2006 Austin Travel Time and Delay Survey
Technical Summary

Texas Department of Transportation

Prepared by the
Texas A&M Transportation Institute
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2006 Austin Travel Time and Delay Survey

TECHNICAL SUMMARY

Texas Department of Transportation Travel Survey Program

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EXECUTIVE SUMMARY

Traffic speed information collected in Travel Time and Delay surveys provide an overview of the operating characteristics of different functionally classified roadways as they pass through diverse regional area types. In the 2006 Austin Travel Time and Delay Survey, data were collected in a fashion that also allowed for analysis of the data by peak and off-peak period, morning and afternoon travel, and 'unimpeded' and 'delay' methods of evaluation.

Various factors can affect the measures of travel time and delay presented in this report. First, posted speed limits on roadways that have the same functional classification and area type often vary. When interpreting the study results, consideration must be given to factors such as the variability in posted speed limits within individual area type-functional class groupings, the size of the study area, and practical limitations with respect to the sample collected.

Another issue to consider is the impact that traffic control devices, traffic calming measures and non-vehicular impediments to travel can have on recorded speeds. Traffic signals, stop signs, yield signs, school-zone warnings, and speed humps on local streets were among the many traffic control devices encountered during the data collection effort. Together with other impediments to vehicular movement such as trains, parked vehicles, pedestrians, and cyclists, these devices have the potential to influence travel times and the perceived level of congestion for a given functional class and area type.

Analysis of the travel time data by peak and off-peak period (Figures 4 to 13) revealed a relatively large discrepancy in speeds on most Austin-area freeways. With the exception of rural freeways (which exhibited free-flow characteristics and minor speed differentials), off-peak freeway speeds were generally 20 to 30 miles per hour (mph) higher than peak-period speeds. Other functional classes exhibited off-peak speeds that were slightly higher (0-5 mph) than peak-period speeds. This result indicates that Austin-area freeways are more susceptible to the effects of peak-period congestion than other types of roadways in the area.

The study team utilized different methods of analysis to determine the extent to which delays at transition areas between functional classes and area types contributed to overall travel time and delay. The "unimpeded" approach excluded travel time at these transition zones, while the "delay" approach measured travel time throughout the entire route, including segment transitions.

A direct comparison of the results of the two data analysis methods (Figures 14 to 23) showed that average speeds obtained using the unimpeded approach were higher than those recorded using the delay methodology for almost all functional class-area type combinations. This result was expected since the delay typically associated with travel through traffic control devices at segment transition areas was removed in the unimpeded approach. The average magnitude of unimpeded versus delay speed differentials on Austin-area roadways (Figure 24) generally ranged from 0 to 5 mph.

Overall, freeways exhibited the least amount of delay due to slowdowns at segment transitions, while arterials, collectors and locals were more significantly impacted. The area type-functional class most adversely affected was CBD-locals during peak periods. Speeds on these segments were 5.7 mph (47 percent) higher when the unimpeded method of analysis was employed. Another roadway type whose operations were substantially impacted by delays at segment transitions were collectors in the CBD Fringe during off-peak periods. On those roadways, unimpeded speeds were over 8.1 mph (43 percent) higher than the respective speeds calculated using the delay methodology.

Delay and unimpeded travel speeds for individual functional classes (Tables 9 and 10) generally increased as activity density went from high (CBD area type) to low (Rural area type). As expected, when compared across functional classes (Figure 25), average peak speeds dropped off sharply between freeways and major arterials, and then gradually declined from major arterials to local streets. An intermediate rise in speeds was observed on Austin-area collectors.

Finally, a comparison of average AM and PM delay speeds was performed for each functional classification-area type combination. This comparison, shown in Figure 26, indicates that morning travel speeds on most Austin-area freeways and arterials (particularly through the CBD and CBD fringe area types) are moderately to significantly higher than afternoon speeds. The most noticeable trend with respect to area type concerned rural PM travel speeds. Unlike speeds recorded in other area types, rural PM speeds were typically comparable to or slightly higher than corresponding AM speeds. These results highlight functional class (predominantly freeway) and activity-density (non-rural) components of traffic congestion in the Austin area.

TABLE OF CONTENTS

List of Figures ix
List of Tables x
Introduction and Study Area Description 1
Route Development and Data Collection 2
Route Development and Scheduling 3
Route Description 6
Data Collection Equipment and Setup 11
Data Processing and Analysis 13
Results 16
Comparison of Peak and Off-Peak Travel Time Data 16
Comparison of Delay and Unimpeded Travel Time Data 25

LIST OF FIGURES

Figure 1. Austin Study Area. 1
Figure 2. Study Routes..... 6
Figure 3. Data Processing in ArcGIS..... 13
Figure 4. CBD - Average Peak vs. Off-Peak Speeds (Unimpeded Method)..... 18
Figure 5. CBD Fringe - Average Peak vs. Off-Peak Speeds (Unimpeded Method). 18
Figure 6. Urban Residential - Average Peak vs. Off-Peak Speeds (Unimpeded Method)..... 19
Figure 7. Suburban Residential - Average Peak vs. Off-Peak Speeds (Unimpeded Method)..... 19
Figure 8. Rural - Average Peak vs. Off-Peak Speeds (Unimpeded Method). 20
Figure 9. CBD - Average Peak vs. Off-Peak Speeds (Delay Method)..... 22
Figure 10. CBD Fringe - Average Peak vs. Off-Peak Speeds (Delay Method)..... 23
Figure 11. Urban Residential - Average Peak vs. Off-Peak Speeds (Delay Method). 23
Figure 12. Suburban Residential - Average Peak vs. Off-Peak Speeds (Delay Method)..... 24
Figure 13. Rural - Average Peak vs. Off-Peak Speeds (Delay Method). 24
Figure 14. CBD - Average 'Delay' vs. 'Unimpeded' Speeds (Peak)..... 25
Figure 15. CBD Fringe - Average 'Delay' vs. 'Unimpeded' Speeds (Peak)..... 26
Figure 16. Urban Residential - Average 'Delay' vs. 'Unimpeded' Speeds (Peak). 26
Figure 17. Suburban Residential - Average 'Delay' vs. 'Unimpeded' Speeds (Peak)..... 27
Figure 18. Rural - Average 'Delay' vs. 'Unimpeded' Speeds (Peak). 27
Figure 19. CBD - Average 'Delay' vs. 'Unimpeded' Speeds (Off-Peak). 28
Figure 20. CBD Fringe - Average 'Delay' vs. 'Unimpeded' Speeds (Off-Peak)..... 28
Figure 21. Urban Residential - Average 'Delay' vs. 'Unimpeded' Speeds (Off-Peak). 29
Figure 22. Suburban Residential - Average 'Delay' vs. 'Unimpeded' Speeds (Off-Peak)..... 29
Figure 23. Rural - Average 'Delay' vs. 'Unimpeded' Speeds (Off-Peak)..... 30
Figure 24. Speed Differentials (Average Unimpeded – Average Delay Speeds)..... 32
Figure 25. Average Peak Speeds for All Area Types (Delay Method). 33
Figure 26. AM and PM Average Speeds (Delay Method)..... 34

LIST OF TABLES

Table 1. Number of Route Segments by Area Type – Functional Class Category. 3
Table 2. Sample Daily Travel Time Data Collection Schedule for the Austin, TX Area. 5
Table 3. Austin Area Route Descriptions by Roadway Name..... 7
Table 4. Summary of Average Speeds for All Routes – Unimpeded Method..... 16
Table 5. Posted Speed Limits..... 17
Table 6. Average Length of Segments – Unimpeded Method..... 17
Table 7. Average Speed Summary for All Routes – Delay Method..... 21
Table 8. Average Length of Segments – Delay Method..... 22
Table 9. Overall Average Speeds – Delay Method..... 31
Table 10. Overall Average Speeds – Unimpeded Method. 31
Table 11. Overall Speed Differentials Between Unimpeded and Delay Methods. 32

INTRODUCTION AND STUDY AREA DESCRIPTION

The purpose of this technical summary is to describe the results of the travel time and delay survey conducted in the Austin, Texas area between December 1, 2006 and December 20, 2006. This technical summary report is organized into four sections. The first provides an introduction and overview of the study area. The second explains the route development and data collection procedures. The third section describes the data processing and analysis methods, and the fourth presents study results.

The Austin study area is located in Williamson, Travis and Hays counties in central Texas. According to U.S. Census Bureau figures, this three-county area covers approximately 2,788 square miles and had an estimated population of 1,346,074 in 2005. Between 2000 and 2005, the population of Williamson, Travis and Hays counties grew by 33.4 percent, 9.3 percent and 27.5 percent respectively[1]. Figure 1 shows the three-county study area and road network.

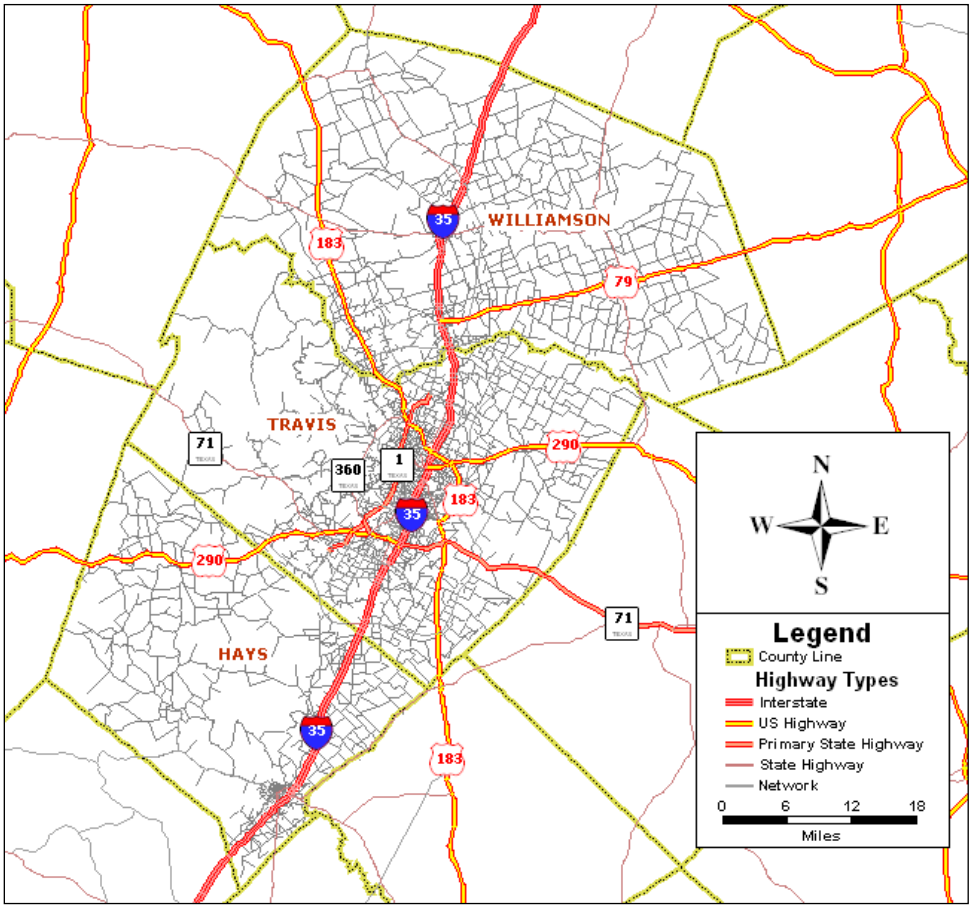

Figure 1. Austin Study Area.

[1] http://quickfacts.census.gov/qfd/states/48000.html

ROUTE DEVELOPMENT AND DATA COLLECTION

To the general public, travel time, or the amount of time required to traverse a route between two points, is a basic concept that influences their daily lives. To transportation engineers and planners, precise travel time measurements can provide valuable insights into the operating characteristics of a roadway network within an urbanized area. Results obtained from travel time and delay studies permit historical trend analyses, assist in the validation of travel demand models, and enable air quality modeling and emissions estimates. Results can also be used in the planning and prioritization of transportation maintenance and improvement projects.

The collection of travel time data entails the measurement of average speeds during peak and off-peak periods for a variety of roadways in the study area. Each segment of roadway examined is stratified by its functional classification and the area type that it traverses. The functional classification of a roadway is based on the importance of movement and access functions assigned to that facility. The different functional classes analyzed in the Austin study area were:

1 – Freeway (limited access to property with traffic movement and mobility as primary function);

2 – Major Arterial (highly continuous roads with inter-community and intra-metropolitan traffic movement as primary function);

3 – Minor Arterial (roads that carry a mix of local and through traffic but give priority to traffic movement over access to property);

4 – Collector (primary function is to distribute traffic between arterial and local streets); and

5 – Local (primary function is to provide access to property).

Urban areas are divided into small geographic sections called traffic analysis zones (TAZ). Each TAZ is normally bounded by transportation facilities and/or geographic features such as bodies of water or parks. The activity that occurs within that zone is typically homogenous. Zones are categorized by the activity density associated with them. This is measured in terms of the zone's population and employment relative to its size in acres. The following formula is used to determine activity density:

$$\text{Activity Density} = (\text{Population} + (X \times \text{Employment})) / \text{Area}$$

In this formula, "X" denotes the population/employment ratio for the entire study area. This density categorization is referred to as area type, and there are typically five-to-six area types within a given urban area. The activity density range per area type, and number of area types, varies from one urban area to another. The following five area types are found in the Austin region:

1 – Central Business District [CBD] (activity density >= 50.0/acre);

2 – Central Business District Fringe (activity density between 15.0 and 50.0/acre);

3 – Urban Residential (activity density between 10.0 and 15.0/acre);

4 – Suburban Residential (activity density between 1.0 and 10.0/acre);

5 – Rural (activity density <1.0/acre).

Route Development and Scheduling

Caliper® TransCAD software was used to identify area types and functional classifications in the study area and to develop the routes used to measure travel time and delay. The paths of most routes were randomly devised and covered a variety of functional classification and area type combinations. Three of the 17 routes examined were designed specifically to reflect travel patterns between study area activity centers.

Each route was comprised of several route segments of varying lengths. One route segment ended and another began when either of the following two conditions existed:

- Change in the functional classification of the roadway; or
- Change in the area type being traversed.

