REGIONAL PRIORITIZATION OF CORRIDORS FOR

TRAFFIC SIGNAL RETIMING

by

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Dedicated to my parents

Mrs. Lakshmi Devi and Mr. Markandeya

and to my country India.

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ABSTRACT

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Every three to four years, the North Central Texas Council of Governments (NCTCOG) funds signal retiming projects to improve air quality in the Dallas-Fort Worth region. As sufficient funds are not available to retime all the signals in the region at the same time, the retiming must be completed in phases. To optimize the impact of the retiming projects, the candidate corridors must be rank ordered or prioritized. NCTCOG applies a ranking model, which uses variables such as delay, number of stops and system type, a dummy variable indicating the interconnection among the intersections. The weighting for each factor is assigned by an expert group.

This thesis proposes a new, improved methodology based on signal retiming benefits rather than the severity of existing traffic conditions. Benefits are estimated from the before and after studies conducted along the corridors where retiming has been executed recently. Benefits in delay, fuel consumption and emissions are to be modeled in terms of various physical characteristics and traffic flow characteristics of the corridors. This model helps in estimating benefits beforehand and prioritizing the retiming projects based on these benefits. Appropriate conversion rates are identified to convert all benefits into dollars.

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CHAPTER 1

INTRODUCTION

According to the Institute of Transportation Engineers (2004), there are about 300,000 traffic signals in the United States. Delay at signalized intersections is a major part of total vehicular traffic delay. Traffic signal retiming is one of the most cost effective ways to reduce delays and is one of the most basic strategies to help mitigate congestion. Signal retiming can reduce variations in vehicle-speeds, which reduces vehicle emissions and improves the air quality of a region. After three to four years, traffic signals may need to be retimed, where new timing plans are established to match the current demand.

This research is concerned with the signal retiming projects proposed in the Dallas-Fort Worth (DFW) region. Figure 1.1 shows the DFW area in the United States map. DFW is a moderate non-attainment zone for Ozone with respect to air quality requirements. The North Central Texas Council of Governments (NCTCOG), the metropolitan planning organization for this region, funds signal retiming projects in this region. NCTCOG works with an aim of improving air quality as well as congestion through these projects.

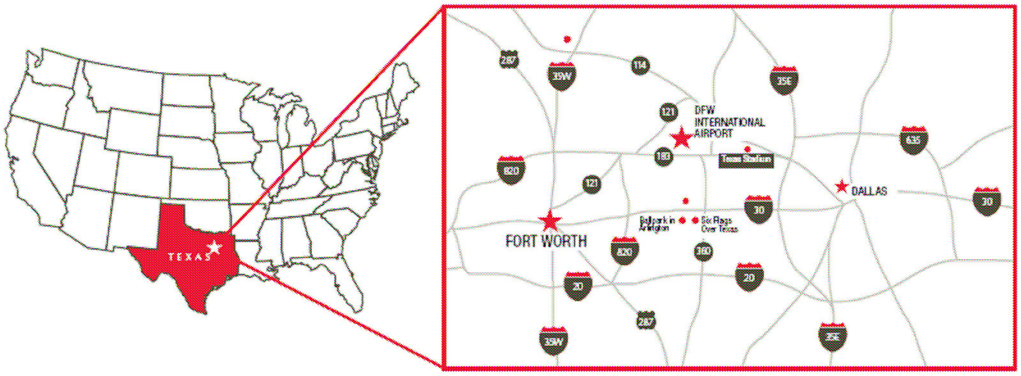


Figure 1.1 Map showing Dallas-Fort Worth region in the U.S. (source: www.fortworth.com)

As sufficient funds are not available to retime all the signals in the region at the same time, the retiming must be completed in phases. For each phase, candidate corridors must be prioritized to make sure the funds are efficiently used. NCTCOG has its own ranking model, which uses delay, number of stops and a dummy variable, system type. Here, system type indicates whether or not the signals along a corridor are connected to a coordinated system. Delay and number of stops are used to indicate the severity of the existing traffic conditions.

