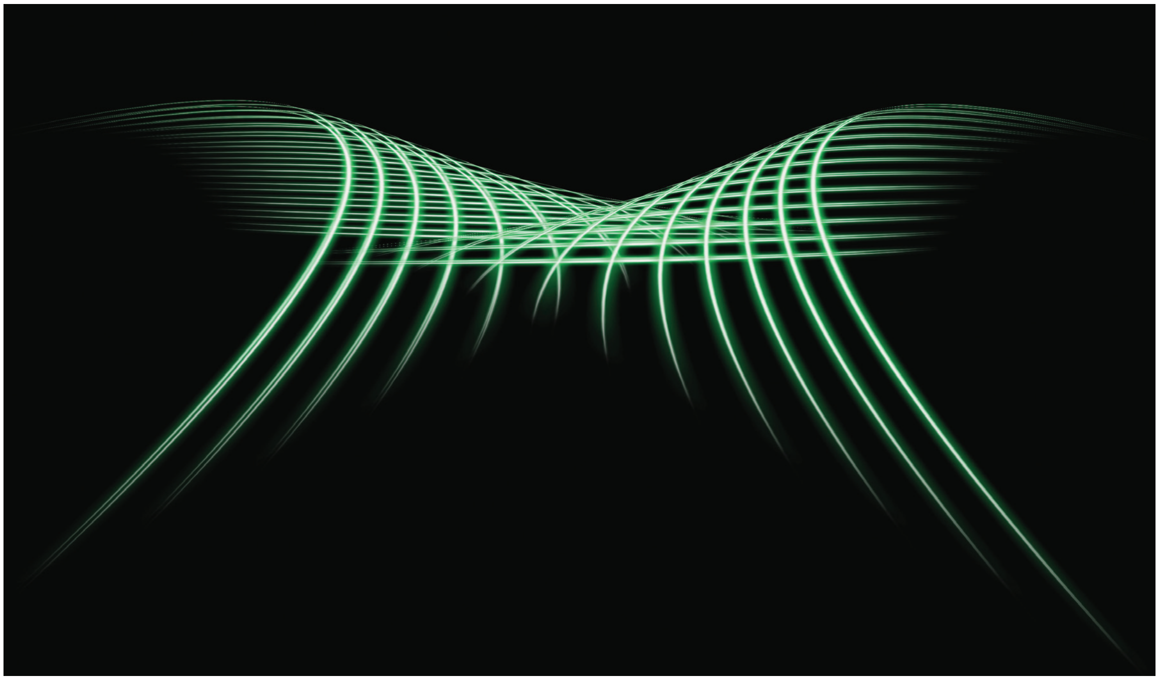
HCM2010

HIGHWAY CAPACITY MANUAL



CHAPTER 28

FREEWAY MERGES AND DIVERGES: SUPPLEMENTAL

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

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HCM2010

HIGHWAY CAPACITY MANUAL

The HCM 2010 significantly enhances how engineers and planners assess the traffic and environmental effects of highway projects by

- Providing an integrated multimodal approach to the analysis and evaluation of urban streets from the points of view of automobile drivers, transit passengers, bicyclists, and pedestrians;
- Addressing the proper application of microsimulation analysis and the evaluation of the results;
- Examining active traffic management in relation to demand and capacity; and
- Exploring specific tools and generalized service volume tables to assist planners in quickly sizing future facilities.

The HCM 2010 consists of four volumes:

Volume 1: Concepts;
Volume 2: Uninterrupted Flow;
Volume 3: Interrupted Flow; and
Volume 4: Applications Guide (electronic only).

The four-volume format provides information at several levels of detail, to help users more easily apply and understand the concepts, methodologies, and potential applications.

Volumes 1, 2, and 3 are issued as a boxed set. Volume 4 is electronic only, accessible to registered HCM users via the Internet, and includes four types of content: supplemental chapters on methodological details and emerging issues; interpretations, clarifications, and corrections; comprehensive case studies; and a technical reference library.

To order HCM 2010, go to **http://books.trbbookstore.org/hcm10.aspx.**

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CHAPTER 28
FREEWAY MERGES AND DIVERGES: SUPPLEMENTAL

CONTENTS

LIST OF EXHIBITS

1. ALTERNATIVE TOOL EXAMPLES FOR FREEWAY RAMPS

Chapter 13, Freeway Merge and Diverge Segments, described a methodology for analyzing ramps and ramp junctions to estimate capacity, speed, and density as a function of traffic demand and geometric configuration. This chapter includes two supplemental problems that examine situations that are beyond the scope of the Chapter 13 methodology. A typical microsimulation-based tool is used for this purpose, and the simulation results are compared, where appropriate, with those of the *Highway Capacity Manual* (HCM).

