Executive Report

Effects of Changing HOV Lane Occupancy Requirements:

El Monte Busway Case Study

Notice

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16. Abstract

In 1999, the California Legislature passed Senate Bill (SB) 63, which lowered the vehicle-occupancy requirement on the El Monte Busway on the San Bernardino (I-10) Freeway from three persons per vehicle (3+) to two persons per vehicle (2+) full time. The California Department of Transportation (Caltrans) was directed to implement this change on January 1, 2000 and to monitor and evaluate the effects of the 2+ requirement on the operation of the Busway and the freeway. Based on the operational effects that resulted from this change, emergency legislation was approved increasing the vehicle-occupancy requirement back to 3+ during the morning and afternoon peak-periods effective July 24, 2000.

This report summarizes information on the effect the change in the vehicle-occupancy requirement had on the operation of the Busway and freeway, public transit services, violation rates, accidents, and public response. Lowering the vehicle-occupancy requirement from 3+ to 2+ full time had a detrimental effect on the Busway. At the same time, significant improvements were not realized in the general-purpose freeway lanes. Morning peak-period travel speeds in the Busway were reduced from 65 mph to 20 mph, while travel speeds in the general-purpose lanes decreased from 25 mph to 23 mph for most of the demonstration. Hourly Busway vehicle volumes during the morning peak-period increased from 1,100 to 1,600 with the 2+ designation, but the number of persons carried declined from 5,900 to 5,200. The freeway lane vehicle volumes and passengers per lane per hour remained relatively similar. Peak-period travel times on the Busway increased by 20- to 30-minutes. Bus schedule adherence and on-time performance declined significantly and passengers reported

delays.

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El Monte Busway Case Study

Katherine F. Turnbull

Texas Transportation Institute

The Texas A&M University System

College Station, Texas

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This study was conducted in cooperation with staff from the Federal Highway Administration (FHWA), the California Department of Transportation (Caltrans), and other agencies. Jon Obenberger, FHWA Office of Traffic Management and ITS Applications, served as the project director. Robert Cady, FHWA California Division, and Antonette Clark and Dawn Helou, Caltrans, provided guidance and information throughout the study. In addition, Bonnie Duke, TTI, was responsible for word processing on the report and Gary Lobaugh provided editorial review. The assistance of these individuals is both recognized and appreciated.

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INTRODUCTION

Case Study Objectives

In 1999, the California Legislature approved Senate Bill 63 (SB 63), lowering the vehicle-occupancy requirement on the El Monte Busway from 3+ to 2+ full-time (1). The legislation directed Caltrans to make this change on January 1, 2000 as part of a temporary demonstration project, which was to extend until June 30, 2001.

The legislation also required the California Department of Transportation (Caltrans) to monitor and analyze the effect of this change on the operation of the freeway and the Busway. Based on the operational effects of the change, as documented in the Caltrans operational study (2), emergency legislation was approved increasing the vehicle-occupancy requirement back to 3+ during the morning and afternoon peak periods and maintaining the 2+ requirement at all other times, effective July 24, 2000 (3).

The Federal Highway Administration (FHWA) sponsored this study examining the effects of lowering the vehicle-occupancy requirement. The analysis conducted by Caltrans focused primarily on the operational impacts of changing the vehicle-occupancy requirement. The FHWA-sponsored study built on, and expands upon, the Caltrans effort.

The primary objective of this study was to examine and present additional information on the effects the change in vehicle-occupancy requirements had on public transportation services, violation rates, accidents, and public responses. A second study objective was to explore the issues, factors, and impacts associated with making operating changes on HOV facilities that agencies should consider.

This report highlights the major effects changing the vehicle-occupancy requirement from 3+ to 2+ had on the operation of the Busway and freeway, public transit services, violation rates, accidents, and public response. Key elements of effective HOV management and operations programs are also summarized. This report is targeted toward policy makers and administrators.

A separate report, *Effects of HOV Lane Occupancy Requirements: El Monte Busway Case Study*, provides more detailed information on the effects of the vehicle-occupancy change and on best practices for managing and operating HOV facilities. The audience for the technical report is agency staff and consultants who may be involved with or responsible for studies, decisions, or actions influencing the operation of HOV facilities.

HOV Facilities

High-occupancy vehicle (HOV) facilities represent one approach used in metropolitan areas throughout the country to help improve the people-moving capacity, rather than vehicle-moving capacity, of congested freeway corridors. Common objectives for HOV facilities are to:

- increase the average number of persons per vehicle,
- preserve the people-moving capacity of a freeway,
- improve bus operations, and
- enhance mobility options for travelers.

