

## Appendix ORA – Orange County, California 2003 Annual Report on Freeway Mobility and Reliability

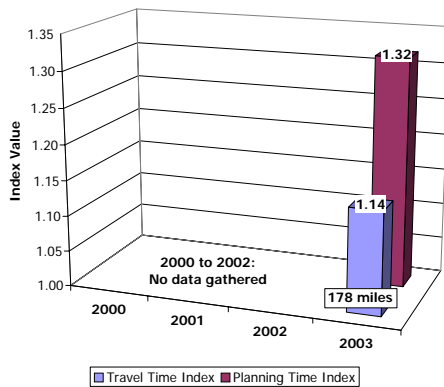
This report is a supplement to: *Monitoring Urban Freeways in 2003: Current Conditions and Trends from Archived Operations Data*. Texas Transportation Institute and Cambridge Systematics, Inc., Report No. FHWA-HOP-05-018, December 2004, available at <http://mobility.tamu.edu/mmp>.

**Exhibit ORA-1: Current Measures and Trends**

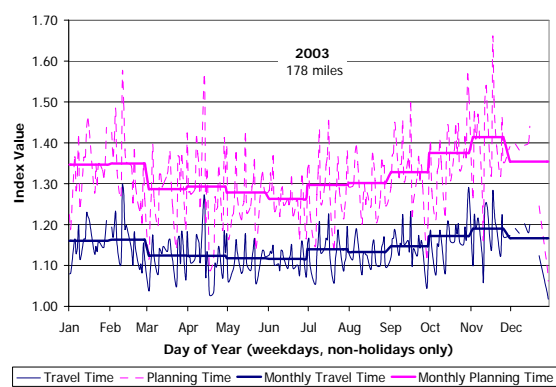
Measures	Current Year	Last Year		Two Years Ago	
	2003	2002	Change	2001	Change
<b>Performance Measures</b>					
Travel Time Index	1.14	n.a.	n.a. —	n.a.	n.a. —
Planning Time Index	1.32	n.a.	n.a. —	n.a.	n.a. —
Buffer Index	13%	n.a.	n.a. —	n.a.	n.a. —
% Congested Travel	26%	n.a.	n.a. —	n.a.	n.a. —
Total Delay (veh-hours) per 1000 VMT	2.60	n.a.	n.a. —	n.a.	n.a. —
<b>Explanatory Measures</b>					
Peak Period VMT (000)	7,690	n.a.	n.a. —	n.a.	n.a. —
Avg. Annual DVMT (000)	30,190	n.a.	n.a. —	n.a.	n.a. —
<b>Data Quality Measures</b>					
% complete	93%	n.a.	n.a. —	n.a.	n.a. —
% valid	98%	n.a.	n.a. —	n.a.	n.a. —
% of VMT covered	91%	n.a.	n.a. —	n.a.	n.a. —
% of freeway miles	91%	n.a.	n.a. —	n.a.	n.a. —

\* See pages 8 and 9 for maps of freeway coverage, measure definitions, and further documentation.

**Exhibit ORA-2: 2000 to 2003 Annual Trends**



**Exhibit ORA-3: Daily and Monthly Trends**



**Comments**

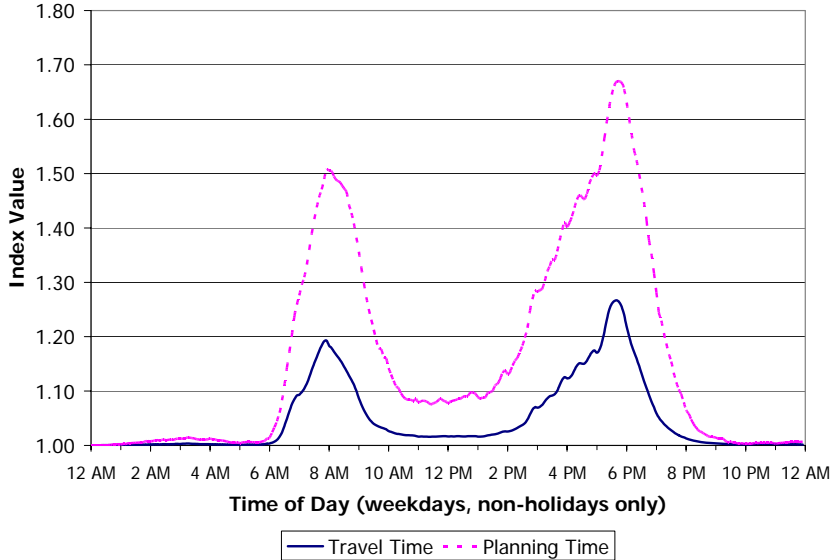
- This is the first year for Orange County to be included in the Mobility Monitoring Program; therefore, trend information is not available yet.
- The data collection system in Orange County accounts for 91% of the freeway miles as well as 91% of the vehicle travel.

