7 DATA REDUCTION, SUMMARY, AND PRESENTATION

This chapter provides guidance on the reduction, summary, and presentation of travel time data. Chapters 3 through 5 contained specific data reduction and quality control procedures for each data collection technique. The procedures in earlier chapters were aimed at producing a common travel time format for each predefined roadway segment or link. The methods described in this chapter can then be used to further reduce, summarize, and/or present this travel time data. Many examples of tabular and graphical summaries of travel time data are provided at the end of the chapter.

7.1 Data Reduction

This section contains a discussion on the purposes and methods used to reduce and/or aggregate travel time data. It is assumed that appropriate data reduction and quality control measures have been applied for the specific data collection technique, and that the travel time data are in an individual link format (i.e., data contains valid individual travel times for each predefined link or segment length). Quality control procedures for each data collection technique were included in Chapters 3 through 6. The purpose of data reduction can be two-fold:

- reduce the number of data records by eliminating invalid data; or
- produce summary data and statistics at different aggregation levels for various applications.

Quality control measures applied to the data immediately after data collection should have identified data errors or invalid data. However, statistical quality control checks can be performed at this point to identify any remaining problems with data integrity. Statistical quality control procedures are available in some spreadsheet and database software programs and in nearly all statistical analysis software packages. Readers interested in statistical quality control procedures should consult a specialized statistics text.

In most cases, data reduction will be necessary to summarize or aggregate the link travel time data to a format usable in many analyses. Travel times from individual runs should be averaged to produce mean or average travel times for the peak hour or peak period. Individual travel times from license plate matching should be averaged to produce average travel times and speeds for 15- or 30-minute time periods or greater. Typical summary statistics computed with link travel time data include:

- **Mean or average travel time, speed, and delay** - These statistics provide information about the typical traffic conditions during the time period of interest. Means or averages can be computed for any time period desired, including but not limited to 15-, 30-, or 60-minute, peak hour, and peak period (Equations 7-1, 7-2, and 7-3). The selected time period typically corresponds to analysis needs and available sample sizes. For example, travel time data collected with license plate matching or ITS probe vehicle techniques can be summarized for shorter time periods because of the typically larger sample sizes. Travel time data collected using test vehicle techniques are generally aggregated to the peak hour or peak period because of smaller sample sizes (less than 10 runs per time period per direction).

$$Average\ Travel\ Time,\ \bar{t} = \frac{\sum_{i=1}^{n} t_i}{n} \tag{7-1}$$

$$Space-Mean\ (Harmonic)\ Speed,\ \bar{v}_{SMS} = \frac{distance\ traveled}{avg.\ travel\ time} = \frac{d}{\frac{\sum t_i}{n}} = \frac{n \times d}{\sum t_i} \tag{7-2}$$

where: $\bar{t}$ = average travel time for time period of interest
t_i = average travel time for i-th run or vehicle
n = total number of travel times
d = vehicle distance traveled or segment length

$$\begin{matrix} Average\ Vehicle \\ (or\ Person)\ Delay \end{matrix} = (\bar{t} - t_{delay}) \times V\ (or\ P) = \frac{d}{|s_{delay} - \bar{s}| \times V\ (or\ P)} \tag{7-3}$$

where: t_{delay} = threshold travel time at which delay occurs
s_{delay} = threshold speed at which delay occurs
V = vehicle volume for the time period of interest
P = person volume for the time period of interest

A more general form for an average space mean speed is presented in Equation 7-4 (1,2). This equation can be used when a different number of travel time observations exist for numerous sequential roadway links. For example, an average corridor travel speed is obtained from Equation 7-4 by computing the average travel time for each roadway link, then weighting each link travel time by the respective number of travel time observations. This approach, which weights each link travel time, has been suggested by Quiroga and Bullock as a better estimator of average corridor travel speeds. An alternative to average travel speed is the average median travel speed as shown in Equation 7-5.

$$\text{Average Space Mean Speed, } \bar{u}_L = \frac{L_T}{t_{T_L}} = \frac{\sum_{i=1}^{n} L_i}{\sum_{i=1}^{n} \bar{t}_i} = \frac{1}{\sum_{i=1}^{n} \left[\frac{L_i}{L_T} \times \frac{1}{m_i} \times \sum_{j=1}^{m_i} \frac{1}{u_{ij}} \right]} \quad (7\text{-}4)$$

where:
- $\bar{u}_L$ = average space mean (harmonic) speed for total length *L*
- L_t = total length of roadway for calculation of average speed
- t_{T_L} = total travel time for entire length of roadway *L*
- L_i = length of roadway link *i*
- m = total number of travel time observations for each link *i*
- u_{ij} = travel speed for roadway link *i* and observation *j*

$$\text{Median Speed, } \bar{u}_L = \frac{L_T}{\sum_{i=1}^{n} t_{m_i}} = \frac{1}{\sum_{i=1}^{n} \left[\frac{L_i}{L_T} \times \frac{1}{u_{m_i}} \right]} \quad (7\text{-}5)$$

where:
- t_{m_i} = median travel time associated with link *i*
- u_{m_i} = median speed associated with link *i*

- **Standard deviation (or coefficient of variation) of speed and travel time** - These statistics provide information about the variability of traffic conditions throughout the time period of interest. The standard deviation and coefficient of variation are statistical measures of variability and are calculated using Equations 7-6 and 7-7, respectively.

$$\text{standard deviation, } s = \sqrt{\frac{\sum_{i=1}^{n} (t_i - \bar{t})^2}{n - 1}} \quad (7\text{-}6)$$

$$\textit{coefficient of variation, c.v.} = \frac{s}{\bar{t}} \tag{7-7}$$

- **Acceleration noise (i.e., standard deviation of acceleration)** - Acceleration noise (Equation 7-8) measures the fluctuation of speed for a typical vehicle and can only be collected with a properly instrumented test or ITS probe vehicle. The desired instrumentation should be capable of providing nearly second-by-second speeds of a vehicle traveling in the traffic stream. Acceleration noise measures the "stop-and-go" nature of congested traffic conditions or poorly timed traffic signals on arterial streets. Previous studies have linked acceleration noise to a number of dependent variables, such as accident rate, fuel consumption and mobile source emissions (3).

$$\textit{acceleration noise, a.n.} = \sqrt{\frac{\sum_{i=1}^{n}(a_i - \bar{a})^2}{n - 1}} \tag{7-8}$$

- **Level of service (LOS) based on speed or travel time criteria** - The 1994 Highway Capacity Manual (HCM) uses average speed as an LOS criteria for arterial streets and the year 2000 HCM is oriented toward similar speed/travel time criteria for most analysis modules.

The aggregation and summarization of travel time data are fairly straightforward using current computer tools. Computer spreadsheets, databases, GIS, and statistical analysis software packages can immensely simplify the data reduction and summarization process. In most cases, data reduction and summarization consists of either averaging or summing travel time or speed data. However, several notes of caution for data reduction are provided below:

- **Ensure that space-mean speeds are calculated** - Space-mean speeds are associated with a given length of roadway and are calculated using Equation 7-2. Time-mean speeds are associated with a specified point along the roadway and are calculated by simply averaging spot speeds. Chapter 1 and Table 1-1 contains a specific example illustrating the proper calculation of space-mean speeds.

- **Use vehicle or person volume to weight average speeds** - Travel time and speed data collected for a specific roadway segment also has a vehicle or person volume associated with that segment. This volume quantifies the number of vehicles or persons traveling at the corresponding average speed. This vehicle or person volume should be used to weight speeds when combining or averaging speeds for different segments or corridors (see Equation 7-9).

$$\textit{average weighted speed},\ spd_w = (spd_1 \times V_1) + (spd_2 \times V_2) + \ldots + (spd_n \times V_n) \tag{7-9}$$

- **Aggregating travel times for a long corridor** - Consider an analysis that requires an average overall travel time for a 30-km roadway corridor. The average overall travel time can be computed by simply summing the individual link or segment travel times (Equation 7-10).

$$\textit{average corridor travel time},\ t_c = t_1 + t_2 + \ldots + t_n \tag{7-10}$$

However, if the overall corridor travel time is greater than the applicable time period in which the travel times were collected, Equation 7-10 does not provide an accurate overall corridor travel time. For example, assume that average link travel times have been collected between 7:00 and 7:30 a.m. (30-minute time period), yet it required 45 minutes (as estimated by Equation 7-10) to traverse the entire 30-km length of the corridor (see Table 7-1, Scenario 1). In this scenario, at least 15 minutes of the "corridor trip" could have occurred outside of the time period in which there is valid travel time data (i.e., 7:00 to 7:30 a.m.). Three solutions exist for this dilemma:

1. Avoid the problem by equipping a test vehicle to perform travel time runs along the entire length of the corridor. Simply average the overall corridor travel time from each test vehicle run.

2. Increase the length of the analysis time period so that it is at least as long as the total time required to traverse the entire corridor (Table 7-1, Scenario 2). In this scenario, travel times were averaged from 7:00 to 8:00 a.m. so that we could simply sum the link travel times for an overall corridor travel time.

3. Collect or obtain data for several small sequential time periods and apply the average link travel time from the correspondingly correct time period (Table 7-1, Scenario 3). In this scenario, average travel times were computed from 7:30 to 8:00 a.m. If we assume that 20 minutes of the estimated 45-minute "corridor trip" occurred in the 7:00 to 7:30 a.m. time period, then we can determine how many roadway segments were traversed during that time period. We can then apply the travel times from the next time period, 7:30 to 8:00 a.m., for the remainder of the roadway segments in the corridor.

Table 7-1. Corridor Travel Time Aggregation Example

Corridor Segment	Travel Time (min:sec)			
	Scenario 1 7:00 to 7:30 a.m.	Scenario 2 7:00 to 8:00 a.m.	Scenario 3	
			7:00 to 7:30 a.m.	7:30 to 8:00 a.m.
1	6:00	5:30	6:00	~~5:00~~
2	5:20	4:40	5:20	~~4:00~~
3	4:40	4:00	4:40	~~3:20~~
4	5:40	5:20	5:40	~~5:00~~
5	6:00	5:40	6:00	~~5:20~~
6	4:30	4:00	~~4:30~~	3:30
7	3:40	3:40	~~3:40~~	3:40
8	4:00	4:00	~~4:00~~	4:00
9	2:30	2:30	~~2:30~~	2:30
10	2:20	2:00	~~2:20~~	1:40
Corridor Travel Time	**45:00** (but analysis period only 30 minutes)	**41:20** (okay since analysis period is 60 minutes)	**43:00** (okay since travel times from corresponding time period are used)	

7.2 Overview of Travel Time Data Applications

Travel time data are collected for a variety of applications and analyses. This section provides a brief overview of common applications of travel time data. The reader is encouraged to review the companion handbook on travel time applications. At press time, this guidance manual on applications of travel time data travel time was being prepared for FHWA by the Texas Transportation Institute.

Travel time data are the raw element for a number of performance measures that permeate many transportation analyses. Examples of travel-time based quantities or measures include the following:

- door-to-door travel time;
- travel time reliability/variability (i.e., standard deviations or confidence intervals);
- average speed;
- person or vehicle delay (as compared to some delay threshold);
- delay rate, relative delay rate, or delay ratio;
- speed of person movement (requires estimate of person volumes);
- travel time or congestion indices for corridors or networks; and
- accessibility to activities or opportunities (e.g., percent of population within 20 minutes of jobs, hospital, etc.).

Travel time-based measures can be used in transportation planning, design and operations, and evaluation. Examples of planning and design applications include:

- *Develop transportation policies and programs* - may rely on current and projected trends in travel time-based performance measures;

- *Perform needs studies or assessments* - may use travel time-based measures to assess transportation deficiencies and potential improvements;

- *Rank and prioritize transportation improvements* - may use numerical magnitude of travel time-based measures to set funding or programming priorities;

- *Evaluate transportation improvement strategies* - compare a number of possible alternatives using a set of travel time-based measures;

- *Input/calibration of planning models* - uses base data such as travel time or speed to compare simulated data to existing conditions, and projecting future scenarios; and

- *Calculate road user costs for economic analyses* - uses basic data as inputs to economic models that estimate costs and benefits.

Examples of operational applications include:

- *Develop historical database of traffic conditions* - an historical database of travel times and speeds can be used in numerous ITS applications;
- *Input/calibration of traffic models* - uses detailed data for model calibration relating to microscopic traffic operations, fuel consumption, mobile source emissions;
- *Real-time traffic control* - uses travel time and speed to operate dynamic message and lane assignment signs, ramp metering, and traffic signal control;
- *Route guidance and navigation* - provides travel time information and alternative routes based on current or historical databases;
- *Traveler information* - provides up-to-date travel time and speed information to the commuting public; and
- *Incident detection* - uses changes or differences in current travel time or speed as compared to historical databases.

Examples of evaluation applications include:

- *Establish/monitor congestion trends* - collect and develop historical data for trend analyses;
- *Congestion management/performance measurement* - tracking trends over time of travel time-based measures, attempt to develop cause-and-effect relationships;
- *Identify congestion locations or bottlenecks* - uses travel time data in combination with geometric or signal information to identify problems and potential solutions;
- *Measure effectiveness and benefits of improvements* - use before-and-after travel time data to gauge the effects of transportation improvements;
- *Communicate information to the public* - use non-technical travel time-based measures to communicate traffic conditions and trends to the general public; and
- *Research and development* - uses travel time data for a wide variety of research applications.

7.3 Understanding Your Audience for Travel Time Summaries

One of the first principles taught in most technical writing courses is the importance of understanding your audience. This same principle also applies to tabular and graphical data summaries. These data summaries often serve as the only interpretation of extensive data collection efforts for a wide variety of audiences. The manner in which data are presented, as well as the actual data itself, is critical for effectively communicating the results of travel time collection activities. The intended audience(s) for data summaries affects several aspects:

- **Underlying message or theme of the summary** - The intended audience directly influences the underlying message or theme of the summary. For example, a mayor of a large city is likely more interested in regional travel time and speed trends and less interested in the number of stops for a particular travel time run. Conversely, a city signal technician is likely more interested in the number and location of stops along an arterial street.

- **Manner of presentation** (e.g., table versus graph/chart) - Concise, easy-to-understand graphs or charts are best suited to non-technical audiences, whereas these concise summaries may not contain enough information for detail-oriented, technical audiences.

- **Use of technical language/terminology** - If decision-makers or elected officials will utilize data summaries, technical language should be avoided if possible. At a minimum, technical terms should be defined for unfamiliar readers.

- **Level of detail** - The level of detail should be appropriate for the intended audiences. If a wide variety of readers is expected, different types of summaries should be provided. Technical appendices can be provided for data collection details, and an executive summary can be used to present the major findings of the study in graphical or brief tabular formats.

7.4 Presenting Dimensions of Congestion with Travel Time and Speed Data

Travel time and speed data are often used to identify and evaluate traffic congestion patterns and trends. It is important to note that traffic congestion has several "dimensions," and that data summaries should be designed to represent these four major dimensions (4):

- **Duration** - amount of time roadway facilities are congested;
- **Extent** - number of people affected or the geographic distribution;
- **Intensity** - level or total amount of congestion; and,
- **Reliability** - variation in the amount of congestion.

These dimensions of congestion can be represented with a number of travel time/speed measures, depending upon the system component as shown in Table 7-2.

