

Need for Management

A recent article by one of the most respected members of the data-processing community (11) contained the following observations:

The language and software for creating commercial DP [data processing] applications are really improving and will continue to do so. Nonprocedural languages and facilities now permit many applications to be created without conventional programming and in some cases permit them to be created by end users. The image of a computerized corporation of the near future which the reader should keep in mind is one in which many people are creating and adjusting the electronic procedures. They have user-friendly software that enables them to do this rapidly. Inexpensive computers are spreading and there is a terminal on most desks. The challenge for both DP and corporate management is: How do you control this environment? The most important aspect of control is coordinating the data used. If this is not done, there will be a Tower of Babel effect.

As the small computer becomes widely used, its use, even more than the introduction of other electronic office devices, can have a marked impact on personnel activities and office layout and organization. The effective implementation of these systems requires sound management. There are many pitfalls in implementing a small computer system (12). The age of application of this new technology has just begun but it will soon be in full bloom. If the potential is not recognized and planned for, by innovative management within an agency, later pressures for its installation will make the transition much more difficult. The process should be begun now.

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Evaluating and Planning HOV Lane Enforcement

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The different high-occupancy-vehicle (HOV) strategies introduced on California freeways in recent years have included reserved ramps, preferential lanes, and bypass lanes at metered ramps. Several factors have frustrated efforts to enforce the traffic laws that accompany these strategies; these include personnel limitations, enforcement priorities, public hostility, confusion, and physical constraints imposed by the geometry and engineering features of specific projects. As a consequence, violations have increased on certain types of HOV lanes. A summary is presented of the results of a two-year study designed to measure and evaluate the effect of different enforcement options, engineering features, and educational programs on violation rates for various transportation system management freeway strategies and trace the resulting impact of these violation rates on safety, freeway performance, and public attitudes. During the study, statistics were assembled on violation rates, enforcement levels, and operating performance on California HOV lanes; drivers were surveyed; special design features were investigated; and different levels and combinations of routine and special enforcement activities were tested on a variety of HOV lanes. Violation rates were measured before, during, and after the assignment of Highway Patrol officers to enforce specific HOV lanes and metered freeway ramps, accident levels were recorded before and after the installation of HOV

lanes, the benefits and costs of HOV lane enforcement were analyzed, and the results of the analysis were used in recommending a program of future enforcement for California HOV lanes.

Adequate control of violation rates on preferential high-occupancy-vehicle (HOV) facilities requires an effective mixture of enforcement, engineering design changes, and public education. Although past operating experience has given the California Department of Transportation (Caltrans) and the California Highway Patrol (CHP) a number of insights regarding the potential effectiveness of different enforcement strategies, engineering changes, and education programs, this experience has not been documented with the quantitative precision necessary to identify the appropriate levels and mixture of these factors needed to obtain adequate motorist compliance.

The purpose of the study described in this paper was to provide a detailed, quantitative, and objective assessment of the effects of different enforcement options, engineering features, and educational programs on violation rates for various transportation system management (TSM) freeway strategies and to trace the resulting impact of these violation rates on safety, freeway performance, and public attitudes.

STUDY OVERVIEW

The investigation described in this paper covered nearly two years and followed a detailed study design laid out by SYSTAN, Inc., in June 1979 (1). Interim reports were prepared after the sixth and twelfth months (2,3); the results obtained through the first six months were published in an earlier paper (4). This paper summarizes the contents of the final project report (5) and covers the full span of the project, including the implementation phase; pre-enforcement and post-enforcement surveys; four waves of special enforcement activities; investigations of special design features, safety aspects, and the costs and benefits of TSM project enforcement; and the development of a recommended program of future enforcement for California HOV lanes.

Projects Evaluated

Main-Line HOV Lanes

In the case of main-line HOV lanes, the different engineering options evaluated were limited to the major projects currently in place on California freeways. These projects include the nonseparated right-of-way on US-101 in Marin County north of the San Francisco Bay Area; the preferential lane of Interstate 580 in Alameda County, which is separated from regular traffic by a buffer lane; and the 11-mile San Bernardino Busway east of Los Angeles, where the preferential lane is separated from general traffic by concrete barriers on the western end of the freeway and by a buffer shoulder and pylons on the easternmost 7 miles of the project. Detailed descriptions of each of these projects can be found in the study design (1).

Ramp Bypass Lanes

In the case of ramp bypass lanes, the full spectrum of lane designs represented on California freeway ramps was tested to determine the impact of design characteristics on enforcement and violations. Existing bypass lanes were classified in groups according to a number of important geometric features, design choices, and performance characteristics, including the availability of a refuge area, the visibility of the enforcing officer, and the current violation rate. More than one-third of the more than 130 ramp bypass lanes operating in Los Angeles at the start of the study were analyzed in detail along with all bypass lanes in San Diego and the San Francisco Bay Area. In addition to the variety of characteristics available for analysis on existing ramps, certain innovative engineering options were tested during the study, including metered HOV bypass lanes, special signing and striping, and separated HOV bypass lanes.

Other Projects

A small sampling of metered ramps without bypass lanes was also investigated, as were the preferential lanes at the toll plaza of the San Francisco-Oakland Bay Bridge.

Enforcement Options

Different levels and combinations of routine and special enforcement were tested to ascertain their effectiveness in controlling violations both on newly opened projects and on those that had been operating for some time. CHP officers were assigned, singly or in teams, to particular bypass lanes and other HOV projects for a specified number of days over periods of 1, 4, or 12 weeks. Typically, special enforcement assignments covered the entire peak commuting period for 1, 2, or 4 days/week. Particular attention was paid to the behavior of motorists after special enforcement activities ceased. In addition, an enhanced version of routine enforcement was studied in which every beat officer on duty during the morning and evening peaks was instructed to spend 10 min/day on ramp enforcement.

Data Collection Patterns

A typical pattern of field observations for a specific HOV project is shown in Figure 1. The pattern called for two or three days' observation of violation rates before the introduction of special enforcement activities and then as many as five observations during the two months after these activities. Four waves of special enforcement were scheduled on ramp bypass lanes, and at least two separate waves were tested on each main-line HOV lane.

HISTORICAL ENFORCEMENT LEVELS AND VIOLATION RATES

Table 1 summarizes key California HOV projects during the study implementation phase, before the introduction of any special enforcement programs.

Enforcement Levels

Past citation rates on main-line HOV lanes ranged from a low of 4 tickets/weekday on I-580 in Alameda County to 14 tickets/weekday on the San Bernardino Busway. The CHP had historically relied on routine enforcement to control violation rates on Alameda County I-580 and assigned motorcycle officers to special enforcement duties during the evening peak on US-101 in Marin County. On the San Bernardino Busway, a combination of routine and special enforcement had been used in which special units were assigned intermittently to lane enforcement.

Violation Rates

The percentage of vehicles using California main-line HOV lanes illegally during the spring of 1980 ranged from 8.8 percent on the San Bernardino Busway to 30.5 percent on the controversial Alameda County I-580 diamond lanes. Occupancy violations on the shoulder-separated right-of-way of the San Bernardino Busway averaged 7.3 percent of all vehicles in the lane during the morning peak and 10.5 percent of all vehicles in the afternoon. These violation rates were lower still (estimated at 3-4 percent) on the portion of the busway where a physical barrier makes lane switching impossible. Violation rates on the San Bernardino Busway and Alameda County I-580 had not increased appreciably over prior measurements, but the 21.5 percent violation rates recorded on Marin County US-101 represented an increase over the 5-15 percent violation rates reported roughly one year earlier.