**Data Source(s):** PeMS (<http://pems.eecs.berkeley.edu>) in cooperation with Caltrans (<http://www.dot.ca.gov/>)  
Includes 178 of 195 (91%) total freeway miles in Orange County; collected using loop detectors; see page 8 for additional information on the data source

**Data Analysis:** Texas Transportation Institute, analysis completed September 2004

### Time of Day Patterns and Trends

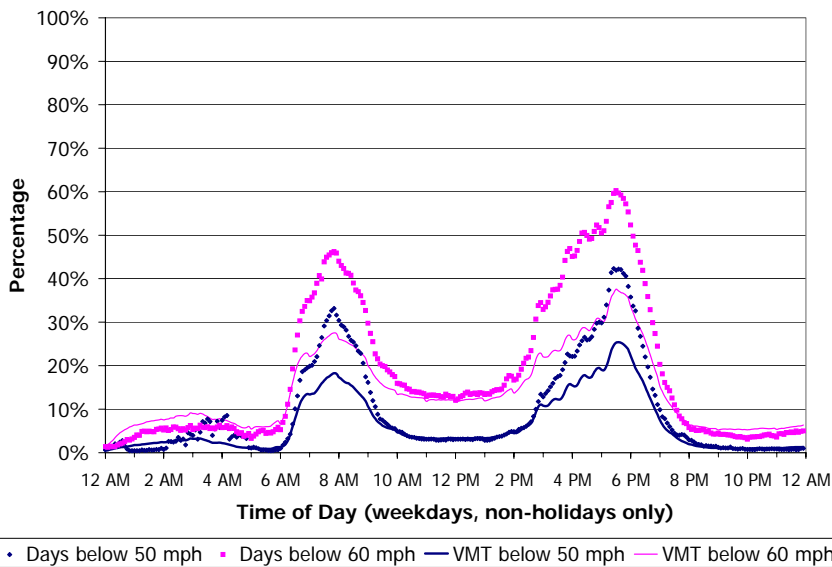
The charts on this page illustrate average weekday (no holidays included) traffic patterns and trends that were measured on the freeway sections instrumented with operations-based traffic sensors.



**Comments**

- This chart shows areawide congestion and reliability patterns. The difference between the solid line (travel time index) and the dashed line (planning time index) is the additional “buffer” or “time cushion” that travelers must add to average trip times to ensure 95% on-time arrival.
- The evening congestion is more severe and longer than the morning congestion.
- Travelers must add 20-30% additional buffer time during peak times to account for traffic unreliability.

**Exhibit ORA-4: Mobility and Reliability by Time of Average Weekday**



**Comments**

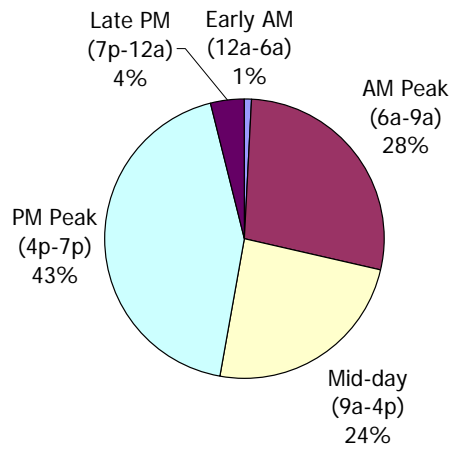
- This chart illustrates the difference in using two different speed thresholds (50 and 60 mph) to compute the percent of congested days as well as the percent of congested travel.
- Using a 50 mph threshold, 15-25% of the VMT and 30-40% of days are congested during the peak hour.
- Using a 60 mph threshold, 25-35% of the VMT and 40-60% of days are congested during the peak hour.

