

**Evaluating the Impacts of the SR 91
Variable-Toll Express Lane Facility
Final Report
May 1998**

EXECUTIVE SUMMARY

This is the final report of a Caltrans and U.S. DOT-sponsored study to evaluate the impacts of the variable-toll express lanes which opened on December 27, 1995 in the median of the Riverside Freeway (State Route 91) in Orange County, Ca. The study spanned a four year period, providing about a year and a half of "baseline" data collection to document conditions which existed prior to the opening, followed by a year and a half of data with the express lanes in operation.

The findings of the study are based on a very large and diverse data set. The data set is itself an important study product, since it provides opportunities for other researchers to investigate aspects of the express lanes which are beyond the scope of what the current study was intended to address.

The California State Route (SR) 91 express lane facility is located between the SR 91/55 junction in Anaheim and the Orange/Riverside County Line. The facility provides two extra lanes in each direction, and incorporates a number of innovative features which make it one of the most interesting and important practical experiments in highway transportation for quite some time. These include tolls which vary by time of day based on expected congestion in the corridor, the requirement that all users be registered customers and carry identifying transponders, the use of discount pricing as an incentive to high occupancy vehicles, photo-enforcement of toll violations, and the fact that the facility was developed and is operated by a private company for profit.

The express lanes were built within what had been one of the most heavily congested freeway corridors of California, with typical peak period delays of 30-40 minutes. The capacity increase which resulted from adding two new toll lanes in each direction considerably reduced congestion in the corridor, at least for the short term.

In April 1997, the California Private Transportation Company (CPTC), which operates the facility, issued its first annual report. The report states that the first year's toll revenues covered operating costs but only a small portion of amortized capital costs. However, CPTC predicted that traffic and revenue growth will lead to financial break-even by the end of 1998.

The following are the principal study findings, drawn from the data and analyses presented in the body of the report. The findings are organized according to the following topic areas: (1) overall changes in traffic and travel behavior, (2) vehicle occupancy, (3) traveler demographics, (4) rail and bus ridership, (5) traffic operations and safety, and (6) public opinions.

Findings about Overall Changes in Traffic and Travel Behavior

1. The toll lanes have attracted a substantial share of the traffic using the SR 91 corridor. Since opening day, toll lane use has grown steadily. By the end of the study's observation period in June 1997, the total two-way average daily weekday traffic (ADT) in the toll lanes was approaching 30,000 vehicles per day (about 13% of the total SR 91 ADT) and weekend toll lane ADT had reached 17,000 vehicles, with both volumes continuing to rise. By summer of 1997, CPTC was reporting it had issued about 100,000 transponders, joining approximately 100,000 additional transponders issued by the public toll road authorities within Orange County.
2. Following a temporary one month decline, the growth trend for the total amount of traffic in the toll lanes continued with no measurable change after the 10% peak period toll increase which occurred in January 1997.
3. Toll road traffic in the morning peak direction is consistently less than in the afternoon peak direction, when congestion in the free lanes is worse. Similarly, toll lane traffic on Friday afternoons consistently and significantly exceeds all other periods.
4. Even though more than 80% of peak period travelers on SR 91 are engaged in home-to-work travel, most commuters do not use the toll lanes on a daily basis. Nearly half the commuters who have used the toll lanes report using the lanes once per week or less. Travelers cite congestion avoidance as the principal reason they choose the toll lanes for particular trips, which accounts for why PM peak traffic in the toll lanes consistently exceeds AM traffic. Surprisingly, the need to be on time for a commitment was an infrequently cited reason for using the toll lanes.
5. The total ADT on SR 91 increased 14% in the first year following the capacity increase resulting from opening the toll lanes. This increase of about 28,000 vehicles per day is approximately equal to the amount that average weekday express lane traffic grew during the same time period. Though the evidence is not entirely conclusive, our best estimate is that 21% of the increased ADT was due to travelers who had previously been diverting to parallel arterials and who returned to SR 91 because of substantially improved travel conditions. We also attribute 20% of the increase in ADT to the underlying long-term traffic growth trend which existed in the corridor before the tolls lanes opened. Therefore, we judge that just under 60% of the first year growth in ADT is traffic induced by improved travel conditions.
6. Changes observed in the overall peak period trip purpose breakdown indicate that most of the new trips induced by improved travel conditions were for non-work purposes. The majority of these new trips used the free lanes. These trips previously were either not made, made elsewhere, or made during off-peak times. The simultaneous growth of public transportation patronage in the corridor indicates that this induced traffic cannot be attributed to diversion of peak period trips previously using competing modes.
7. The increased capacity from adding two new toll lanes in each direction substantially reduced peak period freeway congestion on SR 91, giving short-

