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Evaluation of 1984 Los Angeles Summer Olympics Traffic Management

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The contents of this report reflect the views of the authors and not necessarily the views on official policies of the State of California. All errors and omissions are the responsibility of the authors and not of the State of California.

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Although many people contributed to the virtues of this report, any errors or omissions are the responsibility of the authors.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This report presents the results of an evaluation of the Transportation System Management plan employed during the 1984 Los Angeles Summer Olympics. The Summer Olympics presented Los Angeles area transportation planners with an unprecedented challenge: to manage the circulation of an expected 1.2 million visitors, 6 million spectators, and nearly 25,000 athletes, media, and Olympic family within a regional transportation system which had reached capacity in many areas. Owing to the lack of both funds and time, capital improvements to meet the anticipated increase were not feasible. Rather, Los Angeles transportation planners had no choice but to develop and implement the most ambitious transportation management program ever attempted.

Caltrans District 7, in conjunction with several local transportation agencies and the Los Angeles Olympics Organizing Committee, invested two years of effort in the development of a viable and effective traffic management plan for the 1984 Summer Olympics. From a traffic management perspective, the Los Angeles Summer Olympics were an unqualified success. With few exceptions, major traffic problems failed to materialize, and, for the first time in the recent history of the Olympics, not one group of spectators got stranded and missed an event.

The Los Angeles Olympics provided a unique opportunity to test the effectiveness of transportation system management under extreme conditions. The apparent success of the experiment merits close analysis, both in order to identify what worked and what did not, and to determine whether lessons learned from the experience can provide guidelines for future transportation policy decisions.

The research project has three parts. First, a descriptive analysis of highway system performance was conducted. Traffic volumes, congestion, truck traffic, vehicle occupancy, and traffic accidents were investigated. Results of the analysis may be summarized as follows. The available data indicate that very little change in traffic volumes and congestion occurred outside the downtown Los Angeles/Coliseum area. The most visible changes occurred on the Harbor Freeway (I-110), the north-south freeway which leads directly into the downtown area. Public attention was focused on this area, and a one-way street couplet implemented during the Olympics provided an alternate route through the area. Outside the major venue areas, no significant changes in traffic patterns were observed.

Truck traffic was evaluated on the basis of visual counts at selected freeway screenlines. The data showed somewhat lower truck volumes, and a shift away from peak-period/peak-direction flow in the central Los Angeles area. Vehicle occupancy increased slightly during the Olympics, but the increase is attributable to Olympics spectator traffic, rather than a shift in ridesharing behavior by local commuters. Accident patterns were mixed during the Olympics. Total accidents in the central Los Angeles area decreased, and the drop was likely due to lower traffic volumes, particularly during the first week of the Olympics. A number of major accidents occurred; however, they occurred primarily at non-critical times and locations. When location was critical, response was extremely efficient, and consequently no extensive periods of delay were encountered.

The second part of this research is an analysis of commuter travel behavior during the Olympics. The analysis is based on a survey of employees at four downtown Los Angeles work sites. The survey was designed to examine all aspects of work trip travel during the Olympics, and to determine how Olympics travel compared to normal conditions. Travel times, mode choice, work schedules, absences from work, and route choice were investigated. The survey indicated that commuters made many adjustments in response to the Olympics. The most frequent change was in work attendance: vacations, the modified work week, working at an alternate work place closer to home, and company holidays increased the absence rate during the Olympics.

Scheduling of the work trip also changed, with 23 percent leaving for work earlier than usual and 12 percent leaving later than usual. Favorable traffic conditions were reflected in a reduction of average travel time during the Olympics. Shorter travel times were realized both by those who shifted their work trip schedule and by those who did not. Changes in work attendance and trip scheduling were made possible by greater flexibility on the part of employers during the Olympics and by detailed information on alternate commute options provided by local transportation agencies.

The survey also showed that changes in mode choice during the Olympics were site specific. Carpooling was strongly encouraged at one worksite, and nearly doubled as a result. At another site, the modified work week was encouraged. Temporary shifts to the modified work week resulted in a large decrease in carpooling and transit use. None of these changes were retained after the Olympics.

The third and final part of this research is a simulation study of traffic conditions during the Olympics. The purpose of the simulation study was to evaluate the effectiveness of specific elements of the TSM program. By manipulating transportation system supply and demand characteristics, the impact of individual program elements were simulated. The downtown/Coliseum area was selected as the study site for the modeling analysis.

The simulation study showed that changes in travel behavior had far more impact on traffic conditions than the changes made to increase capacity in the area (one-way streets, ramp metering, and synchronized signals). Changes which reduced total vehicle trips, namely reductions in work related and non-work related travel, were very effective. Flexible work hours were somewhat less effective. The scheduling of major Olympics events outside of peak traffic periods, and spectator use of the special transit services had the greatest impact in the case study area. The simulation study results show that changes in travel behavior were largely responsible for the favorable traffic conditions experienced during the Olympics.

Despite the success of the Olympics, however, it cannot be concluded that the same strategies could be implemented and result in the same outcome under normal conditions. Behavioral changes which occurred during the Olympics were unique and short term. They reflect decisions made to cope with short-term problems. The institutional environment in which the Olympics TSM plan was developed and implemented was also unique. There was a high level of consensus on the nature of the problem to be solved and on the feasible solutions available. Furthermore, potentially controversial strategies could be implemented because of the temporary nature of the problem.

The Olympics experience demonstrated that transportation system management works, and that the tools for managing traffic exist. The Olympics TSM program was successful because there were sufficient temporary incentives for changes in travel behavior to take place. The policy challenge is to identify sufficient long-term incentives for change.

CHAPTER ONE

INTRODUCTION

The Summer Olympics presented Los Angeles area transportation planners with an unprecedented challenge: to manage the circulation of an expected 1.2 million visitors, 6 million spectators, and nearly 25,000 athletes, media, and Olympic family within a regional transportation system which had reached capacity in many areas. Owing to the lack of both funds and time, capital improvements to meet the anticipated increase were not feasible. Rather, Los Angeles transportation planners had no choice but to develop and implement the most ambitious transportation management program ever attempted.

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The Los Angeles Olympics provided a unique opportunity to test the effectiveness of transportation system management under extreme conditions. The apparent success of the experiment merits close analysis, both in order to identify what worked and what did not, and to determine whether lessons learned from the experience can provide guidelines for future transportation policy decisions.

This report presents the results of an evaluation of Olympics transportation system management program. While this report focuses on the activities of Caltrans, it is not possible to isolate the role of any single agency in the TSM program. This research is based on the broader questions of what happened and how the specific strategies employed contributed to the favorable conditions experienced during the Olympics.

1.1 ORGANIZATION OF THIS REPORT

The report is organized as follows. The remainder of this chapter describes the Caltrans TSM program, its objectives and the strategies used to achieve them. Chapter Two discusses highway system performance during the Olympics.* Traffic volumes, truck traffic, vehicle occupancy, and traffic incidents are compared to non-Olympics conditions. Chapter Three presents results of a downtown employee travel survey conducted in order to document work trip travel behavior during the Olympics. The data discussed in Chapters Two and Three were also used in a traffic simulation study. Its purpose was to identify the impact of specific changes in travel behavior and transportation system supply characteristics on system performance. The case study area selected for the simulation was the downtown/Coliseum area. The simulation study approach and the modeling system used in the simulation is described in Chapter Four. Chapter Five describes the case study data and calibration procedures, and Chapter Six presents case study results. Finally,

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* A more detailed review of highway system performance was presented in a preliminary report entitled, "Olympics Transportation System Management Performance Analysis," Institute of Transportation Studies, University of California, Irvine, March 1985.

Chapter Seven presents a summary of the research results and a discussion of their policy implications.

1.2 THE CALTRANS TSM PROGRAM

The Caltrans TSM program was part of a larger program developed and implemented through the cooperative efforts of the California Department of Transportation (Caltrans), the Los Angeles City Department of Transportation (LADOT), the Southern California Rapid Transit District (SCRTD), the Los Angeles Olympics Organizing Committee (LAOOC), Commuter Computer, the California Highway Patrol (CHP), and the Los Angeles City Police Department (LAPD), as well as several cities and counties in the greater Los Angeles area. The TSM program had a dual focus: to facilitate circulation at all 24 venues and to maintain the regional transportation system at an acceptable level of performance during the Olympics. In other words, the objective was to get everyone to and from Olympics events while at the same time allowing normal daily travel to proceed with as little extra congestion as possible.

The plan developed by Caltrans and other agencies included a wide variety of TSM measures. In addition to specific circulation plans for each venue site and a more intensive use of traditional traffic management techniques (e.g., signal synchronization, ramp metering), several innovative strategies were implemented. These included the establishment of an interagency coordination center; a public relations program aimed at informing commuters, businesses, and visitors about expected travel conditions during the Olympics; a joint CHP/Caltrans program to reduce truck traffic during peak hours; a massive system surveillance and monitoring program; and a stepped-up public information program. Together, these measures formed the most comprehensive TSM program ever implemented.

The primary goal of the Caltrans TSM program was that of system balancing: matching system supply (capacity) and demand while achieving an acceptable level of system performance. Given that the regional freeway system operates at capacity in many areas under normal conditions, the management task was a challenging one. To make matters worse, Olympic Villages and major venue sites, the Coliseum complex and UCLA, were located in two of the most congested areas of the region.

Implicit in the concept of system balancing is the management of both travel demand and capacity supply. Travel demand can be managed by shifting trips to less congested routes and/or time periods, by increasing vehicle occupancy, or by reducing the total number of trips. Capacity can be enhanced by increasing the efficiency of traffic flow, by providing extra capacity in bottleneck areas, and by eliminating delay-causing obstructions. Thus demand management refers to behavioral adjustments on the part of travelers, while capacity management refers to the physical characteristics of the transportation system. Elements of all of these methods, as well as many others, were utilized in the TSM program.

The Caltrans program can be described in terms of two objectives: 1) Minimize traffic congestion and delay, and 2) Maximize system person throughput. The first objective refers to achieving system balance as discussed above. The second objective combines demand and supply management by expressing capacity in terms of person-trips. To the extent that some trips are shifted away from peak periods, for example, person throughput (measured on a daily basis), will increase. In the same way, ramp metering and other traffic flow techniques will also increase the system's person-trip capacity. Each of these objectives is composed of several more specific sub-objectives, as presented in Table 1-1. The actual TSM methods or strategies developed by Caltrans were aimed at achieving these objectives.

TABLE 1-1

CALTRANS TSM PROGRAM OBJECTIVES

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1. Minimize traffic congestion and delay.

    a. Reduce venue-related traffic congestion.

    b. Reduce congestion related to non-recurrent traffic events.

    c. Minimize impact of venue-related freeway closures.

    d. Reduce peak period (recurrent, work-trip related) traffic congestion.

2. Maximize system person through-put.

    a. Increase efficiency of traffic flow.

    b. Balance daily traffic volumes.

    c. Maximize roadway capacity.

    d. Increase vehicle occupancy.

    e. Promote transit use.

1.2.1. Strategies of the Caltrans TSM Program

Both venue-related and non-venue traffic were of concern to Caltrans. Venue sites with large spectator capacity, especially when located in normally congested areas, were of particular concern. A series of strategies emerged, some of them specific to venue or non-venue situations; others of general application. The major strategies and their related objectives are summarized in Table 1-2.

It may be noted that Caltrans' implementing responsibility was limited to the freeway system and a few segments of conventional highway. However, Caltrans participated extensively in the planning and development of the complete TSM program. Some of the strategies described below were joint efforts; others were exclusively Caltrans' efforts. Strategies are included here if 1) Caltrans had a major role in the planning effort, and 2) they are relevant to performance of the freeway system.

1.2.1.1. Venue Site Traffic Management

Olympic events took place at 24 different venues located throughout the Los Angeles region. A total of 18 traffic management plans encompassing the 24 venues were developed. These plans were based on event requirements and local conditions. The traffic management plans included preferred spectator routes, bus priority streets and ramps, one-way streets, parking provisions, signing, traffic officer placement, signal timing, and other traffic management techniques as deemed necessary at each site. The Coliseum and Westwood areas were singled out for particularly intensive traffic management plans because of their location and the large number of spectators anticipated.

TABLE 1-2

CALTRANS TSM PROGRAM STRATEGIES

Strategy	Description	Related Objectives
Venue Site Traffic Management	Venue site circulation and parking plans; bus access plans; ramp metering closures	Venue Site Traffic Congestion; Traffic Flow; Transit Use
Venue Site (Spectator) Public Information	Route signage; media programs; marketing of bus patronage and ridesharing	Venue Site Traffic Congestion; Traffic Flow; Vehicle Occupancy; Transit Use
Freeway Closure Management	Provision of alternate routes, media information	Impact of Venue-Related Freeway Closures
Public Information for Commuters, Businesses, Shippers	Marketing of ridesharing, transit, and alternative work hours; media information on daily events; traffic congestion reports; traffic information media service; freeway traffic condition maps	Peak Period Traffic Congestion; Non-Recurrent Traffic Event Congestion; Balance Traffic Volumes; Vehicle Occupancy Transit Use
System Traffic Management	Ramp metering; removal of construction and maintenance activities; use of auxiliary lanes and shoulders for through traffic; truck diversion program; changeable message signs	Traffic Flow; Peak Period Congestion; Roadway Capacity
System Monitoring and Surveillance	Traffic Coordination Center, Traffic Operations Center, CCTV, aerial and field surveillance teams; MITMT; computerized electronic surveillance	Non-Recurrent Event; Venue-Related Traffic Congestion; Peak Period Traffic Congestion; Traffic Flow

The Coliseum area plan, for example, was based on a severe parking constraint. It was determined that 65 percent of the spectators would have to use bus service due to the lack of parking for private vehicles. Bus-only freeway ramps (off the Harbor Freeway (I-110) at Martin Luther King Blvd. and off the Santa Monica Freeway (I-10) at Vermont) and arterial traffic lanes were established. Spectator routes were devised to distribute spectator traffic along several alternate access/egress arterial routes. Ramp metering in the area was adjusted to coincide with anticipated spectator traffic.

1.2.1.2. Venue Site Public Information

An intensive public information program was employed before and during the Olympics to inform the public on how best to access event sites. The centerpiece of this program was a set of maps and guidelines, "Summer Games Spectator Routes," generated by Caltrans in cooperation with LADOT and the LAOOC. This information was distributed to the public, mailed to ticketholders by the LAOOC, and later published in local newspapers. The packet gave specific instructions on auto access and parking, transit services, and travel information sources. Special signs, Olympics Venue Guide Signs, were employed to mark spectator routes, guiding the spectator from the freeway to the designated parking areas. Twice-daily media reports (press conferences) provided route and daily traffic information. Event schedules and locations were also provided daily. In addition, an intensive marketing campaign to encourage transit use to the major event sites was employed. All of these efforts were directed at "getting the word out" so that the traffic management plans could be successfully implemented.

1.2.1.3. Freeway Closure Management

Freeways were closed on six separate occasions (all during weekends) for cycling and marathon practices and events. The most significant was the closure of 17 miles of SR-91. Diversion plans and signed detours, as well as public announcements in media and press, were employed to manage these closures.

1.2.1.4. Public Information for Commuters, Businesses, and Shippers

A particular concern for Los Angeles area transportation planners was the integration of the Olympics traffic with regular commuter traffic. Under normal conditions, freeways in the downtown, Westwood, and South Bay areas regularly experience several hours of congestion during peak periods. In some cases, Olympic events traffic was expected overlap with the peak period in these areas. Therefore, in addition to managing spectator traffic, planners wanted to mitigate the congestion caused by commuter traffic.

An intensive public information campaign was launched to inform the public of anticipated congestion problems and to promote shifts in mode choice, work hours, and work days. Caltrans produced "The Olympic Traffic Picture," a set of maps depicting expected systemwide freeway traffic conditions for Coliseum event days, non-Coliseum events days, and weekends. Maps were produced for 8 AM, 11 AM, 3 PM, and 6 PM, indicating areas where congestion was expected to occur. These maps were based on the assumption that no changes in travel demand or travel patterns would occur.

The map packet, traffic management plans and other information was used by Commuter Computer, the local ridesharing agency, to produce a packet of Olympic commuter traffic information. This packet was distributed to businesses throughout the area, and was made available to local agencies and the media. It contained site-specific information on expected congestion, possible work-hour alternatives, and suggested routes for commercial traffic. Caltrans also distributed a similar packet.

Certain days, e.g., August 3, were identified as being particularly problematic. Employers were encouraged to shift work hours, shift to a four-day work week, give extra days off and observe Admission Day on August 6 in order to lessen commute traffic on these days. Businesses were encouraged to change operating hours and adjust delivery schedules. In addition, a lot of publicity on expected traffic problems was provided by the press.

Traffic information was provided throughout the Olympics period via twice-daily press conferences and traffic reports issued by the Caltrans District Traffic Operations Center (TOC) every 15 minutes throughout the day. These reports were made available to the media. Several radio stations increased the frequency of traffic reporting and reported throughout the day. These efforts provided commuters and other travelers with timely and accurate traffic information. In addition, traffic status telephone hotlines were available to the public.

1.2.1.5. System Traffic Management

In addition to persuading businesses and commuters to adjust travel behavior, several traffic management techniques were employed to increase the carrying capacity of the road system. First, ramp metering was intensified on those freeways leading to and through the Westwood and

Coliseum/downtown areas. Specifically, all-day ramp metering was employed on I-110, I-10, I-5 (Santa Ana Freeway) in the Coliseum/downtown area and on I-10 and I-405 (San Diego Freeway) in the Westwood area. Ramp metering was intensified on SR-101 and SR-170 (the Hollywood/Ventura Freeways) as well. Second, all non-emergency construction and maintenance work was halted. In addition, peak-hour only shoulder traffic lanes on I-5 were made available all day. The intent here was not only to make all roadway capacity available, but also to avoid delay caused by gawking.

A third effort was the truck diversion program, Operation Breezeway, developed and implemented by CHP and Caltrans. Operation Breezeway was primarily a marketing campaign aimed at the trucking industry. Its purpose was to divert truck traffic from highly congested areas during peak hours. Truckers were asked to avoid peak-hour travel on the freeways, and to shift deliveries to non-peak periods. The program depended on industry cooperation, as no enforcement authority was associated with the program.

A fourth component of the traffic management program was the use of changeable message signs (CMS) to inform motorists of problem locations, congestion, and alternate travel routes. CMS are routinely used in Caltrans operations. The Olympics effort was a more comprehensive and responsive use of the equipment to provide timely information to motorists whenever necessary.

1.2.1.6. Field Surveillance

Caltrans devoted significant effort to field surveillance capabilities during the Olympics in order to increase its ability to monitor the system and respond to non-recurrent events. The Traffic Operations Center (TOC) is the focus of system surveillance. Electronic sensors embedded in the freeway system roadway are connected to a computer in the TOC. Traffic flow information is transmitted on a continuous basis to the TOC enabling constant monitoring of approximately 200 miles of the freeway system. In areas where electronic surveillance was lacking, field observers with radios were stationed at strategic points. Additional monitoring capability was provided by closed-circuit TV on I-10 from I-405 to I-110, at the four-level interchange, the East LA interchange, and the SR-101 spur. Helicopters, as well as Caltrans and CHP field teams, were also employed. Taken together, these efforts provided continuous and timely information on the entire freeway system, with the highest level of information provided for the central area of the region. This enabled rapid detection, verification, and response to traffic problems.

A second element of surveillance was the Traffic Coordination Center (TCC), a traffic monitoring center developed expressly for the Olympics to provide a mechanism for interagency communication and coordination. Located in the Caltrans District 7 office, the TCC operated 24 hours per day, and was manned by representatives of several transportation and law enforcement agencies. Traffic information was transmitted from the TOC to the TCC. Information from CHP, LAPD, LADOT, SCRTD, and LAOOC was also available. Closed-circuit TV provided monitoring capability of the Coliseum area venues, as well as portions of the freeway system. The purpose of the TCC was to coordinate decision making and to be able to respond quickly to any emergency situation.

1.2.1.7. Major Incident Traffic Management Team

The Major Incident Traffic Management Team (MITMT) is a Caltrans operational unit organized to respond to major incidents (defined as any unpredictable condition which severely reduces the capacity of the highway system). The MITMT is always available, and is prepared to respond to major incidents. The MITMT made special preparations for the Olympics. Rehearsals of response to major incidents were conducted prior the Olympics, in order to be well prepared for possible emergency situations. Team members participated in venue traffic management and freeway closures.

1.2.2 Summary

The Olympics TSM program was composed of a broad spectrum of management strategies. Every opportunity for marginally affecting traffic flow was exploited. In addition to exploiting all possible means for improving traffic flow, a highly intensive effort to control travel demand, both spectator and non-spectator, was made as well. The following chapters describe the results of these efforts.

CHAPTER TWO

SYSTEM PERFORMANCE

This chapter describes the performance of the highway system during the Olympics. The following issues are discussed: traffic volumes and congestion, truck traffic, vehicle occupancy, and traffic incidents.

2.1 TRAFFIC VOLUMES AND CONGESTION

One of the most notable aspects of the Olympics was the apparent lack of congestion on the freeway system. Commuters in the central Los Angeles and Westside areas found that the trip to and from work took less time than usual. No major traffic jams were reported around large venue sites until late in the second week, when traffic problems surfaced near the Rose Bowl area. National news services, poised to observe imminent "gridlock," issued surprised reports of free flowing traffic.

The comparison of traffic flow conditions during the Olympics with normal (non-Olympics) conditions was constrained by data availability. Only limited baseline data were available: one week of observations from two weeks after the Olympics on the 42-mile loop (the loop formed by I-10, I-110, and I-405), and one or two non-Olympics days for a variety of screenlines from the Caltrans MODCOMP system data. Because of the variability of daily traffic volumes, the baseline data were not sufficient for statistically meaningful comparisons. In addition, many of the 42-mile loop counters are inoperable. For these reasons, VMT could not be estimated, and consequently it was not possible to estimate delay. Screenline speeds were used as a surrogate measure of congestion.

2.1.1. Traffic Volumes

Traffic volumes and speeds were compared at selected screenlines: two on I-110 (Harbor Freeway), two on I-10 (Santa Monica Freeway), one on SR-101 (Hollywood Freeway) and one on SR-91 (Artesia Freeway). Figure 2-1 shows the location of the screenlines with respect to the downtown/Coliseum area. Traffic volumes and speeds were compared by day of week and time of day.

The screenline data indicate that there was a great deal of variation in traffic volumes and patterns from day to day and between different areas. The I-110 screenlines showed much greater change than the I-10 screenlines, implying that response to the Olympics was highly localized. Table 2-1 gives daily traffic volumes for the El Segundo and Century screenlines on the Harbor Freeway. These are one-way volumes in

TABLE 2-1

DAILY 24-HOUR VOLUMES, I-110 SCREENLINES AT EL SEGUNDO AND CENTURY, ONE-WAY NB

Screenline	Day of Week				
El Segundo	Monday	Tuesday	Wednesday	Thursday	Friday
Olympics	90,040	87,389	91,383	90,296	94,688
Non-Olympics	79,501	84,608	85,694	86,438	90,978
Difference	+13.6%	+3.3%	+6.6%	+4.5%	+4.0%
Century					
Olympics	80,497	78,530	82,016	82,045	84,116
Non-Olympics	100,147	106,111	107,142	91,717	116,919
Difference	-19.6%	-26.0%	-23.4%	-10.5%	-28.0%

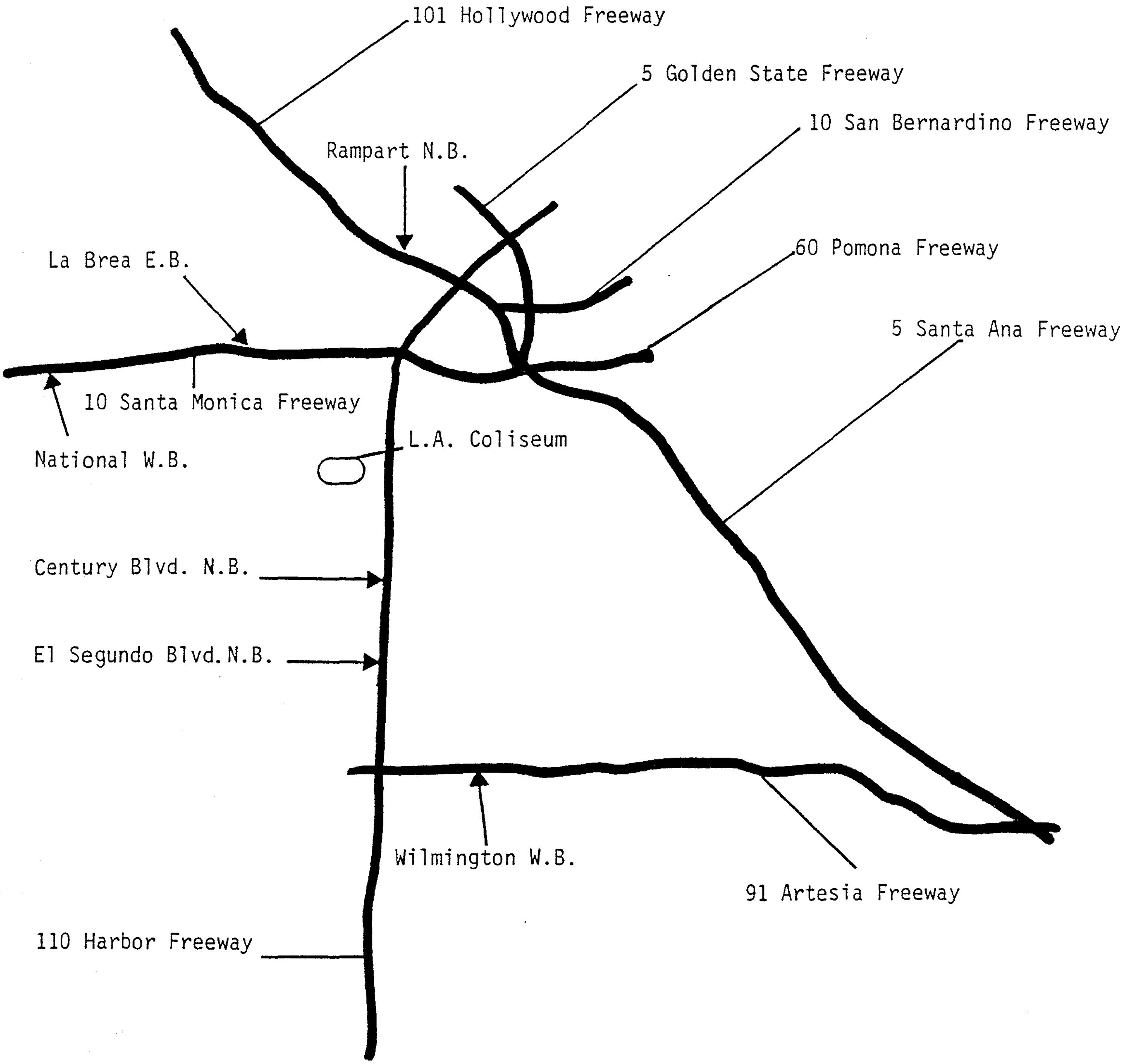

FIGURE 2-1: LOCATION OF TRAFFIC VOLUME SCREENLINES

the northbound direction. While ADT was higher every day during the Olympics at El Segundo, just the opposite occurred at Century.

Motorists apparently avoided the Harbor Freeway near the Coliseum area and switched to surface street routes. The lowest Olympics volume occurred on Tuesday, August 7 at both screenlines, the only non-Coliseum event day of this week. Not unexpectedly, the highest volume occurs on Friday for both Olympics and non-Olympics.

Daily shifts in travel behavior are illustrated in Figures 2-2 through 2-4, which show half-hourly volumes for the AM peak at the El Segundo screenline. Monday (Figure 2-2), a Coliseum event day, shows an earlier start of the peak and higher volumes in the last hour. Tuesday (Figure 2-3) shows lower volumes overall and a later start of the peak. The Thursday pattern (Figure 2-4) is almost identical to the non-Olympics until the last hour, when volumes are again higher.

These patterns might be interpreted as follows. Monday commuters, expecting the worst because this is just the second weekday that Coliseum events are scheduled, start off to work early to avoid spectator traffic. On Tuesday, commuters return to approximately their regular pattern since there are no Coliseum events. By Thursday, commuters have learned that the Coliseum spectator traffic does not seriously affect their commute, and they return to a normal pattern.