Figure 1. Metropolitan Areas with Freeway HOV Facilities

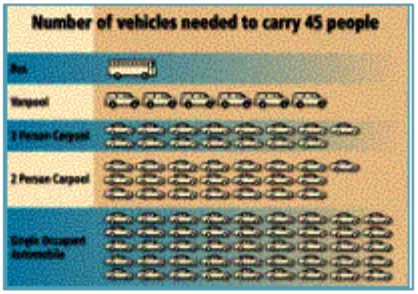

Figure 2. Number of Vehicles Needed to Carry 45 People

Today, freeway HOV facilities and busways are in operation in the 31 metropolitan areas in North America highlighted in Figure 1. Some of these areas, such as the Los Angeles region, have extensive systems of HOV lanes that are important components of a multimodal surface transportation system. Other areas have deployed HOV facilities within specific congested corridors, but the projects have yet to evolve into a true region-wide system. The HOV lanes in Los Angeles are one element of a multimodal transportation system that includes freeways, local roads, buses, light rail transit, and commuter rail.

As shown in Figure 2, buses, vanpools, and carpools can accommodate more travelers in fewer vehicles than automobiles with only one person. The travel time savings and improved trip time reliability offered by HOV facilities are key to attracting travelers to change from driving alone to carpooling, vanpooling, or riding the bus.

The attractiveness of HOV facilities their ability to change travel behavior depends on the travel time savings and the trip reliability, the type and level of the bus service, the location within a metropolitan area, the use requirements, the congestion levels in the corridor, the years of operation, and the supporting policies, programs, and facilities.

Managing and operating HOV facilities to maintain travel timesavings and trip time reliability is key to their ongoing success. Real-time monitoring through closed-circuit television cameras and other technologies, along with incident management, enforcement, public and policy maker outreach efforts, and enhancements to continuously improve the performance of HOV facilities are major components of effective HOV management and operation programs.

El Monte Busway

As illustrated in Figure 3, the San Bernardino (I-10) Freeway is located on the east side of Los Angeles, stretching from the Nevada border to downtown Los Angeles. It was one of the earliest freeways constructed in the area. Along with I-210 to the north and State Route 60 to the south, it serves as a major east/west travel corridor in the region. Like other freeways in the Los Angeles area, the San Bernardino Freeway is heavily congested, especially during the morning and afternoon peak hours.

Figure 3. Location of the El Monte Busway, Freeways, and HOV Lanes in the Los Angeles Area

Opening in 1973, the El Monte Busway on the San Bernardino Freeway is the oldest HOV facility in the Los Angeles area. A one-mile extension into the downtown area was completed in 1989.

The 11-mile Busway includes two design and operation treatments. Part of the Busway is separated from the adjacent freeway lanes by a 10.5 foot painted buffer and the other segment is physically separated from the freeway. Designing, funding, developing, and operating the Busway has been guided by a series of agreements between Caltrans and the Los Angeles Metropolitan Transportation Agency, and their predecessor agencies.

Three bus stations are located along the Transitway at El Monte, the California State University at Los Angeles (University Station), and the Los Angeles County University of Southern California Medial Center (Hospital Station). A direct HOV connector access ramp is located at Del Mar Avenue and a direct connector for buses is provided at the El Monte Bus Station. Park-and-ride lots in the corridor are oriented toward the Busway and provide some 5,100 parking spaces to travelers. Additional lots serve the Metrolink rail system, which also operates in the corridor.

Only buses were allowed to use the facility when it opened in 1973. Three-person carpools were allowed to use the Busway for three months in 1974 due to a strike by bus operators. The Busway was opened to 3+ carpools in 1976 as part of the mixed-mode operation and operated with a 3+ requirement until a legislative mandated change in 2000.

From 1973 to 1976, the number of buses using the lane in the morning peak-hour, peak-direction of travel increased from 21 to 64, with a corresponding increase in passengers from 766 to 3,044. Daily bus ridership levels increased from 1,000 to 14,500 passengers during the same period.

Allowing 3+ carpools on the facility in October 1976 did not cause a noticeable change in bus ridership levels. Overall daily utilization levels increased from approximately 14,420 bus riders, carpoolers, and vanpoolers in October 1976 to 20,440 in April 1978. Use of the Busway continued to grow during the 1980s and 1990s, with peak hour volumes averaging between 835 to 1,500 vehicles and 5,800 to 7,100 passengers (4, 5, 6, 7).

The El Monte Busway continues to be one of the most efficient HOV facilities in North America. With approximately 80 peak hour buses it also has one of the highest levels of bus use. Outside of the bus-only lanes, peak hour bus volumes on the El Monte Busway are third behind the Shirley Highway approaching Washington, D.C. and I-80 on the San Francisco-Oakland Bay Bridge in the San Francisco area.