**Exhibit ORA-5: Frequency and Percentage of Congested Travel by Time of Average Weekday**

### Time Period of the Day Patterns and Trends

The charts on this page illustrate average weekday (no holidays included) traffic patterns and trends that were measured on the freeway sections instrumented with operations-based traffic sensors. The time periods are defined uniformly for all cities to facilitate trend analysis over time and between cities. The time periods are defined as follows:

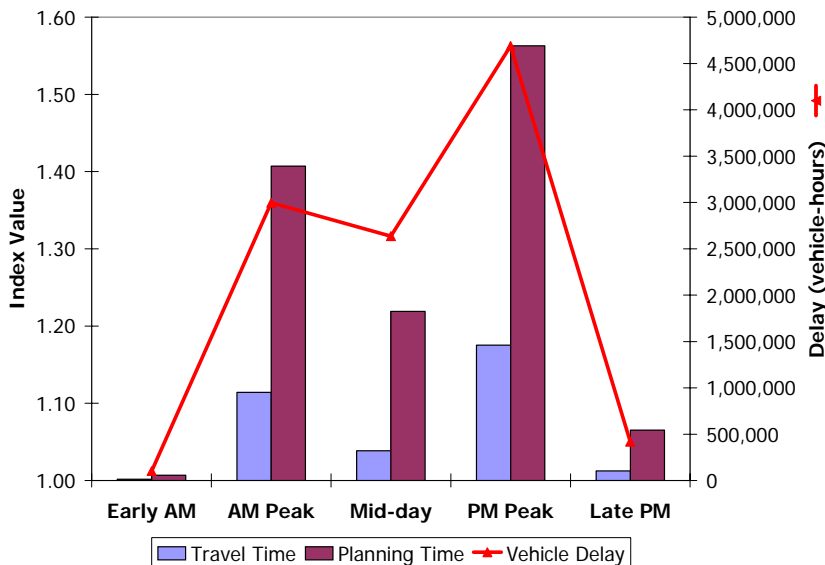
- Early AM: 12 to 6 am
- AM Peak: 6 to 9 am
- Mid-day: 9 am to 4 pm
- PM Peak: 4 to 7 pm
- Late PM: 7 pm to 12 am



#### Comments

- This chart shows the percent of delay that occurred during different time periods of an average weekday. Note that the AM and PM peak periods are the same duration, but that the other time periods have different lengths.
- The delay in the afternoon peak period is significantly greater than during the morning peak period.
- Delay during the mid-day period is almost as great as delay during the morning peak period.

**Exhibit ORA-6: Percent of Delay by Time Period**



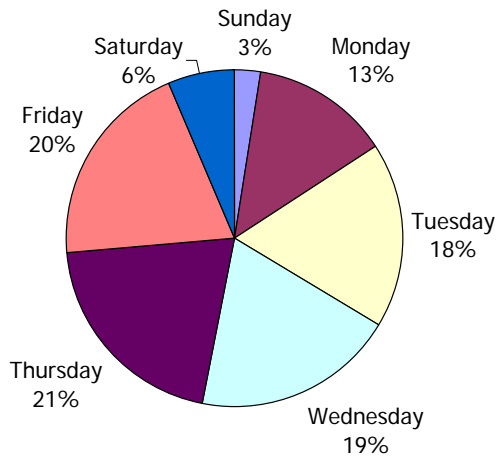
#### Comments

- This chart shows congestion and reliability (shown as bars) as well as delay (shown as a line) during different time periods of an average weekday.
- The trends in this chart follow closely those shown in Exhibit 6.
- The travel time index for the mid-day period is low, but the delay is relatively high because of the length of this time period (7 hours).