Traveling onto a new street did not constitute a segment change unless one or both of the above criteria were met. Table 1 shows a breakdown of the number of route segments examined in the Austin study area (by area type and functional class).

Table 1. Number of Route Segments by Area Type – Functional Class Category.

Functional Class / Area Type	1.Freeway	2. Major Arterial	3. Minor Arterial	3.Collector	4. Local	Total
1. Central Business District	12	24	12	NA	24	72
2. CBD Fringe	60	144	48	12	72	336
3. Urban Residential	48	132	96	12	84	372
4. Suburban Residential	60	240	132	24	120	576
5. Rural	12	72	84	48	36	252
Total	192	612	372	96	336	1,608

It should be noted that that the collector functional class is similar to the minor arterial functional class in the Austin area. Because no collector traversed Austin's Central Business District, no value is shown in that cell. The goal in developing routes for travel time and delay surveys is not to ensure the equal distribution or length of area type and functional class segments, but to reflect the coverage of various area types in the metropolitan region and the prominence of individual functional classes within them. One functional class, the expressway, was traversed on two of the study's 17 routes. Because this functional class was signalized and had different access and operational characteristics than the freeway functional class, expressway route segments were excluded from analyses. However, the detailed route descriptions provided below include these expressway segments.

Austin area travel time data were collected over a three-week period in December 2006. Route paths were plotted using DeLorme Street Atlas USA® 7.0 software. The length of the non-activity center routes was controlled so that two routes could be completed in one day. Activity center routes were typically longer than non activity center routes and often involved freeway segments. A full day was therefore allocated for the completion of each activity center route. This schedule provided sufficient time for a driver to complete each route 12 times at a speed consistent with that of surrounding traffic, without passing or being passed by the majority of other vehicles on the roadway (floating car method of data collection). A total of 17 routes were developed and data were collected between 7:00 a.m. and 6:30 p.m., Monday through Friday. Routes with freeway segments were not conducted on Fridays due to anomalies that can severely impact freeway travel times on that day of the week. No data were collected on any of the routes during school holidays or on days with adverse weather-related driving conditions such as rain.

The 12 runs conducted for each route were split equally by direction. Six were in the A-to-B direction and six were in the B-to-A direction. For each group of six runs, three were conducted during peak travel periods in the Austin area (7:00-9:30 a.m. and 4:00-6:30 p.m.) and three during the off-peak periods (9:30 a.m.-12:00 p.m. and 1:00-4:00 p.m.). Additionally, the number of runs was balanced so that equal amounts of peak and off-peak data were collected during the AM and PM periods. Table 2 shows a sample daily data collection schedule for non-activity center routes.

Table 2. Sample Daily Travel Time Data Collection Schedule for the Austin, TX Area.

Period	Route-Run	Direction	Scheduled Time Slot
Peak Morning (7:00 a.m.-9:30 a.m.)	1-1	5A to 5B	7:00 a.m. – 7:20 a.m.
	1-2	5B to 5A	7:20 a.m. – 7:40 a.m.
	1-3	5A to 5B	7:40 a.m. - 8:00 a.m.
	2-1	6A to 6B	8:00 a.m. - 8:20 a.m.
	2-2	6B to 6A	8:20 a.m. – 8:40 a.m.
	2-3	6A to 6B	8:40 a.m. - 9:00 a.m.
9:00 a.m. - 9:30 a.m. Buffer (redo any a.m. peak runs affected by incidents)			
Off-Peak Morning (9:30 a.m.-12:00 p.m.)	2-4	6B to 6A	9:30 a.m. - 9:50 a.m.
	2-5	6A to 6B	9:50 a.m. – 10:10 a.m.
	2-6	6B to 6A	10:10 a.m. - 10:30 a.m.
	1-4	5B to 5A	10:30 a.m. - 10:50 a.m.
	1-5	5A to 5B	10:50 a.m. - 11:10 a.m.
	1-6	5B to 5A	11:10 a.m. - 11:30 a.m.
11:30 a.m. - 12:00 p.m. Buffer (redo any a.m. off-peak runs affected by incidents)			
12:00 p.m. - 1:00 p.m. Lunch			
Off-Peak Afternoon (1:00 p.m.-4:00 p.m.)	1-7	5A to 5B	1:00 p.m. - 1:20 p.m.
	1-8	5B to 5A	1:20 p.m. - 1:40 p.m.
	1-9	5A to 5B	1:40 p.m. - 2:00 p.m.
	2-7	6A to 6B	2:00 p.m. - 2:20 p.m.
	2-8	6B to 6A	2:20 p.m. - 2:40 p.m.
	2-9	6A to 6B	2:40 p.m. - 3:00 p.m.
3:00 p.m. - 4:00 p.m. Buffer (redo any p.m. off-peak runs affected by incidents)			
Peak Afternoon (4:00 p.m.-6:30 p.m.)	2-10	6B to 6A	4:00 p.m. - 4:20 p.m.
	2-11	6A to 6B	4:20 p.m. - 4:40 p.m.
	2-12	6B to 6A	4:40 p.m. - 5:0 p.m.
	1-10	5B to 5A	5:00 p.m. - 5:20 p.m.
	1-11	5A to 5B	5:20 p.m. - 5:40 p.m.
	1-12	5B to 5A	5:40 p.m. - 6:00 p.m.
6:00 p.m. - 6:30 p.m. Buffer (redo any p.m. peak runs affected by incidents)			

Route Description

Of the 17 routes developed, 14 were "traditional" routes, having non-specific beginning and end points. These were randomly devised to incorporate a diversity of functional class and area type combinations and were not intended to replicate local trips or provide the shortest or quickest route between start and end points. The three remaining routes were developed with activity centers as their origins and destinations.

Activity centers are areas that have unique trip generating capabilities. While similar land use types typically generate similar levels of traffic, activity centers have the ability to produce relatively large and varying amounts of traffic. Activity centers selected for analysis in the Austin Travel Time and Delay Study included the Austin CBD, Austin-Bergstrom International Airport, the Freescale Semiconductor Plant, and the Cabela's Retail Outlet. Figure 2 shows all 17 study routes overlaid on a map with area type and functional class information (excluding the local street network).

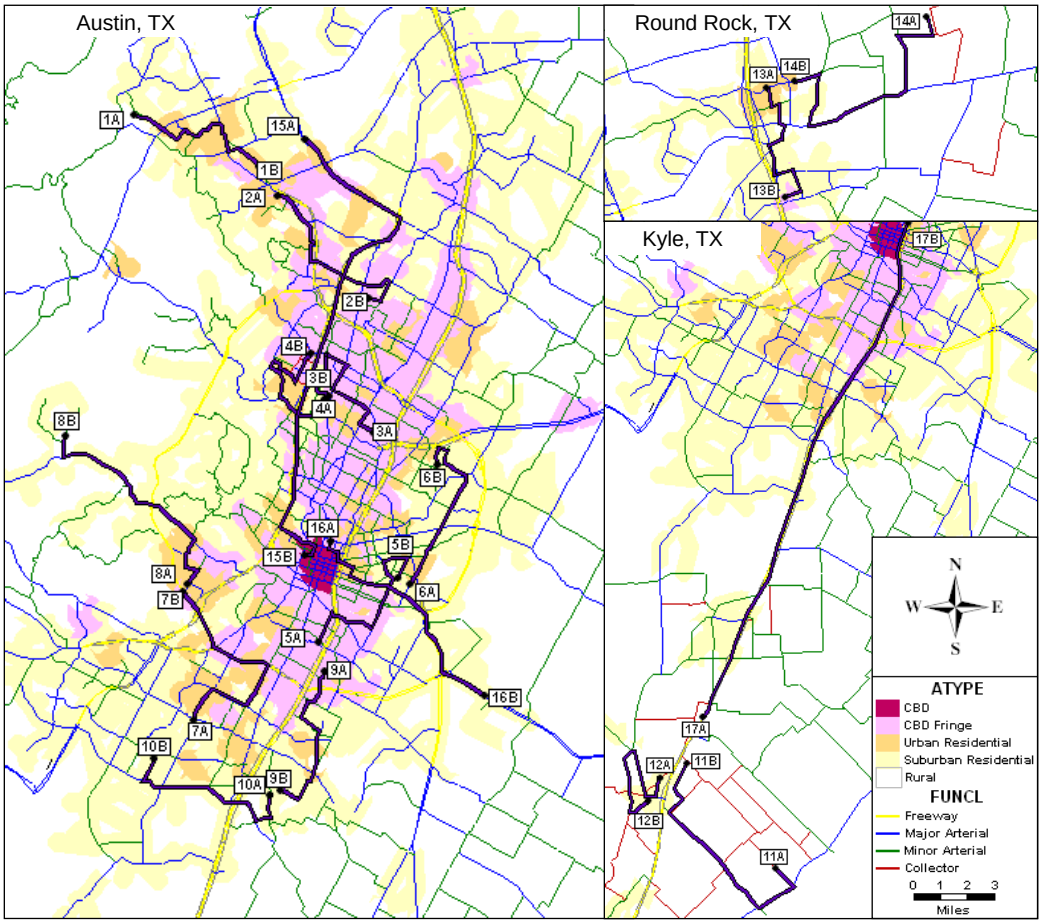

Figure 2. Study Routes.

Table 3 provides detailed descriptions of the routes in the study, including functional class (FUNCL) and area type (ATYPE). For ease of comprehension, individual lines in the route descriptions represent distinct roadways as opposed to route segments. However, the data analysis contained in the remainder of this report is based on routes and route segments, rather than individual streets within route segments.

Table 3. Austin Area Route Descriptions by Roadway Name.

	Roadway	From	To	FUNCL	ATYPE
Route 1	*Begin route at intersection of Blazing Star and Birds Nest*				
	Blazing Star	Birds Nest	Ebony	Local	5
	Ebony	Blazing Star	El Salido	Local	5
	El Salido	Ebony	FM 620	Minor Arterial	5
	El Salido	FM 620	Pecan Creek	Local	3
	Pecan Creek	El Salido	Salt Mill	Minor Arterial	3
	Salt Mill	Pecan Creek	Millwright	Local	3
	Millwright	Salt Mill	Anderson Mill	Local	3
	Anderson Mill	Millwright	US 183	Major Arterial	2
	Anderson Mill	US 183	Pond Springs	Major Arterial	3
	Pond Springs	Anderson Mill	Schick	Minor Arterial	4
	Pond Springs	Schick	Hunters Chase	Minor Arterial	3
	End route at intersection of Pond Springs and Hunters Chase				
Route 2	*Begin route at intersection of Jollyville and Commonwealth*				
	Jollyville	Commonwealth	Oak Knoll	Major Arterial	3
	Jollyville	Oak Knoll	Duval	Major Arterial	4
	Jollyville	Duval	Balcones Woods	Major Arterial	3
	Jollyville	Balcones Woods	Braker	Major Arterial	2
	Braker	Jollyville	Seton Center	Major Arterial	2
	Braker	Seton Center	Balcones Center	Major Arterial	3
	Braker	Balcones Center	Loop 1	Major Arterial	2
	Braker	Loop 1	Burnet	Major Arterial	4
	Braker	Burnet	Metric	Major Arterial	2
	Metric	Braker	Kramer	Minor Arterial	4
	Metric	Kramer	Energy	Minor Arterial	2
	Energy	Metric	Metropolitan	Local	2
	End route at intersection of Energy and Metropolitan				
Route 3	*Begin route at intersection of Denson and Dillard*				
	Denson	Dillard	Lamar	Local	2
	Lamar	Denson	Justin	Major Arterial	2
	Justin	Lamar	Woodrow	Minor Arterial	3
	Justin	Woodrow	Burnet	Minor Arterial	2
	Burnet	Justin	Anderson	Major Arterial	2
	Anderson	Burnet	Shoal Creek	Major Arterial	2
	Shoal Creek	Anderson	Twin Oaks	Minor Arterial	4
	Twin Oaks	Shoal Creek	Daugherty	Local	4
	End route at intersection of Twin Oaks and Daugherty				

Table 3. Austin Area Route Descriptions by Roadway Name (Continued).

	Roadway	From	To	FUNCL	ATYPE
Route 4	*Begin route at intersection of Nasco and Park View*				
	Nasco	Park View	Allendale	Local	4
	Allendale	Nasco	Northland	Major Arterial	4
	Northland	Allendale	Loop 1	Major Arterial	4
	Northland	Loop 1	Ranch 2222	Major Arterial	3
	Ranch 2222	Northland	Dry Creek	Major Arterial	3
	Dry Creek	Ranch 2222	Mountain Climb/ Sierra	Local	3
	Mountain Climb/ Sierra	Dry Creek	Mesa	Local	3
	Mesa	Sierra	North Hills	Major Arterial	4
	North Hills	Mesa	Wood Hollow	Collector	3
	Wood Hollow	North Hills	Far West	Collector	3
	Wood Hollow	Far West	Executive Center	Collector	2
	End route at intersection of Wood Hollow and Executive Center				
Route 5	*Begin route at intersection of Travis Heights and Live Oak*				
	Travis Heights	Live Oak	Riverside	Local	2
	Riverside	Travis Heights	Lakeshore	Major Arterial	2
	Lakeshore	Riverside	Pleasant Valley	Minor Arterial	2
	Pleasant Valley	Lakeshore	7th	Major Arterial	2
	Pleasant Valley	7th	Hargrave	Major Arterial	4
	Hargrave	Pleasant Valley	Rosewood	Local	4
	Rosewood	Hargrave	Webberville	Minor Arterial	4
	Oak Springs	Webberville	Tillery	Minor Arterial	4
	Tillery	Oak Springs	Lyons	Local	4
	End route at intersection of Tillery and Lyons				
Route 6	*Begin route at intersection of Springdale and Lyons*				
	Springdale	Lyons	Airport	Major Arterial	4
	Springdale	Airport	Oak Springs	Major Arterial	3
	Springdale	Oak Springs	Northeast	Major Arterial	4
	Northeast	Springdale	Manor	Local	4
	Northeast	Manor	Vanderbilt	Minor Arterial	4
	Vanderbilt	Northeast	Mira Loma/ Dorchester	Local	3
	Mira Loma/ Dorchester	Vanderbilt	Wheless	Local	3
	End route at intersection of Dorchester and Wheless				

Table 3. Austin Area Route Descriptions by Roadway Name (Continued).