Table 7-2. Measures and Summaries to Display the Dimensions of Congestion

Congestion Aspect	System Type		
	Single Roadway	**Corridor**	**Areawide Network**
Duration (i.e., amount of time system is congested)	Hours facility operates below acceptable speed	Hours facility operates below acceptable speed	Set of travel time contour maps; "bandwidth" maps showing amount of congested time for system sections
Extent (i.e., number of people affected or geographic distribution)	percent or amount of congested VMT or PMT; percent or lane-km of congested road	percent of VMT or PMT in congestion; percent or lane-km of congested road	percent of trips in congestion; person-km or person-hours of congestion; percent or lane-km of congested roadway
Intensity (i.e., level or total amount of congestion)	Travel speed or rate; delay rate; relative delay rate; minute-km; lane-km hours	Average speed or travel rate; delay per PMT; delay ratio	Accessibility; total delay in person-hours; delay per person; delay per PMT
Reliability or Variability (i.e., variation in the amount of congestion)	Average travel rate or speed ± standard deviation; delay ± standard deviation	Average travel rate or speed ± standard deviation; delay ± standard deviation	Travel time contour maps with variation lines; average travel/time ± standard deviation; delay ± standard deviation

Notes: adapted from reference (4)
VMT—vehicle-miles of travel; PMT—person-miles of travel

7.5 Examples of Data Summaries

Tabular summaries contain numerical values in a row or column format, whereas graphical summaries provide information in the form of a chart, graph, or picture. The choice of a tabular or graphical summary depends upon the intended audience and the desired message. In general, tabular summaries are best for presenting large amounts of data with some level of detail. Graphical summaries are best suited to presenting relatively small amounts of easily understandable data. Further, graphical summaries allow the viewer to quickly recognize trends and relative comparisons of data with the visual presentation. Depending upon the level of detail, tabular summaries may take longer to interpret than comparable graphical summaries. Also, technical audiences are generally more effective at interpreting tabular summaries because of their numeric orientation and format.

Travel time data summaries may be provided at several levels of detail:

- **Run summary** - summarizes data on a specific travel time run, and typically includes elapsed time and speed between checkpoints, causes of intermediate delay, and time spent in different speed ranges. Run summaries are useful in performing quality control on data collection efforts and diagnosing traffic operations problems at a detailed scale.

- **Aggregated run summary** - aggregates data for several travel time runs or vehicles along a single route, and typically includes average travel times and speeds between checkpoints and totals for delay. Aggregated run summaries provide average statistics for individual routes segments and are useful for a number of applications. Data collected from license plate matching includes average travel times and speeds for predefined roadway segments.

- **Corridor or route summary** - summarizes data for a corridor or route of consequential length, and includes average travel times, speeds, and delays. Corridor or route summaries are useful for large scale comparisons of traffic conditions and for providing information to non-technical audiences.

- **Functional classification summary** - summarizes data for all roadways within defined functional classifications (see Chapter 2), and includes average travel times, speeds, and delays. Functional class summaries are also useful at a macroscopic level for long range planning and time series trends.

- **Other summaries** - includes activity center summaries, travel time contours, accessibility plots, and other types of summaries not fitting neatly into the above categories. These types of summaries are more “system-oriented” than other summaries and help to identify the system conditions and the system effects of various transportation improvements.

The remainder of this chapter contains examples of these summaries with an interpretation of key features. These examples are a representative sample of travel time data summaries that have been used by transportation agencies. These examples are not a comprehensive inventory of all possible summaries. Two other references (4,5) contain several additional examples of tabular and graphical travel time data summaries. The figures and tables shown throughout this chapter are intended to provide the user of this handbook with examples from previous studies, with the intent of aiding the reader in identifying summaries applicable to their users and uses.

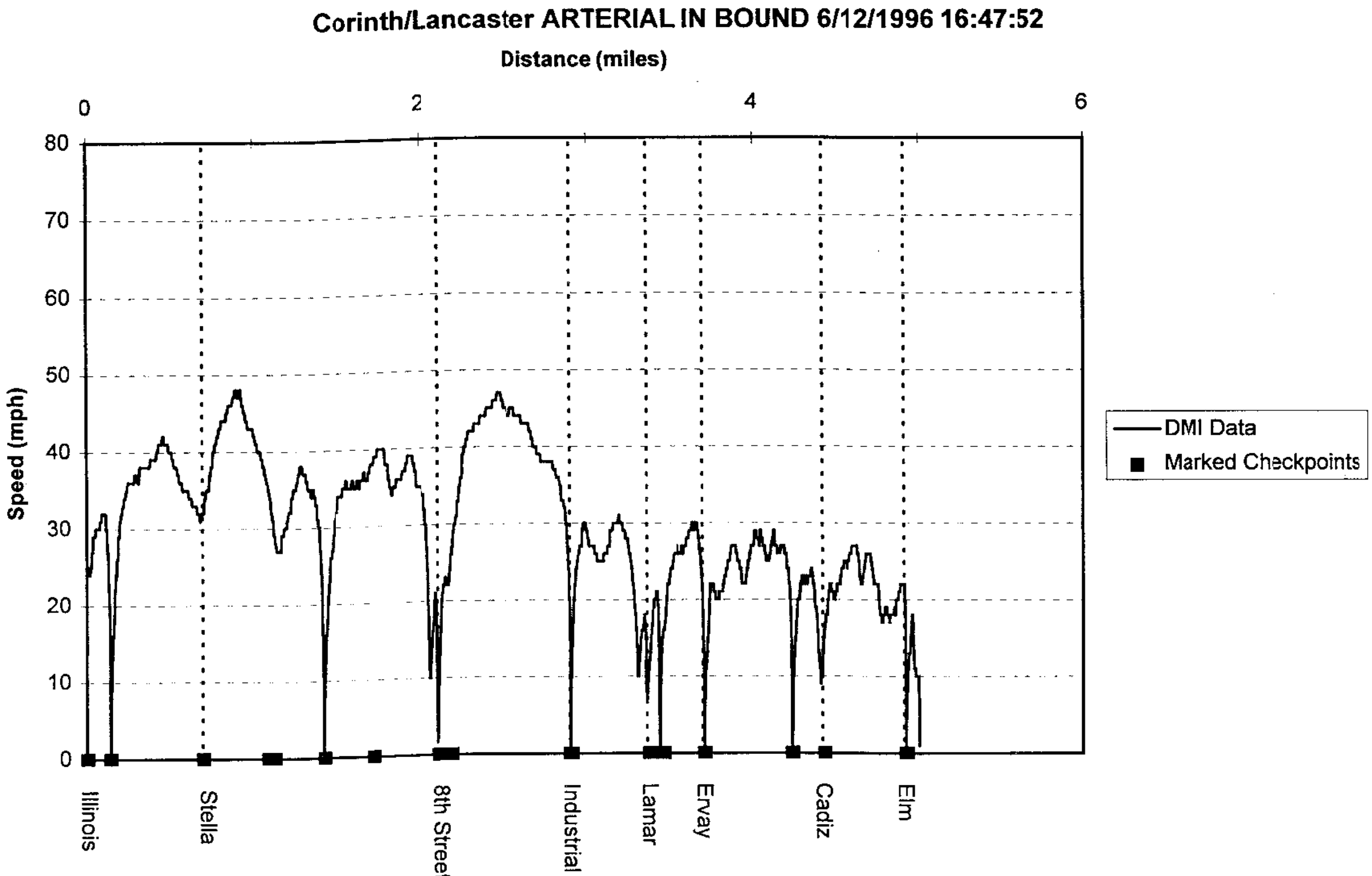
7.5.1 Run Summaries

A run summary includes data that have been collected during a specific travel time run, including elapsed time and speed between checkpoints, causes of intermediate delay, and time spent in different speed ranges. The run summaries are most common for test vehicle methods in which the vehicle is instrumented and data can be frequently collected at intermediate locations. Run summaries provide the finest level of detail for a travel time run, thereby providing a useful tool for performing quality control or diagnosing traffic operations problems.

Figures 7-1 and 7-2 show a run summary for Corinth/Lancaster Street in Dallas. The travel time and speed data shown in these figures were collected using the test vehicle method with an electronic DMI (see Chapter 3). The speed profile in Figure 7-1 illustrates the speed of the test vehicle throughout the entire length of the travel time run. Stops at intersections or mid-block speed reductions are clearly denoted by "dips" in the speed profile. Speed profiles such as Figure 7-1 provide useful information at a glance on signal coordination and progression. Also, note that the speed profile in Figure 7-1 is distance-based (i.e., x-axis is in distance units). A time-based speed profile shows more information about the duration of stops, but systematic identification of cross streets on a graph may be difficult. Graphing functions in most computer spreadsheets simplify the task of producing distance-time, speed-distance, or acceleration-distance profiles. Software macros also simplify the calculation of control delay, stopped delay, and other measures of effectiveness (6).

Figure 7-2 contains a tabular summary of the same travel time run illustrated in Figure 7-1. The tabular summary in Figure 7-2 includes intermediate and cumulative distances, travel times, and average speeds. This type of summary typically includes summary information on the cause and magnitude of stops or traffic disruptions experienced during the travel time run. The tabular summary in Figure 7-2 also contains information about the percent time spent in different speed ranges and the level of service for Highway Capacity Manual calculations.

For less automated test vehicle methods, travel times and speeds may only be available at selected intermediate checkpoints. Figure 7-3 illustrates the display of travel time, speed, and delay for a given travel time run. Note that less detail is available for the speed profile and that only average speeds are known between intermediate checkpoints. Table 7-3 contains an example of a tabular run summary of travel times, speeds, and delays between intermediate checkpoints.



Source: adapted from reference (7)

Figure 7-1. Example of Graphical Run Summary (Speed Profile) for Corinth/Lancaster Street in Dallas

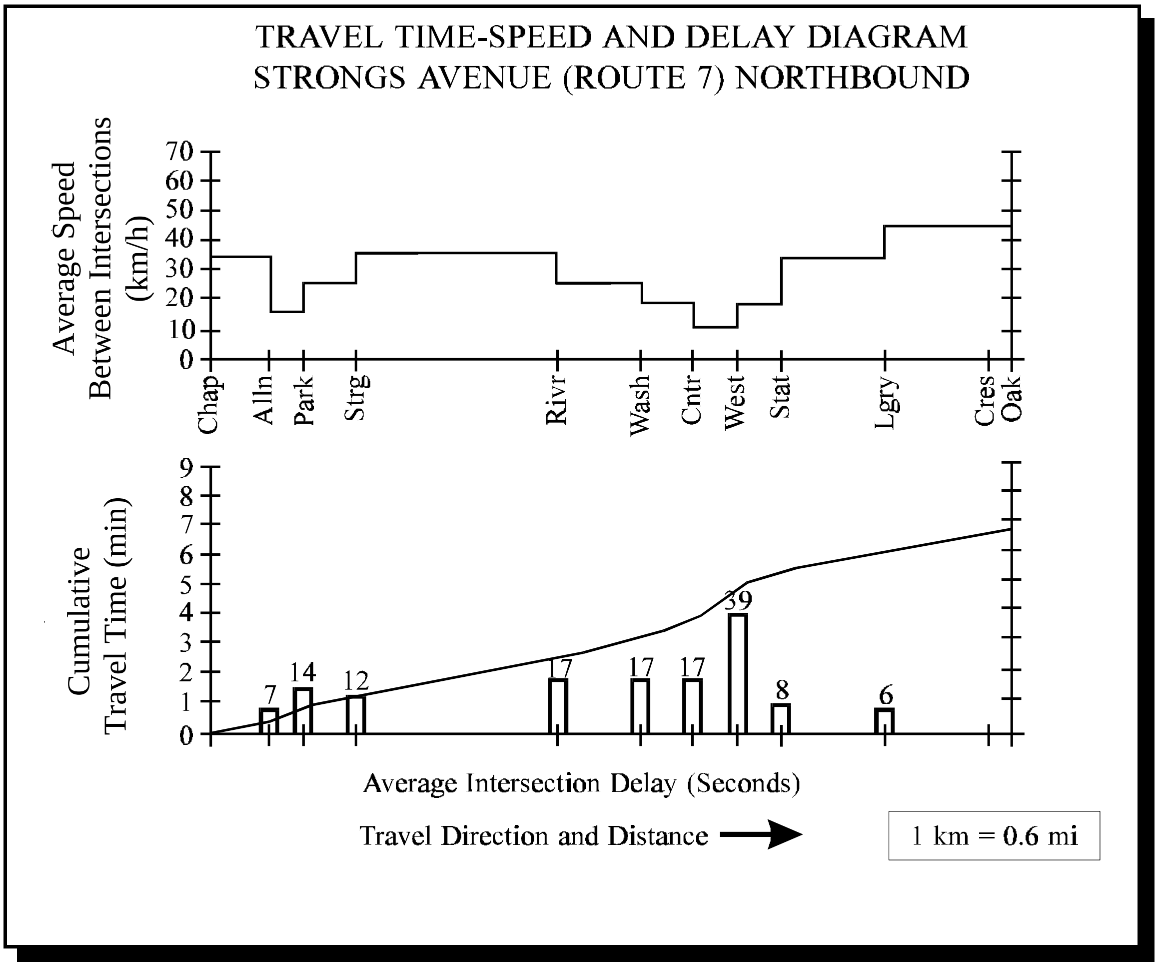
FACILITY NAME	CORINTH/LANCASTER
TRAVEL DIRECTION	IN BOUND
TTR DATE	6/12/96
WEATHER	OVERCAST
PAVEMENT	DRY
LIGHT CONDITION	NORMAL DAYLIGHT
SCHEDULED TIME	16:48
START TIME	16:47

CHECKPOINT	INT DIST (miles)	CUMM DIST (miles)	INT TIME (min)	CUMM TIME (min)	STDEV SPEED (mph)	AVG SPEED (mph)	PERCENT TIME UNDER 5 mph	PERCENT TIME BETWEEN 5-35 mph	PERCENT TIME BETWEEN 35-50 mph	PERCENT TIME OVER 50 mph	LEVEL OF SERVICE
Illinois	0.000	0.000	0.00	0.00	-----	-----	-----	-----	-----	-----	-----
Stella	0.690	0.690	1.60	1.60	14.37	25.90	19.0%	48.7%	32.3%	0.0%	-----
8th Street	1.420	2.110	2.94	4.54	13.06	28.97	10.3%	51.4%	38.3%	0.0%	-----
Industrial	0.790	2.900	1.38	5.92	12.16	34.24	5.9%	33.1%	60.9%	0.0%	-----
Lamar	0.460	3.360	1.71	7.64	11.46	16.11	27.3%	72.7%	0.0%	0.0%	-----
Ervay	0.340	3.700	1.09	8.72	8.97	18.76	12.0%	88.0%	0.0%	0.0%	-----
Cadiz	0.720	4.420	2.70	11.43	10.26	15.99	25.2%	74.8%	0.0%	0.0%	-----
Elm	0.490	4.910	1.36	12.79	3.24	21.63	0.0%	100.0%	0.0%	0.0%	-----
RUN AVERAGES						23.04	15.4%	65.2%	19.4%	0.0%	

REPORTED TRAFFIC CONDITIONS		
INCIDENT TYPE	TIME	MILE
Queue @ Signal	16:48:23	0.139
Queue Ends (Rolling)	16:48:41	0.143
One Lane Blocked	16:50:13	1.088
One Lane Blocked	16:50:14	1.101
Queue Ends (Rolling)	16:51:12	1.421
Construction Starts	16:51:46	1.727
Construction Ends	16:52:54	2.201
Queue @ Signal	16:54:00	2.903
Queue @ Signal	16:55:59	3.436
Queue Ends (Rolling)	16:56:12	3.463
Queue @ Signal	16:56:52	3.712
Queue @ Signal	16:58:25	4.241
Queue Ends (Rolling)	16:58:53	4.248
Queue @ Signal	17:00:55	4.922

Source: adapted from reference (7)

Figure 7-2. Example of Tabular Run Summary for Corinth/Lancaster Street in Dallas



Source: adapted from reference (8)

Figure 7-3. Example Summary of Travel Time, Speed, and Delay Information for an Arterial Street

