Appendix HOU – Houston, Texas
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 HOU-1: Current Measures and Trends

Measures	Current Year	Last Year		Two Years Ago	
	2003	2002	Change	2001	Change
Performance Measures					
Travel Time Index	1.29	1.22	+6% ↑	1.11	+17% ↑
Planning Time Index	1.71	1.55	+10% ↑	1.40	+22% ↑
Buffer Index	26%	22%	+4% ↑	19%	+7% ↑
% Congested Travel	27%	30%	-3% ↓	24%	+3% ↑
Total Delay (veh-hours) per 1000 VMT	3.34	3.78	-12% ↓	3.40	-2% ↓
Explanatory Measures					
Peak Period VMT (000)	n.a.	n.a.	n.a. —	n.a.	n.a. —
Avg. Annual DVMT (000)	n.a.	n.a.	n.a. —	n.a.	n.a. —
Data Quality Measures					
% complete	98%	98%	0% —	98%	0% —
% valid	98%	97%	+1% ↑	97%	+1% ↑
% of VMT covered	n.a.	n.a.	n.a. —	n.a.	n.a. —
% of freeway miles	62%	63%	-1% ↓	65%	-3% ↓

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

Exhibit HOU-2: 2000 to 2003 Annual Trends

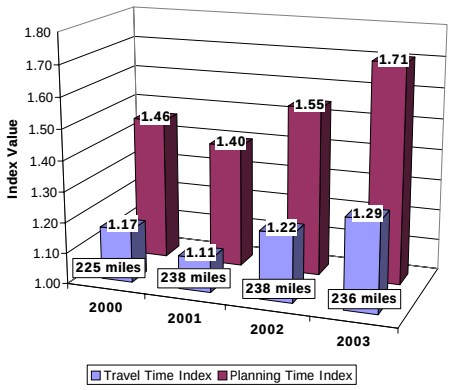
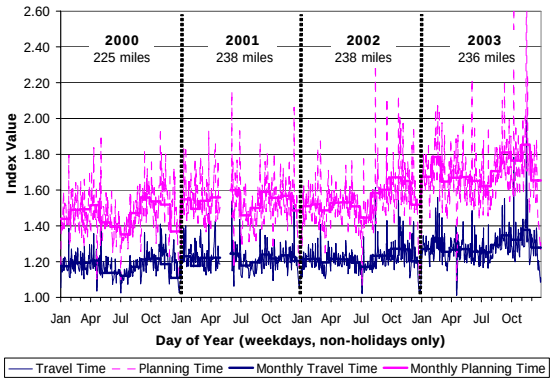


Exhibit HOU-3: Daily and Monthly Trends



Comments

- Most 2003 congestion and reliability measures show increases over 2001 and 2002 levels, with the exception of percent congested travel and total delay.
- Vehicle travel (DVMT) is not available in Houston because the data collection system is based upon a sample of vehicles that have toll tags.
- The data quality remained stable in 2003, with only slight fluctuations.

Data Source(s): Texas Transportation Institute (http://tti.tamu.edu) in cooperation with Texas Department of Transportation and Houston TranStar (http://traffic.houstontranstar.org)
Includes 236 of 383 (62%) total freeway miles in Houston; collected using toll tags; 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.