Traffic volume changes during the Olympics were less evident on I-10. It is one of the most heavily traveled freeways in the region, and operates near capacity all day. It links two major activity centers, the Westwood area and downtown, and parallels the Wilshire corridor, the region's highest density corridor. Daily 24-hour volumes for the La Brea and National Blvd. screenlines are given in Table 2-2. Both are one-way

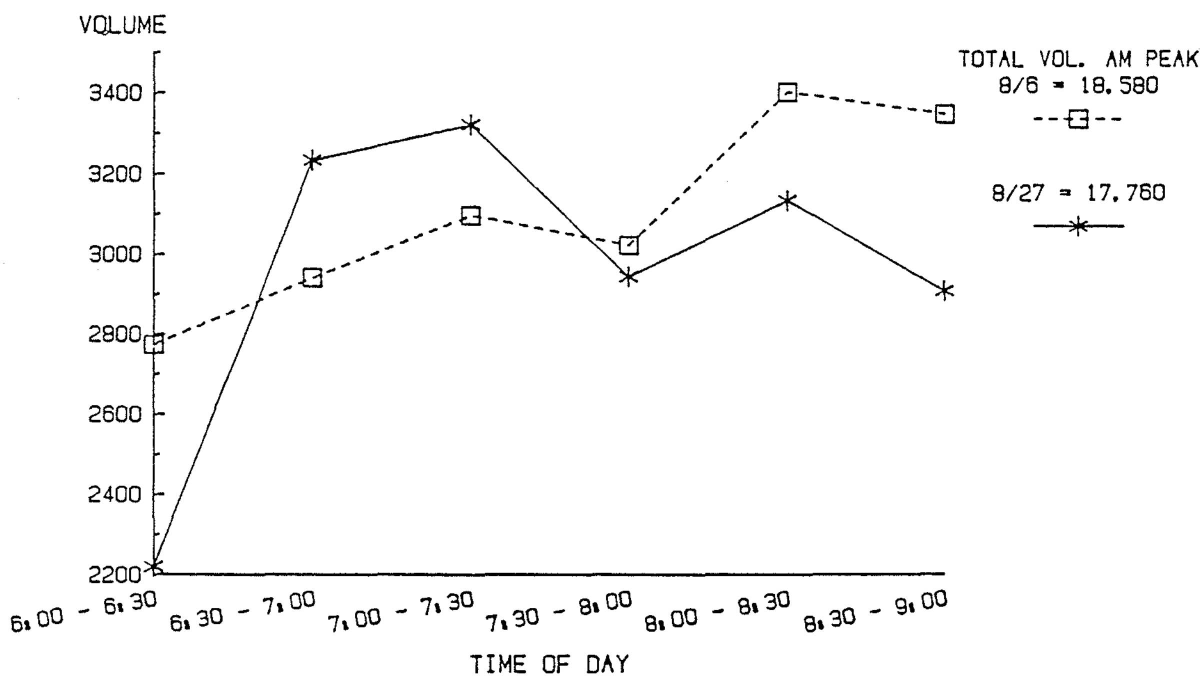

FIGURE 2-2: HARBOR FREEWAY (110) NB AT EL SEGUNDO, AM PEAK VOLUMES, MONDAY

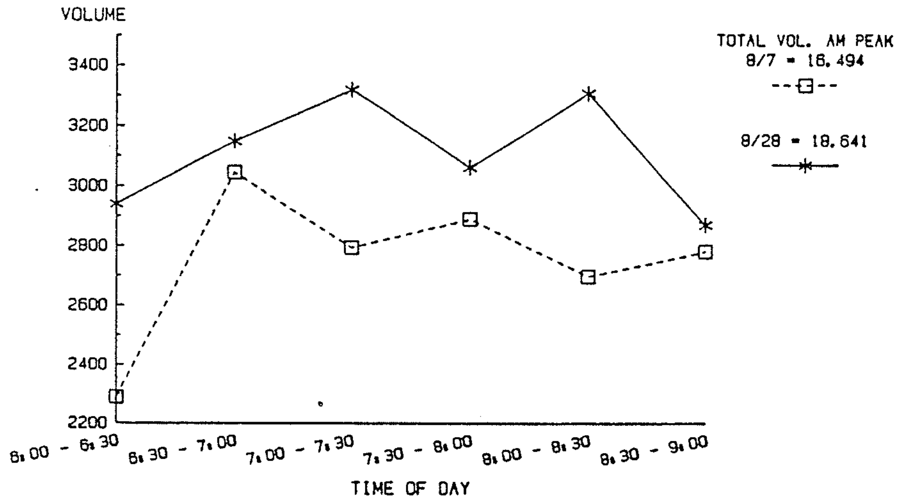

FIGURE 2-3: HARBOR FREEWAY (110) NB AT EL SEGUNDO, AM PEAK VOLUMES, TUESDAY

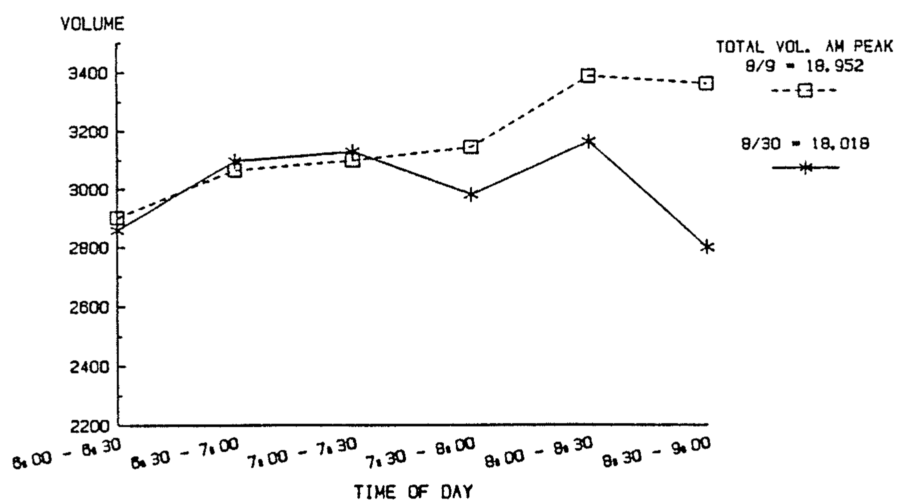

FIGURE 2-4: HARBOR FREEWAY (110) NB AT EL SEGUNDO, AM PEAK VOLUMES, THURSDAY

TABLE 2-2

DAILY ONE-WAY 24-HOUR VOLUMES FOR I-10 AT LA BREA AND NATIONAL BLVD.

Screenline	Day of Week				
	Monday	Tuesday	Wednesday	Thursday	Friday
La Brea (EB)					
Olympics	113,462	133,141	142,198	145,943	147,345
Non-Olympics	135,684	136,726	142,601	142,838	145,985
Difference	-16.4%	-2.6%	under 1%	+2.1%	under 1%
National Blvd. (WB)					
Olympics	124,823	124,375	126,393	129,405	131,336
Non-Olympics	117,148	121,604	122,412	125,167	116,203
Difference	+6.6%	+2.3%	+3.3%	+3.4%	+13.0%

volumes; La Brea is eastbound and National is westbound. With the exception of Monday, La Brea traffic volumes were unchanged during the Olympics. The National Blvd. screenline showed slightly higher daily volumes during the Olympics.

Because of its location between two major venues (Coliseum area and Westwood area), spectator traffic probably made up a substantial portion of the Santa Monica Freeway traffic volumes on Olympic days. However, it is not possible to trace the influence of a specific venue (even the Coliseum), because of the number of events and different times they were scheduled.[1] Evidence from the downtown employee survey data (Chapter 3)

[1] Attendance at nine westside and central Los Angeles area venues was 235,320 on August 6, 93,730 on August 7, and 196,480 on August 9.

indicates that Monday and Friday of both Olympics weeks had the highest employee absence rates, suggesting that commuter trips were replaced by Olympics trips on this facility.

Examples of hourly traffic volume patterns are given for the National Blvd. screenline in Figures 2-5 (Monday) and 2-6 (Tuesday). Traffic volumes during this time period are the same for Olympics and non-Olympics. A slight drop in AM peak volumes is offset by slightly higher day and PM peak volumes. Closer inspection of the AM peak volumes revealed that the only consistent change in pattern during the Olympics was a drop in late peak (8 to 9 AM) traffic. Figures 2-5 and 2-6 also illustrate the heavy use of this freeway: traffic volumes never drop below about 6000 vehicles per hour between 6 AM and 8 PM, or about 1500 vehicles per lane per hour. Since the 24-hour volumes were slightly higher during the Olympics, nighttime traffic also increased in this area during the Olympics.

Similar traffic patterns were observed at other screenline locations. Figure 2-7 gives one-way hourly volumes for SR-101 (Hollywood Freeway) at Rampart. Total volumes are the same; a slight drop in AM peak traffic is offset by slightly higher PM traffic. It should be noted that the screenline is northbound (outbound with respect to downtown), so the PM peak is predominant. Sufficient data were not available to determine whether this pattern occurred on other Olympic days.

Figure 2-8 gives one-way westbound hourly volumes, 5 AM to 12 PM, for SR-91. In this case data were available for both Olympics Wednesdays. Again total volumes are approximately equal. Traffic volumes were higher in the 7 AM to 8 AM period during the Olympics, perhaps indicating some shifts in work trip schedules.

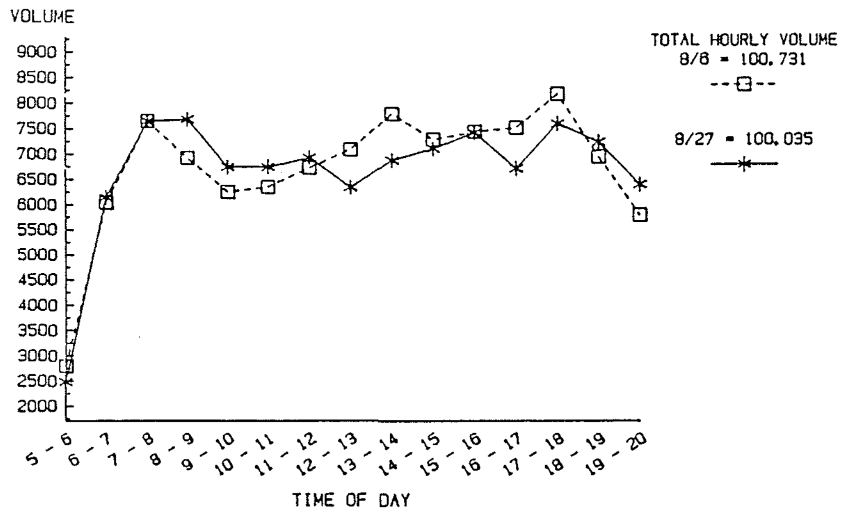

FIGURE 2-5: SANTA MONICA FREEWAY (10) WB AT NATIONAL, HOURLY VOLUMES, MONDAY

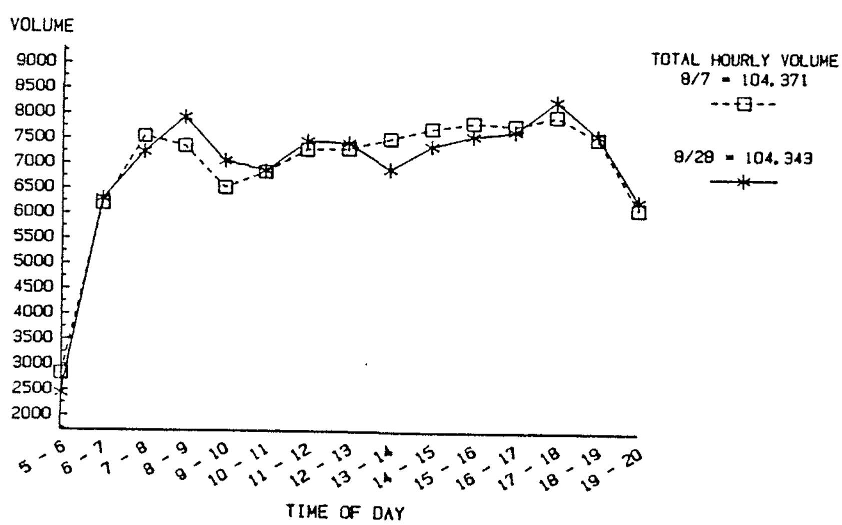

FIGURE 2-6: SANTA MONICA FREEWAY (10) WB AT NATIONAL, HOURLY VOLUMES, TUESDAY

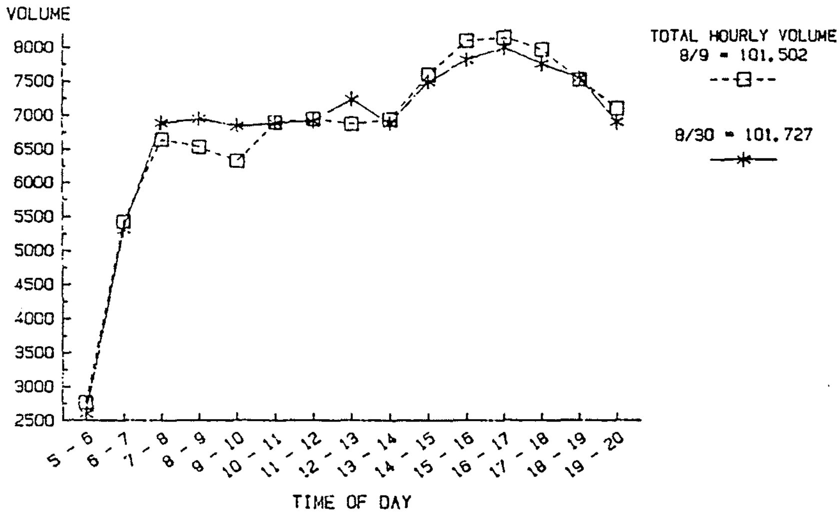

FIGURE 2-7: HOLLYWOOD FREEWAY (101) NB AT RAMPART, HOURLY VOLUMES, THURSDAY

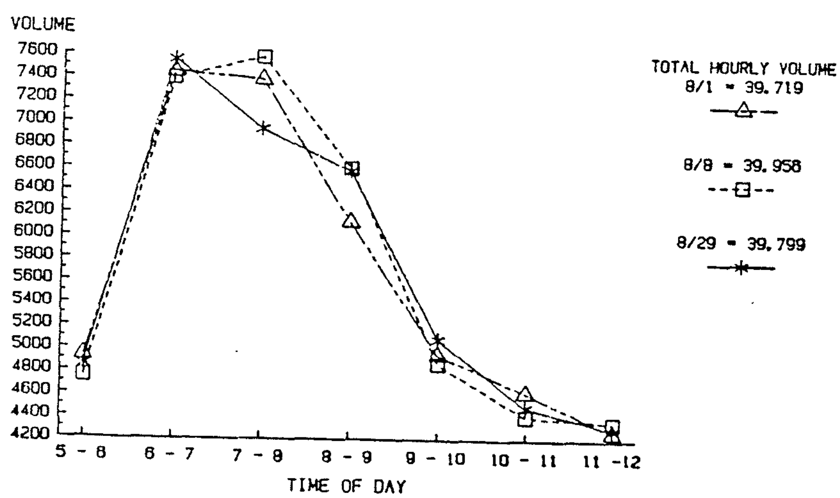

FIGURE 2-8: ARTESIA FREEWAY (91) WB AT WILMINGTON, HOURLY VOLUMES, WEDNESDAY

The preliminary analysis performed by Caltrans indicated that traffic volumes during the weekdays of the second Olympics week were 3 to 5 percent higher than normal. This estimate was based on a summer 1983 baseline. Using the available screenline data, comparisons with a summer 1984 baseline showed a 2 to 5 percent decrease in traffic volumes during the Olympics. Comparison of the 1983 and 1984 data indicated an increase of about 8 percent in daily traffic volumes over the period; so the two results are quite consistent. However, insufficient data were available to determine whether traffic volumes during the Olympics were significantly different from normal summer conditions.

2.1.2. Traffic Congestion

Turning now to the issue of congestion, there was a widespread perception that congestion was much less severe during the Olympics. The Caltrans preliminary analysis concluded that congestion never reached normal levels, even when traffic volumes climbed towards the end of the Olympic period. Using speed as an indicator of congestion, Table 2-3 gives the duration of estimated speeds of less than 45 MPH for Monday, Tuesday, and Thursday at each of the four screenlines, Olympics and Non-Olympics. Estimates of speeds less than 25 MPH, an indicator of heavy congestion, are given for the Century and La Brea screenlines. The National and El Segundo screenlines had no occurrences of speeds less than 25 MPH. Note that the long and uneven durations of less than 45 MPH speeds at La Brea are characteristic of near-capacity conditions. Comparing first the two different speeds, the data indicate that movement is always in the same direction (e.g., differences are consistent), and the 25 MPH measure tends to be associated with larger differences than the 45 MPH measure. This implies that where congestion was down, heavy congestion was down by a larger proportion than moderate congestion. Where congestion was up, heavy congestion increased less than moderate congestion.

TABLE 2-3

DURATION OF ESTIMATED SPEEDS BY DAY AND SCREENLINE, IN HOURS

	Monday		Tuesday		Thursday	
	under 45 MPH	under 25 MPH	under 45 MPH	under 25 MPH	under 45 MPH	under 25 MPH
I-110/El Segundo						
Olympics	.50		.50		.25	
Non-Olympics	0		0		.75	
Difference	large +		large +		-67%	
I-110/Century						
Olympics	2.25	1.25	1.25	.75	.75	0
Non-Olympics	3.50	3.25	3.00	2.25	2.25	1.25
Difference	-36%	-62%	-58%	-66%	-66%	large -
I-10/La Brea						
Olympics	5.75	4.75	5.25	4.50	5.50	4.50
Non-Olympics	4.25	N/A	6.50	6.25	3.25	3.00
Difference	+35%		-19%	-28%	+69%	+50%
I-10/National						
Olympics	.25		1.50		.75	
Non-Olympics	1.00		1.25		.75	
Difference	-75%		+20%		0	

For the twelve observations in Table 2-3, the speed estimates show that congestion was lower in six cases, higher in five, and unchanged in one. The direction of change is consistent only for the I-110/Century screenline, where traffic volumes were significantly lower during the Olympics.

The duration of estimated speeds was measured over the entire day, rather than during the peak period. It may be argued that this is not correct, because congestion is really a peak-period problem, and changes in traffic volumes and speeds which occur during the off peak are not relevant. If a screenline operates well below capacity most of the day, then large changes in volume could occur with no change in peak traffic conditions. That is, the additional traffic could be accommodated in the non-peak periods, and have no effect on peak traffic or on non-peak level of service. As discussed earlier, however, traffic volumes tend to be high throughout the day at these screenlines and thus the entire day is the proper unit of analysis.

Table 2-4 compares changes in ADT with changes in the duration of less than 45 MPH speed for Monday, Tuesday, and Thursday by screenline. The four possible combinations of changes are tabulated at the bottom of the Table. In four cases both volume and less than 45 MPH speed duration went up; in five cases both measures went down. Thus in 9 out of 12 cases, or 75 percent of the time, both volume and congestion (as measured by speed) moved together. Volume and congestion would move in opposite directions only when the highway is over capacity (e.g., on the lower half of the speed/volume curve). The results in Table 2-4 are not surprising. It is to be expected that most of the freeway system operates <u>near</u> but not at or beyond capacity. Further, the results imply that reductions in congestion during the Olympics were largely due to reductions in traffic volumes, rather than shifts in volume patterns.

It also bears noting that these comparisons are based on the second week of the Olympics, when overall volumes were increasing. Caltrans data indicated that traffic volumes and congestion were much lower during the first week of the Olympics.

TABLE 2-4

CHANGES IN TRAFFIC VOLUME AND UNDER 45 MPH SPEED, OLYMPICS VS. NON-OLYMPICS

	Monday	Tuesday	Thursday
I-110/El Segundo			
ADT	+13.6%	+3.3%	+4.5%
Duration of Speed	large +	large +	-67.0%
I-110/Century			
ADT	-19.6%	-26.0%	-10.5%
Duration of Speed	-36.0%	-58.0%	-66.0%
I-10/La Brea			
ADT	-16.4%	-2.6%	+2.1%
Duration of Speed	+35.0%	-19.0%	+69.0%
I-10/National			
ADT	+6.6%	+2.3%	+3.4%
Duration of Speed	-75.0%	+20.0%	0

Less than 45 MPH speed

		up	down
volume	up	4	2
	down	1	5

2.1.3 Conclusions on Traffic Volumes and Congestion

The screenline data indicate that very little change in traffic volumes (and therefore congestion) occurred outside the downtown Los Angeles/Coliseum area. It is not surprising that the most visible changes occurred on the Harbor Freeway. Public attention was focused on the Downtown/Coliseum area, and the Figueroa/Flower one-way streets provided an alternate route through the area. In contrast, the Santa Monica freeway serves a much larger set of destinations. It also regularly operates near capacity most of the day, and consequently only marginal increases in volume were possible.

The limited data available on the Hollywood Freeway (SR-101) shows similar results. The Hollywood Freeway was not expected to be heavily impacted by the Olympics, and, like the Santa Monica Freeway, it serves a high density corridor. Thus, the absence of significant change is to be expected. Finally, the Wilmington area is clearly beyond the Olympics venue area of impact, and once travelers discovered that traffic was no different than normal, there was no incentive for making any changes in travel behavior.

2.2 TRUCK TRAFFIC

Chapter One described the Operation Breezeway program which was aimed at reducing truck traffic during peak periods on both the freeway system and local streets. In order to facilitate truck deliveries during off-peak periods, the City of Los Angeles temporarily withdrew restrictions on night deliveries, and the Teamsters Union agreed to accept regular wage rates for night work. In addition, special legislation was passed to permit certain commodities to be delivered at night. A public information campaign was utilized to persuade the intercity trucking industry to adjust routes and activities to avoid the most congested freeway periods and locations.

Trucks and other large vehicles have an adverse effect on highway capacity because of their size and operating characteristics. In terms of size, one truck is roughly equivalent to two passenger cars. Under congested conditions, trucks probably have more impact because of their limited maneuverability. The purpose of Operation Breezeway was to minimize truck traffic in highly congested areas.

There is very little information available on truck traffic in the Los Angeles area (or in the U.S.), as it is difficult and time consuming to obtain. The electronic vehicle counting system cannot distinguish between different types of vehicles; thus the only way to gather truck data is by visual counts. In order to evaluate the effect of Operation Breezeway, it was therefore necessary to conduct visual counts during and after the Olympics. In order to do so as efficiently as possible, truck counts were incorporated with vehicle occupancy counts already scheduled for selected screenlines. The screenlines included I-110 northbound at 42nd St., I-10 eastbound at 6th Ave. (near Arlington); SR-91 westbound at Lakewood Blvd., and I-5 southbound at Griffith Park (See Figure 2-9). Due to the short start-up time available prior to the Olympics, the non-Olympics comparison data was collected after the Olympics. Comparable weekdays could not be chosen because of manpower scheduling constraints. As a result, the non-Olympics baseline data is not as comparable as the traffic volume data utilized in the previous section.

The truck count data collected with the vehicle occupancy counts are for two hours of the AM peak, from 6:30 to 8:30. In order to obtain

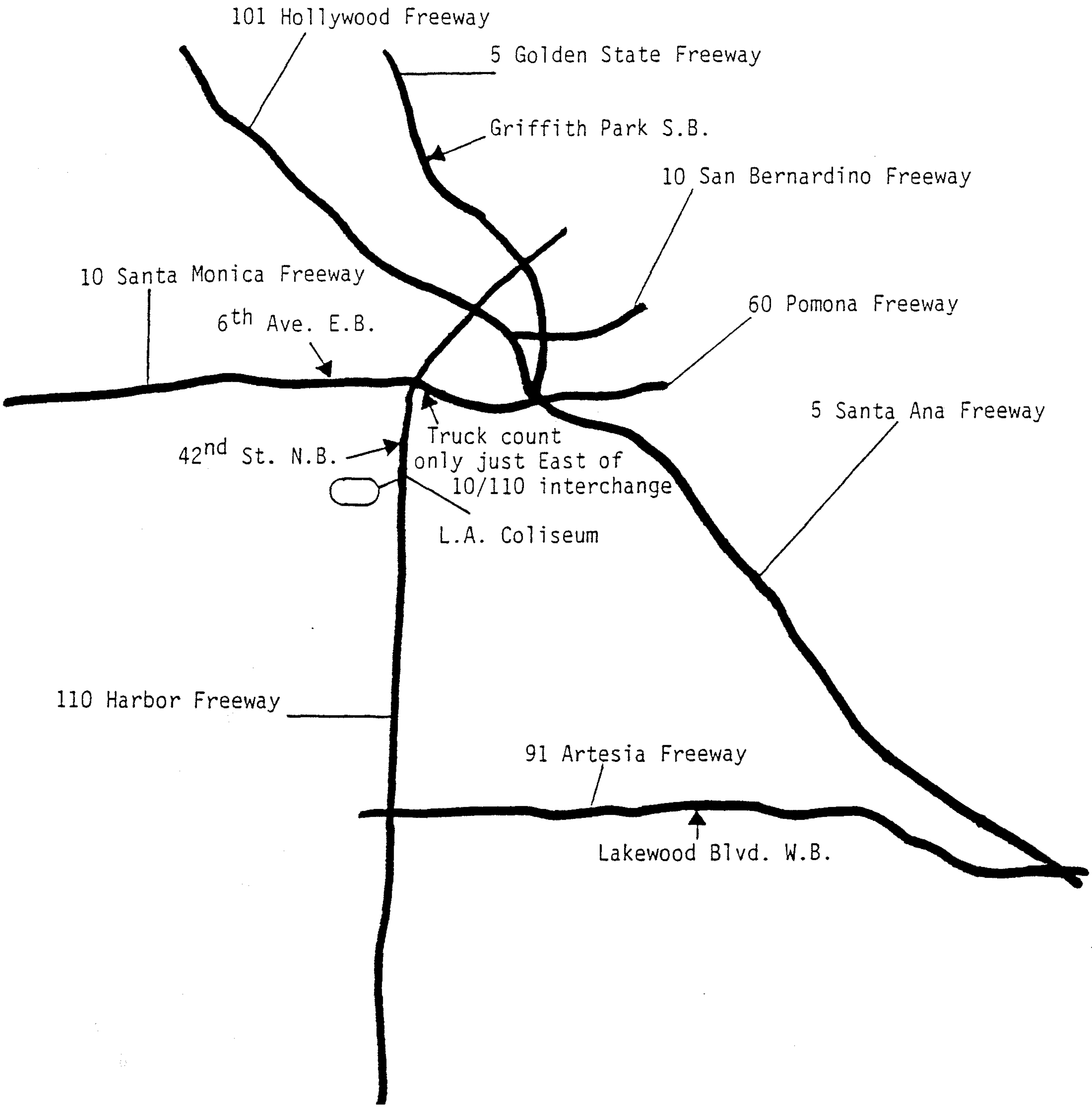

FIGURE 2-9: LOCATION OF TRUCK AND VEHICLE OCCUPANCY COUNTS

daily truck traffic information, CCTV was utilized to videotape daily traffic at I-10 just east of the I-110/I-10 interchange. The CCTV count location is also shown in Figure 2-9. The videotapes were taken on 8/6 (Monday) and 8/30 (Thursday). Visibility allowed a count from 7:30 AM to 7:30 PM.

In all cases, the total number of trucks was counted, but there are some minor differences between the visual counts and the videotape data. The visual counts include all trucks of three or more axles. The count is conducted in 5-minute segments with 1-minute rests. The total count is then factored up to account for the rest periods. The videotape enabled a constant count (since the tape could be stopped). Due to visibility problems, however, it was not possible to make the three-axle distinction, and all trucks were counted.

Table 2-5 presents the results of the visual screenline counts. In three out of four cases, truck volume was lower during the Olympics. The most comparable counts are SR-91 and I-5, since they were taken on the same day of the week. The I-110 count is not too surprising, given the reduction in overall traffic observed near the Coliseum during the Olympics. The I-10 count is probably the least reliable, since it compares an Olympics Monday with a non-Olympics Thursday.

The second part of Table 2-5 gives trucks as a percent of traffic volume. Note that I-5 and SR-91 carry a much larger proportion of trucks than I-110 and I-10. On I-110 and SR-91, truck traffic dropped more than proportionately, while on I-5 the drop was less than proportional. However, none of these changes are statistically significant. On the whole, Table 2-5 indicates that a slight drop in AM-peak, inbound truck traffic occurred during the Olympics.

TABLE 2-5

TRUCK TRAFFIC AT SELECTED SCREENLINES FOR TWO-HOUR AM PEAK

Truck Count	I-110/42nd St.	I-10/6th Ave.	91/Lakewood*	I-5/Griffith Park*
Olympics	188	239	712	720
Non-Olympics	258	174	734	757
Difference	-27%	+37%	-3%	-5%
Trucks as Percent of Total Traffic				
Olympics	1.5%	1.2%	5.3%	5.0%
Non-Olympics	1.8%	.9%	5.5%	4.6%

*same day of the week comparisons

The videotape truck count data is given in Table 2-6. At this screenline, the AM peak is in the westbound direction, and the PM peak is in the eastbound direction. Several interesting changes are evident in Table 2-6. First, total truck traffic in both directions was reduced during the Olympics. Second, truck traffic was down quite significantly in the peak directions: 49 percent eastbound in the afternoon and 10 percent westbound in the morning. It is somewhat surprising that there is such a large difference in these numbers. It is possible that arrival times are more uncertain than departure times, and thus the level of inbound traffic was less likely to change. Third, there was a significant increase in evening truck traffic in both directions, implying that truck activity was deferred to evening hours as advocated by the Operation Breezeway program. Finally, it may be noted that the

TABLE 2-6

TRUCK TRAFFIC ON I-10 EAST OF I-110
BY DAY, DIRECTION, AND TIME PERIOD

Time	Olympics	Non-Olympics	Difference
		Eastbound	
7:30 AM - 9:00 AM	457	441	+3.6%
9:00 AM - 3:00 PM	2527	2860	-11.6%
3:00 PM - 6:00 PM	435	857	-49.2%
6:00 PM - 7:30 PM	268	190	+41.0%
7:30 AM - 7:30 PM	3687	4348	-15%
		Westbound	
7:30 AM - 9:00 AM	623	693	-10%
9:00 AM - 3:00 PM	2395	2891	-17%
3:00 PM - 6:00 PM	629	511	+23%
6:00 PM - 7:30 PM	194	98	+98%
7:30 AM - 7:30 PM	3841	4193	-8.4%

temporal shifts in truck traffic are of much larger magnitude than the reduction in total truck traffic. Because this comparison is between a Monday and a Thursday, the extent to which truck traffic actually declined from a typical Monday is uncertain. If this screenline is representative, Operation Breezeway was quite successful. Given the limited data, however, it can only be concluded that the most notable adjustments were made in the Los Angeles central area, where the most serious traffic problems were expected.

No conclusions regarding the overall level of truck traffic during the Olympics can be drawn from this information because of its limited scope. The California Highway Patrol conducts truck counts at each of its weigh stations. Of the four weigh stations in the Los Angeles area, two showed an increase and two showed a decrease in truck counts for the month of August 1984. The CHP comparison was based on a nine-month average as the baseline. While the increases were larger in magnitude than the decreases, it is not possible to conclude that there was an actual increase in truck traffic during the Olympics. Since the baseline is a nine-month (January through September) average, seasonality is not taken into account. Also, the weigh-station locations do not form a cordon around the region, and thus changes at specific locations may be due to changes in route choice rather than actual changes in volumes. Finally, the counts are monthly, and thus do not separate out the Olympic period.

2.3 VEHICLE OCCUPANCY

A major public information effort was aimed at encouraging commuters to carpool or take transit during the Olympics in order to reduce anticipated congestion problems. Ridesharing has historically been considered a primary means of increasing the person-trip capacity of the transportation system in congested areas. The rate of ridesharing is quite significant in central cities. Commuter Computer estimates that about 40 percent of Los Angeles downtown commuters engage in some form of ridesharing: carpools, vanpools, or public transit.

In order to measure changes in carpooling and vanpooling during the Olympics, Caltrans conducted a series of vehicle occupancy counts. Caltrans has an ongoing program of monitoring vehicle occupancy, and consequently has established a well-defined procedure for doing so.

Regular counts at selected screenlines in Los Angeles and Orange County have been conducted since 1979. Therefore, baseline data is extremely good. Under normal conditions, the vehicle occupancy rate (on general purpose travel lanes) in Los Angeles County averages 1.21 for August, and ranges from 1.15 to 1.24. The occupancy rate has been quite stable over the past two years.

Four screenlines surrounding the central Los Angeles area were selected for analysis. It was reasoned that in view of the congestion problems anticipated in the central area, there would be a lot of incentive for increased ridesharing during the Olympics. The screenlines are I-5 at Griffith Park Blvd.; I-10 at 6th Ave. (near Arlington); I-110 at 42nd St., and SR-91 at Lakewood Blvd. (See Figure 2-9). The Griffith Park screenline has been identified by Caltrans as the most representative for Los Angeles County. The 6th Ave. and 42nd St. screenlines typically have lowest and highest occupancy rates respectively, and also are located in the vicinity of the Coliseum area. The Lakewood screenline is furthest away from the central L.A. area.

Occupancy counts are conducted in the inbound direction during the AM peak from 6:30 to 8:30. This count tends to capture the "peak of the peak." Counts do not begin before 6:30 because of visibility problems, and the 8:30 cut-off time is chosen because the proportion of work trip traffic drops considerably after 8:30. During the Olympics, however, some counts were continued until 9:00.