**Exhibit ORA-7: Mobility, Reliability, and Delay by Time Period**

### Day of Week Patterns and Trends

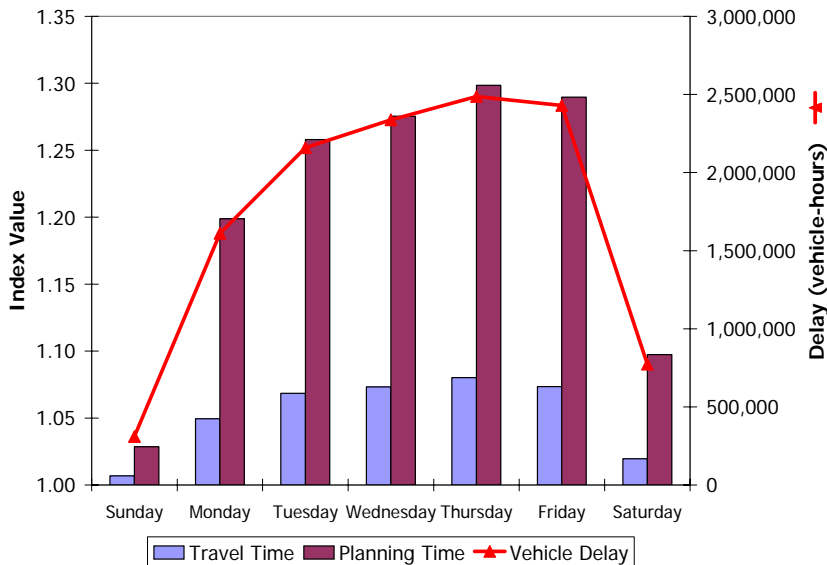
The charts on this page illustrate average traffic patterns and trends that were measured on the freeway sections instrumented with operations-based traffic sensors. Because of different peak period times and lengths on weekdays and weekends, the statistics presented on this page are 24-hour daily totals or averages.



#### Comments

- This chart shows the percent of total daily delay that occurred during each day of the week.
- The delay on all weekdays except Monday is comparable. Monday delay is significantly less than other weekdays.
- Both weekend days combined have about half of the normal weekday delay.

**Exhibit ORA-8: Percent of Daily Vehicle Delay by Day of Week**



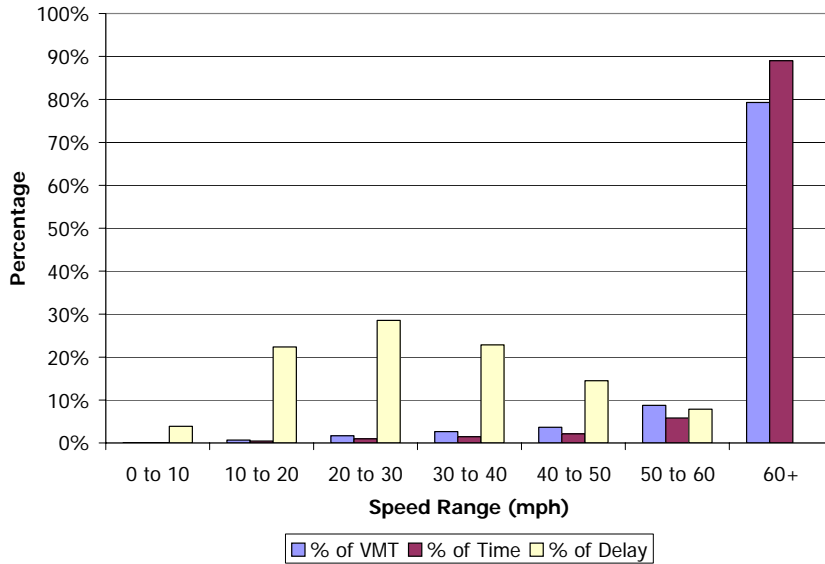
#### Comments

- This chart shows average daily congestion and reliability (shown as bars) as well as total daily delay (shown as a line) during each day of the week.
- The trends in this chart follow closely those shown in Exhibit 8.
- Thursday has the most delay and is the least reliable day (highest planning time index).

**Exhibit ORA-9: Mobility, Reliability, and Delay by Day of Week**

### Other Traffic Data Patterns and Trends

The chart on this page illustrates average traffic patterns and trends that were measured on the freeway sections instrumented with operations-based traffic sensors.



#### Comments

- This chart shows the percent of VMT, time, and delay in different speed ranges. This chart is useful to determine how much VMT and delay occurred at different congestion levels.
- About 80% of the VMT is at speeds greater than 60 mph.
- About 80% of the delay occurred at speeds less than 40 mph.

**Exhibit ORA-10: Percent of VMT, Delay and Time Periods in Different Speed Ranges**

### Mobility and Reliability Statistics for Specific Freeway Sections

The table in this section illustrates average weekday (no holidays included) statistics from the freeway sections instrumented with operations-based traffic sensors. Where possible, the freeway sections have been defined to begin and end at major interchanges, streets, or other locations where traffic conditions are likely to change. The freeway sections are typically between 5 and 10 miles in length.