term travel time benefits to all commuters in the corridor. In the six months after opening of the express lanes, the typical PM peak trip delay on the freeway fell from 30-40 minutes to less than 10 minutes per trip. A year later, at the end of our observation period in June 1997, the PM peak trip delay had increased by about 5 minutes to the 12-13 minute range, reflecting both time shifts in travel demand and the effect of the underlying long-term traffic growth trend. A small travel time improvement of about 6 minutes per trip was observed on one of the parallel arterials.

8. The dramatic delay reduction continued even though the amount of daily traffic diverted from the free lanes to the express lanes during the first year closely matched the increase in the total SR 91 ADT. Apparently, an equilibrium has been established between the free lanes and express lanes. One result of the new equilibrium is that, during the first half of 1997, average monthly growth in ADT for the entire SR 91 highway (averaging 500 vehicles per day each month) was about equal to the average monthly growth in express lane traffic.
9. There exists a strong correlation between express lane patronage and travel time savings. In spring 1997, the percentage of SR 91 travelers who used the express lanes ranged from about 7% in the mid-day off-peak, when time savings were minimal, to a high of 35% during the peak hour when delay to freeway users was an estimated 12-13 minutes. These observations imply a value of time for SR 91 commuters of \$13-14 per hour.
10. Despite the correlation between travel time savings and the percentage of SR 91 traffic using the toll lanes, some toll lane users choose to use the toll lanes under traffic conditions where the expected value of their time savings is clearly less than the tolls paid. Driving comfort and the perception of greater safety were cited by travelers as the principal supplemental benefits motivating this behavior.
11. Surveys conducted with SR 91 peak period travelers provide evidence that many commuters overestimate their true time savings when using the express lanes. Actual time savings estimated from loops installed at half mile spacing along the freeway consistently showed maximum time savings of 12-13 minutes per trip on normal traffic days. This compares to savings in excess of 20 minutes per trip reported by over a third of the survey respondents.
12. Examination of time-of-day distributions of SR 91 traffic shows that, in the year following opening of the express lanes, after the increased highway capacity no longer constrained demand, the PM peak traffic distribution shifted to become sharper than prior to and shortly after the opening. The reemergence of a sharp afternoon peak at approximately 5:00 PM occurred in the presence of a toll schedule which charged the same amount, \$2.75, for the entire peak period from 3:00 to 7:00 PM. From opening day until the toll change implemented in September 1997, the uniform peak period toll provided no deterrent to the gradual reemergence of the sharper peak.
13. About half of regular SR 91 commuters report they never use the toll lanes. When asked their reasons, the majority (just over 50%) gave reasons indicating

that the amount of congestion avoided is not worth the cost. About 20% said that their trip patterns were not conveniently served by the express lanes. Only 10% said they do not approve of the facility and will not participate.

14. Travel times of many SR 91 commuters are long compared to most commute corridors in the U.S. The average one-way trip time for SR 91 commuters is over an hour. Travelers with long commutes, especially HOV commuters, report using the express lanes more frequently than persons with short commutes.
15. By June 1997, most peak period travelers on SR 91 (about 90%) had obtained FasTrak transponders and most of these (about 80%) obtained their transponders during the first six months of operation.
16. Our survey conducted in June 1997 showed that only 5% of peak period express lane users had signed up for the "Express Club." For a flat monthly fee, Club membership reduces the total tolls for persons making more than 25 express lane trips per month.
17. Throughout the study period, traffic volumes remained generally stable in the SR 57/60 freeway corridor located roughly parallel to SR 91, about 25 km. (15 mi.) to the north. In addition, field observations showed no association between opening the SR 91 toll lanes and any changes in the HOV traffic using the SR 57/60 corridor. This indicates that the influence of the toll lanes, while locally important, apparently did not induce traveler route shifts at the regional scale.