Both problems are based on Chapter 13's Example Problem 3, which analyzes an eight-lane freeway segment with an entrance and an exit ramp. The first problem evaluates the effects of the addition of ramp metering, while the second evaluates the impacts of converting the leftmost lane of the mainline into a high-occupancy vehicle (HOV) lane.

The need to determine performance measures based on the analysis of vehicle trajectories was emphasized in Chapter 7, Interpreting HCM and Alternative Tool Results. Specific procedures for defining measures in terms of vehicle trajectories were proposed to guide the future development of alternative tools. Pending further development, the examples presented in this chapter have applied existing versions of alternative tools and therefore do not reflect the trajectory-based measures described in Chapter 7.

For purposes of illustration, the default calibration parameters of the simulation tool (e.g., lane-changing behavioral characteristics) were applied to these examples. However, most simulation tools offer the ability to adjust these parameters. The parameter values can have a significant effect on the results, especially when the operation is close to full saturation.

PROBLEM 1: RAMP-METERING EFFECTS

This problem analyzes the impacts of ramp metering along the segment. The HCM procedure for ramp-merge junctions cannot estimate the impacts of ramp metering. These impacts can be approximated to some extent by not allowing the ramp demand to exceed the ramp-metering rate. To address ramp metering at a more detailed level, a typical microsimulation tool was used to evaluate the impacts of ramp metering on the density and capacity of the merge.

The subject segment consists of an on-ramp followed by an off-ramp, separated by 1,300 ft. The upstream segment is 1 mi long. Each simulation run was for 1 full hour. It was assumed that the mainline demand was 6,111 veh/h and that the ramp demand was 444 veh/h. The ramp metering is clock-time based (i.e., the metering rate does not change as a function of the mainline demand).

Experiments were conducted to obtain the density and capacity of the subject segment as a function of the ramp-metering rate. The queue length upstream of the ramp meter was also obtained as a function of the ramp-metering rate. Exhibit 28-1 provides a graphics capture of the simulated site.

Exhibit 28-1
Graphics Capture of the Ramp Merge with Ramp Metering

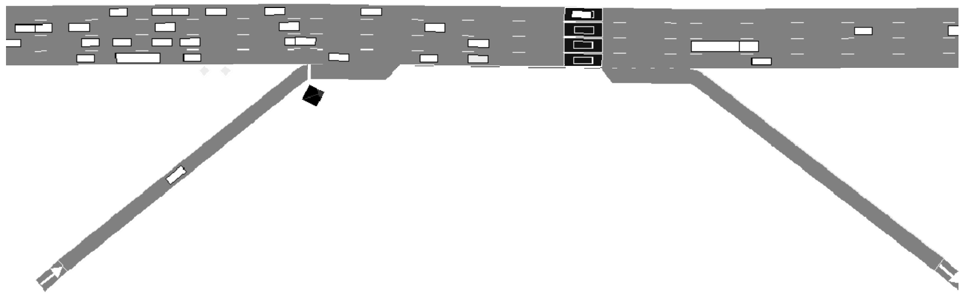


Exhibit 28-2 provides the density of the segment between the on-ramp and the off-ramp as a function of the ramp-metering rate (or discharge headway from the on-ramp). As shown, the density is not much affected by the ramp-metering rate. As expected, the density of Lane 1 (the rightmost lane) is the highest, while the density in Lane 4 is the lowest.