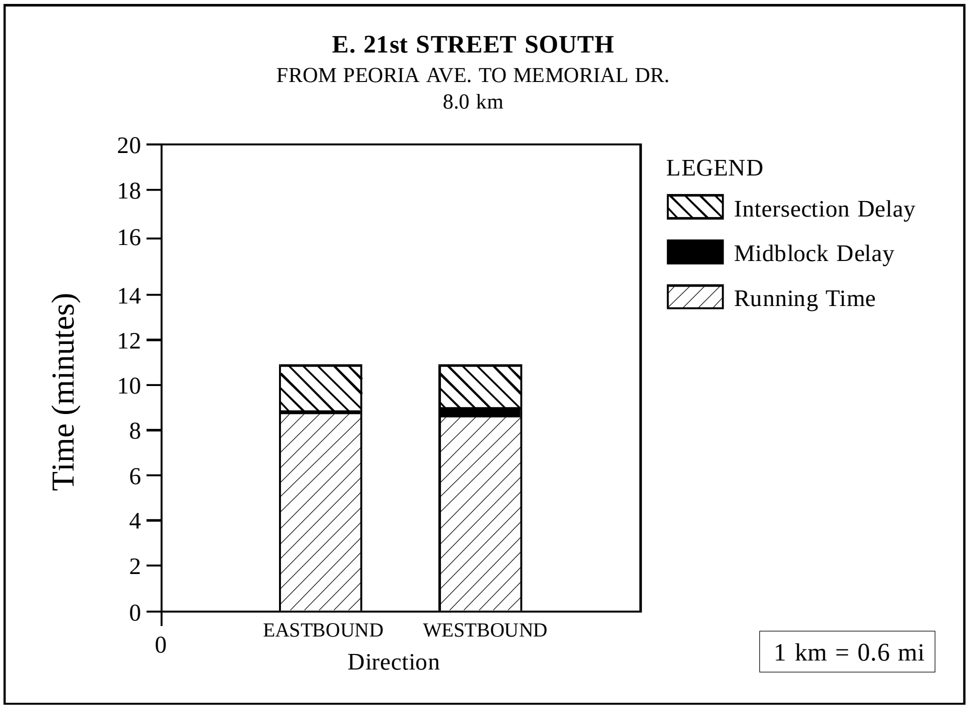
Table 7-3. Example Tabular Run Summary in Hampton Roads, Virginia

RUN SUMMARY OF: VA BEACH BLVD, FILE: VABEACHE.R10
FROM: NEWTON RD. TO: GREAT NECK DIRECTION: EASTBOUND
DATE OF RUN: 03-05-1990 TIME OF RUN: 16:19:36

Link #	Cross St. at end of link	Link Length (m)	Delay Time (sec)	Number of Stops	Travel Time (sec)	Average Speed (km/h)	Cruise Speed (km/h)
	Newtown Rd						
1	Davis St	591	22	2	81	26.2	44.3
2	Clearfield	751	38	1	97	27.9	53.0
3	Witchduck Rd	783	67	1	124	22.7	55.9
4	Dorset Ave	448	0	0	26	62.0	62.3
5	Aragona Blvd	553	0	0	32	62.3	64.7
6	Kellam Rd	352	0	0	19	66.8	66.8
7	Independence	451	25	1	62	26.2	58.6
8	Pembroke Mall	262	0	0	18	52.3	53.3
9	Constitution	249	39	1	63	14.2	47.2
10	Cox Dr	401	0	0	27	53.5	53.8
11	Thalia Rd	503	80	1	163	11.1	32.4
12	Stephey Ln	493	0	0	27	65.8	65.8
13	Lynn Shores	660	0	0	34	69.9	69.9
14	Outlet Mall	477	0	0	25	68.7	71.0
15	Rosemont Rd	511	68	1	104	17.7	71.6
16	Little Neck	619	40	1	86	25.9	63.4
17	King Richard	234	0	0	15	56.2	59.9
18	Cranston Ln	581	0	0	29	72.1	72.1
19	Kings Grant	342	0	0	23	53.5	60.1
20	Lynnhaven Rd	592	0	0	34	62.6	63.6
21	Yorktown Ave	182	18	1	36	18.2	60.4
22	Mustang Tr	393	0	0	25	56.7	58.4
23	Lynnhaven Pk	261	0	0	13	72.3	72.3
24	Byrd Ln	960	0	0	49	70.5	71.5
25	Great Neck	349	19	1	49	25.6	53.5
Route Summary:		11,998 (11.9 km)	416 (6:56)	11	1261 (21:01)	34.2	60.7

Source: adapted from reference (9)

Figure 7-4 contains an example of a run summary that combines graphical and tabular elements. The chart illustrates the travel time in relation to intersection and mid-block delay, whereas the table below contains specific travel time and delay values for the chart.



E. 21st STREET SOUTH

	EASTBOUND	WESTBOUND
Day of Week	Wednesday	Wednesday
Time of Day	Off-Peak	Off-Peak
Trip Length (km)	8.0	8.0
Travel Time (Minutes)	10:46	10:46
Intersection Delay	2:06	1:52
Midblock Delay	0:01	0:20
Running Time	8:39	8:36
Posted Speed (km/h)	55	55
Travel Speed (km/h)	44.9	44.9
Running Speed (km/h)	55.9	56.2

Source: adapted from reference (10)

Figure 7-4. Example of Combined Graphical and Tabular Data Summary from Tulsa, Oklahoma

7.5.2 Aggregated Run Summaries

An aggregated run summary includes data for several travel time runs along the same route, such as average elapsed time, average travel time and speeds between checkpoints, and totals for delay. Aggregated run summaries can be used to compare the travel times and speed for several runs that have been performed at different times or different days of the week. Most of the detail for an individual travel time run may, however, be omitted from these summaries for the sake of brevity or clarity. Data collection managers or personnel commonly use aggregated run summaries for quality control to ensure that travel time runs for the same route produced comparable results.

Figure 7-5 contains a tabular summary that includes the travel time data from three separate test vehicle runs. In this figure, one can note that the data from Figure 7-1 and 7-2 is represented in the first major column of Figure 7-5. Also note in this figure that delay and stops information from individual runs have been omitted. An average travel time and speed between each intermediate checkpoint is provided in the last column. These average travel time and speed values will then be used in subsequent facility or system summaries.

For some aggregated run summaries, it may be desirable to present only the average travel times and speeds for all runs. Figure 7-6 presents an average speed profile along an arterial street in southeastern Virginia. The average speed is shown in relation to applicable level of service (LOS) criteria. With this notation, the audience can clearly see when average speeds drop below LOS D.

Table 7-4 contains a tabular summary for a freeway corridor in Houston, Texas for both directions and three different time periods (a.m. peak, off peak, and p.m. peak). The tabular summary includes only average travel times and speeds between intermediate checkpoints. Note also that the summary provides route subtotals at major cross streets, as well as total travel times and average speeds for the entire length of the surveyed route.

Figure 7-7 shows a travel time “strip map” that was developed for the congestion management system in Baton Rouge, Louisiana. The “strip map” format correlates interchange and ramp layouts to travel time and speed data on sequential segments and also includes information about segment length and posted speed limits. Figure 7-8 contains a “speed deficit” map that illustrates the differences between measured average travel speeds and posted speed limits.

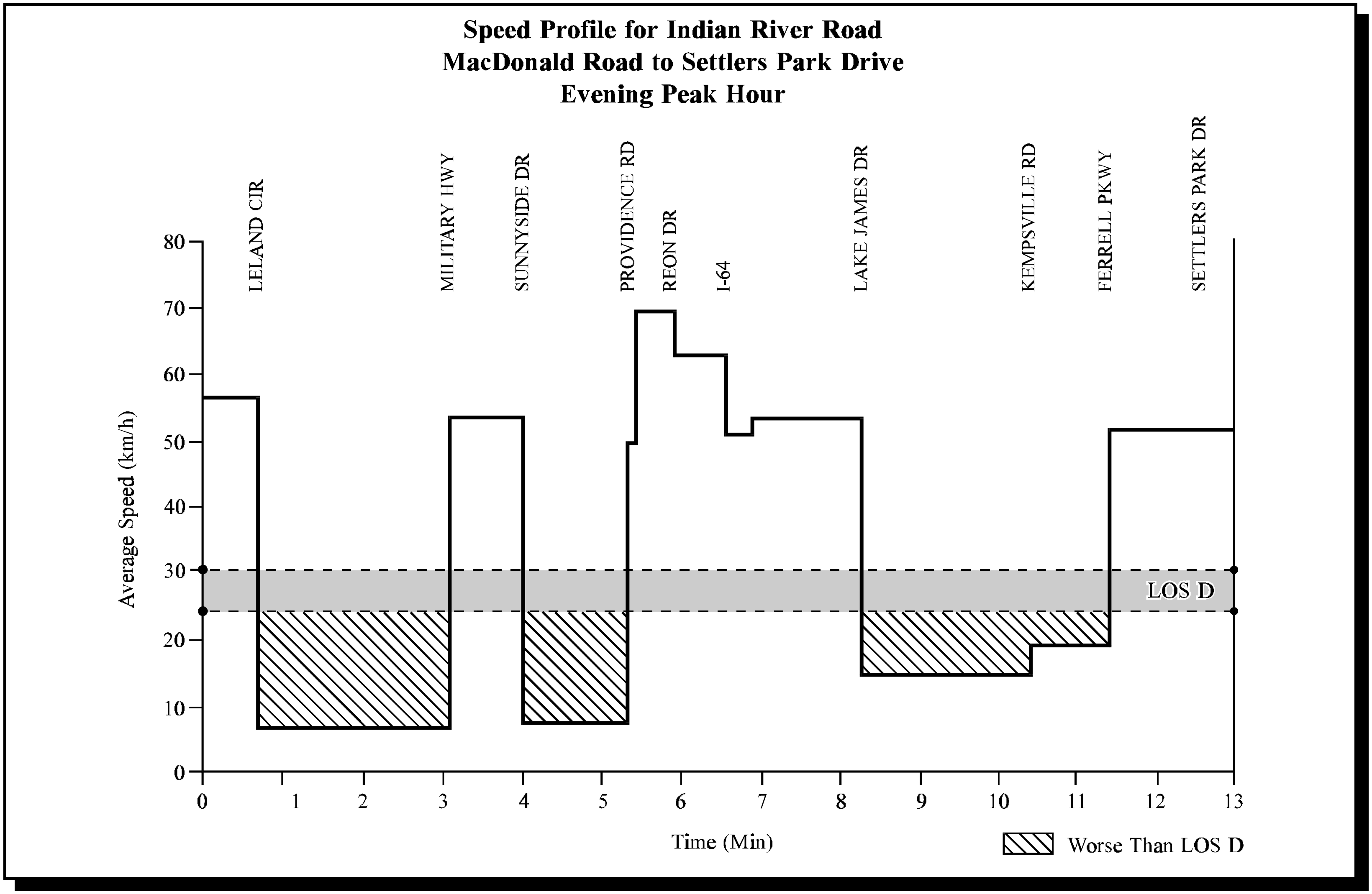
Figure 7-9 provides a graphical summary of average speeds on I-77 in Cleveland, Ohio. The figure provides average speeds for both directions and for three different time periods. Note that in this figure the average speeds appear to correspond with a single point along the corridor. Closer inspection of the accompanying report text indicate, however, that the average speeds shown correspond to six long sections of freeway.

Corinth/Lancaster
ARTERIAL
INBOUND
PM TIME PERIOD

				COAI6F12.16J 16:48 6/12/96			COAI6F12.17F 17:30 6/12/96			COAI6F10.18H 18:40 6/10/96			AVERAGE		
TRAVELED FACILITY	SEGMENT CHECKPOINT	INT DIST (miles)	CUMM DIST (miles)	INT TIME (min)	CUMM TIME (min)	AVG SPEED (mph)	INT TIME (min)	CUMM TIME (min)	AVG SPEED (mph)	INT TIME (min)	CUMM TIME (min)	AVG SPEED (mph)	INT TIME (min)	CUMM TIME (min)	INT SPEED (mph)
Corinth	Illinois	0.000	0.000	0.00	0.00	—	0.00	0.00	—	0.00	0.00	—	0.00	0.00	—
Corinth	Stella	0.690	0.690	1.60	1.60	25.90	1.04	1.04	39.88	1.43	1.43	29.05	1.35	1.35	30.58
Corinth	8th Street	1.420	2.110	2.94	4.54	28.97	2.60	3.63	32.83	3.13	4.56	27.21	2.89	4.24	29.49
Corinth	Industrial	0.790	2.900	1.38	5.92	34.24	1.44	5.08	32.87	1.47	6.02	32.32	1.43	5.67	33.13
Corinth	Lamar	0.460	3.360	1.71	7.64	16.11	1.05	6.13	26.17	1.89	7.92	14.57	1.55	7.23	17.76
Corinth	Ervay	0.340	3.700	1.09	8.72	18.76	1.31	7.44	15.57	1.27	9.19	16.08	1.22	8.45	16.69
Ervay	Cadiz	0.720	4.420	2.70	11.43	15.99	2.29	9.73	18.86	2.60	11.78	16.65	2.53	10.98	17.08
Ervay	Elm	0.490	4.910	1.36	12.79	21.63	1.29	11.02	22.73	1.37	13.15	21.50	1.34	12.32	21.94
				—	—	23.04	—	—	26.72	—	—	22.40	—	—	23.91

Source: adapted from reference (7)

Figure 7-5. Example Aggregated Run Summary for Corinth/Lancaster Street in Dallas



Source: adapted from reference (11)

Figure 7-6. Example of Aggregated Run Summary (Average Speed Profile) in Southeastern Virginia

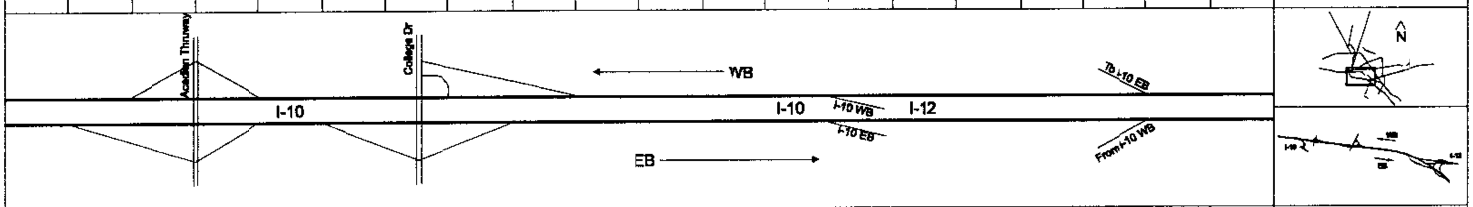
Table 7-4. Example of a Tabular Aggregated Run Summary in Houston, Texas

HOUSTON-GALVESTON REGIONAL TRANSPORTATION STUDY
1994 TRAVEL TIME AND SPEED SURVEY
ROADWAY NAME : US 290 (NORTHWEST FREEWAY)
FUNCTIONAL CLASS : OTHER FREEWAY OR EXPRESSWAY

