

Appendix SAF – San Francisco, 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 SAF-1: Current Measures and Trends

Measures	Current Year	Last Year		Two Years Ago	
	2003	2002	Change	2001	Change
Performance Measures					
Travel Time Index	1.11	n.a.	n.a. —	n.a.	n.a. —
Planning Time Index	1.36	n.a.	n.a. —	n.a.	n.a. —
Buffer Index	18%	n.a.	n.a. —	n.a.	n.a. —
% Congested Travel	27%	n.a.	n.a. —	n.a.	n.a. —
Total Delay (veh-hours) per 1000 VMT	2.05	n.a.	n.a. —	n.a.	n.a. —
Explanatory Measures					
Peak Period VMT (000)	11,610	n.a.	n.a. —	n.a.	n.a. —
Avg. Annual DVMT (000)	46,560	n.a.	n.a. —	n.a.	n.a. —
Data Quality Measures					
% complete	92%	n.a.	n.a. —	n.a.	n.a. —
% valid	100%	n.a.	n.a. —	n.a.	n.a. —
% of VMT covered	94%	n.a.	n.a. —	n.a.	n.a. —
% of freeway miles	94%	n.a.	n.a. —	n.a.	n.a. —

* See pages 9 and 10 for maps of freeway coverage, measure definitions, and further documentation.

Exhibit SAF-2: 2000 to 2003 Annual Trends

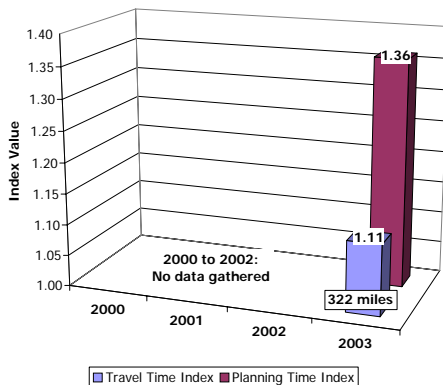
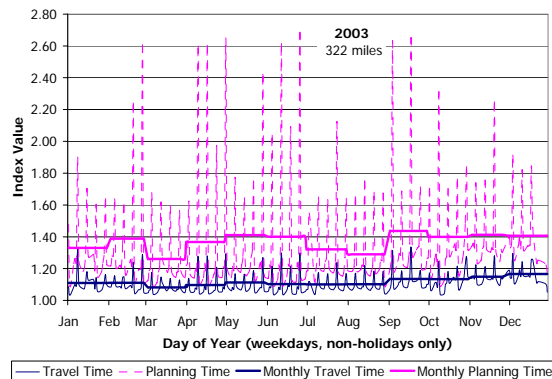


Exhibit SAF-3: Daily and Monthly Trends



Comments

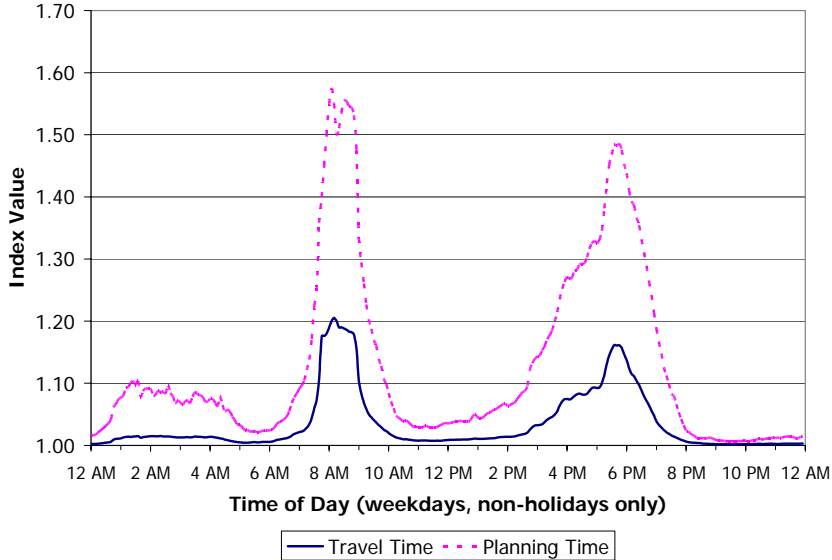
- This is the first year for San Francisco to be included in the Mobility Monitoring Program; therefore, trend information is not available yet. The weekday trends (Exhibit 3) display an odd repeating pattern—this could illustrate suspect data.
- The data collection system in San Francisco accounts for 94% of the freeway miles as well as 94% of the vehicle travel.