Exhibit 28-2
Density as a Function of Ramp-Metering Headways

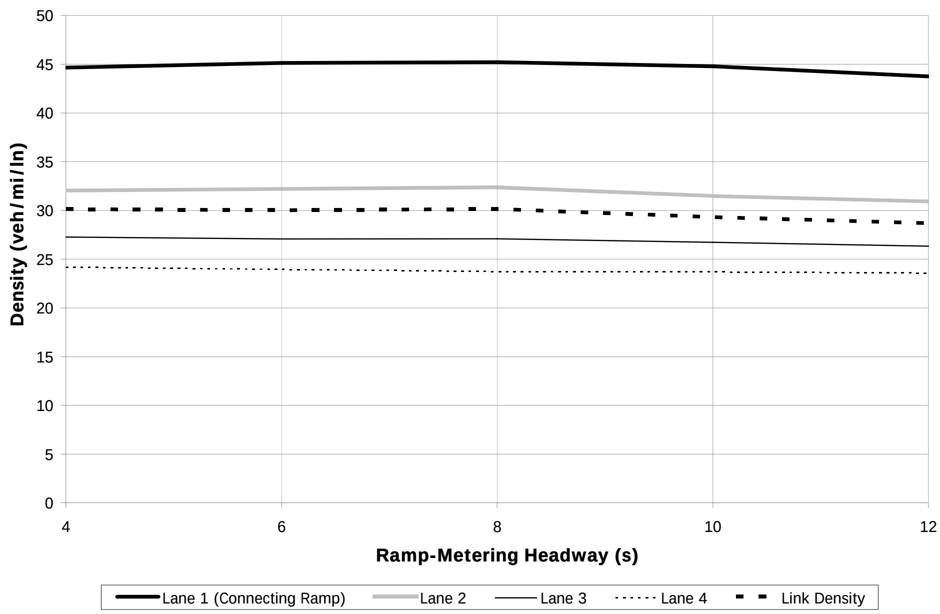


Exhibit 28-3 provides capacity as a function of the ramp-metering headway and the estimated maximum throughput when no ramp metering is implemented. As shown, the simulation model predicts that capacity is higher when ramp metering is implemented.

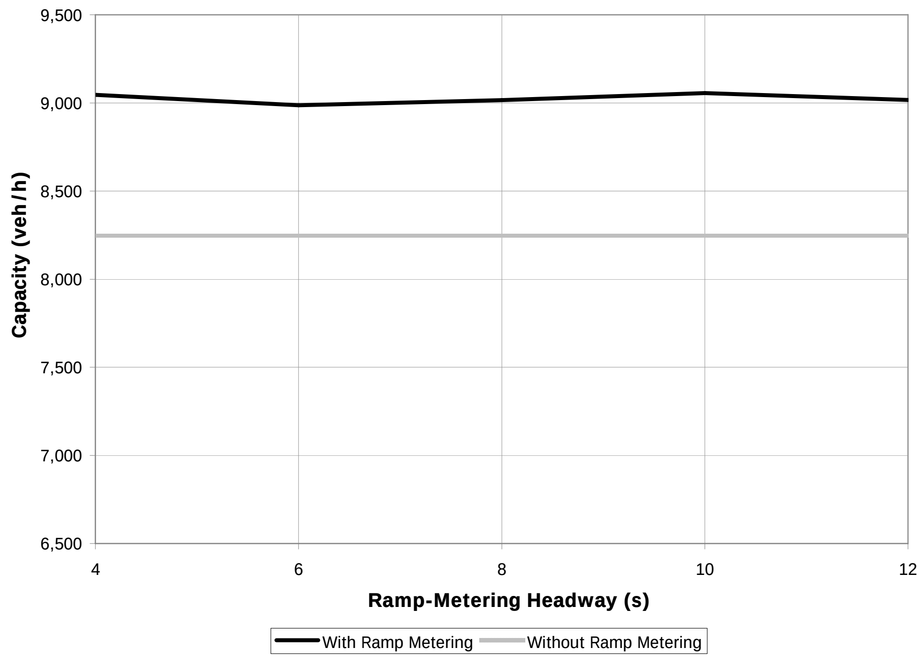


Exhibit 28-3
Capacity at a Ramp Junction as a Function of Ramp-Metering Headways

Exhibit 28-4 provides the queue length expected on the ramp, as a function of ramp metering and when no ramp metering is implemented. As expected, the queue length is somewhat higher when ramp metering is implemented, and it increases dramatically when the ramp-metering rate exceeds 8 s/veh.

