

Appendix PHX – Phoenix, Arizona 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 PHX-1: Current Measures and Trends

Measures	Current Year	Last Year		Two Years Ago	
	2003	2002	Change	2001	Change
Performance Measures					
Travel Time Index	1.16	1.17	-1% ↓	1.15	+1% ↑
Planning Time Index	1.38	1.37	+1% ↑	1.33	+4% ↑
Buffer Index	16%	14%	+2% ↑	14%	+2% ↑
% Congested Travel	48%	44%	+4% ↑	54%	-6% ↓
Total Delay (veh-hours) per 1000 VMT	2.60	2.79	-7% ↓	2.62	-1% ↓
Explanatory Measures					
Peak Period VMT (000)	3,000	2,080	+44% ↑	1,760	+70% ↑
Avg. Annual DVMT (000)	11,040	7,770	+42% ↑	6,580	+68% ↑
Data Quality Measures					
% complete	60%	53%	+7% ↑	72%	-12% ↓
% valid	68%	66%	+2% ↑	72%	-4% ↓
% of VMT covered	46%	34%	+12% ↑	31%	+15% ↑
% of freeway miles	39%	36%	+3% ↑	30%	+9% ↑

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

Exhibit PHX-2: 2000 to 2003 Annual Trends

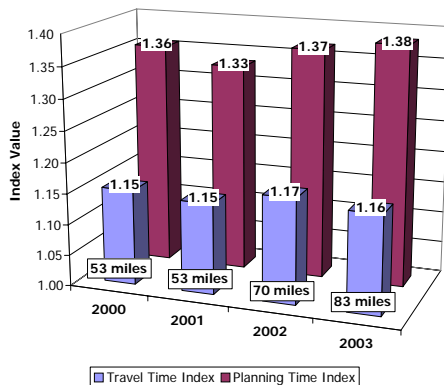
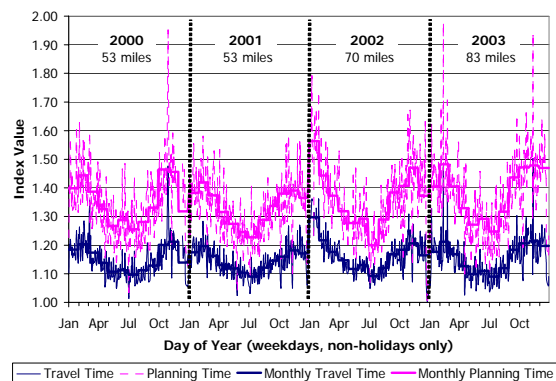


Exhibit PHX-3: Daily and Monthly Trends



Comments

- The 2003 trends in Phoenix are mixed: the travel time index is down by 1% while the buffer index is up 2%. The 2003 percent of congested travel is up 4% from 2002 levels, but down 6% from 2001 levels.
- Vehicle travel (DVMT) has increased significantly, mostly because of increases in freeway coverage. All 2003 data quality indicators showed improvement over 2002 levels.

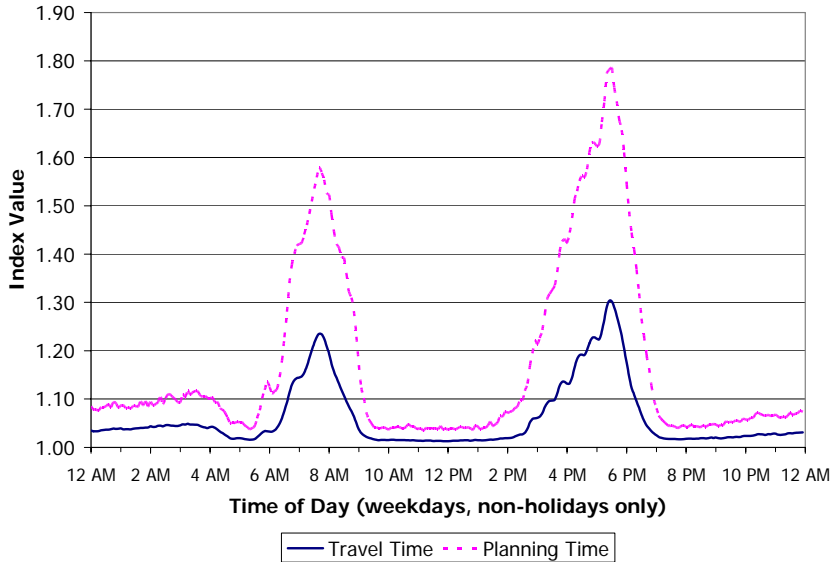
Data Source(s): Arizona DOT (<http://www.dot.state.az.us/> and <http://www.az511.com>)