Ramp Meter Bypass Lanes

Enforcement Levels

In the past, the CHP had applied a policy of rela-

tively low-priority, routine enforcement to bypass lanes, using available personnel to enforce the lane restrictions in addition to regular patrol duties. As the number of bypass lanes in Los Angeles exceeded 150, however, the supply of bypass lanes in some CHP command areas actually outnumbered the supply of officers available for all patrol duties during the peak traffic periods. As a result, the average number of occupancy citations issued per bypass lane was slightly more than one per week at the start of this study.

Violation Rates

Under the prevailing enforcement policy, violations increased annually on most ramp meter bypass lanes in the Los Angeles area, and bypass lanes that had been operational for several years had significantly higher ramp violation rates than newly opened lanes.

Before the start of this study, the average lane violation rate for a sampling of 39 metered ramps with HOV bypass lanes in the Los Angeles area was 37.7 percent, appreciably higher than the comparable violation rate on any main-line HOV project in California. This corresponded to an average ramp violation rate of 12.8 percent. In Los Angeles, the relative number of vehicles using bypass lanes illegally ranged from 13.4 percent on one heavily enforced ramp (Colorado Boulevard on LA-5) to more than two-thirds of all vehicles in the bypass lane on the Western Avenue ramp to the westbound Santa Monica Freeway.

In San Diego, where the peak traffic periods are shorter, meters are traffic-responsive, and the HOV lanes themselves are meter-controlled, HOV lane violation rates were found to be considerably lower

(averaging 19.5 percent on a sampling of seven HOV bypass lanes, a 3.0 percent ramp violation rate.

Ramp Meter Violations

The number of drivers who ignore meter restrictions by running the red light is relatively low and is not considered to be a major problem by either Caltrans or the CHP, particularly because such violations tend to occur when traffic volumes are low and ramp queues are short or nonexistent. In Los Angeles, the level of meter violations is significantly higher on ramps without bypass lanes than on ramps with such lanes (3.8 percent versus 1 percent of all vehicles on the ramp) because the bypass lane itself provides a convenient pathway to those potential violators who might otherwise simply run the red light.

Bridge Toll Plaza

The lowest lane violation rate recorded on any HOV project in California was the 5.4 percent violation rate on the San Francisco-Oakland Bay Bridge, which consistently offers carpoolers substantial time savings of 4-5 min in addition to a toll-free trip across the San Francisco Bay.

ENFORCEMENT IMPACTS

Ramp Meter Bypass Lanes

Special Enforcement Activities

Four waves of special ramp enforcement activities were scheduled in Los Angeles, San Diego, and San Jose between June 1980 and August 1981. During each enforcement wave, officers were assigned to particular ramps for a specified number of days each week for periods of 1, 4, or 12 weeks. These special assignments were applied randomly and interspersed with periods of routine enforcement that lasted at least 9 weeks. The composite results of each wave of enforcement are summarized in Table 2.

The first wave of enforcement was easily the most effective in reducing violation rates. During the first wave, special enforcement activities proved successful in reducing occupancy violations on almost every ramp where they were tried. Even the lowest levels of special enforcement (one officer, one day per week, for four weeks) had a significant, measurable impact in lowering violation rates (see Figure 2). Moreover, violation rates tended to

Figure 1. Typical pattern of field observations.

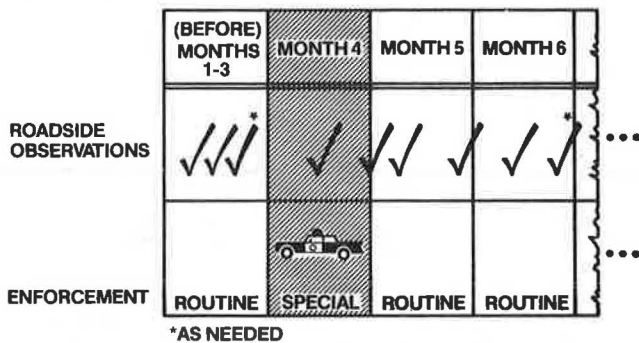


Table 1. HOV project violation rates and routine enforcement levels: base period, spring 1980.

Project	Violation Data		Enforcement Data		Operating Data
	Lane Violation Rate (%)	Ramp or Freeway Violation Rate (%)	Past Citation Rate (no./day)	Apprehension Rate (%)	Avg HOV Time Savings (min during peak hour)
Main-line HOV lanes					
Nonseparated lanes					
Marin 101	21.5		11.6	2.6	N ^a
Santa Monica ^b	15.1	1.0	55		5-6
Separated lanes					
Alameda I-580	30.5		2.5	0.8	N ^a
San Bernardino	8.8		10.8	3.3	5-7
Metered ramps					
Without bypass lanes	3.8 ^c	3.8 ^c	NA	NA	NA
With bypass lanes					
Los Angeles	37.7	12.8	0.27 ^d	0.18	1.3
San Diego	19.5	3.0	0.07 ^d	0.24	0.4
Exclusive HOV bridge lane					
San Francisco-Oakland Bay Bridge	5.4	0.7	2.4	1.1	4-5

^aNegligible, average less than 20 s. ^bProject discontinued. ^cMeter violation rate. ^dPer ramp per day.

remain low for as long as four to eight weeks after the cessation of special enforcement activities.

Although the relative effectiveness and residual impact of special enforcement diminished somewhat after the first wave, heavier enforcement levels (enforcement two or more times a week) still caused violation rates to decline (see Figure 3), and the lower enforcement levels (enforcement once a week or less) generally managed at least to keep rates from rising and maintain earlier reductions.

Table 2. Composite impacts of successive special enforcement waves.

Wave	Time Period	No. of Ramps	Ramp Violation Rate (%)			
			Enforcement Period			Change
			Before	During	After	
First	June-September 1980	37	11.8	7.6	7.9	-32.7
Second	September-December 1980	27	8.9	7.8	7.9	-12.2
Third	January-April 1981	34	8.7	7.1	7.4	-14.3
Fourth	May-August 1981	32	8.6	6.7	7.2	-16.9

Figure 2. Composite enforcement impacts: low enforcement levels.

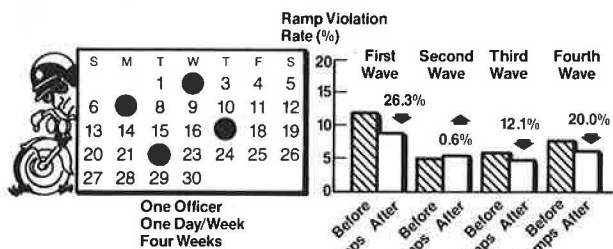


Figure 3. Composite enforcement impacts: high enforcement levels.