Table 2-7 gives Olympics and non-Olympics occupancy counts for the four screenlines. Two non-Olympics baselines are presented; August 1983 and September 1984. Day of the week is also presented. Vehicle occupancy during the Olympics is higher in all cases than the September

TABLE 2-7

VEHICLE OCCUPANCY COUNTS, OLYMPICS VS. NON-OLYMPICS, TWO-HOUR AM PEAK

	I-5/Griffith Park	I-10/6th Ave.	I-110/42nd St.	SR-91/Lakewood
August 1983*	1.17	1.15	1.24	1.20
September 1984	1.17 (Wed)	1.13 (Thurs)	1.25 (Tues)	1.13 (Tues)
Olympics	1.19 (Wed)	1.29 (Mon)	1.27 (Mon)	1.19 (Tues)

* Day of week not available.

1984 baseline. At Lakewood Blvd., however, the Olympics count is not as high as the August 1983 baseline. Caltrans previous research indicates that August vehicle occupancy is always higher because of the influence of vacation travel. Thus the August baseline is probably more appropriate.

At first glance, it would seem that commuters did indeed do more ridesharing during the Olympics. However the pattern of occupancy during the peak shows that the observed increase was due largely to Olympics-related traffic. Table 2-8 gives half-hourly vehicle occupancy for three screenlines. In each case there is a trend toward higher occupancies towards the end of the peak. The difference is most pronounced at the I-10/6th Ave. screenline. The I-10 tends to have a lower than average occupancy rate, making the Olympics spectator traffic influence more

TABLE 2-8

VEHICLE OCCUPANCY BY TIME PERIOD,
OLYMPICS VS. NON-OLYMPICS

	Location					
	I-5/Griffith Park		I-10/6th Ave.		I-110/42nd St.	
Time	Olympics	Non-Olympics	Olympics	Non-Olympics	Olympics	Non-Olympics
6:30-7:00 AM	1.20	1.21	1.18	1.14	1.22	1.41
7:00-7:30 AM	1.18	1.17	1.16	1.10	1.28	1.21
7:30-8:00 AM	1.21	1.13	1.24	1.15	1.23	1.21
8:00-8:30 AM	1.25	1.17	1.34	1.10	1.32	1.20
8:30-9:00 AM	N/A	N/A	1.40	N/A	1.40	N/A

obvious. The counts for 6th Ave. and 42nd St. were taken on Monday, August 6. Coliseum activities began at 9:30 AM, and their effect seems quite clear. The 6th Ave. screenline was located upstream from the signed spectator route, while the 42nd St. screenline was downstream from the route. It was anticipated that spectator traffic would therefore not be a factor at 42nd St., but the numbers indicate that this was not the case. It should also be noted that August 6 was a particularly light work day, and the proportion of work-trip travel was probably lower than normal. The screenline occupancy counts indicate that there was little change in the level of ridesharing during the Olympics. The employee survey results also support this conclusion, as will be further discussed in Chapter Three.

2.4 TRAFFIC INCIDENTS

Traffic incidents are a major source of congestion on the highway system, and every effort was made to minimize their impact during the Olympics. As described in Chapter One, a much higher level of surveillance activity was employed during the Olympics, and special response tactics were employed to reduce the duration of incidents. Due to data constraints, however, incident duration during the Olympics could not be examined. This section discusses incident frequency.

Three sets of data were examined: a summary of the major incidents which occurred during the Olympics; all accidents reported in the TASAS[2] accident file data for the Los Angeles central area, and TASAS file data for Los Angeles, Orange, and Ventura counties, truck accidents only. The truck accident data was collected in connection with another Caltrans-UCI research project.[3]

2.4.1 Major Incidents

A major incident is defined as one which affects two or more lanes of traffic for two or more hours. The definition is used more as a rule of thumb in determining response to an incident, rather than on any particular characteristic of the incident itself. Major incidents are relatively rare occurances, but cause a great deal of delay when they do occur.

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2 Traffic Accident Surveillance and Analysis System, the accident file maintained by the State of California. It contains all reported accidents.

3 Analysis of Truck Related Freeway Incidents, UCI Contract RTA-13945-55D281.

During the month spanning the Olympics (7-25-84 to 8-24-84), there were 33 major incidents, 20 of which involved trucks, within the District 7 area. For a comparable period in 1983 (7-27-83 to 8-27-83), there were 25 major incidents, 19 of which involved trucks. For the two-week period of the Olympics, there were ten major incidents (five involving trucks) compared to six (four involving trucks) for the same period in 1983.[4] Further information showed that only two of the Olympics period incidents occurred at times and in locations which could have impacted Olympics traffic. One incident occurred on the Harbor Freeway, but on a non-Coliseum day and in the off-peak direction. The other was a helicopter crash which occurred on the southbound Harbor Freeway just prior to closing ceremonies. Rapid response and clearing of this incident was credited for averting a major traffic tie-up. Thus while more major incidents occurred during the Olympics than during a comparable period in 1983, they occurred mostly at non-critical times and locations. When location was critical, response was extremely efficient.

2.4.2 Accidents in Los Angeles Central Area

TASAS data was used to examine the frequency of accidents during the Olympics. The 14-day period of the Olympics (7/24 to 8/14) was compared with the same period of 1983. Each 14-day period had the same number of weekdays and weekend days. TASAS records for the five freeways serving the central Los Angeles area were used, since this area was

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[4] This information is based on MITMT and TOC data only, and may not be complete. It is a complete list of all major incidents which involved Caltrans participation.

expected to be most affected by the Olympics. Overall, fewer accidents occurred during the Olympics: 270 compared to 320 during the 1983 period. Table 2-9 presents a breakdown by freeway. Information is also given on severity and truck involvement. The total reduction in traffic accidents range from 4 percent on I-10 to 25 percent on SR-101. The small change on I-10 is not surprising, given the lack of change in traffic volumes discussed earlier. The reduction on I-110 is also expected in view of the decreased traffic volumes observed during the Olympics. However, the decrease on SR-101 is somewhat surprising, as it was not accompanied by a decrease in traffic volumes.

The severity of incidents as measured by injuries per accident is similar for both periods. Truck involvement, measured by trucks per accident, is also similar for both periods. The very high truck involvement rate on I-5 may be due to relatively greater truck traffic on this freeway. It is interesting to note the high proportion of truck involvement in these accidents. Trucks typically represent less than 10 percent of the traffic, yet they are involved in 44 percent of the accidents in this data sample.

2.4.3 Truck Accidents in Los Angeles, Orange, and Ventura Counties

TASAS data collected for a research project on truck-related accidents was made available to this project and provided an opportunity to conduct a brief statistical analysis of accident patterns during the Olympics. The data is limited to truck accidents only, and may not be representative of all accidents.

Comparisons of accident characteristics were made in three different ways. The first way was a comparison of similar 16-day periods

TABLE 2-9

ACCIDENT PATTERNS ON CENTRAL LOS ANGELES PORTIONS OF FIVE FREEWAYS
OLYMPICS VS. NON-OLYMPICS

Freeway	# Accidents	Severity			Truck Involvement		
		Inj	(%)	Non-Inj	Lrg Truck	Sml Truck	% Truck Acc
I-10 (from Bundy to Santa Fe)							
Olympics	46	13	28%	33	6	10	35%
Non-Olympics	48	14	29%	34	6	15	44%
Difference:	-4%						
I-110 (from El Segundo to end (Pasadena))							
Olympics	83	28	34%	55	9	22	37%
Non-Olympics	104	29	28%	75	10	27	36%
Difference:	-20%						
I-101 (from 7th St. to SR-170)							
Olympics	50	13	28%	36	3	13	32%
Non-Olympics	67	25	37%	42	7	15	33%
Difference:	-25%						
I-5 (Slauson to Los Feliz)							
Olympics	77	28	36%	49	27	23	65%
Non-Olympics	85	35	41%	50	30	24	64%
Difference:	-9%						
I-60 (L.A. River to Wilcox Ave.)							
Olympics	14	6	43%	8	3	3	43%
Non-Olympics	16	4	31%	11	3	5	50%
Difference:	-13%		33%				44%
ALL FREEWAYS							
Olympics	270	Average:	33%				44%
Non-Olympics	320						
Difference	-16%						

in the summer of 1984: pre-Olympics, during Olympics, and post-Olympics. Each period has the same number of weekdays and weekend days. The second way was a comparison of similar one-month periods for 1983, 1984, and 1985. The third way was a comparison across the appropriate 16-day periods for the same three years.

The statistical analysis showed no significant difference in the total number of accidents during the Olympics on I-10 and I-405. Table 2-10 shows that the decrease during the Olympics in 1984 reflects the same pattern as 1983, while the pattern in 1985 is just the opposite. However, when the corresponding 16-day periods are compared across the three years, the decrease observed in 1984 is significant, because it is counter to the underlying increasing trend. Cross-tabulation results are given in Table 2-11. The decrease during the Olympics is possibly greater than indicated here, because the increased level of surveillance during the Olympics may have increased the accident reporting rate. There was a slight difference in accident location during the Olympics; a greater share of ramp accidents occurred, as shown in Table 2-12. The number of accidents by route was also examined. Cross-tabulations across all routes[5] revealed no significant difference during the Olympics for any of the three methods of comparison.

Accident type, accident severity, and occurrance by time of day were also examined. Accidents are categorized as follows: sideswipe, rear end, broadside, hit object, overturn, and other. Relatively fewer

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[5] The routes are SR-2, I-5, I-10, SR-14, SR-22, SR-47, SR-55, SR-57, I-60, SR-91, SR-101, I-110, SR-118, SR-126, SR-134, I-170, I-210, I-405, I-605, and I-710.

TABLE 2-10

TOTAL ACCIDENTS:
COMPARISON OF THREE 16-DAY PERIODS BY YEAR,* I-10 AND I-405

Year	Pre	During	Post	Row Totals
1983	152	140	164	456
1984	167	136	164	467
1985	144	186	175	505

*Cross-tabulation, no significant difference.

rear end collisions and more overturns occurred during the Olympics. These changes may be indicative of less congestion and lower traffic volumes during the Olympics. This pattern was observed both for I-10 and I-405, as well as for the entire set of state highways in the

TABLE 2-11

ACCIDENTS BY ROUTE AND TIME PERIOD*

Route	Pre '83	During '84	Post '85
I-10	43	40	86
I-405	97	96	100
Column Total:	140	136	186

*Cross-tabulation, significant at 99 percent.

TABLE 2-12

ACCIDENTS BY LOCATION:
COMPARISON OF 16-DAY PERIODS BY YEAR,* I-10 and I-405

Location	Time Period		
	Pre '83	During '84	Post '85
Highway	119	99	140
Ramp	21	37	46

* Cross-tabulation, difference significant at 95 percent.

TABLE 2-13

ACCIDENT FREQUENCY BY 16-DAY TIME PERIOD, I-10 and I-405*

Time Period	Pre 1983	During 1984	Post 1985
12 AM - 6 AM	11	18	24
6 AM - 9 AM	9	14	17
9 AM - 12 PM	22	16	22
12 PM - 3 PM	28	18	37
3 PM - 6 PM	42	39	43
6 PM - 9 PM	23	12	26
9 PM - 12 AM	5	18	17

*Cross-tabulation, significant difference at 90 percent.

three-county area. Accident severity was measured by calculating the rate of injuries per accident and the rate of vehicles per accident. No significant difference was found in either measure during the Olympics. Accident frequency by time of day also showed little change during the Olympics. Table 2-13 shows that there was a slight increase in late evening (9 PM to 12 AM) accidents during the Olympics, compared to the corresponding 16-day periods in the other years. However, when compared over one-month periods, the difference is insignficant. There was also a slight decrease in midday accident frequency, but again in comparisons with longer time periods the difference is not significant.

2.4.4 Summary

Accident patterns were mixed during the Olympics. More major incidents occurred than during a comparable prior year period, but there is no way to determine whether the increase was due to the upward trend over time or to other factors. Total accidents in the central Los Angeles area decreased, and the drop was likely due to lower traffic volumes, particularly during the first week of the Olympics. The statistical analysis of truck accident data showed very few differences during the Olympics when both before and after data are compared. This section completes the analysis of highway system performance.

CHAPTER THREE

TRAVEL BEHAVIOR

This chapter presents the results of the downtown employee travel survey conducted to provide information on how commuters responded to the anticipated Olympics traffic conditions. As discussed in Chapter One, the purpose of this research is to evaluate the long-term policy implications of the Olympics experience, and consequently the focus of study is the travel behavior of residents (commuters), rather than spectators.

The survey research was a joint effort of UCI, Commuter Computer, and the Southern California Association of Governments (SCAG). Two different survey instruments were developed. A short form was distributed by Commuter Computer/SCAG to the employment centers located in West Los Angeles, Mid-Wilshire district (Los Angeles City), Pasadena, El Segundo, Long Beach, and Commerce.[1] A long form survey was distributed in the Los Angeles downtown area for UCI by Commuter Computer.

3.1 RESEARCH METHODOLOGY

The survey was designed to examine all aspects of work trip travel during the Olympics, and to determine how Olympics travel compared to normal conditions. The focus of the survey was on work-related travel, since the potential for severe traffic problems was greatest for peak-hour travel. Travel times, mode choice, work schedules, absences

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[1] Survey results are available in, Olympics Impact Report, Southern California Association of Governments. Los Angeles, CA, May 1985.

from work, and route choice were investigated.[2] In most cases, behavior before the Olympics was compared to that during the Olympics. The survey also contained a daily work trip travel diary for the two-week period of the Olympics.

Four large downtown employers with a combined work force of about 9,200 employees participated in the survey. All four employers utilize ridesharing services provided by the local ridesharing agency, Commuter Computer, and/or have an in-house employee transportation program. Survey questionnaires were distributed to a total of almost 5,000 employees in late August, 1984.[3] Distribution and collection procedures were at the discretion of the employer. At Sites B and C, surveys were distributed to all employees, and at Site D the surveys were randomly distributed. All employees at three of five downtown work sites received surveys at Site A.

TABLE 3-1

SAMPLE BREAKDOWN BY EMPLOYER SITE

Site	No. of Empl.	No. Surveys Distributed	No. in Sample	Response Rate
A	3000	1,200	281	23%
B	1100	1,100	799	73%
C	1600	1,600	586	37%
D	3500	1,000	326	33%
Total:	9200	4,900	1992	41%

2 See Appendix A for the survey instrument.

3 Preparations for the Olympics precluded distribution of the survey prior to the Olympics.

The breakdown of the sample by employer is presented in Table 3-1. The response rate ranged from 23 percent at Site A to 73 percent at Site B. A total of 1,992 completed and verified responses were used in the analysis, yielding a response rate of 41 percent for the total sample. The sample was weighted according to the total number of employees. The weights were adjusted for both the different survey distribution methods and the different response rates.

3.2 SURVEY RESULTS

3.2.1 Work Force Participation

Anticipated difficulties as a result of the Olympics games led to numerous changes in the work week, choice of work site, and in absences from work. Table 3-2 presents the absence rate during the Olympics. This rate includes all absences from the regular work place. The data show that the absence rate was slightly higher during the second week, and the highest absence rates occurred on Monday and Friday in both weeks. Table 3-3 shows that these variations are explained by the fact that more people were on vacation during the second week, and days off due to a modified work week occurred primarily on Monday and Friday. (Monday, August 6, had also been designated an optional state holiday.) In contrast, those who worked at an alternate work place (counted as an absence from the regular work place), and absences for other reasons, remained fairly constant throughout the Olympics. Since vacation plans and work week schedules were most likely made in advance of the games, these shifts probably reflect efforts of employees and employers to avoid the anticipated traffic problems.

TABLE 3-2

PERCENTAGE OF PEOPLE WHO DID NOT COME TO WORK* FOR ALL REASONS

Date		Percentage
Monday	7/30	17.1
Tuesday	7/31	16.2
Wednesday	8/1	16.3
Thursday	8/2	15.9
Friday	8/3	21.4
Monday	8/6	19.5
Tuesday	8/7	16.9
Wednesday	8/8	19.0
Thursday	8/9	19.4
Friday	8/10	23.9

Total number of respondents = 476

* Did not work at the regular work place.

TABLE 3-3

PERCENTAGE DISTRIBUTION OF THOSE WHO DID NOT WORK
AT USUAL WORK PLACE DURING THE OLYMPICS

Date		Vacation	Alt. Work Place	Mod. Week	Other*
Monday	7/30	9.6	2.8	1.8	2.9
Tuesday	7/31	9.9	3.2	0.1	3.0
Wednesday	8/1	9.5	3.3	0.2	3.3
Thursday	8/2	9.9	3.2	0.2	2.6
Friday	8/3	11.8	2.8	3.5	3.3
Monday	8/6	11.7	2.8	1.8	3.2
Tuesday	8/7	11.3	3.0	0.4	2.2
Wednesday	8/8	11.9	3.4	0.4	3.3
Thursday	8/9	11.9	3.7	0.3	3.5
Friday	8/10	13.8	3.3	3.0	3.8

Total number of respondents = 476

* Other is the sum of regular day off, sick leave, company holiday, and other reasons.

3.2.2 Work Trip Characteristics

Most analysts predicted serious traffic congestion in the downtown areas during the Olympic games. Such was not the case. Many roadways were less congested than at any time in recent memory. How, then, did travel times for the commute to and from downtown change during the Olympics?

3.2.2.1 Travel to Work

The survey data show that travel time to work decreased significantly during the Olympic games. The average employee working in downtown Los Angeles travels 19.5 miles to work, and the average pre-Olympics trip to work took 42.4 minutes. During the games, the average commute to work took just 36.8 minutes--a time savings of 5.6 minutes, or 14 percent. Each respondent was also asked to provide the longest time required to commute to work during the games. Even the average of these responses, 40.2 minutes, did not exceed the pre-games travel time figure.

Travel time for the trip home from work also decreased during the Olympics. Before the games the average commute home took 48.6 minutes. During the games this figure was reduced to 42.2 minutes--a savings of 6.4 minutes or 13 percent. The average maximum during the games was 46.0 minutes. Graphical representations of travel time to and from work are provided in Figures 3-1 and 3-2.

Time savings were experienced during the games in part because a high percentage of employees changed their time of departure during the games. The most frequent change was to leave home earlier than usual (23.3 percent), as shown in Table 3-4. About two thirds of all commuters

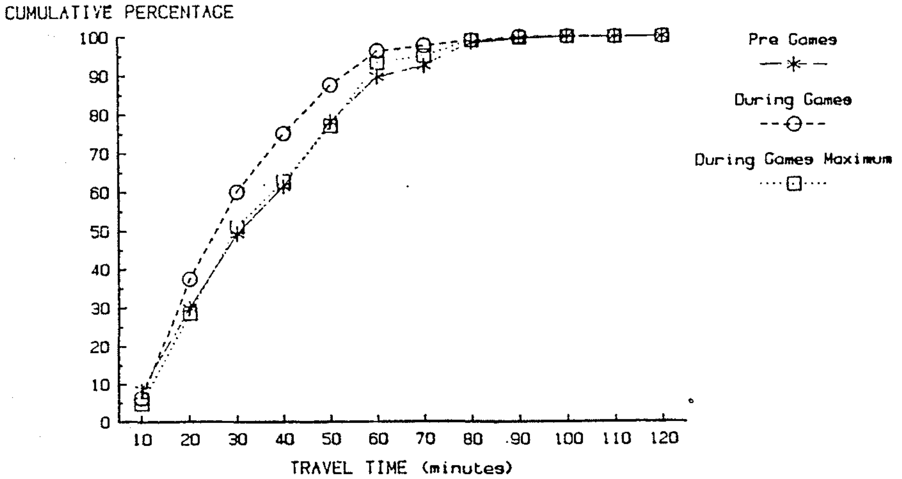


FIGURE 3-1: CUMULATIVE DISTRIBUTION, TRAVEL TIME TO WORK

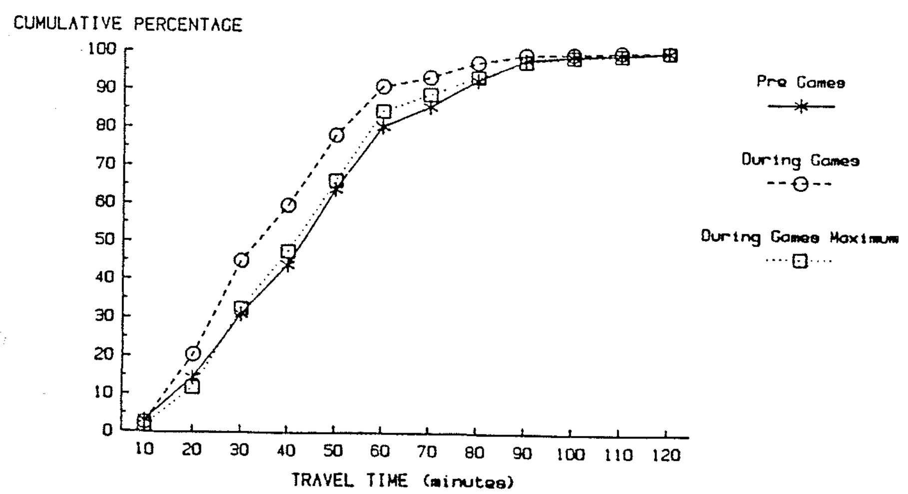


FIGURE 3-2: CUMULATIVE DISTRIBUTION, TRAVEL TIME FROM WORK

TABLE 3-4

DEPARTURE TIME FROM HOME DURING OLYMPICS

	Minutes Relative to Usual	Percentage	
earlier	-75 or earlier	3.7	23.3
	-60	3.8	
	-45	2.2	
	-30	5.6	
	-15	8.0	
	0	65.1	
later	+15	8.3	11.6
	+30	2.6	
	+45	0.2	
	+60	0.1	
	+75 or more	0.1	

n = 1668

left at their usual time (in 15 minute intervals), and only 11.6 percent left later than usual. These shifts resulted in a "flatter" (e.g., more evenly distributed) peak travel period, particularly in the morning. Figure 3-3 gives the cumulative distribution of trip start times from home to work before and during the Olympics, and Table 3-5 gives the percentage distribution of start times. Note, for example, that about 10 percent of the sample had left for work by 6:00 AM during the Olympics, compared to about 5 percent before the Olympics. Similarly, slightly more people left for work after 8:30 during the Olympics than before, while fewer left between 6:30 and 8:00 during the Olympics (68.3 percent before vs. 62.3 percent during).

Further evidence of travel time savings is provided by comparing Figures 3-3 and 3-4. Note that the pre-games and during-games lines are closer to one another in the Leave Home For Work graph (Figure 3-3) than in the Arrive At Work graph (Figure 3-4), meaning that more people arrived at work earlier than usual during the Olympics than had left earlier than usual. The survey data indicates that 45.7 percent of all employees claimed to have arrived at work earlier than usual during the games, far more than had left earlier than usual (23.3 percent). Also, only 5.7 percent arrived later than usual, a smaller proportion than had left later than usual.

TABLE 3-5

PERCENTAGE DISTRIBUTION OF TIME
LEAVE FROM HOME TO WORK

	Before Games	During Games
before 5:00 AM	.2	.7
5:00 - 5:30 AM	1.0	2.6
5:30 - 6:00 AM	3.7	6.6
6:00 - 6:30 AM	11.7	14.2
6:30 - 7:00 AM	21.7	19.3
7:00 - 7:30 AM	24.4	23.0
7:30 - 8:00 AM	22.2	20.5
8:00 - 8:30 AM	12.8	10.5
8:30 - 9:00 AM	1.0	1.3
after 9:00 AM	.8	1.1

3.2.2.2 Travel Home

The Olympic games did not affect departure times from work as dramatically as departure times from home. Table 3-6 shows that a smaller proportion of commuters changed their departure time from work than had changed departure time to work. The pattern is the same, however, with a greater shift towards leaving work earlier than usual. The difference in shifting patterns between the trip to work and the trip home suggests that the morning shift was made at least in part in

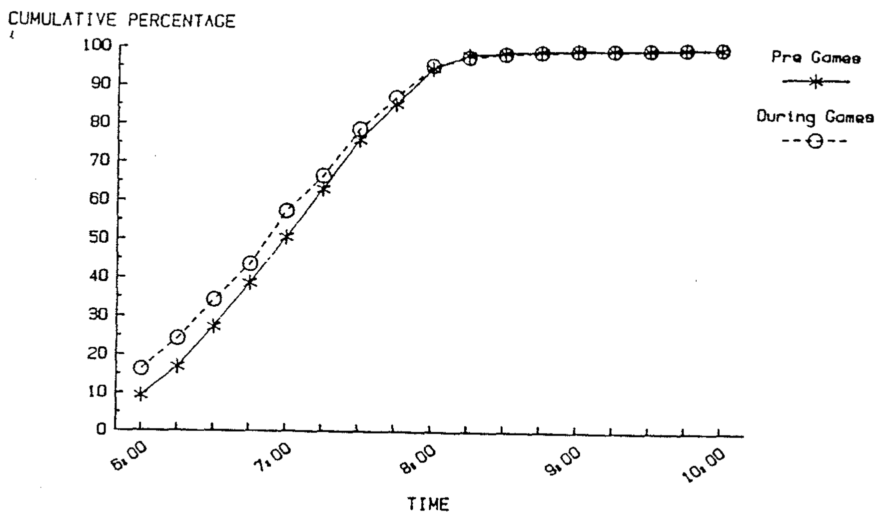


FIGURE 3-3: CUMULATIVE DISTRIBUTION, LEAVE HOME FOR WORK

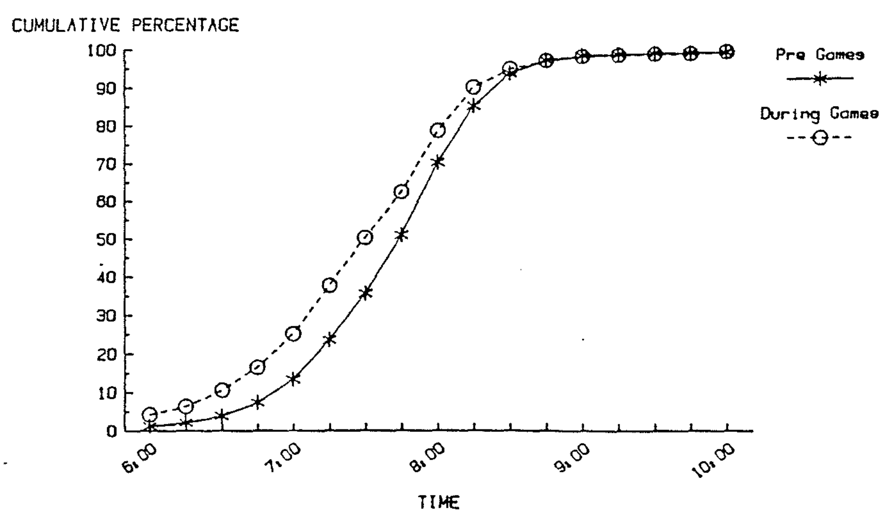


FIGURE 3-4: CUMULATIVE DISTRIBUTION, ARRIVE AT WORK

TABLE 3-6

DEPARTURE TIME FROM WORK

	Minutes Relative to Usual	Percentage	
earlier	-75 or earlier	0.8	17.9
	-60	2.8	
	-45	1.0	
	-30	4.5	
	-15	4.8	
	0	72.6	
later	+15	2.8	8.2
	+30	2.7	
	+45	0.7	
	+60	1.4	
	+75 or later	0.6	

n = 1676

anticipation of heavier Olympics traffic. That is, people started for work earlier expecting that the trip would take longer than usual. A comparison of time leaving work and time arriving home provides further evidence of travel time savings during the Olympics. About 18 percent of the employees left work earlier than usual, while about 50 percent of all employees arrived home earlier than usual.

Figure 3-5 gives the cumulative distribution of work departure times, and Table 3-7 gives percentage distributions. Again, a slight flattening of the peak is apparent: during the Olympics more departures occurred before 4:00 PM and after 5:30 PM, while fewer occurred between 4:00 and 5:30 PM. Figure 3-6 gives the cumulative distribution of arrival home times. Note that the greatest differences occurred between 4:45 and 5:45 PM, suggesting that part of the travel time savings was due to the shift to earlier departure times.

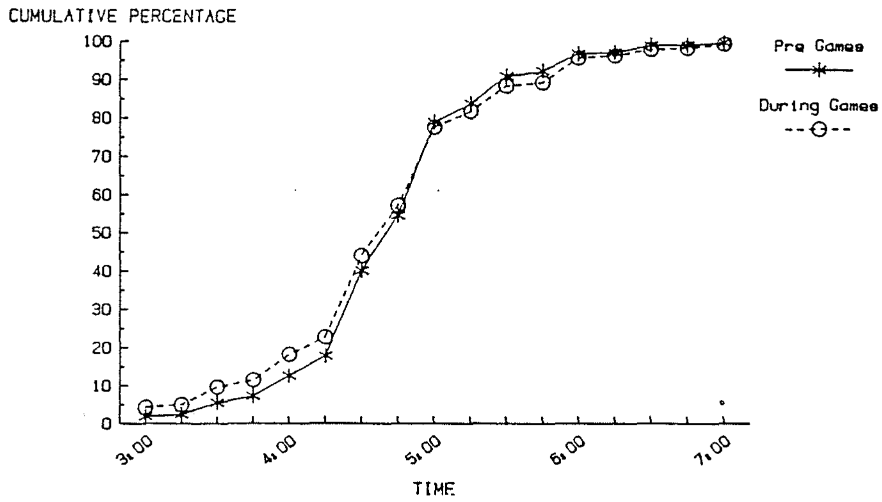


FIGURE 3-5: CUMULATIVE DISTRIBUTION, LEAVE WORK FOR HOME

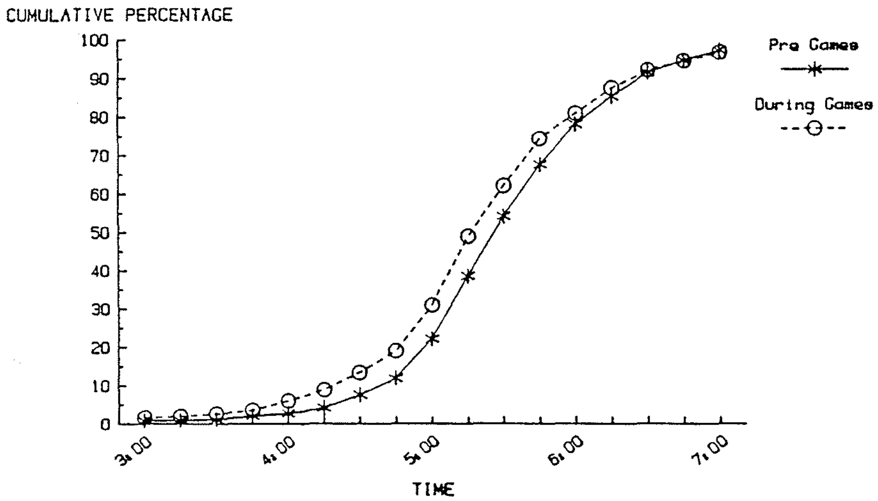


FIGURE 3-6: CUMULATIVE DISTRIBUTION, ARRIVE AT HOME

TABLE 3-7

DISTRIBUTION OF TIME
LEAVE FROM WORK TO HOME

	Before Games Percentage		During Games Percentage	
Before 3:00 PM	1.2		2.2	
3:00 - 3:30 PM	1.0		2.8	
3:30 - 4:00 PM	4.9		6.2	
4:00 - 4:30 PM	10.5		11.2	
4:30 - 5:00 PM	36.7	76.5	34.4	70.1
5:00 - 5:30 PM	29.3		24.5	
5:30 - 6:00 PM	8.5		7.5	
After 6:00 PM	7.6		10.8	
	n = 1965		n = 1673	

3.2.2.3 Flexible Work Hours

Work trip schedule changes and the ensuing time savings were partially the result of increased flexibility demonstrated by employers with respect to work hours. Prior to the Olympics, employers specified the work hours for 56.2 percent of all employees, and 34.2 percent of all employees chose their own hours with the approval of their employer. During the games, employers specified the work hours of only 41.3 percent of their employees. Some 47.8 percent of all employees chose their own hours.