Includes 83 of 214 (39%) total freeway miles in Phoenix; collected using loop detectors and passive acoustic sensors; 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

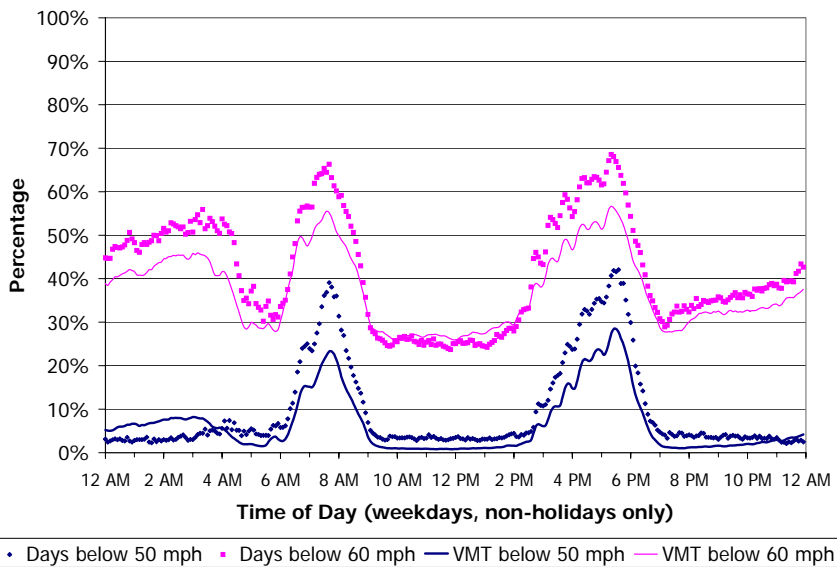
The charts on this page illustrate average weekday (no holidays included) traffic patterns and trends that were measured on the freeway sections instrumented with operations-based traffic sensors.



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 level is worse than the morning congestion level.
- Travelers must add 20-35% additional buffer time during peak times to account for traffic unreliability.

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



Comments

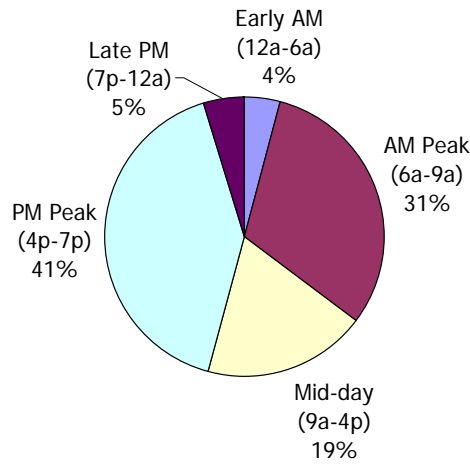
- This chart illustrates the difference in using two different speed thresholds (50 and 60 mph) to compute the percent of congested days as well as the percent of congested travel.
- Using a 50 mph threshold, 20-30% of the VMT and 35-40% of days are congested during the peak hour.
- Using a 60 mph threshold, 50-60% of the VMT and 60-70% of days are congested during the peak hour.

Exhibit PHX-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:

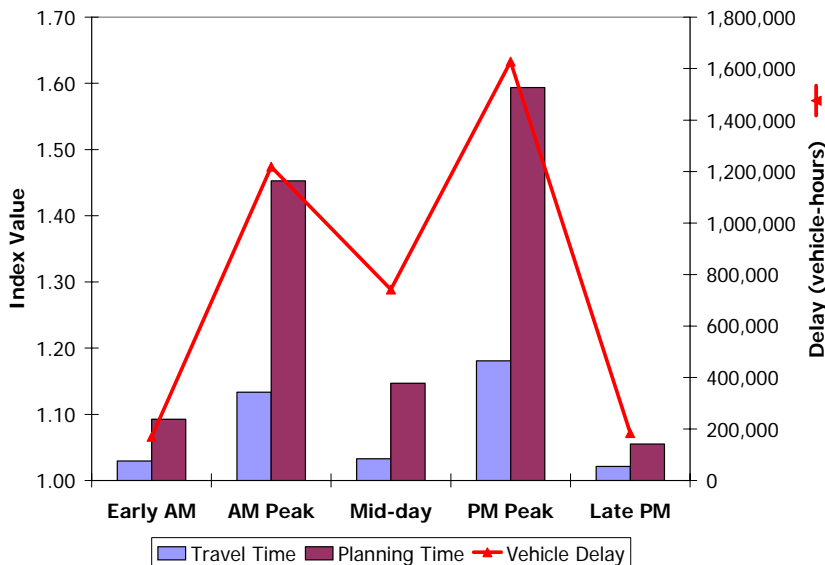
- Early AM: 12 to 6 am
- AM Peak: 6 to 9 am
- Mid-day: 9 am to 4 pm
- PM Peak: 4 to 7 pm
- Late PM: 7 pm to 12 am



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 greater than the morning peak period.
- Delay during the mid-day period is less than seen in other cities.

Exhibit PHX-6: Percent of Delay by Time Period



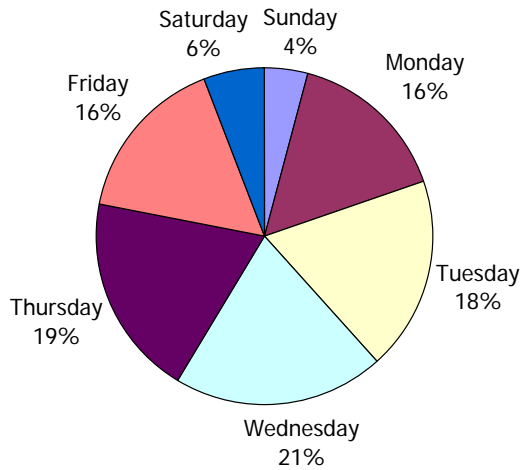
Comments

- 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.

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

Day of Week Patterns and Trends

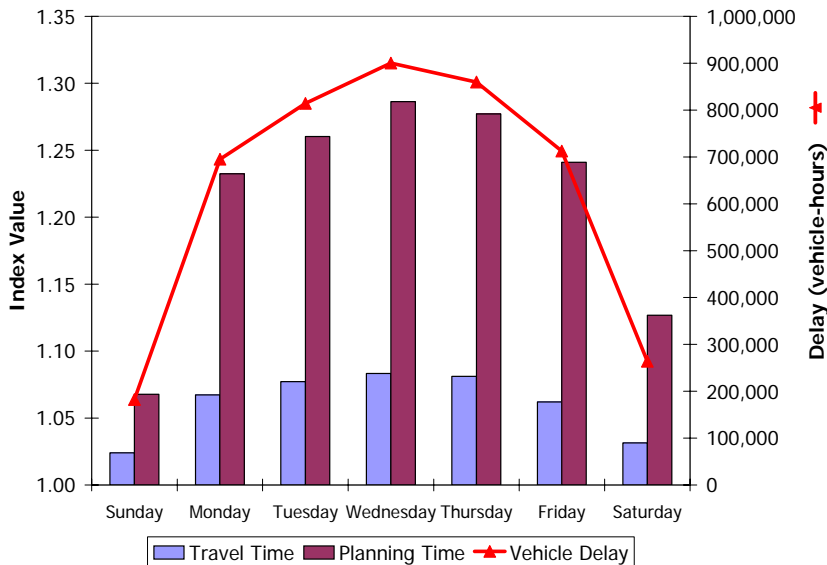
The charts on this page illustrate average traffic patterns and trends that were measured on the freeway sections instrumented with operations-based traffic sensors. Because of different peak period times and lengths on weekdays and weekends, the statistics presented on this page are 24-hour daily totals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



Comments

- This chart shows the percent of total daily delay that occurred during each day of the week.
- Wednesday has the most delay, with Monday and Friday having the least delay of all weekdays.
- Each weekend day has 20-30% of the delay of a typical weekday.