Data Source(s): PeMS (<http://pems.eecs.berkeley.edu>) in cooperation with Caltrans (<http://www.dot.ca.gov/>)
Includes 322 of 342 (94%) total freeway miles in San Francisco; collected using loop detectors; see page 9 for additional information on the data source

Data Analysis: Texas Transportation Institute, analysis completed September 2004

Time of Day Patterns and Trends

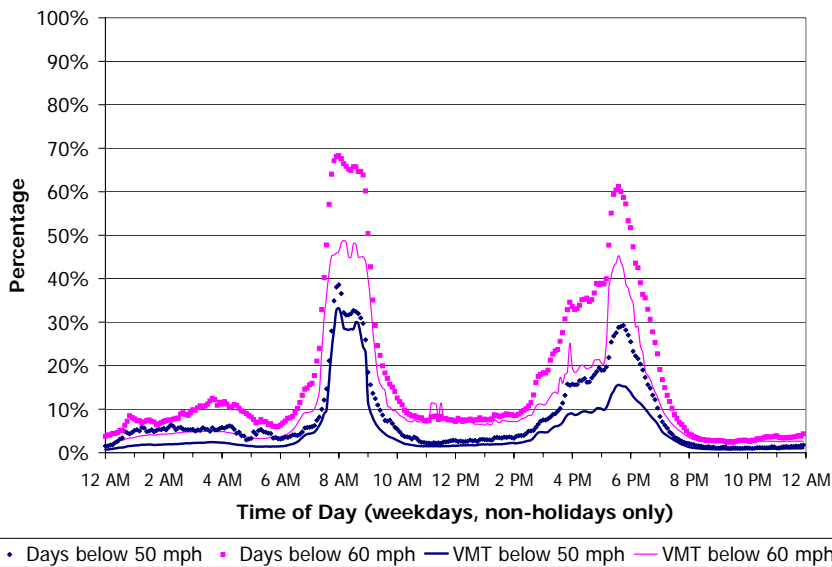
The charts on this page illustrate average weekday (no holidays included) traffic patterns and trends that were measured on the freeway sections instrumented with operations-based traffic sensors.



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 longer but not as severe as the morning congestion.
- Travelers must add 20-30% additional buffer time during peak times to account for traffic unreliability.

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



Comments

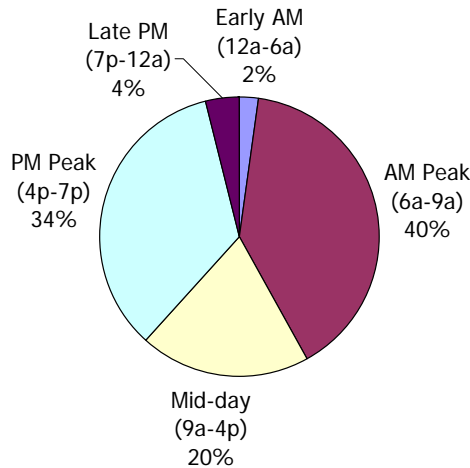
- This chart illustrates the difference in using two different speed thresholds (50 and 60 mph) to compute the percent of congested days as well as the percent of congested travel.
- Using a 50 mph threshold, 15-30% of the VMT and 30-40% of days are congested during the peak hour.
- Using a 60 mph threshold, 40-50% of the VMT and 60-70% of days are congested during the peak hour.