**Exhibit ORA-11. Mobility and Reliability by Section and Time Period**

Freeway Section (sorted from most congested to least congested sections)	Length (mi)	Travel Time Index				Buffer Index			
		Morning Peak (6a-9a)	Midday (9a-4p)	Evening Peak (4p-7p)	Average peak period	Morning Peak (6a-9a)	Midday (9a-4p)	Evening Peak (4p-7p)	Average peak period
SR-57 HOV NB: SR-91 to Tonner Canyon Rd	6.92	1.01	1.12	1.71	1.52	3%	60%	67%	50%
SR-91 EB: SR-90 to SR-71	6.94	1.01	1.14	2.16	1.52	0%	66%	96%	43%
SR-91 HOV WB: SR-39 to Orangethorpe Ave	2.23	1.13	1.20	1.78	1.50	48%	94%	90%	72%
I-5 SB: SR-57 to SR-55	4.15	1.71	1.05	1.28	1.49	46%	30%	62%	54%
I-5 HOV NB: I-405 to SR-55	8.62	1.05	1.09	1.65	1.40	16%	38%	75%	51%
SR-57 NB: I-5 to SR-91	4.47	1.01	1.10	1.79	1.38	4%	53%	100%	49%
SR-57 SB: SR-91 to I-5	4.81	1.49	1.06	1.21	1.35	89%	27%	69%	79%
SR-57 HOV NB: I-5 to SR-91	4.86	1.01	1.09	1.47	1.34	6%	32%	96%	72%
I-5 HOV NB: SR-55 to SR-57	4.00	1.00	1.05	1.51	1.34	0%	30%	67%	45%
SR-57 NB: SR-91 to Tonner Canyon Rd	6.92	1.00	1.09	1.63	1.33	0%	36%	58%	30%
I-405 SB: I-605 to SR-39	7.79	1.46	1.06	1.21	1.33	81%	27%	37%	58%
SR-55 NB: Victoria St to I-5	7.81	1.12	1.08	1.49	1.30	41%	38%	63%	51%
SR-57 SB: Tonner Canyon Rd to SR-91	7.27	1.45	1.06	1.07	1.26	48%	32%	31%	40%
I-405 SB: SR-39 to SR-55	7.78	1.51	1.03	1.02	1.26	62%	15%	8%	34%
I-5 NB: SR-55 to SR-57	4.35	1.02	1.09	1.49	1.25	9%	36%	54%	31%
I-5 NB: I-405 to SR-55	8.62	1.12	1.05	1.35	1.23	32%	23%	43%	37%
SR-55 NB: SR-91 to I-5	7.07	1.42	1.03	1.04	1.23	74%	18%	18%	46%
SR-91 WB: SR-90 to SR-57	5.84	1.13	1.10	1.31	1.21	33%	29%	38%	35%
SR-22 EB: I-405 to SR-55	12.40	1.27	1.09	1.14	1.20	42%	34%	33%	37%
I-5 HOV SB: SR-57 to SR-55	4.25	1.32	1.01	1.05	1.19	31%	3%	23%	27%
I-405 NB: I-5 to SR-55	8.22	1.09	1.02	1.30	1.19	29%	8%	68%	47%
SR-22 WB: SR-55 to I-405	12.60	1.03	1.03	1.30	1.17	19%	13%	37%	28%
SR-91 WB: SR-57 to Orangethorpe Ave	9.08	1.07	1.07	1.26	1.16	25%	26%	33%	29%
I-405 HOV NB: I-5 to SR-55	8.22	1.00	1.01	1.26	1.15	2%	2%	84%	48%
I-405 SB: SR-55 to I-5	8.14	1.01	1.01	1.28	1.15	4%	3%	46%	26%
I-405 HOV SB: I-605 to SR-39	7.79	1.16	1.03	1.12	1.14	51%	15%	32%	41%
I-405 NB: SR-39 to I-605	7.58	1.17	1.04	1.10	1.13	53%	23%	24%	39%
I-5 SB: I-405 to SR-73	8.50	1.01	1.03	1.22	1.13	5%	16%	29%	18%
SR-57 HOV SB: Tonner Canyon Rd to SR-91	7.27	1.18	1.02	1.02	1.11	34%	7%	7%	23%
I-5 HOV SB: SR-91 to SR-57	7.22	1.19	1.01	1.00	1.11	44%	0%	0%	24%
I-405 NB: SR-55 to SR-39	7.99	1.03	1.03	1.18	1.10	17%	12%	24%	21%
SR-91 HOV WB: SR-57 to Harbor Blvd	2.96	1.00	1.02	1.17	1.10	0%	14%	46%	26%
SR-91 EB: SR-57 to SR-90	5.42	1.01	1.05	1.17	1.09	5%	17%	58%	31%
SR-57 HOV SB: SR-91 to I-5	4.81	1.14	1.01	1.03	1.09	51%	0%	10%	33%
SR-55 HOV SB: SR-91 to I-405	10.69	1.08	1.03	1.09	1.08	16%	11%	25%	20%
SR-91 EB: Orangethorpe Ave to SR-57	9.41	1.12	1.03	1.04	1.08	44%	15%	22%	33%
I-405 HOV SB: SR-39 to SR-55	7.78	1.16	1.00	1.00	1.08	37%	0%	0%	18%
I-5 SB: SR-39/Artesia Blvd to SR-57	10.20	1.14	1.00	1.00	1.07	42%	0%	0%	22%
SR-55 NB: I-5 to Victoria St	7.81	1.02	1.03	1.12	1.07	8%	16%	37%	23%
SR-241 NB: SR-261 to SR-91	5.91	1.00	1.00	1.09	1.06	0%	0%	45%	29%