During the 1980s, 1990s, and 2000s concurrent flow HOV lanes were added to numerous freeways in the Los Angeles area. These HOV lanes operate with a 2+ vehicle occupancy requirement. As of 2000, some 377 lane-miles of freeway HOV facilities were in operation in Los Angeles County. To help manage traffic, Caltrans has added metered freeway entrance ramps, HOV ramp meter bypasses at selected ramps, and a Freeway Service Patrol to freeways in the area.

EFFECTS OF VEHICLE-OCCUPANCY CHANGE

Caltrans District 7 was responsible for implementing the 2+ occupancy requirement change directed in SB 63 and for monitoring the effects of the legislation. Caltrans established the SB 63 Implementation Committee to help support and coordinate the change. The Implementation Committee was comprised of representatives from Caltrans headquarters, divisions within Caltrans District 7, the Los Angeles Metropolitan Transportation Authority, the Southern California Association of Governments, Foothill Transit, the California Highway Patrol, toll operators, and FHWA.

Caltrans monitored the effects that lowering the vehicle-occupancy requirement had on the operation of the Busway and the freeway. The results of the monitoring effort were summarized in regularly issued fact sheets and presented in an Executive Summary. A separate traffic safety analysis was also conducted by Caltrans. This assessment was completed in March 2002. Foothill Transit monitored the affects of the 2+ demonstration on bus operating speeds, bus travel times, on-time performance, service overtime, safety incidents, and customer complaints.

The Caltrans assessment focused on the morning and afternoon peak periods, when demands on the freeway system are greatest and traffic volumes are highest. The peak periods are from 6:30 a.m. to 9:30 a.m. and from 3:00 p.m. to 7:00 p.m. The morning peak hour is 6:45 a.m. to 7:45 a.m. and the afternoon peak hour is 4:30 p.m. to 5:30 p.m.

The data collection and analysis focused on the peak direction of travel during these time periods. The peak direction of travel is westbound into downtown Los Angeles in the morning and eastbound out of the downtown area in the afternoon. Off-peak conditions were not examined as traffic in the Busway and the general-purpose lanes usually reflects relatively free-flowing conditions.

Freeway and Busway Operations

Traffic conditions in the morning and afternoon peak periods are generally similar, with some variations. Slightly higher volumes are experienced in the Busway in the morning peak period than in the afternoon peak period. The freeway general-purpose lanes experience the opposite trend, with vehicle volumes slighter higher in the afternoon peak periods. Information from the morning peak-period is presented here (2).

* **Travel Speeds**. Figure 4 illustrates the congested conditions experienced in the Busway during the peak periods with the 2+ requirement. As highlighted in Figure 5, peak-period travel speeds in the Busway were negatively effected during the 2+ demonstration. Travel speeds in the Busway declined from freeflow conditions of 65 mph to approximately 20 mph in the morning westbound direction.

Figure 4. Congestion in El Monte Busway with 2+ Requirement (Top photo - Caltrans, bottom photo - Foothill Transit)

A significant corresponding increase in travel speeds did not occur in the general-purpose lanes. As illustrated in Figure 5, travel

speeds on the freeway lanes averaged 25 mph in the morning westbound peak period before the demonstration. Travel speeds in the morning westbound direction increased to 37 mph on the freeway lanes during the first month of the 2+ demonstration, but decreased to 23 mph for the remainder of the operation.

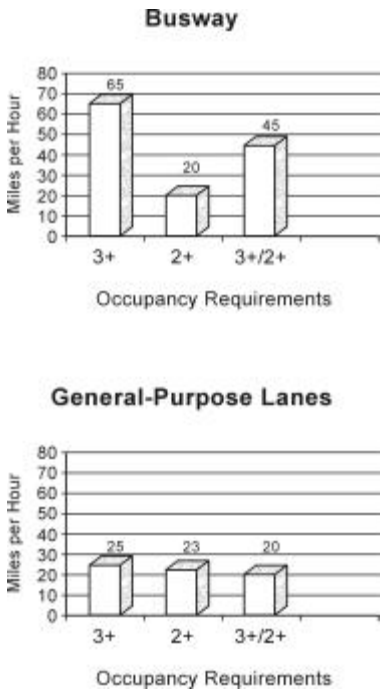

Figure 5. Changes in Morning Peak Hour Travel Speeds (2)

Travel speeds on both the Busway and the freeway lanes returned to close to pre-demonstration levels with the implementation of emergency legislation, AB 769, and the return to the 3+ occupancy requirement during weekday peak-periods. Travel speeds on the Busway increased to 45 mph in the morning peak-period. Although lower than the pre-demonstration 65 mph, this speed represents generally freeflow conditions. Travel speeds in the general-purpose lanes were slightly lower than the pre-demonstration speeds at 20 mph the morning peak period.