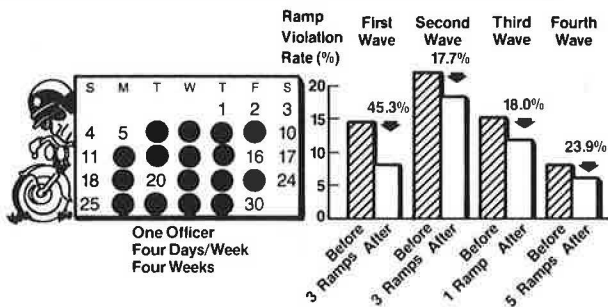
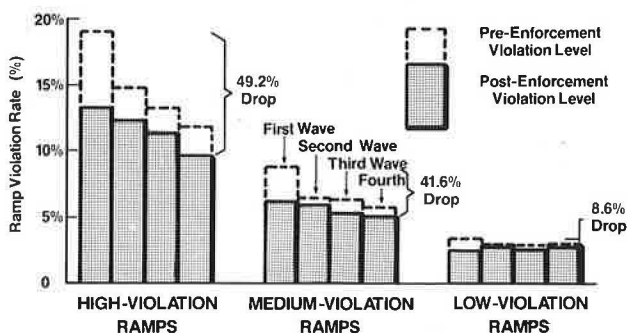


Figure 4. Enforcement impacts on ramps classified by historical violation levels.



At the close of the fourth wave, violation rates on the ramps subjected to special enforcement stood at 6.5 percent, a 45.4 percent reduction below the 11.9 percent rate that characterized those ramps at the start of the study. In all, almost 10 000 citations were issued during special ramp enforcement efforts, and the number of violations on the average ramp dropped by 72 violations/day. The median span of time before violation rates approached pre-enforcement levels was two weeks after the later waves of enforcement compared with eight weeks after the first wave.

Special Enforcement Tactics

The most popular and effective tactic for enforcing ramp bypass lanes required that officers park their vehicles beyond the meter and assume a stationary position in order to wave violators over to a safe refuge area where a citation could be issued. Officers who were able to stand out of the view of potential violators issued more citations per day than officers who assumed more visible positions. Some officers appreciated the extra margin of safety afforded by in-view enforcement, however, and these officers tended to be no less effective in reducing violations. Violations were somewhat slower in returning to pre-enforcement levels when enforcement officers took up less visible positions.

Enforcement tactics involving vehicle pursuit were much less efficient than stationary enforcement in generating citations, reducing violations, and providing a cautionary example to other ramp users.

Effect of Violation Levels

Special enforcement was most effective on ramps where violation rates were medium or high to begin with (see Figure 4). On ramps where violation rates were already low (i.e., less than 6.5 percent), special enforcement was less effective in reducing occupancy violations further and violation rates returned to pre-enforcement conditions much faster. This suggests that there is a practical limit on the reductions that can be brought about by enforcement and, consequently, that special enforcement efforts should not be made in an attempt to make tolerably low violation rates lower still.

The need to relate enforcement levels to existing violation rates underscores the need for close, continuing cooperation between the enforcement agency and the agency responsible for maintaining, operating, and monitoring ramp meter bypass lanes.

Duration of Special Assignments

Twelve-week periods of enforcement were not found to be significantly more effective than four-week periods either in reducing violations further or in generating longer residual impacts. The diminished effectiveness of longer periods of enforcement, coupled with the lessened impact of later waves of special enforcement and the difficulty of driving ramp violation rates below 4 or 5 percent, suggests that enforcement impacts are subject to a law of diminishing returns.

Number of Officers

Assigning two officers to a single ramp was almost, but not quite, as effective as assigning a single officer for twice as many days (see Figure 5). On some heavily violated ramps, the officers preferred working in pairs so that fewer violators went unticketed and help was close at hand in the event that apprehended drivers became unruly while waiting to be ticketed.

Figure 5. Effect of multiple officers.

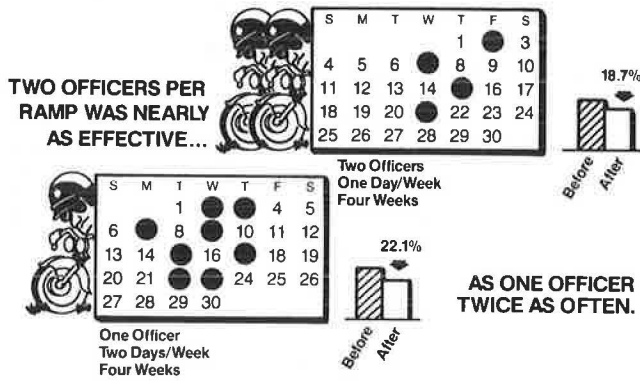
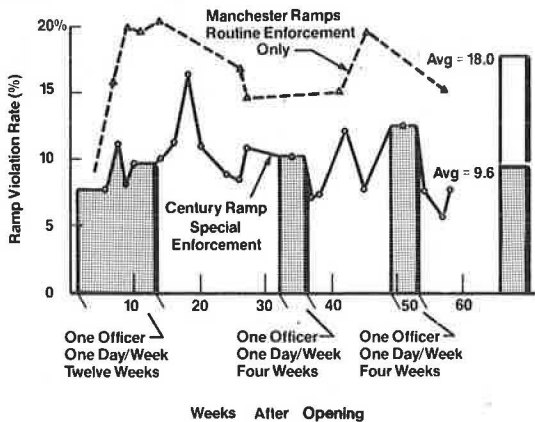


Figure 6. Effect of routine and special enforcement on newly opened bypass lane.



Bail Schedules

Bail schedules for HOV lane occupancy violations vary from \$21 to \$52 in the CHP's Southern and Golden Gate Divisions and are set at a low of \$13.50/offense in the San Diego area. There is no evidence that higher fines lead to significantly lower violation rates.

Impacts on Traffic Flow

As special enforcement encouraged more single-occupant automobiles to join the metered queue rather than use the HOV lanes illegally, queue lengths grew and the average delay encountered by drivers entering Los Angeles freeways rose from 45 to 54 s. In addition, special ramp enforcement actions were found to reduce speeds on adjacent freeways by between 20 and 30 percent in the vicinity of the ticketing activity.

Start-Up Strategies

Start-up enforcement strategies were tested by selecting matched pairs of newly opened ramp bypass lanes similar in geometric configuration and enforcement visibility and initiating special enforcement activities on one ramp of each pair while restricting the other ramp to low-priority routine enforcement. Special enforcement activities lasted for four weeks and were repeated quarterly on certain ramps. After one year of ramp operation, ramps that received special enforcement during the opening

weeks had significantly lower violation rates than their opposite numbers. The composite ramp violation rate on ramps with special enforcement was 7.3 percent compared to a rate of 14.0 percent on control ramps exposed only to routine enforcement. Figure 6 shows violation rates measured during the first year of operation for a matched pair of bypass lanes on the San Diego Freeway in Los Angeles.

Special enforcement activities should be initiated immediately after a ramp is opened and be continued for at least two days a week during the first month of operations. If an initial grace period is desired, it should last no more than a week and should generally not be publicly announced. Officers should be present throughout that week to issue warnings, answer questions, and instill a degree of respect for the HOV restrictions.

Routine Enforcement

In the absence of special enforcement, routine enforcement proved to be an ineffective means of controlling ramp violation rates. Under a policy of routine enforcement, ramp violation rates in Los Angeles had risen steadily before the start of this study. Attempts to increase routine enforcement levels by requiring officers to spend 10 min each day on ramp enforcement also proved ineffective. Such efforts produced a low level of citations, were difficult to direct and control, were unpopular with some officers, and tended to encourage one-shot enforcement tactics that involved pursuit rather than a sustained effort from a stationary position.

Routine ramp enforcement can be effective if applied in conjunction with special enforcement in a selective enforcement program. Violation rates rose relatively slowly during the periods of routine enforcement between special enforcement sessions on sample ramps. As drivers became aware of special enforcement activities on sample ramps, moreover, violation rates dropped on other routinely enforced ramps. On six Los Angeles ramps subjected only to routine enforcement, violation rates dropped 20 percent between the first and fourth waves of special enforcement.