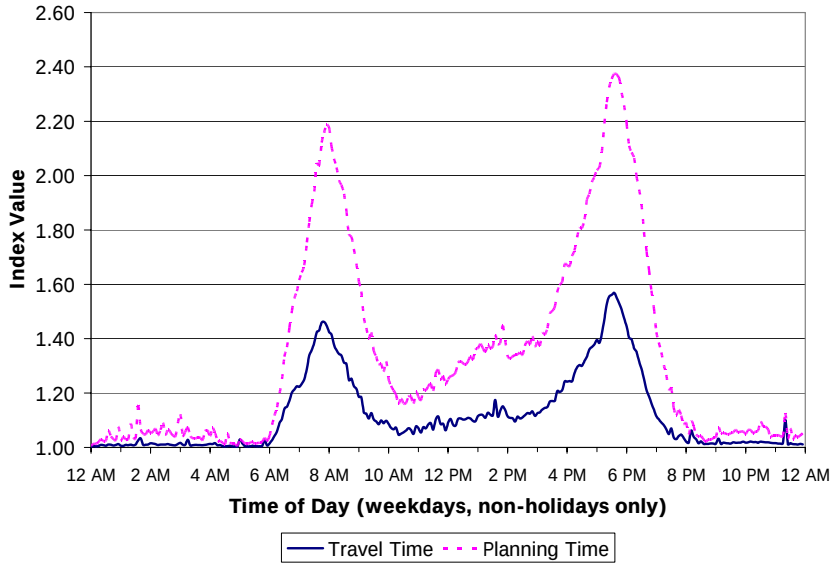


Exhibit HOU-4: Mobility and Reliability by Time of Average Weekday

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 slightly worse than in the morning.
- Travelers must add 30-50% additional buffer time during peak times to account for traffic unreliability.

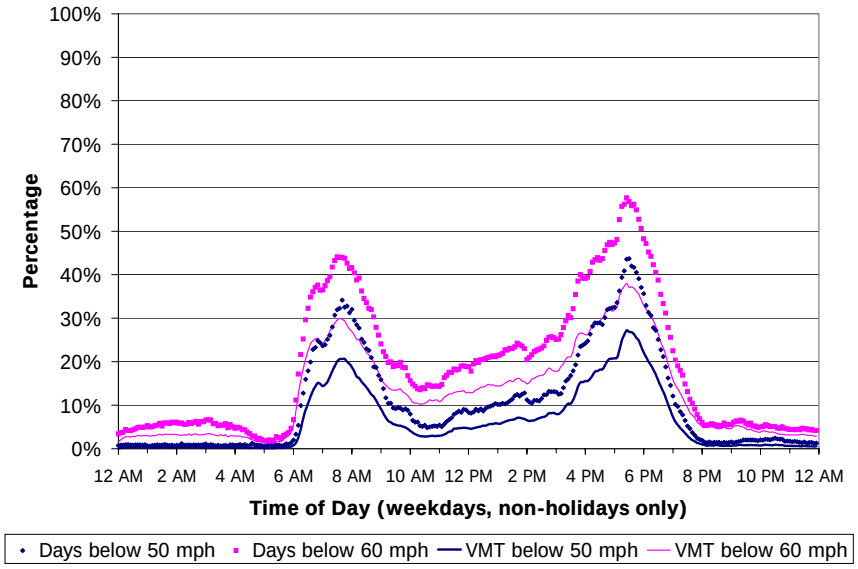


Exhibit HOU-5: Frequency and Percentage of Congested Travel by Time of Average Weekday

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.
- In Houston, there is only a slight difference in the frequency and percentage of congestion using different speeds thresholds.
- This chart indicates that most congestion in Houston happens below 50 mph (see Exhibit 10 for more detail).

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

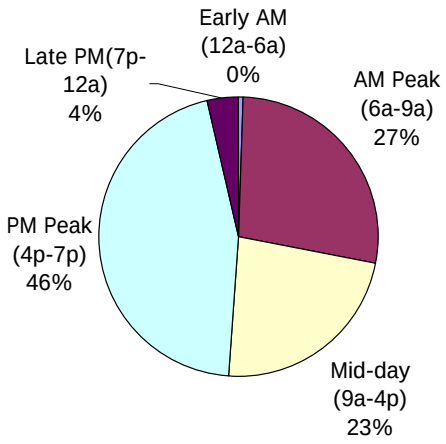


Exhibit HOU-6: Percent of Delay by Time Period

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 almost as great as during the morning peak period.