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



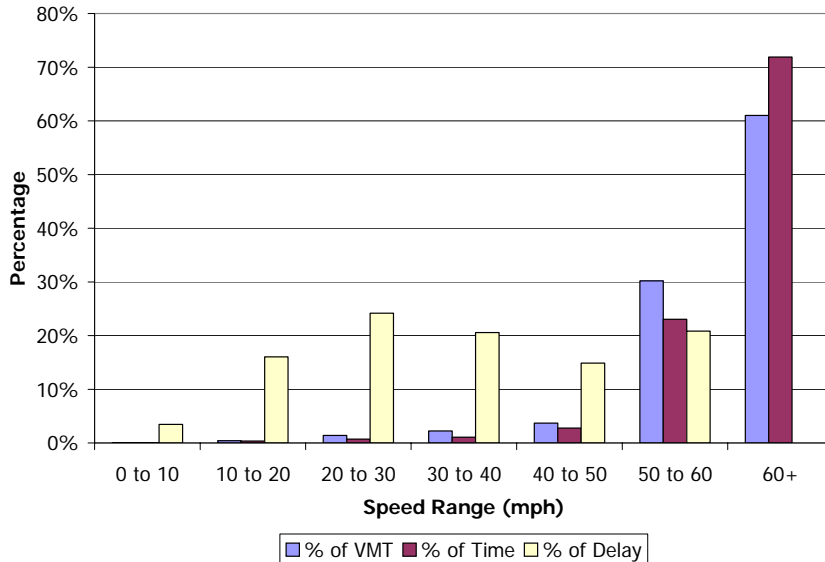
Comments

- 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.
- Wednesday has the most delay and also is the least reliable day (highest planning time index).

Exhibit PHX-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.
- More than 20% of the delay is in the 50 to 60 mph range.
- Only 2% of the VMT is below 30 mph, but 44% of the delay occurred below 30 mph.

Exhibit PHX-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 PHX-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
US 60 WB: Loop 101 to I-10	4.17	1.66	1.03	1.10	1.41	72%	12%	39%	57%
I-10 WB: Gold Poppy Way to Southern Ave	6.09	1.55	1.01	1.01	1.31	73%	0%	0%	41%
Loop 101 SB: L202 Hwy to Golf Ave	2.78	1.00	1.03	1.50	1.30	0%	14%	56%	33%
US 60 EB: I-10 to Loop 101	4.29	1.04	1.08	1.45	1.28	3%	28%	48%	29%
Loop 202 EB: 47th St to 88th St	6.10	1.00	1.04	1.43	1.27	0%	18%	73%	45%
I-10 WB: 26th Ave/I-17 to 82nd Ave	7.50	1.01	1.04	1.45	1.26	2%	17%	60%	36%
I-17 SB: Beryl Ave to Moreland/I- 10	8.14	1.37	1.13	1.14	1.26	42%	19%	21%	32%
I-10 EB: Roosevelt/SR 51 to Fairmont/AZ 60	7.17	1.01	1.02	1.47	1.25	1%	11%	54%	29%
I-17 NB: Portland/I-10 to Beryl Ave	8.19	1.02	1.07	1.41	1.23	4%	23%	47%	26%
I-10 EB: 81st Ave to 26th Ave/I-17	7.30	1.39	1.02	1.01	1.22	71%	2%	1%	40%
Loop 101 NB: Golf Ave to L202 Hwy	2.76	1.38	1.01	1.01	1.22	63%	0%	0%	35%
US 60 EB: Loop 101 to Val Vista	8.20	1.02	1.07	1.33	1.21	2%	29%	32%	20%
I-10 WB HOV: 26th Ave/I-17 to 82nd Ave	7.50	1.01	1.02	1.25	1.19	2%	9%	50%	38%
I-10 WB HOV: Fairmont/SR 60 to Roosevelt/SR 51	7.00	1.17	1.16	1.19	1.18	57%	61%	68%	61%
Loop 202 WB: 46th St to 22nd St	3.27	1.21	1.06	1.14	1.18	50%	26%	65%	57%
I-10 EB HOV: Roosevelt/SR 51 to Fairmont/AZ 60	7.17	1.01	1.01	1.21	1.16	0%	5%	48%	36%
I-10 WB: 18th/SR 51 to 22nd Ave/I-17	4.41	1.03	1.07	1.28	1.16	10%	27%	61%	36%
Loop 101 NB: Guadalupe Rd to Southern Ave	2.14	1.28	1.00	1.00	1.15	53%	0%	0%	29%
I-10 EB HOV: 81st Ave to 26th Ave/I-17	7.30	1.23	1.01	1.00	1.15	59%	0%	0%	38%
I-17 SB: Moreland/I-10 to 22nd St/I-10	6.29	1.15	1.01	1.08	1.12	39%	3%	39%	39%
I-10 EB: 22nd Ave/I-17 to 19th/SR 51	4.47	1.14	1.02	1.08	1.11	31%	11%	25%	28%
I-10 WB HOV: 18th/SR 51 to 22nd Ave/I-17	4.41	1.00	1.04	1.18	1.11	0%	20%	50%	30%
Loop 202 WB: 89th St to 47th St	6.12	1.16	1.01	1.00	1.11	30%	0%	0%	19%
SR 51 SB: Juniper Ave to Maryland Ave	7.73	1.14	1.00	1.00	1.09	45%	0%	0%	28%
Loop 202 EB HOV: 47th St to 88th St	6.10	1.01	1.01	1.10	1.08	3%	1%	24%	19%
US 60 WB HOV: Loop 101 to I-10	4.17	1.10	1.01	1.04	1.08	27%	3%	15%	23%
I-10 EB: Southern Ave to Gold Poppy Way	6.15	1.00	1.01	1.12	1.08	0%	1%	39%	24%
SR 51 NB: Maryland Ave to Paradise Ln	7.62	1.00	1.00	1.12	1.08	0%	0%	29%	19%
I-17 NB: 23rd St/I-10 to Portland/I- 10	6.27	1.01	1.05	1.13	1.07	3%	25%	42%	23%