MAIN-LINE HOV LANES

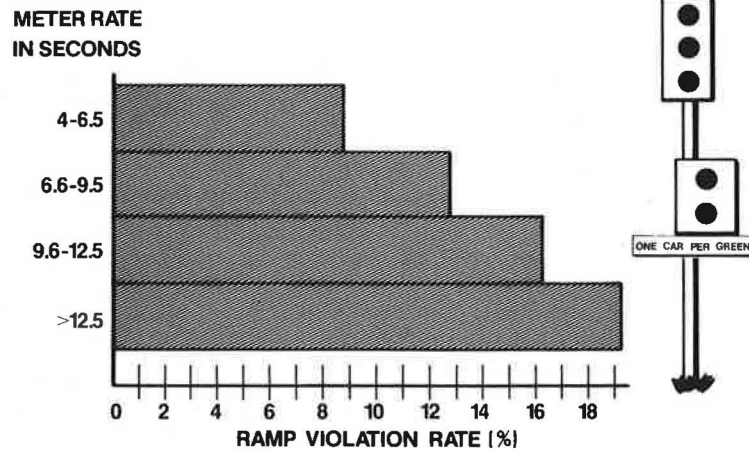
Special Enforcement Activities

Two waves of special enforcement activities were scheduled on each main-line HOV lane in California between May 1980 and June 1981. During the first wave, from two to four additional officers were assigned to each project for a two-week period in May 1980. During the second wave, a similar number of officers were assigned to enforcement throughout either the morning or evening commuting hours (but not both) for a period of four weeks.

The first wave of special enforcement reduced violation rates significantly on all three projects. Violation rates on both Alameda County I-580 and the San Bernardino Busway remained lower than pre-enforcement levels for at least eight weeks, when the summer vacation period began. On US-101 in Marin County, there were large reductions in violation rates during both the morning and evening peaks even though special enforcement activities were only scheduled during the evening commuting hours. The percentage reduction, however, was smaller in the morning, and conditions returned to normal faster.

On both I-580 and the San Bernardino Busway, the second enforcement wave reduced violation rates during both commuting periods even though special enforcement was limited to the evening peak in Alameda County and the morning peak on the San Bernardino

Figure 7. Impact of meter rate on ramp violations.



Busway. Violations returned to pre-enforcement levels within two to six weeks after special enforcement ceased. For the morning peak in Alameda County and the evening peak on the busway, however, these violation levels were significantly lower than those measured a year earlier at the start of the study. In Marin County, violation rates fluctuated wildly after the second enforcement wave and reached levels considerably higher than those measured before enforcement. During the morning peak period, which had received only relatively low levels of routine enforcement throughout the study, violation rates on US-101 had doubled by the close of the study. There was no significant increase during the evening peak, during which there were higher levels of routine enforcement than on any other HOV project.

The results of the study suggest that a program of selective enforcement in which a month of special enforcement is undertaken at relatively infrequent intervals can control violation rates on main-line HOV lanes as long as routine enforcement is not neglected during the intervening periods. Routine enforcement levels averaged 2 citations/peak period on I-580, 4/period on the San Bernardino Busway, and nearly 11/period during the evening peak on US-101. It is cost effective to concentrate special enforcement during any month in a single peak period as long as neither peak is neglected in the long run. Enforcement should be concentrated most often in the direction that least interferes with traffic flow.

Impact of Enforcement on Traffic Flow

When main-line lanes are congested, special enforcement activities can cause further traffic disruption as gawkers slow to observe ticketing activities. To minimize the effect of these activities on main-line flow, special enforcement officers should avoid bunching together, limit stacking so that no more than one car is waiting to be ticketed at any time (in addition to the vehicle being cited), release cited motorists into the busway rather than into the main-line lanes, and avoid pursuing violators across several lanes of traffic.

DESIGN IMPLICATIONS

Several aspects of HOV project design have a critical bearing on enforcement and violation rates. Foremost among these are the need for collaboration between design and enforcement agencies early in the planning process and the need for adequate refuge areas to support field enforcement activities. Early collaboration between design and enforcement

agencies will (a) open a channel of communication and promote cooperative relations, (b) ensure that enforcement costs will be reflected in budget projections and alternatives analysis, (c) incorporate enforcement requirements in project design, and (d) provide advance warning so that field officers can be alerted to special enforcement requirements. Adequate refuge areas for apprehending and ticketing violators are essential for the safe and efficient enforcement of ramp meter bypass lanes, main-line HOV lanes, and exclusive lanes to toll plazas.

Ramp Meter Bypass Lanes

Impact of Design on Violations

Delay

Driver delays on metered ramps are a function of both queue lengths and the designed metering rate. Little correlation was found between the duration of these delays and ramp violation rates. Although violation rates under conditions of routine enforcement increased slightly with the delay in the queue, increasing to an average of 19 percent for delays of 2 min, the violation rate recorded for delays of less than 20 s was a still formidable 12 percent. Because drivers tended to overestimate the time to be saved by using the ramp bypass lanes, even the shortest delays were accompanied by significant violation rates. Short delays were not uncommon on Los Angeles and San Diego ramps: the majority of the data points recorded by roadside observers showed delays of less than 20 s.

Metering Rate

Although violation rates varied widely and unpredictably with ramp conditions, there was some evidence to suggest that drivers' perceptions of delay stemmed not so much from the queue length as from the metering rate. Given the same delay, drivers appeared to be more willing to stay in a long queue that was moving relatively fast than in a short queue that was moving slowly because of a long red phase in the meter cycle (see Figure 7).

Visibility

Geometric configurations that hid patrol officers from the view of potential violators contributed surprisingly little to the effectiveness of enforcement activities. Special enforcement actions taken from hidden positions had slightly longer residual

impacts than enforcement actions taken in full view of motorists entering the ramp. From the standpoint of reduced violation rates, however, the differences between the results of ramp enforcement actions taken from visible and nonvisible positions were neither striking nor statistically significant. Visible enforcement proved to be nearly as effective as nonvisible enforcement, and many officers felt that added visibility increased the safety margin associated with roadside enforcement.

Special Striping

During the first six months of bypass lane operation, sample ramps with bold stripes painted to form a continuous diamond pattern had significantly lower violation rates than ramps with conventional striping. As time went on, however, the deterrent effect of special striping apparently diminished, and after nearly two years of operation comparison tests showed no significant difference between violation rates on routinely enforced ramps with and without special striping. The first wave of special enforcement caused violation rates to drop appreciably on ramps with and without special striping, and the presence of special striping apparently had little impact on violation rates during and after special enforcement activities.

Delineators

Candlestick delineators separating the HOV lane and general traffic lane had no measurable effect on violations, and the short life span of the delineators made their use expensive as well as ineffective.

Trapping Ramps

Certain ramp designs have the potential for trapping law-abiding drivers against their will in reserved lanes, particularly when left turns are permitted from a surface street onto a ramp where the left-hand lane is reserved for buses and carpools. Violation rates are almost universally higher on these ramps when the right-hand lane overflows onto the surface street so that left-turning vehicles are trapped in the carpool lane. Such "trapping" designs pose special problems for both drivers and enforcing officers and should be avoided if possible.