* **Vehicle Volume and Persons Per Hour Per Lane**. Changes in peak hour vehicle volumes over the three time periods, the changes in person per hour per lane (pphpl), and the total vehicle and person volumes for the freeway lanes and the Busway were examined. Analyzing these measures is significant as vehicle volumes may increase as the result of a change in the vehicle-occupancy requirement, but the total number of people being carried may decline or may increase at a much lower rate.

This trend did occur on the Busway in the morning peak-period. As shown in Figure 6, the number of vehicles on the Busway in the morning peak hour increased from 1,100 to 1,600 during the 2+ demonstration. As highlighted in Figure 7, however, the number of persons carried declined from 5,900 to 5,200. Thus, more vehicles carrying fewer people were on the Busway.

Vehicle volumes in the general-purpose lanes increased slightly or remained relatively constant over the three time periods, as did the number of pphpl. Thus, lowering the vehicle-occupancy rate on the Busway, and the subsequent increase in 2+ carpools on the

Busway, did not have a corresponding affect of lowering vehicle volumes in the freeway lanes. The increase in vehicles may have resulted from latent demand in the corridor, with commuters diverting from other routes.

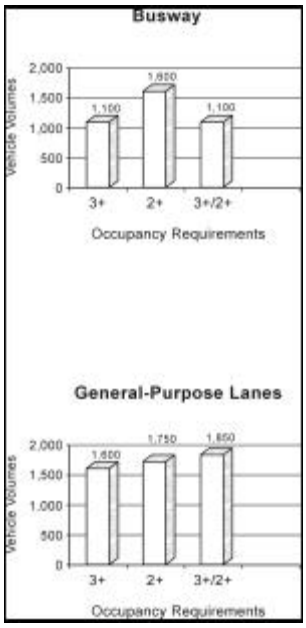

Figure 6. Changes in Morning Peak Hour Vehicle Volumes (2)

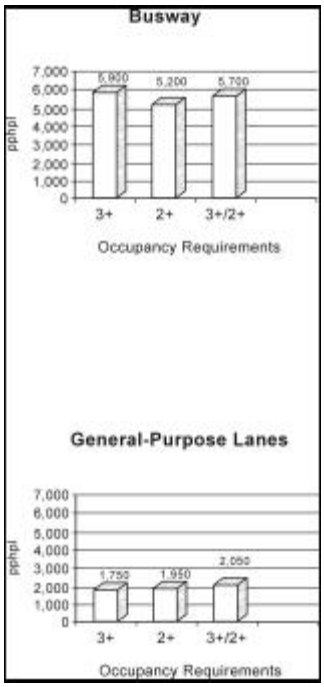

Figure 7. Changes in Morning Peak Hour Persons Per Hour Per Lane (pphpl) (2)

Figures 8 shows the total vehicles and the total persons carried in the morning peak hour on the facility the four freeway general-purpose lanes and the one-lane Busway. This figure provides an indication of the total vehicle and person throughput for the freeway corridor. In the morning peak hour, total vehicle volumes increased by 15 percent with the change to the 2+ operating requirement, but total person volumes increased by less than one percent.

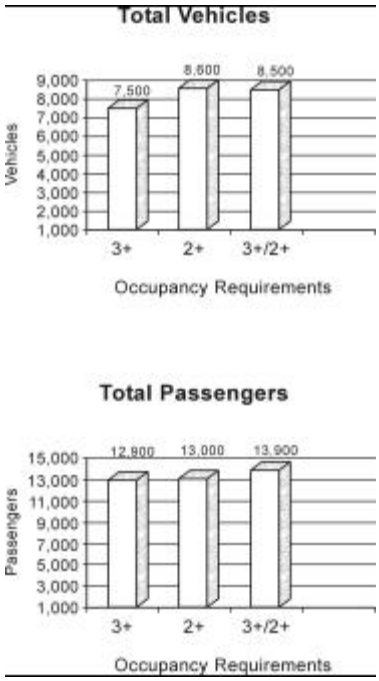

Figure 8. Changes in Morning Peak Hour Total Vehicle and Person Volumes for the Freeway Lanes and the Busway (2)

Public Transit Services

Buses have always been a key element of the El Monte Busway. Prior to the vehicle-occupancy change, approximately 80 buses operated on the Busway during the morning peak hour. This figure is one of the highest hourly bus volumes on exclusive or concurrent flow HOV facilities in the country.

Foothill Transit operates the majority of buses on the Busway, with the Metropolitan Transportation Authority (MTA) providing some service. Both express routes and local/express routes operate on the Busway. Overall, Foothill Transit buses make 500 trips per day on the Busway carrying some 18,000 passengers.