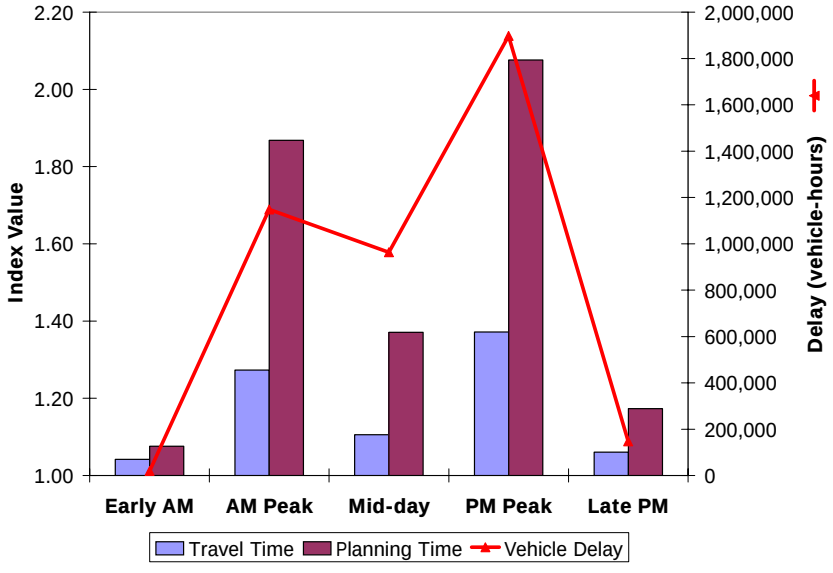


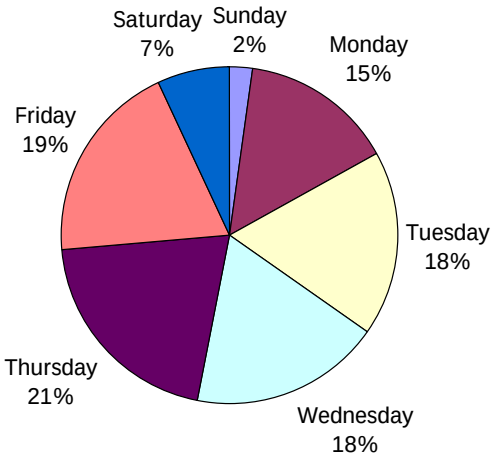
Exhibit HOU-7: Mobility, Reliability, and Delay by Time Period

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).

Day of Week Patterns and Trends

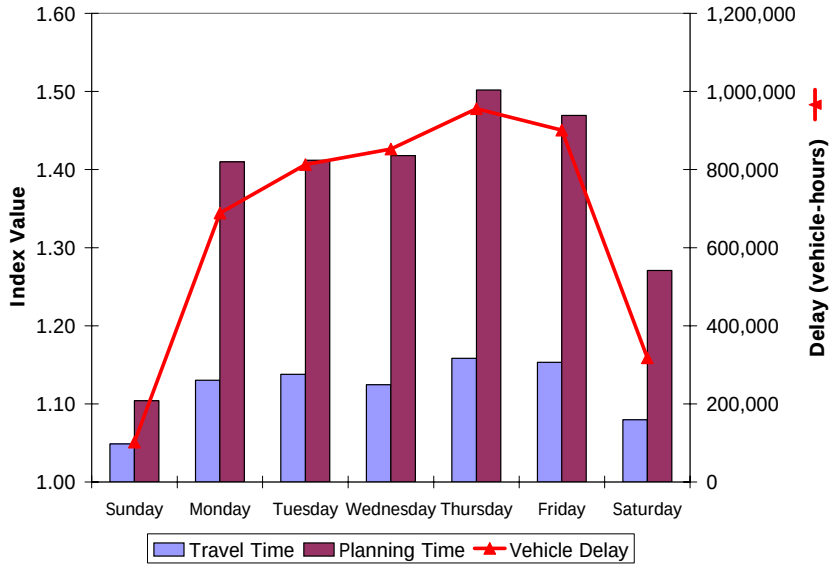
The charts on this page illustrate average traffic patterns and trends that were measured on the freeway sections instrumented with operations-based traffic sensors. Because of different peak period times and lengths on weekdays and weekends, the statistics presented on this page are 24-hour daily totals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



Comments

- This chart shows the percent of total daily delay that occurred during each day of the week.
- Thursday has the most delay, while Tuesday, Wednesday, and Friday have slightly less delay.
- Both weekend days combined have about half of the normal weekday delay.