Problems are minimized on such ramps, and violation levels respond to enforcement efforts, when overflows are infrequent and relatively few automobiles make the turning movement that springs the trap. When most of the vehicles entering a ramp make the turning movement that can potentially leave them trapped in the carpool lane, however, violation rates are not likely to respond to enforcement. In such cases, carpool restrictions should be avoided and all lanes should be opened to general traffic.

Metering HOV Lanes

Violation statistics in California provide no strong support for or against metering the HOV lane itself. With pretimed meters, more drivers run the red signal when both lanes are metered (3 percent versus 1 percent of all drivers on ramps with an unmetereed bypass lane) because the HOV lane no longer provides a convenient avenue around the metered signal. Meter violations are not noticeably higher when both lanes are metered with traffic-responsive meters because the meters tend to be inoperative during slack periods when meter violations would be highest. Enforcement actions are somewhat simpler and safer when both lanes are metered be-

cause occupancy violators are generally traveling slower after stopping to observe the red signal.

Impact of Violations on Freeway Performance

Less than 20 percent of the drivers using ramp bypass lanes illegally do so through maneuvering that could represent a direct safety hazard to other drivers. By using bypass lanes illegally, however, all violators represent an indirect threat to the long-term time savings, accident relief, and other benefits obtainable through metered ramp control. A sensitivity analysis undertaken on a model of a single roadway, the Santa Monica Freeway, suggested that violations are likely to have a disproportionate impact on these benefits.

The relation of ramp violations to freeway flow is heavily dependent on the characteristics of the individual roadway, the number of ramps provided with bypass lanes, and the metering strategy selected. In most cases, however, the following general design procedures should limit the adverse impacts of ramp violations on freeway flow:

1. Designers should treat the possibility of violations explicitly and assume that a violation rate of 5 percent will exist on all ramps provided with HOV bypass lanes. Metering rates should be set to accommodate this level of violations.

2. Sensitivity analyses should be undertaken to identify those critical ramps (generally those ramps just upstream from bottlenecks) on which violations are likely to have the most negative impact on freeway flow. On these ramps, designers should either provide no HOV bypass lanes or build into the metering rate a safety factor greater than the 5 percent level suggested above to offset the adverse impacts of violations.

Main-Line HOV Lanes

Hours of Operation

On US-101 in Marin County, violations tend to cluster on the fringes of the morning and evening operating hours; a high proportion occur just after restrictions come into play at 6:00 a.m., again at 4:00 p.m., and just before restrictions are removed at 9:00 a.m. and 7:00 p.m. In the case of I-580 in Alameda County, preferential lane restrictions begin officially on Monday at 6:00 a.m. and are legally in force until Friday at 6:00 p.m. However, an unusually high proportion of violations occurs between 6:00 p.m. and 7:00 p.m. every weekday, which suggests that a large number of drivers wrongly interpret the operating hours to be 6:00 a.m. to 6:00 p.m., Monday through Friday. In this case, a significant proportion of peak-period violations could be eliminated by either redesigning the signs or changing the operating hours.

On the separated right-of-way of the San Bernardino Busway, violations during the evening peak coincide with peak traffic volumes whereas violations during the morning peak are concentrated during the first hour of lane operations, when darkness and CHP shift changes combine to create a lull in enforcement activities.

The limited number of projects examined provides little insight into the question of whether all-day operation is preferable to peak-period operation for main-line HOV lanes. The opening of such lanes to all-day operations is not likely to increase either violation level or enforcement requirements appreciably and may simplify signing problems and reduce confusion during the changeover times. At the same time, it is impossible to enforce occupancy restric-

Table 3. Accident rates on main-line HOV lanes.

Lane Type	Project	Morning Peak			Evening Peak		
		Before HOV (accidents per million vehicle miles)	Increase over Before Period (%)		Before HOV (accidents per million vehicle miles)	Increase over Before Period (%)	
			First HOV Year	Subsequent Years		First HOV Year	Subsequent Years
Nonseparated	Marin County US-101	1.71	-17	-39	4.18	+122	+62
	Santa Monica Freeway	1.36	+201	-	1.76	+221	
	San Francisco-Oakland Bay Bridge Toll Plaza	4.86	+210	+56			
Buffered	Alameda County I-580	1.50	-40	-79	1.67	-11	-29
	San Bernardino Busway, eastern segment	1.72	-20	-15	1.24	+94	+36
Physically separate	San Bernardino Busway, western segment	1.15	-21	-29	2.34	-22	-39

tions after dark, and the additional hours of HOV lane operation at times when there is no time advantage to be gained from using the lane are not likely to encourage many additional carpools.

Refuge Area

Both the San Bernardino Busway and I-580 have adequate refuge areas either on the buffer strips separating the preferential lanes from general traffic or on the median. The absence of such areas on US-101 highlights the need for suitable refuge areas.

On US-101, the lack of buffers separating the carpool lane from general traffic, coupled with the narrowness of the lanes and the absence of a median, made it necessary for officers to escort violators across heavy traffic to issue citations on the shoulder of the roadway. Because patrol cars had particular difficulty making the maneuvers needed to pursue and apprehend violators under these circumstances, motorcycle patrols had to be used for special enforcement. In this case, then, certain project design features made enforcement difficult and required the use of special officers. Surveys showed, moreover, that the need to issue tickets on the shoulder of the roadway at a location well removed from the preferential lane left many drivers unaware that the lane restrictions were actually being enforced.

Lane Separation

By the close of the study, it appeared that the degree of separation between general traffic lanes and the preferential lanes had a measurable impact on violation rates. Lane violation rates were lowest (3-4 percent) on the lightly enforced western section of the San Bernardino Busway, where a physical barrier made lane switching impossible, and considerably higher (27 percent) on heavily enforced Marin County US-101, where there was no separation whatever between preferential and general lanes. Violation rates were also low (7 percent) on the buffer-separated portion of the San Bernardino Busway. Violation rates were highest (36 percent) on the lightly enforced buffer-separated lanes of the controversial I-580 project in Alameda County.

SAFETY IMPLICATIONS

Metered Ramps and Bypass Lanes

For a sample of freeways under ramp control, accident rates on the freeways alone dropped 10.4 percent, from 1.15 to 1.03 accidents/million vehicle miles, after the introduction of ramp metering. At

the same time, accident rates on the ramps increased significantly, nearly tripling during the first year of meter control. Whereas accident rates dropped in subsequent years on ramps without bypass lanes, accidents on bypass ramps showed no sign of decline. Accident rates appeared to be highest and most persistent on ramps with high violation rates.

Even with the increases associated with metering and bypass lanes, the annual incidence of ramp accidents was relatively infrequent, averaging one peak-period accident every three years on a ramp with a bypass and one peak-period accident every four years on a metered ramp without a bypass. This increase was not sufficient to offset the decline in freeway accidents associated with ramp control. Total system accidents after ramp metering amounted to 1.28 accidents/million vehicle miles, a decline of 4.5 percent below pre-metering accident rates. (Accidents were measured during the peak periods of traffic flow and meter operations.)

Main-Line HOV Lanes

Table 3 summarizes accident statistics for several main-line HOV projects in California. Accident levels increased dramatically during the first year of operations on those three projects--US-101 in Marin County, the Santa Monica diamond lanes, and the San Francisco-Oakland Bay Bridge Toll Plaza--where there was no separation between the HOV lane and general traffic lanes. Although accident rates subsequently declined on US-101 and the Bay Bridge, these rates remained significantly higher than pre-project levels five years after project implementation.