**Exhibit ORA-11 (Continued). Mobility and Reliability by Section and Time Period**

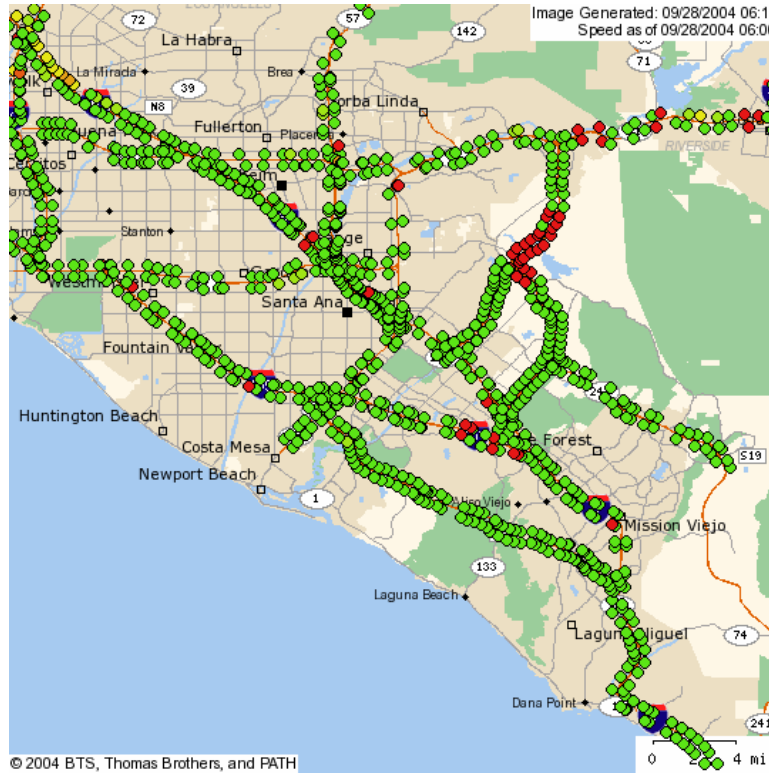
Freeway Section (sorted from most congested to least congested sections)	Length (mi)	Travel Time Index				Buffer Index			
		Morning Peak (6a-9a)	Midday (9a-4p)	Evening Peak (4p-7p)	Average peak period	Morning Peak (6a-9a)	Midday (9a-4p)	Evening Peak (4p-7p)	Average peak period
I-405 HOV NB: SR-39 to I-605	7.58	1.03	1.02	1.07	1.05	12%	11%	24%	18%
I-5 NB: SR-73 to I-405	9.02	1.07	1.03	1.02	1.05	30%	18%	13%	22%
I-5 HOV SB: SR-55 to I-405	9.12	1.03	1.01	1.07	1.05	16%	5%	25%	20%
I-5 NB: SR-57 to SR-39/Artesia Blvd	10.08	1.00	1.00	1.08	1.05	0%	0%	26%	14%
SR-91 HOV EB: SR-55 to SR-71	8.90	1.00	1.00	1.05	1.04	0%	0%	29%	24%
SR-55 NB: I-5 to SR-91	6.76	1.00	1.00	1.07	1.04	0%	0%	21%	12%
I-5 HOV SB: I-405 to SR-73	8.32	1.00	1.02	1.06	1.03	0%	12%	23%	14%
SR-55 HOV NB: I-405 to SR-91	10.36	1.00	1.01	1.04	1.03	0%	3%	11%	8%
I-405 HOV NB: SR-55 to SR-39	7.99	1.00	1.00	1.04	1.03	0%	0%	15%	9%
I-5 SB: SR-55 to I-405	9.19	1.01	1.01	1.02	1.02	8%	2%	13%	11%
I-5 NB: Cristianitos Rd to SR-1	6.35	1.02	1.03	1.02	1.02	5%	16%	4%	4%
I-5 NB: SR-1 to SR-73	5.97	1.03	1.02	1.00	1.02	15%	5%	0%	8%
I-405 HOV SB: SR-55 to I-5	8.14	1.00	1.00	1.03	1.02	0%	0%	13%	8%
SR-91 WB: SR-71 to SR-90	7.25	1.02	1.01	1.02	1.02	6%	2%	7%	7%
I-5 HOV SB: SR-73 to SR-1	4.28	1.00	1.01	1.02	1.02	0%	2%	4%	2%
SR-91 HOV EB: Harbor Blvd to SR-57	2.96	1.00	1.01	1.03	1.02	0%	0%	4%	2%
I-5 HOV NB: SR-57 to SR-91	7.22	1.00	1.00	1.02	1.01	0%	0%	12%	8%
I-5 HOV NB: SR-73 to I-405	8.30	1.00	1.01	1.01	1.01	0%	8%	8%	4%