Exhibit HOU-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 as well as being the least reliable day (highest planning time index).

Exhibit HOU-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.

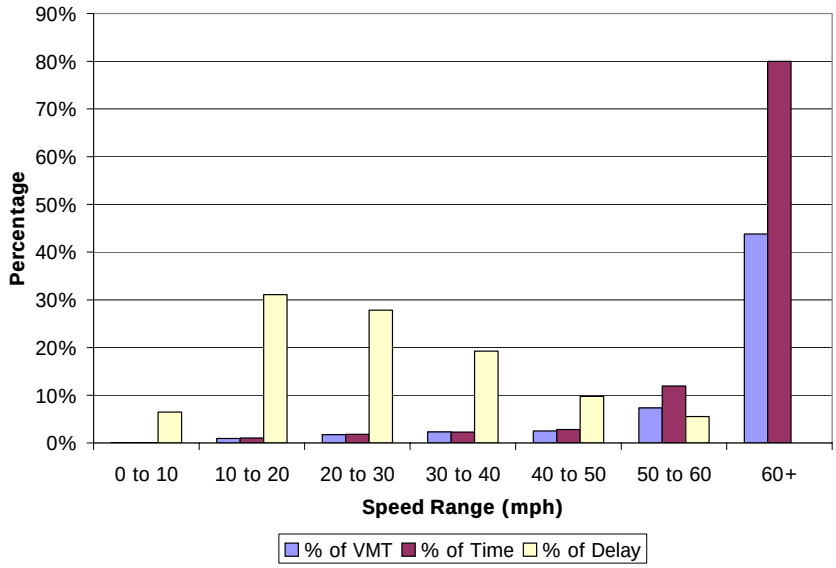


Exhibit HOU-10: Percent of VMT, Delay and Time Periods in Different Speed Ranges

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.
- Only 6% of the delay is in the 50 to 60 mph range.
- Only 5% of the VMT is below 40 mph, but 85% of the delay occurred below 40 mph.