Findings Related to Vehicle Occupancy

1. Within three months after the SR 91 toll lanes opened, traffic observations on all lanes of the highway showed a greater than 40% jump in the number of peak period high occupancy vehicles carrying three or more people (HOV-3+). During that time, HOV-3+ vehicles paid zero toll.
2. Data on vanpooling at a major regional employer with numerous employees using SR 91 show a 10-15% jump in vanpool formation and ridership in the spring of 1996, shortly after the express lanes opened. Since this occurred at a time when company employment was not increasing, it is possible that the increased vanpooling was due to the new express lanes.
3. During the first eighteen months of operation of the express lanes, increasing numbers of toll-paying commuters, in particular single-occupant vehicles (SOVs), greatly exceeded the traffic growth in the free (HOV-3+) lanes. An estimated 37% of the post-opening SOV growth during the height of the PM peak period appears to be the continuation of the established long-term growth trend in single-occupant vehicles which had existed in the corridor prior to introduction of the express lanes. Another 25% of the peak SOV growth appears to be due to traffic returning to the state highway from parallel city streets. Therefore, just under 40% of the peak SOV growth during the eighteen month period was traffic above and beyond the previously established growth trend and the diversion from city streets. This compares to 60% of the first year growth in overall ADT that was judged to be induced. Note that about half of the post-opening peak period growth in SOV traffic occurred abruptly during the first three months after opening.

4. Through the eighteen month observation period before the toll lanes opened, the peak period counts of dual occupant (HOV-2) vehicles remained essentially unchanged. However, following the opening, peak period HOV-2 traffic showed a small but statistically significant increase compared to the previous flat trend. HOV-2 users of the express lanes pay the same tolls as SOV users, or half the toll on a per person basis.
5. The increase in HOV traffic which occurred after the toll lanes opened is measured relative to a small initial base. For example, throughout 1995, before the express lanes opened, HOV-3+ vehicles averaged 3.7% of the total SR 91 PM peak traffic. After the express lanes opened, the comparatively much larger growth in SOV traffic resulted in a small but statistically significant downward trend in average vehicle occupancy (AVO), for both the AM and PM peak periods, through the first eighteen months of express lane operation. Notwithstanding this small reduction in AVO, the actual counts of HOV-2 and HOV-3+ commuters increased significantly compared to the conditions which existed previously.
6. Some of the relative growth in SOV traffic after opening the express lanes occurred because the traffic diverted to the state highway from parallel city streets contained a significantly higher percentage of SOVs (83%) compared to the pre-opening SR 91 traffic (76% SOVs). Also, the post-opening induced peak period traffic, consisting largely of non-work trips, also contained a greater percentage of SOVs (nearly 82%) compared to the pre-opening SR 91 traffic (76%). Finally, as discussed below, the number of commuters continually using the corridor during the time period who switched from HOVs to SOVs exceeded the number who switched the other way.
7. Our survey found that a larger number (but not a larger percent) of SR 91 commuters shifted from HOV to SOV than vice versa during the year after the express lanes opened. Among commuters contacted in our fall 1996 travel survey who had been commuting in the SR 91 corridor since before the toll lanes opened, 11% reported switching from either HOV-2 or HOV-3+ to SOV, while 4% reported switching from SOV to either HOV-2 or HOV-3+. Due to the population size differences among the different occupancy categories, these shifts correspond to about 15% of 1996 SOV commuters who switched from HOV and about 25% of 1996 HOV commuters who switched from SOV. The net effect is a 7% decrease in the proportion of HOV users among all surveyed commuters continually using the corridor through the time period considered.
8. Commuters in high occupancy vehicles (HOVs) are much more likely than those in single occupant vehicles (SOVs) to be frequent users of the express lanes. About 75% of HOV-3+ work commuters were found to be frequent express lane users, defined as using the lanes for at least 60% of their work trips. This compares to 26% and 16%, respectively, of HOV-2 and SOV commuters.
9. Data on the utilization of park and ride lots convenient to SR 91 commuters show no widespread and consistent changes related to opening the express lanes. Usage trends for these ridesharing facilities vary greatly, probably due to a variety of local factors rather than the influence of the express lanes.