SEGMENT DESCRIPTION	SEGMENT LENGTH (MILES)	A.M. PEAK (6:30 - 8:30)				OFF PEAK (9:30 - 15:30)						P.M. PEAK (16:30 - 18:30)			
		NORTHBOUND		SOUTHBOUND		NORTHBOUND		SOUTHBOUND		AVERAGE		NORTHBOUND		SOUTHBOUND	
		TIME	SPEED	TIME	SPEED	TIME	SPEED	TIME	SPEED	TIME	SPEED	TIME	SPEED	TIME	SPEED
IH 610 TO MANGUM	0.80	0.80	60.00	2.12	22.60	0.93	51.89	0.78	61.94	0.85	56.47	1.78	27.02	0.77	62.07
MANGUM TO W 34TH	0.83	0.84	59.64	1.60	31.07	0.87	57.57	0.85	58.93	0.86	58.25	1.51	33.09	0.84	59.29
W 34TH TO ANTOINE	0.42	0.47	53.90	0.74	34.19	0.45	56.63	0.42	60.00	0.43	58.27	0.90	28.16	0.44	57.27
ANTOINE TO W 43RD	0.87	0.86	61.05	1.30	40.15	0.89	58.98	0.89	58.65	0.89	58.82	1.72	30.44	0.84	62.39
W 43RD TO BINGLE	0.50	0.51	59.41	0.82	36.52	0.54	56.07	0.49	61.22	0.51	58.54	0.97	30.98	0.49	61.86
BINGLE TO PINEMONT	0.30	0.30	61.02	0.40	44.84	0.33	55.38	0.30	60.00	0.31	57.60	0.52	34.84	0.33	55.10
PINEMONT TO HOLLISTER	0.95	0.97	59.07	1.35	42.09	0.97	59.07	0.95	60.00	0.96	59.53	1.60	35.59	0.96	59.38
HOLLISTER TO TIDWELL	0.29	0.33	53.13	0.65	26.65	0.32	55.24	0.31	56.13	0.31	55.68	0.59	29.66	0.30	58.00
TIDWELL TO F-BANKS N HOUSTON	1.06	1.02	62.66	1.73	36.82	1.06	60.00	1.08	58.89	1.07	59.44	1.77	35.86	1.05	60.57
F-BANKS N HOUSTON TO GESSNER	1.13	1.12	60.54	2.13	31.81	1.12	60.81	1.13	60.00	1.12	60.40	1.48	45.86	1.12	60.45
GESSNER TO LITTLE YORK	0.49	0.51	57.37	0.56	52.50	0.49	60.00	0.48	61.89	0.48	60.93	0.50	59.00	0.48	60.83
LITTLE YORK TO SAM HOUSTON TOLLWAY	0.49	0.50	59.39	1.42	20.75	0.53	56.00	0.51	58.22	0.52	57.09	0.67	43.99	0.51	57.65
SUBTOTAL	8.13	8.19	59.54	14.83	32.89	8.45	57.73	8.17	59.71	8.31	58.70	13.98	34.88	8.13	60.02
SAM HOUSTON TOLLWAY TO SENATE	0.51	0.53	58.01	1.45	21.12	0.51	60.00	0.56	54.64	0.54	57.20	0.63	48.96	0.54	57.20
SENATE TO JONES ROAD	1.60	1.58	60.66	1.61	59.68	1.54	62.34	1.58	60.95	1.56	61.64	1.36	70.42	1.62	59.20
JONES RD TO ELDRIDGE	1.41	1.34	63.25	1.42	59.64	1.44	58.75	1.37	61.98	1.40	60.32	1.42	59.44	1.38	61.23
ELDRIDGE TO FM 1960	1.28	1.27	60.35	1.26	61.09	1.26	61.20	1.23	62.69	1.24	61.94	1.30	59.23	1.28	59.84
SUBTOTAL	4.80	4.72	61.02	5.73	50.24	4.75	60.70	4.73	60.95	4.74	60.82	4.71	61.17	4.82	59.73
CUMULATIVE SUBTOTAL	12.93	12.91	60.08	20.56	37.73	13.20	58.79	12.90	60.16	13.05	59.47	18.69	41.51	12.95	59.92
FM 1960 TO HUFFMEISTER	0.91	0.96	56.88	0.93	58.98	0.93	59.03	0.93	59.03	0.93	59.03	0.97	56.10	0.95	57.47
HUFFMEISTER TO TELGE	1.58	1.53	61.86	1.58	60.16	1.53	62.16	1.54	61.56	1.53	61.86	1.57	60.32	1.62	58.46
TELGE TO BARKER CYPRESS	1.84	1.80	61.45	1.71	64.56	1.79	61.85	1.83	60.49	1.81	61.16	1.71	64.44	1.87	59.04
BARKER CYPRESS TO CYPRESS-ROSEHILL	1.80	2.01	53.64	1.88	57.55	1.99	54.41	1.90	56.99	1.94	55.67	2.03	53.29	1.96	55.01
CYPRESS-ROSEHILL TO BECKER RD	6.90	6.69	61.88	6.75	61.33	7.03	58.93	6.52	63.55	6.77	61.15	6.45	64.15	6.62	62.57
BECKER RD TO WARREN RANCH RD	3.03	2.97	61.14	3.02	60.27	3.15	57.71	3.04	59.90	3.09	58.79	3.10	58.65	2.96	61.35
WARREN RANCH RD TO FM 2920	4.43	4.40	60.41	4.47	59.42	4.75	55.96	4.44	59.86	4.60	57.85	4.82	55.11	4.61	57.70
FM 2920 TO HARRIS/WALLER CO LINE	0.53	0.75	42.59	0.59	53.60	0.82	38.78	0.58	55.30	0.70	45.59	0.69	45.87	0.59	53.90
SUBTOTAL	21.02	21.11	59.74	20.92	60.28	21.97	57.42	20.75	60.78	21.36	59.05	21.36	59.06	21.18	59.54
TOTAL	33.95	34.03	59.87	41.48	49.10	35.16	57.94	33.65	60.54	34.40	59.21	40.05	50.87	34.13	59.68

Source: adapted from reference (12)

BATON ROUGE										CORRIDOR No. 1 -- I-10										9/1/95 to 5/3/96
																				PM PEAK
53	51	54	54	50	47	48	48	55	55	54	55	55	57	56	57	56	55	52	47	Avg. Travel Speed (mph)
233	224	216	203	191	177	162	153	144	135	122	108	95	86	74	61	48	35	24	10	Cum. Travel Time (sec)
																				OFF PEAK
53	52	56	56	50	54	51	52	55	55	55	55	52	42	60	59	59	59	57	57	Avg. Travel Speed (mph)
227	219	211	198	187	172	159	151	142	134	120	107	94	84	67	55	43	31	20	8	Cum. Travel Time (sec)
																				AM PEAK
43	40	49	50	44	43	39	38	36	37	38	39	40	35	37	39	47	49	41	28	Avg. Travel Speed (mph)
306	296	285	271	258	242	225	215	202	190	170	151	132	119	98	79	61	46	32	15	Cum. Travel Time (sec)
55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	Posted Speed Limit (mph)
0.12	0.12	0.20	0.18	0.20	0.20	0.11	0.13	0.13	0.20	0.20	0.20	0.15	0.20	0.20	0.20	0.20	0.18	0.20	0.12	Segment Length (mi)
14262	12412	12421	12422	12423	12428	12423	12435	12434	12439	12438	12437	12436	12448	12447	12462	12446	12445	12481	12480	Segment ID

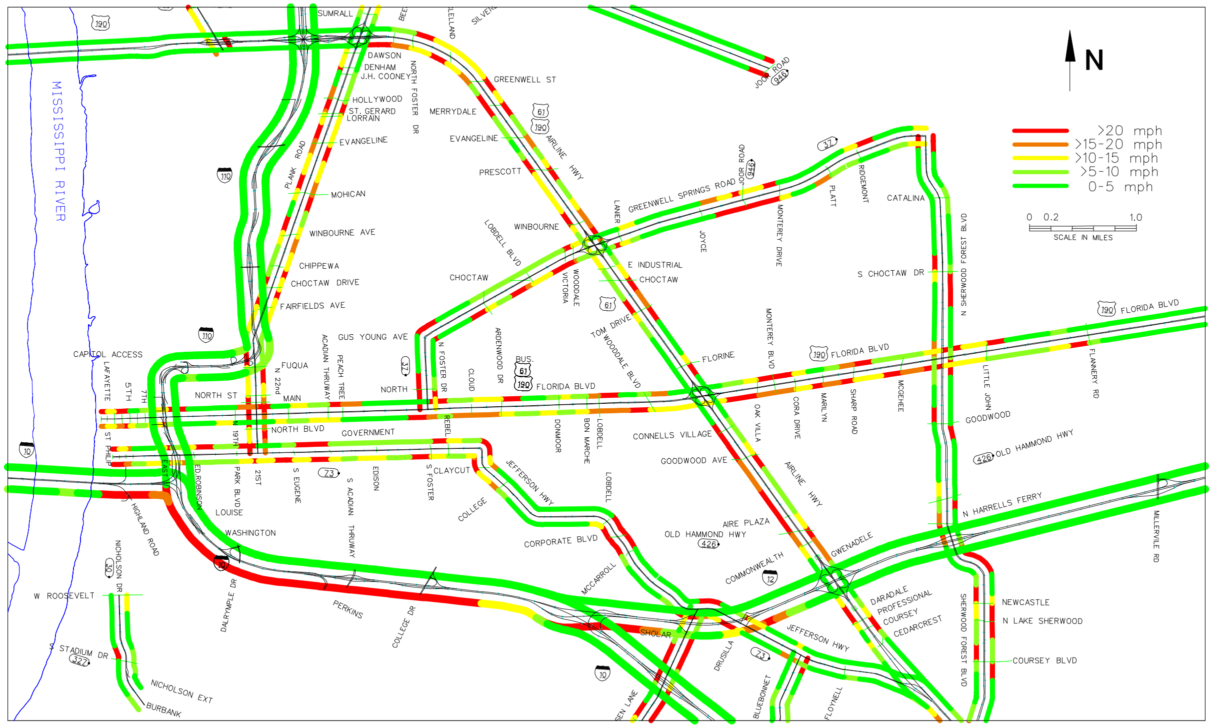


12139	12414	12420	12415	11810	12426	12429	12427	12440	12441	12442	12443	12444	12451	12450	12463	12464	12449	12478	12479	Segment ID
0.15	0.14	0.20	0.20	0.12	0.14	0.20	0.20	0.12	0.20	0.20	0.20	0.20	0.10	0.10	0.20	0.20	0.20	0.17	0.20	Segment Length (mi)
55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	Posted Speed Limit (mph)
																				AM PEAK
51	52	53	52	51	53	52	53	52	53	53	53	53	52	53	54	54	53	54	55	Avg. Travel Speed (mph)
10	19	33	47	56	66	79	93	102	115	129	143	156	163	170	184	197	210	222	235	Cum. Travel Time (sec)
																				OFF PEAK
51	56	55	53	50	54	52	52	50	53	54	54	55	57	58	62	63	63	61	61	Avg. Travel Speed (mph)
10	19	33	47	55	65	79	93	101	115	128	142	155	161	167	179	190	202	213	224	Cum. Travel Time (sec)
																				PM PEAK
21	14	12	13	22	23	22	20	23	33	37	39	41	31	17	20	21	16	22	35	Avg. Travel Speed (mph)
26	61	118	173	193	215	249	284	304	326	345	354	382	393	415	451	486	531	559	580	Cum. Travel Time (sec)

09/17/96	Remote Sensing and Image Processing Laboratory	Avg Travel Speed/Posted Speed Limit Ratio: >0.9, 0.8-0.9, 0.7-0.8, 0.5-0.7, 0.3-0.5, <0.3	Secion 11

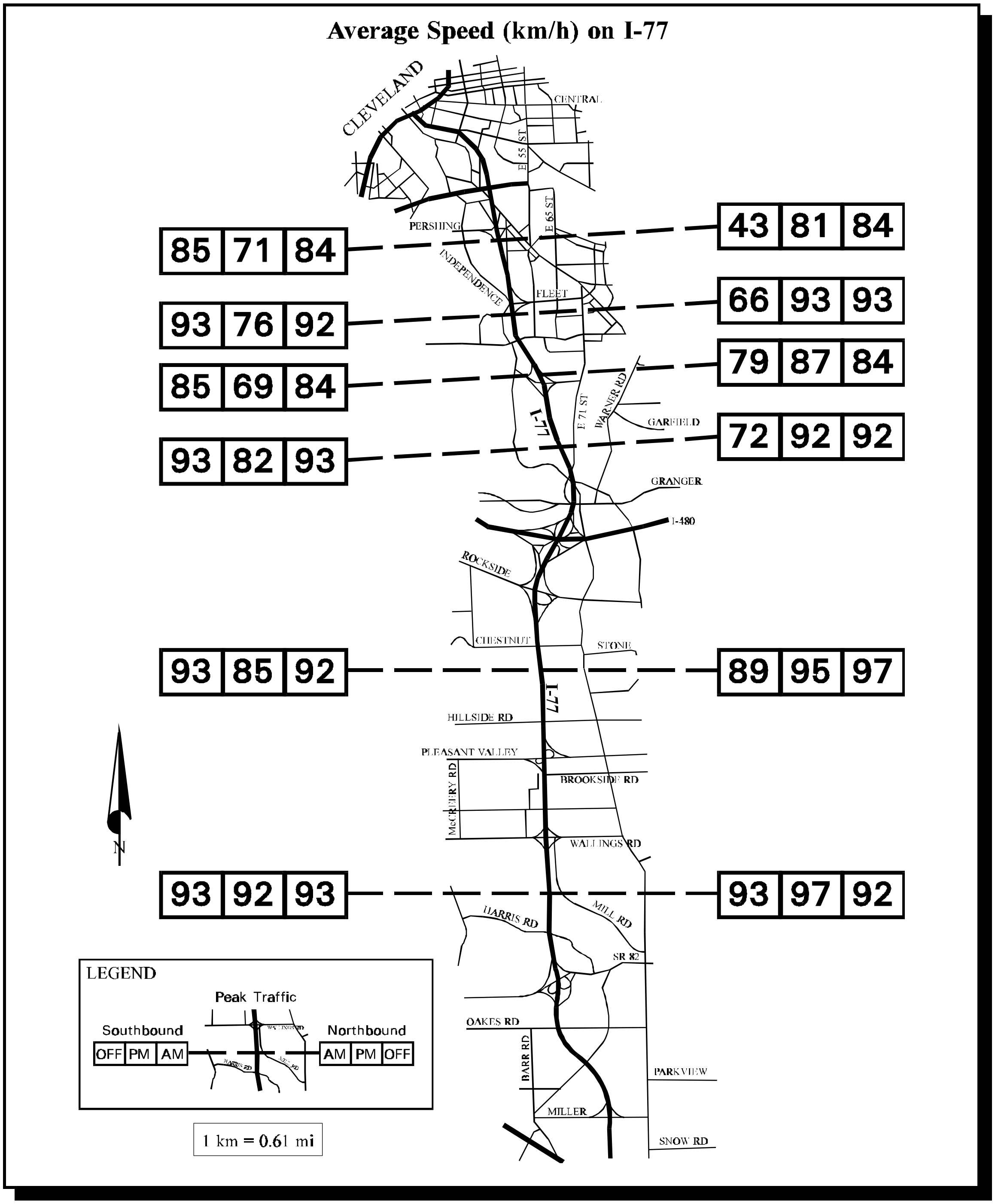
Source: adapted from reference (13)

Figure 7-7. Example of Travel Time "Strip Map" in Baton Rouge, Louisiana



Source: adapted from reference (12).

Figure 7-8. Example of a "Speed Deficit" Map in Baton Rouge, Louisiana



Source: adapted from reference (15)

Figure 7-9. Example of Graphical Aggregated Run Summary in Cleveland, Ohio

Figure 7-10 presents a speed contour diagram that shows the average speeds along a corridor for different times of the day. In this figure, the morning and evening peak periods are shown. Similar speed contour diagrams are available through computer simulation programs, such as the speed diagram shown in Figure 7-11. Note that although these two figures only show speeds to the nearest 10 or 15 mph, one can clearly see the patterns and trends of congestion and any associated bottleneck locations.