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 HOU-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
Hempstead Road EB: Sam Houston to I-610	8.30	3.34	2.40	2.19	2.76	83%	34%	21%	52%
Hempstead Road WB: I-610 to Sam Houston	8.30	2.09	2.43	3.28	2.68	33%	66%	66%	50%
I-10 Katy WB: Post Oak Blvd to Sam Houston	6.55	1.38	1.45	2.94	2.16	52%	62%	76%	64%
I-10 Katy EB: Sam Houston to I-610	6.30	2.08	1.58	2.14	2.11	97%	67%	61%	79%
US 290 Northwest WB: Dacoma Rd to Sam Houston	8.00	1.01	1.15	2.49	1.85	2%	60%	69%	40%
I-10 Katy EB: Barker Cypress to Sam Houston	7.60	1.98	1.26	1.63	1.82	95%	86%	108%	101%
I-610 West Loop SB: Ella Blvd to S Post Oak	9.50	1.56	1.35	1.86	1.71	78%	64%	81%	80%
I-10 Katy WB: Sam Houston to Barker Cypress	7.40	1.04	1.08	2.04	1.68	9%	36%	70%	49%
US 290 Northwest EB: Sam Houston to Dacoma Rd	8.00	2.04	1.11	1.20	1.64	99%	50%	88%	93%
US 59 Southwest EB: I-610 to I-45	7.40	1.07	1.14	2.22	1.58	24%	49%	106%	60%
US 59 Eastex SB: I-610 North to I-45 Gulf	4.45	1.83	1.07	1.07	1.52	115%	25%	23%	77%
US 59 Southwest WB: I-45 to I-610	7.40	1.24	1.06	1.62	1.46	49%	24%	105%	82%
I-45 North NB: I-10 to Crosstimbers	2.50	1.02	1.17	1.75	1.46	1%	71%	73%	44%
I-45 Gulf SB: I-10 to Woodridge	8.45	1.10	1.15	1.69	1.46	38%	41%	75%	61%
I-45 North SB: Aldine Bender to Crosstimbers	8.20	1.60	1.11	1.21	1.40	81%	41%	50%	66%
I-45 Gulf NB: Woodridge to I-10	8.35	1.48	1.14	1.27	1.39	69%	48%	69%	69%
I-10 East WB: I-610 East Loop to US 59 Eastex	4.10	1.70	1.08	1.05	1.39	112%	34%	16%	66%
US 59 Southwest EB: Wilcrest to I-610	8.31	1.60	1.09	1.11	1.39	98%	38%	45%	75%
I-45 Gulf NB: Fuqua to Woodridge	7.65	1.68	1.04	1.07	1.38	83%	15%	32%	58%
Sam Houston Tollway NB: Memorial Dr to US 290@Fairbanks-N Houston	8.80	1.24	1.07	1.51	1.37	49%	34%	59%	54%
I-45 North SB: Crosstimbers to I-10	2.50	1.51	1.07	1.04	1.32	70%	20%	8%	44%
I-610 West Loop NB: US 59 Southwest to Ella Blvd	6.50	1.03	1.14	1.60	1.32	9%	39%	67%	38%
I-45 North NB: Crosstimbers to Aldine Bender	8.20	1.04	1.12	1.55	1.32	6%	42%	45%	27%
I-45 Gulf SB: Fuqua to Nasa Road 1	7.90	1.01	1.04	1.48	1.32	0%	16%	76%	49%
I-10 Katy WB: Taylor St to N Post Oak	4.65	1.36	1.14	1.23	1.28	108%	61%	80%	91%
US 59 Southwest WB: I-610 to Wilcrest	8.31	1.01	1.02	1.38	1.25	0%	2%	78%	50%
US 290 Northwest EB: Barker Cypress to Sam Houston	9.15	1.47	1.01	1.01	1.24	120%	0%	0%	59%