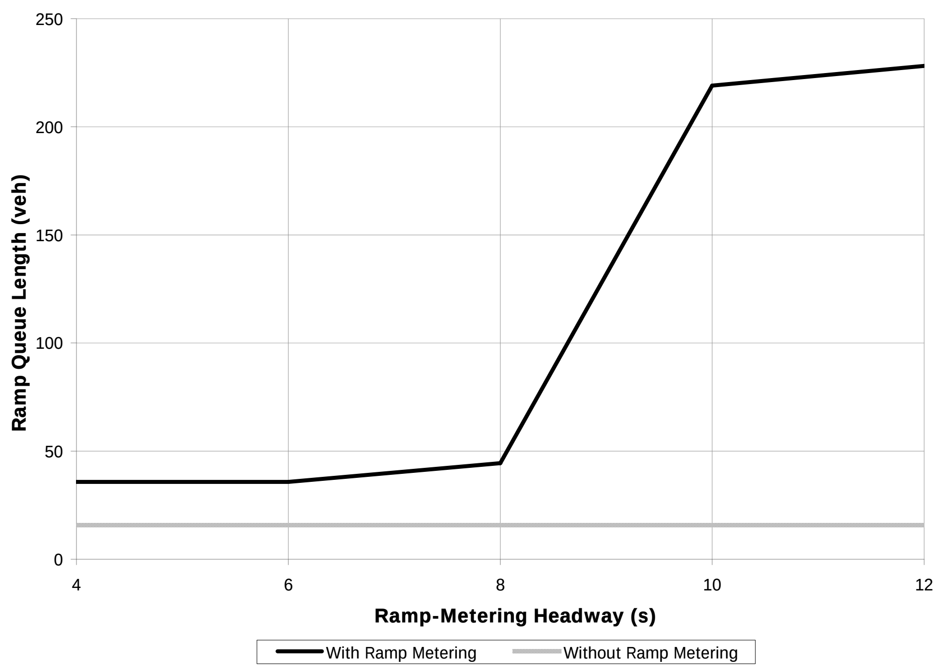


Exhibit 28-4
Queue Length on the Ramp as a Function of Ramp-Metering Headways

As indicated above, the effects of ramp metering cannot be evaluated with the HCM. The freeway facilities methodology (HCM Chapter 10) can handle changes in segment capacity; however, other tools are required to estimate what the maximum throughput would be under various types of ramp-metering algorithms and rates. Also, the HCM cannot estimate the queue length on the on-ramp as a function of ramp metering. An analytical method could be developed to estimate queue length as a function of demand and service rate at the meter.

PROBLEM 2: CONVERSION OF LEFTMOST LANE TO AN HOV LANE

This problem is also based on Chapter 13's example problem. It evaluates operating conditions when the leftmost lane of the mainline is converted into an HOV lane. Exhibit 28-5 provides a graphics capture of the segment.

Exhibit 28-5
Graphics Capture of the Segment with an HOV Lane

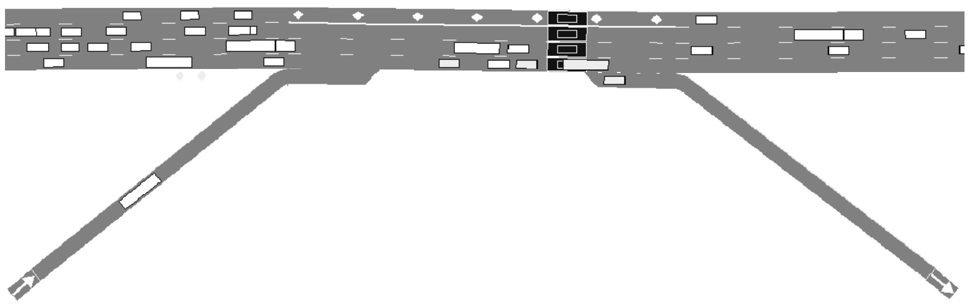


Exhibit 28-6 and Exhibit 28-7 show the density and capacity of the ramp junction as a function of the percentage of carpools. As shown, when the percentage of carpools increases, the density of the HOV lane and the overall link capacity increase. This occurs because for the range of values tested here, the utilization of the HOV increases, thus improving the overall link performance.