7.5.3 Corridor or Route Summaries

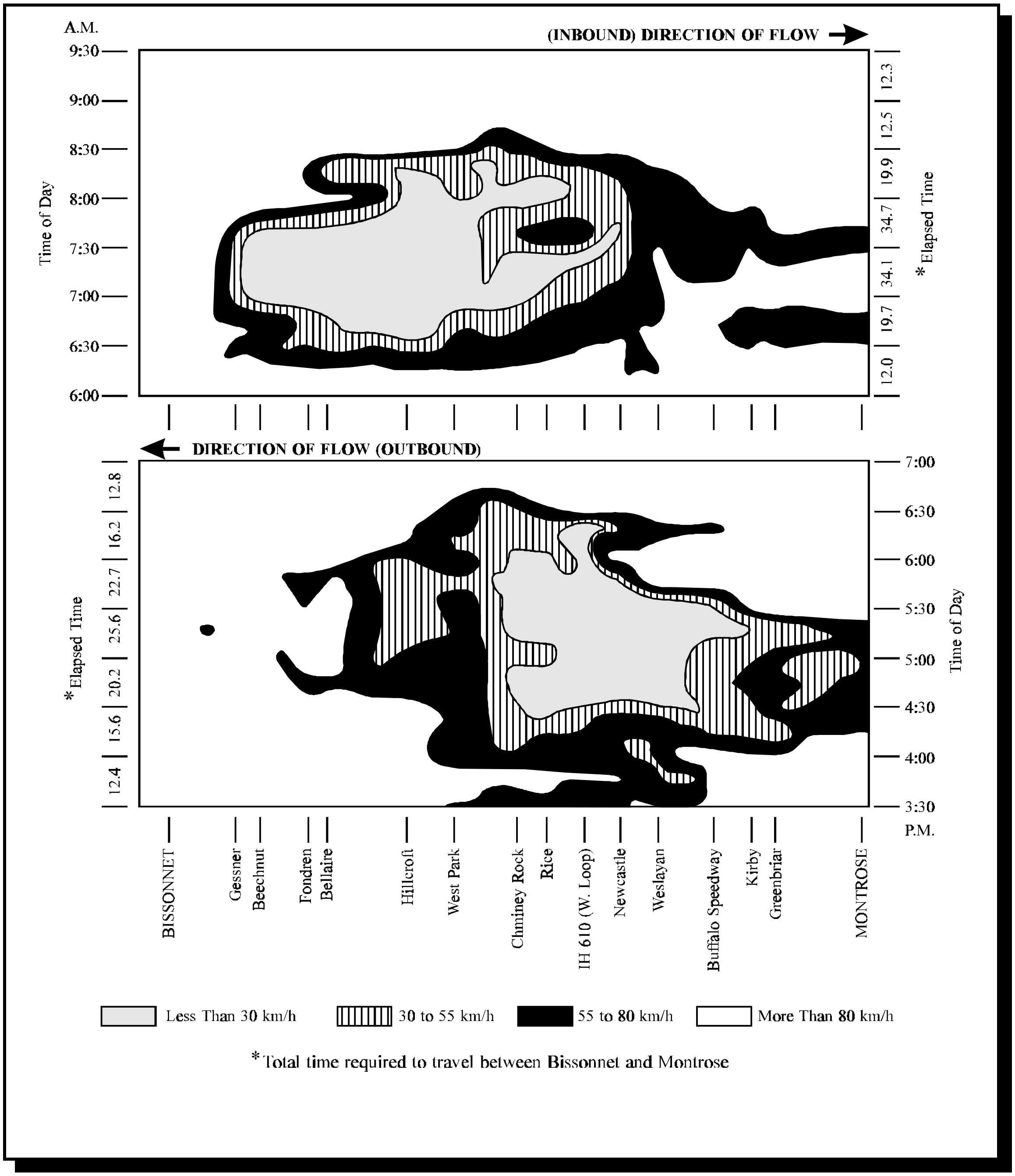
A corridor or route summary includes travel time, speed and delay data for corridor or routes of consequential length (typically eight km (five mi) or longer). The main purpose of these types of summaries is to compare travel times and speeds between several different routes or corridors.

Figure 7-12 illustrates the differences between average speeds in an HOV lane and the adjacent freeway mainlanes using travel time data collected using license plate matching techniques. The figure represents the range in travel speeds during the morning peak period on an eight-kilometer freeway section in Dallas, Texas. The large number of speed samples provides a better perspective on the variability of speeds during the morning peak and between the different roadway facilities.

The corridor summary in Table 7-5 compares the average speeds for two freeways and four arterial streets over a period of three years. Note that the addition of a fourth column containing the percentage change of average speed between 1977 and 1979 would improve the comprehension of speed trends for each facility.

Figure 7-13 and 7-14 show a similar perspective on the differences between travel times on Houston's Katy (IH-10) freeway HOV lane and the adjacent mainlanes. The travel time data shown in these figures were obtained from probe vehicles in Houston's automatic vehicle identification (AVI) traffic monitoring system. Figure 7-13 also shows the average monthly and daily travel time values, illustrating that the HOV lane offers a significant travel time savings and a more reliable travel time than the adjacent freeway mainlanes. Figure 7-14 more clearly illustrates the variability of travel times using an 85 percent confidence interval for average peak hour travel times.

The chart in Figure 7-15 compares the travel times, speeds, and delays for both directions of two arterial streets for different times of the day. Note that although the chart contains a wealth of information, it takes more time to interpret the graphics than most charts. This figure contains more detail than most typical corridor summaries.



Source: adapted from reference (16)

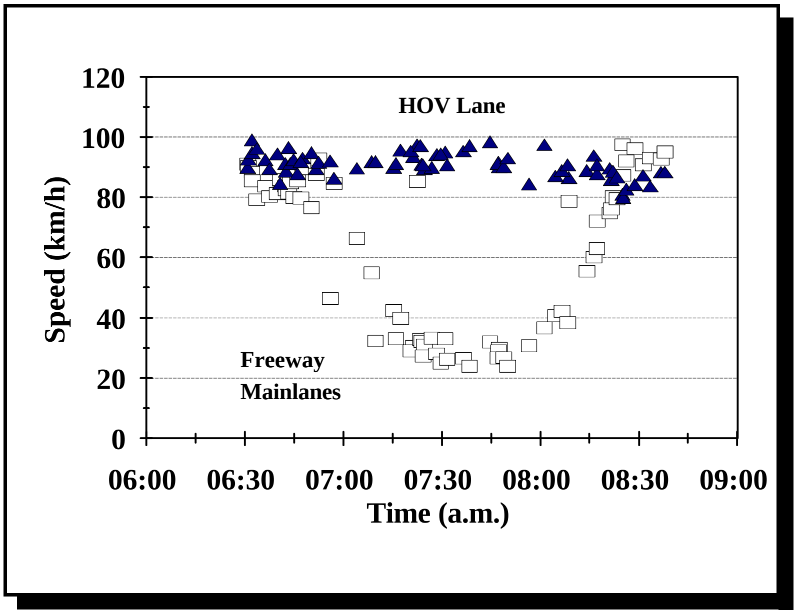
Figure 7-10. Example of Speed Contour Diagrams from Data Collection

```
CONTOUR DIAGRAM OF SPEED     ALL LANES
BEFORE  IMPLEMENTATION

        TIME                                                                                                        BEGIN
        SLICE ....................................................................................................   TIME
              .                                                                                                    .
            1 .6666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666. -  6:00
            2 .6666666666666666666666666666666666666666666666666666666666666665555555566666666666666666666555555555. -  6:15
            3 .6666666666666666666666666666666666666666666666666666666666665555555555555555555555555555555555555555. -  6:30
            4 .6666666666666666666666666666666666666666666666666666666666666555555555555555555555555555555555555555. -  6:45
            5 .6666666666666666666666666666644444444433333333322222223333333335555555555555555556666666666655555555 5. -  7:00
            6 .3333333332222222221111111111111111122222222211111112222222225555555666666666666666666666666555555555. -  7:15
            7 .1111111112222222221111111111111111122222222222222222223333333335555555555555555556666666666655555555 5. -  7:30
            8 .1111111111111111111111111111111111122222222211111112222222225555555666666666666666666666666555555555. -  7:45
            9 .2222222222222222222222222222222222222222222222222222223333333335555555555555555556666666666655555555 5. -  8:00
           10 .1111111112222222221111111111111111122222222211111112222222225555555666666666666666666666666555555555. -  8:15
           11 .2222222222222222222222222222222222222222222222222222223333333335555555555555555556666666666655555555 5. -  8:30
           12 .3333333332222222222222222222222222222222222222222222224444444445555555555555555555555555555555555555. -  8:45
           13 .6666666665555555554444444444433333333333333333222222224444444445555555555555555555555555555555555555. -  9:00
           14 .6666666666666666666666666666666666666666666663333333333333333335555555555555555556666666666655555555 5. -  9:15
           15 .6666666666666666666666666666666666666666666666666666666666666665555555566666666666666666666555555555. -  9:30
           16 .6666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666. -  9:45
           17 .6666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666. - 10:00
           18 .6666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666. - 10:15
           19 .6666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666. - 10:30
           20 .6666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666. - 10:45
           21 .6666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666. - 11:00
           22 .6666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666. - 11:15
           23 .6666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666. - 11:30
           24 .6666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666666. - 11:45
              .                                                                                                    .
              .....................................................................................................
               :        :        :          :        :        :       :        :       :          :       :
              ML     FM 1325   GAP        WBP      GAP     Howard   WBP     Howard Parmer     Yager    Parmer
            Origin     Entr    Exit       Exit     Entr     Exit    Entr      Entr  Exit       Exit     Entr

         THE DIGIT LEVELS DENOTE THE FIRST DIGIT OF THE OPERATING SPEED (EX. 4 MEANS 40-49 MPH).
```

Figure 7-11. Example Speed Contour Diagram from FREQ Computer Program



Source: adapted from reference (17)

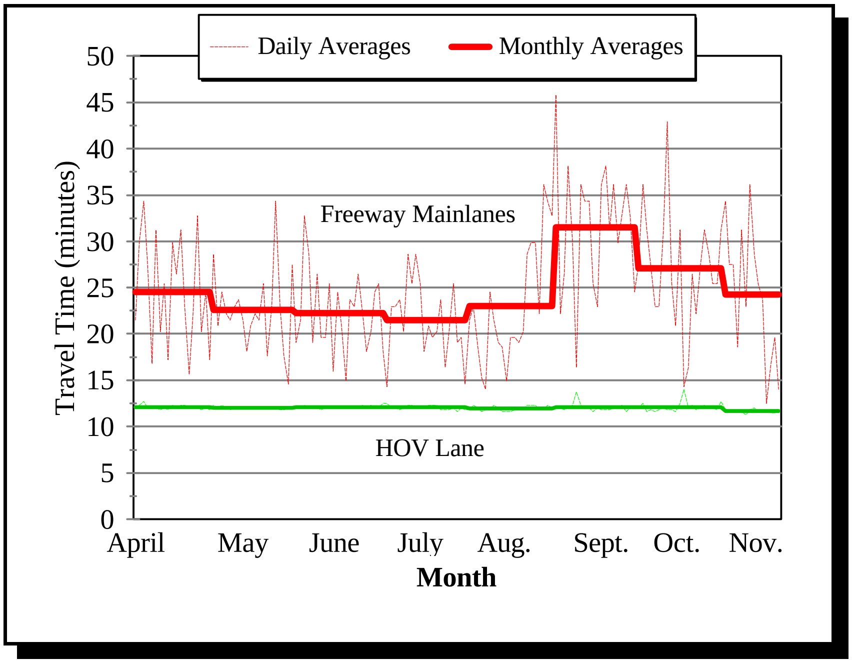
Figure 7-12. Example Corridor Summary Illustrating Variability of Travel Speeds

.

Table 7-5. Example of Tabular Corridor Summary in Tulsa, Oklahoma

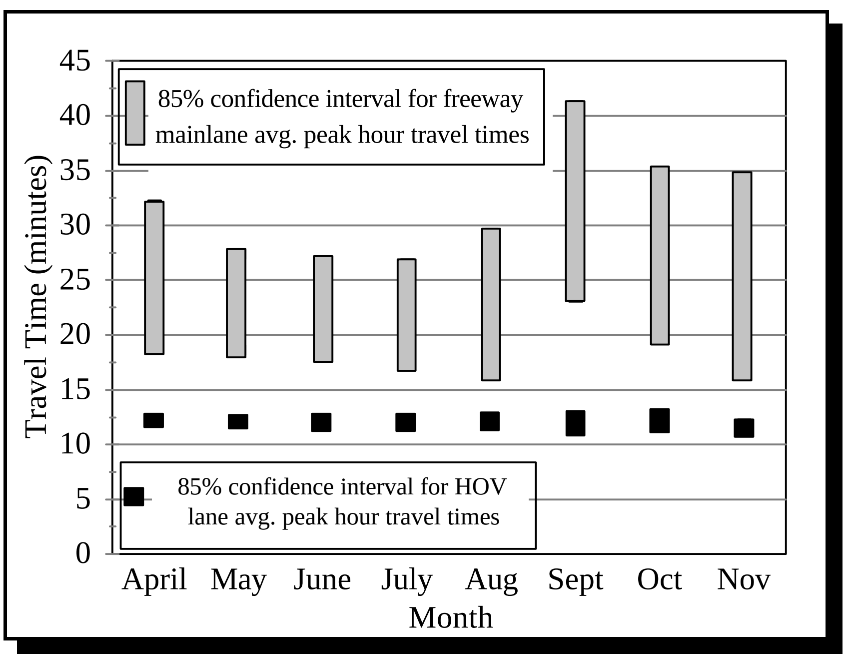
Facility	Average Speed, km/h		
	1977	1978	1979
Crosstown Expressway (I-244)	86.4	86.4	88.0
Skelly Drive (I-44)	81.5	83.6	86.4
11th Street	39.9	38.0	43.8
Memorial Drive	35.7	33.8	33.8
Riverside Drive	63.6	59.7	60.2
Union Avenue	53.3	54.2	57.5

Source: adapted from reference (18)