Exhibit HOU-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
Sam Houston Tollway WB: Ella Blvd to US 290@Fairbanks-N Houston	13.30	1.19	1.06	1.28	1.23	47%	30%	57%	52%
I-610 North Loop EB: Ella Blvd to N Wayside	9.05	1.02	1.05	1.42	1.22	3%	21%	49%	26%
Sam Houston Tollway SB: US 290@ Fairbanks-N-Houston to I-10 Katy	7.20	1.40	1.03	1.04	1.22	59%	7%	15%	37%
SH 288 South SB: US 59 to Holly Hall St	3.30	1.01	1.02	1.35	1.22	6%	5%	87%	55%
Sam Houston Tollway SB: I-10 Katy to US 59 Southwest	8.80	1.01	1.01	1.36	1.18	4%	0%	69%	37%
Sam Houston Tollway NB: Beechnut to Memorial Dr	6.20	1.09	1.04	1.26	1.18	36%	23%	86%	61%
I-10 Katy EB: I-610 to Smith	6.05	1.04	1.03	1.36	1.17	16%	10%	94%	48%
I-610 North Loop WB: N Wayside to Ella Blvd	9.40	1.30	1.04	1.03	1.17	60%	18%	12%	36%
I-10 Katy HOV WB: Silber to Bunker Hill	4.10	n.a.	1.02	1.16	1.16	n.a.	9%	49%	24%
US 290 Northwest HOV WB: Old Katy Road to Pinemont	5.00	n.a.	1.04	1.16	1.16	n.a.	9%	25%	12%
I-45 North HOV SB: Shepherd to I-10	7.95	1.14	1.03	n.a.	1.14	36%	14%	n.a.	18%
US 59 Eastex NB: I-45 Gulf to I-610 North	4.45	1.00	1.05	1.22	1.14	0%	21%	23%	14%
I-45 North HOV NB: I-10 to Shepherd	7.95	n.a.	1.04	1.12	1.12	n.a.	12%	20%	10%
SH 288 South NB: Holly Hall St to US 59	3.30	1.14	1.02	1.09	1.12	41%	10%	36%	39%
I-45 Gulf SB: Woodridge to Fuqua	7.65	1.00	1.02	1.21	1.11	0%	5%	42%	21%
I-10 East WB: Beltway 8 to I-610 East Loop	7.00	1.19	1.02	1.02	1.11	53%	0%	0%	28%
US 290 Northwest WB: Sam Houston to Barker Cypress	9.15	1.00	1.00	1.17	1.10	0%	0%	42%	26%
US 59 Southwest HOV EB: Bissonnet to Newcastle	8.05	1.10	1.02	n.a.	1.10	31%	9%	n.a.	16%
I-10 East EB: Smith to I-610 East Loop	5.50	1.00	1.03	1.15	1.10	0%	11%	42%	27%
I-45 Gulf NB: Nasa Road 1 to Fuqua	7.90	1.06	1.02	1.14	1.10	29%	3%	57%	42%
I-610 South Loop EB: S Post Oak to S Wayside	9.20	1.01	1.01	1.18	1.09	0%	0%	61%	31%
US 59 Eastex NB: N Sam Houston Pky to Townsen	5.10	1.00	1.01	1.15	1.09	0%	0%	48%	29%
I-45 Gulf HOV NB: Broadway to Scott Street	5.45	1.09	1.02	n.a.	1.09	18%	9%	n.a.	9%
I-610 South Loop WB: S Wayside to Stella Link	6.50	1.13	1.01	1.02	1.08	54%	0%	2%	28%
US 59 Southwest HOV WB: Newcastle to Bissonnet	8.05	n.a.	1.03	1.08	1.08	n.a.	10%	17%	9%
Sam Houston Tollway EB: US 290@ Fairbanks-N Houston to Ella Blvd	13.20	1.08	1.04	1.06	1.07	34%	14%	31%	32%
I-10 Katy HOV EB: Bunker Hill to Silber	4.10	1.07	1.04	n.a.	1.07	14%	18%	n.a.	7%
I-45 Gulf HOV SB: Scott Street to Broadway	5.45	n.a.	1.04	1.07	1.07	n.a.	13%	14%	7%
I-45 North HOV SB: FM 1960 to Shepherd	10.60	1.06	1.00	n.a.	1.06	24%	0%	n.a.	12%