This thesis presents a new methodology for prioritization, which models expected benefits based on both the system's physical characteristics and traffic conditions before signal retiming. In this methodology, all benefits such as reduction in delay, fuel consumption and emissions are converted into monetary terms using a reasonable dollar rate. While this thesis proposes the structure for this model, the model itself is not estimated because the before and after studies associated with the recent traffic signal retiming projects in this region have not been completed.

This thesis first introduces traffic signal retiming and then talks about the need for prioritization of signal retiming projects. Existing methodology used by the NCTCOG is discussed before proposing a new methodology.

The second chapter defines traffic signal retiming and thoroughly discusses how it is implemented. The problem statement is given in chapter three. Chapter four reviews some earlier research on prioritization of projects, while the need for prioritization of signal retiming projects and various factors involved in such an effort are discussed in chapter five. NCTCOG's ranking methodology for prioritizing signal retiming projects is explained in chapter six. Chapter seven demonstrates how corridor benefits from signal retiming are estimated. The proposed methodology is explained in chapter eight. Chapter nine concludes this thesis with some recommendations for future research.

CHAPTER 2

TRAFFIC SIGNAL RETIMING

According to the Institute of Transportation Engineers (ITE), traffic signal retiming is one of the most cost efficient methods to solve traffic congestion problems and to improve air quality (ITE, 2006). Every time signals at an intersection are adjusted or new signals are installed, a traffic engineer's aim is to make them operate at the most efficient timing. A traffic signal system is efficient when it produces the least possible delays and number of stops at that intersection with some limitations such as any delays caused due to pedestrian crossing time.

Because of continuous growth in traffic and variation in travel patterns, the efficiency of a traffic signal system may deteriorate. Hence, retiming the signals may be necessary once every three to four years or when traffic patterns change considerably. Sunkari (2004) encourages retiming signals every three years to reduce growth in user costs. Figure 2.1 shows how user costs decrease in a case where signal retiming is done after 3 years and 6 years.

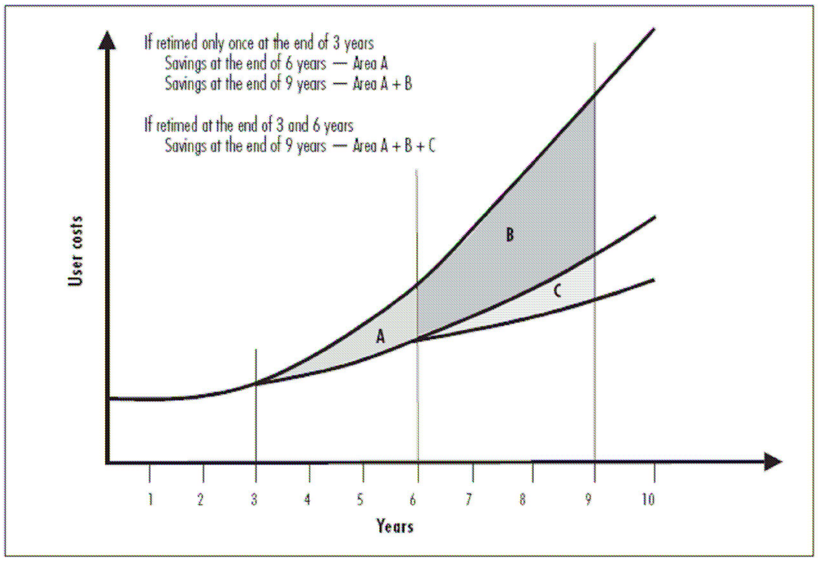


Figure 2.1 User costs vs. number of years for two different signal retiming scenarios (source: Sunkari (2004))

Signal retiming is defined by Sunkari (2004) as**:**

Traffic signal retiming is a process that optimizes the operation of signalized intersections through a variety of low-cost improvements, including the development and implementation of new signal timing parameters, phasing sequences, improved control strategies and, occasionally, minor roadway improvements.