Foothill Transit monitored the effect of the change in the vehicle-occupancy requirement on its operations. Information regarding bus on-time performance, service overtime and operating costs, safety, and customer complaints was collected over the course of the demonstration. Periodic fact sheets were published highlighting this information and a video was produced documenting some of the effects. Passenger complaints, including letters and other correspondence, were recorded.

Lowering the vehicle-occupancy requirement to 2+ had a significant effect on bus operations. The increase in the number of two-person carpools, which caused congestion on the Busway, resulted in lower bus operating speeds, longer bus travel times and reduced on-time performance, increased service overtime and operating costs, increases in safety incidents, and increases in customer complaints.

* **Bus Operating Speeds, Bus Travel-Times, and On-Time Performance**. Bus operating speeds slowed during the 2+ demonstration affecting overall bus travel times and on-time performance. Historically, buses operating on the Busway experienced freeflow speeds, averaging 65 mph prior to the 2+ demonstration. As noted previously, during the 2+ period, travel speeds for all vehicles in the Busway declined to 20 mph in the westbound direction during the morning peak period (2).

The slower operating speeds resulted in longer bus travel times and reduced on-time performance. Bus travel times from the eastern end of the Busway into downtown Los Angeles were 20 to 30 minutes longer during the morning peak-period. Schedule adherence and on-time performance dropped from an average of 88 percent in the fall of 1999 to 48 percent in May 2000. The consistent 20-minute travel time savings provided to bus passengers over vehicles in the general-purpose lanes was lost during the 2+ demonstration (8).

* **Service Overtime and Operating Costs**. The slower bus operating speeds, longer travel times, and reduced on-time performance also caused declines in service productivity. Bus operators finishing their runs late were frequently not able to return for a second trip in the corridor. To fill these voids and to maintain schedules, extra buses and operators had to be dispatched when available.

At some points during the demonstration, as many as 10 extra buses and operators were staged in the downtown area to help ensure that trips were not missed and schedules were maintained. Foothill Transit estimated that the personnel and fuel costs associated with providing these extra buses were approximately $1,250 per weekday. Over the course of the demonstration, Foothill Transit estimated spending close to $150,000 for the extra buses and operators. If the 2+ requirement had been continued, the annual cost of providing the additional buses would have been approximately $325,000 (8, 9, 10).

Enforcement and Vehicle-Occupancy Violations

The changes in vehicle-occupancy levels significantly affected the violation rates on the Busway. Before the 2+ demonstration, violation rates averaged seven percent in the morning peak period and two percent in the afternoon peak period. The violation rates declined to one percent during the 2+ demonstration, as 2+ person carpools, which would previously have been cited, became authorized users.

The violation rates increased significantly to 41 percent and 56 percent during the early phase of the 3+ peak/2+ off-peak operations. Extra enforcement and more visible enforcement was not provided during the initial 3+/2+ operation. As a result, it appears that many 2+ carpools continued to use the lane during the 3+ peak-period.

In response to concerns over these high violation rates, CHP undertook an aggressive enforcement program in January 2001. Elements of the program included briefings for all CHP shifts, press releases and radio broadcasts highlighting the correct occupancy requirements, and announcing increased enforcement of the rules, and four weeks of enforcement saturation with extra offices assigned to the Busway. These efforts resulted in the violation rates returning to levels similar to those before the 2+ demonstration (11).

Accidents

The Caltrans District 7 Office of Freeway Operations in the Division of Operations conducted a safety study of the effects of SB 63 and AB 769 on the El Monte Busway (12). The study examined accident records for the following three time periods:

_ six-months before the 2+ vehicle-occupancy requirement became operational (July 1, 1999 to December 31, 1999),

_ six-months when the 2+ vehicle-occupancy requirement was in effect (January 1, 2000 to July 24, 2000), and

_ 12-months when the 3+ peak-period and 2+ off-peak vehicle-occupancy requirement was in effect (July 25, 2000 to June 30, 2001).

In addition, the Busway was divided into two sections for the safety assessment to coincide with the different geometrics. The first segment included the section from Alameda Street to Route 710, which is physically separated from the freeway main lanes. The second section included the segment from the Route 710 interchange to the eastern terminus at Baldwin Avenue. The HOV lanes are separated from the general-purpose lanes by a painted buffer in this segment.

Data from the Caltrans District 7 Traffic Accident Surveillance and Analysis System (TASAS) were examined for each segment for the three time periods. TASAS is a sophisticated electronic data processing record system that includes an accident database linked to a highway database. The accident

rates (accidents per million vehicle miles) by segments for the three periods were examined. Fatal accidents, fatal plus injury accidents, and total accidents were also examined along with the average or expected rates (12).