Exhibit SAF-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:

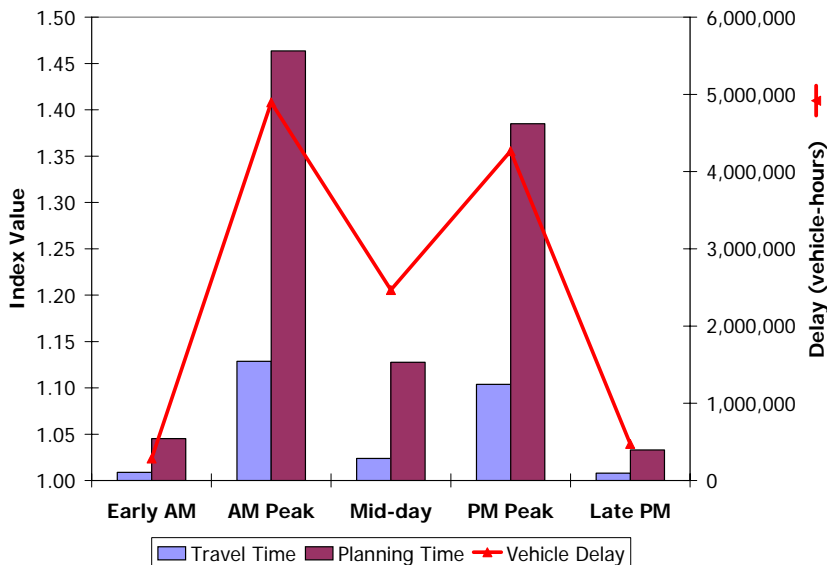
- Early AM: 12 to 6 am
- AM Peak: 6 to 9 am
- Mid-day: 9 am to 4 pm
- PM Peak: 4 to 7 pm
- Late PM: 7 pm to 12 am



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 slightly less than the morning peak period.
- Delay during the mid-day period is half of the delay during the morning peak period.

Exhibit SAF-6: Percent of Delay by Time Period



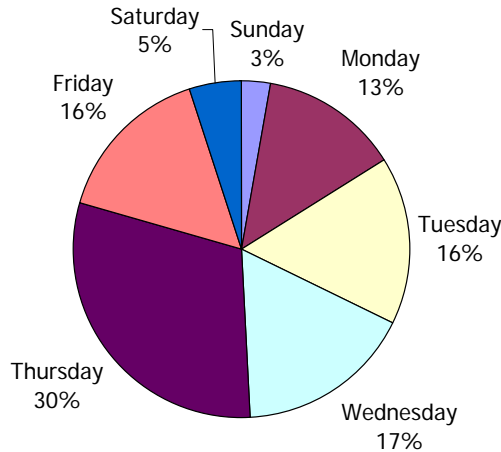
Comments

- 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 SAF-7: Mobility, Reliability, and Delay by Time Period

Day of Week Patterns and Trends

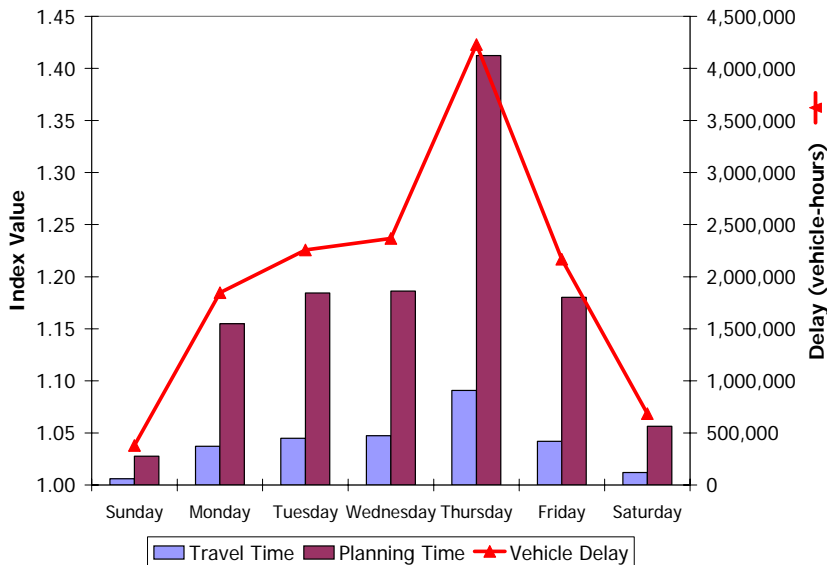
The charts on this page illustrate average traffic patterns and trends that were measured on the freeway sections instrumented with operations-based traffic sensors. Because of different peak period times and lengths on weekdays and weekends, the statistics presented on this page are 24-hour daily totals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



Comments

- This chart shows the percent of total daily delay that occurred during each day of the week.
- The delay on Thursday is significantly greater than all other weekdays (possibly due to suspect data—see Exhibit 3). Delay on all other weekdays is comparable.
- Both weekend days combined have about half of the normal weekday delay.