	Roadway	From	To	FUNCL	ATYPE
Route 7	*Begin route at intersection of Manchaca and William Cannon*				
	Manchaca	William Cannon	Stassney	Major Arterial	3
	Stassney	Manchaca	Kings	Major Arterial	3
	Stassney	Kings	1st	Major Arterial	2
	1st	Stassney	Philco	Minor Arterial	4
	1st	Philco	US 290	Minor Arterial	3
	US 290	1st	Banister	Expressway	3
	US 290	Banister	Loop 360	Expressway	2
	Loop 360	US 290	Loop 1	Expressway	3
	Loop 360	Loop 1	Walsh Tarlton	Expressway	2
	End route at intersection of Loop 360 and Walsh Tarlton				
Route 8	*Begin route at intersection of Walsh Tarlton and Tamarron*				
	Walsh Tarlton	Tamarron	Pinnacle	Minor Arterial	3
	Pinnacle	Walsh Tarlton	Allen	Local	3
	Allen	Pinnacle	Westbank	Local	3
	Westbank	Allen	Bee Cave	Major Arterial	3
	Bee Cave	Westbank	Sundown	Major Arterial	3
	Bee Cave	Sundown	Canyon Rim	Major Arterial	4
	Bee Cave	Canyon Rim	Barton Creek	Major Arterial	5
	Bee Cave	Barton Creek	Cuernavaca	Major Arterial	4
	Cuernavaca	Bee Cave	Commons Ford	Major Arterial	5
	Cuernavaca	Commons Ford	El Viejo Camino	Major Arterial	4
	End route at intersection of Cuernavaca and El Viejo Camino				
Route 9	*Begin route at intersection of Parker and Timber Ridge*				
	Parker	Timber Ridge	Woodward	Local	2
	Woodward	Parker	Freidrich	Minor Arterial	2
	Freidrich	Woodward	St. Elmo	Local	2
	Freidrich	St. Elmo	Teri	Local	4
	Teri	Freidrich	Pleasant Valley	Minor Arterial	4
	Pleasant Valley	Teri	Stassney	Major Arterial	4
	Pleasant Valley	Stassney	Nuckols Crossing	Major Arterial	3
	Pleasant Valley	Nuckols Crossing	William Cannon	Minor Arterial	3
	Pleasant Valley	William Cannon	Quicksilver	Major Arterial	4
	Quicksilver	Pleasant Valley	Jenibeth	Local	4
	End route at intersection of Quicksilver and Jenibeth				
Route 10	*Begin route at intersection of Bluff Springs and Chateau Village*				
	Bluff Springs	Chateau Village	Brandt	Minor Arterial	4
	Brandt	Bluff Springs	Slaughter	Minor Arterial	5
	Slaughter	Brandt	I 35	Major Arterial	5
	Slaughter	I 35	Curlew	Major Arterial	4
	Curlew	Slaughter	Guidepost	Local	4
	End route at intersection of Curlew and Guidepost				

Table 3. Austin Area Route Descriptions by Roadway Name (Continued).

	Roadway	From	To	FUNCL	ATYPE
Route 11	*Begin route at intersection of Grist Mill and Plum Creek*				
	Grist Mill	Plum Creek	SH 21	Collector	5
	SH 21	Grist Mill	FM 150	Major Arterial	5
	FM 150	SH 21	Lehman	Minor Arterial	5
	Lehman	FM 150	Masonwood	Collector	5
	Masonwood	Lehman	Goforth	Local	5
	Goforth	Masonwood	CR 130	Local	5
	End route at intersection of Goforth and CR 130				
Route 12	*Begin route at intersection of Burelson and Spring Branch*				
	Burleson	Spring Branch	Blanco	Collector	4
	Blanco	Burleson	FM 150	Local	4
	FM 150	Blanco	Old Stagecoach	Minor Arterial	5
	Old Stagecoach	FM 150	Scott	Collector	5
	Scott	Old Stagecoach	Opal	Collector	5
	Opal	Scott	Sledge	Collector	5
	Sledge	Opal	Center	Collector	4
	End route at intersection of Sledge and Center				
Route 13	*Begin route at intersection of Greenhill and Old Settlers*				
	Greenhill	Old Settlers	Bowman	Local	3
	Bowman	Greenhill	Egger	Minor Arterial	4
	Egger	Bowman	Palm Valley	Local	4
	Palm Valley	Egger	Georgetown	Major Arterial	4
	Georgetown	Palm Valley	Brushy Creek	Minor Arterial	5
	Georgetown	Brushy Creek	Main	Minor Arterial	4
	Main	Georgetown	Mays	Minor Arterial	4
	Mays	Main	Gattis School	Major Arterial	4
	Gattis School	Mays	Oxford	Major Arterial	4
	Gattis School	Oxford	Greenlawn	Major Arterial	2
	Greenlawn	Gattis School	Dell	Major Arterial	4
	Dell	Greenlawn	Williamson	Local	2
	End route at intersection of Dell and Williamson				
Route 14	*Begin route at intersection of Lemens and Hyview*				
	Lemens Ave	Lemens Cir	CR 109	Local	5
	CR 109	Lemens	CR 110	Collector	5
	CR 110	CR 109	Palm Valley	Minor Arterial	5
	Palm Valley	CR 110	FM 1460	Major Arterial	5
	FM 1460	Palm Valley	Chandler Creek	Minor Arterial	4
	FM 1460	Chandler Creek	Old Settlers	Minor Arterial	5
	Old Settlers	FM 1460	Settlement	Major Arterial	5
	End route at intersection of Old Settlers and Settlement				

Table 3. Austin Area Route Descriptions by Roadway Name (Continued).

	Roadway	From	To	FUNCL	ATYPE
Route 15 AC	*Begin route at intersection of Parmer and Anderson Mill (Freescale Semiconductor Plant)*				
	Parmer	Anderson Mill	Dallas	Major Arterial	4
	Parmer	Dallas	McNeil	Major Arterial	3
	Parmer	McNeil	Europa	Major Arterial	2
	Parmer	Europa	Adelphi	Major Arterial	3
	Parmer	Adelphi	Loop 1	Major Arterial	4
	Loop 1	Parmer	Park Bend	Freeway	2
	Loop 1	Park Bend	Stonelake	Freeway	4
	Loop 1	Stonelake	Braker	Freeway	2
	Loop 1	Braker	Loop 360	Freeway	3
	Loop 1	Loop 360	US 183	Freeway	4
	Loop 1	US 183	Far West	Freeway	2
	Loop 1	Far West	Ranch 2222	Freeway	3
	Loop 1	Ranch 2222	35th	Freeway	2
	Loop 1	35th	Westover	Freeway	4
	Loop 1	Westover	Enfield/15th	Freeway	3
	Enfield/15th	Loop 1	Lamar	Minor Arterial	3
	15th	Lamar	Rio Grande	Major Arterial	1
	Rio Grande	15th	10th	Minor Arterial	1
	10th	Rio Grande	Lamar	Local	1
	End route at intersection of 10th and Lamar (Austin CBD)				
Route 16 AC	*Begin route at intersection of Congress and MLK (Austin CBD)*				
	Congress	MLK	15th	Local	1
	15th	Congress	Red River	Major Arterial	1
	Red River	15th	11th	Major Arterial	1
	11th	Red River	I 35	Major Arterial	1
	11th	I 35	Lydia	Minor Arterial	3
	Lydia	11th	7th	Local	3
	7th	Lydia	Springdale	Major Arterial	2
	7th	Springdale	US 183	Major Arterial	4
	US 183	7th	SH 71	Expressway	4
	SH 71	US 183	Spirit of Texas	Major Arterial	4
	End route at intersection of SH 71 and Spirit of Texas (Austin-Bergstrom International Airport)				
Route 17 AC	*Begin route at intersection of I 35 and Cabelas (Buda, TX)*				
	I 35	221	Onion Creek	Freeway	5
	I 35	Onion Creek	Foremost	Freeway	4
	I 35	Foremost	William Cannon	Freeway	3
	I 35	William Cannon	Stassney	Freeway	4
	I 35	Stassney	Cesar Chavez	Freeway	2
	I 35	Cesar Chavez	12th	Freeway	1
	End route at intersection of I 35 and 12th (Austin CBD)				

Data Collection Equipment and Setup

The equipment used for data collection included a vehicle, a Global Positioning System (GPS) satellite receiver, a laptop computer, and a voice recorder. The satellite receiver employed was the GPS 35/36 TracPak™ manufactured by the Garmin Corporation. Positioning data were collected on a second-by-second basis and included longitude, latitude, speed, time, and date. Special software was installed on the laptop to facilitate recording and analysis of the data. A

geographic information system (GIS) software package called Maptitude® was also used to collect and archive the GPS data stream. A small voice recorder enabled the driver to record speed signage along the route and safely log the time, location, and duration of any non-recurring incidents affecting travel times.

DATA PROCESSING AND ANALYSIS

After the field work was complete, raw data were processed into a format that allowed for easier manipulation during analysis. A simple FORTRAN program was used to remove extraneous information from each file. The data were then imported into a Microsoft® Excel spreadsheet, where the longitude and latitude values were converted from the degrees-minute-second format to the decimal degrees format. These Excel GPS files were subsequently imported into a Microsoft® Access database for further analysis and querying.

The X-Y coordinate information in the Access database was loaded into ESRI ArcGIS™ to facilitate visual determination of segment begin/end points (changes in functional class or area type). A bar was drawn across the route at these locations and polygons were constructed around them so that delay due to turning maneuvers or traffic control devices at segment transitions could be identified. The size of the polygon drawn around each transition point depended on the amount of delay recorded at that location. Polygons were constructed to encompass the largest amount of delay time experienced on any of the 12 runs for the route in question.

Figure 3 is a screenshot from the GIS software showing segment begin/end points (solid bars) and transition areas (shaded polygons) for a portion of one run. The per-second longitude and latitude readings recorded by the GPS unit appear as individual dots forming the actual route path. Dots that appear increasingly close together represent slowing. Dots that are further apart represent higher speeds and less delay.

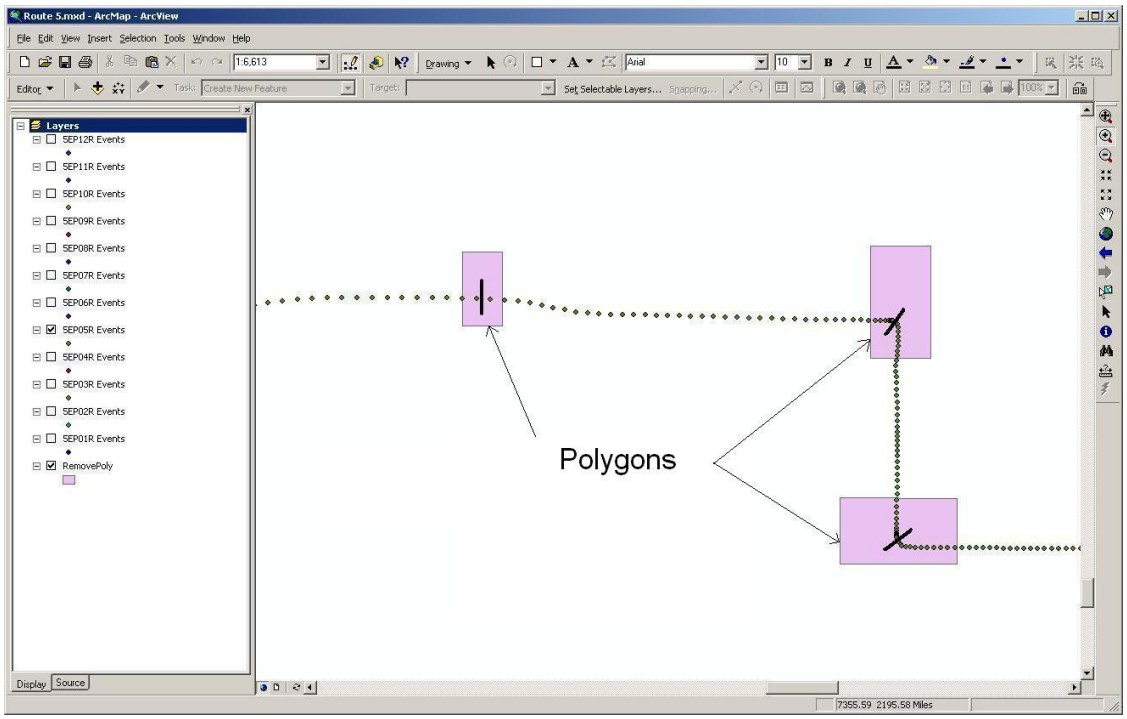

Figure 3. Data Processing in ArcGIS.

After the raw data were reduced and imported into ArcGIS™, they were analyzed to obtain the average speed for each segment based on the formula below:

$$\text{Speed} = \frac{\text{Distance (miles)}}{\text{Time (seconds)} / 3600}$$

The following two methods of data analysis were used to determine segment begin and end points and average speed per segment:

Travel Time Unimpeded – was determined by excluding the area in the buffer polygons (shaded areas in Figure 3) developed for each route. Only the distance between the outside borders of consecutive polygons and the time required to traverse that distance were measured. With the shaded polygon areas (segment transitions) removed, the result was generally a higher average speed per segment. This method of analysis was useful in ascertaining the speeds at which vehicles are able to travel on various types of roadways within an urban area.

Travel Time with Delay – was determined by using the entire distance between segment endpoints (solid lines within each polygon in Figure 3) and the amount of time needed to travel between these points. The average speed that results is representative of actual conditions and is normally lower than the average speed obtained using the unimpeded method. The delay approach accounts for congestion created at friction areas that are often encountered when transitioning between different functional classes and area types. These transition zones are frequently characterized by signalized intersections or other traffic control devices.

The concept of comparing two travel time analysis methods was implemented to provide a correlation between the actual operational conditions of a road segment (travel time with delay) versus conditions that might exist if travel at segment transitions was excluded (travel time unimpeded).

For both methods of analysis, average speeds on roadways are cross-classified by area type and functional class. As expected, the travel time unimpeded approach resulted in speeds that were typically higher than those obtained when the travel time delay method of analysis was used. In rare instances, the travel time unimpeded method yielded a lower average segment speed due to acceleration of travelers through transition points during the data collection runs. While the delay method provides more accurate information on average operational speeds for various road segments within an area, the unimpeded method enables estimates of what average speeds could be if measures are taken to preserve the transportation network. Both methods are useful depending on the intended planning application.