- The overall conclusion from the assessment was that no definite conclusion could be drawn indicating there were significant differences in accident rates or accident types during the three study periods.
- No accidents were recorded in the HOV lane during the six-months prior to the enactment of SB 63. Five accidents were recorded in the HOV lane during the six-months at the 2+ vehicle-occupancy requirement and eight accidents were recorded during the 12 months of 3+ peak/2+ off-peak operations. The number of accidents increased from the 3+ operations, but the differences were not statistically significant. There were also no apparent significant differences in the number of accidents by section during these time periods. The accident rates for all three periods are lower than the average or expected rate.
- Although the total number of accidents in the general-purpose lanes increased during the 2+ and the 3+/2+ operating periods, these differences were not found to be significant.

Foothill Transit operators record safety incidents as part of their daily reporting. During 1999 an average of 13 safety incidents a day were reported by operators on the El Monte Busway. During the 2+ demonstration the number of recorded safety incidents increased substantially. For example, on January 27, 140 safety incidents were reported by Foothill Transit operators.

The most frequently cited problems were rapid deceleration of cars in front of buses, cars illegally crossing the double-lines, and improper merging of cars into and out of the Busway. Figure 9 shows an example of a carpooler illegally exiting the Busway to avoid congestion in the lane. Approximately 60 percent of the incidents occurred in the buffer separated section of the Busway (9). Although these incidents are not crashes, they represent the potential degradation of safety along the Busway. The incidents posed safety hazards to bus operators, passengers, and motorists.

Public Response

Caltrans, Foothill Transit, the MTA, and other agencies received letters, telephone calls, faxes, and E-mails related to the change to the 2+ occupancy level required by SB 63. The overwhelming majority of the correspondence and calls were critical of the change, with individuals complaining about the negative effects it had on their travel. Although no total official log was maintained, it appears that at least 1,000 comments were received by the various agencies. Foothill Transit alone received almost 900 complaints from passengers. A summary of the comments received is highlighted below.

Figure 9. Vehicle Illegally Exiting Busway(Foothill Transit)

* Bus passengers were the most vocal group responding to the effects of the 2+ demonstration. As noted previously, Foothill Transit received almost 900 complaints from riders. The MTA also received complaints from passengers. Bus Riders noted the 20- to 30-minute longer travel times with the 2+ requirement. Passengers reported missing connections to other buses and rail service, and being late for work, school, and daycare pick-ups. Riders reported having to adjust their schedules to leave earlier in the morning and to make arrangements in the afternoon for children and other responsibilities.

_ I live in Covina. What used to be a two-hour round trip is now a three-hour round trip. Please, this is so inconvenient. I have family I need to get home to.

_ The 2+ defeats the purpose of the carpool lane. It takes an additional 15-25 minutes to get to or from work.

_ Since January 3rd, I have been late to work every day. I am a single mother and I need my job, but my kids need me too. Instead of reaching work in 20 minutes, it is taking over 40 minutes. The commute home is no better and I can no longer pick my daughter up from school in the evenings, because I cannot afford $5.00 for every minute late. I have to spend more money on babysitting than before and had to find someone to take care of my children now that I can't be there.

_ I am a single, working parent whose livelihood relies heavily on keeping a specific schedule. I have been late to work on an average of 10-15 minutes since this new bill affected my route January 1st. Fortunately, I have been arriving at day care only moments before the 6:30 p.m. closing time. I do not own a vehicle, but I have regularly utilized public transportation as a means to get to work.

_ I commute 24 miles each way to downtown Los Angeles. Normally the commute is about one hour. Now it has increased each way by at least 20 minutes.

- Individuals in existing 3+ carpools reported longer travel times and delays. These individuals indicated they had to adjust their schedules to leave earlier in the morning to arrive at work on time.
- Bus riders, individuals in 3+ carpools and vanpools, as well as others complained that the incentive for using these modes and the Busway was gone. Many of the individuals suggested the 2+ operations represented a step backward and was detrimental to achieving environmental, air quality, and energy goals.
- It does not appear that motorists in the general-purpose freeway lanes were vocal in support of the 2+ demonstration. This

lack of interest may be logical given the fact that the change to the 2+ requirement did not noticeably improve travel conditions in the freeway lanes.

The local print and broadcast media covered the passage of SB 63, the change in the vehicle-occupancy requirements, the effects of the change, the passage of AB 769, and the return to a 3+ peak-period occupancy requirement. Caltrans issued press releases informing the media of the various changes in occupancy requirements, lane closures to install new signs, and other changes. Caltrans also provided regular updates on conditions in the Busway and the freeway general-purpose lanes during the demonstration.

Articles in the *Los Angeles Times* and the *San Gabriel Tribune* described the effects of the 2+ occupancy-requirement on the Busway and the change back to a 3+ requirement during weekday peak periods. During the demonstration, media coverage focused on the increased congestion levels in the Busway, the decline in travel speeds, and the increase in trip times (13, 14, 15, 16). No surveys were conducted of HOV lane users, motorists in the general-purpose lanes, or the public before, during, or after the demonstration.