Exhibit 28-6
Density of a Ramp Junction as a Function of the Carpool Percentage

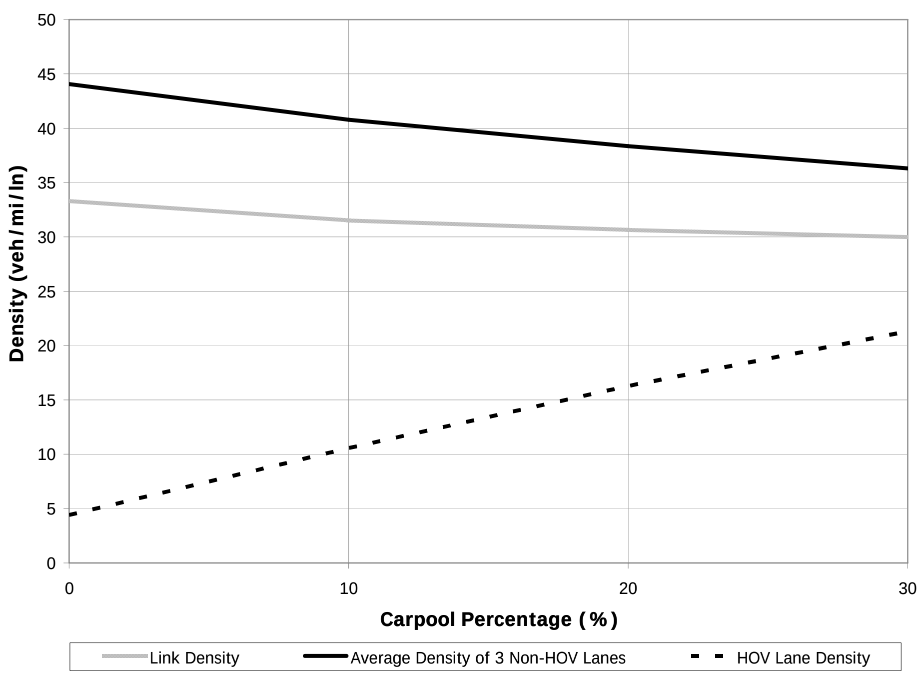


Exhibit 28-7
Capacity of a Ramp Junction as a Function of the Carpool Percentage

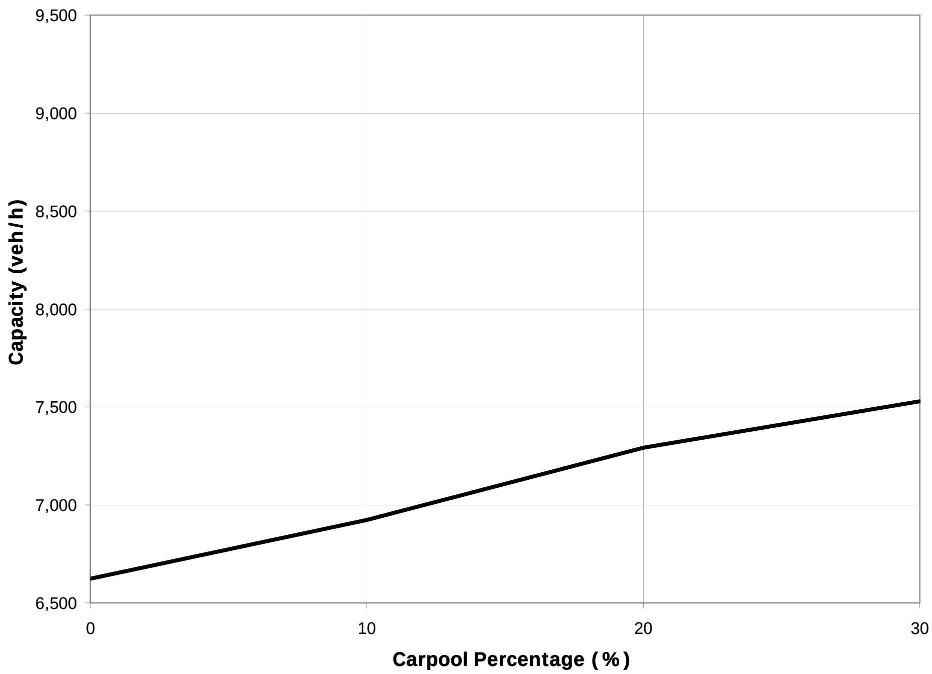


Exhibit 28-8 presents the density as a function of HOV violators, while Exhibit 28-9 presents the corresponding capacity. These two graphs assume that there are 10% carpools in the traffic stream. As shown, density generally decreases while capacity increases as the percentage of HOV violators increases. The reason is that under this scenario, the facility is more efficiently utilized as violations increase with general traffic using the HOV lane.