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



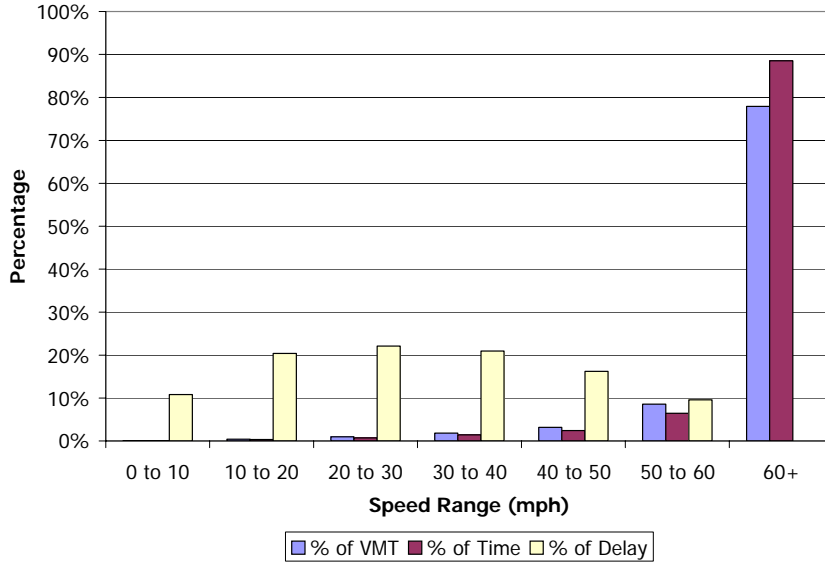
Comments

- 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 SAF-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 75% of the delay occurred at speeds less than 40 mph.

