Abridgment

Assessment of Violations on Priority Entry Ramps

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ABSTRACT

Priority entry ramps are a transportation system management technique implemented to provide travel time savings to high-occupancy vehicles delayed in access to freeway main lanes because of congestion. The effectiveness of priority entry ramps is diminished as violations by unauthorized, low-occupancy vehicles increase. Violations on priority entry ramps were analyzed from data collected at two sites in Houston. The results indicate an approximate, average violation rate that exceeds 40 percent when no enforcement is present. The results of random, intermittent enforcement indicate a decrease in violations to an approximate average rate of 15 percent. The priority entry exposure ratio, which is defined as service time of nonpriority vehicles divided by the arrival time headway between priority vehicles, was also determined to be an influencing factor on violation rate. For the limited data within this study, a linear equation was statistically established to predict a decrease in ramp violations as the priority entry exposure ratio increases. A graphical illustration of this relationship is presented to allow determination of enforcement requirements for priority entry ramps.

Priority entry ramps are specially designated or physically separated preferential lanes that allow high-occupancy vehicles (HOVs) to bypass low-occupancy vehicles delayed in access to freeway main lanes because of congestion. This transportation system management (TSM) technique is implemented to produce travel time savings as an incentive for motorists to use an HOV mode of travel and, therefore, to increase the person capacity of freeway corridors. National statistics on priority entry ramps report approximately 200 installations either in operation or planned (1).

The efficiency or effectiveness of priority entry ramps is diminished as violations by unauthorized vehicles increase. The violation rate or ratio, which is the total number of unauthorized vehicles using the priority ramp divided by the total number of vehicles on the priority ramp, is influenced by various factors (2). A wide range of violation rates on priority entry ramps (bypass ramps) have been observed--from 0 to 40 percent (3). Other studies (4) have purported a mushrooming effect of violation rate if enforcement is not observed at priority entry ramps. The objectives of this study were to determine the level, influencing factors, and potential alleviation or control of violations on priority entry ramps from study data at sites in Houston.

SITE DESCRIPTION

Priority entry ramps were installed in Houston at two sites on the Southwest Freeway (US-59 S) more than 5 years ago. The locations were along the Southwest Freeway (US-59) at Bellaire Boulevard and Hillcroft Avenue. Each of these sites has ramp metering signalization for nonpriority traffic. The priority and nonpriority ramps at each site are physically separated at both the connections to the frontage road and the freeway merge points. Ramp alignment at both sites is similar. Buses and vanpools are authorized to use the priority entry ramps with access at all times. Significant travel time savings are realized by priority vehicles because of the queuing of nonpriority vehicles at the ramp signal. Enforcement is applied on a random basis to control the violations to both signals and priority ramp use.

STUDY DESIGN

Both operational performance data and physical inventory data were collected at each of the two priority entry ramp sites in Houston. Each location was monitored over an extended period (October to December 1982) during typical weekdays (Tuesday through Thursday) during the morning peak period in clear and dry weather with no incidents. Distinctions were made within the data set as to the presence or absence of enforcement. All data were measured manually from an inconspicuous observation point so as not to be perceived as enforcement personnel and thus influence violations.

Operational performance data were separated by measured conditions on the priority ramp versus the nonpriority ramp. A preliminary examination of this data set indicated an apparent relationship among nonpriority service rate (time waiting in queue), priority vehicle arrival rate (time headway between vehicles), and violation rate. This led to a subsequent data-collection effort at the previous two sites over a 1-month period (March through April 1983) with no enforcement influence.

Consideration was also given to the nature and impact of priority entry violations on safety. Accident records at the two ramp sites were examined for a 5-year period. No accident was found at either site that could be attributed to or result from a violation of the priority entry ramp. It was observed during the field data-collection effort, however, that there were several instances associated with violation maneuvers that caused operational conflicts or potential conflicts.

RESULTS

A summary of data results relative to priority and nonpriority ramp volumes, occupancy levels, and travel time (delay) savings is given in Table 1.