Exhibit PHX-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-10 WB: Fairmont/SR 60 to Roosevelt/SR 51	7.00	1.07	1.04	1.06	1.07	27%	17%	34%	30%
US 60 WB: Val Vista to Loop 101	8.29	1.09	1.02	1.03	1.06	25%	2%	2%	15%
US 60 EB HOV: Loop 101 to Val Vista	8.20	1.00	1.02	1.07	1.06	0%	13%	17%	13%
Loop 202 EB: 26th St to 46th St	3.02	1.01	1.00	1.09	1.05	1%	0%	47%	26%
SR 143 SB: Moreland/Loop 202 to Kerby Ave/I-10	3.52	1.02	1.04	1.08	1.05	0%	13%	34%	17%
Loop 101 SB: Southern Ave to Guadalupe Rd	2.27	1.00	1.00	1.07	1.05	0%	0%	25%	15%
I-17 NB HOV: Granada/I-10 to Beryl Ave	7.89	1.00	1.01	1.06	1.05	0%	5%	15%	11%
Loop 202 WB HOV: 46th St to 22nd St	3.27	1.04	1.03	1.06	1.05	15%	4%	26%	20%
I-10 WB HOV: Gold Poppy Way to Southern Ave	6.09	1.06	1.01	1.00	1.04	15%	0%	0%	10%
I-10 EB HOV: 22nd Ave/I-17 to 19th/SR 51	4.47	1.06	1.01	1.02	1.04	22%	0%	1%	12%
SR 51 SB: Maryland Ave to I- 10/Loop 202	5.59	1.06	1.00	1.01	1.04	15%	0%	4%	10%
US 60 EB HOV: I-10 to Loop 101	4.29	1.00	1.01	1.04	1.03	1%	3%	7%	6%
I-17 SB HOV: Beryl Ave to Catalina Dr/I-10	6.96	1.04	1.00	1.01	1.02	12%	0%	0%	7%
I-10 EB HOV: Southern Ave to Gold Poppy Way	6.15	1.00	1.01	1.03	1.02	0%	0%	14%	11%
SR 51 NB: Granada/I-10/Loop 202 to Maryland Ave	5.22	1.00	1.00	1.03	1.02	0%	0%	15%	8%
Loop 202 EB HOV: 26th St to 46th St	3.02	1.00	1.00	1.02	1.01	0%	0%	11%	7%
Loop 202 WB HOV: 89th St to 47th St	6.00	1.01	1.00	1.00	1.01	4%	0%	0%	3%
SR 143 NB: Kerby Ave/I-10 to Moreland/Loop 202	3.40	1.00	1.00	1.00	1.00	1%	0%	1%	1%
US 60 WB HOV: Val Vista to Loop 101	8.29	1.00	1.00	1.00	1.00	0%	0%	0%	0%
Average for all Sections		1.13	1.03	1.18	1.16	25%	11%	32%	29%