On the two projects where the HOV lane was separated from general traffic either by a buffer lane or a physical barrier--Alameda County I-580 and the San Bernardino Busway--there was no upward surge in accident rates during the first year of project implementation. In fact, accident rates have declined steadily on all sections of the San Bernardino Freeway since the implementation of the busway. No trends are discernible on I-580, where the relatively low accident levels fluctuate from year to year.

The increases in accident rates that accompanied barrier-free preferential lanes raise serious questions regarding the suitability of this design in certain settings. These questions appear to exist whether the lanes are created by reserving an existing lane, as was done on the Santa Monica Freeway, or by creating an entirely new lane, as was done in Marin County. Short segments of barrier-free HOV lane operation--as on toll plazas, ramps, and freeway-to-freeway connectors--are not likely to gen-

erate accident increases great enough to offset the benefits of the carpool lane itself. Long stretches of barrier-free main-line HOV lanes operating next to stop-and-go traffic, however, can easily cause unacceptable increases in accident rates.

DRIVER ATTITUDES

Survey Results

Surveys mailed to a sample of single drivers, carpoolers, and carpool lane violators on 13 sample projects before and after special enforcement activities led to the following conclusions regarding driver attitudes.

General Attitudes

Although the differences between violators, carpoolers, and general users on a particular project are few and generally predictable, there are major differences in the attitudes and perceptions of users of individual projects. This was especially true on the main-line HOV lanes. All classes of drivers on the controversial I-580 project in Alameda County viewed the preferential lanes unfavorably. Drivers using US-101 in Marin County, the San Francisco-Oakland Bay Bridge, and the San Bernardino Busway were generally more tolerant of HOV projects: relatively few drivers on these three projects opposed the idea of more freeway lanes for carpools. Among the users of ramp bypass lanes, San Diego drivers viewed the idea of dedicated freeway lanes more favorably than Los Angeles drivers.

Perceptions of Enforcement

Drivers are significantly more aware of in-place, in-view enforcement than of enforcement that requires pursuit and ticketing on freeway shoulders. This distinction was particularly evident before special enforcement activities were initiated.

On the San Bernardino Busway, where violators are usually apprehended and ticketed in the buffer lane in full view of passing motorists, only 13 percent of all respondents said they had never seen the CHP ticketing violators. On Marin County US-101, however, where the CHP must escort violators to the side of the freeway before issuing tickets, 22 percent of all respondents reported that they had never seen an occupancy citation issued. On one San Diego ramp that had an ample refuge area where CHP officers could stand and wave over violators in full view of other drivers, 25 percent of all respondents reported that they had never seen a citation issued for illegal use of the carpool lane. On a nearby ramp with a scanty refuge area that forces officers to pursue violators and issue tickets some distance from the ramp, the corresponding percentage was 70 percent.

Although special enforcement activities significantly improved driver awareness of enforcement on the surveyed projects, a surprisingly high percentage of drivers using the ramps with bypass lanes remained oblivious to the presence of enforcement. After three waves of special enforcement, between 15 and 45 percent of the drivers on the sample ramps reported that they had never seen a driver ticketed for using the bypass lanes illegally. More than two-thirds of all drivers surveyed felt that enforcement levels "stayed about the same" during the year of special enforcement.

Drivers themselves perceive a need for more enforcement. Only about 10 percent of the drivers interviewed before the first wave of enforcement believed that current enforcement levels were suffi-

cient. This was uniformly true on all projects surveyed except Alameda County I-580, where 33 percent of the respondents believed that there was no need for the CHP to enforce more often.

Perceptions of Ramp Metering

Ramp users have mixed feelings regarding the benefits of ramp metering. Although more than two-thirds of all drivers believed that metering had improved flow, less than 21 percent believed that it had shortened their individual trip times.

Perceptions of Violations

Drivers tended to overestimate low violation rates and underestimate high violation rates. Although drivers appeared to be sensitive to major improvements in the violation picture, they were not likely to detect changes in the range below a 25 percent lane violation rate (or a 6.5 percent ramp violation rate).

Most drivers feel that HOV lane violations are a minor problem. Drivers on the San Bernardino Busway and the Guadalupe Expressway felt that violations represented a more serious problem than did drivers on other projects, whereas drivers on I-580 in Alameda County were less concerned than other drivers about the presence of violators. Forty-three percent of the I-580 respondents thought that violators were no problem whatsoever, which presumably reflects the adverse media publicity and public hostility directed toward that project.

Perceived Time Savings

Violators, carpoolers, and general drivers alike greatly overestimate the average time savings afforded by HOV lanes (see Figure 8). This tendency to perceive greater time savings in the carpool lane undoubtedly makes the carpool lanes appear more attractive to drivers than to statisticians comparing raw numbers, and indicates that there may be a psychological advantage in providing a carpool lane even when the available time savings appear minimal. The illusion of greater time savings also helps to explain the relatively high violation rates observed on ramps in the face of negligible delays.

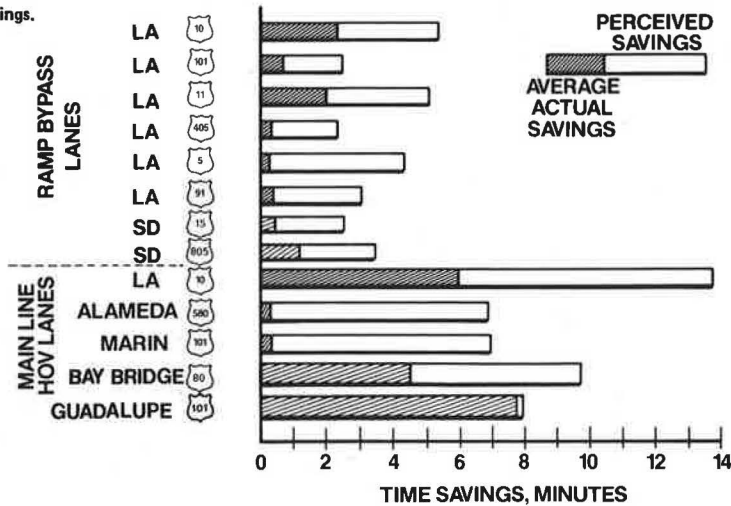
Driving Records

HOV lane violators are likely to have poorer overall driving records than nonviolators. An examination of driver records on main-line freeway lanes, bridges, and other HOV projects that serve drivers from a wide range of geographic areas showed that HOV lane violators on these projects had significantly worse driving records than nonviolators. On ramp bypass lanes that serve narrowly circumscribed geographic areas, however, few differences were found between the driving records of violators and nonviolators using a particular ramp. Nonetheless, comparisons among different ramps showed a strong correlation between the records of all drivers using the ramp and the ramp violation rate: The worse the driving record, the higher was the ramp violation rate.

Repeat Violations

The relatively low incidence of repeat violations over short periods suggests that HOV lane violation rates tend to reflect the actions of a large number of drivers transgressing at infrequent intervals rather than the day-to-day actions of a small group of repeaters. There was, however, a small group of

Figure 8. Actual and perceived HOV lane time savings.



persistent repeaters on certain projects who managed to remain undaunted by the first year of special enforcement.

PUBLIC INFORMATION

Media Coverage

Media coverage of California's HOV projects has tended to be sporadic and generally negative. Negative coverage has peaked during election years and has tended to focus on individual projects rather than on the concept of preferential lanes. In Los Angeles, the Santa Monica Freeway diamond lanes were mauled by the media whereas the San Bernardino Busway, further east on the same Interstate route, has generally been treated fairly and favorably. In the San Francisco Bay Area, Alameda County I-580 is the focus of predominantly negative press coverage and hostile public opinion whereas Marin County US-101 goes virtually unnoticed and the Bay Bridge toll plaza receives moderately favorable coverage.