2.1 Corridor-Based Signal Retiming

Traffic signal retiming can be implemented at a single intersection, or a group of intersections can be retimed at the same time. In deciding whether to retime a single intersection or a group of intersections, both operational and funding issues should be taken into account.

When an intersection is isolated, where operation at this intersection does not affect any subsequent intersections, it is usually retimed individually. When a group of intersections have a short spacing, operation at one intersection affects operations at other intersections. In this case, all interrelated intersections should be coordinated to obtain the highest efficiency. The starting of green time at any intersection depends on the time taken for a vehicle to reach the intersection.

Coordinatability is the desirability of coordinating intersections. Synchro 6 (Husch and Albeck, 2004) develops a Coordinatability Factor (CF), which is an indicator for the need for coordinating signals. The CF is based on numerous input variables: volume, travel time, distance, vehicle platoons, vehicle queuing and natural cycle length.

Generally when allocating funds, retiming signals along a street or a part of it is considered as a single corridor. A group of such corridors can be combined into one project when awarding it to a consultant. As similar traffic is flowing through all the intersections, retiming of a signal separately may cause major delays at subsequent intersections. If the street is so long that traffic patterns change considerably at some points, these points may be taken as break points. For example, a major highway crossing the arterial street or a jurisdictional boundary can become a break line.

Also, travel time studies along a corridor give more meaningful results than at a single intersection. Cost of data collection and analysis along the whole corridor will be less than that of each intersection separately. A whole corridor or group of corridors that are part of a single project can be retimed for a lower price than individually.

2.2 Benefits of Signal Retiming

Traffic signal retiming improves traffic flow conditions with a low cost. One should clearly understand the benefits of signal retiming to decide whether or not to retime a set of intersections. Sunkari (2004) discusses many benefits, both direct and indirect, associated with signal retiming; these include:

- Reduced delay experienced by motorists, which is more apparent to users traveling along a street with a coordinated system of signals.
- Fewer stops at red lights and reduced fuel consumption.
- Less motorists' frustration caused by less delays and stops, which improves safety.
- Reduced numbers of accelerations after stopping at red lights also reduces emissions. Emissions during acceleration are often an order of magnitude higher than when a vehicle traveling at a constant speed.
- Reduced fuel consumption reduces emissions and improves air quality.
- Less diversion of traffic to local and residential neighborhoods, potentially improving safety and traffic conditions in those areas.
- An opportunity for operating agencies to conduct quality control checks on controller settings for pedestrian, preemption and priority requirements.

Because of their lower costs, traffic signal retiming projects have a benefit to cost ratio of about 40:1 (Sunkari, 2004). Sunkari (2004) describes some of the successes associated with traffic signal retiming projects all over the United States.

2.3 The Process of Signal Retiming

The Federal Highway Administration (FHWA) and ITE have been championing the benefits of signal retiming and encouraging cities and road authorities to implement this low cost alternative to improve roadway conditions. Their video, "It's About Time, Traffic Signal Management: Cost-Effective Street Capacity and Safety" on signal retiming briefly explains the process of retiming. Sunkari (2004) discusses a detailed method for conducting signal retiming, which is summarized in the rest of section 2.3.

2.3.1 Existing data collection

- Existing geometric conditions and other pertinent information about the corridor are gathered.
- Current traffic conditions during peak traffic periods, as well as traffic counts including through and all turning movements at intersections, are collected. Pedestrian volumes on all the crosswalks are also collected simultaneously.
- Travel time data between the two ends of the corridor are also collected to assess the present operating conditions.
- Crash data along the corridor for the last three years are obtained and analyzed to determine whether or not a change in the signal operation would provide safer conditions.

2.3.2 Signal optimization

Signal optimization can be achieved using a software although manual methods also are available.

- The existing network is coded in signal optimization software using the data collected. Existing timing and turning movements are applied and capacity and LOS are determined.