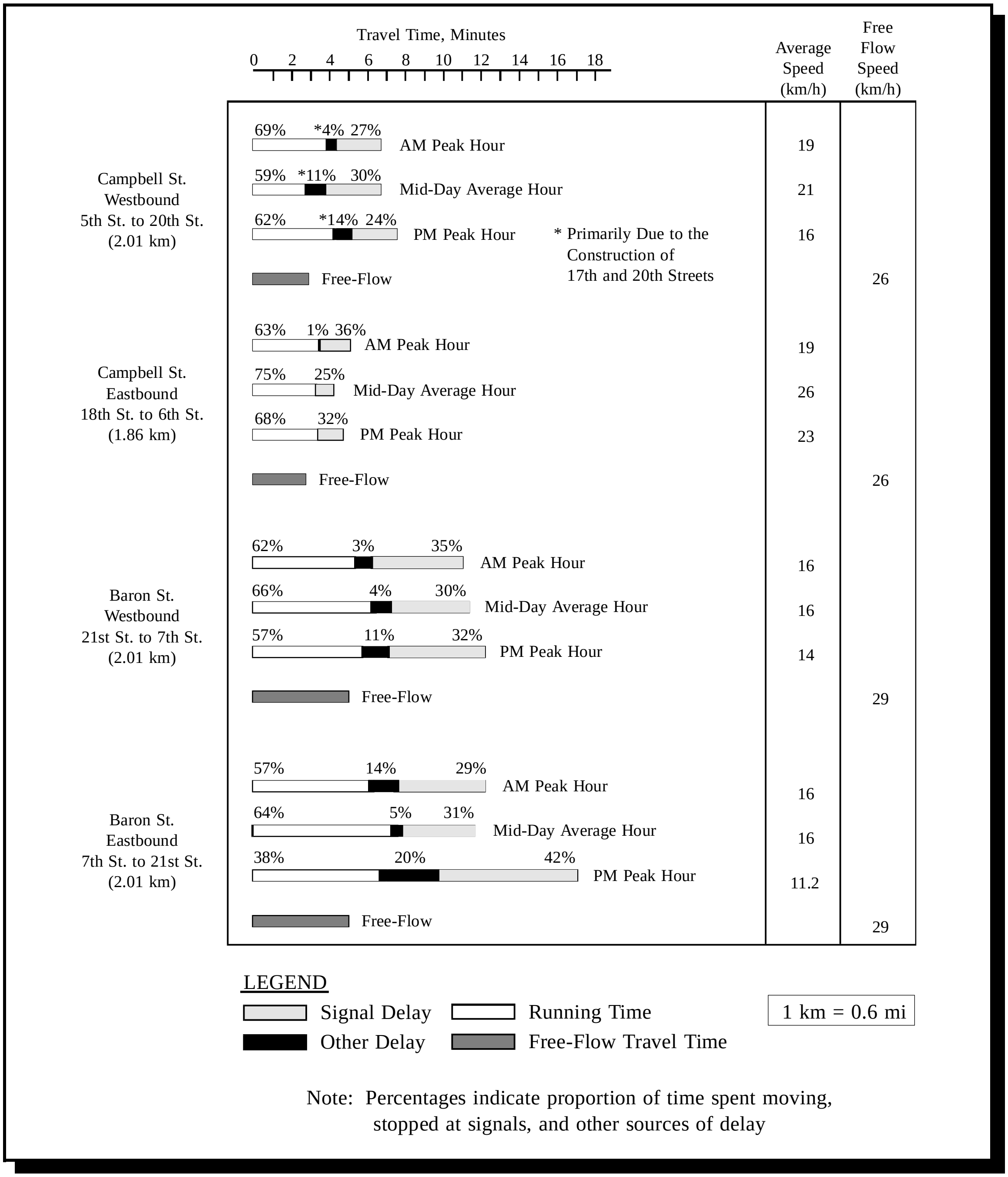
Source: adapted from reference (19)

Figure 7-13. Example Summary Illustrating Daily and Monthly Travel Time Variability



Source: adapted from reference (19)

Figure 7-14. Example Summary Illustrating Differences in Travel Time Variability



Source: adapted from reference (4)

Figure 7-15. Example of Corridor Summary with Detailed Information

Table 7-6 summarizes the average speeds for all freeways in Houston and Harris County, Texas. Note that the freeways are differentiated by their system location (e.g., radial versus circumferential) and by their proximity to downtown and major circumferential facilities. Also note that averages and totals are provided for sub-categories and all freeways.

Table 7-7 summarizes the morning peak period average speeds for freeways and arterial streets in Dallas, Texas. These average speeds served as the “before” conditions in an assessment of the effects of the light rail transit (LRT) starter system in Dallas. Note the inclusion of a control freeway and arterial street that will eventually be used to compare overall changes in average speeds.

Figure 7-16 illustrates a color-coded map of average travel speeds in the Chicago, Illinois area. Note that the map shows both directions of travel for the arterial streets, and that the color codes chosen correspond to drivers’ perception of speed (yellow equals slow speeds, red equals slowest speeds).

Table 7-6. Example of Tabular Freeway Speed Summary in Houston, Texas

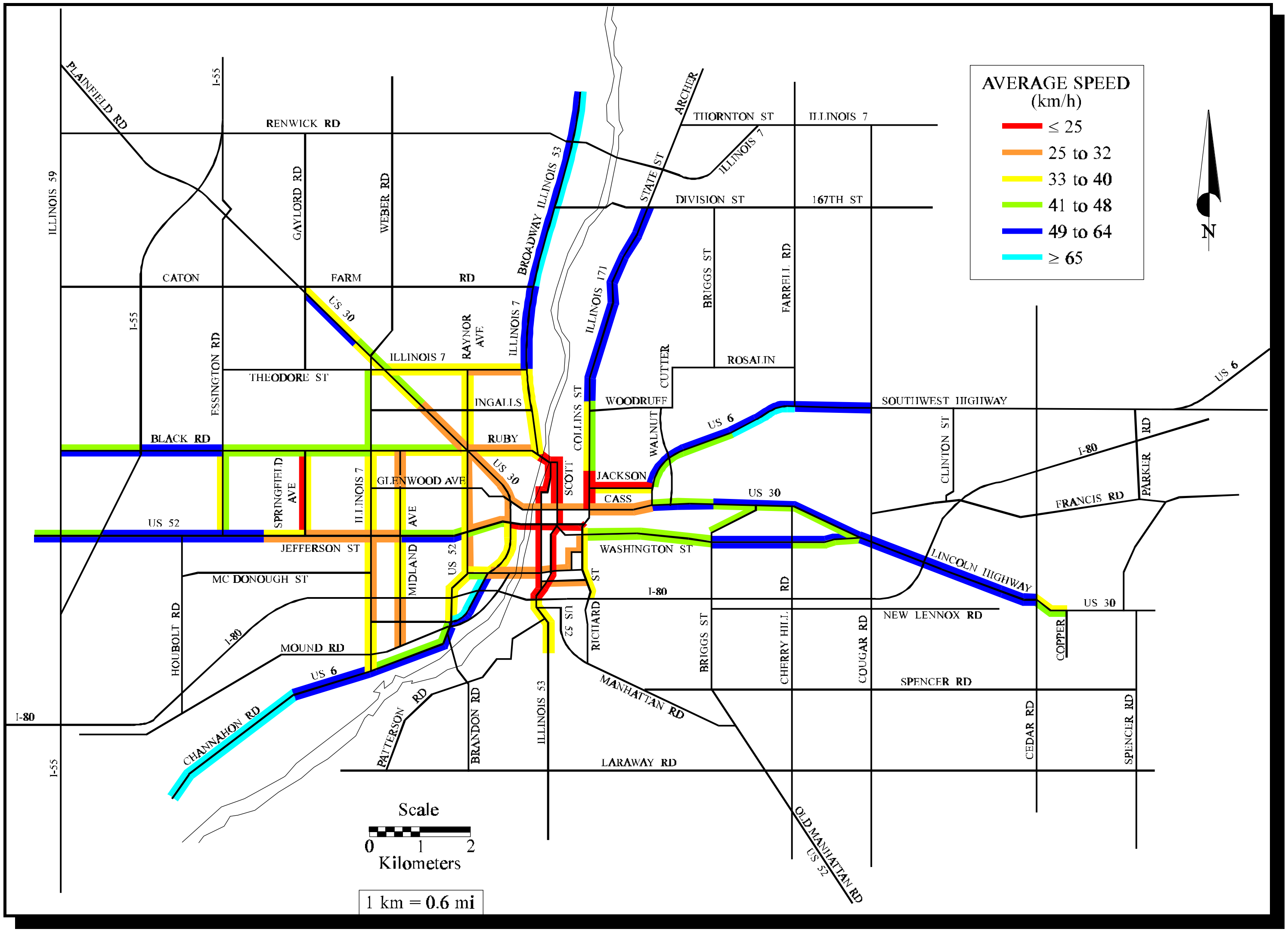
Freeways	1991 Average Speed, km/h (by proximity to downtown Houston)			
	IH-610 & Inside	**IH-610 to Beltway 8**	**Outside Beltway 8**	**Total Corridor**
Radial Freeways				
IH-10, Baytown East Freeway	89	93	98	95
IH-10, Katy Freeway	85	47	89	72
IH-45, Gulf Freeway	58	43	93	60
IH-45, North Freeway	77	76	72	74
US 59, Eastex Freeway	76	64	71	69
US 59, Southwest Freeway	50	45	97	48
US 290, Northwest Freeway	-	72	95	82
SH 225, LaPorte Freeway	-	93	92	93
SH 288, South Freeway	87	93	93	90
US 90, Crosby Freeway	-	-	92	92
Hardy Tollroad	-	89	92	90
Average-All Radial	**69**	**89**	**87**	**74**
Circumferential Freeways				
IH-610, East Loop	95		-	95
IH-610, North Loop	87		-	87
IH-610, South Loop	85		-	85
IH-610, West Loop	50		-	50
Beltway 8, E Sam Houston Pkwy	-	69	-	69
Beltway 8, N Sam Houston Pkwy	-	50	-	50
Sam Houston Tollway	-	84	-	84
Average- All Circumferential	**76**	**72**	**-**	**74**
Total Freeway System Average	**72**	**68**	**87**	**74**

Source: adapted from reference (20)

Table 7-7. Example of Facility Summary--Morning Peak Period Travel Times and Speeds in Dallas, Texas

Facility	From	To	Average Travel Time (min:sec)	Average Travel Speed (km/h)
Freeways				
IH-35E Northbound	IH-20	Lamar@Ross	19:28	53
IH-35E Southbound	Lamar@Ross	IH-20	12:17	84
IH-45 Northbound	IH-20	Lamar@Ross	15:26	64
IH-45 Southbound	Lamar@Ross	IH-20	14:49	68
Control Freeway				
IH-30 Eastbound	Loop 12	Lamar@Ross	9:38	72
IH-30 Westbound	Lamar@Ross	Loop 12	8:21	79
Arterial Streets				
Corinth Street Northbound	Illinois Avenue	Ervay@Elm	12:05	39
Corinth Street Southbound	St. Paul@Elm	Illinois Avenue	11:29	40
Illinois Avenue Eastbound	Cockrell Hill Road	IH-45	16:35	47
Illinois Avenue Westbound	IH-45	Cockrell Hill Road	16:20	47
Jefferson Blvd. Eastbound	Cockrell Hill Road	Zang Boulevard	9:15	43
Jefferson Blvd. Westbound	Zang Boulevard	Cockrell Hill Road	10:13	39
Kiest Avenue Eastbound	Cockrell Hill Road	Illinois Avenue	15:49	40
Kiest Avenue Westbound	Illinois Avenue	Cockrell Hill Road	13:45	45
Zang Boulevard Northbound	Saner Avenue	Lamar@Ross	11:54	43
Zang Boulevard Southbound	Lamar@Ross	Saner Avenue	14:27	35
Control Arterial Street				
Singleton Blvd. Eastbound	Loop 12	Lamar@Ross	14:29	45
Singleton Blvd. Westbound	Lamar@Ross	Loop 12	14:38	43

Source: adapted from reference (13)



Source: adapted from reference (21)

Figure 7-16. Example of Color Map Showing Average Speeds

7.5.4 Functional Class Summaries

A functional class summary contains data for all roadways within defined functional classifications (see Chapter 2) and typically includes average travel times, speeds, and delays. The functional class summary is similar to the corridor or route summary, only several facilities within a functional class are averaged together.

Figure 7-17 contains a comparison of average speeds on arterial streets in several urban areas in Arizona for 1979 and 1986. The figure provides an overall perspective on arterial street system speeds in several different locations and for two separate years. Note that the chart emphasizes general trends in average speeds and not necessarily the numerical values (which can only be estimated from the chart).

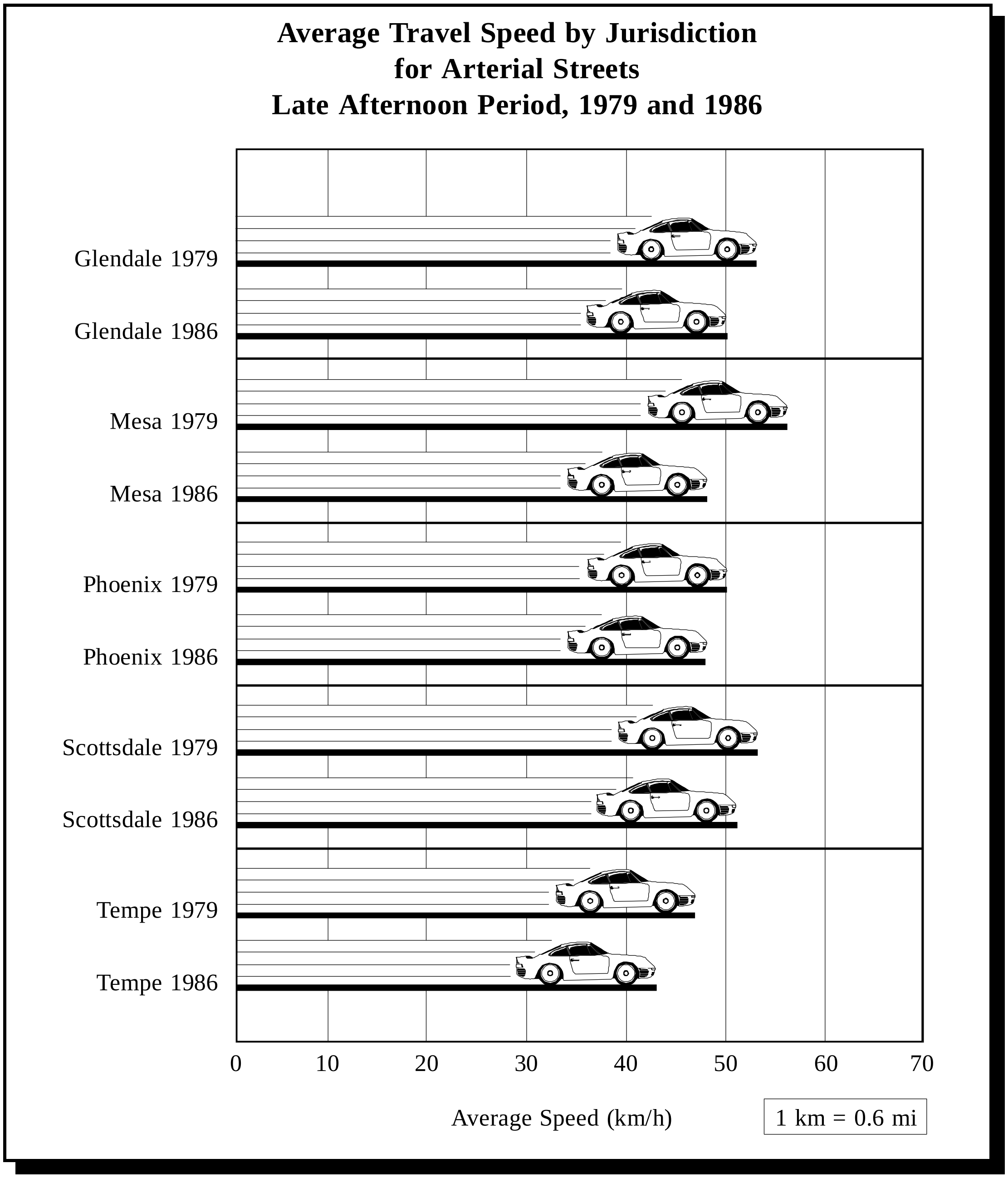
Figure 7-18 presents an historical perspective (1969 to 1994) for average speeds on freeways in Harris County, Texas with a simple bar graph. The figure clearly illustrates that average speeds dropped in the early 1980s, only to increase in the 1990s to original levels. A line graph could also be used to illustrate time series speed or travel time trend.

Table 7-8 contains average speeds for freeways and arterial streets in Albuquerque, New Mexico. The table contains the average speeds for the a.m. peak, p.m. peak, and both peak periods combined. The total facility mileage is also included in the table to indicate the extent of each functional class.

Table 7-9 presents average speeds for several different functional classes in Harris County, Texas. For each functional class, the table compares average speeds for different time periods and three study years (e.g., 1988, 1991, 1994). Note that the table also includes the percentage change in average speeds over the years illustrated. The inclusion of percent change in speed makes the time series comparison easier to interpret.