The permissible time intervals for beginning and ending work were also greater during the Olympics. The predominant shift was to earlier allowed start and end times, as shown in Tables 3-8 and 3-9, but the latest allowable start and end times shifted as well. Thus, the earliest allowed arrival time was earlier than usual and the latest allowed arrival time was later than usual during the games.

TABLE 3-8

PERCENTAGE DISTRIBUTION OF ALLOWED ARRIVAL TIMES

	Earliest Allowed Arrival at Work		Latest Allowed Arrival at Work	
	Pre Games	During Games	Pre Games	During Games
Before 6:00 AM	1.8	6.5	0.1	0.3
6:00 - 6:30 AM	6.9	13.7	0.4	0.3
6:30 - 7:00 AM	4.6	5.1	0.1	0.4
7:00 - 7:30 AM	23.9	24.0	1.3	2.8
7:30 - 8:00 AM	13.3	9.4	3.5	3.4
8:00 - 8:30 AM	36.9	30.3	46.5	41.8
8:30 - 9:00 AM	11.5	9.1	28.6	25.9
9:00 - 9:30 AM	0.5	8.0	13.2	14.8
9:30 -10:00 AM	0.2	0.2	2.1	2.4
After 10:00 AM	0.2	0.6	2.3	6.4

TABLE 3-9

PERCENTAGE DISTRIBUTION OF ALLOWED DEPARTURE TIMES

	Earliest Allowed Departure from Work		Latest Allowed Departure from Work	
	Pre Games	During Games	Pre Games	During Games
Before 3:00 PM	2.7	9.5	1.6	1.1
3:00 - 3:30 PM	6.0	9.3	0.2	0.7
3:30 - 4:00 PM	11.9	12.0	0.2	0.6
4:00 - 4:30 PM	15.3	14.5	3.1	3.2
4:30 - 5:00 PM	38.8	34.0	23.7	21.2
5:00 - 5:30 PM	22.2	16.9	34.2	31.1
5:30 - 6:00 PM	1.9	2.1	12.3	10.8
6:00 - 6:30 PM	0.3	0.8	9.8	12.1
6:30 - 7:00 PM	0.0	0.1	3.2	4.5
After 7:00 PM	0.4	0.9	11.8	14.9

Similarly, the earliest allowed departure time was earlier and the latest allowed departure time was later during the games. The predominant shift to an earlier schedule was in keeping with the desire to avoid Olympics congestion. Coliseum events began around 9:00 AM and ended around 5:00 PM. Earlier work schedules made it possible for commuters to avoid the peak travel times for event attendees.

3.2.2.4 Stops on the Trip to and from Work

Another factor which can greatly influence travel time is the number of stops made during the commute. The fact that the average trip to work takes less time than the commute home is due in part to the fact that fewer stops are made on the way to work than on the way home. Table 3-10 shows that stops on the trip to work were unchanged during the Olympics. Both the ratio of stops per respondent and the stops per person stopping are almost identical. Stops on the way home decreased slightly during the Olympics, although the number of stops per person stopping remained almost constant.

Types of stops made on trips to and from work are presented in Tables 3-11 and 3-12. On the trip to work, shopping and social visits increased, while work-related stops decreased and other categories were unchanged. On the trip home, a slightly greater proportion of stops were to pick up or drop off passengers, while work-related business and "other" trips decreased. These changes suggest that business-related travel was curtailed during the Olympics, and that some stops were shifted from the PM to the AM work trip.

TABLE 3-10

PERCENTAGE OF PEOPLE WHO MADE STOPS DURING THE WORK COMMUTE

Trip to Work	Pre Games	During Games
Did Stop	27.3%	27.4%
Did Not Stop	72.3%	72.6%
Total Number of Respondents	1982	1693
Total Number of Stops	608	542
Ave. No. stops/respondent	.31	.32
Ave. No. stops/person who stopped	1.12	1.17
Trip From Work	**Pre Games**	**During Games**
Did Stop	39.9%	37.5%
Did Not Stop	60.1%	62.5%
Total Number of Respondents	1966	1678
Total Number of Stops	1197	938
Ave. No. stops/respondent	.61	.56
Ave. No. stops/person who stopped	1.53	1.49

3.2.2.5 Route to Work

Another way the work trip could be adjusted during the Olympics was to change the regular route. The survey asked which downtown area freeways, if any, were used before the Olympics; whether the route to and from work changed during the Olympics; and if so, which freeways were chosen. Table 3-13 shows the route choice probabilities for the entire sample before the Olympics. Listed are the major downtown area freeways (see Figure 3-7). The probabilities sum to more than 100 percent, because more than a single freeway might have been used on the work trip. As might be expected, the most frequently used freeways are I-110,

TABLE 3-11

FREQUENCY OF STOPS BY CATEGORY, AS PERCENT OF ALL STOPS

	Trip to Work	
Characteristics	Before Games	During Games
Pick up or drop off passenger	57.1	56.1
Work Related business	9.4	7.4
Shopping	5.6	8.7
Social Visit	1.3	2.8
Eating	6.9	6.3
Personal Business	8.9	8.5
Other	10.8	10.3

TABLE 3-12

FREQUENCY OF STOPS BY CATEGORY, AS PERCENT OF ALL STOPS
TRIP FROM WORK

Characteristics	Before Games	During Games
Pick up or drop off passenger	30.2	33.0
Work-related business	5.2	3.6
Shopping	25.7	24.6
Social visit	6.2	7.0
Eating	6.3	8.3
Personal business	16.2	17.0
Other	10.2	6.4

I-10 and SR-11 (Pasadena Freeway). About 31.6 percent of the sample used no downtown area freeways.

During the Olympics, about 10 percent of the respondents changed their route to and from work. Table 3-14 gives the choice probabilities of the various freeways by people who changed their route during the

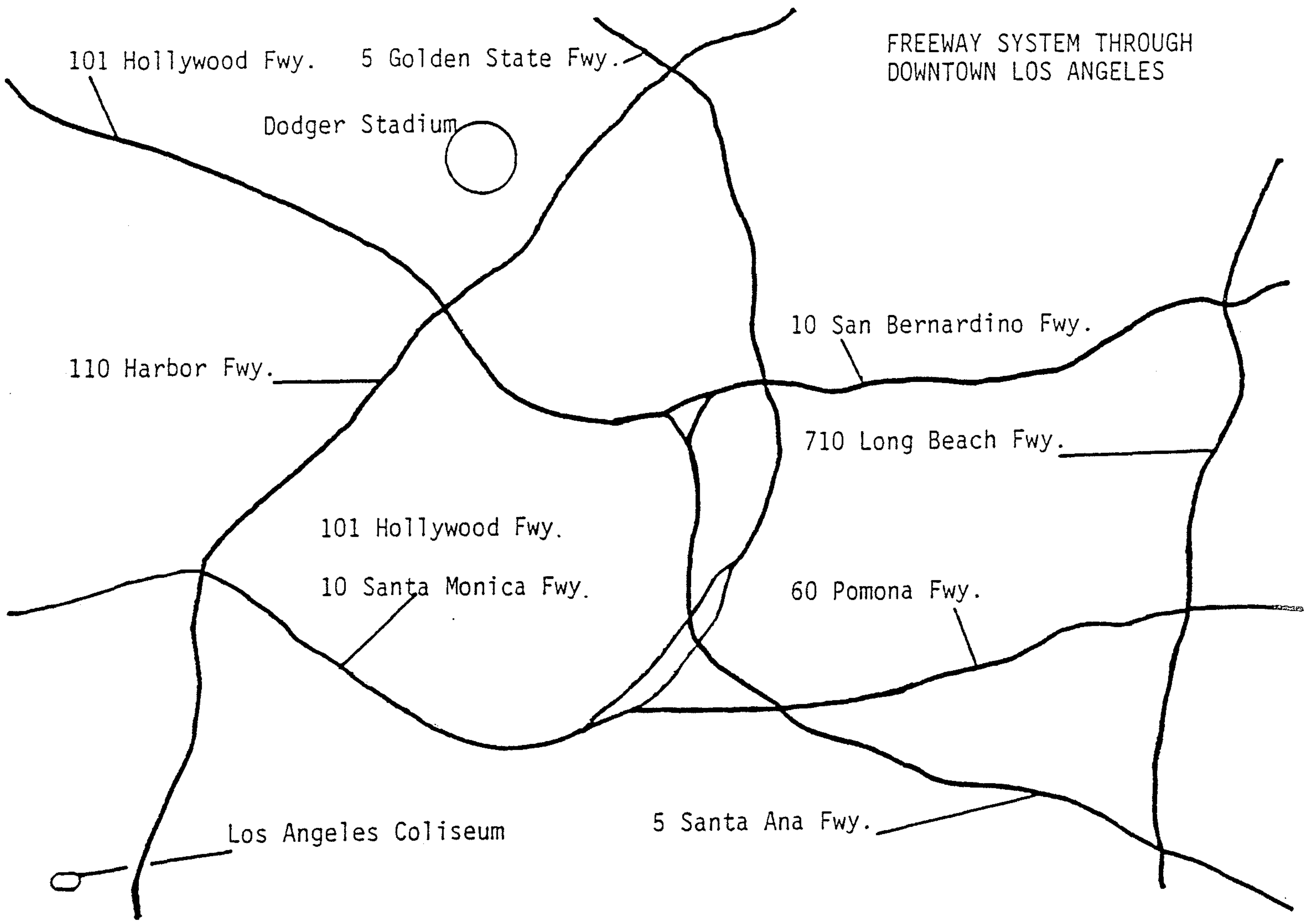


FIGURE 3-7: FREEWAYS IN THE CENTRAL LOS ANGELES AREA

TABLE 3-13

CHOICE PROBABILITIES OF FREEWAYS TO AND FROM WORK
FOR THE TOTAL SAMPLE BEFORE THE GAMES

Freeway	Choice Probability
Santa Ana (I-5)	5.5%
Santa Monica (I-10)	17.0%
Pasadena (SR-11)	9.1%
Pomona (I-60)	2.4%
Ventura/Hollywood (SR-101)	2.4%
Harbor (I-110)	15.0%
San Bernardino (I-10)	.8%
All Other Freeways	16.2%
No Freeways	31.6%

n = 253

games. The first column of Table 3-14 presents the choice probabilities before the games, the second column during the games. Note that among those who changed their route of travel, the choice probabilities of freeways I-110, I-10, and SR-11 (Table 3-14) before the game are much higher than in the total population (Table 3-13). All three were major venue access routes. Also, the probability of not choosing a freeway is lower (26.3 percent) in the group which changed its route than in the total population (31.6 percent), meaning that of those who changed their route during the Olympics, a greater proportion were normally freeway users than in the entire sample. The choice probabilities of freeways before and during the games for people who changed their route to work (Table 3-14) indicate that there was a large decrease in usage of I-110. This is consistent with the drop in traffic observed on I-110. As mentioned in Chapter Two, parallel arterials, Figueroa and Flower

TABLE 3-14

CHOICE PROBABILITIES OF FREEWAYS TO AND FROM WORK
FOR PEOPLE WHO CHANGED THEIR ROUTE DURING THE GAMES

Freeway	Before Olympics	During Olympics
Santa Ana (I-5)	10.5%	9.2%
Santa Monica (I-10)	21.2%	26.7%
Pasadena (SR-11)	16.3%	13.2%
Pomona (I-60)	4.3%	1.9%
Ventura/Hollywood (SR-101)	6.2%	3.9%
Harbor (I-110)	35.1%	24.3%
San Bernardino (I-10)	3.0%	1.4%
All Other Freeways	20.6%	23.0%
No Freeways	26.3%	38.6%

n = 159

Streets, were operated as a one-way couplet, providing an alternate route for traffic in the area. In contrast, somewhat heavier traffic during the Olympics was observed on I-10, and Table 3-14 indicates somewhat higher choice probability for this facility. This result is consistent with the traffic volume data discussed in Chapter Two. The other significant change was a shift from the freeways to arterials. Note that this shift is of the same magnitude as that of I-110 usage.

3.2.3 Mode of Travel

It was anticipated that many commuters would change their mode of travel during the Olympics to avoid driving in the expected heavy congestion. In fact, only a small number of all employees changed their commute mode during the Olympics. Those who did change cited numerous reasons for doing so, as shown in Table 3-15. The most frequently cited

TABLE 3-15

REASONS FOR CHANGING MODE

Characteristic	Percentage of Those Who Changed*
Employer encouraged	52.4
Media encouraged	29.9
Wanted to help reduce congestion	34.2
Avoid anticipated Olympic traffic	71.2
Olympic work schedule prevented from using regular mode	8.0
Other	4.3

*Total is higher than 100% because more than one reason could be chosen.

reasons were to avoid anticipated Olympic traffic (71.2 percent) and employer encouragement (52.4 percent).

Table 3-16 gives the mode choice distribution for each regular work day during the Olympics, as well as for before and after the Olympics. The data show that mode shares for drive alone, vanpool, and bus dropped, while the carpool share increased during the Olympics. When the mode choice data is partitioned by firms, it is evident that most of this shift took place at one firm, as will be further discussed below. Mode shares remained relatively constant during the Olympics. Fluctuations in vanpool and transit modes were likely due to vacations and other absences.

Commuters were asked whether changes in mode choice made during the Olympics were maintained after the Olympics. Not surprisingly, the data show that the games have had very little impact upon mode choice in the post-games period.

TABLE 3-16

PERCENTAGE DISTRIBUTION OF MODE OF TRAVEL

Date	Drive Alone	Carpool	Vanpool	Bus	Other
Before	50.2	22.0	5.5	20.6	1.6
Monday 7/30	48.7	23.9	5.1	20.4	2.9
Tuesday 7/31	49.6	23.7	5.1	19.7	2.3
Wednesday 8/1	49.2	23.6	5.0	20.1	2.3
Thursday 8/2	49.0	24.0	4.8	20.4	2.0
Friday 8/3	49.8	23.4	4.6	20.1	2.3
Monday 8/6	48.6	23.7	4.7	21.1	2.3
Tuesday 8/7	48.6	23.4	4.9	20.9	2.4
Wednesday 8/8	50.5	22.1	4.8	20.5	2.2
Thursday 8/9	50.1	22.7	4.8	20.5	2.2
Friday 8/10	51.9	23.0	4.2	18.8	2.6
Average during Olympics:	49.6	23.3	4.8	20.3	2.3
After	48.6	21.6	6.0	22.2	1.6

3.2.4 The Four Firms

The survey results indicate that response to the Olympics differed dramatically from firm to firm. These differences apparently reflect different strategies adopted by management to deal with the Olympics, as well as each firm's regular policies regarding employee work schedules.

As mentioned earlier, all four firms are involved to some degree in employee transportation programs. The extent of these programs differ widely, however. Firm A has one of the most extensive programs in the region; it sponsors employee vanpools and buspools, promotes carpools, and subsidizes public transit fares. Firm C has the most intensive flexible work hours program among the four firms. Firms B and D have more traditional programs, concentrating primarily on ridesharing services provided by Commuter Computer.

Employers had a number of options for dealing with the Olympics. They could encourage vacations and grant extra time off, shift work hour schedules, and/or promote modified work weeks. They could also encourage employees to work temporarily at work sites closer to home, promote ridesharing and transit use, or do nothing.

Differing policies with respect to employees' time off is reflected in the individual firm's absence data presented in Table 3-17. Firm C had the highest vacation rate, closely followed by Firms B and A. Firm D had the lowest vacation rate. Since Firm D anticipated being very busy during the Olympics, management did not encourage employees to take time off. Firm B had the largest number of employees working at an alternate work place, while Firm C was the only firm which had a significant number of employees on the modified work week (4 days, 10 hours/day).

Flexibility in work hour scheduling was increased during the Olympics by all firms. Table 3-18 presents data on choice of work hours for each firm, before and during the Olympics. The non-Olympics pattern was maintained during the Olympics; that is, the firm which gave employees the most freedom in choosing work hours under normal conditions also gave the most freedom during the Olympics, and the firm giving the least choice under normal conditions also gave the least choice during the Olympics. However, a large shift to giving employees greater discretion in choosing work hours occurred at all the firms. Firm C provided the most flexibility during the Olympics, as is also evident by the large number of employees who worked on a modified week schedule during the Olympics.

TABLE 3-17

DISTRIBUTION OF THOSE WHO DID NOT WORK AT
USUAL WORK PLACE, BY FIRM

Firm A

Date		Vacation	Alt. Work Place	Mod. Week	Other
Monday	7/30	10.3	1.8	0.4	3.9
Tuesday	7/31	11.7	2.9	-	3.5
Wednesday	8/1	9.6	2.5	0.4	4.3
Thursday	8/2	10.0	3.2	0.4	2.1
Friday	8/3	13.9	2.2	1.1	3.2
Monday	8/6	12.5	2.2	0.4	3.2
Tuesday	8/7	11.7	2.6	0.4	1.8
Wednesday	8/8	12.1	3.2	0.7	3.9
Thursday	8/9	12.8	3.9	0.4	4.7
Friday	8/10	16.4	3.6	0.7	5.3

Firm B

Date		Vacation	Alt. Work Place	Mod. Week	Other
Monday	7/30	11.3	10.4	-	1.4
Tuesday	7/31	10.8	10.1	0.3	1.8
Wednesday	8/1	11.1	11.3	0.4	2.4
Thursday	8/2	12.0	9.7	0.3	1.9
Friday	8/3	14.1	10.4	0.3	2.5
Monday	8/6	15.1	9.8	0.3	1.5
Tuesday	8/7	13.3	10.0	0.1	1.8
Wednesday	8/8	13.4	10.6	0.3	2.0
Thursday	8/9	13.9	9.3	0.1	2.4
Friday	8/10	15.6	9.4	0.3	2.5

Firm C

Date		Vacation	Alt. Work Place	Mod. Week	Other
Monday	7/30	13.5	2.2	9.7	1.5
Tuesday	7/31	13.5	2.4	0.3	1.3
Wednesday	8/1	13.8	2.7	0.5	1.5
Thursday	8/2	14.8	2.6	0.2	1.9
Friday	8/3	16.7	2.2	16.0	2.2
Monday	8/6	16.2	1.7	9.4	2.9
Tuesday	8/7	15.9	2.4	1.4	1.9
Wednesday	8/8	16.9	2.4	0.7	1.6
Thursday	8/9	16.9	2.2	0.9	2.4
Friday	8/10	18.6	1.2	14.7	2.4

Firm D

Date		Vacation	Alt. Work Place	Mod. Week	Other
Monday	7/30	6.7	1.5	-	3.4
Tuesday	7/31	6.4	1.8	-	4.0
Wednesday	8/1	7.1	1.8	-	3.7
Thursday	8/2	7.1	1.5	-	3.7
Friday	8/3	7.1	1.2	0.9	4.3
Monday	8/6	8.0	1.8	-	3.7
Tuesday	8/7	8.3	1.5	-	3.1
Wednesday	8/8	8.9	1.8	-	3.7
Thursday	8/9	8.3	2.4	-	3.4
Friday	8/10	8.9	2.1	0.6	3.4

TABLE 3-18

CHOICE OF WORK HOURS AS PERCENT OF TOTAL RESPONDENTS BY FIRM

	Before Olympics		During Olympics	
Firm	Employer Chose	Employee Chose*	Employer Chose	Employee Chose
A	58.5	35.0**	38.2	51.7
B	67.0	22.6	56.1	33.5
C	33.6	61.9	17.9	74.5
D	61.6	24.1	51.2	35.3

* With the approval of employer

** Row sums by firm do not sum to 100%, as "other" response not included.

Changes in daily work schedules are reflected in the shifts in employee work trip times which took place during the Olympics. Table 3-19 gives changes in employee departure times from home to work during the Olympics for each firm. The change is measured in 15-minute intervals from the usual (non-Olympics) schedule. It should be noted that these shifts cannot be attributed entirely to work schedule changes; rather, as noted earlier, some of the shift was probably made in anticipation of heavier congestion and longer travel times during the Olympics. Table 3-19 shows that Firm A had the largest proportion of employees (76.1 percent) who did not shift departure time from home to work. This is not surprising, given the large share of Firm A employees who participate in some form of ridesharing, as will be further discussed below. Shifts in departure time also were relatively limited at Firm D, where the permissible work schedule intervals (e.g., the earliest and latest work start times allowed) were not substantially altered during the Olympics. A majority of employees at Firms B and C changed departure

TABLE 3-19

DEPARTURE TIME FROM HOME, BY FIRM

Minutes Relative To Usual		Firm A Percentage	(subtotal)	Firm B Percentage	(subtotal)	Firm C Percentage	(subtotal)	Firm D Percentage	(subtotal)
	-75 and earlier	1.2		10.2		11.8		-	
	-60	1.2		4.3		11.0		2.7	
earlier	-45	1.2	13.0	2.6	39.3	5.1	47.3	1.5	16.5
	-30	4.9		6.7		9.2		4.2	
	-15	4.5		15.5		10.2		8.1	
	0	76.1		47.8		43.9		69.9	
	+15	7.7		6.1		6.3		10.4	
	+30	2.4		3.8		1.8		2.7	
later	+45	0.4	10.5	1.0	12.8	-	8.8	-	13.1
	+60	-		1.1		-		-	
	+75 and later	-		0.8		0.7		-	

times, and for all firms the shift was predominantly to an earlier schedule. The most extreme change occurred at Firm C, where almost 23 percent left for work an hour or more earlier, in keeping with the use of the modified work week at that firm.

It was pointed out earlier that shifts in mode choice among commuters were minimal during the Olympics. Mode choice data by firm presented in Table 3-20 shows that significant changes took place only at Firms B and C. At Firm A, an extremely large proportion of employees commute by carpool, vanpool, or bus. Firm A already had an exceptionally efficient employee transportation program in place; thus there was little perceived need to make special adjustments for the Olympics. Moreover, since carpool, vanpool, and bus transportation require adherence to a schedule, it is not surprising that employee work hours changed very little.

TABLE 3-20

MODAL SPLIT BEFORE AND DURING OLYMPICS, BY FIRM

Before

Modal Split	Firm A Percentage	Firm B Percentage	Firm C Percentage	Firm D Percentage
Drive Alone	26.0	72.7	46.7	65.7
Carpool	27.0	19.1	24.6	17.3
Vanpool	12.8	.9	3.6	1.5
Bus	21.0	5.0	20.7	11.4
Park & Ride	11.0	.6	3.8	1.9
Bike/Walk/Other	2.1	1.6	.7	1.8

During

Modal Split	Firm A Percentage	Firm B Percentage	Firm C Percentage	Firm D Percentage
Drive Alone	27.9	54.6	52.9	65.2
Carpool	27.8	34.2	17.9	20.3
Vanpool	11.2	.8	1.4	2.7
Bus	20.7	6.7	10.8	18.5
Park & Ride	10.0	.5	3.1	4.2
Bike/Walk/Other	2.5	3.3	1.5	1.9

The biggest change in mode choice occurred at Firm B, where large numbers of carpools were formed in response to strong encouragement by management. In fact, among all employees who changed modes during the Olympics, Firm B employees most frequently cited "employer encouragement" as their motivation. A decrease in ridesharing occurred at Firm C during the Olympics. The drive alone share increased, while carpool, vanpool, and bus decreased. This is most likely due to the shifts in work schedules (particularly to the modified work week) which made it impractical for some employees to maintain ridesharing arrangements. Interestingly, the employees of Firm C experienced greater travel time savings during the Olympics than did the average employee of any of the other firms surveyed, most likely because of unusual commute times and changes in mode choice. Finally, at Firm D, the lack of change in mode choice is in keeping with the general "business as usual" approach taken by this firm during the Olympics.

3.3 CONCLUSIONS

The survey results show that downtown employees made significant changes in travel behavior during the Olympics. An unusually high number of workers took vacation during the Olympics. Absences at downtown work places also increased due to the use of modified work week schedules and temporary assignments to alternative work sites. Work schedule flexibility for employees also increased during the Olympics, and many employees responded by shifting their work schedule. These shifts were predominantly to an earlier daily schedule, and were more pronounced in the morning (work start time) than in the evening (work end time). Results of the highway system performance analysis complement these findings.

These changes were possible because commuters were provided with a wide variety of choices. Employers gave employees greater freedom in selecting work schedules, while local transportation agencies provided detailed information on alternative commute options. Individuals were free to choose the alternative most suitable to their specific needs.

The survey results also provide some insight on relative preferences between alternative changes. The most frequent changes were in work trip scheduling and work attendance. It is reasonable that faced with a short-term situation, many would choose simply to avoid the problem completely by taking vacation or other time off. Changes in trip scheduling are also a likely choice, particularly for the short term. Unlike carpool or transit, they do not require a cooperative effort or adherence to someone else's schedule. Moreover, work trip scheduling to avoid peak traffic will result in travel time savings. Thus the benefits of such a strategy, particularly for the short term, are clear.

Conversely, it is not surprising that few changes in mode choice occurred, except where the employer made a concerted effort to organize employee carpools. The financial benefits of ridesharing are inconsequential for a two-week period, and costs in terms of longer travel times would be incurred. Thus, while ridesharing is an attractive long-term strategy for central city commuters, it was not an attractive short-term strategy.

Chapters Two and Three indicate that changes in work trip travel behavior in the central Los Angeles area contributed to the traffic conditions observed during the Olympics. Some rescheduling and rerouting of truck traffic also occurred. However, these results do not provide information on the individual impact of each of the changes observed during the Olympics. A more analytical approach is required to do so. The following chapters present the results of a simulation study conducted to evaluate the impact of specific Olympics TSM strategies.

CHAPTER FOUR

CASE STUDY SIMULATION: INTRODUCTION

The purpose of this research is to evaluate the effectiveness of the Olympics TSM program. The previous chapters have described transportation system and travel characteristics during the Olympics. These observations imply that the level of service on the highway system was the result of traffic management strategies which affected both supply and demand. However, descriptive analysis is not sufficient for evaluating the effectiveness of specific elements of the TSM program; all that can be concluded is that in the aggregate, the combination of changes made during the Olympics was effective.

From a public policy perspective, it is important to disaggregate the impact of the Olympics TSM program. The favorable outcome (e.g., satisfactory traffic flow conditions) could have been the result of the marginal impact of many strategies, or the result of the major impact of one or two strategies. The relative effectiveness of each strategy is the important issue, as potential TSM alternatives should be evaluated in terms of effectiveness as well as feasibility. Thus a method for evaluating the role of each strategy is necessary.

4.1 STUDY APPROACH

A simulation study approach was selected as the most appropriate method of analysis. Traffic conditions for a small area can be simulated using a traffic flow model. By altering inputs to the model, the impact of each change that occurred during the Olympics can be measured.

Traffic simulation models have been widely used for traffic engineering and planning (Knapp and Ghosh, 1977; May, 1981) Traffic engineering applications include signal timing optimization, intersection improvement analysis, and ramp metering. Simulation models are also used to evaluate alternative network plans, such as proposed highway routes and access points.

Traffic flow models simulate traffic flow on a network for a given traffic assignment. That is, the total number of vehicle trips as well as their origins, destinations and paths through the network are fixed. For short-term analysis, as in most traffic engineering applications, traffic simulation models are calibrated using actual traffic counts. In planning applications, the simulation model receives traffic volumes and turning movements from a traffic assignment model. The purpose of the traffic flow model is to provide information on the level of service for a given level of travel demand. Traffic flow models are time based; they simulate conditions for a given time period. Computing requirements are a function of the size and complexity of the network, as well as the level of detail of the simulation.

4.2 MODEL REQUIREMENTS FOR OLYMPICS ANALYSIS

The TSM program included both network and travel demand changes, thus the first requirement was that the simulation model had to accommodate changes in traffic assignment as well as changes in the transportation network. It was therefore necessary to use a modeling system in which traffic assignment changes could be directly input to the traffic flow model. Second, the Olympics affected both the freeway and arterial system, and the model had to have the capacity to simulate both systems in an interactive fashion. The TSM program also contained a significant transit/HOV element; thus a third requirement was the capability to incorporate these features in the simulation.

Two additional practical requirements were also identified. First, the model should be easy to manipulate, as several different scenarios would be tested. Second, computing requirements should be minimized to the extent possible.

4.3 THE TRAF MODEL

Given these requirements, the TRAF Integrated Simulation Model was selected as the most appropriate for this study. TRAF was developed by the Federal Highway Administration (1985). The TRAF model is an integration of several different traffic simulation models, and allows the total urban transportation system, freeways and arterials, to be simulated at various levels of detail. The logical structure of TRAF is designed to permit the interface of these independent models to form a coherent, integrated system. The TRAF model includes the following:

1) ROADSIM - a microscopic simulation model of traffic on a two-lane, two-way rural road.

2) NETSIM - a microscopic simulation model of urban traffic

3) FREFLO - a macroscopic freeway simulation model

4) NETFLO - a collection of macroscopic urban simulation submodels consisting of:

    Level I - a detailed macroscopic (pseudo-microscopic event based) simulation submodel of urban traffic

    Level II - a less detailed macroscopic (platoon-based) simulation submodel of urban traffic

    Level III - a very fast macroscopic simulation submodel of urban arterial traffic

5) TRAFFIC - an Equilibrium Traffic Assignment model

4.3.1 The Traffic Environment

The input to the TRAF model must convey the physical features of the traffic environment. Input is provided by the user to describe the following physical features:

- Topology of the roadway system
- Geometries of the roadway components
- Operational performance of vehicles in the system as determined by motorist behavior
- Traffic circulation on roadway system
- Characteristics of bus transit system: routes, stations, and service frequency
- Traffic volumes
- Traffic channelization on roadway components
- Intersection control devices
- Traffic composition

To make use of these input specifications, the roadway system is represented as a collection of uni-directional links (analogous to streets and freeway sections) and nodes (analagous to urban intersections or locations where roadway geometry changes). Traffic enters and exits the simulation network through entry and exit nodes. These nodes are located on the periphery of the global network. The global network is composed of one or more subnetworks, and each subnetwork is simulated by a different component model of TRAF. Different subnetworks are adjoined by interface nodes, the mechanism that preserves the flow of vehicles from one subnetwork to another.