Exhibit SAF-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 SAF-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
I-84 WB: I-880 to Dumbatton Bridge	4.95	1.61	1.38	1.29	1.48	57%	51%	54%	56%
US-101 SB: San Antonio Rd to SR-237	4.44	1.21	1.08	1.72	1.47	41%	48%	24%	32%
I-880 NB: SR-84 to SR-92	6.61	1.33	1.10	1.50	1.42	54%	41%	49%	51%
SR-87 SB: SR-85 to I-280	5.16	1.00	1.03	1.60	1.39	0%	21%	35%	22%
I-84 EB: Dumbatton Bridge to I-880	4.95	1.26	1.24	1.29	1.28	66%	60%	79%	74%
US-101 SB: SR-37 to Miller Creek Rd	3.57	1.45	1.04	1.00	1.24	124%	0%	0%	67%
I-880 NB: US-101 to SR-262	6.77	1.01	1.01	1.42	1.24	1%	0%	93%	53%
US-101 NB: I-280 to Hayes St	3.66	1.26	1.07	1.20	1.23	45%	45%	69%	57%
I-880 SB: 29th Ave to I-238	7.93	1.04	1.08	1.40	1.23	16%	34%	55%	36%
US-101 SB: SR-84 to San Antonio Rd	7.76	1.24	1.03	1.18	1.21	57%	17%	43%	50%
SR-24 WB: I-680 to Gateway Blvd/SR-13	7.95	1.12	1.04	1.29	1.19	34%	23%	43%	38%
I-680 NB: Crow Canyon Rd to SR-24	10.34	1.14	1.02	1.23	1.19	35%	8%	49%	43%
US-101 SB: SR-237 to I-280	12.01	1.01	1.02	1.30	1.19	1%	14%	49%	30%
US-101 NB: SR-84 to SR-92	3.77	1.14	1.02	1.22	1.19	62%	7%	54%	58%
I-580 WB: SR-13 to I-80/I-880	7.00	1.34	1.02	1.03	1.19	75%	5%	13%	44%
I-880 NB: I-238 to 29th Ave	7.29	1.27	1.12	1.08	1.17	71%	55%	36%	53%
I-880 SB: I-238 to SR-92	4.76	1.24	1.03	1.11	1.17	47%	16%	41%	44%
I-85 SB: I-280 to SR-17	7.91	1.03	1.00	1.24	1.17	4%	0%	67%	46%
I-80 EB: Bay Bridge/I-880/I-580 to I-580/Cleveland Ave	7.05	1.17	1.03	1.17	1.17	23%	14%	26%	24%
I-880 SB: SR-92 to SR-84	6.41	1.19	1.03	1.13	1.16	46%	13%	26%	35%
I-580 EB: I-680 to N Livermore Ave	14.96	1.08	1.06	1.23	1.16	19%	31%	53%	36%
I-680 NB: Dixon Rd to SR-262	3.51	1.04	1.04	1.25	1.15	6%	18%	71%	41%
I-80 WB: I-580/Cleveland Ave to Bay Bridge/I-880/I-580	7.14	1.14	1.03	1.16	1.15	23%	15%	29%	26%
US-101 SB: I-380 to SR-92	8.00	1.08	1.04	1.21	1.15	24%	19%	37%	31%
SR-24 EB: SR-13 to I-680	8.50	1.15	1.01	1.13	1.14	22%	0%	33%	28%
I-80 EB: I-580/Cleveland Ave to El Portal Dr	4.87	1.12	1.02	1.16	1.14	27%	12%	30%	29%
I-880 SB: SR-84 to SR-262	7.48	1.24	1.09	1.04	1.14	53%	50%	16%	35%
I-580 EB: I-80/I-880 to SR-13	17.32	1.16	1.01	1.12	1.14	28%	5%	37%	33%
US-101 NB: SR-92 to I-380	8.00	1.10	1.02	1.17	1.14	31%	9%	34%	33%
US-101 SB: SR-92 to SR-84	4.26	1.26	1.03	1.01	1.13	34%	22%	5%	19%
I-280 SB: I-880 to US-101	4.55	1.26	1.00	1.02	1.13	35%	2%	8%	20%
I-80 EB: SR-29 to SR-37	4.41	1.24	1.03	1.02	1.13	61%	6%	11%	35%
US-101 NB: SR-237 to San Antonio Rd	4.85	1.25	1.00	1.01	1.12	33%	0%	7%	19%
I-80 WB: Travis Blvd to SR-12/I-680	10.23	1.24	1.00	1.01	1.12	32%	0%	6%	18%
I-80 WB: El Portal Dr to I-580/Cleveland Ave	4.79	1.17	1.03	1.05	1.11	41%	11%	16%	30%
I-880 NB: I-280 to US-101	5.60	1.17	1.05	1.04	1.11	44%	28%	22%	35%

Mobility Monitoring Program
Sponsored by the Federal Highway Administration, Office of Operations