Comments

- This table shows average weekday congestion (travel time index) and reliability (buffer index) for specific routes for different time periods of the day.
- All freeway sections have travel time index values less than 1.50. In fact, most freeway sections have travel time index values less than 1.25.

Source and Coverage of Data

This report was produced using data collected and archived by the Arizona Department of Transportation (<http://www.dot.state.az.us/> and <http://www.az511.com>). A map of the freeway routes on which traffic data was collected is shown below.

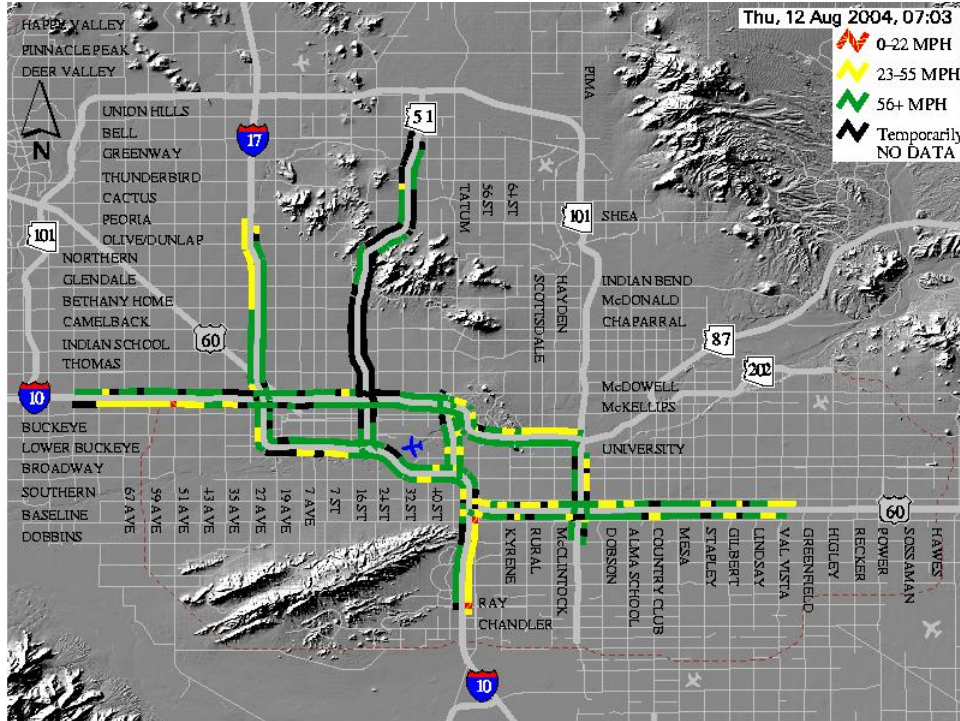


Exhibit PHX-12: Freeway Routes with Traffic Sensors in Phoenix
 (Source of graphic: Arizona DOT, <http://www.az511.com>)

Exhibit PHX-13: Instrumented Freeway Coverage in Phoenix

Coverage Measures	Year	Instrumented Freeway Routes	Total Freeway System ¹	Percent Coverage
Lane-miles	2000	420	1,030	41%
	2001	420	1,140	37%
	2002	565	1,250	45%
	2003	729	1,360	54%
Centerline-miles	2000	53	163	33%
	2001	53	179	30%
	2002	70	197	36%
	2003	83	214	39%
Average annual daily vehicle-miles of travel (DVMT) (1000)	2000	4,680	19,425	24%
	2001	6,590	21,600	31%
	2002	7,770	22,550	34%
	2003	11,035	24,113	46%

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.