Because there are a total of six subnetworks (1 ROADSIM, 1 NETSIM, 1 FREFLO, and 3 NETFLO) up to six subnetworks can be specified at one time. This allows the user to apply different levels of detail to each subnetwork of the global network. The choice of an appropriate model for a subnetwork depends on several factors, including the desired level of detail; computer resources available; network topology; expected level of traffic congestion; level of mass transit operations; and the precision associated with input data.

4.3.2 Model Integration

The unique feature of the TRAF model is that it allows the integration of its various component submodels. The submodels are used to simulate the operation of a single subnetwork within the global network. TRAF interfaces the adjoining subnetworks by recognition of the interface nodes. The model identifies these interface nodes by the unique number series to which these nodes are assigned. Each interface node has a corresponding "vehicle holding area" (VHA). A vehicle is stored in this holding area once it leaves a subnetwork until it can be moved by the submodel simulating traffic on the adjoining subnetwork. Model logic preserves the continuity of flow between subnetworks.

Each submodel utilizes a different representation of the traffic stream, so it is necessary to identify the traffic stream by a common method at each interface node. The common unit at these points is the individual vehicle disaggregated from the incoming stream. Just downstream of the interface node the individual vehicles are aggregated into the adjoining subnetwork-specific traffic stream. This process is handled internally within the model logic; all that is necessary is the specification of interface nodes when the standard network is constructed.

Each simulation run consists of a series of time intervals. The number of time intervals to be simulated and the temporal duration of each interval (in seconds) is specified by the user. The spatial relationship of each subnetwork to the global network is also described by user inputs. Each submodel enters the central computer memory one time during each interval, and vehicles due to enter the presently simulating subnetwork from adjacent subnetworks are removed from the VHA at the proper time. The submodel creates all traffic movements for this time interval, while vehicles arriving at adjacent subnetworks are placed in the appropriate VHA, with their scheduled time to enter the next subnetwork stored.

After a time interval has elapsed, all data pertaining to the subnetwork is stored on a peripheral unit, and the subnetwork leaves the central memory. The next subnetwork then enters the central memory and is simulated over the same time interval. This procedure is repeated until all the subnetworks of the global network have been simulated over the same time interval. This process is then repeated for all the subnetworks for subsequent time intervals until the desired length of the simulation run is obtained (e.g., until a sufficient number of intervals to correspond to the designated simulation period have been completed).

4.3.3 Submodel Selection

The selection of appropriate TRAF models to be used in the evaluation of TSM strategies employed during the Los Angeles Olympics was based on matching the input data requirements with the level of resolution desired in model output. This meant that for a given amount of desired model output, the input data collection effort would be minimized.

The desired outputs of the model included aggregate statistics on the volume of trips made on the global network and on individual links, as well as vehicle miles, travel speeds, and total travel time broken down into delay time and move time. These measures are determined for an arterial system using the NETSIM and NETFLO Level I models, but these models also include detailed information on individual vehicle operations which require additional data. This output can also be obtained using the NETFLO Level II model without the additional input data requirements. The NETFLO Level III model represents an arterial system too coarsely for this study to provide the desired level of output detail. Thus the NETFLO Level II model was selected as the most appropriate arterial submodel.

The FREFLO model outputs the same measures of effectiveness for freeway performance as the NETFLO Level II model does for the arterial system. Interface nodes allow the two models to be integrated. Thus a mixed arterial/freeway case study network could be modeled using the NETFLO Level II model to describe arterial operation and the FREFLO model to describe freeway operation.

As discussed earlier, many of the Olympics TSM program elements affected travel demand. Testing their impact requires adjustments to the origin-destination matrix. Thus TRAFFIC, the traffic assignment model, is also used. The following sections describe each of these models.

4.3.4 FREFLO

The FREFLO component of TRAF is a macroscopic freeway simulation model which represents traffic according to aggregate operational characteristics of a freeway section. These operational characteristics are the flow rate, density, and space-mean-speed within the section.

The FREFLO model is an improvement over earlier freeway simulation models in that it incorporates an equilibrium speed-density relationship in a dynamic speed equation. Other significant attributes of the FREFLO model are that it accommodates a network that is not just a single linear segment but a general collection of disjoint segments, and that it recognizes buses, carpools, and trucks and autos as different types of vehicles.

Entry on the freeway submodel is made either at the upstream end or at a freeway on-ramp. Exit is made at the downstream end of the freeway or at an off-ramp. Since FREFLO models only the movement of vehicles on the freeway system (e.g., mainline traffic only), vehicles entering at on-ramps merge immediately at the ramp gore. Similarly, when vehicles leave the FREFLO subnetwork at an off-ramp, they are deposited at the gore of the off-ramp by FREFLO and travel off the ramp under the simulation of the appropriate arterial submodel.

FREFLO allows the user to specify two types of lanes: special high occupancy vehicle lanes (HOV) for buses and/or carpools, and regular use lanes for the movement of all vehicles including buses and carpools. The user specifies the number of each type of lane, and traffic is uniformly distributed over the lanes of each type separately.

Bus traffic is accommodated in two steps. The first is the actual moving of an individual bus once it has entered the freeway system to its exit point at the proper time of arrival. The second step is to include the bus in the bus entry flow rate to ensure that an aggregate measure of the buses' impact on system performance can be made. Carpools as a second vehicle type, and autos and trucks together as a third vehicle type, are represented by aggregate variables only. Turn percentages, applicable to traffic exiting each section, apply to all vehicle types. However, use restrictions on special purpose lanes are taken into account. This last feature can be used to provide separately for turn percentages specific to special purpose and regular vehicles.

4.3.5 NETFLO Level II

This TRAF submodel is derived from the TRANSYT flow model. It has incorporated several improvements to the TRANSYT model to significantly reduce the number and complexity of user inputs and to provide improved accuracy and detail.

NETFLO II simulates the traffic stream by a collection of link-specific statistical flow histograms. These histograms describe platoon structure of the traffic stream on each network link. NETFLO Level II identifies five types of histograms:

1) Entry histograms describe platoon flow at the upstream end of a subject link. This histogram is an aggregation of the appropriate turn movement specific output histograms of all feeder links.

2) Input histograms describe platoon flow arriving at the stop line. These histograms describe the turning movements of vehicles by disaggregating the entry histogram into turn

movement specific histograms and then allowing for platoon dispersion while vehicles travel the link.

3) Service histograms describe time-history of discharge service rates for each turn movement histogram of traffic. This histogram reflects the control device applied at the intersection (i.e., traffic light, stop sign).

4) Queue histograms describe time-history of queue length for each turn movement histogram of traffic.

5) Output histograms describe the flow of traffic on the subject link through the intersection. These are the net result of the interaction of the input histograms with the service histograms for the subject link. The output histograms then correspond to the proper turn movement components of the entry histograms for the links they feed.

Buses are treated as individual entities in NETFLO II. Bus travel times along each link are simulated by the use of kinematic relationships and the effects of "dwell" time at bus stops. Bus interaction with regular traffic is explicitly considered in terms of the related traffic congestion and blockage due to spillback.

Trucks are dealt with through the impedance they cause to general traffic by their presence. They are not explicitly considered. The rates of discharging traffic are reduced to simulate the effect of longer, slower moving vehicles in the traffic flow. The user specifies the percentage of trucks in the traffic stream. Carpools are not recognized by the Level II model.

4.3.6 TRAFFIC

TRAFFIC is the equilibrium traffic assignment model of the TRAF system. It is a modified version of the "Traffic" model designed by Nguyen and James-Lefebvre (1975). Its purpose is to perform the assignment of traffic to links in a given transportation network to satisfy demand between origins and destinations such that cost to each individual user of the network is minimized. The travel cost on each link is an increasing function of the total link flow, and no explicit capacity constraint is employed on the network links.

The TRAFFIC assignment model is included in TRAF to interface the origin-destination information supplied by the user with the data requirements needed to execute a simulation run. The origin-destination information supplied by the user describes trip volumes between origins and destinations for a given period of time. The simulation model however, requires this data to be specified as link-specific turning percentages. The TRAFFIC assignment model provides these turn movement percentages on each link.

The cost function used by the traffic assignment model is based on the Bureau of Public Roads (BPR) "travel time" function:

$$T = T_o [1 + a(V/C)^b]$$

where,

- T = Mean travel time on a link
- T_o = Free-flow travel time on a link (computed by dividing the link length by the free-flow speed).
- V = Volume on the link, by turn movement
- C = Capacity on the link, by turn movement
- a,b = Coefficient to be specified

The specified cost function applies to all links and all subnetworks of the FREFLO and NETFLO models. The program reads the characteristics of the network links and the demand volumes between origin and destination pairs. The assignment solution is performed iteratively, according to the specified cost function.

The interfacing logic of TRAF is designed to perform all data manipulation internally. The logic reads and checks origin-destination the data, and then performs all the necessary data organization to provide the TRAFFIC program with its data requirements. The output of TRAFFIC is translated into turn percentages and input into the specified component simulation programs. The simulation process then automatically begins.

4.3.7 Model Output

The output of the TRAF model relevant to the evaluation of TSM strategies is the traffic assignment and network performance measures of effectiveness produced by the FREFLO and NETFLO Level II submodels. The simulation runs over each subnetwork produce statistics for each link coded in the network. These statistics are also aggregated over each subnetwork and over the global network, providing several different levels of information.

The measures of effectiveness produced by the NETFLO Level II submodel describe the operation of the arterial system in the network. This model output provides:

- The number of vehicle miles traveled, person-miles traveled, and number of trips made
- Vehicle minutes and person-minutes of travel for each link including move time, delay time, and total time

- The ratio of move time to total time
- The number of minutes per mile on each link and minutes of delay per mile on each link
- The number of vehicle seconds on each link, and the number of seconds of vehicle delay on each link
- Mean speed in MPH
- Mean number of stops on each link in percent

In addition, separate statistics classified by route are provided for any transit lines in operation. The FREFLO model output is similar to that produced by the NETFLO Level II. The operation of the freeway component of the analysis network is described by providing data on the number of vehicle trips, vehicle miles, vehicle minutes, vehicle speed, person trips, person miles, person minutes, and average person speed.

4.4 OVERVIEW OF SIMULATION CASE STUDY

The case study simulation consists of using the TRAF model to simulate traffic flow conditions for a set of alternative scenarios. Each scenario corresponds to a specific TSM measure, e.g., work schedule changes, ramp closures, one-way streets. Comparisons across different scenarios yield information on their effectiveness. The case study procedure is illustrated in Figure 4-1.

The first step in the process is the establishment of an appropriate baseline for comparison. Non-Olympic weekday AM peak hour was selected as the baseline for model calibration because more data were available for non-Olympics than for the Olympics period, enabling a more accurate calibration. Due to data availability, the baseline selected for evaluation of the TSM program was the actual Olympics condition.

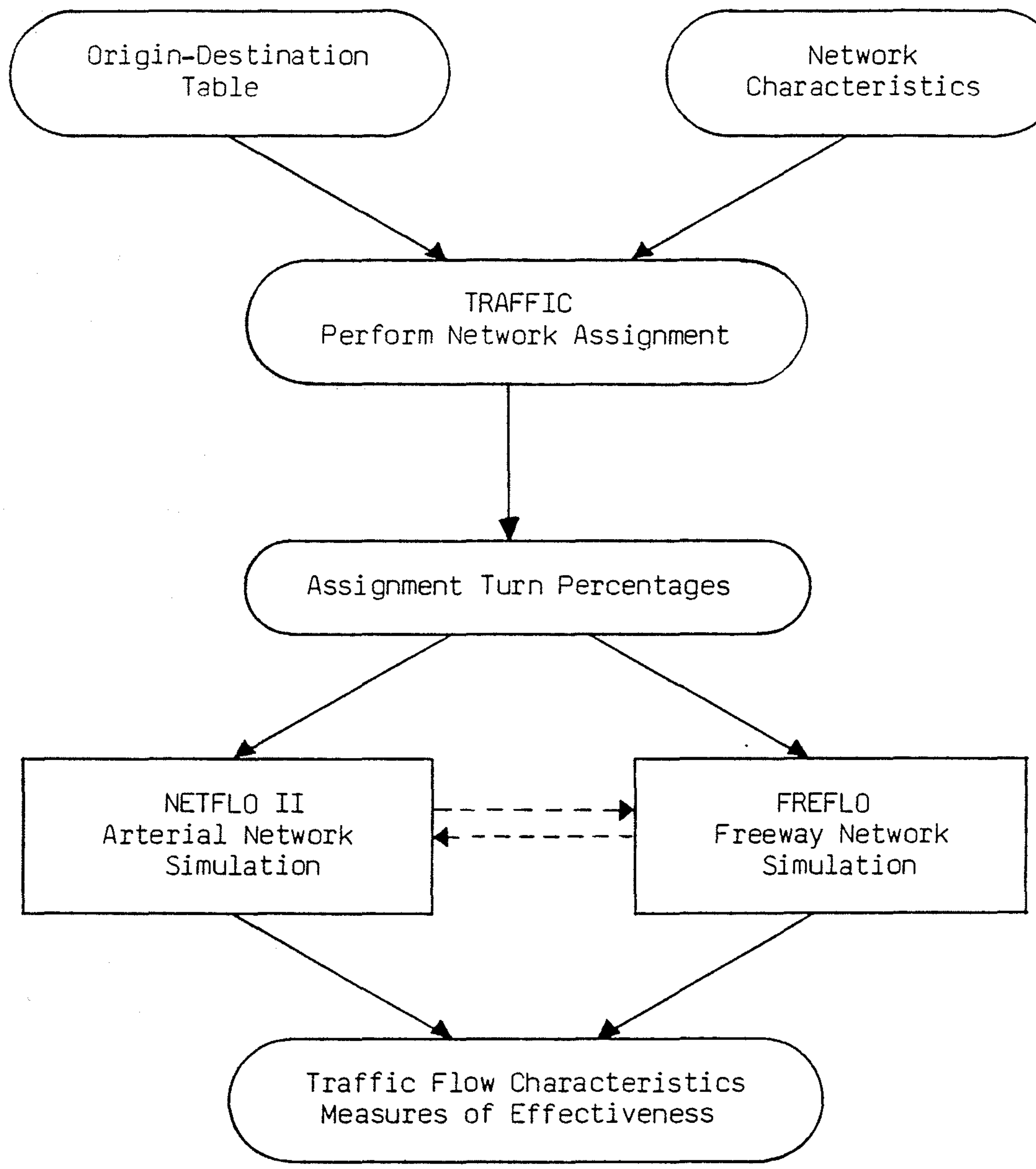


FIGURE 4-1: SIMULATION MODEL PROCEDURE

Actual flow conditions reflected the implementation of the TSM program, including both network changes and travel demand changes.

The second step is the construction of an origin-destination (O-D) table for the traffic assignment model. Two alternatives were available for this purpose: develop an updated O-D matrix by adjusting 1980 data and calibrating to actual traffic counts, or use the traffic count data to develop a synthetic O-D matrix. The latter alternative was chosen because the available traffic data were more comprehensive and reliable. Development of the baseline O-D matrices is described in Chapter Five.

Construction of the Olympics and Non-Olympics freeway and arterial networks for the FREFLO and NETFLO II models is the third step of the simulation study. The fourth step is the construction of appropriate O-D tables and networks to represent each of the TSM program elements. A simulation is conducted for each alternative, and the selected measures of effectiveness are compared to the baseline case.

4.5 SELECTION OF THE CASE STUDY AREA

The primary consideration in selecting a case study area was the extent to which the Olympics were expected to have an impact. The two most critical areas were UCLA/Westwood and Coliseum/downtown. The Coliseum area was selected as the case study site. Because of the anticipated parking shortage at the Coliseum, this venue was the focus of the most bus service, and therefore the most intensive High Occupancy Vehicle circulation plan. In addition, the one-way street couplet parallel to the Harbor Freeway was implemented. Thus the Coliseum area provided the greatest number of transportation network changes to evaluate. The Coliseum/downtown area was also expected to experience significant changes in travel demand because of anticipated traffic congestion. The study area selected is an approximately four square mile area bounded by Slauson Avenue on the south, Arlington Avenue on the west, San Pedro Street on the east, and by Washington Boulevard and I-10 on the north (Figure 4-2). The size of the study area was determined by the limits on the size of the network that could be coded. Since the network changes made during the Olympics were highly localized, it was necessary to code each arterial separately in order to capture their impact.

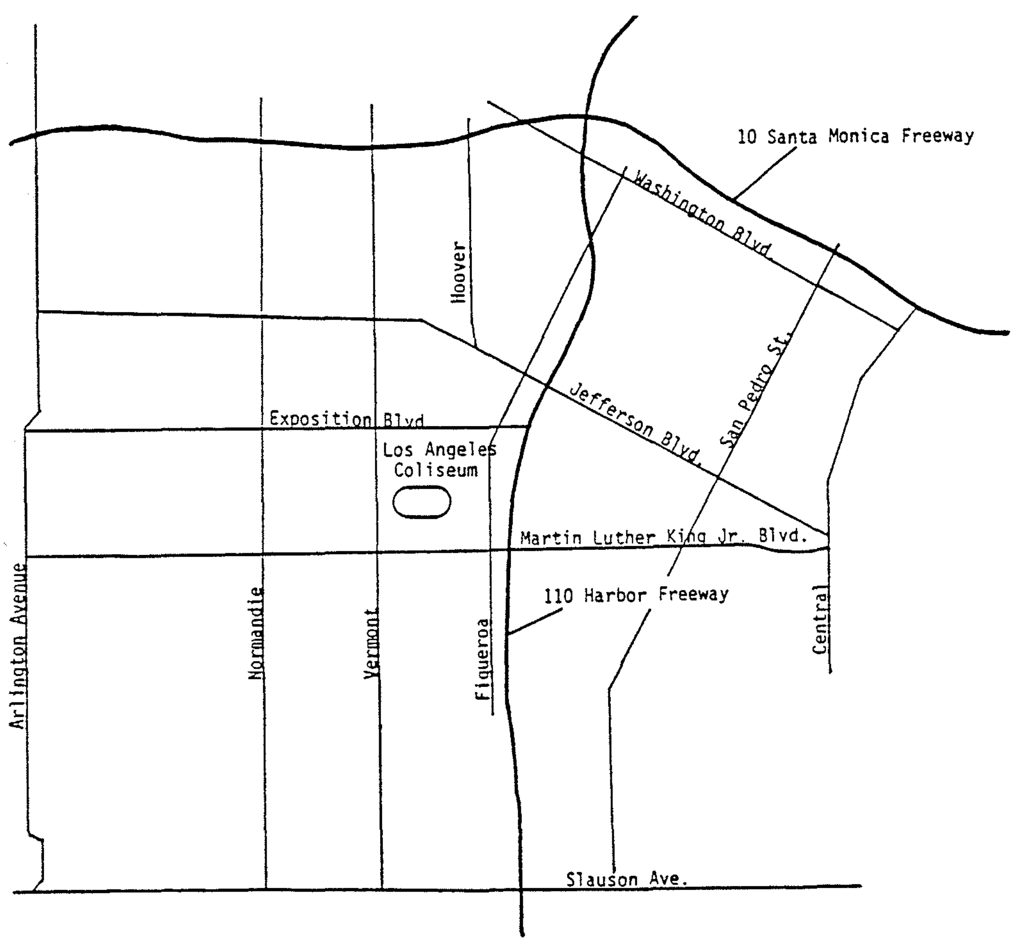


FIGURE 4-2: THE CASE STUDY AREA

The simulation study requires detailed data on transportation system characteristics, traffic flow, and trip patterns, and the Coliseum/downtown area proved to be the richest data source. Through the cooperative efforts of SCAG and the Los Angeles City Department of Transportation, traffic flow data for this area were collected both before and during the Olympics. Origin-destination data were available through the LARTS Section of Caltrans District 7. Finally, the freeway system is more extensive in the Coliseum/downtown area, and the 42-mile loop SIGMA system provided the most comprehensive and reliable traffic flow data. Thus for Caltrans' purpose, the Coliseum/downtown area was the most appropriate case study site.

CHAPTER FIVE

CASE STUDY SIMULATION: DATA AND CALIBRATION

This chapter describes the data and procedures used to develop the baseline simulations and generate the TSM program alternatives to be tested. As described in the previous chapter, the TRAF modeling system requires two types of data, origin-destination (O-D) derived travel flows and network characteristics. In this case two sets of data were required, one for the Olympics and one for the non-Olympics baselines.

5.1 TRAF MODEL NETWORK DATA

Both FREFLO and NETFLO II represent the network as a series of nodes and links. Links are specified with respect to relative location in the network. Geometric characteristics (e.g., length, number of lanes, free flow speed, discharge headway) are coded for each link. Nodes are coded according to their relative location and connections with links. For the arterial network, intersection control type and signal phasing are also coded for nodes. Figure 5-1 shows the case study network as coded for the non-Olympics baseline. The network represents as closely as possible the alignment and geometrics of the actual facilities.

Nodes also serve as entry and exit points for the network. Nodes along the periphery of network are the points of entry into and exit from the study area. Because of the small size of the case study area (only approximately four square miles), most of the trips either begin or end outside the area, and location of the peripheral nodes is a critical

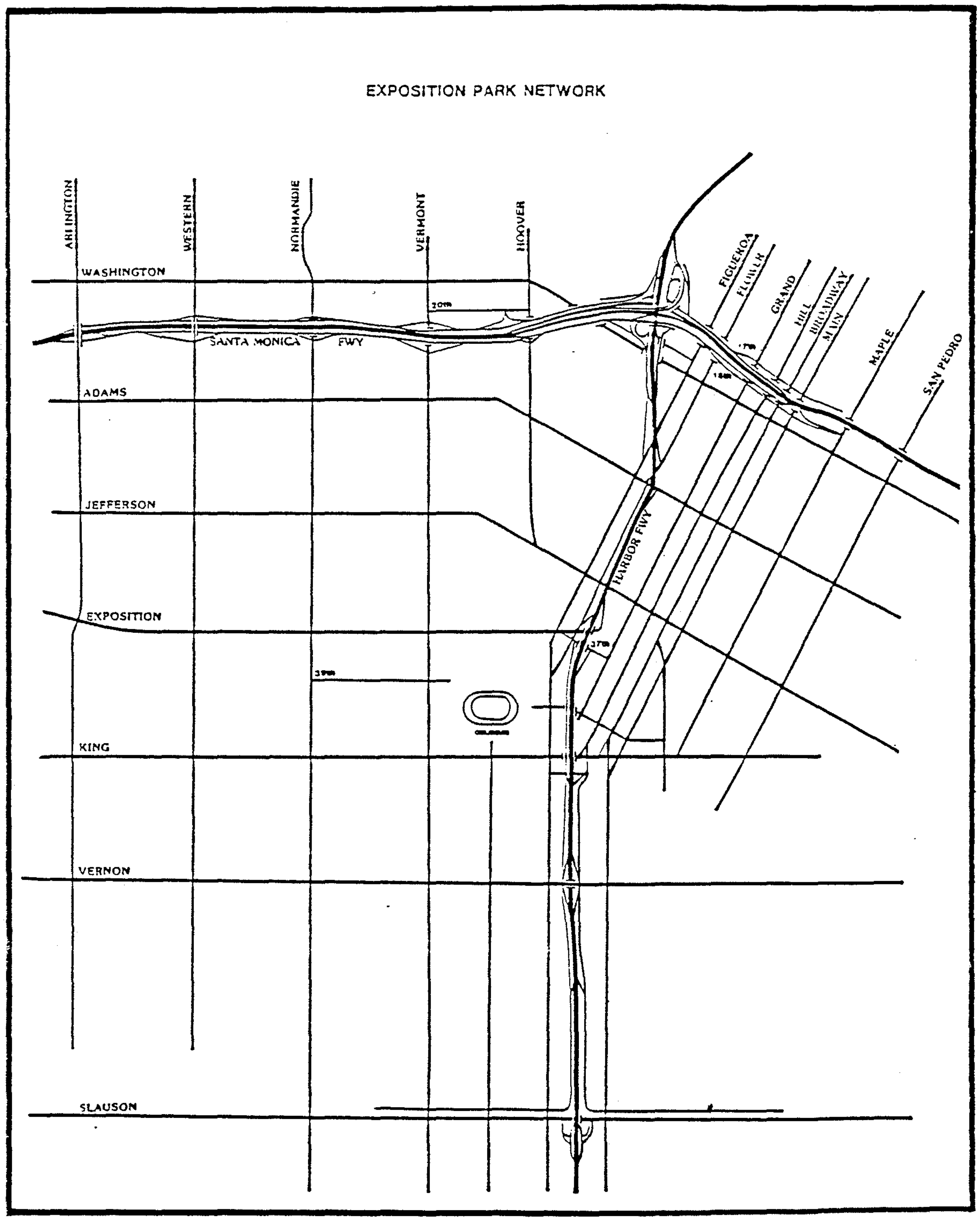


FIGURE 5-1: NON-OLYMPICS BASELINE NETWORK

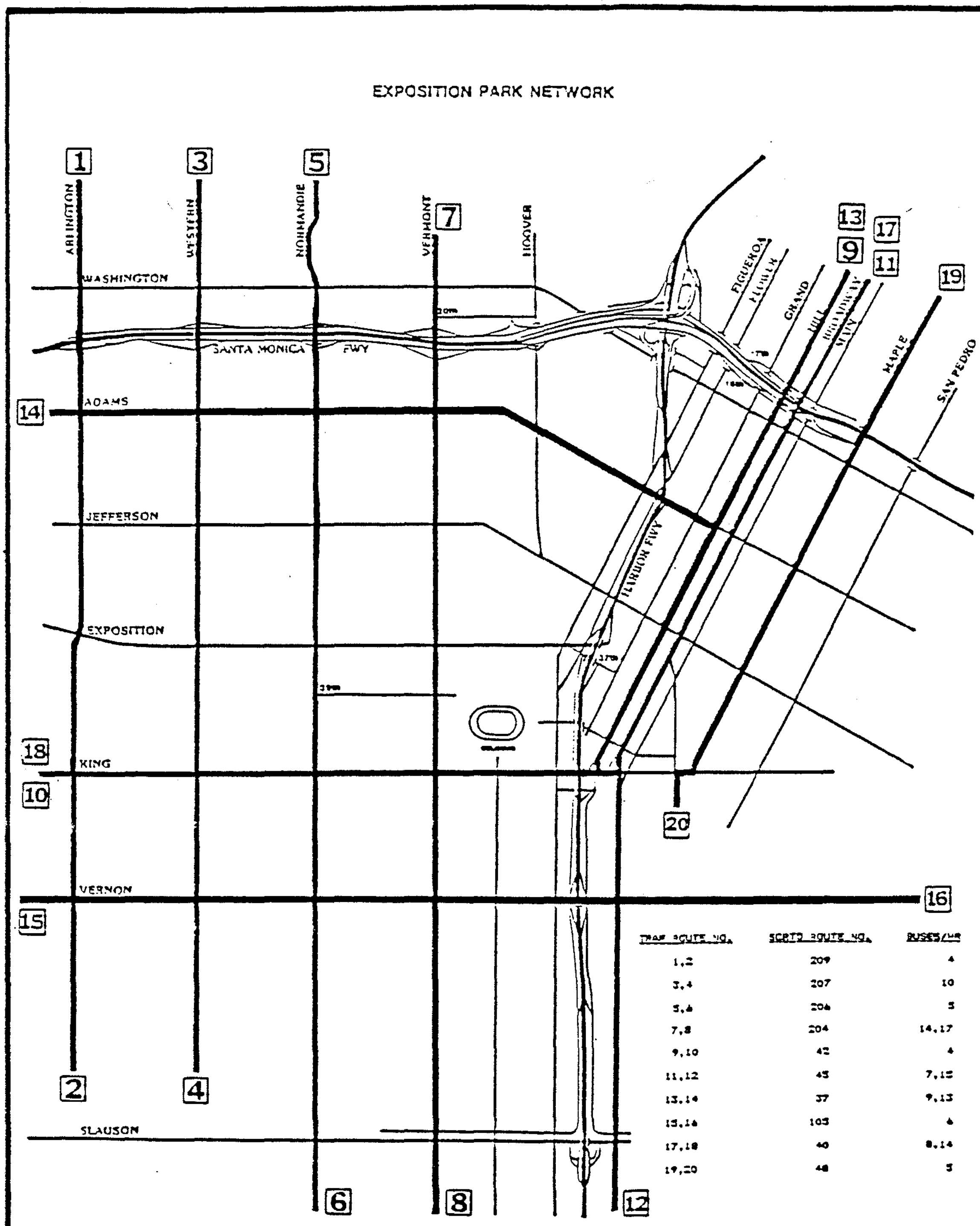
factor in calibrating the model. Origins and destinations within the study area are also represented by nodes located near major attractors.

5.1.1 The Regular Transit Network

Bus transit service is modeled separately in the TRAF system. The representation of Coliseum area transit service included 86 bus stops and 20 routes serviced by 165 buses. These routes were not changed during the Olympics, so regular transit service is identical in both the Olympics and non-Olympics baseline networks. Regular transit service as coded in TRAF is shown in Figure 5-2. Each route has two numbers, one for each direction of service. The number of buses on each route is also shown.

5.1.2 The TRAF Olympics Network

The Olympics network was generated by applying the necessary modifications to the non-Olympics network. The arterial and freeway networks were adjusted to reflect one-way streets as well as freeway ramp and street closures to automobiles. Differences in signal timing and ramp metering were also taken into account. Figure 5-3 shows the Olympics network. For comparative purposes, the Coliseum area venue plan is shown in Figure 5-4. Streets and ramps designated as "bus only" were modeled by closing those links to automobile traffic. Where specific arterial lanes were reserved for buses, the number of lanes was reduced accordingly in the link geometrics coding. Special Olympics bus and shuttle services were not modeled explicitly because the volume of service far exceeded the TRAF limits. Their impact was estimated indirectly, as will be described in the following chapter.