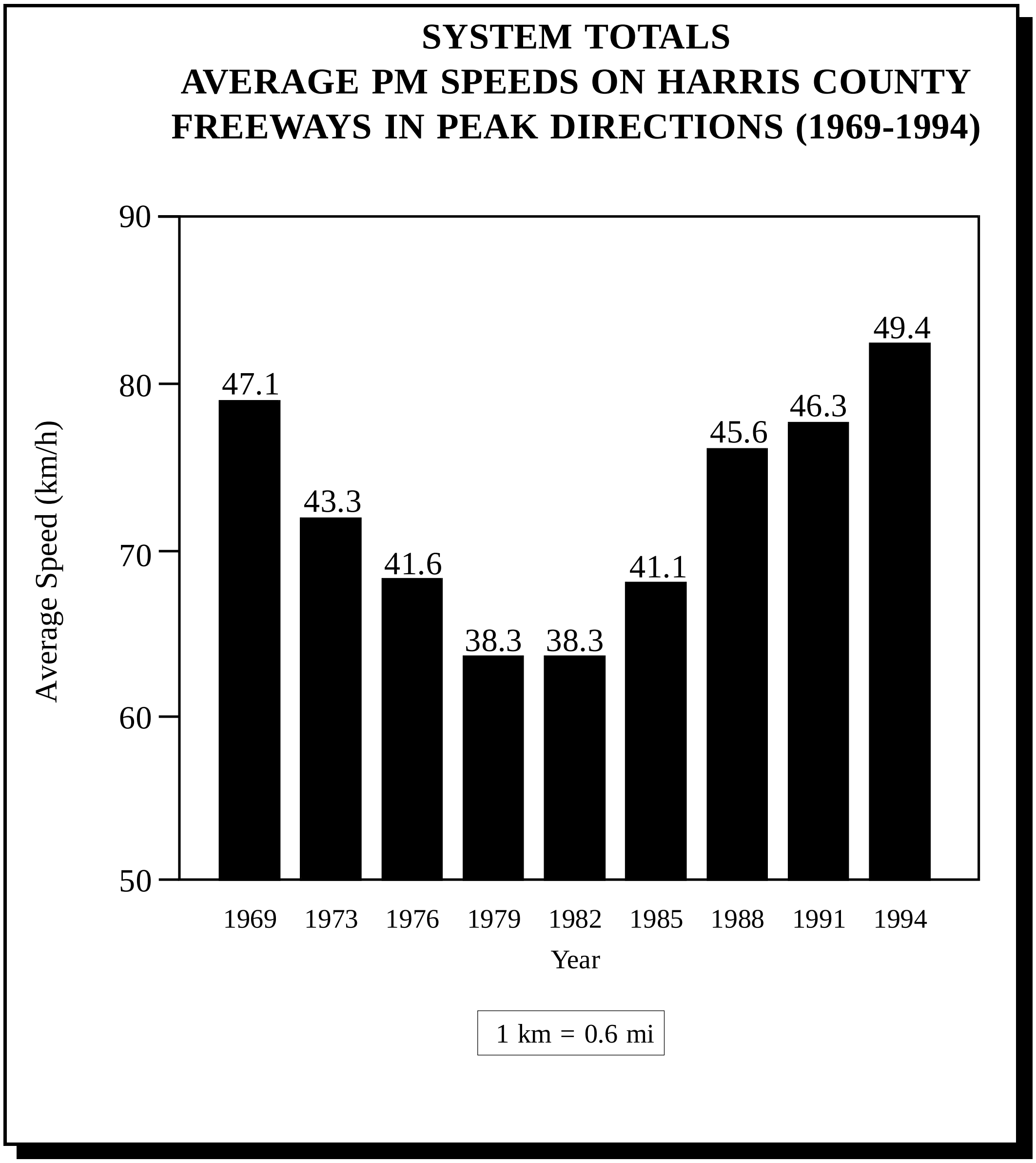
Figure 7-19 shows several regional freeway speed trends using different types of graphical presentations. Using bar graphs, the figure shows several dimension of congestion, including the miles of congested freeway, the location of congestion, the congestion trend between 1969 and 1979, and the congestion location trend between 1973 and 1979.

Figure 7-20 provides a summary of speed characteristics for all Class I arterial streets (as defined by the 1994 Highway Capacity Manual) for data collected on streets in Houston, Texas. The speed distributions presented in this figure are most appropriate for mobile source emissions modeling, in which it is necessary to project the vehicle miles traveled (VMT) for various speed ranges. An instrumented test vehicle is best suited for this application because the instrumentation is capable of recording second-by-second changes in vehicle speed and acceleration.



Source: adapted from reference (22)

Figure 7-17. Example of Functional Class Summary in Arizona Cities



Source: adapted from reference (23)

Figure 7-18. Example of Functional Class Summary in Harris County, Texas

Table 7-8. Example of Functional Class Summary for 1986 Albuquerque Travel Time Study

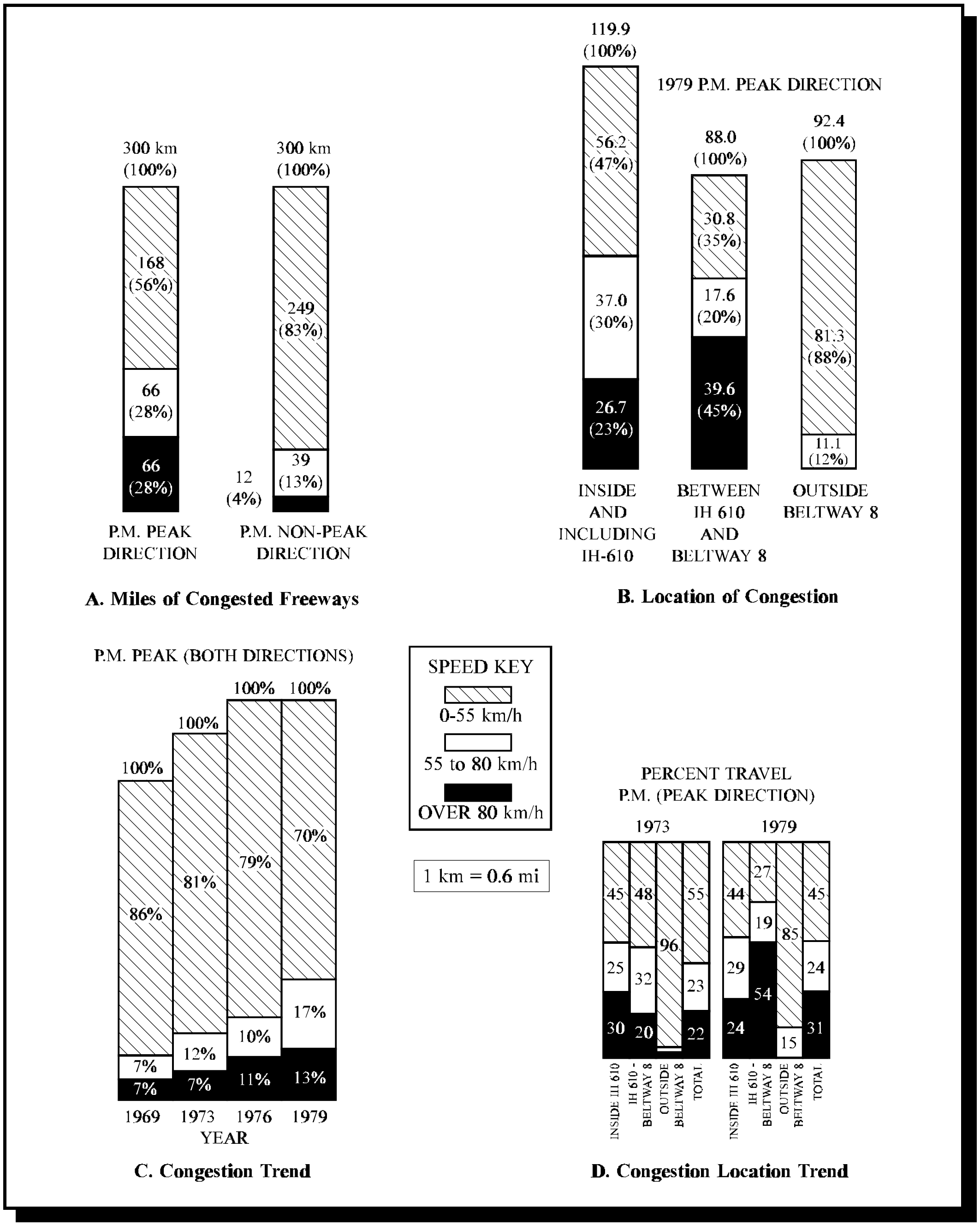
Functional Class	Average Speed, km/h		
	AM Peak	PM Peak	AM and PM Peak
All Streets Combined			
Total Length	309.4 km	305.5 km	614.9 km
Mean Speed	43.6 km/h	41.9 km/h	42.7 km/h
Median Speed	41.7 km/h	40.7 km/h	41.4 km/h
Freeways			
Total Length	58.0 km	55.9 km	113.9 km
Mean Speed	80.3 km/h	76.60 km/h	78.4 km/h
Median Speed	82.8 km/h	82.8 km/h	82.8 km/h
Arterials, Collectors, and Ramps			
Total Length	251.4 km	249.5 km	500.9 km
Mean Speed	40.6 km/h	38.7 km/h	39.7 km/h
Median Speed	40.8 km/h	39.7 km/h	40.6 km/h

Source: adapted from reference (24)

Table 7-9. Illustration of Functional Classification Summary for Harris County, Texas

Functional Class	**Roadway Extent (km)**			**Average Speeds, km/h** (for both directions of travel)															
				AM Peak				**Off Peak**				**PM Peak**				**Total**			
	1988	1991	1994	1988	1991	1994	▲, 91-94	1988	1991	1994	▲, 91-94	1988	1991	1994	▲, 91-94	1988	1991	1994	▲, 91-94
HOV Lanes	-	82	101	-	87.1	80.7	-7 %	-	94.5	86.1	- 9 %	-	83.9	82.3	-2 %	-	88.2	82.9	-6 %
Interstates	230	230	232	79.9	81.0	82.4	2 %	93.9	94.8	96.0	1 %	82.9	81.1	79.2	-2 %	85.2	85.2	85.3	0 %
Freeways	274	311	356	73.3	76.6	79.4	4 %	80.3	81.5	81.8	0 %	72.9	74.9	77.9	4 %	75.3	77.6	78.7	1 %
Principals	630	678	927	51.2	52.8	50.6	-4 %	53.3	53.9	53.6	-1 %	51.0	49.7	48.5	-3 %	51.8	52.0	50.9	-2 %
Arterials	765	407	164	44.9	46.9	44.0	-6 %	47.0	49.1	46.9	-5 %	44.3	43.8	44.9	3 %	45.4	46.5	45.2	-3 %
Totals Systemwide	1,898	1,708	1,782	49.6	54.4	55.1	1 %	52.2	56.8	58.3	3 %	49.1	51.5	53.6	4 %	50.2	54.3	55.4	-3 %

Note: "▲, 91-94" represents the percent change in average speeds between 1991 and 1994.
Source: adapted from reference (25)

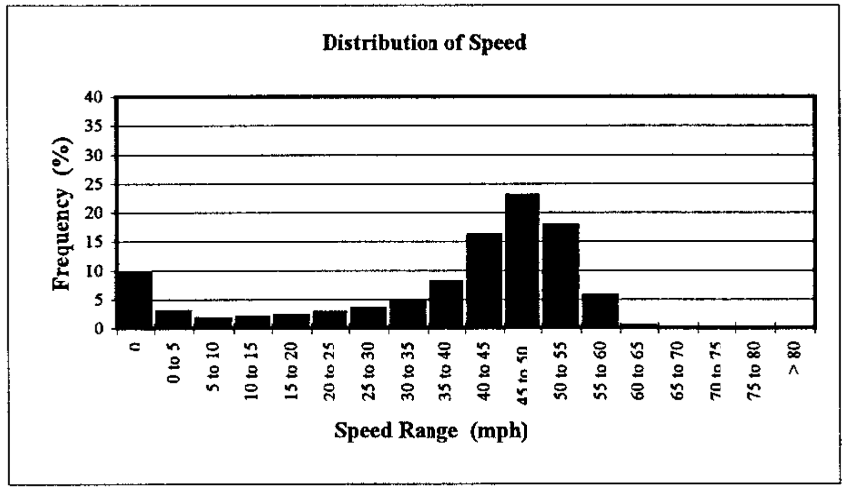


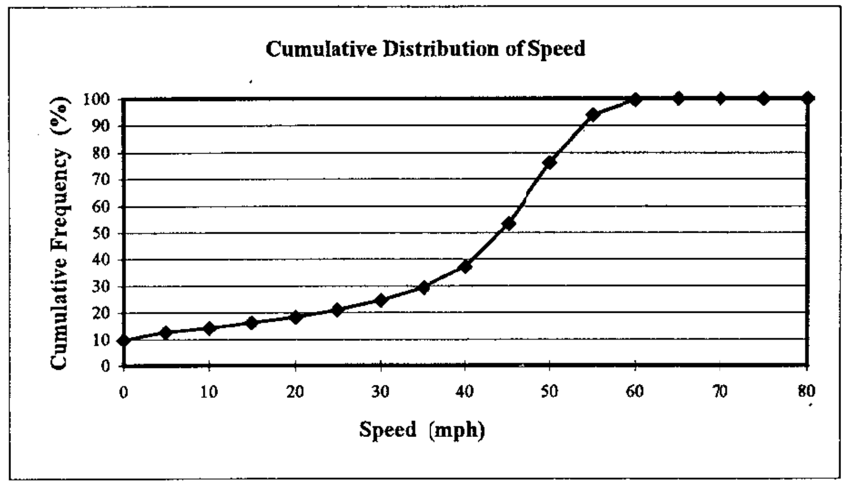
Source: adapted from reference (16)

Figure 7-19. Example Summary of Congestion and Average Speed Trends

CLASS I ARTERIAL STREETS
Morning and Evening Peak Period
(6 to 9 am, 4 to 7 pm)

Speed Frequency Distribution		
Speed Range (mph)	**Range Frequency (%)**	**Cumulative Frequency (%)**
0	9.7	9.7
0 to 5	2.9	12.6
5 to 10	1.6	14.2
10 to 15	1.9	16.1
15 to 20	2.2	18.3
20 to 25	2.7	21.0
25 to 30	3.5	24.4
30 to 35	4.8	29.3
35 to 40	8.0	37.2
40 to 45	16.1	53.3
45 to 50	22.9	76.2
50 to 55	17.7	93.9
55 to 60	5.6	99.6
60 to 65	0.4	100.0
65 to 70	0.0	100.0
70 to 75	0.0	100.0
75 to 80	0.0	100.0
> 80	0.0	100.0





Source: adapted from reference (26)

Figure 7-20. Example Summary of Regional Speed Distribution for Class I Arterial Streets

7.5.5 Other Summaries

There are several other travel time data summaries that do not fit neatly into any of the above categories. Included in this group are activity center summaries, travel time contour maps, and accessibility maps. Activity center summaries present trends or comparisons of travel time or average speed between major activity centers in an urban area. Travel time contour maps use isochronal lines (i.e., lines of equal time) to illustrate the distances that one can travel away from a selected point (e.g., central business district (CBD) or major activity center) in given time intervals. The isochronal lines are typically centered around a downtown or CBD area and are in ten-minute increments. Accessibility maps show the accessibility (in terms of time increments) of land uses, jobs, or services to transportation facilities.