Compliance and violations of priority entry ramps have been historically (5) calculated by the following equations:

$$\text{Compliance (\%)} = [(\text{Total number of nonpriority vehicles using nonpriority ramp}) \div (\text{Total number of nonpriority vehicles})] \times 100\% \quad (1)$$

TABLE 1 Summary of Operational Results (volume, occupancy, delay)

Priority Entry Ramp Site	Avg Nonpriority Volume (vehicles/hr)	Avg Priority Volume (vehicles/hr)		Avg Total Passenger Volume (persons/hr)	Avg Occupancy Nonpriority (persons/vehicle)	Avg Total Combined Occupancy, All Vehicles (persons/vehicle)	Avg Delay Savings (min/vehicle)
		Bus	Van				
Bellaire	875	9	12	1,734	1.20	1.94	4.03
Hillcroft	1,019	15	41	2,495	1.17	2.32	4.92

TABLE 2 Summary of Operational Results (compliance, violations)

Priority Entry Ramp Site	Total Avg Volume Nonpriority Vehicles Using Nonpriority Ramp (vehicles/hr)	Total Avg Volume Nonpriority Vehicles (vehicles/hr)	Compliance Ratio[a] (%)	Total Avg Volume Unauthorized for Priority Entry (vehicles/hr)	Total Avg Volume Vehicles Using Priority Entry Ramp, All Vehicles (vehicles/hr)	Violation Ratio[b] (%)
Bellaire	852	875	97.4	23	42	54.8
Hillcroft	1,010	1,019	99.1[c]	9	65	13.8[c]

[a] Compliance ratio = (Total average volume nonpriority vehicles using nonpriority ramp) ÷ (Total average volume nonpriority vehicles).
[b] Violation ratio = (Total average volume unauthorized for priority entry) ÷ (Total average volume vehicles using priority entry ramp).
[c] Random enforcement at site.

$$\text{Violation (\%)} = [(\text{Total number of vehicles unauthorized to use the priority entry ramp})/(\text{Total number of vehicles using the priority entry ramp})] \times 100\% \quad (2)$$

A summary of average compliance and violation rate results is given in Table 2. Generally, as the compliance ratio is increased, the violation ratio is decreased. Note the influence of the random enforcement presence at the Hillcroft site, with a 40 percent difference in average violation ratio exhibited between the Bellaire and Hillcroft sites.

The service time of nonpriority vehicles and time headway between arrival of priority vehicles was used to calculate the factor defined as the priority entry exposure ratio. This factor is the time ratio a nonpriority vehicle is exposed to a confirmed use of the priority entry ramp by an HOV. This associated equation is as follows:

$$\text{Priority entry exposure ratio} = \{[\text{Service time of nonpriority vehicles (min)}]/[\text{Arrival time headway of priority vehicles (min)}]\} \quad (3)$$

The hypothesis that follows is that as the exposure ratio increases, the violation rate will decrease. The exposure ratio is influenced by both delay time to nonpriority vehicles and the volume of the priority entry ramp, which confirms the worth of the priority entry ramp and acts as an incentive for modal shift.

A linear-regression model was developed from the data and was tested for significance with the exposure ratio established as the independent variable and the violation rate established as the dependent variable. The correlation coefficient (R^2) was calculated to be 0.6659 (acceptable significance). The linear equation is given as follows:

$$\text{Violation rate} = 0.55 - 0.08\ (\text{exposure ratio}) \quad (4)$$

Figure 1 shows a plot of the actual versus predicted data. It should be noted that, even with the calculated significance of these results, the study sample size is limited and no extrapolation may be made outside the limits of the observed data.

SUMMARY AND CONCLUSIONS

The average violation was measured to exceed approximately 40 percent for the designated study sites under investigation. Two factors were assessed as influencing the violation rate. First, random intermittent enforcement appears to decrease the violation rate to approximately 15 percent, as evidenced by the limited comparative data within this study. This level of violations--10 to 15 percent--was reported by previous research (6) as an acceptable standard on priority bypass lanes that use reasonable enforcement.

Second, violations appear to decrease with an increase in the priority entry exposure ratio, which is defined as average service time of nonpriority vehicles divided by average arrival time headways of priority vehicles. A linear relationship was determined (Equation 4) with correlation coefficient (R^2) equal to 0.6659.