TRAF ROUTE NO.	SCRTD ROUTE NO.	BUSES/HR
1,2	209	4
3,4	207	10
5,6	206	5
7,8	204	14,17
9,10	42	4
11,12	45	7,12
13,14	37	9,13
15,16	105	6
17,18	40	8,14
19,20	48	5

FIGURE 5-2: TRAF REGULAR TRANSIT SERVICE NETWORK

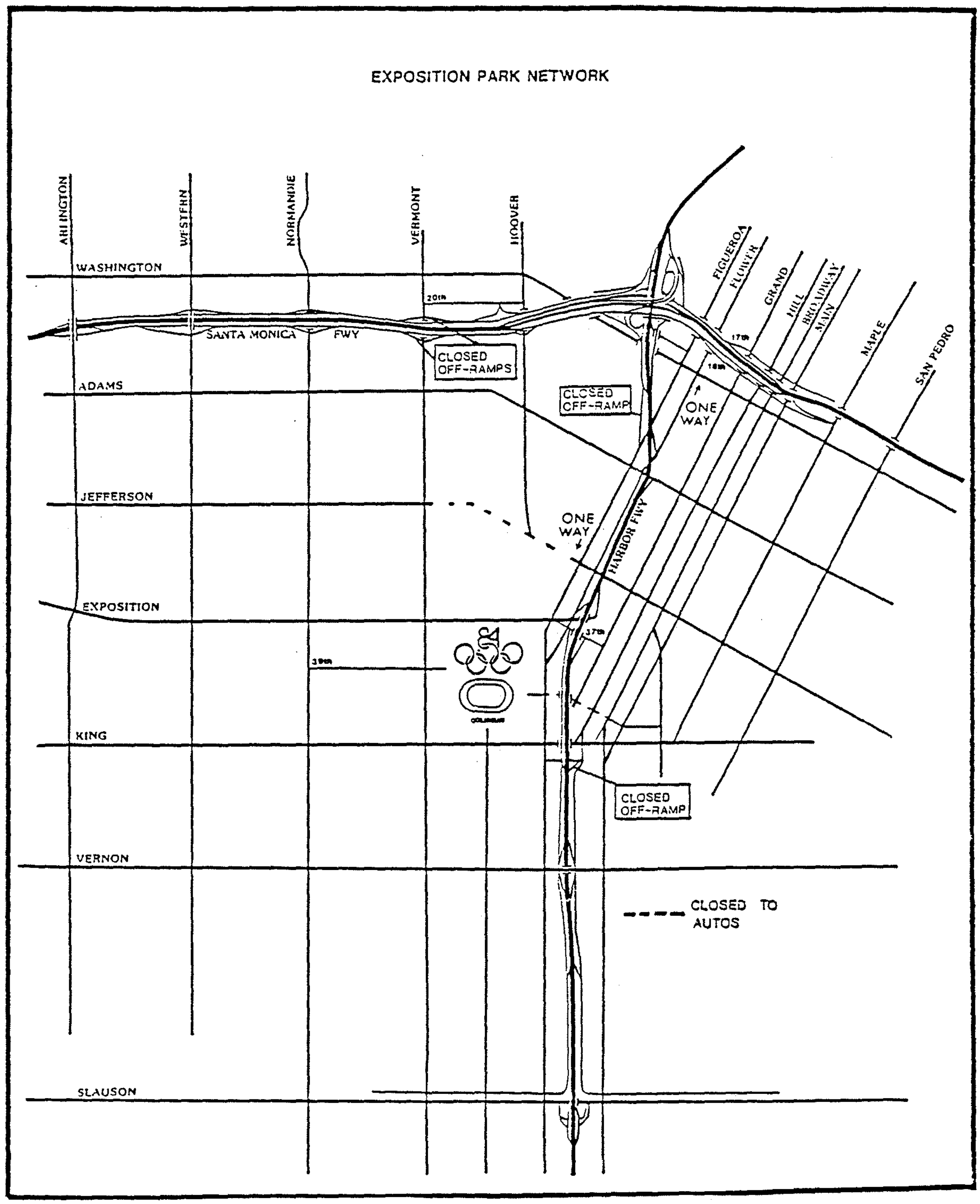


FIGURE 5-3: TRAF OLYMPICS NETWORK

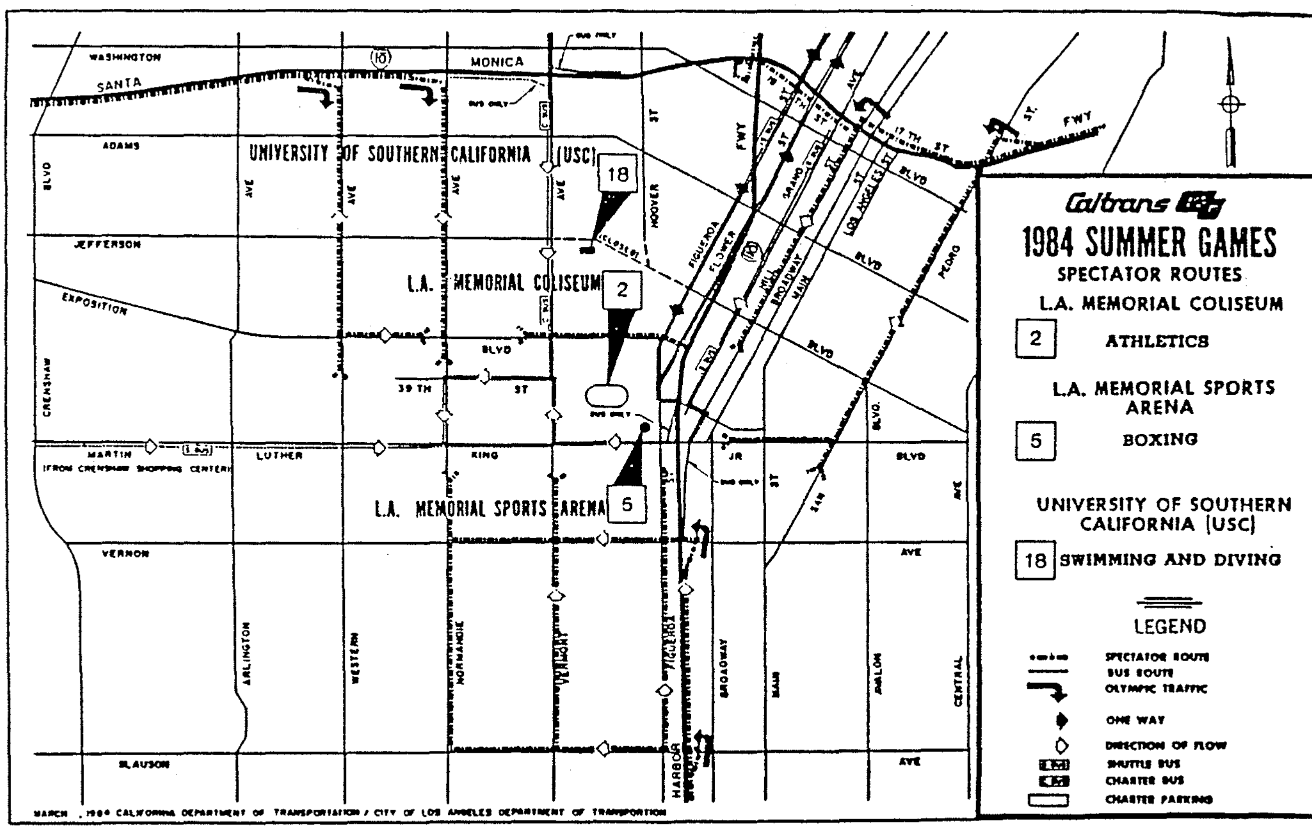


FIGURE 5-4: COLISEUM AREA VENUE PLAN

5.2 TRAFFIC MODEL DATA

Development of a satisfactory origin-destination matrix was a key element in the case study simulation, as all of the changes in travel behavior which occurred during the Olympics required manipulation of the O-D data. This proved to be the greatest challenge of the TRAF study. The basic problem was one of scale: the analysis required using a very small, detailed network, yet the only O-D data available was at the level of traffic zones, and these zones are aggregates of several census tracts. If the traditional method of locating one centroid in each zone were used, traffic flow would be skewed toward the streets closest to the centroid.

A second related problem was the relationship of the study area to the larger system. This is a common small-area analysis problem: the smaller the area, the greater the number of external and through trips. Trips to be assigned fall into three categories: internal, which begin and end within the area; external, which either begin or end outside the area; and through, which both begin and end outside the area. Because of the small size of the study area, most of the trips to be assigned were external or through trips. Thus O-D data for a much larger area was required.

5.2.1 Traditional Method of Traffic Assignment

The traditional method of traffic assignment develops a trip distribution table from origin/destination data, and assigns those trips along paths within the network. The calibration process compares the assignment model-generated link flows to actual street count data. The assignment model is calibrated by adjusting speed/density parameters until the link flows are acceptably close to the actual count data.

The traditional approach proved to be infeasible in this study for a number of reasons. The most recent O-D data was based on 1980 census data and available only at the traffic analysis zone (TAZ) level. In order to further disaggregate the O-D data, multiple centroids were identified in each zone and trip ends were uniformly apportioned among the centroids. Two sources of error were consequently introduced and comingled: the 1980 data was obviously out of date, and the attractions at each centroid were arbitrary. The O-D data were also insufficient for assigning through trips; there was no way to determine how many through trips should be assigned short of performing a region-level assignment, and available resources were insufficient for doing so. Moreover, the accuracy of the O-D data relative to the available flow data did not warrant such an approach. Rather, a new approach based on the traffic flow data was used.

5.2.2 The LINKOD Traffic Assignment

The richest set of data available to this project was freeway and arterial system data. Actual (one-way) counts for every freeway link and ramp for both Olympics and non-Olympics were obtained by Caltrans. Complete arterial information for the non-Olympics baseline including signal timing, intersection configurations, and actual turn percentages, was provided by the Los Angeles City DOT. Therefore, the most feasible approach to generating the necessary O-D data was to work backwards and generate an O-D matrix that fit the traffic flow data. This was accomplished by using the LINKOD model (Hamburg, 1979). The model was designed for short-term, small-area analysis which requires assignment data for network performance evaluation, and thus was appropriate for this project. The LINKOD model has been estimated and tested in two previous applications, and its performance was found to be acceptable (Han, et al., 1981).

LINKOD estimates a synthetic O-D trip table from the observed traffic flows. Accuracy of the estimation depends on the amount of flow data available. In this case "accuracy" is measured in terms of the ability of the estimated O-D table to replicate traffic flow conditions. LINKOD does not necessarily estimate the "true" O-D matrix, because any number of O-D combinations can lead to the same traffic flow. Previous applications indicate that reasonable results can be obtained with as little as 25 percent coverage. Actual counts were available for about 70 percent of all possible movements in the study area.

The baseline O-D matrix was estimated with LINKOD in the following manner. First, the study area network coding was transposed into LINKOD format. Next, the available O-D data provided by LARTS, adjusted for estimated 1984 zonal employment and population, was used to generate a "target" O-D matrix. The target matrix is used as the initial estimate of the matrix which generates the observed traffic flow. LINKOD then iteratively adjusts the target matrix until it generates traffic flow conditions sufficiently close to the actual counts.

The synthetic O-D matrix was then input into the TRAFFIC model. Because of differences in the assignment algorithms used in the two models, it was necessary to calibrate the LINKOD matrix in TRAFFIC. A weighted average of the summation of differences between observed and predicted volumes for all links (for which actual data were available) divided by the total observed volume was used as the criterion for calibration. The value was computed separately for under-predicted and over-predicted links. An arbitrary value of 70 percent correct on both measures was selected as acceptable calibration. With minor adjustments to both networks, 30 percent of the link volumes were overestimated and 24 percent were underestimated, yielding an overall score of 73 percent correct on the calibrated non-Olympics baseline traffic assignment.

5.3 THE OLYMPICS BASELINE

Had there been no significant changes in travel patterns during the Olympics, a traffic assignment could have been generated by applying the calibrated non-Olympics O-D matrix to the Olympics network. However, travel patterns changed significantly, and thus the non-Olympics matrix had to be modified.

5.3.1 Work Trips and Other Daily Travel Changes

The employee travel survey discussed in Chapter Three was the primary source for work-trip travel behavior changes. These include work schedule changes, absences from work, and mode choice. An estimate of the change in non-work trips was obtained from a survey conducted by the Los Angeles Times. Information on vehicle occupancy and truck traffic were obtained from the data described in Chapter Two. Transit ridership and service information was provided by Southern California Rapid Transit District (SCRTD).

The traffic simulation analysis period was one hour of the AM peak, the "peak of the peak." Given Los Angeles commute patterns, this corresponds to 7:00 to 8:00 AM. The changes that occurred during the

Olympics were adjusted according to their effect on vehicle trips during this one-hour period. For example, the impact of work schedule changes was estimated as follows. Changes in work schedules resulted in a "flattening" of the peak, as more trips occurred either before or after the peak hour. The actual reduction in the proportion of work trips made during the peak was estimated from the survey data. This factor (8 percent) was then applied to the work trip share of the O-D matrix.[1] It was assumed that work schedule changes were evenly distributed among downtown employees, that is, the reduction factor was applied to all work trips with downtown/Coliseum area destinations. The work schedule change factor was not applied to work trips outside the downtown area, because SCAG survey data showed that employee shifts were different in other areas. This process is graphically illustrated in Figure 5-5. All of the other travel behavior changes were implemented in the same manner. Thus, each demand-oriented TSM strategy was quantified in terms of peak hour vehicle trips. To give some idea of the magnitude of these changes, a total of 11,400 peak hour vehicle trips were removed due to work schedule changes, absences from work, and firm closures in the Coliseum area out of a non-Olympics baseline total of 78,400. Reductions in discretionary travel removed an additional 8,000 trips.

5.3.2 Spectator Travel

Spectator travel was an additional component to be considered in the Olympics traffic assignment. The first Coliseum event started at

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[1] The LARTS estimate of work trips making up 68 percent of all vehicle trips in the AM peak was used in this study.

9:30 AM, thus only vehicles accessing the area between 7:00 and 8:00, at least 1 1/2 hours before start time, would be included. Shuttles and park-and-ride buses were in operation by 7:00 AM, and they were incorporated into the Olympics assignment. However, the available evidence showed that spectators using private autos did not begin arriving until after 8:00 AM. Vehicle occupancy counts taken near the Coliseum area did not increase until after 8:00 AM, and aerial photographs showed that the Coliseum was more than half empty 40 minutes before start time. The literature supports these findings; virtually all vehicular traffic arrives within one to one and one half hours of a sporting event start time (Ashwood, 1973; Thayer and Ax, et al., 1973; JHK, 1975). Consequently no additional vehicle trips were added to the baseline Olympics O-D matrix.

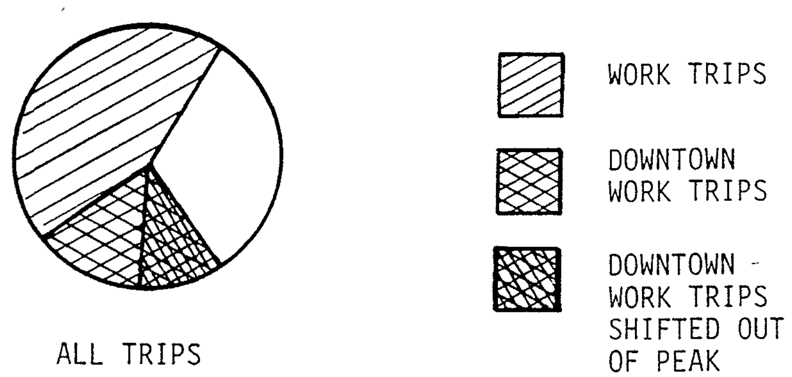

FIGURE 5-5: IMPACT OF WORK TRIP SCHEDULE CHANGES ON O-D MATRIX

5.3.3 Baseline Olympics Calibration

The Olympics calibration was performed by applying TRAFFIC to the Olympics O-D matrix and network. Much less arterial actual count data were available for the Olympics. However, speed studies had been conducted during the Olympics, and the calibration was based on both speed and volume data. Because of the integrity of the baseline matrix, few adjustments were necessary for calibration. Link volumes on the calibrated network were 87 percent correct, and the under- and over-predictions were approximately equal. However, because fewer actual counts were available, this does not necessarily mean that the Olympics baseline calibration is more precise than the non-Olympics baseline.

5.4 DEVELOPMENT OF THE TSM PROGRAM SCENARIOS

The TSM program strategies to be tested were divided into two general categories: supply-side and demand-side strategies. These were further subdivided into spectator and non-spectator strategies. The list of program strategies is presented in Table 5-1. A work trip mode shift scenario was not included because no significant shift took place. The demand and supply aspects of the Olympics transit service were combined since the HOV system was developed specifically for the transit operation. A global scenario was also simulated in order to quantify the cumulative impact of all of the TSM strategies. A total of ten different scenarios were simulated.

A final issue to be resolved was the appropriate method of measuring the impact of these strategies. Two choices were considered. One was to estimate a worst case scenario, assuming no changes had been made to accommodate the Olympics, then implement each of the strategies

TABLE 5-1

TSM PROGRAM STRATEGIES EVALUATED IN THE SIMULATION STUDY

Demand Side		
	Non-Spectator	Work Scheduling Work Absences Non-Work Travel Truck Traffic
	Spectator	Olympics Transit/HOV System
Supply Side		
	Non-Spectator	One-Way Streets Ramp Metering Ramp Closures
	Spectator	Olympics Transit/HOV System Event Scheduling
Global		All Strategies

and measure the improvement they generate. The other choice was to use the Olympics baseline and remove each of the strategies individually. In this case the impact had the strategy not been implemented is being measured. The latter alternative was chosen because the Olympics baseline was a more reliable basis of comparison. To summarize, then, each strategy is evaluated by appropriately adjusting the O-D matrix or the network, performing the traffic simulation, and comparing the results to the baseline simulation. Chapter Six presents results of the simulation study.

CHAPTER SIX

CASE STUDY RESULTS

The purpose of the Olympics TSM program was to efficiently accommodate Olympic spectator traffic while minimizing disruption of regular traffic. The results of the case study simulation provide the best estimate of the role each of the TSM strategies played in accomplishing this objective.

6.1 DEMAND STRATEGIES

The TSM strategies aimed at managing transportation demand relied on the voluntary actions of individual travelers. Local agencies conducted intensive promotional efforts to persuade travelers to avoid key locations and peak travel times and to utilize mass transportation services to access Olympic events, but there were no requirements for doing so. The changes in travel behavior that took place during the Olympics reflect the choices made by individuals to cope with the expected travel conditions, and the outcome was the result of these choices. Travel behavior changes were made in the context of available alternatives and constraints, and these changes provide some rare insight on relative preferences between the available strategies.

This analysis reflects the extent to which changes in demand took place. Measurement of their effectiveness is not based on some arbitrary level of implementation, but on actual behavior as observed during the Olympics. That is, the relative effectiveness of each strategy is evaluated based on the degree to which it occurred during the Olympics.

Each strategy is evaluated by comparing performance of the baseline Olympics scenario to a scenario with the selected strategy removed, as described in Chapter Five. Performance is evaluated by comparing various "measures of effectiveness," MOEs, between the two scenarios. The MOEs include freeway and arterial speed, freeway and arterial delay, total travel time on the system (global vehicle hours), and global network speed. Freeway delay is measured as the amount of time vehicles are traveling below 40 MPH, and arterial delay measures stop time. Global vehicle hours is the total amount of time vehicles are traveling on the sytem, and global speed is simply total VMT divided by global vehicle hours.

6.1.1 Non-Spectator Travel Changes

Measurable non-spectator travel changes include work schedule changes, absences from work (days off, vacations, and firm closures), reductions in non-work travel, and reductions in truck traffic. As mentioned in Chapter Five, changes in mode choice, another strategy promoted in the TSM program, did not occur, and therefore is not simulated. Each strategy is evaluated by adjusting the O-D network.

Results of the analysis are given in Table 6-1. Values for the six MOEs and the percent change from the baseline are given for each of the four scenarios. The reported Olympics baseline freeway and arterial speeds are quite reasonable. These are systemwide averages, and thus incorporate the congestion at bottleneck areas like the Harbor-Santa Monica interchange area. The arterial speeds reflects intersection delay time as well as link speeds. As expected, each strategy has some impact, and the change in the delay measures is much greater than the change in

TABLE 6-1

CONTRIBUTIONS OF NON-SPECTATOR TRAVEL CHANGES
TO SYSTEM PERFORMANCE

	MOE					
Scenario	Freeway MPH	Freeway Delay (VH)	Arterial MPH	Arterial Delay (VH)	Global MPH	Global VH
Baseline	35.5	316	13.9	1,671	24.1	5,914
Work Schedule Change	33.8	494	12.6	2,202	22.3	6,972
Percent Change From Baseline	-5%	+56%	-9%	+32%	-7%	+18%
Absence from Work	24.5	1,732	12.4	2,349	18.8	8,469
Percent Change	-31%	+448%	-11%	+40%	-22%	+43%
Reduce Non-work Trips	25.4	1,485	12.5	2,369	19.0	8,140
Percent Change	-28%	+370%	-10%	+42%	-21%	+38%
Reduce Truck Traffic	34.4	417.5	13.1	2,024	22.8	6,577
Percent Change	-3%	+21%	-6%	+21%	+5%	+11%

speed. Recall that in each case the given strategy was removed from the baseline scenario. The results measure the deterioration in system performance that would have occurred had the strategy not been implemented during the Olympics.

The results in Table 6-1 show that reductions in work trips and non-work trips had the most favorable impact on system performance. This is reasonable, since these strategies removed a greater number of trips.

However, their impact relative to the other two strategies was far greater than the actual difference in the number of trips removed, illustrating the increasing marginal impact of additional trips on a congested network. The results also indicate that global impact depends both on the absolute magnitude of the change in demand and its distribution on the system. Table 6-2 gives total vehicle miles traveled (VMT) on the arterial and freeway networks for the same four scenarios. As might be expected, work-related changes had more impact on the freeway system, since work trips are, on average, longer than non-work trips and therefore more likely to be freeway trips. For example, comparing absences from work and non-work trip reductions, absences from work removed 10,415 freeway VMT and 6,096 arterial VMT, while non-work reductions result in removing 4,456 freeway VMT and 7,527 arterial VMT. In terms of VMT, reduced truck traffic had the same effect on both

TABLE 6-2

VMT ON FREEWAY AND ARTERIAL NETWORK
FOR NON-SPECTATOR TRAVEL CHANGE SCENARIOS

Scenario	Freeway VMT	Change from Baseline	Arterial VMT	Change from Baseline
Baseline	99,320	N/A	43,373	N/A
Work Schedule Change	107,577	8,257	47,701	4,328
Absence from Work	109,735	10,415	49,469	6,096
Reduce Non-Work Trips	103,776	4,456	50,900	7,527
Reduce Truck Traffic	102,980	3,660	46,889	3,576

systems, a direct result of the assumed uniform distribution of truck traffic in the O-D matrix employed in generating this scenario.

Reduced truck traffic was the least effective non-spectator TSM strategy according to the simulation study, but these results may be somewhat misleading. Truck volumes in the case study area are very low--1 to 2 percent--and consequently they have little impact. Had the simulation been conducted for an area with more truck traffic, the results would have been different. In addition, the FREFLO and NETFLO II models represent trucks as car equivalents, and thus cannot capture the impact of the poorer performance characteristics of trucks.

6.1.2 Spectator Travel Change

Olympics transportation planners conducted an intensive promotional effort to induce spectators to use the transit system. Many park-and-ride, shuttle, and express buses were employed to provide access to the Coliseum and other major venues. A system of bus-only facilities was devised to serve the Coliseum area. These included bus-only off-ramps from the two freeways, and bus-only lanes on arterials leading to the Coliseum (see Figure 5-4). The spectator bus service was operating during the AM peak.

This strategy was simulated by assuming that the bus service did not exist. All of the Olympics transit users were assumed to originate from the same area as the bus they took, to travel at the same time, and to carpool at the observed Olympic vehicle occupancy rate of 2.5 persons per vehicle. During this simulation the bus-only ramps and arterial lanes were opened to all traffic. Table 6-3 presents the results.

TABLE 6-3

CONTRIBUTION OF OLYMPIC SPECTATOR TRANSIT USE TO SYSTEM PERFORMANCE

	MOE					
Scenario	Freeway MPH	Freeway Delay (VH)	Arterial MPH	Arterial Delay (VH)	Global MPH	Global VH
Baseline	35.5	316	13.9	1,671	24.1	5,914
No Transit	28.4	1,108	8.9	3,497	17.4	8,815
Percent Change From Baseline	-20%	+251%	-36%	+109%	-28%	+49%

At the global level, spectator transit use has a somewhat greater impact than work-trip reductions. However, since all of the extra trips are converging on the Coliseum, the impact on the arterial system in absolute value is far greater than in any of the other scenarios. The results indicate that had the transit service not been available and utilized, freeway and arterial speed would have decreased 20 and 36 percent, respectively. Freeway delay would have increased about 2 1/2 times, and arterial delay would have more than doubled. Transit patronage data indicated that the Coliseum spectator mode split was about 45 percent. These results demonstrate that the Olympics transit service played an extremely important role in managing Olympics traffic.

6.2 SUPPLY STRATEGIES

The most significant changes in the transportation network during the Olympics occurred in the Coliseum area. These included one-way streets, ramp closures (including the HOV ramps which were closed to general traffic), and ramp metering.

6.2.1 One-Way Streets

In this scenario the one-way streets that provided improved access to the Exposition Park area and supported bus HOV lanes were returned to two-way operation. The HOV lanes still existed on the two-way streets. This scenario tested the effects of designating Figueroa and Flower Streets open to southbound and northbound traffic, respectively. The configuration of Figueroa Street in two-way and one-way operation are shown in Figures 6-1 and 6-2. The configurations of Flower Street in two-way and one-way operation are illustrated in Figures 6-3 and 6-4. Table 6-4 shows that the implementation of one-way streets had a slight positive effect on the arterial system and a negative impact on the freeway system.

When Figueroa and Flower Streets were taken out of one-way operation, predicted total arterial average speed dropped 1.4 percent and total arterial delay increased by 2.4 percent. At the locations where these network changes occurred--Figueroa and Flower Streets--the impacts of the one-way facilities are more apparent. In one-way operation these facilities carried slightly less traffic, but at considerably higher speeds and with much less delay.

Table 6-5 shows that Figueroa Street accommodated 4,115 southbound vehicle trips over its one-way portion, as compared to 4,577 over this same portion in two-way operation. Average speed in one-way operation was 15.9 MPH and 6.4 MPH in two-way operation. Estimated delay was 1.75 minutes per vehicle mile in one-way operation compared to 7.42 minutes per vehicle mile in standard operation. Table 6-6 shows that a greater improvement occurred when Flower Street was converted to one-way operation: 5,406 northbound vehicle trips occurred over the portion of Flower Street designated one-way, while 5,394 occurred on this same section in conventional operation. The average speed of traffic on the one-way facility was 18.6 MPH, a considerable increase from the 11.3 MPH obtained when Flower reverted back to two-way operation. Delay was 1.22 minutes per vehicle mile under one-way operation and 3.44 minutes per vehicle mile under two-way operation.

TABLE 6-4

CONTRIBUTION OF NETWORK CHANGES TO SYSTEM PERFORMANCE, HOLDING OLYMPICS TRAFFIC CONSTANT

Scenario	Fwy Speed (MPH)	Fwy Delay (Veh-Hrs)	Art Speed (MPH)	Art Delay (Veh-Hrs)	Global Veh-Hrs	Global Speed (MPH)
Baseline	35.5	316	13.9	1,671	5,914	24.1
One-Way Streets	37.2	190.8	13.7	1,712	5,837	24.5
Percent Change From Baseline	+4.8%	-39.6%	-1.4%	+2.4%	-1.3%	+1.6%
Ramp Closures	37.2	186.1	14.4	1,593	5,739	25.1
Percent Change	+4.8%	-41.1%	+3.6%	-4.6%	-2.9%	+4.1%
Ramp Meter	35.4	324.9	13.9	1,681	5,935	24.0
Percent Change	0	+2.85	0	0	0	0

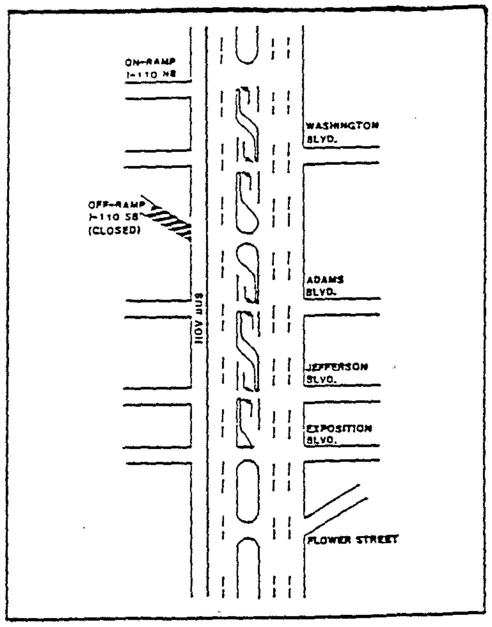

FIGURE 6-1: FIGUEROA STREET IN TWO-WAY OPERATION

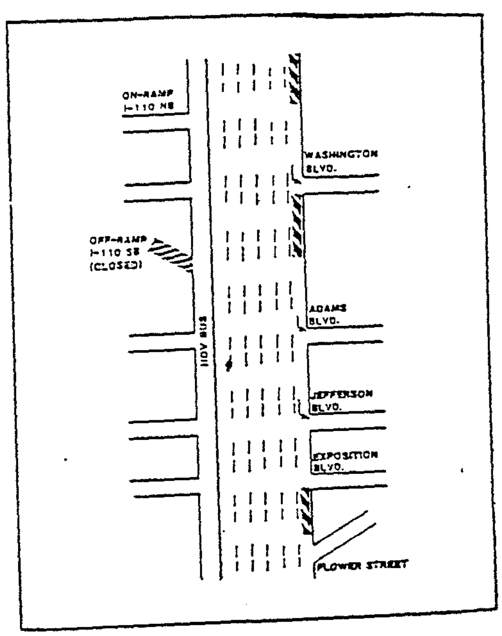

FIGURE 6-2: FIGUEROA STREET IN ONE-WAY OPERATION

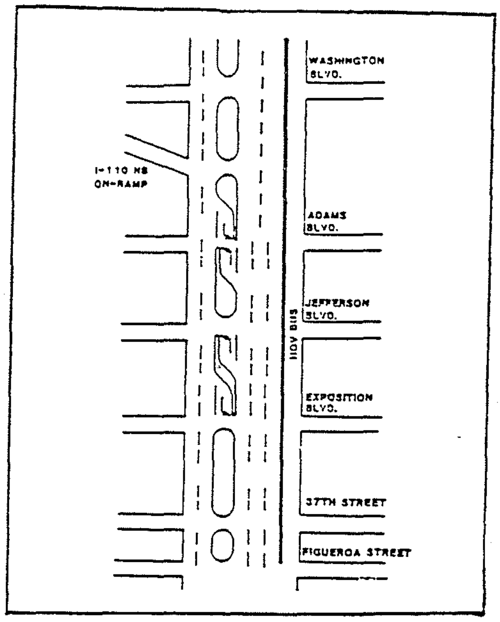

FIGURE 6-3: FLOWER STREET IN TWO-WAY OPERATION

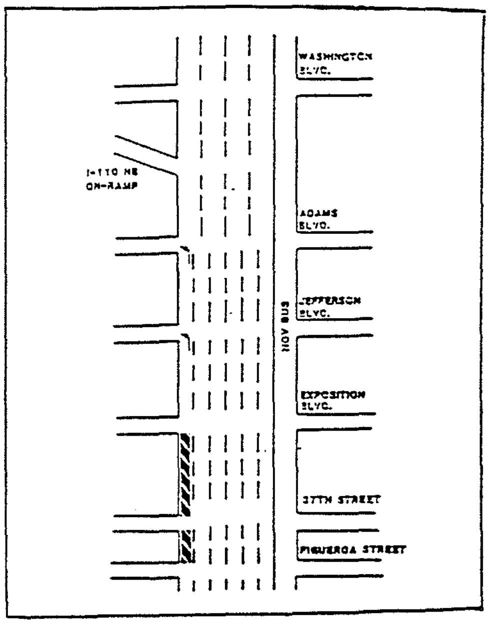

FIGURE 6-4: FLOWER STREET IN ONE-WAY OPERATION

TABLE 6-5

EFFECT OF FACILITY TYPE ON ARTERIAL PERFORMANCE: FIGUEROA STREET

	Trips	Veh-Mi	Veh-Mins	Speed (MPH)	Delay (Veh-Mins)
One Way (SB)	4,115	819.3	3090.9	15.9	1432.8
Two Way	4,577	959.6	9048.6	6.4	7124.5
Percent Change From One Way	+11.2%	+17.1%	+192.7%	-59.7%	+397.2%

TABLE 6-6

EFFECT OF FACILITY TYPE ON ARTERIAL PERFORMANCE: FLOWER STREET

	Trips	Veh-Mi	Total Time (Veh-Mins)	Speed (MPH)	Delay (Veh-Mins)
One Way (NB)	5,406	1127.2	3628.7	18.6	1374.1
Two Way	5,394	1007.5	5356.5	11.3	3463.2
Percent Change From One Way	-0.2%	-10.6%	+47.6%	-39.2%	+152.0%

Table 6-7 combines the information in Tables 6-5 and 6-6 and compares the total effect of one-way operation on Figueroa and Flower Streets with their use as two-way streets. Without the use of one-way streets, the total number of trips increased by 4.7 percent and vehicle miles increased by 1.1 percent. However, with two-way operation speed decreased by 52.9 percent and delay was increased by 277.2 percent. This translates into 1.44 minutes of delay per vehicle mile under one-way operation and 5.38 minutes per vehicle mile under two-way operation.