Exhibit SAF-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-580 WB: N Livermore Ave to I-680	4.57	1.21	1.00	1.01	1.11	31%	0%	6%	18%
I-880 SB: I-80/I-580 to 29th Ave	6.29	1.05	1.04	1.16	1.10	21%	24%	37%	29%
US-101 NB: I-280 to SR-237	11.25	1.18	1.02	1.00	1.10	46%	11%	0%	26%
US-101 NB: San Antonio Rd to SR-84	7.52	1.12	1.01	1.09	1.10	41%	0%	47%	44%
I-880 SB: SR-262 to US-101	6.95	1.17	1.03	1.03	1.10	26%	14%	13%	20%
I-680 SB: I-780 to SR-4	5.39	1.19	1.00	1.00	1.10	31%	0%	3%	17%
I-880 NB: 29th Ave to I-80/I-580	6.84	1.03	1.02	1.16	1.09	11%	6%	45%	28%
I-680 NB: I-780 to I-80	11.61	1.00	1.04	1.15	1.09	0%	5%	72%	43%
SR-92 WB: I-880 to US-101	12.89	1.19	1.00	1.00	1.09	27%	0%	2%	14%
SR-237 EB: US-101 to I-880	6.08	1.06	1.00	1.11	1.09	18%	0%	25%	22%
US-101 NB: Wilfred Ave to SR-12	5.00	1.18	1.00	1.01	1.09	23%	0%	5%	13%
SR-92 EB: US-101 to I-880	12.30	1.18	1.00	1.00	1.09	26%	0%	3%	14%
I-680 NB: SR-4 to I-780	5.97	1.16	1.01	1.02	1.08	28%	5%	8%	17%
I-680 NB: SR-24 to SR-4	7.05	1.08	1.02	1.08	1.08	22%	7%	21%	21%
US-101 SB: SR-12 to Wilfred Ave	4.28	1.17	1.00	1.00	1.08	25%	0%	2%	13%
I-80 EB: SR-12/I-680 to Travis Blvd	6.87	1.12	1.02	1.04	1.08	29%	9%	27%	28%
US-101 SB: Hayes St to I-280	4.61	1.14	1.00	1.02	1.08	25%	0%	10%	17%
I-280 NB: US-101 to I-880	5.80	1.13	1.01	1.02	1.08	34%	0%	4%	19%
US-101 SB: I-280 to I-380	7.25	1.14	1.00	1.01	1.07	27%	0%	3%	15%
I-280 NB: I-380 to SR-1	6.15	1.04	1.00	1.09	1.07	7%	0%	31%	21%
I-880 NB: SR-92 to I-238	4.78	1.08	1.05	1.06	1.07	27%	25%	26%	26%
I-580 EB: Castro St to I-80	5.80	1.13	1.01	1.01	1.07	41%	0%	0%	20%
I-680 SB: Crow Canyon Rd to I-580	6.25	1.12	1.01	1.02	1.07	23%	4%	9%	16%
I-280 SB: SR-1 to I-380	6.45	1.14	1.00	1.00	1.07	27%	0%	2%	14%
I-85 NB: SR-87 to SR-17	4.78	1.12	1.01	1.01	1.07	52%	0%	0%	28%
US-101 NB: SR-85 to I-280	8.28	1.11	1.01	1.00	1.07	27%	6%	2%	16%
SR-237 WB: I-880 to US-101	6.08	1.08	1.00	1.04	1.06	19%	0%	16%	17%
I-280 NB: SR-1 to I-80	7.72	1.11	1.00	1.01	1.06	37%	0%	0%	19%
I-80 EB: El Portal Dr to Cummings Skyway	9.24	1.04	1.02	1.08	1.06	9%	6%	37%	25%
I-680 SB: SR-24 to Crow Canyon Rd	10.26	1.09	1.01	1.04	1.06	22%	3%	14%	18%
I-880 SB: US-101 to I-280	4.78	1.04	1.00	1.07	1.06	10%	0%	25%	19%
I-80 WB: Cummings Skyway to El Portal Dr	9.24	1.11	1.00	1.01	1.06	33%	0%	0%	17%
I-680 SB: SR-262 to Dixon Rd	3.23	1.08	1.01	1.03	1.06	26%	0%	17%	22%
I-680 NB: I-580 to Crow Canyon Rd	6.38	1.07	1.00	1.04	1.06	16%	0%	22%	20%
I-280 SB: SR-85 to I-880	11.01	1.09	1.00	1.03	1.06	27%	0%	16%	21%
I-85 SB: SR-17 to SR-87	4.80	1.04	1.01	1.06	1.05	7%	1%	23%	17%
I-680 SB: SR-4 to SR-24	6.87	1.08	1.00	1.02	1.05	23%	0%	8%	16%
I-85 NB: SR-17 to I-280	7.91	1.08	1.02	1.00	1.05	34%	0%	0%	20%
I-80 WB: SR-37 to SR-29	8.06	1.08	1.01	1.02	1.05	25%	0%	13%	18%
SR-87 NB: I-280 to SR-85	5.02	1.08	1.03	1.01	1.05	33%	18%	0%	18%
US-101 SB: I-280 to SR-85	7.20	1.02	1.01	1.06	1.04	2%	0%	12%	8%
SR-4 EB: I-680 to Bailey Rd	7.14	1.03	1.00	1.05	1.04	9%	0%	20%	15%
I-280 SB: I-80 to SR-1	7.73	1.05	1.00	1.03	1.04	14%	0%	16%	15%
I-880 NB: SR-262 to SR-84	7.47	1.03	1.01	1.04	1.03	6%	3%	19%	14%
SR-17 NB: Bear Creek Rd to I-280	8.61	1.06	1.01	1.00	1.03	21%	0%	0%	12%
US-101 NB: I-380 to I-280	7.36	1.05	1.00	1.02	1.03	14%	0%	7%	10%
I-280 NB: I-880 to SR-85	9.95	1.06	1.00	1.01	1.03	18%	0%	4%	11%