In the past, the development of travel time contour and accessibility maps were considered time-consuming and labor-intensive. The advent of geographic information systems (GIS) substantially reduces the work and time required to prepare these types of graphical displays. Even if travel time data are not collected with global positioning system (GPS) units, agencies may wish to consider importing travel time data into a GIS platform for the ease of future analyses.

Table 7-10 shows an example of an activity center travel time matrix for Harris County, Texas (this table has been shortened from the original travel time matrix). The table shows travel times between major activity centers for three different time periods during the day: off peak, a.m. peak, and p.m. peak. The travel times shown are for the most direct route and may include portions of several different arterial streets and/or freeways.

Figure 7-21 illustrates average speeds between major activity centers and two airports in the Philadelphia area. The average speeds are compared for two years, 1971 and 1983. As with the activity center matrix in Table 7-10, the average speeds shown in Figure 7-21 presumably contain portions of trips on arterial streets and/or freeways.

Figure 7-22 shows an example of a travel time contour map that compares average travel times between 1980 and 1991. The decreases in mobility can be seen from the shaded areas. Travel time contour maps can be used to show many regional trends relating to mobility:

- Trends over time (e.g., historical comparisons every five years);
- Differences between peak and off-peak traffic conditions;
- Reliability of travel times;
- Comparison of transportation alternatives; and,
- Trends before and after regional transportation improvements.

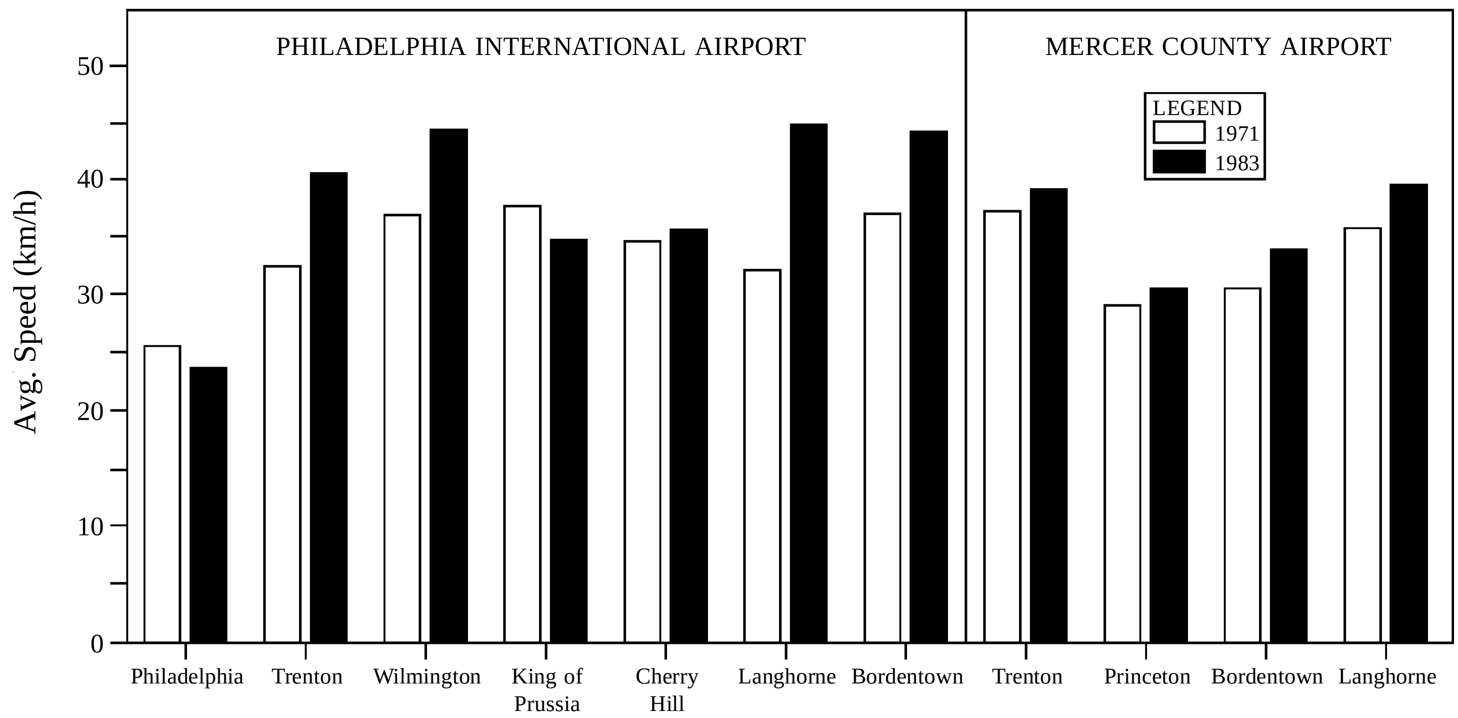
Figure 7-23 shows an example of an accessibility map for a proposed transportation improvement (i.e., Inter-County Connector) in Montgomery County, Maryland. In this example, the figures show the accessibility to jobs within a 45-minute commute, and the additional accessibility to jobs created by the transportation improvement.

Table 7-10. Example of Activity Center Travel Time Matrix

From	Time Period	Travel Time (minutes) to						
		CBD	MED CTR	ASTR	HOBBY	INTRC	CLR LK	SGLD
CBD Main @ McKinney (CBD)	Off Peak AM Peak PM Peak	- - -	11 9 10	11 13 14	17 16 24	25 25 28	26 27 38	27 27 39
Medical Center Main @ University (MED CTR)	Off Peak AM Peak PM Peak	11 8 10	- - -	6 6 8	19 19 28	31 33 39	29 29 41	24 24 34
Astrodome Kirby @ IH 610 (ASTR)	Off Peak AM Peak PM Peak	11 13 12	6 6 7	- - -	13 13 19	30 31 36	22 22 33	20 22 27
Hobby Airport Airport Entrance (HOBBY)	Off Peak AM Peak PM Peak	17 19 19	19 21 25	13 14 17	- - -	33 36 40	14 14 16	32 36 45
Intercontinental Airport Terminal B (INTRC)	Off Peak AM Peak PM Peak	25 27 25	34 37 35	30 36 31	34 35 41	- - -	43 45 52	44 47 48
Clear Lake City Bay Area Blvd@IH 45S (CLR LK)	Off Peak AM Peak PM Peak	26 33 25	28 36 31	22 29 24	15 18 15	43 51 46	- - -	41 50 51
Sugar Land SH 6 @ US 59S (SGLD)	Off Peak AM Peak PM Peak	27 37 26	26 34 24	22 28 21	34 41 40	45 48 48	43 50 53	- - -

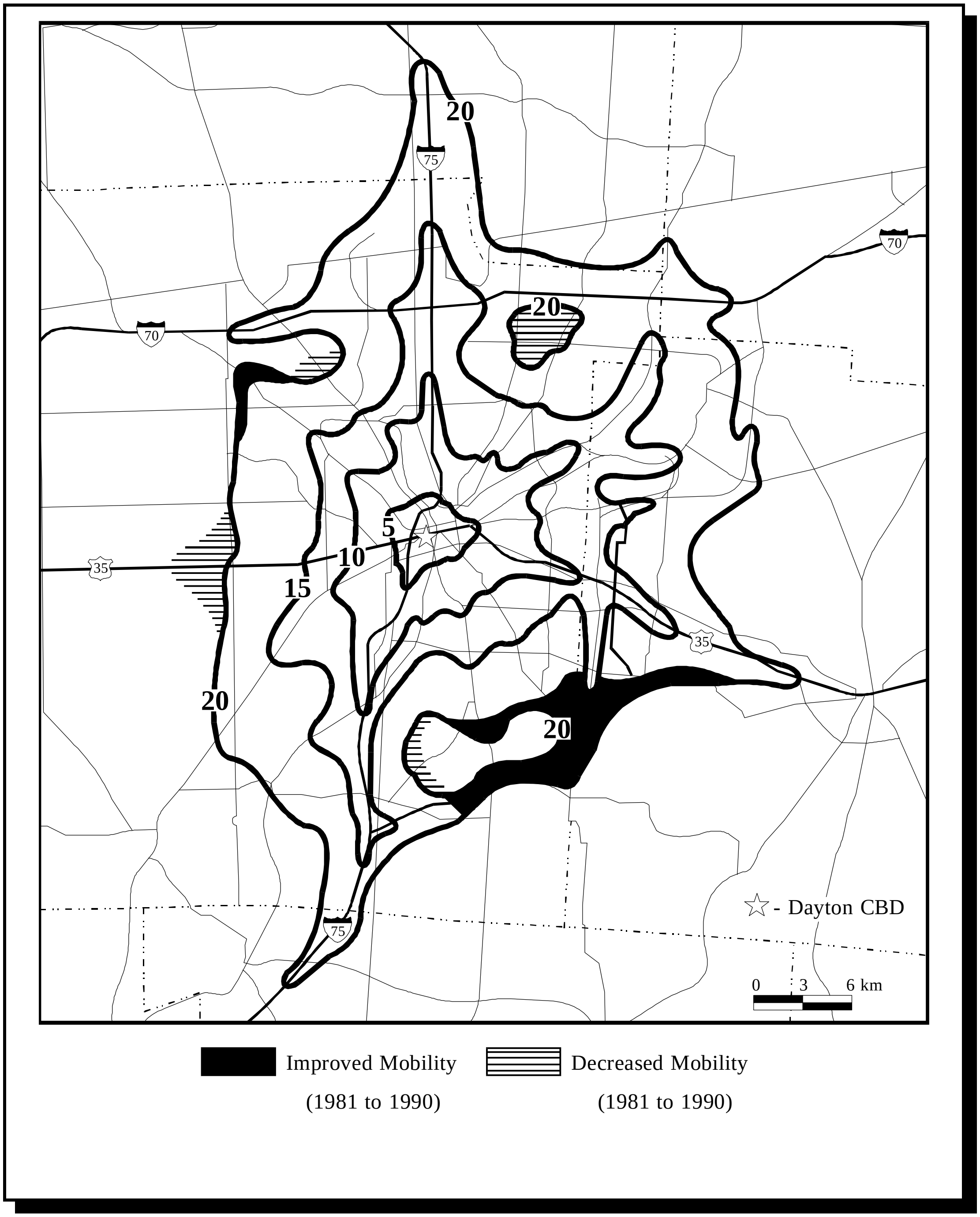
Source: Houston-Galveston Regional Transportation Study, 1991.

Peak Period Travel Speeds Between Major Regional Activity Centers and Philadelphia International and Mercer County Airports



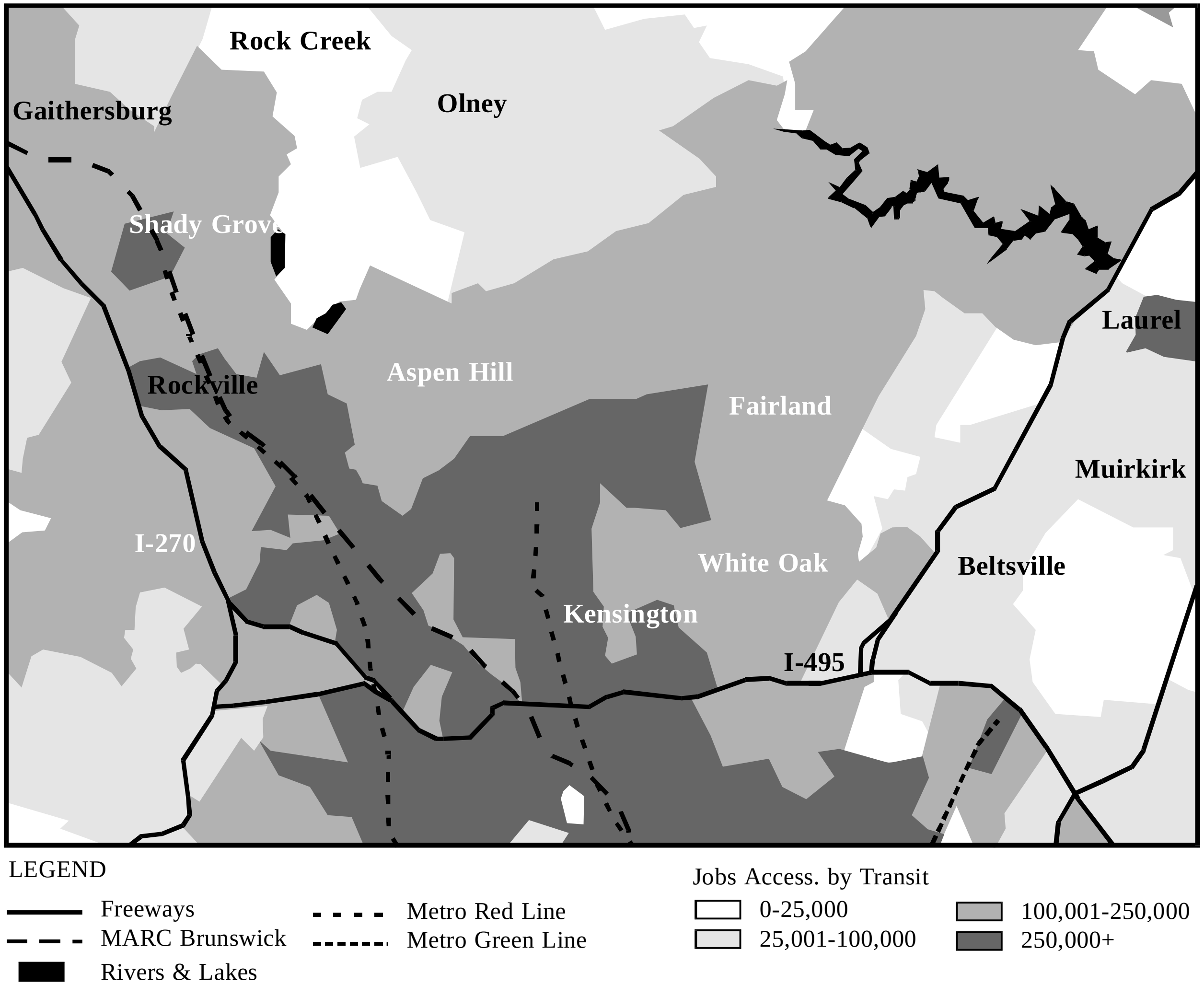
Source: adapted from reference (27)

Figure 7-21. Example of Activity Center Average Speed Comparison in Philadelphia, Pennsylvania



Source: adapted from reference (28).

Figure 7-22. Example of a Travel Time Contour Map



Source: Metropolitan Washington Council of Governments, 1996.

Figure 7-23. Example of an Accessibility Map for Montgomery County, Maryland

Other good examples of travel time or speed summaries can be found on the World Wide Web. Tens of thousands of daily commuters rely on these web page summaries for real-time information on travel times and speeds. Because of the dynamic nature of these pages, several examples are referenced below for the reader to explore. The following are examples of web pages that provide real-time travel time or speed information:

- Atlanta, Georgia: http://www.georgia-traveler.com/traffic/rtmap.htm
- Gary-Chicago-Milwaukee: http://www.ai.eecs.uic.edu/GCM/GCM.html
- Houston, Texas: http://traffic.tamu.edu/traffic.html
- Houston, Texas: http://www.accutraffic.com/accuinfo/cities/houston.tx/
- Long Island, New York: http://metrocommute.com:81/LI/#heading
- Los Angeles, California: http://www.scubed.com/caltrans/la/la_big_map.shtml
- Minneapolis-St. Paul, Minnesota: http://www.traffic.connects.com/
- Orange County, Ca: http://www.maxwell.com/yahootraffic/OC/OC_W/map.html
- Phoenix, Arizona: http://www.azfms.com/Travel/freeway.html
- San Diego, California: http://www.scubed.com/caltrans/sd/big_map.shtml

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