When the one-way streets were removed, a 4.8 percent increase in freeway speed resulted, indicating that one-way operation had a negative effect on freeway performance. This increase in speed reduced freeway delay by 39.6 percent. The degradation of the freeway system was the result of congestion caused on the eastbound Santa Monica Freeway near Figueroa and Flower. This congestion also affected the interchange with

TABLE 6-7

EFFECT OF FACILITY TYPE ON ARTERIAL PERFORMANCE

	Trips	Veh-Mi	Total Time (Veh-Mins)	Speed (MPH)	Delay (Veh-Mins)
One Way	9,521	1946.5	6719.6	17.4	2806.9
Two Way	9,971	1967.1	14405.1	8.2	10587.7
Percent Change From One Way	+4.7%	+1.1%	+114.4%	-52.9%	+277.2%

the Harbor Freeway. Improved circulation on Grand, Hill, and Broadway as a result of the one-way facilities on Figueroa and Flower attracted more traffic in the area, and generated a capacity problem at the Grand Avenue off-ramp from the eastbound Santa Monica Freeway. At the global network level, speed increased 1.6 percent when the one-way streets were returned to two-way operation. This increase in speed reflected a 1.3 percent decrease in vehicle hours.

Although traffic signal timings and phasings were held constant, and signal optimization was not employed when evaluating the effectiveness of one-way streets, additional analysis indicated that the benefits of converting these streets to one-way operation were enhanced when traffic signals were optimized. Global network speed under these circumstances was 2.7 percent higher with one-way street operation. Thus, any consideration of implementing one-way streets on a permanent basis should be based on optimized signal timings.

6.2.2 Ramp Closures

The closure of freeway off-ramps to vehicular traffic in order to make these ramps accessible only to HOV buses, had the greatest negative impact on the transportation system (Table 6-4). Both arterial and freeway network performance deteriorated in the presence of ramp closures. Four ramps were closed; two at Vermont Avenue from the east- and westbound Santa Monica Freeways, one at Martin Luther King Jr. Boulevard from the northbound Harbor Freeway, and one from the southbound Harbor Freeway to Adams Boulevard.

Freeway traffic responded to these ramp closures by utilizing alternate off-ramps in close proximity to the ramps closed. Table 6-8

TABLE 6-8

FREEWAY OFF-RAMP VOLUMES

Off-Ramp Location	Volume (VPH) With Ramp Closures	Volume (VPH) With No Ramp Closures	
I-10 WB/Vermont	closed	548	
I-10 WB/20th Street	606	455	-24.9%
I-10 EB/Grand	1273 (congested)	1456	
I-10 EB/Vermont	closed	223	
I-10 EB/Western	298	220	-26.2%
I-10 EB/Normandie	246	195	-20.7%
I-10 EB/Hoover	542	421	-22.3%
I-110 NB/King	closed	520	
I-110 NB/Vernon	598	378	-36.7%
I-110 NB/37th Street	364	308	-15.4%
I-110 NB/Adams	1170	1053	-10.0%
I-110 SB/Adams	closed	765	
I-110 SB/Exposition	618	356	-42.4%
I-110 SB/Flower Drive	166	81	-51.2%

provides volumes for freeway off-ramps most affected by the ramp closures. Most of the off-ramps that received the diverted traffic operated considerably under capacity. These ramps accommodated the additional traffic without a decline in speed, as did the freeway sections immediately upstream of these off-ramp locations. The speeds of freeway sections in the area of the ramp closures also experienced no change in speed.

The one exception responsible for most of the deterioration in freeway performance associated with the ramp closures was the Santa Monica Freeway eastbound off-ramp at Grand Avenue. The simulation model showed heavy congestion at this location due to the closure of the Harbor Freeway southbound off-ramp at Adams Boulevard, resulting in a ramp speed of only 2.0 MPH. This congestion affected the eastbound Santa Monica Freeway back to the interchange with the southbound Harbor, as shown in Figure 6-5. This one area of congestion accounts for 115.4 percent of the total difference in freeway delay estimated between the baseline and no ramp closures scenarios. This percentage is greater than 100 percent because although the difference in total freeway delay for these two scenarios was 129.9 vehicle hours, at just the congested location discussed above the difference between scenarios is 149.9 vehicle hours for freeway delay. The extra 20 hours of freeway delay does not show up

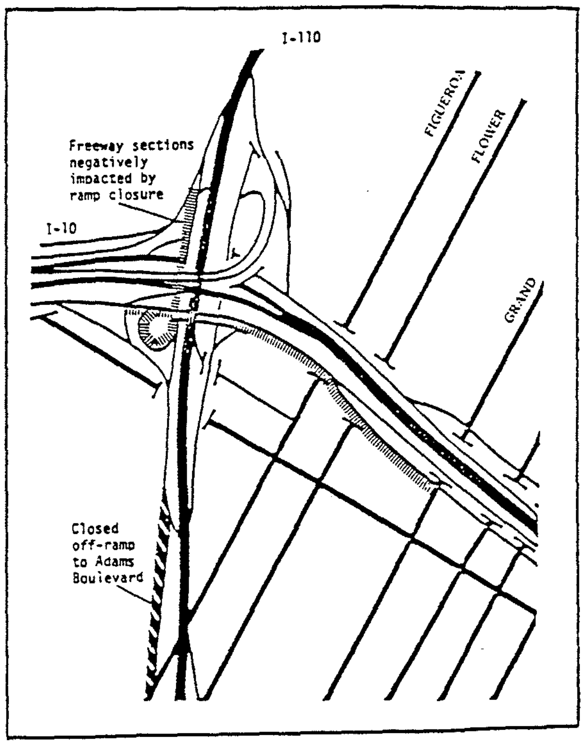

FIGURE 6-5: FREEWAY SECTIONS AFFECTED BY OFF-RAMP CLOSURE

in the table because it is nullified by improvements in freeway speed that resulted throughout the network from the ramp closures. Delay is the most sensitive of all the measures of effectiveness and is affected by even very small changes in speed. Therefore, these spread-out locations totaling the 20 hours of decreased delay associated with the ramp closures do not represent locations where significant improvements occurred. The identification of so much delay on the congested section verifies that it was the sole contributor to the decline in freeway performance when the ramps closures were made. With all ramps in service and the Grand Avenue off-ramp relatively uncongested, freeway speed increased by 4.8 percent to just over 37.0 MPH, and delay on the freeway decreased by 41.1 percent.

Once off the freeway system, these trips re-routed over arterials until they picked up their original routes. However, not all trips that were diverted from an arterial by a closed off-ramp found their way to that facility. In the case of Vermont Avenue, for example, southbound traffic volumes increased by 37.0 percent when the closed off-ramps were reopened.

On the Santa Monica Freeway, the model predicted that vehicles adapted to the closure of Vermont Avenue off-ramps by utilizing ramps located before these closed facilities. On the westbound Santa Monica Freeway, the primary route to Vermont Avenue was to exit the freeway via the 20th Street off-ramp and access Vermont from 20th Street. This alternate route was easily identified by the considerably higher volume of traffic experienced on 20th Street between the off-ramp and Vermont Avenue when the Vermont ramp was closed. With the ramp closure, 20th Street accommodated 431 vehicle trips, as opposed to 278 vehicle trips when the ramp was reopened. The ramp to 20th Street experienced a 25 percent reduction in volume when the closed ramps were reopened. The increased travel volumes on 20th Street reduced the average speed from 22.1 MPH to only 2.2 MPH. When the ramps were reopened this congestion was alleviated and normal operating speeds returned.

On the eastbound Santa Monica Freeway off-ramps to Western, Normandie, and Hoover, each received a portion of the traffic volume that would have normally been serviced by the Vermont off-ramp. In the cases where the Western and Normandie off-ramps provided alternate routes to the Vermont ramp closure, the model trips accessed Vermont by traveling eastbound on Adams Boulevard. At the Hoover off-ramp, trips accessed Vermont via Hoover and Adams for southbound travel, and via Hoover and 20th Street for northbound travel. The magnitude of traffic volumes diverted to each alternate ramp was similar, ranging from a 21 to 26 percent decrease in volume when the closed ramps were reopened.

Similar diversion of traffic occurred on the Harbor Freeway with the King and Adams Boulevard off-ramp closures. Northbound off-ramps that received diverted traffic included the ramps at Vernon Avenue, 37th Street, and Adams Boulevard. Southbound off-ramps that experienced heavier volumes due to ramp closures included Exposition Boulevard and Flower Drive.

The overall effect of the ramp closures on vehicles on the arterial network was to decrease arterial speed and increase delay. With the reopening of the closed ramps, arterial speed increased by 3.6 percent and delay decreased by 4.6 percent. Global network performance with all off-ramps in service improved with a 4.1 percent increase in speed and an almost 3 percent decline in total vehicle hours. The simulation results for both the one-way streets and ramp closures graphically illustrate the interdependence of the arterial and freeway networks, and demonstrate the need to evaluate TSM strategies for the system as a whole.

6.2.3 Ramp Metering

This scenario was developed to test the effects of ramp metering on network performance. Unlike the previous two scenarios, this strategy could be tested by adding it to the baseline, as there was no ramp metering in the baseline case. In this scenario all freeway on-ramps in the study network were metered at the rate of 900 vehicles per hour.

Ramp metering had no significant impact (Table 6-4). This was the case because no on-ramp in the network had a volume in excess of the metering rate. The only measurable impact of ramp metering was a 2.85 percent increase in freeway delay imparted on the metered trips. Because the metering of vehicles entering the freeways did not improve their operation and only increased total freeway delay, the metering of these trips was unwarranted. However, these results are also somewhat misleading, as the simulation period was the AM peak, a time when on-ramp volumes in this vicinity are low. Had a PM peak simulation been conducted, the results would no doubt have been quite different.

It may be noted that in the three scenarios discussed above many of the observed differences in performance are of small magnitude. Therefore, the question of how significant these differences might be is of interest. Given that the network changes themselves were quite minor in the context of the network as a whole, it would seem that these small differences are an accurate reflection of the effect of limited network modifications on total network performance. Furthermore, the observed differences between these scenarios and the baseline were considerably greater in the vicinity where the change occurred. Therefore, while the absolute validation of simulation output is impossible, the comparative analysis across MOEs for the different simulations does provide a meaningful way to evaluate these strategies.

6.2.4 Conclusions on Network Changes

Ramp closures had the most severe effects on the movement of traffic in the study area. The global reduction in vehicle hours when the ramps were re-opened was 2.2 times as great as the reduction associated with the removal of the one-way streets. Similarly, the increase in global network speed was 2.5 times greater with the re-opening of the closed ramps as compared to the elimination of the one-way streets.

The fact that in this study global statistics improved with the removal of one-way streets should not overshadow the fact that performance on the one-way facilities improved as compared with two-way operation. This is particularly true since, when traffic signal optimization was considered, global statistics actually declined with the removal of the one-way streets.

It is also important to consider the trade-offs that exist between arterial network performance and freeway network performance when discussing global network statistics. Often, as was the case with one-way street implementation, a strategy that benefits the arterial system will produce negative impacts for the freeway system. With the use of one-way facilities, capacity improved on Figueroa and Flower Streets, but at the expense of producing travel volumes on an adjacent freeway off-ramp that caused congestion and delay on the freeway system. Similarly, ramp closures, while causing no deterioration in freeway performance, have the potential for disrupting arterial and street flows when these facilities provide alternate routes for the closures. Policy guidelines for the implementation of TSM strategies must take these trade-offs into consideration.

The improvement of operation on Figueroa and Flower Streets in one-way operation could be attributed to the removal of bottlenecks that occurred on these facilities in two-way operation. These bottlenecks on the two-way facilities were relatively short sections of roadway that easily became congested. Another potential benefit of one-way street operation is the simplification of signal phasings and reduction of delay by eliminating protected turn movements on the formerly two-way approaches. The scenarios analyzed in this report held signal phasings and timings constant when considering the effectiveness of one-way streets, however the actual implementation of one-way streets would include signal modifications. Safety can also be improved by the use of one-way streets which separate opposing flows of traffic.

The ramp closures and creation of one-way streets had similar impacts on the freeway system. The magnitudes of the speed increases and delay reductions when these network modifications were removed were very similar.

No conclusions can be drawn from this study regarding the effects of ramp metering other than the fact that when vehicles are erroneously metered at freeway entrances delay is increased. This was the case because all of the on-ramps in the study network experienced volumes below the metering rate. A PM peak period of analysis in this case study area would be more conducive to studying the effects of ramp metering. Furthermore, the use of a simulation model to determine the effectiveness of ramp metering would probably be more successful if it involved using a microscopic simulation model.

The HOV facilities that provided access to the Coliseum area for large volumes of spectators resulted from the network modifications discussed above. The minimal negative impacts to auto traffic in order to provide HOV bus service were more than offset by the benefits of shuttle, express, and park-and-ride bus services, as discussed in Section 6.1.2 above.

Finally, to provide the "best picture" of simulated Olympic traffic conditions, all of the supply-side TSM strategies were employed simultaneously with signal optimization. With signal optimization, arterial speed increased 22.3 percent to 17.0 MPH from the non-optimized Olympic baseline arterial speed of 13.9 MPH. Arterial delay decreased 30.3 percent in the presence of signal optimization. The optimized arterial speed increased global network speed by 9.5 and reduced global vehicle hours by 6.7 percent.

6.2.5 Olympics Event Scheduling

A final supply-side strategy is that of scheduling major Olympic events. As mentioned earlier, Coliseum events were scheduled to avoid the heaviest weekday peak periods, and as a result, very little Olympic spectator traffic was present during the AM peak hour (7:00 to 8:00 AM). In order to measure the impact of event scheduling, the final simulation assumes a Coliseum starting time of 8:00 AM. Utilizing Coliseum attendance data, mode split information, vehicle occupancy counts, and

TABLE 6-9

CONTRIBUTION OF SCHEDULING OLYMPIC EVENTS OUTSIDE PEAK PERIOD

	MOE					
Scenario	Freeway MPH	Freeway Delay (VH)	Arterial MPH	Arterial Delay (VH)	Global MPH	Global VH
Baseline	35.5	316	13.9	1,671	5,914	24.1
Peak Start	14.3	4,445	7.3	4,484	12,832	11.0
Percent Change from Baseline	-59.7%	1,306%	-47.5%	+168.3%	+117%	-54%

SCRTD forecasts of spectator origin points, the additional trips were estimated and the O-D matrix adjusted accordingly. Table 6-9 gives results.

Scheduling the Olympic start time at 8:00 AM adds 26,840 trips to the O-D matrix, all of which are destined for the Coliseum zone. Not surprisingly, the impact on both the freeway system and arterial system is severe: freeway speed is reduced by half, and arterial speed declines by a similar amount. Delay on both systems increase by orders of magnitude. It should be noted that the Olympics transit service is in effect, thus the change is entirely due to moving (carpool) vehicle trips that had occurred between 8:00 and 9:30 into the peak hour. Comparing these results with those of the other scenarios (Tables 6-1, 6-3, and 6-4) shows that event scheduling had the single greatest impact--about twice as great as spectator transit use, absences from work, or reductions in non-work trips. These results are biased in the sense that the case study area is the area which would have been most heavily impacted. On the other hand, because spectator trips were much longer (on average) than other trips, they would have had an impact far beyond the Coliseum area. It is also worth noting that this scenario has by far the greatest negative effect on the freeway system. A possible explanation is that freeways attract more trips because of the relatively more favorable travel speed, leading to overcapacity conditions which result in a rapid deterioration in level of service.

6.3 THE OVERALL IMPACT OF THE OLYMPICS TSM PROGRAM

The case study simulation results indicate that the various elements of the TSM program contributed in varying degrees to the traffic conditions observed during the Olympics. Another way of evaluating their impact is to estimate what might have happened had none of the TSM strategies been employed. That is, what would have happened if there were no changes in non-spectator travel behavior, no Olympics transit service, no changes in the network, and no effort to avoid scheduling Olympic events during the peak? Two "worst case" scenarios were simulated to show what might have happened, and the results are given in Table 6-10. "Black Monday" assumes no change in travel behavior and no changes in the network; spectator travel has the baseline non-Olympics non-work mode split and vehicle occupancy. "Black Monday with Transit"

TABLE 6-10

THE OVERALL IMPACT OF THE OLYMPICS TSM PROGRAM: WORST CASE RESULTS

	Freeway Speed	Delay	Veh-Trips	VMT
Baseline Olympics	35.5	316	16,921	99,320
Black Monday	2.8	28,180	8,826	85,421
Black Monday + Transit	4.2	18,767	11,010	91,128

	Arterial Speed	Delay	Veh-Trips	VMT
Baseline Olympics	13.9	1,671	24,060	43,373
Black Monday	3.0	11,872	30,592	45,687
Black Monday + Transit	4.3	9,351	33,842	53,270

	Global Speed	Delay	Veh-Trips	VMT
Baseline Olympics	24.1	5,914	40,981	142,693
Black Monday	2.9	40,052	39,418	131,108
Black Monday + Transit	4.2	28,118	44,852	144,398

is the same as Black Monday, except that a 40 percent mode split for spectator travel is assumed.

The results in Table 6-10 imply the type of traffic conditions transportation planners feared and wanted to avoid. The system falls into breakdown conditions and capacity drops significantly, as indicated by the number of trips. Although approximately 50,000 and 28,000 trips were added to the non-Olympics baseline O-D matrix respectively in these two simulations, the global number of trips actually dropped in the Black Monday scenario and increased by only 4,000 in Black Monday with Transit.[1] This is the result of heavy congestion; some of the trips were never able to enter the network. To illustrate, spillback (vehicle queuing) occurred on four links in the baseline Olympics simulation and on 11 links in the baseline non-Olympics simulation. Spillback occurred on 95 links in Black Monday and on 71 links in Black Monday with Transit. Congestion is so extensive that vehicles literally fill up all of the available roadspace. Thus as freeway traffic queues up, more trips are diverted to the arterials until the level of service is approximately equal on both systems (note the similarity of arterial and freeway speeds in the two scenarios). Since there is actually more space on the arterial system, it carries a much greater proportion of the trips. This is reflected both in the number of vehicle trips and VMT. Had no changes been made to accommodate the Olympics, the threatened gridlock conditions may have indeed occurred.

6.4 CASE STUDY CONCLUSIONS

The case study simulations have provided a means for measuring the impact of each of the TSM strategies implemented during the Olympics. Table 6-11 summarizes the results by rank-ordering the simulated strategies by their global impact. The table provides several

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[1] The vehicle trips reported by TRAF do not directly correspond to the O-D trips, as trips are counted by subnetwork. Any trip using both arterials and freeways is counted as two trips.

TABLE 6-11

RELATIVE IMPACTS OF OLYMPIC TSM PROGRAM STRATEGIES

Scenario	Impact on Global Speed* (Percent)	Impact on Global Veh-Hrs* (Percent)
Event Scheduling	-54%	+117%
Spectator Transit Use	-28%	+49%
Absence from Work	-22%	+43%
Reduce Non-Work Trips	-21%	+38%
Work Schedule Change	-7%	+18%
Reduce Truck Traffic	-5%	+11%
Ramp Metering	0	0
One-Way Streets	+1.6%	-1.3%
Ramp Closures	+4.1%	-2.9%

* Compared to baseline Olympics.

interesting insights. First, as noted previously, Olympics event scheduling clearly was the most effective of the strategies tested. Had major events conflicted with regular peak-hour traffic, a great deal of congestion (delay) would have resulted. Second, absences from work and reductions in non-work trips were approximately equally effective, and nearly as effective as spectator transit use. Third, work schedule changes and reductions in truck traffic had a smaller impact than any of the other demand-side strategies, but their impact was significant. The differences between the demand-related strategies are a direct result of the number of trips they remove. The increase in absences from work during the Olympics, for example, resulted in a greater reduction in peak hour work trips than shifts in work hours.

In contrast, the traffic engineering strategies--ramp metering, ramp closures, and one-way streets--have mixed effects. As discussed earlier, ramp closures near the Harbor/Santa Monica Freeway interchange caused significant spillback and delay which more than offset improvements in other locations. Similarly, one-way streets improved arterial system flow but caused a deterioration in freeway performance. These results are not unexpected, since the same number of trips must be accommodated on the system. Only strategies which can significantly improve traffic throughput are effective. Thus, the addition of signal timing optimization generates a global benefit for these strategies. It should be noted, however, that many of the network changes were made to accommodate the Olympics transit service, and the small negative impact on regular traffic was more than offset by benefits of the transit service. The special HOV facilities carried a great many more person-trips than the adjacent general traffic lanes.

It should be noted that these results are reflective of the case study area selected, and cannot be generalized to all of Los Angeles. Had a larger case study area been used, the impact of the demand-side strategies possibly would have been more pronounced relative to the supply-side strategies because of the limited supply-side options available. For example, higher than normal absences from work occurred throughout Los Angeles, and consequently probably had a widespread positive impact on traffic conditions. The impact of the Olympics spectator-related strategies is also a function of the case study area, since Coliseum-bound travel amounted to a large proportion of the total travel in this area. While the absence of Olympics transit service would have resulted in severe traffic problems in the Coliseum area, it is doubtful that serious problems would have occurred outside the downtown area, as long as most of the spectator travel did not compete with peak commute periods. On the other hand, had events been scheduled during the peak, traffic congestion would have been severe throughout the area.

These results also illustrate that demand-oriented strategies are potentially far more effective than supply-oriented strategies, with the notable exception of event scheduling, because demand-oriented strategies reduce the amount of travel that must be carried by the system. Given the level of congestion that exists at peak hour, any reduction in trips generates a greater than proportional reduction in delay. On the other hand, supply-side strategies can only improve the flow of trips on the network, and in the absence of significant increases in capacity (e.g., adding a lane), the potential for improvement is limited.

Finally, these results must be interpreted in the proper context. The case study simulations provide a good estimate of the relative effectiveness of the TSM strategies employed during the Olympics, given the level at which they were implemented. They do not provide good absolute estimates because the simulation approach is approximate and subject to error. Moreover, they also cannot be directly generalized to a larger area, because the Coliseum area is not necessarily representative of congested urban areas.

CHAPTER SEVEN

CONCLUSIONS

This research has provided a comprehensive analysis of the Olympics TSM program. Changes in system performance and travel behavior were documented, and the effectiveness of various TSM strategies was evaluated. Thus, the question of what worked has been answered. The final issue remaining is whether the Olympics experience can provide insight for transportation policy.

7.1 SUMMARY OF RESEARCH FINDINGS

7.1.1 System Performance

The extensive data collection effort showed that highway performance was most affected in the central Los Angeles area. The only significant and consistent traffic volume reductions were observed on I-110 in the vicinity of the Coliseum. In other areas, traffic volumes were lower than normal during the first week, but gradually increased to regular summertime levels by the second week. Traffic volume data reflected limited changes in work scheduling (e.g., shifts to an earlier peak), again primarily in the central area. The traffic volume data suggested that Olympics-related trips replaced other trips; this observation was corroborated in the travel survey data. Due to data limitations, traffic congestion during the Olympics could not be measured. Indirect evidence based on speed data for the second week of the Olympics indicated that reductions in congestion were largely due to reductions in traffic volumes.

The central area concentration of impact was also evident in truck traffic patterns. Peak-hour truck traffic was lower during the Olympics, and the one all-day count available suggested that truck scheduling had changed in response to the Operation Breezeway program. Peak hour/peak direction traffic declined and night traffic increased.

Traffic incident patterns during the Olympics were mixed. Fewer accidents occurred within the central portion of Los Angeles County compared to the previous year, but more major incidents occurred. The high level of surveillance and response capability is credited with minimizing the impact of these incidents. A larger sample of truck accident data showed few differences in accident patterns and characteristics during the Olympics.

7.1.2 Travel Behavior

The downtown employee survey conducted for this research showed that commuters made many changes during the Olympics. The most frequent change was absence from the regular place of work; employee absences were higher than usual due to vacations, use of the modified work week, rescheduled holidays, temporary transfers to offices closer to home, and firm closures.

The commuter work trip also changed during the Olympics. Travel time averaged 14 percent less than before the Olympics. Travel time savings was due in part to changes in work scheduling; about one-third of the commuters shifted their commute time, and most shifted to an earlier time, thus avoiding peak hour congestion. Some commuters shifted their travel route, and commuters who regularly used the I-110, I-10, and SR-11 were most likely to change. These routes were all major venue access routes. The shift of commute trips from I-110 to the parallel one-way streets was reflected in the survey data.

Contrary to the expectations of Olympics planners, there was little change in mode choice among commuters during the Olympics. This is not surprising, given the number of other choices available to commuters and the short-term nature of the adjustment.

The downtown survey also demonstrated the importance of employer policies in affecting commuter behavior. The provision of flexible work hours and modified schedules gave employees a wide range of options for modifying their commute trip. An increased level of ridesharing occurred at only one firm, where management had made it a priority to reduce vehicle trips during the Olympics. The survey data also revealed that all of the employers provided more flexibility in work scheduling during the Olympics.

7.1.3 Simulation Study

The simulation study provided a means for evaluating the relative impact of the various TSM strategies implemented during the Olympics. The simulation study was of somewhat broader scope, as both spectator and non-spectator travel was examined. Its purpose was to determine how each of the measurable TSM strategies contributed to the favorable level of system performance observed during the Olympics.

Using a set of traffic simulation models, traffic flow in the downtown/Coliseum area was simulated for a set of scenarios corresponding to the major elements of the TSM program. These simulations showed that scheduling of major Olympic events to avoid peak commute periods had the single greatest impact on traffic flow within the case study area. The heavy use of Olympics transit service to access the Coliseum was the second most important factor, as the transit service greatly reduced the number of vehicle trips within the area. It was noted that the impact of spectator-related strategies was particularly strong because Olympics traffic made up such a large proportion of the traffic in the case study area. Reductions in work trips and non-work trips also contributed significantly to favorable traffic conditions. Shifts in work schedules to an earlier time and truck traffic reductions had a favorable but more limited effect.

Traffic management strategies, including one-way streets, ramp metering, and ramp closures had mixed effects because of the interdependence of the freeway and arterial systems. Measures which benefit one system tend to negatively impact the other, as the total traffic that must be accommodated is the same. An exception is signal optimization, which in effect marginally increases the capacity of the entire system. It was also noted that many of the network changes were made in order to provide the HOV facilities, and the benefits generated by these facilities far outweighed the cost to the general traffic. Given the limitations of the simulation study, namely the small size of the case study area, the constraint of a one peak hour analysis, and the margin of error inherent in this research approach, the results appear reasonable. The simulation study provided an effective means for evaluating the relative roles of the TSM program elements.

7.2 POLICY IMPLICATIONS

The Olympics TSM program was indeed a success. Olympic activities were accommodated, and satisfactory traffic conditions were maintained.

The positive experience of the Olympics leads to an obvious question: can strategies employed during the Olympics be implemented on a permanent basis to address current and future traffic problems? In order to answer this question, the Olympics must be understood as a short-term problem which required short-term solutions. Furthermore, short-term solutions do not necessarily translate into long-term solutions. The uniqueness of the Olympics experience is well illustrated by the patterns of travel behavior that occurred, and by the Olympics institutional environment.

7.2.1 Patterns of Travel Behavior During the Olympics

One of the most notable characteristics of traffic conditions during the Olympics was its day-to-day variability. During the first week, traffic volumes were much below normal levels. Traffic volumes gradually increased through the second week, and the little evidence available suggests that travel demand gradually reverted to normal, pre-Olympics patterns. The employee survey data showed that the proportion of workers who drove alone gradually increased over the two-week Olympic period. The same pattern was evident in the freeway screenline volume data. On screenlines where a shift in the peak was discernable, the shift was gone by the end of the second week. As a result, traffic conditions were back to normal by the end of the Olympics. The implication is that once it became clear that gridlock conditions would not materialize, there was no longer any incentive to make changes in travel behavior. That is, once these adjustments proved to be unnecessary, they were abandoned, despite the fact that the mutual benefits of these collective actions had been demonstrated. Since traffic congestion is a classic externality problem, this result is not surprising. Without a method for internalizing congestion costs, less congested conditions will not persist.

A second aspect of travel behavior relative to this issue is the apparent reduction in discretionary travel (non-Olympics related) which occurred during the Olympics. Anecdotal evidence collected via interviews as well as data from the Los Angeles Times survey suggest that everyday activities such as shopping and doctor or dentist visits were avoided by many Los Angeles area residents. Business-related travel, including sales calls and interoffice meetings, was also curtailed. These changes are clearly short term.

Finally, it is also noteworthy that the greatest changes were concentrated in the downtown/Coliseum area. Again, the traffic volume data provides evidence, as does the survey work performed by SCAG (1985). Travel adjustments were made where they were perceived to be necessary--where traffic conditions were expected to be the worst. These adjustments were made possible by the intensive Olympics public information program which gave area travelers all the data they needed to make informed travel choices. These choices were probably as close to optimal as they could be in a real world situation.