SR-73 NB: SR-133 to I-405	11.05	1.01	1.00	1.01	1.01	2%	0%	5%	3%
I-5 SB: SR-73 to SR-1	5.89	1.00	1.01	1.01	1.01	0%	3%	0%	0%
I-5 SB: SR-1 to Cristianitos Rd	6.20	1.00	1.01	1.01	1.01	0%	5%	4%	2%
I-5 HOV NB: SR-1 to SR-73	6.74	1.00	1.02	1.01	1.00	0%	5%	0%	0%
SR-73 NB: I-5 to SR-133	6.35	1.01	1.00	1.00	1.00	0%	0%	0%	0%
SR-91 HOV EB: Orangethorpe Ave to SR-39	1.68	1.00	1.00	1.00	1.00	0%	0%	0%	0%
SR-73 SB: SR-133 to I-5	6.35	1.00	1.00	1.00	1.00	0%	0%	0%	0%
SR-91 HOV WB: SR-71 to SR-55	8.96	1.00	1.00	1.00	1.00	0%	0%	0%	0%
SR-133 SB: SR-241 to I-5	4.80	1.00	1.00	1.00	1.00	0%	0%	0%	0%
SR-241 SB: SR-261 to SR-133	5.23	1.00	1.00	1.00	1.00	0%	0%	0%	0%
SR-73 SB: I-405 to SR-133	11.15	1.00	1.00	1.00	1.00	0%	0%	0%	0%
SR-133 NB: I-5 to SR-241	4.66	1.00	1.00	1.00	1.00	0%	0%	0%	0%
SR-241 SB: SR-91 to SR-261	5.91	1.00	1.00	1.00	1.00	0%	0%	0%	0%
SR-261 SB: SR-241 to I-5	6.02	1.00	1.00	1.00	1.00	0%	0%	0%	0%
SR-241 NB: Antonio Pky to SR-133	9.62	1.00	1.00	1.00	1.00	0%	0%	0%	0%
SR-241 NB: SR-133 to SR-261	5.23	1.00	1.00	1.00	1.00	0%	0%	0%	0%
SR-241 SB: SR-133 to Antonio Pky	9.23	1.00	1.00	1.00	1.00	0%	0%	0%	0%
SR-261 NB: I-5 to SR-241	5.92	1.00	1.00	1.00	1.00	0%	0%	0%	0%
Average for all Sections		1.11	1.04	1.18	1.15	23%	17%	29%	26%

**Comments**

- This table shows average weekday congestion (travel time index) and reliability (buffer index) for specific routes for different time periods of the day.
- There are many freeway sections that operate at or near free-flow speeds (travel time index near 1.00 and buffer index near 0%) during the peak period.
- Several of the freeway sections with the highest levels of congestion are HOV lanes.