- Software such as Synchro or Passer II is used to optimize the timing splits and determine the offsets for the coordination. Synchro has a factor called coordinatability factor, which gives an idea whether to go forward with coordination. The coordinatability factor is a measure of the desirability of coordinating the intersections. Later, simulation software such as CORSIM can be used to test the effectiveness of a proposed timing plan.

2.3.3 Implementation

The new timing is implemented at the intersection(s). It is evaluated in the field during various critical time periods and final adjustments are made. Sometimes, travelers' complaints are also taken as guidance.

2.3.4 Documentation

Before and after studies are conducted to document the improvements resultant of the signal retiming. Travel time and delay studies are conducted just before implementing the new timing. When the final timing plans are in place, travel time and delay studies are conducted again. These are called 'after' studies. Results are compared with 'before' studies and benefits are documented.

The next chapter describes the objectives of this thesis.

CHAPTER 3

PROBLEM STATEMENT

NCTCOG is conducting retiming projects for many of the corridors in the DFW area. This is being done in various phases. This thesis considers the selection of these projects among all candidate corridors in the Metroplex. NCTCOG officials indicate that they have more than one method for selecting these corridors. One of them is a sophisticated strategy where a ranking model is used to prioritize the corridors. As a baseline scenario, this serves as starting point of this thesis. This research develops a methodology to critically analyze this model and measure its effectiveness in project selection. In the process, the author proposes a modified and more efficient methodology, which can be used for prioritization of signal retiming projects.

The objectives of this thesis are summarized below:

- To understand the importance of traffic signal retiming and the process of signal retiming,
- To comprehend the need for prioritization of signal retiming projects,
- To study current methods in selecting retiming projects,
- To know how the NCTCOG's ranking model methodology works and determine any disadvantages in using the model,
- To gain knowledge about the before and after studies for signal retiming and identify a method for calculation of benefits,

- To propose a new and more efficient methodology for prioritizing the corridors, and

A review of research on prioritization of transportation related projects is discussed in the next chapter.

CHAPTER 4

PRIORITIZATION OF PROJECTS – A REVIEW

Various MPOs and cities have well-documented procedures for selection of major development projects. Developments related to such things as roadway alignment, addition of lanes, building a new highway alignment come under major developments. These require a higher range of funds than signal retiming. Turochy (2001) discusses methods used by various states throughout the United States to prioritize transportation improvement projects. There are methods documented by various departments for particular improvement projects. Unfortunately, low cost developments, such as signal retiming, are not well documented, and little to no research is found on prioritization of signal retiming projects.

Witkowski (1992) developed a method for prioritizing signalized intersection operational deficiencies in the City of Tucson, Arizona. He described a two-level screening process for evaluating short to medium term improvements for signalized intersections. These improvements also cost significantly more than signal retiming.

Accident history at an intersection used to be the basis for initial screening of signalized intersections in the City of Tucson. Witkowski (1992) proposed a parallel screening of the intersections for operational and safety deficiencies. A Deficiency Index (DI) was proposed for ranking the operational deficiencies, and the priority order would be based on the decreasing order of DI.

Witkowski studied twenty-one independent variables, which fall into five basic categories: traffic volume, present peak hour traffic operations, safety, air quality and transit operations. He developed a linear utility function for DI, which takes the form:

$$DI = W_1X_1 + W_2X_2 + \ldots + W_nX_n \qquad (4.1)$$

where X_i is the normalized value of criterion i and W_i is the weighting applied to criterion i. He judged the interdependence of criteria using linear regression analysis techniques. The impact of the criteria and their weighting on the ranking was based on a sensitivity analysis.

He used accident rates for the last three years before present date, but the accident rate did not significantly affect the ranking and was ignored. In his sensitivity analysis, he examined the variation in ranks, when removing one variable at a time. As a second step of ranking, different weightings were used for different variables and the sensitivity each time was examined. Witkowski tries to prioritize the intersections with operational deficiencies, while this thesis prioritizes various corridors in need of retiming.