Exhibit 28-8
Density of a Ramp Junction as a Function of the HOV Violation Percentage

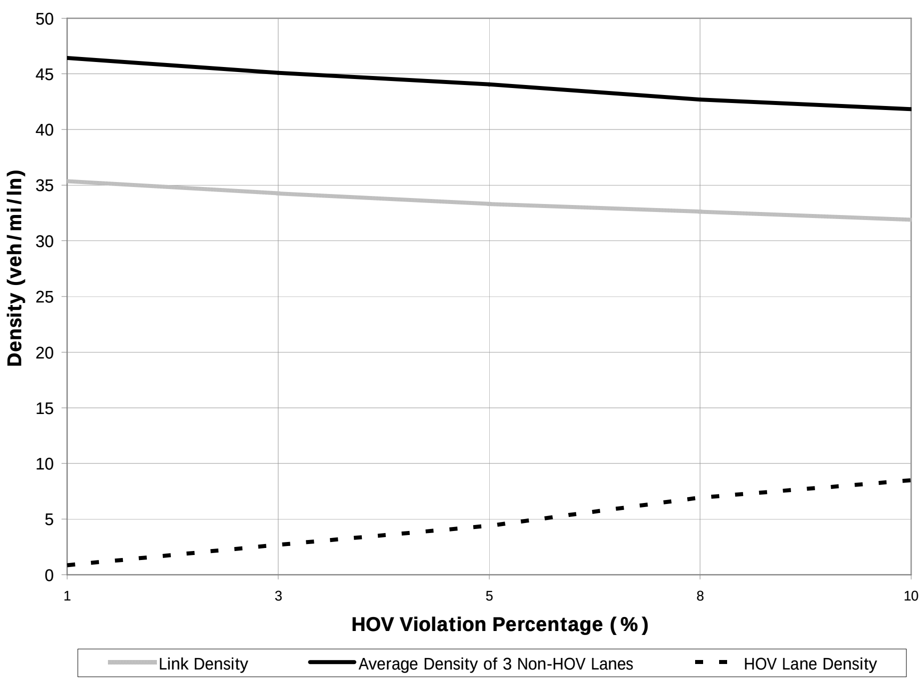


Exhibit 28-9
Capacity of a Ramp Junction as a Function of the HOV Violation Percentage

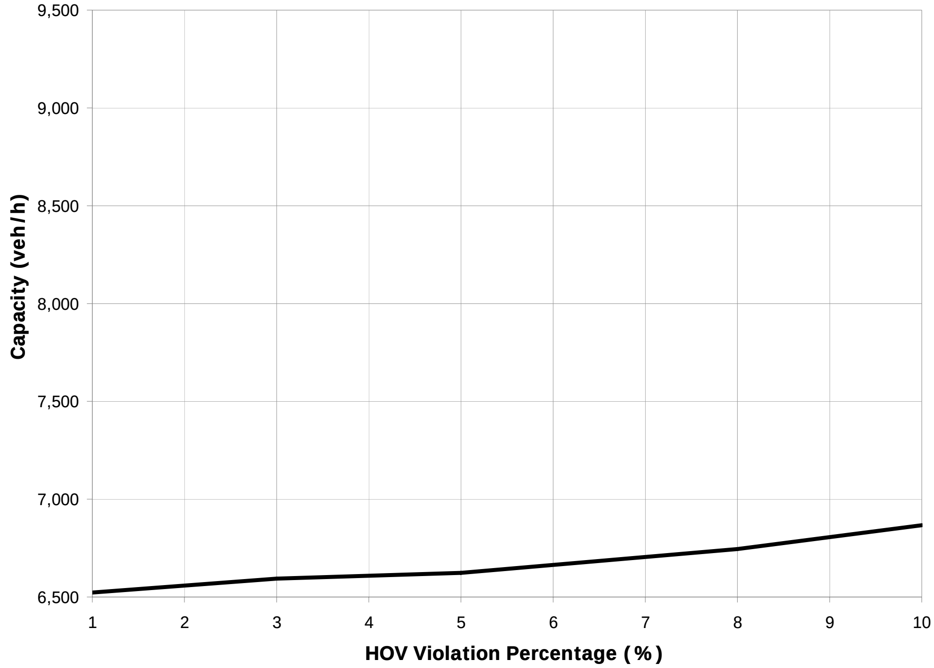
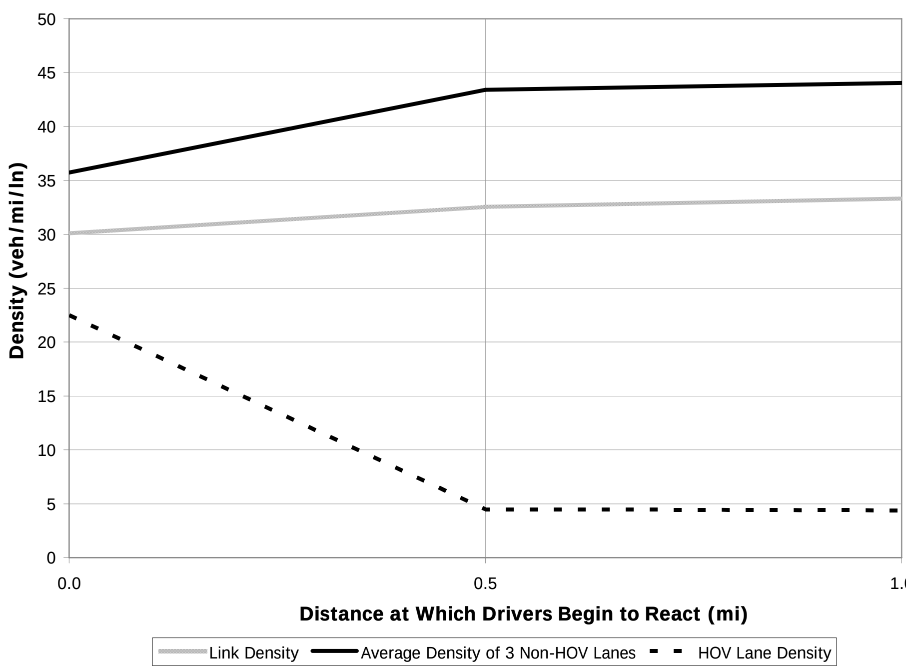