Findings Related to Traveler Demographics

1. Our surveys show that commuters in high income groups are just over twice as likely as commuters in the low income group to be frequent toll lane users (23% compared to 10%) and about half as likely to be non-users (37% compared to 73%). Although there is clearly a correlation between income and frequency of toll lane use, 50% of the highest income travelers (> \$100,000 annual household income) report they never or infrequently use the toll lanes, while 25% of the lowest income travelers (< \$25,000 annual household income) report they use the toll lanes on a frequent basis. In interpreting the implications of the income relationship, it should be noted that the typical commuter in the SR 91 corridor is a professional or manager from a relatively high income, multiple vehicle, family household.
2. It was found that income is unrelated to whether persons changed their ridesharing behavior after the toll lanes opened. Just under 20% of commuters in every income group reported some change in ridesharing behavior between 1995 and 1996. However, the nature of the changes may be income related. Of the 20% who switched, more than 90% in the lowest income group of peak direction work commuters (less than \$40,000 annual household income) switched to higher occupancy vehicles, compared to 60-70% of commuters in other income groups.
3. 42% of female commuters on SR 91, compared to 28% of male commuters, said they were frequent users of the express lanes (more than 50% of trips). The percentage of females in HOV-2 groups who were frequent express lane users exceeded that of females in SOV groups, and both female groups reported significantly higher frequencies of express lane use than the corresponding male groups. Following the opening of the express lanes, relatively more women than men switched to lower occupancy modes (8% of all female commuters compared to 4% of all male commuters). About a third of peak period travelers on SR 91 are females. Higher proportions of females use the two transit modes, especially bus.
4. Age is associated with frequency of toll lane use. The youngest and oldest travelers are significantly less likely to be frequent toll lane users than travelers in intermediate age categories. Age and occupation distributions for the SOV, HOV-2, HOV-3+, and Metrolink modes are not significantly different from one another. However, bus users in the SR 91 corridor are significantly younger, less affluent, and less likely to be engaged in home-to-work travel than users of the other modes.

Findings About Rail and Bus Ridership

1. In October 1995, two months before the express lanes opened, Metrolink commuter rail service began in the SR 91 corridor, directly parallel to the express lanes. An initial period of flat patronage was followed in September 1996 by a service and schedule adjustment, after which Metrolink patronage steadily increased. Currently, the commuter rail line enjoys a small but growing level of ridership. There is no indication that the express lanes had any effect on the development of commuter rail patronage in the corridor.

2. Ridership on the Route 149 express bus in the SR 91 corridor appears not to have been affected by the express lanes. In addition, there is no evidence that traffic changes influenced the bus operation in any way.

Findings about Traffic Operations and Safety

1. The accident rate for the section of SR 91 containing the express lanes decreased significantly after the express lanes opened. This most likely reflects the reduced peak period congestion. Over the same 1995-96 period, no significant changes in accident characteristics were found.
2. The weaving volumes observed at the entrances of the express lanes are moderate and within the capacities of the weaving sections located just upstream of the toll lanes. Although heavy PM peak weaving exists in the section just downstream of the eastbound toll lanes exit, this weaving section provides an acceptable level of service under current operating conditions. Some of these eastbound vehicles previously traveling in the free lanes aggressively weave left immediately after the toll lane exit. However, these aggressive lane changes do not appear to be creating a safety problem.