Prior to completion of the AB 769 demonstration project, Caltrans representatives met with the Implementation Committee to discuss ongoing operations of the El Monte Busway. Based on input from all stakeholders, an operational report and request was submitted to FHWA for consideration since the 3+ peak/2+ off-peak operation was identified as a significant change from the original operation of the Busway. FHWA approval was granted and the permanent dual 3+/2+ occupancy requirement continues to be in place.

MANAGEMENT AND OPERATION OF HOV FACILITIES

Once an HOV project has been opened, the focus of the responsible agency or agencies changes from planning, designing, financing, and constructing to managing and operating the facility. As highlighted in this section, key elements to be considered in effectively managing and operating HOV facilities include performance monitoring, incident management, enforcement, public and policy maker outreach efforts, and ongoing consideration of enhancements. Real-time monitoring of freeways and HOV lanes, through closed-circuit television cameras (CCTV) and other technologies, is an important component of proactive management and operation of the transportation system in many metropolitan areas.

Many areas use multi-agency teams to coordinate the management and operation of freeway HOV facilities. These teams are usually comprised of representatives from the state department of transportation, the regional transit agency, the state highway patrol, the metropolitan planning organization, local communities, and FHWA and the Federal Transit Administration (FTA). Depending on the institutional structure in an area, other possible groups to involve include local police departments, the regional rideshare agency, transit operators, emergency management services (EMS), and air quality or environmental agencies.

The exact agencies and groups included on management and operation teams should be matched to the roles, responsibilities, and institutional structures of a specific area. Further, if an area has an advanced transportation management system (ATMS),

representatives from the state department of transportation, transit agency, state patrol, and other agencies may be located in the operations center or many interact and share information on a regular basis.

Multi-agency management and operation teams provide numerous benefits for helping ensure the efficient operation of HOV facilities. Multi-agency teams provide an ongoing mechanism for communication, cooperation, and coordination among agencies. They provide a regular forum for the discussion of issues and opportunities, and allow agencies to better coordinate projects and activities.

* **Performance Monitoring**. Monitoring conditions on freeways and freeway HOV facilities is a key element of successful proactive management and operational efforts. Many major metropolitan areas use a variety of advanced technologies to monitor the freeway and HOV system. ATMS provides real-time monitoring, incident detection, and rapid response capabilities. In addition, many areas conduct ongoing monitoring and performance evaluations of HOV facilities. These efforts combine to enhance the day-to-day operation of HOV and freeway facilities and to provide the information needed for ongoing operational changes.

* **Incident Management**. Managing accidents and incidents on HOV lanes and freeways is a key part of management and operation. Elements of an incident management program include detecting a problem, responding appropriately, clearing the incident and returning the facility to normal operations, and communicating necessary information to motorists to help manage the situation. These four elementsdetecting, responding, clearing, and communicating form the basis of an incident management program.

* **Enforcement**. Enforcement of vehicle-occupancy requirements and other policies are critical to the successful operation of HOV facilities. HOV enforcement programs help ensure that operating requirements, including vehicle-occupancy levels, are maintained

to protect HOV travel time savings, to discourage unauthorized vehicles, and to maintain a safe operating environment. Visible and effective enforcement promotes fairness and maintains the integrity of the HOV facility to help gain acceptance of the project among users and non-users.

* **Public and Policy Maker Outreach Activities**. Ongoing outreach efforts should focus on communicating the use of HOV facilities to the public and policy makers. The results from the performance monitoring program should be communicated to the public and policy makers on a regular basis. In addition, ongoing education and marketing programs explaining the use of the HOV lanes and promoting carpooling, vanpooling, and transit are needed.

A variety of methods and techniques can be used to communicate information about HOV facilities to the public and policy makers. Providing clear, accurate, and timely information on a regular basis is important. Examples of possible communication methods are newsletters, brochures, Internet sites, news releases, videos, and individual meetings with key stakeholders.

Experience indicates that ongoing outreach efforts with the public and policy makers are needed even with effective HOV facilities. Given the turnover in elected and appointed officials, the numerous demands on these individuals, and the multitude of projects and programs vying for the attention of officials and the public, regular updates on the use, effectiveness, and benefits of HOV facilities are needed.

* **Ongoing Consideration of Enhancements**. A key part of the management and operations philosophy is continually looking for opportunities to enhance the performance of HOV and freeway facilities. Information from performance monitoring programs can be used to help identify possible areas for improvements or changes. Examples of possible enhancements include new or expanded bus services, innovative rideshare programs and public outreach activities, motorists service patrols, ramp metering and HOV bypass lanes, and special treatments for HOVs at major destinations. The use of new technologies, techniques, and strategies should also be considered on an ongoing basis. These approaches may include advanced transportation management systems, variable message signs, advanced traveler information systems, and other techniques.