As stated, the priority entry exposure ratio is influenced by both delay time to nonpriority vehicles and volume on the priority entry ramp. Measured delay times used in the calculation of the exposure ratio varied from approximately 2.0 to 6.0 min. It is only within this range of delay time that the linear relationship between violation rate and priority entry exposure ratio has been tested.

At some undetermined minimum delay time less than 2.0 min, it is reasonable to expect that violations will decrease because the delay, and the resulting frustration, is not excessive and will be sustained without unauthorized use of the priority ramp. However, it is also difficult, below this minimum delay level, to politically, economically, or operationally justify the priority entry ramp. The incentive for modal shift and priority treatment is questionable. Even if violations exist, the impact is inconsequential; therefore, enforcement may not be required or justified.

At some undetermined maximum tolerable delay time greater than 6.0 min, confirmation of the priority ramp by exposure (volume) will have little impact. Delay time has reached an excessive level, which induces diversion (violations) by nonpriority vehicles. Increased enforcement to control violations is not only required, but the added cost incurred may be offset by the delay savings to priority vehicles.

A graphical representation between the parameters of nonpriority delay and priority vehicle headway relative to enforcement necessary to affect an acceptable violation rate is shown in Figure 2.

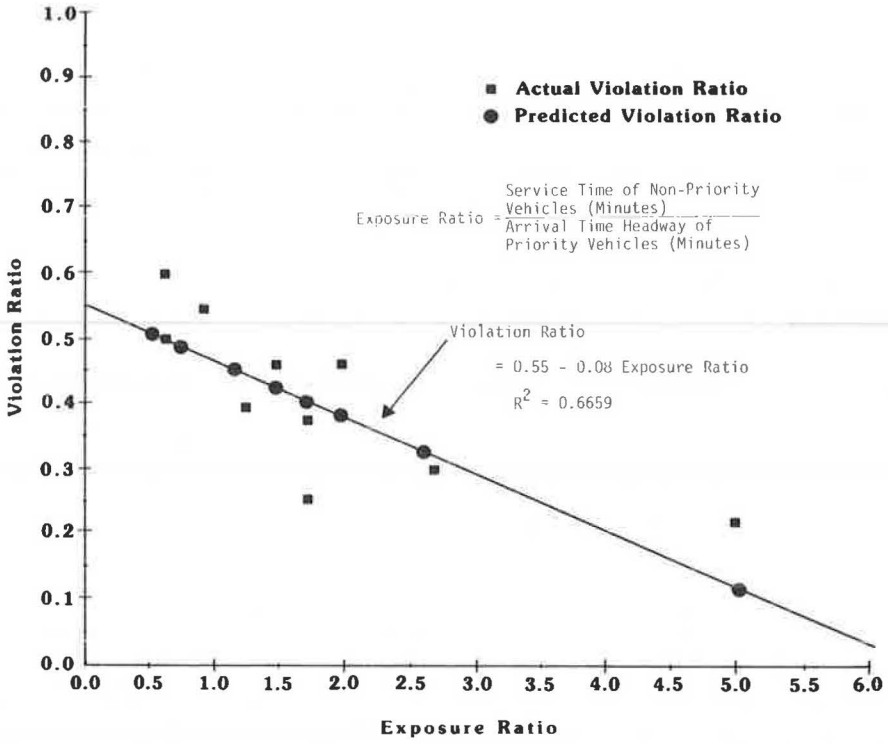

FIGURE 1 Violation ratio versus exposure ratio.

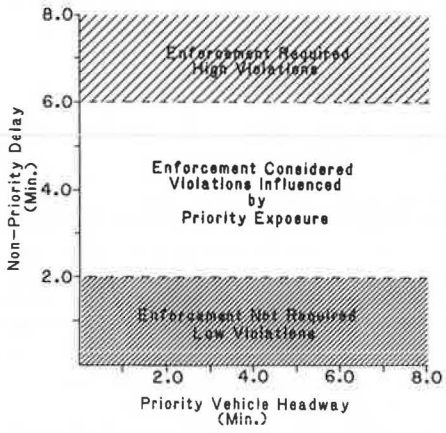

FIGURE 2 Recommended enforcement relative to delay savings and volume on priority entry ramps.

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