Findings about Public Opinions

1. The idea of providing extra toll-financed lanes to bypass congestion was consistently popular among SR 91 commuters, receiving approval percentages in the 60-80% range, starting with the survey conducted just before the express lanes opened. The approval percentages for toll lane users were 5-10% higher than for non-users, with little variation among the different vehicle occupancy categories. Respondents expressed similarly high approval of toll financing in general as a means of providing more highway capacity. Overall, nearly 80% of the commuters surveyed in the corridor approved of providing more highway capacity, regardless of how it is financed.
2. The idea of varying tolls depending on the severity of the congestion bypassed was not very popular in our first survey. However, by the third survey, conducted about a year after the toll lanes opened, the percent of commuters approving of congestion-based tolls had increased from approximately the 45% level recorded initially to the 60-75% range. In the third survey, the percent approval for SOV and HOV-2 toll lane users exceeded the corresponding non-users by about 15%. Otherwise, little variation was found among the different vehicle occupancy categories.
3. Our fourth and final survey conducted in spring 1997 revealed that 50-60% of SR 91 commuters approve of replacing the published toll schedule with a dynamic toll scheme, through which tolls would be based on actual current traffic conditions, subject to an established maximum, rather than following a predetermined schedule.
4. In our first two surveys conducted in fall 1995 and spring 1996, the private for-profit aspect of the SR 91 express lanes was not very popular among commuters, receiving approval percentages in the 35-50% range across all the

different vehicle occupancy categories. However, in the third survey, conducted in fall-winter of 1996-97, approval levels for most, but not all, vehicle occupancy groups increased, with the approval of SOV and HOV-2 toll paying users increasing much more than other groups, to the 70-75% range. Approval levels for HOV-3+ commuters and SOV/HOV-2 free lane users remained about 50%. Proponents of private for-profit highway development among SR 91 users most often cite the efficiency of the private sector as their reason for supporting the concept. Opponents most often cite that it is the government's job to provide highways, or that for-profit operation of highways is unfair.

5. Respondents to the commuter surveys conducted both before and after the toll lanes opened expressed high levels of approval for other technical and institutional features of the express lanes, including exclusive AVI toll collection, photo-enforcement, and toll discounts for HOV-3+ users. Modest commuter support, in the 40-50% range, was given to the idea (as yet unimplemented) of a special toll discount for low income commuters which would operate like "life line" telephone and utility rates.
6. Approximately half of a randomly selected sample of area businesses expressed the opinion that the new express lanes improved ease and reliability of travel, not only for their workers but also for customers, suppliers, and the firm's own work-related travel. 63% of companies contacted said that the express lanes are good for local business.
7. For the most part, respondents to the business survey expressed levels of approval for the various features of the toll lanes in the same range as SR 91 users. The major exception was that only 45% of business survey respondents approved of replacing conventional toll booths with fully electronic toll systems, compared to 75-90% of highway users. In addition, only 72% of business respondents expressed approval of electronic toll enforcement, compared to almost 90% of commuters.

Based on study findings through June of 1997, and from four years' experience working to understand the significance of the SR 91 project, we offer the following additional observations:

- Commuters have adjusted their travel behavior in the presence of the form of congestion-based pricing initially implemented on SR 91. It remains an open question how precisely the SR 91 operator can fine-tune traffic patterns using pricing. The latest toll schedules, implemented in September 1997 and April 1998, create more time variations in tolls than had previously existed, and HOV-3+ users first became subject to tolls in January 1998. We believe continued investigation of SR 91 peak period traffic and travel behavior may show additional responses to these new, more differentiated toll schedules.
- In extending congestion-based pricing to other settings, it is important to keep in mind the key attributes which likely contributed to the high level of public approval enjoyed by the SR 91 project. These include optional toll lanes, immediate and visible travel benefits for those choosing to pay, and the operator's consistent efforts toward favorable public relations and marketing. It is reasonable to expect that future projects sharing these key attributes

would meet with similar acceptance and, over time, would help familiarize urban commuters with the advantages of market-based pricing of road capacity.

The express lanes constructed on California State Route 91 have demonstrated that providing new highway travel options, in this case, premium service for a premium price, can win public acceptance and produce significant travel changes. In many urban highway corridors, there are limited options available to persons whose trip urgency or personal situation justify paying extra to better satisfy their travel requirements. Providing additional choices through pricing is working well in its first major American implementation in California. What we have learned from studying the impacts of the SR 91 value-priced express lanes suggests that this innovative approach merits consideration for further experimentation elsewhere.