Exhibit 28-10 and Exhibit 28-11 present the density and capacity of the ramp junction as a function of the distance at which drivers begin to react to the presence of the HOV lane (i.e., the distance to the regulatory sign). As shown, the longer that distance, the lower the density of the HOV lane, and the higher the density in the other lanes. The reason is that under this scenario the percentage of carpools is relatively low (10%). When the HOV lane begins, non-HOVs congregate in the remaining lanes. Capacity is reduced as the distance at which drivers begin to react increases, because the HOV lane is not utilized as much when drivers are given early warning to switch lanes.

Exhibit 28-10
Density of a Ramp Junction as a Function of the Distance at Which Drivers Begin to React



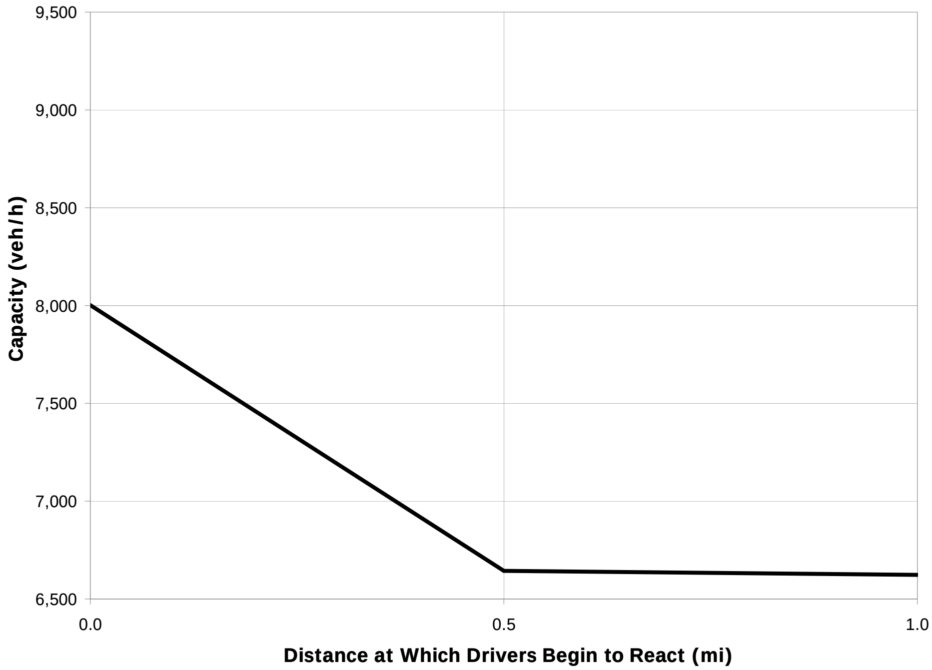


Exhibit 28-11
Capacity of a Ramp Junction as a Function of the Distance at Which Drivers Begin to React

Exhibit 28-12 and Exhibit 28-13 present the density and capacity of the ramp junction as a function of the percentage of HOV usage. As expected, when usage of the HOV lane increases, the density of the HOV lane and the overall link capacity increase.