Taken as a whole, then, changes in travel behavior during the Olympics were temporary. They reflect decisions made to cope with short-term problems. The choices made, and the extent of those choices, were appropriate as a short-term response, but not necessarily as a long-term response. In fact, travel demand theory suggests that mode and destination choice would change in response to congestion-generated changes in accessibility, rather than the frequency of travel, as happened during the Olympics.

7.2.2 The Institutional Environment of the Olympics

The institutional environment in which the Olympics TSM plan was developed and implemented was extraordinary. Local polital leaders who had worked to bring the Olympics to Los Angeles had a strong incentive to avoid major traffic problems. The gravity of the problem was likened by at least one participant to World War II; what might have been unthinkable under normal conditions was feasible during the Olympics. Everyday conflicts between local agencies were forgotten, and all efforts were directed at making the Olympics work.

The TSM program was formulated over almost two years by the Los Angeles Olympic Transportation Advisory Group, an interagency planning group organized to develop a traffic management plan for the Olympics. Unlike most such groups, local agency leaders actively participated in the group, and took personal responsibility in mobilizing all agency resources necessary for program implementation. This atmosphere of cooperation and leadership made it possible to implement policies that under normal conditions would be unacceptable. Thus truckers gave up overtime pay, legal holidays were shifted, on-street parking prohibitions were employed, and arterial lanes and freeway ramps were reserved for buses.

With the exception of the synchronized signal system in downtown Los Angeles, however, none of the TSM strategies survived the Olympics, despite the favorable press they received. To give just one example, the Coliseum access plan has never been implemented, despite the fact that traffic tie-ups are a routine part of every Coliseum event. Once the crisis passed, institutional conflicts resurfaced, and traffic problems lost their political visibility. The Olympics accomplishments have not been lost on local agency leaders, and various efforts have been launched to preserve the "Olympics legacy." However, the everyday decision-making environment is much less receptive to the traffic solutions employed during the Olympics.

From an institutional perspective, the Olympics presented a unique transportation planning environment. There was an unusual level of consensus on the nature of the problem that had to be solved, as well as the feasible solutions available. Because of the temporary nature of the problem, potentially controversial strategies could be implemented. Once the games were over, however, these strategies were no longer acceptable.

7.2.3 Lessons Learned

Although the Olympics experience was unique and not directly transferable to solving ongoing transportation problems, it does provide some insight on possible policy strategies. This research has shown that the TSM program played an important role in the favorable traffic conditions of the Olympics. The case study simulation identified the relative impact of the individual program elements that could be measured. These results have some interesting policy implications.

7.2.3.1 The Supply Side

The simulation study results indicated that the supply-side strategies employed during the Olympics were less effective than the demand-side strategies. It was pointed out, however, that although the performance of the Coliseum area strategies was evaluated with respect to the general traffic, their primary purpose was to provide space for

Olympics HOV traffic. Given the constraints of the system, there was no other option but to take from existing general purpose travel facilities, and this taking was in fact quite minimal. Also, the limits of the simulation study did not allow for a more complete testing of some of the other supply-side strategies implemented, such as no-parking zones in the downtown area, and ramp metering during the PM peak.

Despite these caveats, it is not surprising that the supply-side strategies were found to be less effective. The traditional traffic engineering strategies (ramp metering, signal optimization) are easy to implement and politically acceptable. Consequently, these strategies have already been exploited, and there is little potential for further implementation. In areas like Los Angeles, traffic engineering is at its technological limits. For example, extensive signal synchronization is becoming routine. Efforts to increase highway capacity by using shoulders and medians have also already been widely implemented in bottleneck areas. Non-traditional strategies that favor selected user groups like HOVs, on the other hand, are much less acceptable. Furthermore, TSM supply-oriented strategies are by definition marginal; they seek to improve throughput with no significant capital investment. Because the transportation system in so many areas of Los Angeles operates at or near capacity, and because of the interdependence of the arterial and freeway systems, these marginal changes tend to have little net positive effect.

A supply-side strategy that could not be measured, namely the hightened level of surveillance employed during the Olympics, also merits discussion. Surveillance activities were organized to keep incident-related congestion on the highway system to an absolute minimum. Given that non-recurrent congestion accounts for a large proportion of total congestion, it seems reasonable to assume that these extra surveillance efforts contributed significantly to favorable traffic conditions during the Olympics. Intensive surveillance was accomplished by reorganizing priorities and assigning extra man hours and equipment to the central Los Angeles area, especially by the CHP. Certain practices, such as moving citations and other incidents off the freeway, were employed temporarily to minimize gawkers block.

The Olympics surveillance strategies are certainly technically feasible, and probably would have a significant positive impact if employed on a regular basis. They would add substantially to surveillance costs, however, and given current state funding realities, are not financially feasible. Indeed, Caltrans has conducted several studies to develop better methods for managing non-recurrent congestion, but the costs of the most effective strategies were found to be prohibitive.

The surveillance program is just one example of the financial costs incurred by public agencies during the Olympics. No documentation of these costs was available to the research team, but it appears that the cost of the Olympics was significant for most local agencies. For example, large numbers of engineers, planners, and public safety personnel worked extra shifts before and during the Olympics. The surveillance program thus demonstrates an important lesson of the Olympics: intensive management of the system is not cost free, and any widespread implementation of Olympics strategies would require a significantly higher level of funding than exists today.

7.2.3.2 The Demand Side

The simulation study results showed that demand-side strategies employed during the Olympics were quite effective. The simulation study replicated the actual changes that occurred, and the results are a function of those changes. For example, a greater proportion of workers were absent from work than changed their work schedule; thus work absences had the greater impact. Had fewer absences occurred, the results would have been different. Thus, relative effectiveness as measured in the simulation depended on the extent to which the given strategy was implemented. For demand-oriented strategies, the extent of implementation was the result of voluntary, individual choices. To the extent that the changes are true reflections of travel demand, they provide valuable insight on the responsiveness of demand to expected travel conditions.

Demand-oriented strategies are potentially effective because they reduce peak period trips, and any reduction in trips on a congested netowrk will have a significant positive effect. Since demand-oriented strategies must rely largely on voluntary compliance, they have not been extensively implemented. However, when incentives are created which promote behavioral change, as happened during the Olympics, their impact on traffic conditions is quite significant.

The Olympics results indicate that long-term transportation management strategy should be developed around management of demand rather than supply. How do the strategies employed during the Olympics compare in terms of feasibility? Again, the issue is political and institutional feasibility, rather than technical feasibility. From a technical standpoint, many trip reduction strategies are feasible. Work trips can be reduced through modified work weeks, provision of alternative work sites, and working at home. Flexible work schedules are also feasible, and, in fact, are already widely implemented. Mode choice shifts, which did not occur during the Olympics, are also feasible. Indeed, increases in ridesharing and transit use have been achieved through subsidies and parking constraints. Diversion and management of truck traffic is also technically feasible through regulation of truck access and delivery schedules.

There is no question that the technical tools exist for increasing the throughput of the transportation system. The individual elements of the Olympics TSM program were not particularly unique or innovative; what was unique was their implementation. Thus, the critical issue for policy development is implementing feasibility. When evaluated from this perspective, the potential of demand-oriented strategies is more limited. Any effort to reduce work trips, for example, would have impacts on the work place, and therefore must depend on the actions and policies of employers. Thus, the promotion of work trip reductions must be conditional on possible employee productivity impacts. To give another example, management of truck traffic is even more problematic. During the Olympics, delivery schedules were adjusted, and truckers gave up overtime pay. Needless to say, truckers have no reason to permanently give up extra pay for the sake of traffic flow. Consideration of any policy to regulate truck traffic would require the analysis of current truck travel patterns, as well as the economic consequences of changing those patterns.

The Olympics experience demonstrated that transportation system management works. The tools for managing traffic exist, and their effectiveness has been illustrated. The Olympics TSM program was successful because there were sufficient incentives for changes in travel behavior to take place. These incentives were short term: a fear of severe traffic problems, and a desire to make the Olympics work. The policy challenge is to identify sufficient long-term incentives for change. So far, acceptable and effective long-term incentives have not been established. Effective incentives--primarily parking and pricing constraints--are controversial and difficult to implement. Acceptable incentives, such as rideshare marketing and transit subsidies, are much less effective. As congestion increases and traffic conditions worsen, however, public perceptions of acceptable management strategies will likely change. And as public perceptions change, the results of the Olympics can serve as a guideline for the development of an effective long-term TSM program.

REFERENCES

Ashwood, John E. "Transportation Planning Considerations for New Stadia." Traffic Engineering 43.10 (1973): 36-46.

Barton-Aschman Associates, Inc. Traveler Response to Transportation System Changes. Second Edition. Washington, DC: Federal Highway Administration, Office of Highway Planning, Urban Planning Division, 1981.

Barton-Aschman Associates, Inc., R.H. Pratt & Co. Division. Traveler Response to Transportation System Changes. Second Edition. Washington, DC: Urban Mass Transportation Administration, Office of Policy and Program Development, 1981.

Battelle Memorial Institute. Columbus Laboratories. Urban Goods Movement Program Design. By N. Simons, et al. Washington, DC: Urban Mass Transportation Administration, 1972.

Capelle, Donald G. Freeway Traffic Management. Washington, DC: Transportation Research Board, National Research Council, 1979.

Crowley, K.W., E.L. Sequin, W.D. Zweig and R.J. Gable. Urban Freeway Truck Characteristics. Pennsylvania: Institute of Research, State College Pennsylvania, Federal Highway Administration, 1982.

Crowell, William H. Preferential Bus Lanes on Urban Arterials: Selected Studies on their Feasibility and Performance. Washington, DC: Urban Mass Transportation Administration, Research and Education Division, 1978.

Eisenberg, Melissa A. Rides for Bay Area Commuters. San Francisco, California: Metropolitan Transportation Commission, 1981.

Fisher, Ronald J. and Howard J. Simkowitz. Priority Treatment of High Occupancy Vehicles in the United States: A Review of Recent and Forthcoming Projects. Washington, DC: U.S. Department of Transportation, Urban Mass Transportation Administration, 1978.

Giuliano, G. "Olympics Transportation System Management Performance Analysis." Preliminary Report, Working Paper UCI-ITS-85-3. Irvine, CA: Institute of Transportation Studies, University of California. March 1985.

Goodman, Leon. Preferential Treatment for Transit and Other High Occupancy Vehicles. Special Report No. 172. Washington, DC: Transportation Research Board, 1977. 7-8.

Haboian, Kevin. An Evaluation of Demand-Oriented Transportation System Management Strategies: A Case Study of the 1984 Olympic Games. Unpublished Master's Thesis. Irvine, CA: School of Engineering, University of California, Irvine, 1986.

Hamburg, John & Associates. Estimation of an Origin-Destination Trip Table Based on Observed Link Volumes and Turning Movements. Final Report, Vol. I. Washington, DC: Federal Highway Administration, Office of Research, 1979.

Han, Anthony F., Richard G. Dowling, Edward C. Sullivan and Adolf D. May. Deriving Origin-Destination Information From Routinely Collected Traffic Counts, Volume II: Trip table synthesis for multipath networks. Berkeley, CA: Institute of Transportation Studies, University of California, 1981.

Harrison, Frances, David Jones and Paul Jovanis. Flex-time and Commuting Behavior in San Francisco: Some Preliminary Findings: Summary Report. Berkeley, CA: Institute of Transportation Studies, University of California, 1979.

Higgins, Thomas. Comparing Strategies for Reducing Traffic Related Problems: The Potential for Road Pricing. Washington, DC: The Urban Institute, 1978.

JHK & Associates. Recommended Parking and Access Management Strategies: King County Stadium and CBD Transportation and Parking Management Strategies. San Francisco, California, 1975.

Jones, D.W. and E.C. Sullivan. "TSM: Tinkering Superficially at the Margin?" Transportation Journal of ASCE 104.6 (1978): 817-834.

Jovanis, P. and A.D. May. "Alternative Objectives in Arterial-Traffic Management." Transportation Research Record 682 (1978): 1-8.

Kain, John F. and Gary R. Fauth. Increasing the Productivity of Urban Expressways: Combining TSM Techniques and Transit Improvements: Final Report. Prepared by the Department of City and Regional Planning, Harvard University. Washington, DC: U.S. Department of Transportation, Urban Mass Transportation Administration, Office of Policy & Program Development, 1978.

Keyani, Barbara Ibarra and Evelyn S. Putnam. Transportation System Management: State of the Art. Washington, DC: Department of Transportation, Urban Mass Transportation Administration, Office of Policy and Program Development, 1977.

KLD Associates. TRAF User Guide, Release 2 (pre-release). Washington, DC: Federal Highway Administration, 1985.

Knapp, C.H. and P. Ghosh. "Simulation and Control of Traffic on a Diamond Interchange." Transportation Research Record 644 (1977): 132-137.

Knoxville-Knox County Metropolitan Planning Commission. 1982 World's Fair Transportation System Evaluation: Phase I Report. Washington, DC: Urban Mass Transportation Administration, Office of Planning Assistance, 1982.

Knoxville-Knox County Metropolitan Planning Commission. A Closer Look: The 1982 World's Fair Transportation System: Phase II Report. Washington DC: Urban Mass Transportation Administration, Office of Planning Assistance, July 1983.

Lantz, K.E., Jr., and E.D. Arnold, Jr. "Summary of Operational Characteristics and Anticipated Evaluation of I-66 HOV Facility." Transportation Research Record 906 (1983): 26-33.

Levinson, H.S., W.F. Hoe, D.B. Sanders, and F.H. Wynn. Bus Use of Highways: State of the Art. Washington, DC: Highway Research Board, National Research Council, 1973.

May, A.D. "Demand-Supply Modeling for Transportation System Management." Transportation Research Record 835 (1981): 80-86.

McCasland, William R. Truck Operations and Regulations on Urban Freeways. College Station, TX: Texas Transportation Institute, Texas A & M University System, 1984.

Meyer, Michael D. Enforcement of Transportation Systems Strategies: Four Case Studies. Prepared by Center for Transportation Studies, Massachusetts Institute of Technology. Washington, DC: U.S. Department of Transportation, Urban Mass Transportation Administration, 1981.

Michael, H.L. "Impact of Intersection Controls in Urban Areas," Traffic, Transportation and Planning. Vol. 2. Stroudsburg, PA: Hutchinson Ross Publishing Co., 1981. 155-164.

Multisystems, Inc. Paratransit for the Work Trip, Commuter Ridesharing: Final Report. Washington, DC: Urban Mass Transportation Administration, Office of Policy Research, in cooperation with Technology Sharing Program, Office of the Secretary of Transportation, 1982.

Ott, M., H. Slavin, and D. Ward. The Behavior Impacts of Flexible Working Hours, Final Report No. UMTA-MA-06-0049-79-12. Cambridge, MA: Transportation System Center, U.S. Department of Transportation, 1981.

Owens, Robert D. and Helen L. Sever. The 3M Commute-A-Van Program: Status Report II. St. Paul, MN: Minnesota Mining and Manufacturing Company, 1977.

Powers, L.D. and Wm. Dunn, Jr. Future of Freeway Corridor Traffic Management. Washington, DC: Federal Highway Administration, 1980.

Remak, Roberta and Sandra Rosenblum. Peak Period Traffic Congestion. Options for Current Programs. Washington DC: Transportation Research Board, National Research Council, 1976.

Rutherfurd, K. An Analysis of Supply-Oriented Transportation System Management Strategies: A Case Study of the 1984 Los Angeles Olympics. Unpublished Master's Thesis. Irvine, CA: School of Engineering, University of California, Irvine, 1986.

Safavian, Reza and Keith G. McLean. "Variable Work Hours: Who Benefits?" Traffic Engineering 45.3 (1975): 17-25.

Southern California Association of Governments. Olympics Impact Report: Effectiveness of Transportation Strategies Implemented During The 1984 Summer Games in Los Angeles, Final Report. Los Angeles, CA: SCAG, 1985.

Southern California Rapid Transit District. Evaluation of Transit Services for the 1984 Olympic Games. Los Angeles, CA: SCRTD, 1984.

Tannir, Anis A. The Impacts of Feasible Staggered Work Hours and Compressed Workweek Policies on Highway Networks, Transportation Economics, Organizations and Employees. Albany, NY: New York State Department of Transportation, Planning Research Unit, 1977.

Thayer, Scott D. Vehicle Behavior in and Around Complex Sources and Related Complex Source Characteristics. Vol. VII. Rockville, MD: Geomet Inc., 1973.

Transportation Research Board. Tranpsortation System Management. Special Report 172. Washington, DC: TRB, 1977.

Vecellio, R.L. "Traffic Behavior on One-way Signalized Arterials." Transportation Engineering Journal of ASCE 105.5 (1977): 575-589.

Wagner, Frederick A. Evaluation of Carpool Demonstration Projects. Phase I Report. Washington, DC: Department of Transportation, Federal Highway Administration, Office of Highway Planning, 1978.

Weinstein, H.G. A Comparison of Three Alternative Work Schedules: Flexible Work Hours, Compact Work Week, and Staggered Hours. Philadelphia, PA: Industrial Research Unit, Wharton School, University of Pennsylvania, 1975.

Wolfe, Thomas L. Los Angeles Regional Transportation Study: Trips in Motion. Los Angeles, CA: California Department of Transportation, LARTS Division, 1975.

APPENDIX A:

Downtown Employee Survey Instrument

Office Use Only

COID

1-2___

EMPLOYEE TRANSPORTATION AND THE OLYMPIC GAMES

PLEASE COMPLETE AND RETURN THIS QUESTIONNAIRE EVEN IF YOU WERE ON VACATION OR SPECIAL CIRCUMSTANCES APPLIED. SIMPLY WRITE IN YOUR RESPONSES OR CHECK THE BOXES NEXT TO THEM AS APPROPRIATE. FEEL FREE TO ADD COMMENTS OR SUGGESTIONS.

First we would like to ask you a few questions about how you usually commute to work under normal (no Olympics) conditions.

ID
3-6___

1. On the average, how many minutes does it take to get to and from work using your usual pre-Olympics route?

7-9 a. __________ minutes to get to work
10-12 b. __________ minutes to get home from work

2. Prior to the Olympics, what time did you usually leave your home to go to work?
13-16,17 _____ : _____ a.m. or p.m. (CIRCLE ONE)

3. Prior to the Olympics, what time did you usually arrive at work?
18-21,22 _____ : _____ a.m. or p.m. (CIRCLE ONE)

4. Prior to the Olympics, what time did you usually leave work to go home?
23-26,27 _____ : _____ a.m. or p.m. (CIRCLE ONE)

5. Prior to the Olympics, what time did you usually arrive home from work?
28-31,32 _____ : _____ a.m. or p.m. (CIRCLE ONE)

6. Do you usually have a car available for driving to work?
   - ☐ yes
   - ☐ no

7. Prior to the Olympics, how did you usually travel to work?

   1 ☐ Drive alone
   2 ☐ Carpool → if carpool → 7a. On the average, with how many people, including yourself? __________ people (35-36)
   3 ☐ Vanpool → if vanpool → 7a.
34 4 ☐ Public Bus
   5 ☐ Private Commuter Bus
   6 ☐ Park & Ride Bus
   7 ☐ Bicycle
   8 ☐ Walk
   9 ☐ Other: __________

8. Prior to the Olympics did you make other stops while on the way to work? (Check one)
37 1 ☐ yes
   2 ☐ no

   If you did make other stops, what was the nature of the stops? (PLEASE CHECK ALL THAT APPLY)

   1 ☐ Pick up or drop off passengers
   2 ☐ Work-related business
38 3 ☐ Shopping
   4 ☐ Social visit
   5 ☐ Eating
   6 ☐ Personal business (e.g., bank, post-office, etc.)
   7 ☐ Other ____________________

9. Prior to the Olympics did you normally make other stops while on the way home from work?

39 1 ☐ yes → If you did make other stops, what was the nature of the stops? (PLEASE CHECK ALL THAT APPLY)
2 ☐ no

1 ☐ Pick up or drop off passengers
2 ☐ Work-related business
3 ☐ Shopping
40 4 ☐ Social visit
5 ☐ Eating
6 ☐ Personal business (e.g., bank, post-office, etc.)
7 ☐ Other

10. If you either drove or were a passenger in a personal vehicle for your trip to and from work prior to the Olympics:

a. Which freeways in the downtown L.A. area did you usually use to get to and from work? (SPECIFY BY EITHER NAME OR NUMBER)

41-42 ______________________

43-44 ______________________

44-45 ______________________

☐ did not use any freeways in downtown area.

b. Which major surface streets (for example: Olympic, Venice Blvd., etc.) did you usually use in getting to and from the downtown L.A. area on your work trip? (SPECIFY BY NAME)

46-47 ______________________

48-49 ______________________

50-51 ______________________

☐ did not use any major surface streets

11. On your usual pre-Olympics route, how many miles is it from your home to work?

______________ miles (one way)

☐ don't know

12. Prior to the Olympics, were you able to choose your regular work hours, or did your employer specify your work hours? (CHECK ONE)

54 1 ☐ Employer specified hours
2 ☐ I chose hours with employer's approval
3 ☐ Other: ______________________________

13. Prior to the Olympics,

a. what was the earliest time you could start work?
55-58,59 _____ : _____ a.m. or p.m. (CIRCLE ONE)

b. what was the latest time your could start work?
60-63,64 _____ : _____ a.m. or p.m. (CIRCLE ONE)

c. what was the earliest time your could leave work?
65-68,69 _____ : _____ a.m. or p.m. (CIRCLE ONE)

d. what was the latest time you could leave work?
70-73,74 _____ : _____ a.m. or p.m. (CIRCLE ONE)

14. Please check the days during the July 28 to August 12 Olympics period that you <u>did not</u> go to your regular workplace. For each of the days that your did not go to your regular workplace, indicate the reason by checking the appropriate box

				REASON YOU DID NOT TO TO WORK								
	DAYS YOU DID NOT GO TO WORK			Worked at home	Worked at alternate worksite	Worked in the field	Regular day off	Vacation	Sick leave	Company holiday	Day off due to modified work week	Other
75-76	Sat July 28	☐	→	☐	☐	☐	☐	☐	☐	☐	☐	☐
77-78	Sun July 29	☐	→	☐	☐	☐	☐	☐	☐	☐	☐	☐
79-80	Mon July 30	☐	→	☐	☐	☐	☐	☐	☐	☐	☐	☐
1- 2	Tues July 31	☐	→	☐	☐	☐	☐	☐	☐	☐	☐	☐
3- 4	Wed Aug 1	☐	→	☐	☐	☐	☐	☐	☐	☐	☐	☐
5- 6	Thurs Aug 2	☐	→	☐	☐	☐	☐	☐	☐	☐	☐	☐
7- 8	Fri Aug 3	☐	→	☐	☐	☐	☐	☐	☐	☐	☐	☐
9-10	Sat Aug 4	☐	→	☐	☐	☐	☐	☐	☐	☐	☐	☐
11-12	Sun Aug 5	☐	→	☐	☐	☐	☐	☐	☐	☐	☐	☐
13-14	Mon Aug 6	☐	→	☐	☐	☐	☐	☐	☐	☐	☐	☐
15-16	Tues Aug 7	☐	→	☐	☐	☐	☐	☐	☐	☐	☐	☐
17-18	Wed Aug 8	☐	→	☐	☐	☐	☐	☐	☐	☐	☐	☐
19-20	Thurs Aug 9	☐	→	☐	☐	☐	☐	☐	☐	☐	☐	☐
21-22	Fri Aug 10	☐	→	☐	☐	☐	☐	☐	☐	☐	☐	☐
23-24	Sat Aug 11	☐	→	☐	☐	☐	☐	☐	☐	☐	☐	☐
25-26	Sun Aug 12	☐	→	☐	☐	☐	☐	☐	☐	☐	☐	☐

15. Please check the days during the July 28 to August 12 Olympic period that your did go to your regular workplace. For each of the days that you did go to your regular workplace, check the travel mode that you used. If you used either carpool or vanpool, please indicate the total number of people in the vehicle including yourself.

	DAYS YOU WENT TO WORK			TRAVEL MODE									
				Drive Alone	Carpool	Vanpool	How many people in vehicle	Public bus	Private commuter bus	Park-&-Ride bus	Bicycle	Walk	Other
27-28	Sat July 28	☐	→	☐	☐	☐	___	☐	☐	☐	☐	☐	☐
29-30	Sun July 29	☐	→	☐	☐	☐	___	☐	☐	☐	☐	☐	☐
31-32	Mon July 30	☐	→	☐	☐	☐	___	☐	☐	☐	☐	☐	☐
33-34	Tues July 31	☐	→	☐	☐	☐	___	☐	☐	☐	☐	☐	☐
35-36	Wed Aug 1	☐	→	☐	☐	☐	___	☐	☐	☐	☐	☐	☐
37-38	Thurs Aug 2	☐	→	☐	☐	☐	___	☐	☐	☐	☐	☐	☐
39-40	Fri Aug 3	☐	→	☐	☐	☐	___	☐	☐	☐	☐	☐	☐
41-42	Sat Aug 4	☐	→	☐	☐	☐	___	☐	☐	☐	☐	☐	☐
43-44	Sun Aug 5	☐	→	☐	☐	☐	___	☐	☐	☐	☐	☐	☐
45-46	Mon Aug 6	☐	→	☐	☐	☐	___	☐	☐	☐	☐	☐	☐
47-48	Tues Aug 7	☐	→	☐	☐	☐	___	☐	☐	☐	☐	☐	☐
49-50	Wed Aug 8	☐	→	☐	☐	☐	___	☐	☐	☐	☐	☐	☐
51-52	Thurs Aug 9	☐	→	☐	☐	☐	___	☐	☐	☐	☐	☐	☐
53-54	Fri Aug 10	☐	→	☐	☐	☐	___	☐	☐	☐	☐	☐	☐
55-56	Sat Aug 11	☐	→	☐	☐	☐	___	☐	☐	☐	☐	☐	☐
57-58	Sun Aug 12	☐	→	☐	☐	☐	___	☐	☐	☐	☐	☐	☐

IF YOU DID NOT COMMUTE TO WORK AT ALL DURING THE OLYMPICS, STOP HERE AND RETURN THE QUESTIONNAIRE. Thank you for your time and cooperation.

16. If you changed from your usual, pre-Olympic commute mode to a different mode(s) at any time because of the Olympics, what were your main reasons for changing? (CHECK NO MORE THAN TWO RESPONSES)

59-60

1 ☐ Employer encouraged alternate modes
2 ☐ Media encouraged alternate modes
3 ☐ I wanted to help reduce traffic congestion
4 ☐ To avoid driving in anticipated Olympics-related traffic
5 ☐ My Olympics work schedule prevented using my usual commute mode
6 ☐ Other: ______________________________

17. If you changed to a different mode because of the Olympics, did you at any time change back to your usual pre-Olympics mode because of unexpectedly light traffic? (CHECK ONE)

61 1 ☐ yes
2 ☐ no

18. During the Olympics, what time did you usually leave your home to go to work?

62-65,66 _____ : _____ a.m. or p.m. (CIRCLE ONE)

19. During the Olympics, what time did you usually arrive at work?

67-70,71 _____ : _____ a.m. or p.m. (CIRCLE ONE)

20. During the Olympics, what time did you usually leave work to go home?

72-75,76 _____ : _____ a.m. or p.m. (CIRCLE ONE)

21. During the Olympics, what time did you usually arrive home from work?

77-80,1 _____ : _____ a.m. or p.m. (CIRCLE ONE)

22. During the Olympics, were you required to travel on the job with your own car <u>more than half of the days you commuted to work</u>? (CHECK ONE)

2 1 ☐ yes
2 ☐ no

23. On the average, how many minutes did it take to get to and from work during the Olympics?

3-5 a. __________ minutes to get to work
6-8 b. __________ minutes to get home from work

24. What was the longest it took you to get to and from work?

9-11 a. __________ minutes to get to work
12-14 b. __________ minutes to get home from work

25. Did your employer specify your Olympic work hours, or were you able to choose them with your employer's approval?

15 1 ☐ Employer specified hours
2 ☐ I chose hours, with employer's approval
3 ☐ Other: ______________________________________

26. During the Olympics,

16-19,20 a. what was the earliest time you could start work?
_____ : _____ a.m. or p.m. (CIRCLE ONE)

21-24,25 b. what was the latest time your could start work?
_____ : _____ a.m. or p.m. (CIRCLE ONE)

26-39,30 c. what was the earliest time your could leave work?
_____ : _____ a.m. or p.m. (CIRCLE ONE)

31-34,35 d. what was the latest time you could leave work?
_____ : _____ a.m. or p.m. (CIRCLE ONE)

27. a. During the Olympics did you usually make other stops while on the way to work?

36 1 ☐ yes
2 ☐ no

If you did make other stops, what was the nature of the stops? (PLEASE CHECK ALL THAT APPLY)

1 ☐ pickup or drop off passengers
2 ☐ Work-related business
37 3 ☐ Shopping
4 ☐ Social visit
5 ☐ Eating
6 ☐ Personal business (e.g., bank, post-office, etc.)
7 ☐ Other________________________________

28. During the Olympics did you usually make other stops while on the way home <u>from</u> work? (CHECK ONE)

38 1 ☐ yes
2 ☐ no

If you did make other stops, what was the nature of the stops?
(PLEASE CHECK ALL THAT APPLY)

1 ☐ pickup or drop off passengers
2 ☐ Work-related business
39 3 ☐ Shopping
4 ☐ Social visit
5 ☐ Eating
6 ☐ Personal business (e.g., bank, post-office, etc.)
7 ☐ Other________________________________

40 29. During the Olympics, did you ever change the route you usually take to or from work to avoid Olympic spectator traffic? (CHECK ONE)

1 ☐ yes
2 ☐ no

If you <u>did</u> change your route and you either drove or were a passenger in a personal vehicle for your trip to and from work during the Olympic,

a. which freeways in the downtown LA area did you usually use to get to and from work (SPECIFY BY EITHER NAME OR NUMBER)

41-42 ______________________

43-44 ______________________

45-46 ______________________

☐ did not use any freeway in downtown area

b. Which major surface streets did you usually use in getting to and from the downtown LA area on your work trip (SPECIFY BY NAME)

47-48 ______________________

49-50 ______________________

51-52 ______________________

☐ did not use any major surface streets

30. Which of the following did you use during the Olympics to get information about <u>traveling to work</u>? (CHECK ALL THAT APPLY)
1 ☐ Newspaper articles
2 ☐ Radio traffic reports
3 ☐ Television news reports
4 ☐ Employer-supplied information
53-72 5 ☐ Bus schedules
6 ☐ Traffic congestion maps
7 ☐ Commuter Computer ridesharing matchlist
8 ☐ Commuter Computer for general information
9 ☐ Caltrans hotline
10 ☐ Other: ________________________________
11 ☐ None