FEDERAL INTEREST IN HOV OPERATIONAL CHANGES

FHWA has periodically issued guidance on HOV facilities. The most recent *Program Guidance on HOV Operations* was issued on March 28, 2001 (17). The Program Guidance identifies the circumstances under which federal action is required to initiate changes in the operation of an HOV facility, and the federal review process and requirements to be used in these situations. The Program Guidance is available on the FHWA Internet site at http://www.fhwa.dot.gov/legsregs/directives/policy/index.htm.

Federal action is required when significant changes are proposed to existing HOV facilities constructed with federal funds. Significant changes include major alterations in operating hours and converting an HOV lane to general purpose use. Minor modifications in operating hours and changing from different multi-person occupancy levels (from 3+ to 2+, for example) do not require federal approval. Coordination and consultation with FHWA is appropriate even when an operational change is only being considered or discussed, however, as a basis to determine what may be needed for actual changes to occur.

The Program Guidance identifies the information to be included as part of a federal review. Examples of needed information include original studies and plans for the HOV facility, project agreements, commitments made in the environmental process, operational assessments, analysis of future conditions, examination of alternative operating scenarios, and possible impacts on air quality levels and plans. The Program Guidance further outlines the federal review requirements related to air quality conformity, the state implementation plan, the congestion management system, the National Environmental Policy Act (NEPA) process, and other issues.

The Program Guidance and other available documents support the need to examine HOV systems on a regional, not just individual project, basis. Elements in this approach include a multi-year regional HOV system strategic plan, which is integrated into the metropolitan area long-range plan, and a multi-agency program to manage implementation of the system plan and to support day-to-day operation of HOV facilities and supporting services. This approach allows for the long-term regional commitment for infrastructure improvements, the careful phasing of operating segments, and coordinating the development and operation of supporting services, facilities, and policies.

CONCLUSIONS

Lowering the vehicle-occupancy requirement from 3+ to 2+ full time had a detrimental affect on the Busway. At the same time, significant improvements were not realized in the general-purpose freeway lanes. The major negative effects on the Busway and the neutral effects on the general-purpose lanes are highlighted below.

* Morning peak-hour travel speeds in the Busway were reduced from 65 mph to 20 mph in the morning eastbound direction, while travel speeds in the general-purpose lanes decreased from 25 mph to 23 mph for most of the demonstration.

* Morning peak-hour Busway vehicle volumes increased from 1,100 to 1,600 with the 2+ designation, but the number of persons

carried declined from 5,900 to 5,200. The freeway lane vehicle volumes and passengers per lane per hour remained relatively similar.

* Peak-hour travel times increased on the Busway during the 2+ demonstration. Morning peak-period travel times from the eastern end of the corridor increased by 20 to 30 minutes.

* Bus schedule adherence and on-time performance declined significantly. Bus speeds declined from 65 mph to 20 mph during the morning peak hour. The consistent 20-minute travel time savings over vehicles in the general-purpose lanes was lost during the demonstration.

* Foothill Transit experienced declines in service productivity. Extra buses and operators had to be added to maintain service since many bus operators were not able to return for a second trip due to the delays experienced in the lane. As many as 10 extra buses and operators were staged in downtown Los Angeles to help ensure that trips were not missed. The cost of providing these extra buses and operators was approximately $1,250 per day or $150,000 over the course of the demonstration.

* There was no statistically significant increase in accident rates during the 2+ demonstration. An increase in safety incidents, including stop-and-go traffic, cars illegally crossing the double-lines, and improper merging of vehicles into and out of the Busway was reported.

* Bus riders reported significant delays and increased trip times. These delays caused riders to miss connections to other buses and trains, and to be late to work and daycare pick-ups.

* Violation rates declined during the 2+ demonstration. Violation rates increased significantly immediately after the return to the 3+ occupancy requirement during the peak periods. The violation rates declined to a lower pre-demonstration level after a period of heightened enforcement.

For the most part, conditions on the Busway returned to those experienced prior to the 2+ demonstration with the implementation of the 3+ peak and 2+ off-peak requirements. As noted previously, enforcement problems were initially encountered with the operation of the 3+ peak and 2+ off-peak occupancy requirements. The lack of additional enforcement immediately after the change to the variable occupancy requirement appears to have contributed to 2+ carpools continuing to use the Busway during the 3+ restricted period. The extra enforcement conducted by CHP addressed this problem, with violation rates returning to pre-demonstration levels. Bus operations also returned to pre-demonstration conditions with the variable occupancy requirements.

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