Results from the 2006 Austin Travel Time and Delay Study are presented in the following section of the report. After compiling the segment average speeds, a review of the data tables was conducted to identify speeds that were unusually low or high. For those segments with speeds that were considered outside of the typical range of values, a determination was made as to why the speed varied. This determination was based on a review of driver audio recordings for each run and whether the unusual speed was a result of a recurring or non-recurring event.

If the unusual speed reading was the result of recurring events such as a traffic control devices (e.g., traffic signal, stop sign, school zone signage, speed humps) or trains, then the data were not excluded from analysis. However, if the low speed was the result of adverse weather conditions or an event that was not recurring (such as a crash, disabled vehicle, construction on the travel lanes, or power outage affecting signal operation), the data were excluded. Runs disrupted by non-recurring incidents were redone whenever possible to reduce the need for data exclusion.

RESULTS

Comparison of Peak and Off-Peak Travel Time Data

Delay at segment transitions can be caused by queuing at traffic control devices or turning movements. The unimpeded analysis method does not remove all causes of delay because many segments traverse multiple intersections while maintaining the same functional classification and area type. Average speed data generated using the unimpeded method of analysis excludes portions of travel at segment begin/end points, but includes delays caused by traffic signals or turning movements between segment transitions. Table 4 shows a summary of average unimpeded speeds for each route by peak and off-peak period and by direction.

Table 4. Summary of Average Speeds for All Routes – Unimpeded Method.

Route	Peak Period			Off-Peak Period		
	Average Speed			Average Speed		
	A → B	B → A	Overall	A → B	B → A	Overall
1	25.4	25.3	25.3	29.0	30.7	29.8
2	31.7	35.2	33.4	32.8	37.3	34.9
3	23.1	25.4	24.2	20.7	24.4	22.4
4	24.7	23.8	24.3	25.5	26.5	26.0
5	23.8	19.9	21.7	23.6	25.1	24.3
6	22.9	22.4	22.7	22.7	23.3	23.0
7	22.9	22.8	22.9	31.3	28.5	29.8
8	25.2	27.2	26.2	31.4	32.8	32.1
9	27.0	23.0	24.8	28.9	30.2	29.6
10	29.3	31.5	30.4	30.0	32.8	31.3
11	40.5	39.1	39.8	44.1	44.8	44.4
12	34.5	34.9	34.7	34.1	34.9	34.5
13	29.8	28.4	29.1	26.2	30.0	28.0
14	39.3	44.4	41.7	43.1	45.3	44.2
15	28.9	39.5	33.4	52.0	51.4	51.7
16	21.3	26.3	23.5	26.6	29.7	28.1
17	36.6	45.2	40.5	64.7	56.4	60.2

Figures in miles per hour.

Speed limit signs posted along the data collection routes are helpful in assessing the significance of the data collected. Table 5 shows the speed limit or range of speed limits for each functional classification and area type combination encountered in the Austin Travel Time and Delay study. Due to variability in segment lengths, certain speed-limit ranges are larger than others. An

asterisk denotes route segments whose speed limits were affected by the presence of school zones or speed bumps. The letters "NP" indicate that speed limit signs were not posted on that functional classification-area type combination for the routes traversed.

Table 5. Posted Speed Limits.

Area Type \ Functional Class	Freeway	Major Arterial	Minor Arterial	Collector	Local
Central Business District	NP	30-35	20*	-	30
CBD Fringe	55-65	20*-60	20*-35	NP	20*-35
Urban Residential	65-70	20*-45	20*-40	20*-30	20*-30
Suburban Residential	65-70	20*-60	20*-55	30	20*-45
Rural	70	40-65	35-55	30-45	20*-35

Figures in miles per hour. * - School Zone. NP - Not Posted.

The average segment length of each functional class–area type combination was determined during data processing. Table 6 presents these results using the unimpeded method of analysis, which excludes travel at segment transition areas.

Table 6. Average Length of Segments – Unimpeded Method.

Area Type \ Functional Class	Freeway		Major Arterial		Minor Arterial		Collector		Local	
	# of Segments	Avg. Length (miles)	# of Segments	Avg. Length (miles)	# of Segments	Avg. Length (miles)	# of Segments	Avg. Length (miles)	# of Segments	Avg. Length (miles)
CBD	12	0.78	24	0.43	12	0.33	0	-	24	0.21
CBD Fringe	60	1.82	144	0.85	48	0.56	12	0.58	72	0.44
Urban Res.	48	0.81	132	0.60	96	0.42	12	1.18	84	0.73
Suburb. Res.	60	1.28	240	0.97	132	0.74	24	0.73	120	0.53
Rural	12	3.53	72	1.19	84	1.29	48	1.23	36	0.81

After the speed data for individual routes were compiled, the data were aggregated into tables showing summary information for each functional class-area type cohort in the study. Figures 4 through 8 show the results of aggregating the data into groups according to functional classification and peak and off-peak periods (using the unimpeded method of analysis). Each figure presents the average peak and off-peak speeds collected for every functional classification in the specified area type.

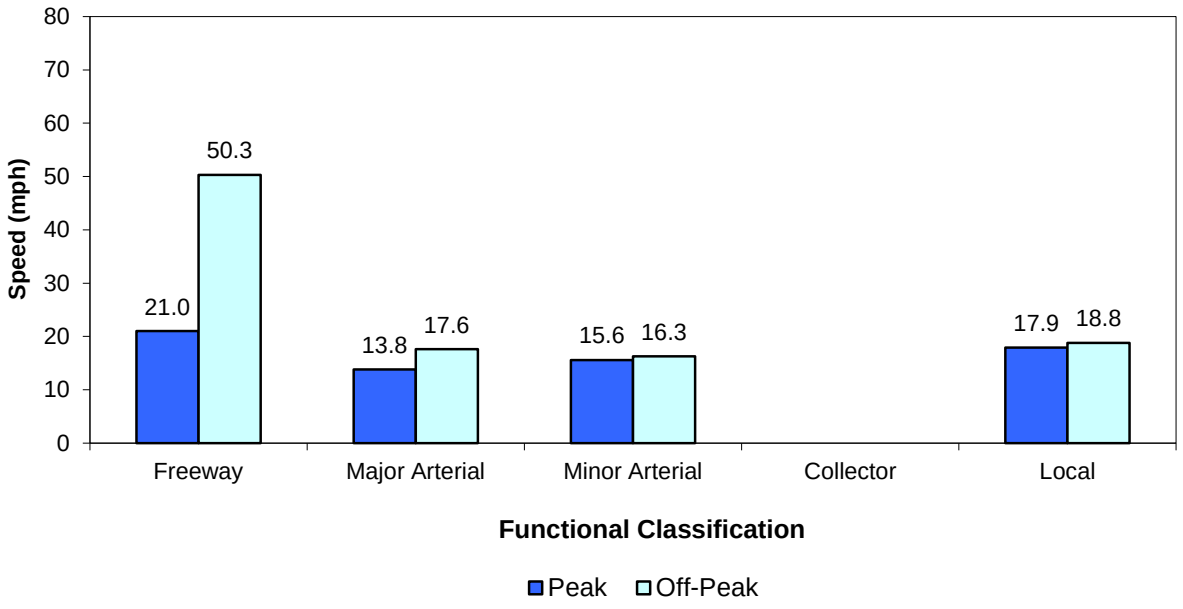

Figure 4. CBD - Average Peak vs. Off-Peak Speeds (Unimpeded Method).

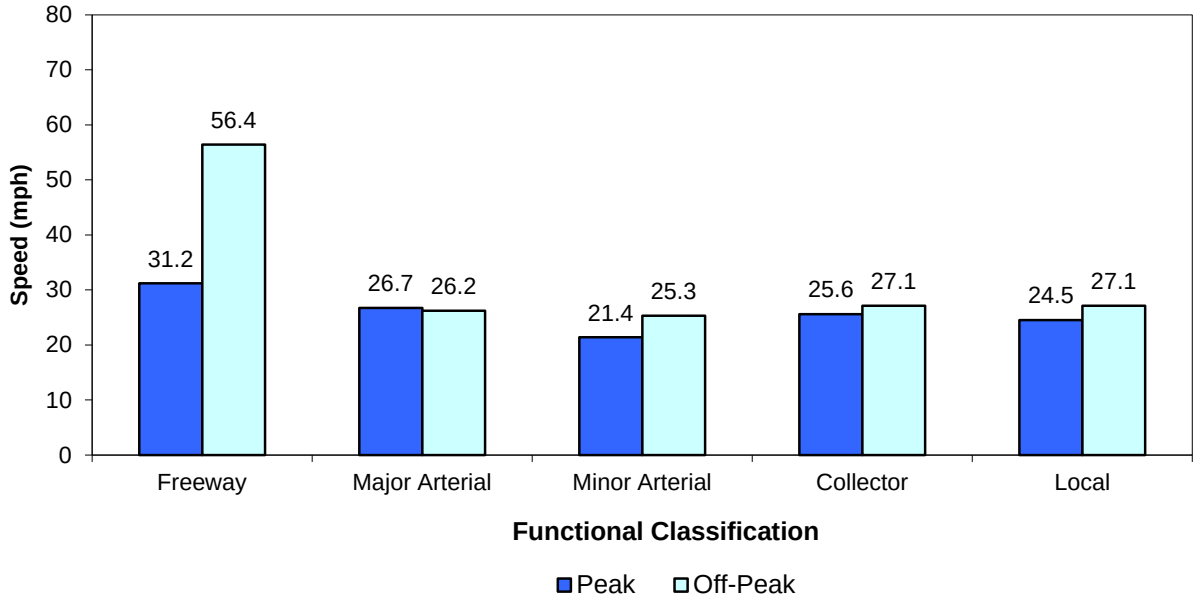

Figure 5. CBD Fringe - Average Peak vs. Off-Peak Speeds (Unimpeded Method).

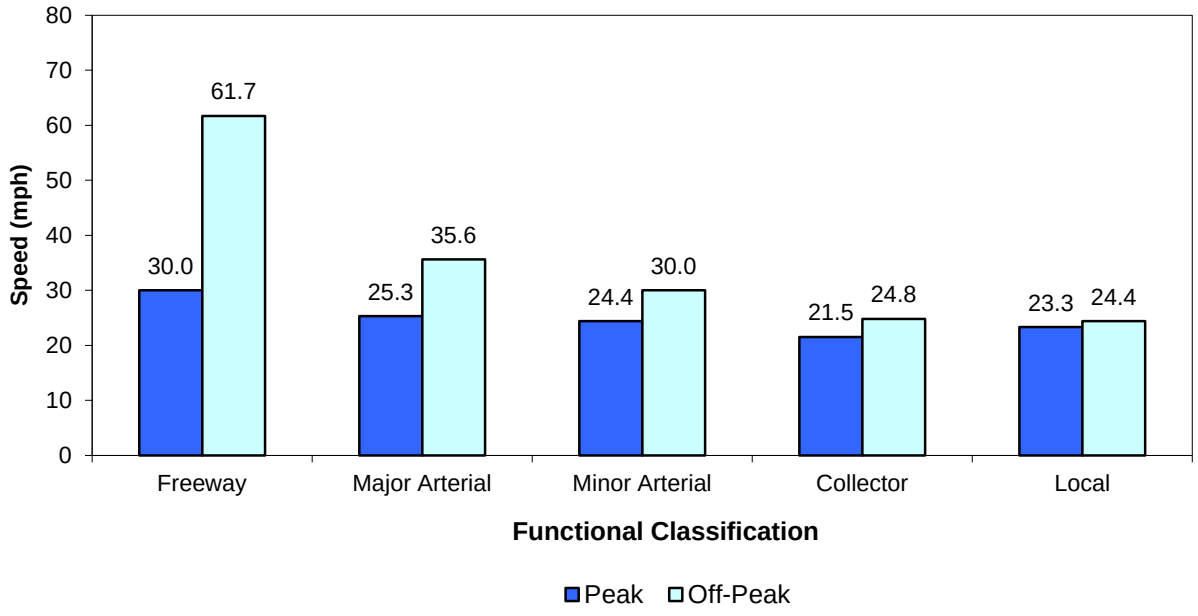

Figure 6. Urban Residential - Average Peak vs. Off-Peak Speeds (Unimpeded Method).

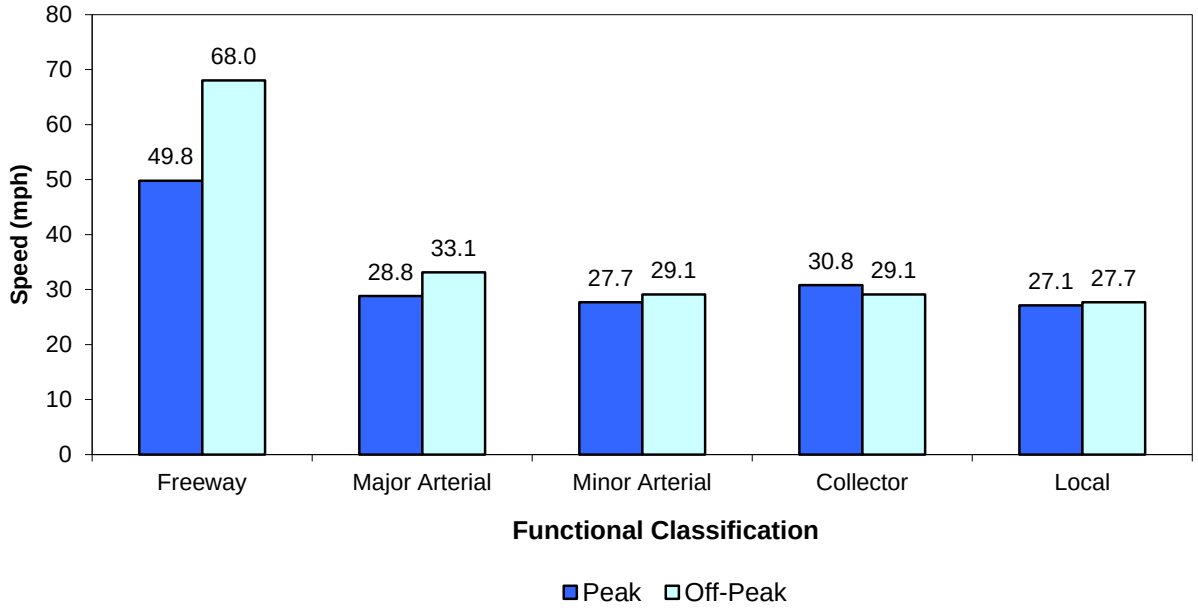

Figure 7. Suburban Residential - Average Peak vs. Off-Peak Speeds (Unimpeded Method).