Although it is impossible to quantify the impact of media coverage and public attitudes on violation rates, it is worth noting that the two California HOV projects that have received the most favorable press notices--the San Bernardino Busway and the San Francisco-Oakland Bay Bridge--have the lowest lane violation rates of all the projects included in this study. On the other hand, if media popularity were the sole criterion governing HOV lane compliance, the Santa Monica diamond lanes would have been packed bumper-to-bumper with violators. As it was, lane violation rates on this manifestly unpopular project fluctuated between 10 and 20 percent, well below the levels recorded on ramp bypass lanes, US-101, and I-580.

Education Campaigns

Education campaigns aimed at instructing the public regarding HOV lanes make use of many channels, including news releases, media campaigns, ramp and freeway handouts, driver education courses, public speeches, mailed brochures, freeway signs, and the driver's handbook published by the Department of Motor Vehicles. These campaigns tend to be concentrated at the beginning of a project to announce the opening date, explain the purpose of the project, and outline proper use of the new facility.

As with media coverage, it is difficult to gauge the impact of education campaigns on violations. An informal poll of violators taken by CHP officers

revealed that relatively few apprehended violators (15 percent of those surveyed) pleaded ignorance of the law, which suggests that existing education programs have at least made noncarpoolers aware of the illegality of using the lanes. A previous study by Caltrans concluded that freeway handouts had little impact on violation rates.

As part of the current study, it was determined that a two-month radio and television campaign using public service announcements had no impact on ramp violation rates in the San Diego area. Although effective public information programs are essential at the time a project is introduced and may increase public acceptance during the life of the project, there is no evidence to date that they are able to affect violation rates.

PROPOSED ENFORCEMENT PROGRAM

A consideration of the effects of different enforcement options and design features on HOV project violation rates and the resulting effect of violations on freeway performance, safety, and public attitudes led to the development of a proposed enforcement program for HOV projects on California freeways. The proposed program was designed to keep both the costs of enforcement and the resulting violation rates within reasonable bounds.

Ramp Meter Bypass Lanes

Criteria for Tolerable Violation Rates

The task of keeping violation rates within reasonable bounds implies an ability to determine a tolerable or acceptable violation rate. Criteria for establishing tolerable ramp violation rates would include safety, freeway operations, public attitudes, legal integrity, and practicality. This study has provided insights into the impact of violations on several of these important criteria.

Safety

Less than 20 percent of the drivers who use ramp bypass lanes illegally do so through maneuvering that presents a direct safety hazard to other drivers. However, there is some statistical evidence that accident levels are significantly higher on ramps with high violation rates. Furthermore, increased violations reduce the effectiveness of the ramp metering system and tend to nullify the freeway accident reductions that result from entry control (discussed further in the following paragraph).

Figure 9. Ramp enforcement program.

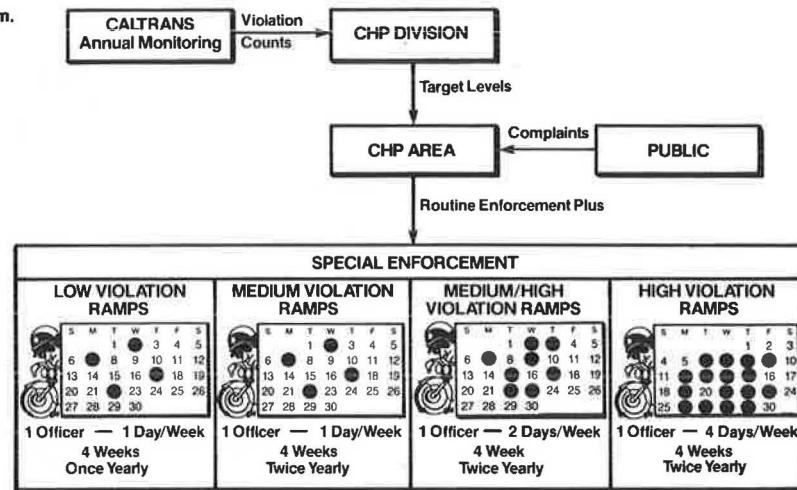


Figure 10. Average benefits and costs per ramp for metered-ramp/bypass-lane configuration.

INITIAL INVESTMENT		
\$27,000 (ramp meter)		
4,000 (bypass lane)		
TOTAL INVESTMENT:		
\$31,000		
ANNUAL COSTS		AVERAGE ANNUAL BENEFITS
\$1,500 (operations)		\$9,255 (improved freeway travel times)
3,000 (maintenance)		815 (reduced freeway accidents)
235 (power)		717 (priority entry time savings)
481 (increased ramp accidents)		\$1,577n (savings per new carpool formed)
\$336 to \$2,684		
(traffic disruption resulting from enforcement)		
\$838 to \$8,549		
(out-of-pocket enforcement costs)		
TOTAL COSTS:		TOTAL BENEFITS:
Violation Rate	(Overtime) (New Personnel)	\$10,787 + \$1,577n
High	\$ 6,054 to \$ 6,281	(where n = number of new carpools formed)
Medium	7,495 to 8,177	
Low	10,535 to 11,858	

Freeway Operations

By using bypass lanes illegally, all violators threaten the time savings, accident reductions, and other benefits obtainable through metered ramp control. For any particular freeway, the impact of violations on freeway flow will depend on roadway characteristics, the number of ramps provided with bypass lanes, and the metering strategy selected. A sensitivity analysis of a single freeway, however, suggests that ramp violations can have a disproportionate impact on freeway flow. Violation rates of 20 percent on the sample freeway brought about a 34 percent reduction in passenger time savings. Violation rates of less than 10 percent had a less pronounced impact.

Public Attitudes

The majority of the public regards ramp violations as a minor problem and tends to overestimate low violation rates and underestimate high violation rates. Drivers are not likely to be sensitive to changes in ramp violation rates below the 6.5 percent range. Law enforcement agencies should be alert to public complaints about violation rates, however, and respond with special enforcement when such complaints are aired.

Practicality

It is virtually impossible to get ramp violation rates significantly below 5 percent, even with relatively heavy levels of enforcement. These violation rates should definitely be tolerated; in fact, metering strategies should be designed to accommodate a 5 percent violation rate.

Program Description

In the light of these conditions, a proposed enforcement program was designed to meet the following objectives:

1. Reduce violations dramatically on ramps with violation rates greater than 12 percent (particularly on ramps with violation rates in excess of 20 percent),
2. Control violation rates and achieve further reductions on ramps with violation rates between 6.5 and 12 percent, and
3. Maintain violation levels on ramps with low violation rates (less than 6.5 percent) through a program of routine enforcement and a minimum amount of special enforcement.

An overview of the proposed ramp enforcement pro-

gram is shown in Figure 9. The proposed program combines the annual monitoring of violations with scheduled applications of special enforcement interspersed with long stretches of routine enforcement:

1. Ramps with medium and high violation rates require twice-yearly applications of four-week periods of special enforcement.
2. Ramps with low violation rates (6.5 percent or less) will receive relatively low levels of special enforcement once a year.
3. Newly opened bypass lanes will receive four weeks of special enforcement at the levels recommended for ramps with medium and high violation rates during the first month of operation.

