use model that is used with a travel model, poorly represent time and cost variables throughout the of the model system, and lack the local data that are needed to develop commercial vehicle travel submodels. SACMET96 is, however, one of the more advanced MPO regional travel

demand models in the U S As a result, this study underscores some of the difficulties that regional travel demand models have in simulating more innovative transportation policies

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