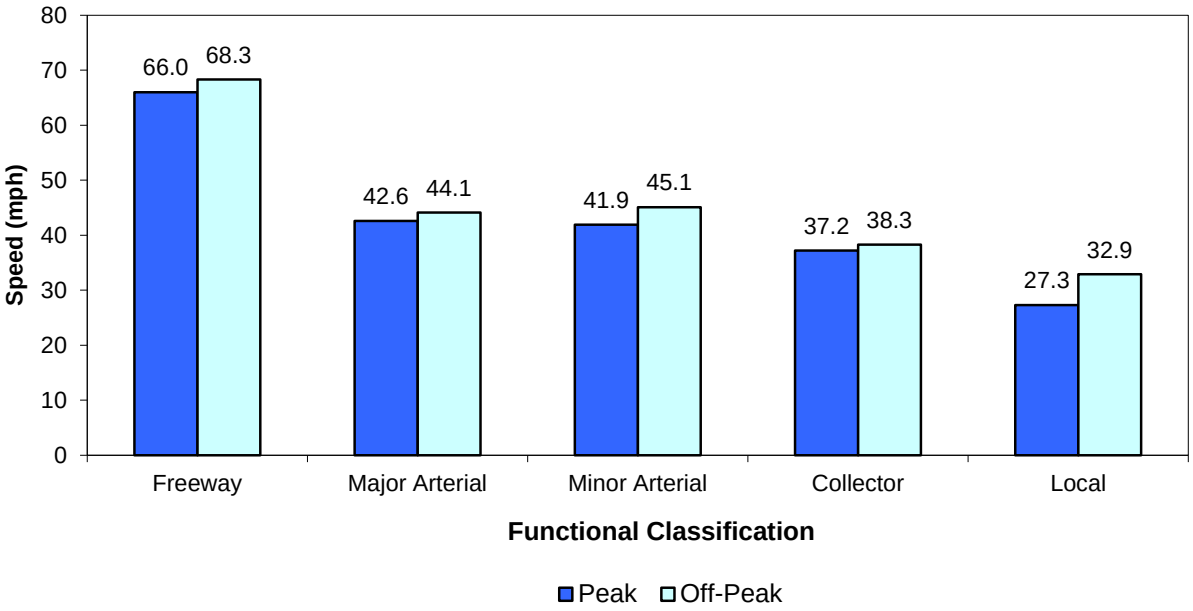

Figure 8. Rural - Average Peak vs. Off-Peak Speeds (Unimpeded Method).

The delay method of analyzing travel time data incorporates all regular delays encountered while traveling along a route. Slowdowns associated with occurrences such as queuing at traffic control devices and turning at intersections are included in this type of analysis. Table 7 provides a summary of average speeds for each route, in both directions, by peak and off-peak period, using the delay method.

Table 7. Average Speed Summary for All Routes – Delay Method.

Route	Peak Period			Off-Peak Period		
	Average Speed			Average Speed		
	A → B	B → A	Overall	A → B	B → A	Overall
1	20.8	21.7	21.2	20.7	22.6	21.6
2	28.4	29.7	29.0	30.2	32.5	31.3
3	20.2	21.3	20.7	18.0	22.2	19.9
4	21.0	20.3	20.6	22.1	22.9	22.5
5	20.8	17.8	19.2	21.3	22.6	21.9
6	20.1	20.0	20.0	20.3	20.3	20.3
7	19.3	22.7	20.9	24.4	27.5	25.9
8	24.4	26.2	25.3	30.8	31.7	31.2
9	22.8	19.0	20.7	25.1	26.4	25.7
10	27.9	29.0	28.5	26.7	28.9	27.8
11	39.3	35.8	37.4	42.8	42.0	42.4
12	33.2	33.2	33.2	32.3	33.4	32.8
13	24.4	23.5	24.0	21.2	22.8	22.0
14	32.5	38.0	35.1	40.0	37.0	38.4
15	27.7	34.6	30.8	46.8	46.0	46.4
16	17.5	23.2	19.9	22.7	26.7	24.6
17	36.5	44.9	40.3	64.8	56.7	60.5

Figures in miles per hour.

The average segment length of each functional class-area type combination was determined during data processing. Table 8 presents these results using the delay method of analysis, which *includes* travel at segment transition areas.

Table 8. Average Length of Segments – Delay Method.

Functional Class / Area Type	Freeway		Major Arterial		Minor Arterial		Collector		Local	
	# of Segments	Avg. Length (miles)	# of Segments	Avg. Length (miles)	# of Segments	Avg. Length (miles)	# of Segments	Avg. Length (miles)	# of Segments	Avg. Length (miles)
CBD	12	0.80	24	0.52	12	0.37	0	-	24	0.24
CBD Fringe	60	1.91	144	0.91	48	0.62	12	0.63	72	0.46
Urban Res.	48	0.90	132	0.68	96	0.49	12	1.24	84	0.76
Suburb. Res.	60	1.35	240	1.04	132	0.79	24	0.75	120	0.56
Rural	12	3.57	72	1.26	84	1.36	48	1.27	36	0.83

As in the unimpeded analysis, speed data for individual routes examined using the delay methodology were compiled and aggregated into tables showing summary information for each functional class-area type cohort. Figures 9 through 13 show the aggregate speed results according to functional classification and peak and off-peak periods (using the delay method of analysis). Each figure presents the average peak and off-peak speeds collected for every functional classification in the specified area type.

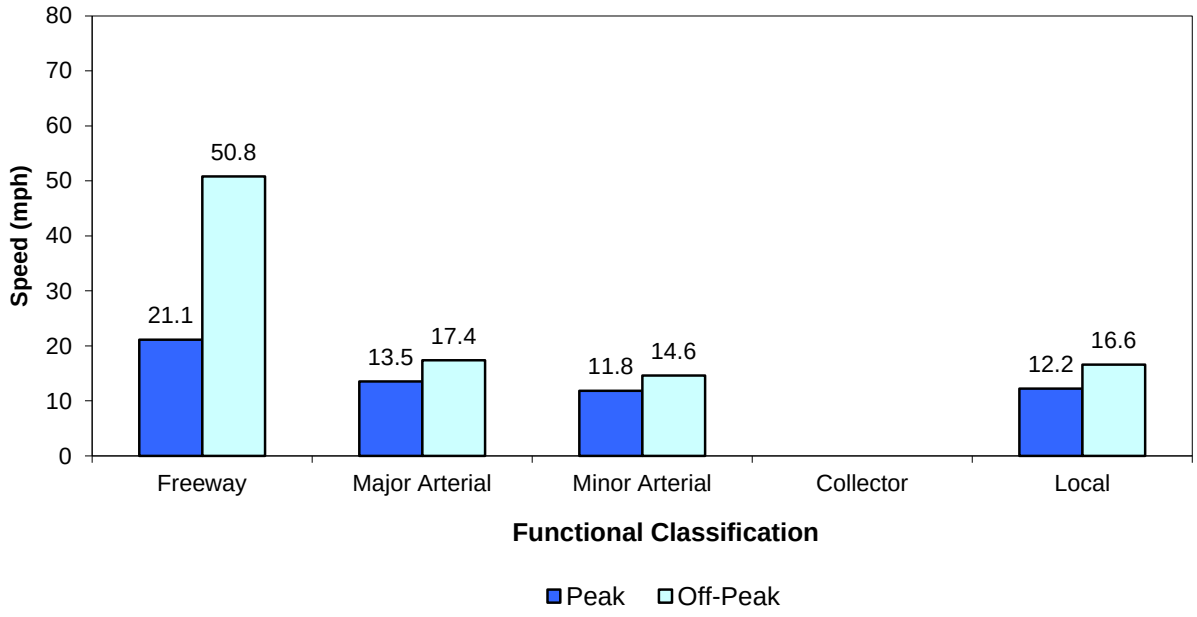

Figure 9. CBD - Average Peak vs. Off-Peak Speeds (Delay Method).

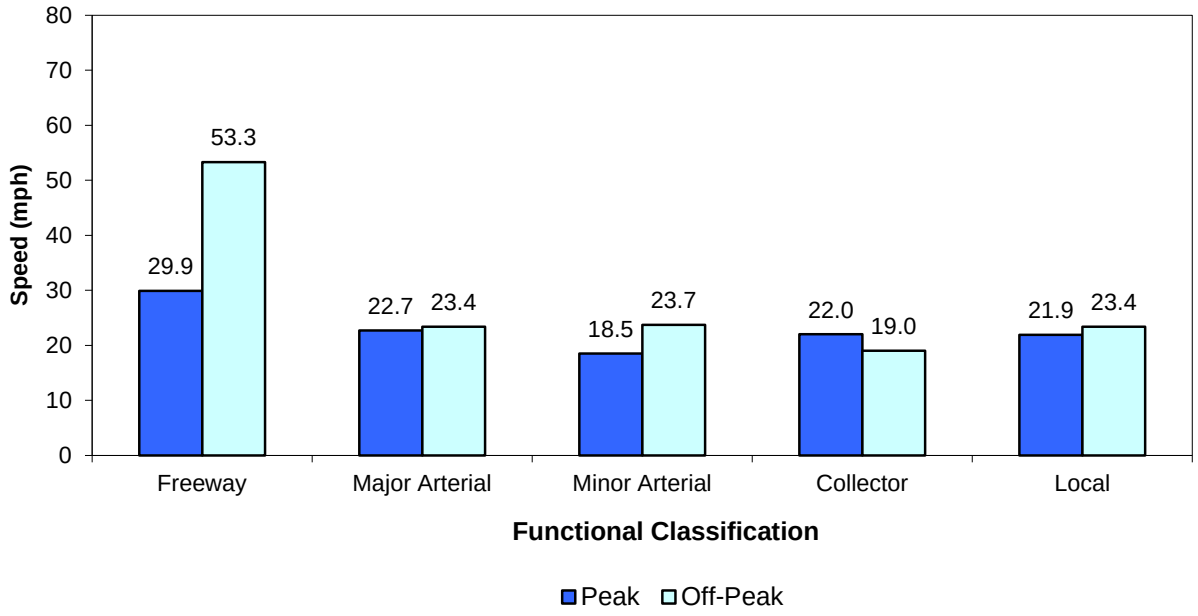

Figure 10. CBD Fringe - Average Peak vs. Off-Peak Speeds (Delay Method).

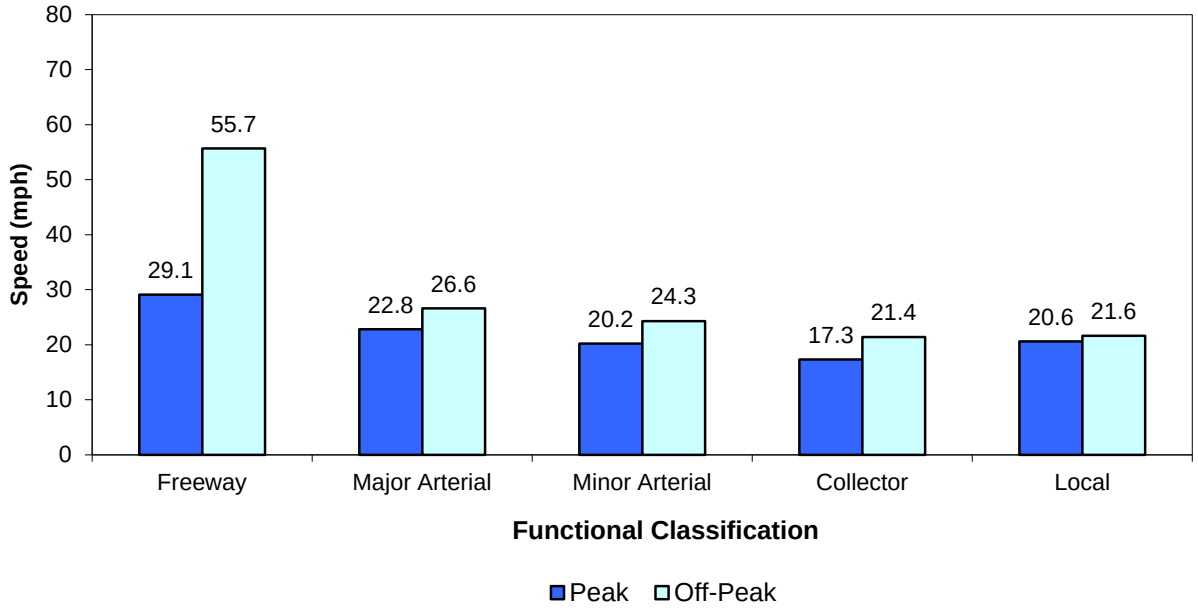

Figure 11. Urban Residential - Average Peak vs. Off-Peak Speeds (Delay Method).