The proposed program will require the following commitments of officer time:

Level of Violation Rate	Enforcement (h/year)		
	Routine	Special	Total
Low	6	16	22
Medium	7	48	55
High	48	96	144

The enforcement levels recommended on ramps with medium and high violation rates are analogous to those that proved effective in reducing violation rates on comparable ramps during this study. As the proposed enforcement program progresses, it is anticipated that more and more ramps will be shifted into the low category, where they will require minimum attention.

Costs

The costs of the proposed program amount to an average of \$1365/ramp if current officers receive overtime pay for special enforcement and \$2000/ramp if new personnel are hired specifically for the program.

Operational Benefits and Costs

The out-of-pocket costs of the proposed enforcement program are roughly commensurate with the societal costs incurred in delays and increased freeway accidents if violations are not controlled. Figure 10 shows an overview of the average costs and benefits associated with a single metered-ramp/bypass-lane combination. (The costs and benefits shown in Figure 10 reflect average values that assume that all ramps have an equal impact on freeway flow. This is not the case, and it is possible that a low level of violations on a few critically positioned ramps could negate most of the positive benefits of ramp metering.)

Even if a bypass lane generates no additional carpools, the average annual benefits from installing a ramp meter and bypass lane comfortably exceed the average annual costs of ramp operations and enforcement on all but high-violation ramps. Although the effectiveness of ramp bypass lanes in encouraging the formation of new carpools is not well understood, even a modest degree of success in this area will generate enough benefits to offset both the cost of enforcement and the initial investment in the average bypass lane.

Main-Line HOV Lanes

Criteria for Tolerable Violation Rates

As in the case of ramp meter bypass lanes, questions of safety, freeway operations, and public attitudes

have been explored in attempting to define a tolerable violation rate for main-line HOV lanes.

Safety

Although it is impossible to correlate accident rates with violation rates on any of the main-line projects, the practice of illegally weaving in and out of a main-line lane creates a direct safety hazard. Unsafe weaving has been and should continue to be the primary focus of officers assigned to HOV lane enforcement.

Freeway Operations

The practical capacity of a main-line HOV lane is estimated to be 1400 vehicles/h. Except for a 1-h period during the morning peak on the San Bernardino Busway, existing violation rates could increase substantially on all California main-line projects without substantially affecting flow in the carpool lane.

Violators do not improve general traffic conditions appreciably by leaving the main-line flow to enter the HOV lane. During congested periods, latent demand easily replaces the small number of violators drawn off into the carpool lanes. At less congested times, the potential for improvement is minimal.

Public Attitudes

Even on I-580, where public sentiment runs heavily against the HOV lane, most freeway users still think that the use of the HOV lane by violators is at least a minor problem. Drivers tend to overestimate violation rates on most main-line projects.

On the San Bernardino Busway, the tolerable lane violation rate is strictly defined by operational considerations to be 16 percent or less during the morning peak period. At other times, the violation rate could be greater from an operational standpoint. Realistically, a tolerable violation rate should be set at 10 percent or less at all times to keep violations from increasing beyond their present level and prevent the pool of violators from increasing to a point where morning-peak violation rates could hamper busway operations. For the other projects, the suggested acceptable violation rate is the current normal level. Thus, the main goal of the proposed program is to keep violations from increasing to a point where complaints from the public become common and mass disobedience to the law becomes apparent.

Program Description

The proposed program of enforcement for California's main-line HOV lanes is summarized in Table 4. This program is aimed at maintaining main-line HOV violations at current levels or lower and represents little change from existing levels on the San Bernardino Busway and the San Francisco-Oakland Bay Bridge. On Alameda County I-580 a small increase in special enforcement is suggested, whereas less enforcement could probably be used on Marin County US-101 without incurring adverse effects.

ACKNOWLEDGMENT

This paper reports on a two-year study conducted by SYSTAN, Inc., under contract with the CHP. The project was jointly sponsored by Caltrans and the Caltrans Office of Traffic Safety, which provided funding. J.E. Smith served as project director, and Maury Hannigan of the CHP long-range planning unit was the project manager.

Table 4. Proposed enforcement program: main-line HOV lanes and San Francisco-Oakland Bay Bridge.

Route	Person Hours per Year			Total Cost (\$)
	Special Enforcement	Routine Enforcement	Total	
Marin County US-101	4800	^a	4800	111 600 (overtime) to 180 000 (new personnel)
Alameda County I-580	64	384	448	10 070
San Bernardino Busway	448	1920	2368	53 328
San Francisco-Oakland Bay Bridge	256	120	376	8628

^aNegligible.

A steering committee composed of representatives from the CHP, Caltrans, the Office of Traffic Safety, and the public at large was responsible for overall project guidance and for approving the products of major project tasks. In addition to J.E. Smith, other members of the steering committee were William Oliver of the CHP Sacramento Office, David Roper of Caltrans District 07, William Schaeffer of the Caltrans Sacramento Office, Thornton Piersall of the League of California Cities, David Grayson of the Automobile Club of Southern California, and G. Van Oldenbeek of the Office of Traffic Safety. Valuable contributions were also made by Jesse Glazer of Crain and Associates and Adolf D. May of the Institute of Transportation Studies, University of California.

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Evaluation of Boise Selective Traffic Enforcement Project

GREGORY J. SALI

Boise, Idaho, implemented a Selective Traffic Enforcement Program (STEP) in October 1979. Before that time, the city typically had one of the worst accident rates in the state. The objective of the program was to reduce the number of injury accidents occurring in Boise. The program included both enforcement and a media information campaign to deter accidents. An impact evaluation was performed to determine what reductions had occurred during the first 22 months of implementation. A multivariate time series design was used, and a comparison group was selected. The Box-Jenkins technique was used. The analysis identified a statistically significant reduction of 14 injury accidents/month for Boise. This represents a 17 percent reduction from the base period. No significant reduction occurred in the comparison group. An estimated \$1 600 000 in accident costs was avoided, and the total program cost was \$788 000. Both traditional enforcement and media influence were determined to be essential elements of this successful program. Improved coordination and communication with other local agencies are also believed to have contributed significantly to the program.

The results of an impact evaluation of the first 22 months of a Selective Traffic Enforcement Project (STEP) implemented in Boise, Idaho, on October 1, 1979, are presented in this paper. The project was partially supported by federal highway safety funds under Section 402 of the Surface Transportation Assistance Act of 1966. The project evaluation was undertaken by the Idaho Office of Highway Safety. The methodology used in the study was selected to provide answers to the following questions:

1. Has there been a measurable reduction in injury accidents that can be correlated with implementation of STEP in Boise?

2. If such a reduction did occur, can it be reasonably attributed to STEP?

3. What were the relative cost savings to Boise citizens?

REVIEW OF LITERATURE

Identifying effective elements of STEP has been a matter of national concern since passage of the Highway Safety Act of 1966. That Act provided federal funds for implementation of improved police traffic-enforcement routines that would be effective in reducing the number of traffic accidents. This review addresses several evaluations that deal with the traditional enforcement model of compliance (i.e., strict sanctions induce high compliance) and the contextual model of compliance (i.e., compliance is influenced by the attitudes of peers and by social norms).

The traditional enforcement model was explored by Hauer and others (1) in a study that examined speed reductions induced by conspicuous enforcement (a clearly visible, stationary police cruiser). The study involved four experimental locations, each paired with a corresponding control site. Two dif-