Exhibit SAF-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
SR-17 SB: I-280 to Bear Creek Rd	11.55	1.03	1.00	1.03	1.03	8%	0%	13%	11%
SR-92 EB: I-280 to US-101	4.83	1.04	1.01	1.01	1.02	14%	0%	1%	7%
SR-4 WB: Bailey Rd to I-680	7.32	1.04	1.00	1.00	1.02	12%	0%	0%	7%
SR-92 WB: US-101 to I-280	4.83	1.01	1.00	1.03	1.02	3%	0%	17%	11%
US-101 NB: Miller Creek Rd to SR-37	3.57	1.04	1.00	1.01	1.02	9%	0%	4%	6%
I-85 SB: SR-87 to US-101	5.31	1.04	1.00	1.00	1.02	6%	0%	0%	3%
I-85 NB: US-101 to SR-87	5.63	1.03	1.00	1.00	1.02	12%	0%	0%	6%
I-580 WB: I-80 to Castro St	4.59	1.03	1.00	1.00	1.02	6%	0%	0%	3%
I-680 SB: I-80 to I-780	10.83	1.01	1.00	1.00	1.01	0%	0%	0%	0%
Average for all Sections		1.13	1.02	1.10	1.12	29%	10%	24%	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.

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).

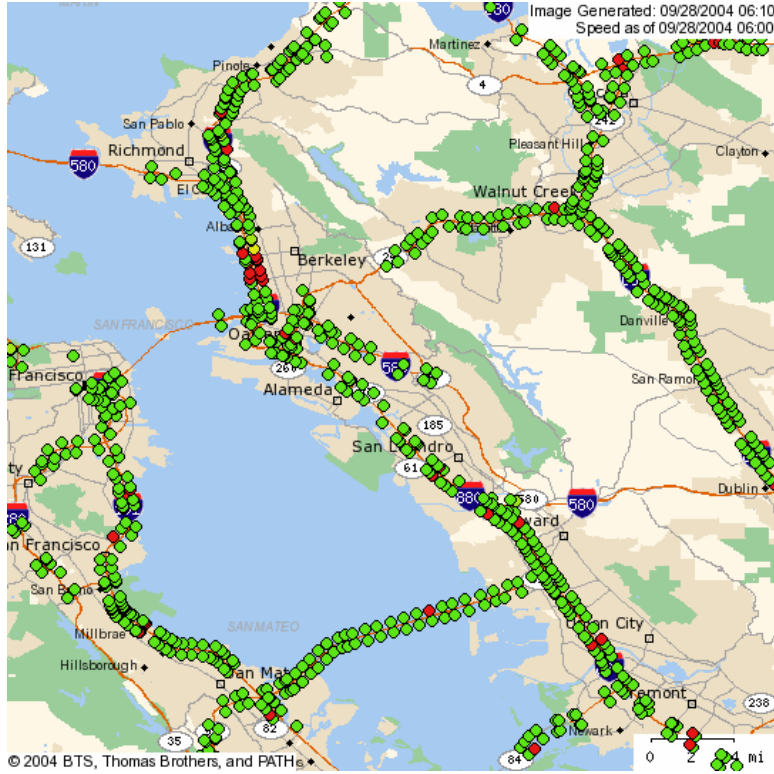


Exhibit SAF-12: Freeway Routes with Traffic Sensors in San Francisco

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

Exhibit SAF-13: Instrumented Freeway Coverage in San Francisco

Coverage Measures	Year	Instrumented Freeway Routes	Total Freeway System ¹	Percent Coverage
Lane-miles	2000	n.a.	2335	n.a.
	2001	n.a.	2400	n.a.
	2002	n.a.	2415	n.a.
	2003	2349	2455	96%
Centerline-miles	2000	n.a.	330	n.a.
	2001	n.a.	330	n.a.
	2002	n.a.	337	n.a.
	2003	322	342	94%
Average annual daily vehicle-miles of travel (DVT) (1000)	2000	n.a.	46,500	n.a.
	2001	n.a.	47,000	n.a.
	2002	n.a.	48,585	n.a.
	2003	46,560	49,628	94%

¹Source 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.