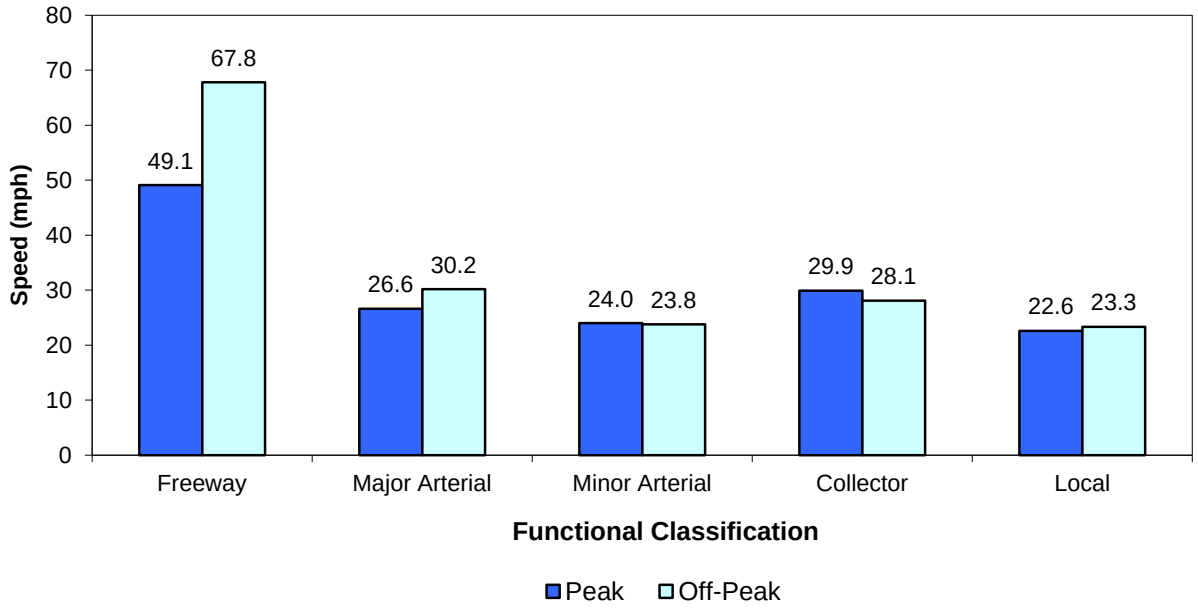

Figure 12. Suburban Residential - Average Peak vs. Off-Peak Speeds (Delay Method).

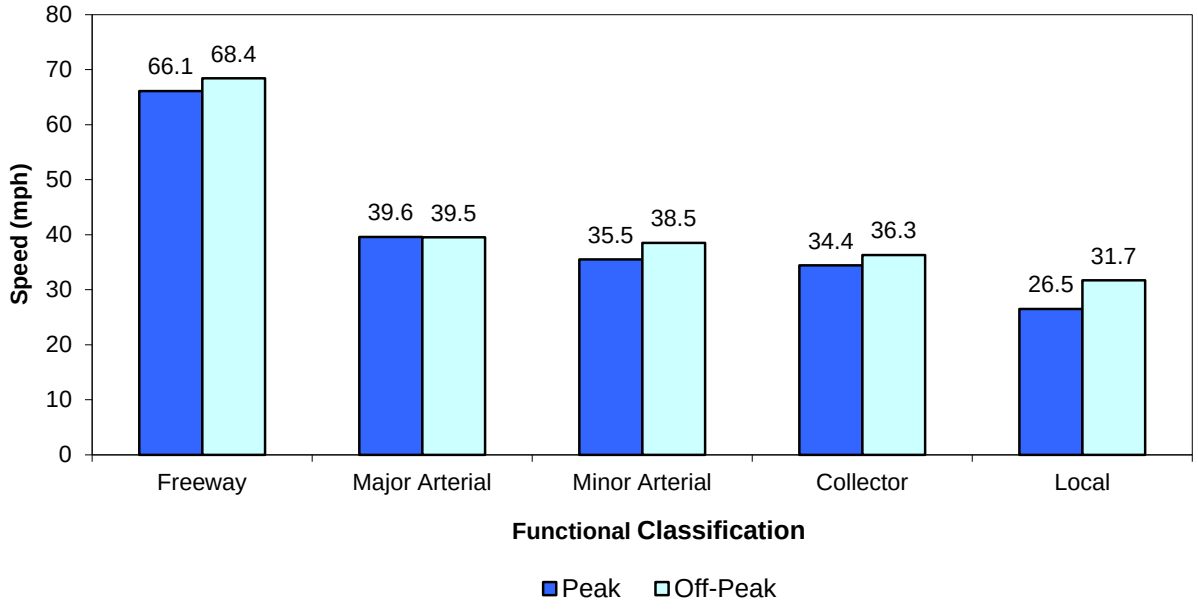

Figure 13. Rural - Average Peak vs. Off-Peak Speeds (Delay Method).

Figures 4 to 13 illustrate differences between the delay and unimpeded speeds recorded for each area type and functional class. Relatively large peak versus off-peak speed discrepancies are observed on freeways vis-à-vis other functional classes. While speeds on freeways varied from approximately 20 to 70 mph, speeds on other functional classes generally ranged from 10 to 40 mph. With the exception of rural freeways (which exhibited free-flow characteristics and only minor peak-off peak speed differentials), off-peak freeway speeds were typically 20 to 30 mph higher than peak-period speeds. Other functional classes exhibited off-peak speeds that were only slightly higher (0-5 mph) than peak-period speeds. This result indicates that freeways are more susceptible to the effects of peak-period congestion than other functional classes in the Austin area.

Comparison of Delay and Unimpeded Travel Time Data

Average speeds obtained using the unimpeded approach were higher than those recorded using the delay methodology for almost all functional class-area type combinations. This result was expected since the delay typically associated with travel through traffic control devices and intersections at segment transition areas was removed in the unimpeded approach. A side-by-side comparison of the results of the two data analysis methods is shown in Figures 14 to 23. Figures 14 through 18 show the average *peak* period speeds for each functional class within a particular area type for both analysis methods. Figures 19 through 23 provide the same comparison for *off-peak* period speeds.

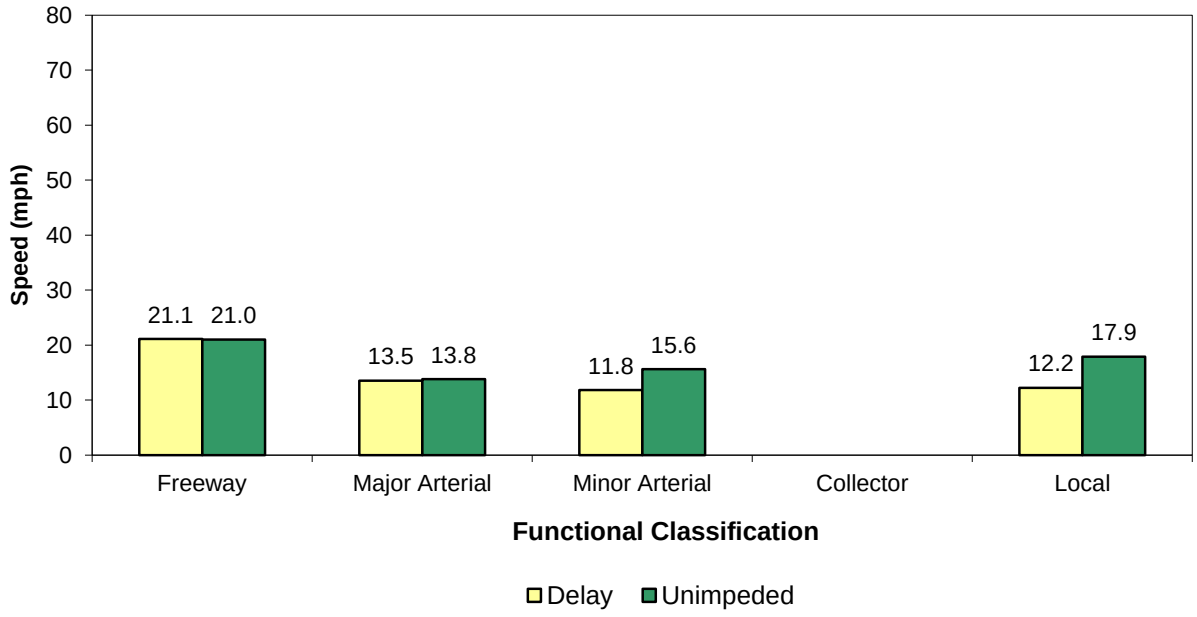

Figure 14. CBD - Average 'Delay' vs. 'Unimpeded' Speeds (Peak).

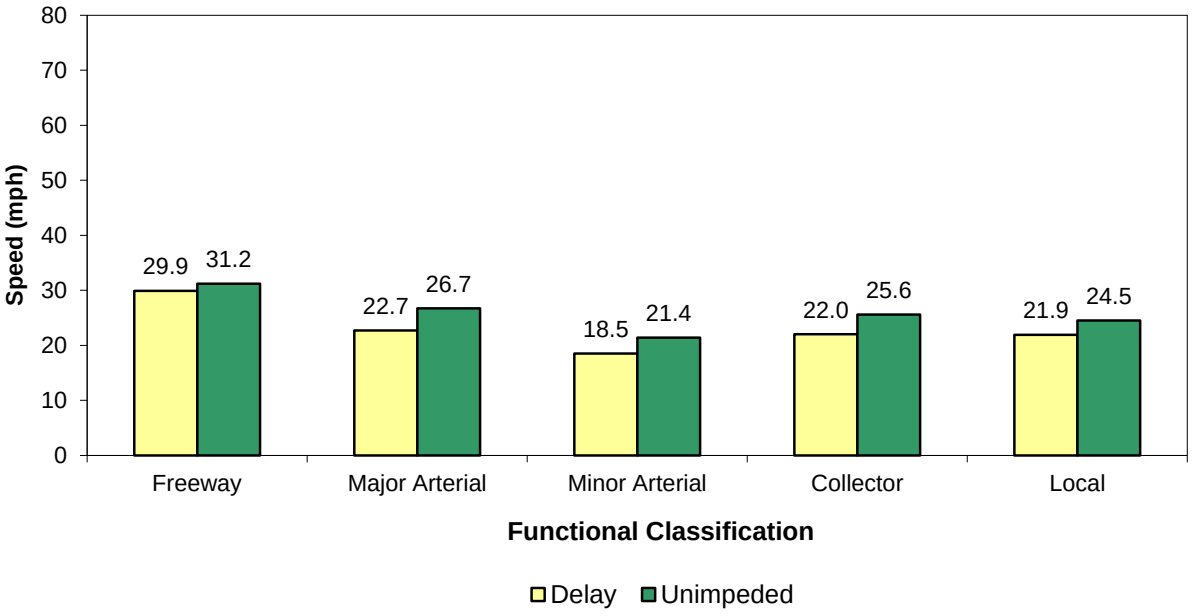

Figure 15. CBD Fringe - Average 'Delay' vs. 'Unimpeded' Speeds (Peak).

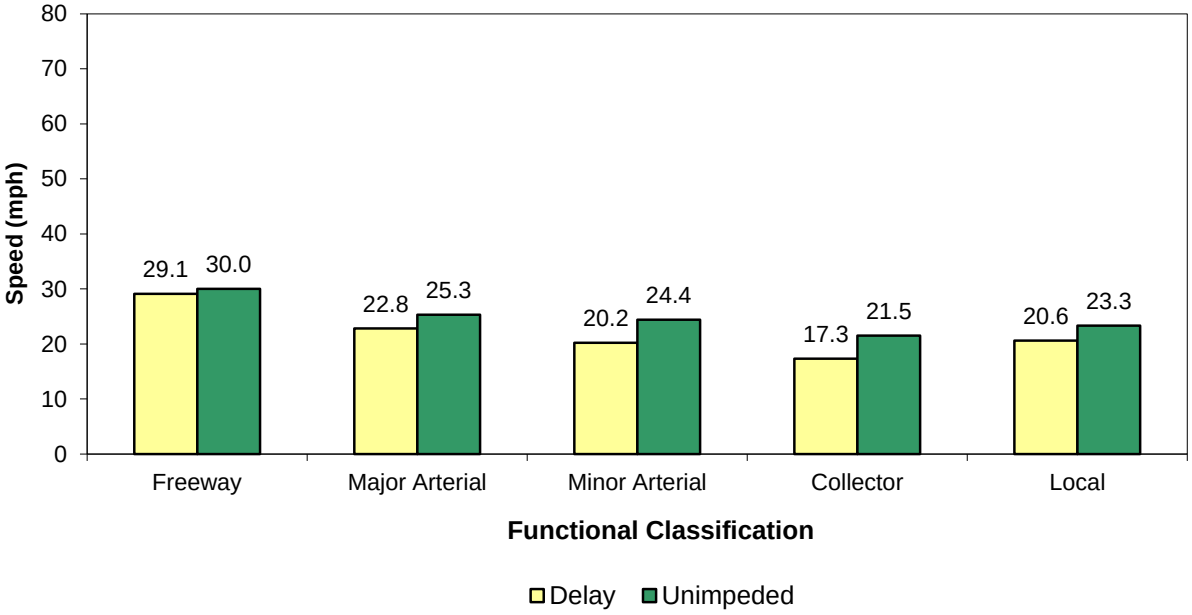

Figure 16. Urban Residential - Average 'Delay' vs. 'Unimpeded' Speeds (Peak).

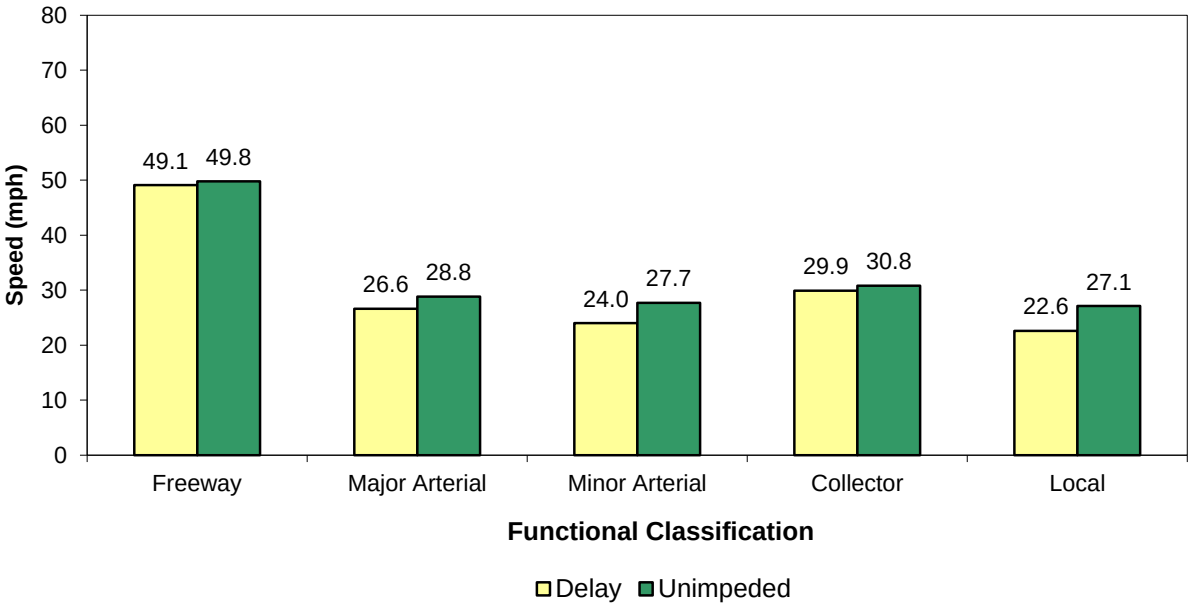

Figure 17. Suburban Residential - Average 'Delay' vs. 'Unimpeded' Speeds (Peak).