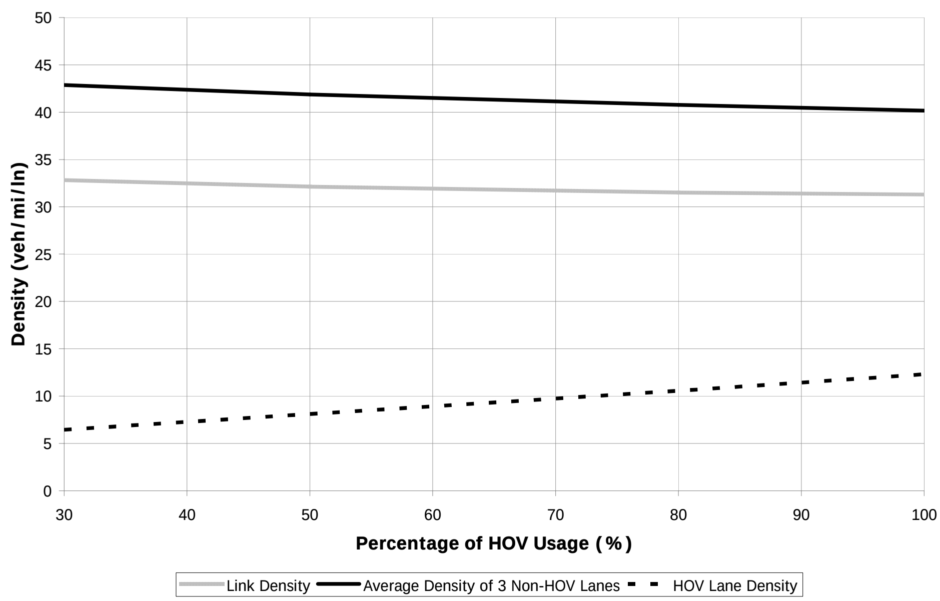
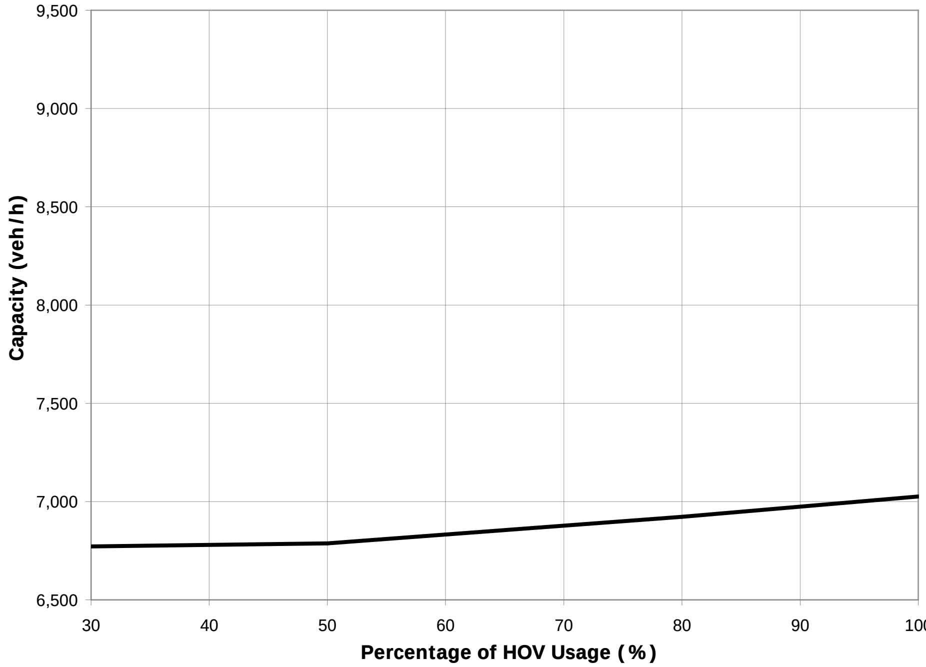


Exhibit 28-12
Density of a Ramp Junction as a Function of the Percentage of HOV Usage

Exhibit 28-13
Capacity of a Ramp Junction as a Function of the Percentage of HOV Usage



The type of analysis presented in this example cannot be conducted with the HCM, since the method does not estimate the HOV lane density separately. Variables such as the impact of the distance of the HOV regulatory sign cannot be evaluated, since they pertain to driver behavior attributes and their impact on density and capacity. The impact of the percentage of carpools and the percentage of violators could perhaps be estimated with appropriate modifications of the existing HCM method.