Exhibit HOU-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 East EB: I-610 East Loop to Beltway 8	7.00	1.00	1.01	1.09	1.06	0%	0%	36%	23%
I-610 East Loop NB: S Wayside to N Wayside	10.10	1.01	1.02	1.10	1.05	0%	1%	34%	17%
I-610 East Loop SB: N Wayside to S Wayside	10.30	1.06	1.02	1.04	1.05	23%	2%	19%	21%
US 290 Northwest HOV EB: Pinemont to Old Katy Road	5.00	1.05	1.02	n.a.	1.05	11%	9%	n.a.	5%
Sam Houston Tollway EB: Ella Blvd to JFK Boulevard	6.20	1.06	1.01	1.04	1.05	23%	0%	0%	12%
Sam Houston Tollway WB: JFK Boulevard to Ella Blvd	6.10	1.00	1.01	1.09	1.05	0%	0%	36%	18%
US 290 Northwest HOV EB: West Road to Pinemont	7.35	1.05	1.01	n.a.	1.05	16%	1%	n.a.	8%
US 290 Northwest HOV WB: Pinemont to West Road	7.35	n.a.	1.01	1.05	1.05	n.a.	3%	16%	8%
I-45 North SB: Hardy Toll Road to FM 1960	5.40	1.08	1.01	1.00	1.04	51%	0%	0%	27%
I-45 Gulf HOV NB: Fuqua to Broadway	6.35	1.04	1.01	n.a.	1.04	16%	5%	n.a.	8%
I-45 North SB: FM 1960 to Aldine Bender	7.00	1.03	1.02	1.05	1.04	10%	0%	15%	12%
I-10 Katy HOV EB: SH 6 to Bunker Hill	5.95	1.04	1.00	n.a.	1.04	13%	0%	n.a.	6%
I-10 Katy HOV WB: Bunker Hill to SH 6	5.95	n.a.	1.00	1.03	1.03	n.a.	0%	8%	4%
I-45 North NB: FM 1960 to Hardy Toll Road	5.40	1.01	1.00	1.03	1.03	0%	0%	16%	10%
US 59 Eastex SB: N Sam Houston Pky to I-610 North	10.00	1.04	1.01	1.00	1.02	18%	0%	0%	9%
I-45 Gulf HOV SB: Broadway to Fuqua	6.35	n.a.	1.01	1.02	1.02	n.a.	5%	7%	3%
I-45 North NB: Aldine Bender to FM 1960	7.00	1.01	1.01	1.03	1.02	0%	0%	12%	7%
US 59 Eastex NB: I-610 North to N Sam Houston Pky	10.00	1.00	1.01	1.02	1.01	0%	0%	10%	5%
I-45 North HOV NB: Shepherd to FM 1960	10.60	n.a.	1.01	1.01	1.01	n.a.	1%	3%	2%
Hardy Toll Road NB: Aldine Bender to FM 1960	7.35	1.00	1.00	1.01	1.01	0%	0%	0%	0%
US 59 Eastex SB: Townsen to N Sam Houston Pky	5.10	1.00	1.00	1.00	1.00	0%	0%	0%	0%
Hardy Toll Road SB: FM 1960 to Aldine Bender	7.35	1.01	1.00	1.00	1.00	0%	0%	0%	0%
Hardy Toll Road SB: I-45 to FM 1960	6.00	1.00	1.00	1.00	1.00	0%	0%	0%	0%
Hardy Toll Road NB: I-610 to Aldine Bender	7.80	1.00	1.00	1.00	1.00	0%	0%	0%	0%
Hardy Toll Road SB: Aldine Bender to I-610	7.80	1.00	1.00	1.00	1.00	0%	0%	0%	0%
Hardy Toll Road NB: FM 1960 to I-45	6.00	1.00	1.00	1.00	1.00	0%	0%	0%	0%
I-610 West Loop NB: US 59 Southwest to TC Jester	5.40	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Average for all Sections		1.27	1.11	1.37	1.32	35%	21%	42%	38%

Source and Coverage of Data

This report was produced using data collected and archived by the Texas Department of Transportation and Houston TranStar (http://traffic.houstontranstar.org). A map of the freeway routes on which traffic data was collected is shown below.

Exhibit HOU-12: Freeway Routes with Traffic Sensors in Houston
(Source of graphic: Houston TranStar, http://traffic.houstontranstar.org)

Exhibit HOU-13: Instrumented Freeway Coverage in Houston

Coverage Measures	Year	Instrumented Freeway Routes	Total Freeway System[1]	Percent Coverage
Lane-miles	2000	1,747	2,435	72%
	2001	1,764	2,460	72%
	2002	1,764	2,510	70%
	2003	1,764	2,548	69%
Centerline-miles	2000	225	368	61%
	2001	238	368	65%
	2002	238	377	63%
	2003	236	383	62%
Average annual daily vehicle-miles of travel (DVMT) (1000)	2000	n.a.	40,100	n.a.
	2001	n.a.	41,500	n.a.
	2002	n.a.	42,750	n.a.
	2003	n.a.	44,075	n.a.

[1]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: buffer index = (95^{th} percentile travel time – average travel time) / 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.