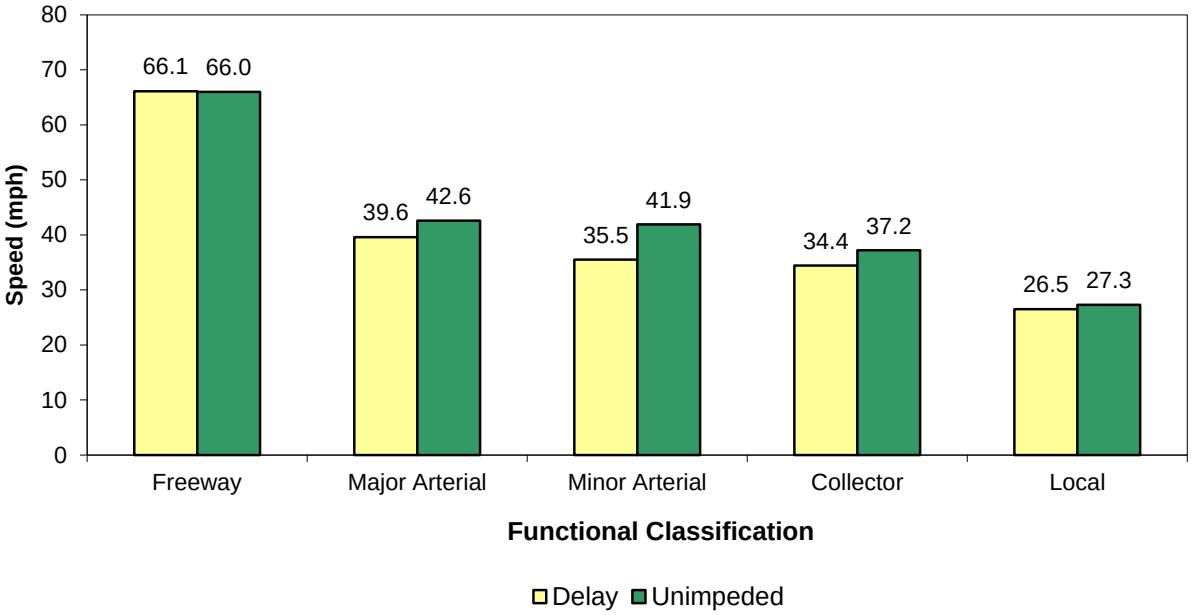

Figure 18. Rural - Average 'Delay' vs. 'Unimpeded' Speeds (Peak).

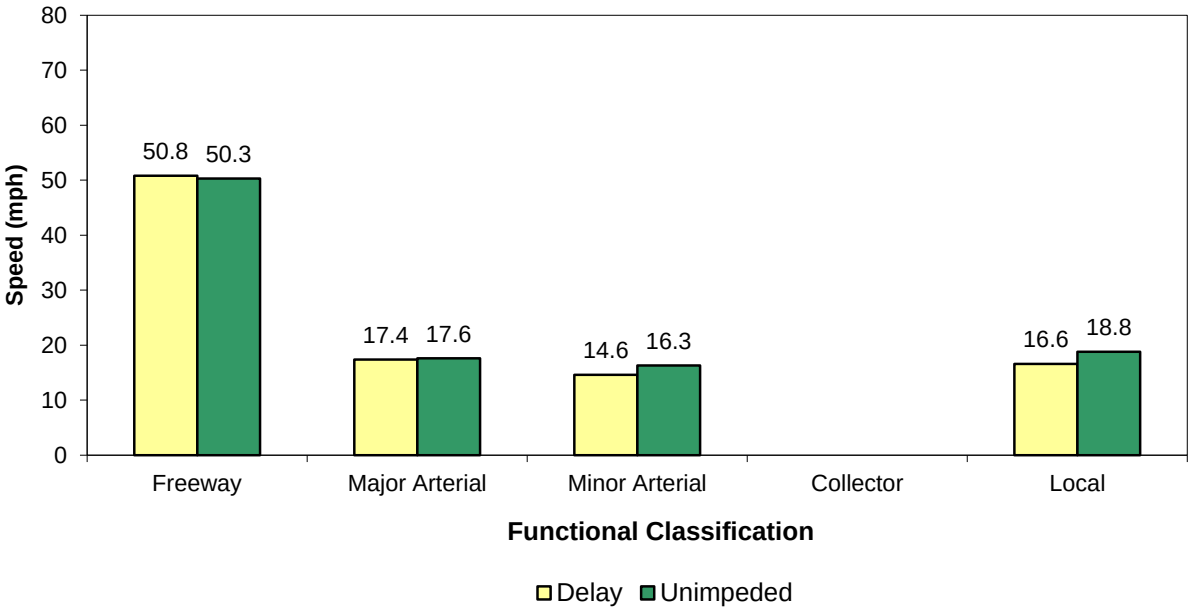

Figure 19. CBD - Average 'Delay' vs. 'Unimpeded' Speeds (Off-Peak).

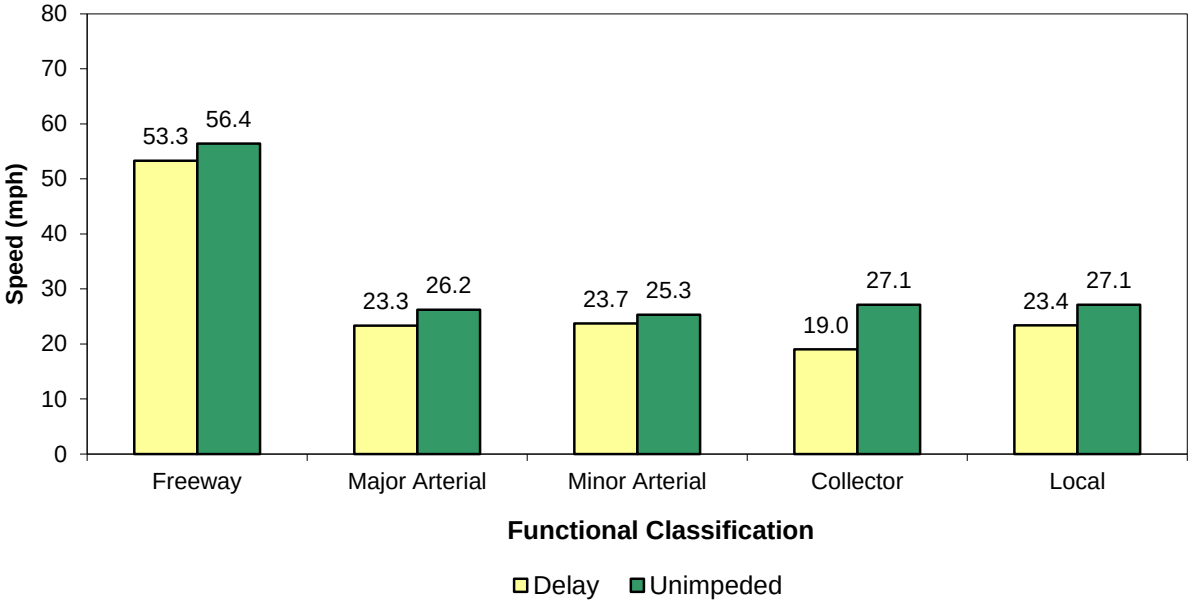

Figure 20. CBD Fringe - Average 'Delay' vs. 'Unimpeded' Speeds (Off-Peak).

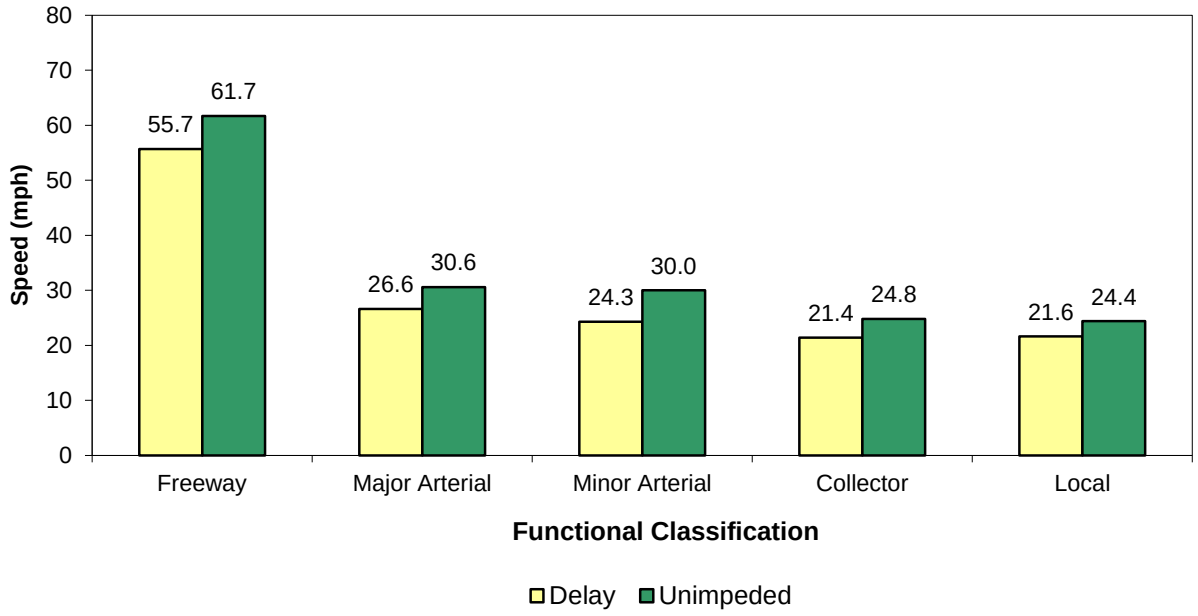

Figure 21. Urban Residential - Average 'Delay' vs. 'Unimpeded' Speeds (Off-Peak).

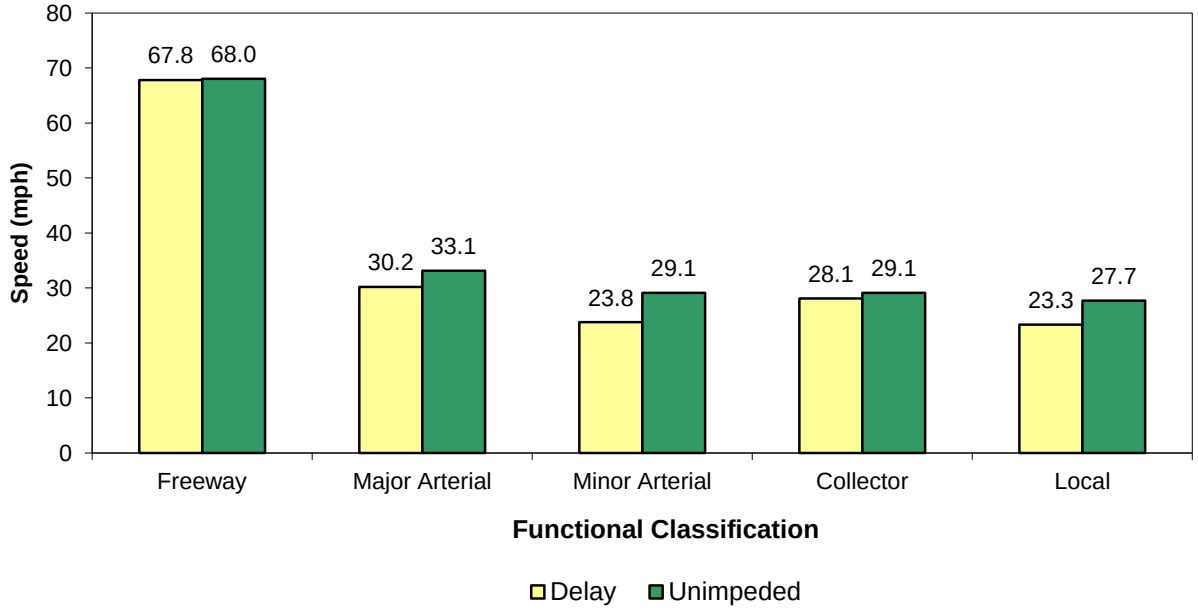

Figure 22. Suburban Residential - Average 'Delay' vs. 'Unimpeded' Speeds (Off-Peak).

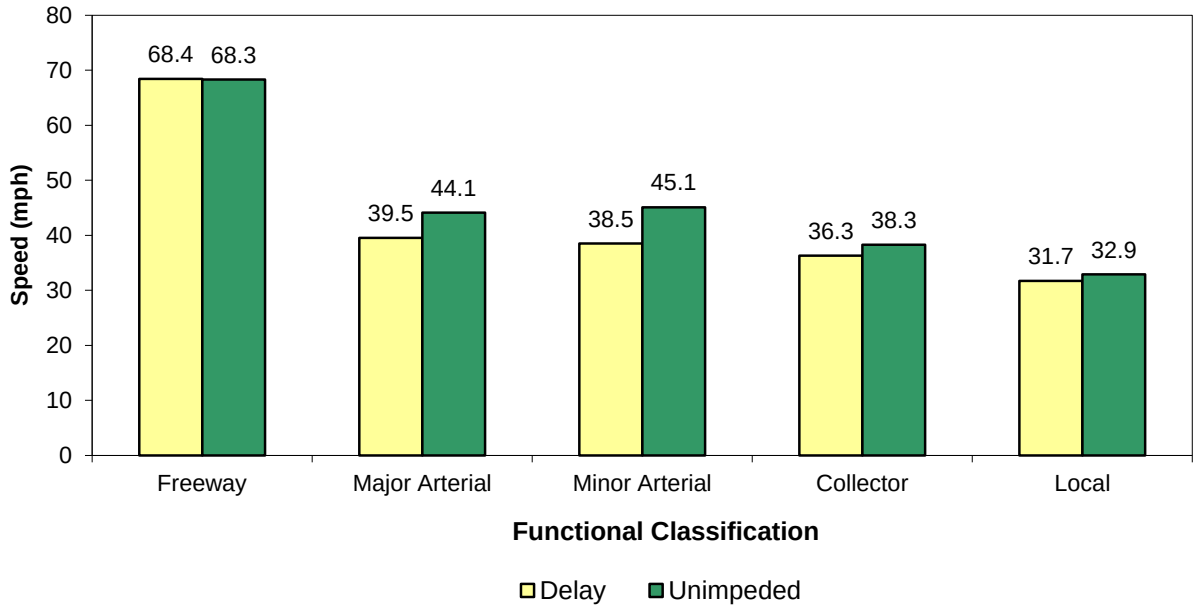

Figure 23. Rural - Average 'Delay' vs. 'Unimpeded' Speeds (Off-Peak).