**Source and Coverage of Data**

This report was produced using data collected by Caltrans and archived by PeMS (<http://pems.eecs.berkeley.edu>). A map of the freeway routes on which traffic data was collected is shown below (dots indicate sensor locations).



**Exhibit ORA-12: Freeway Routes with Traffic Sensors in Orange County**

(Source of graphic: PeMS, <http://pems.eecs.berkeley.edu>)

**Exhibit ORA-13: Instrumented Freeway Coverage in Orange County**

Coverage Measures	Year	Instrumented Freeway Routes	Total Freeway System <sup>1</sup>	Percent Coverage
Lane-miles	2000	n.a.	1,295	n.a.
	2001	n.a.	1,440	n.a.
	2002	n.a.	1,490	n.a.
	2003	1,557	1,530	102%
Centerline-miles	2000	n.a.	160	n.a.
	2001	n.a.	185	n.a.
	2002	n.a.	190	n.a.
	2003	178	195	91%
Average annual daily vehicle-miles of travel (DVMT) (1000)	2000	n.a.	31,515	n.a.
	2001	n.a.	31,945	n.a.
	2002	n.a.	32,250	n.a.
	2003	30,190	33,300	91%

<sup>1</sup>Source is FHWA’s Highway Performance Monitoring System and the Texas Transportation Institute’s Urban Mobility Study (<http://mobility.tamu.edu/ums>).



## Documentation and Definitions

### Performance Measures

- **Travel Time Index:** ratio of the average peak period travel time to an off-peak travel time. For example, a value of 1.20 means that average peak travel times are 20% longer than off-peak travel times. In this report, the morning peak period is from 6 to 9 a.m. and the evening peak period is from 4 to 7 p.m. The off-peak travel time is calculated by assuming a free-flow speed of 60 mph.
- **Planning Time Index:** statistically defined as the 95th percentile Travel Time Index, this measure also represents the extra time most travelers include when planning peak period trips. For example, a value of 1.60 means that travelers plan for an additional 60% travel time above the off-peak travel times to ensure 95% on-time arrival.
- **Buffer Index:** the extra time (or buffer) needed to ensure on-time arrival for most trips. For example, a value of 40% means that a traveler should budget an additional 8 minute buffer for a 20-minute average peak trip time to ensure 95% on-time arrival. In this report, the buffer index is a VMT-weighted average of the buffer index for each route for the morning and evening peak period. The buffer index is calculated for each route and time period as follows:  $\text{buffer index} = (95^{\text{th}} \text{ percentile travel time} - \text{average travel time}) / \text{average travel time}$ .
- **% Congested Travel:** the congested peak period vehicle-miles of travel (VMT) divided by total VMT in the peak period. This is a relative measure of the amount of peak period travel affected by congestion.
- **Total Delay per 1000 VMT:** the total vehicle delay (in vehicle-hours) divided by the amount of VMT. This is a relative measure of the total delay and will not be as affected by changes in the level of sensor instrumentation for a particular city.
- **Vehicle Delay:** the delay (in vehicle-hours) experienced by vehicles traveling less than free-flow speeds (assumed to be 60 mph in this report).

### Explanatory Measures

- **Peak Period VMT:** the average amount of VMT within the defined peak periods (weekdays from 6 to 9 a.m. and 4 to 7 p.m.) for the year. Peak period VMT is reported by 1000s.
- **Average Annual DVMT (000):** the average annual amount of daily VMT (DVMT) for all days and times for the year. Average annual DVMT is reported by 1000s.

### Data Quality Measures

- **% complete:** the number of valid reported data values divided by the number of total expected data values (given the number of active sensors and time periods). In this report, % complete is reported as the lowest value of either traffic volume or speed data.
- **% valid:** the number of reported data values that passed defined acceptance criteria divided by the total number of reported data values. In this report, % valid is reported as the lowest value of either traffic volume or speed data.
- **% of DVMT covered:** the amount of average annual DVMT reported by sensors divided by the areawide average annual DVMT as estimated in FHWA's Highway Performance Monitoring System and TTI's Urban Mobility Study. This measure characterizes the relative amount of areawide travel that has the performance indicated in this report.
- **% coverage of freeway mileage:** the amount of freeway lane-miles containing sensors divided by the areawide freeway lane-miles as estimated in FHWA's Highway Performance Monitoring System and TTI's Urban Mobility Study. This measure characterizes the relative amount of areawide freeways that has the performance indicated in this report.