Overall, freeways exhibited the least amount of delay due to slowdowns at segment transitions, while arterials, collectors and locals were more significantly impacted. The area type-functional class most adversely affected was CBD-locals during peak periods. Speeds on these segments were 5.7 mph (47 percent) higher when the unimpeded method of analysis was employed. Another roadway type whose operations were substantially impacted by delays at segment transitions were collectors in the CBD Fringe during off-peak periods. On those roadways, unimpeded speeds were over 8.1 mph (43 percent) higher than the respective speeds calculated using the delay methodology.

As previously mentioned, the size of the transition areas constructed between segments was dependent upon the maximum amount of delay observed at that location during any run. A curious feature of the data presented in Figures 14-23 is that the removal of segment transitions on CBD and rural freeways (in both the Peak and Off-Peak periods) did not result in slowing. The exclusion of these portions of travel actually yielded average delay speeds that were marginally faster than the average unimpeded speeds (calculated with segment transitions removed). These minor aberrations in the data were attributed to practical sample size limitations, freeway access controls, and the absence of traffic signals on these facilities.

The degree to which speeds on individual functional classes fluctuate with changes in activity density provides another indication of the nature and scale of congestion within an urban area. The overall difference between the slowest and fastest average speeds recorded on individual functional classes in the Austin area varied from approximately 10 mph to 40 mph. The greatest variation in speeds was observed on freeways, while the most consistent functional class speeds across all area types were recorded on local streets. The weighted averages for delay and unimpeded travel speeds for every functional class and area type combination are shown in

Tables 9 and 10. Speeds on all functional classes exhibit an increasing trend as activity density goes from high (CBD area type) to low (Rural area type).

Table 9. Overall Average Speeds – Delay Method.

Functional Class / Area Type	Freeway	Major Arterial	Minor Arterial	Collector	Local
Central Business District	29.8	15.2	13.0	-	14.1
CBD Fringe	38.3	23.1	20.8	20.4	22.6
Urban Residential	38.2	24.6	22.1	19.1	21.1
Suburban Residential	57.0	28.3	23.9	29.0	22.9
Rural	67.3	39.6	36.9	35.3	28.8

Figures in miles per hour.

Table 10. Overall Average Speeds – Unimpeded Method.

Functional Class / Area Type	Freeway	Major Arterial	Minor Arterial	Collector	Local
Central Business District	29.6	15.5	16.0	-	18.4
CBD Fringe	40.1	26.5	23.2	26.3	25.7
Urban Residential	40.4	27.7	26.9	23.1	23.8
Suburban Residential	57.5	30.8	28.4	29.9	27.4
Rural	67.1	43.3	43.4	37.8	29.9

Figures in miles per hour.

Another method of illustrating discrepancies between the unimpeded and delay results is speed differentials. These differentials are calculated by subtracting the average speed obtained through the delay method of analysis from the average speed obtained using the unimpeded approach. The magnitude of speed differentials for functional class-area type cohorts in the Austin area is listed in Table 11 and shown graphically in Figure 24. The results of this analysis show that the minor arterial and collector functional classes and the CBD Fringe and Urban Residential area types in Austin are most adversely affected by slowdowns and delays at signalized intersections and other segment transitions.

Table 11. Overall Speed Differentials Between Unimpeded and Delay Methods.

Area Type \ Functional Class	Freeway	Major Arterial	Minor Arterial	Collector	Local
Central Business District	-0.2	0.2	2.9	-	4.3
CBD Fringe	1.8	3.4	2.4	5.9	3.1
Urban Residential	2.1	3.1	4.8	3.9	2.7
Suburban Residential	0.5	2.5	4.5	0.9	4.5
Rural	-0.1	3.8	6.5	2.5	1.0

Figures in miles per hour (may not reflect values in previous tables due to rounding).

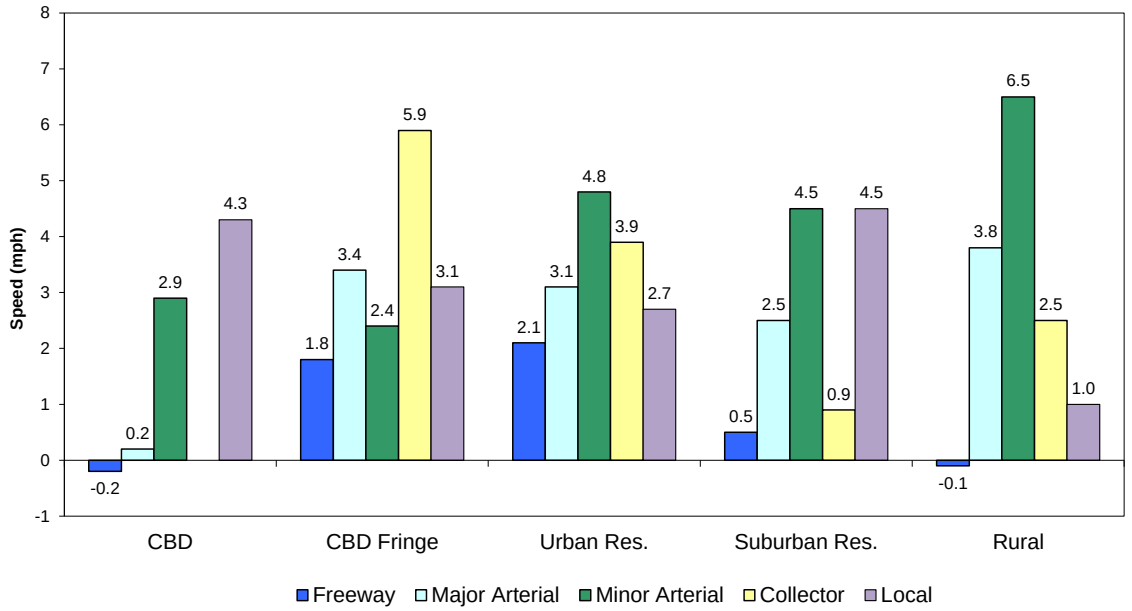

Figure 24. Speed Differentials (Average Unimpeded – Average Delay Speeds).

After disaggregating the travel time data and examining it by functional class, area type, peak and off-peak period, and the "unimpeded" and "delay" methods of analysis, an aggregate comparison of Austin speeds was performed. Figure 25 presents the average peak-period speeds for each functional class across all area types using the delay method of analysis. The results show speeds dropping off sharply between freeways and major arterials, and then declining gradually from major arterials to local streets. An intermediate rise in speeds was observed on Austin-area collectors.

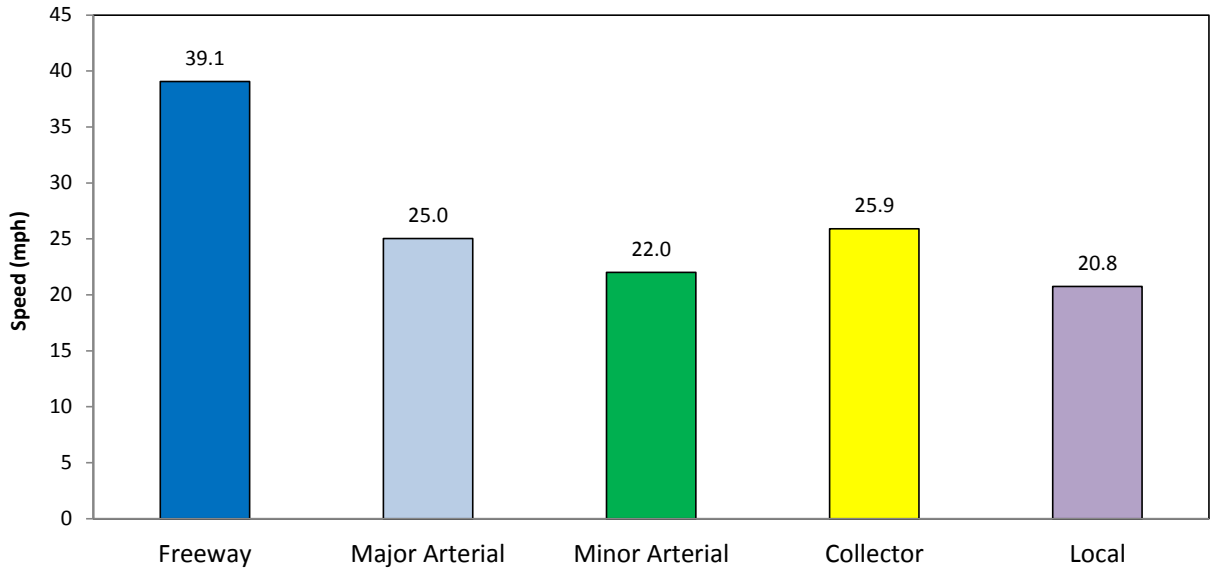

Figure 25. Average Peak Speeds for All Area Types (Delay Method).

Finally, a comparison of average AM and PM delay speeds was performed for each functional classification-area type combination. This comparison, shown in Figure 26, indicates that morning travel speeds on most Austin-area freeways and arterials (particularly through the CBD and CBD fringe area types) are moderately to significantly higher than afternoon speeds. The most noticeable trend with respect to area type concerned rural PM travel speeds. Unlike speeds recorded in other area types, rural PM speeds were typically comparable to or slightly higher than corresponding AM speeds. These results highlight functional class (predominantly freeway) and activity-density (non-rural) components of traffic congestion in the Austin area.

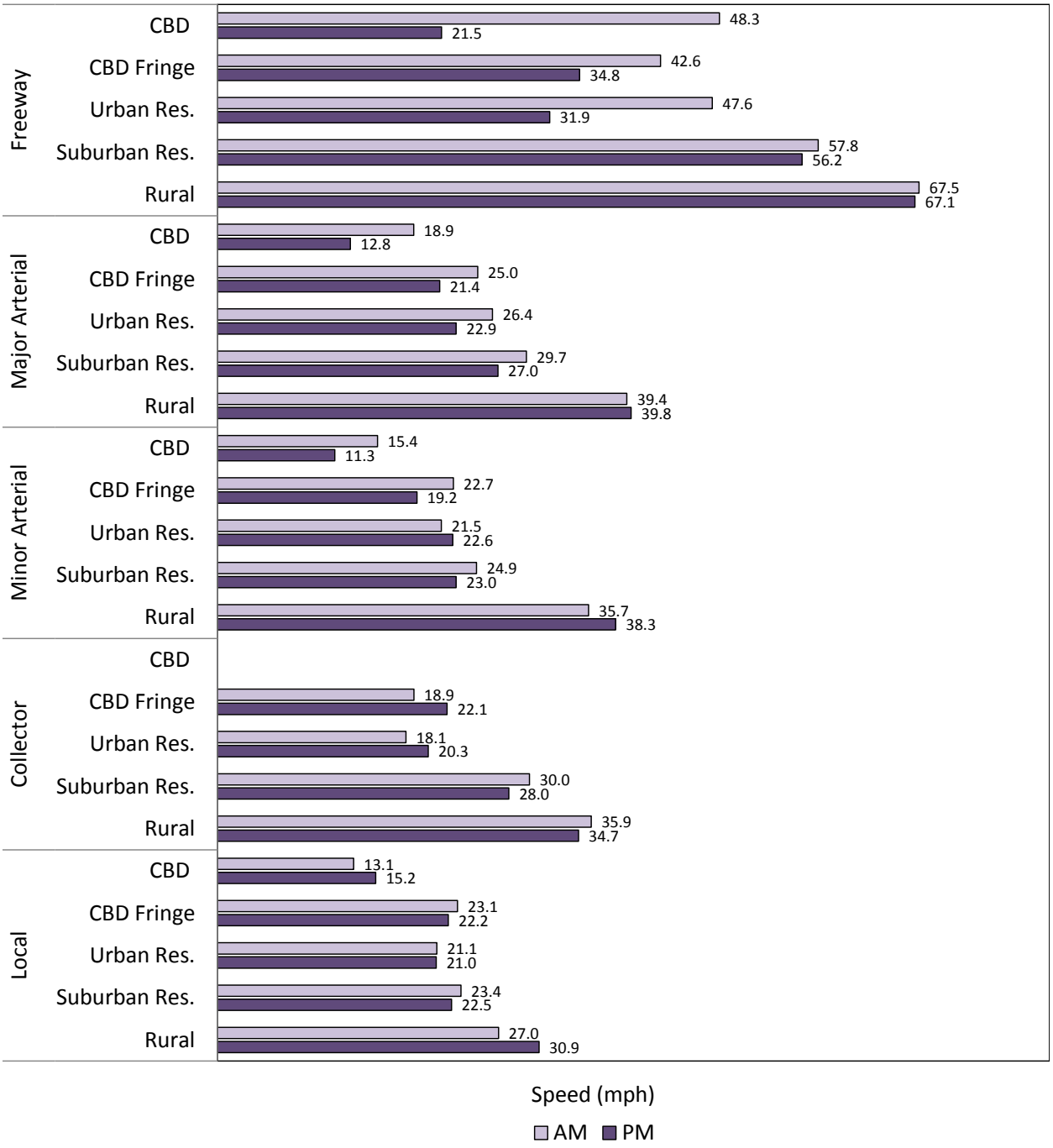

Figure 26. AM and PM Average Speeds (Delay Method).