When data cannot be quantified for use in the ranking process, a multiple criteria decision making tool, such as the Analytic Hierarchy Process, can be used for prioritizing alternatives (Guegan, 2000). Guegan et al. (2000) applied this tool to prioritize traffic calming projects. They used traffic volumes, vehicle speeds, emergency vehicle access and pedestrian facilities and safety as the criteria for evaluation of each alternative. Need for prioritization of signal retiming projects and some of the existing procedures followed in the DFW area are given in next chapter.

CHAPTER 5

PRIORITIZATION OF SIGNAL RETIMING PROJECTS

5.1 Need for Prioritization of Signal Retiming Projects

ITE and the FHWA recommend that every three to four years or whenever traffic patterns change significantly, signals should be retimed. Retiming each intersection takes less than three thousand dollars and is considered a minor project. Unfortunately, many cities and MPOs neither have funding nor staff and expertise to achieve this task, which may increase this cost. As cities face recurring congestion on roads and poor air quality, they may begin to realize the importance of undertaking retiming projects.

Normally, transportation planning organizations organize the funding for these projects just as they do for other projects. When there are a number of corridors to be retimed, there may not be sufficient funds to complete all the projects.

This research examines strategies for retiming projects throughout the United States through an informal e-mail survey of transportation departments. Survey recipients were selected randomly form the FHWA Directory of MPOs. The following is the survey question:

"Suppose if you have a list of corridors to be retimed and there is not enough money, how do you pick the most important projects?"

The list of nineteen organizations to which the survey was sent is given in Appendix A. The following seven organizations replied for the survey.

- City of Indianapolis
- Knoxville Regional Transportation Planning Organization
- Miami-Dade Public Works
- S. California Association of Governments –Ventura County
- S. California Association of Governments – Riverside County
- Metropolitan Orlando, Florida
- Michigan Department of Transportation

None of the organizations that responded has a prioritization method for signal retiming projects. In fact, two of the seven respondents indicate that they did not have funds or staff to conduct retiming on regular basis. They only conduct retiming when the signals are upgraded or a significant number of complaints are lodged about the signals. One of them uses their congestion management system plan to identify the corridors and another uses a Congestion Mitigation and Air Quality Improvement Program (CMAQ) selection process. All the seven responses from various departments for this query are given in Appendix A.

This research is concerned with the signal retiming projects proposed in the DFW region, which is a moderate non-attainment zone with respect to Ozone air quality requirements. The NCTCOG funds signal retiming projects in this region. As mentioned in the NCTCOG's public meeting in March 2006, apart from implementing new signal timing, a traffic signal retiming project may include:

- Installation of new traffic signal controllers,
- Replacement of existing traffic signal controllers,
- Replacement of vehicle detectors (loop, video, etc.),
- Installation of communication equipment, and
- Installation of communication software.

An effort is being made to retime all the traffic signals in DFW area which have not been retimed in the last three years. NCTCOG works with an objective of improving air quality as well as reducing congestion through these projects.

For a region such as DFW, the number of corridors to be retimed is too high to be completed at one time due to insufficient funds and limited staff availability. Hence, retiming of signals is completed in phases. For each phase, candidate corridors must be prioritized to make sure the funds are efficiently spent.

5.2 Existing Procedures in Dallas-Fort Worth Region

In the DFW region, NCTCOG, Texas Department of Transportation (TxDOT) and the member cities are involved in the retiming of traffic signals. NCTCOG does the programming to get funds allocated from the FHWA and the Federal Transit Administration (FTA). In 2002, NCTCOG conducted the most recent regional signal retiming effort. NCTCOG tries to retime signals every three years. At present, signal retiming projects come under the Thoroughfare Assessment Program.

Cities provide an initial set of candidate corridors, because they know the corridors that have severe problems. Each city may have any number of corridors in its jurisdiction where they think travel times are adversely affected and signals should be retimed, but on some corridors, there may not be enough capacity to satisfy demand. In some circumstances, other roadway improvements may be occurring which may increase capacity. NCTCOG examines these corridors for such issues and removes them from the list. In 2004, NCTCOG came up with about 200 corridors around the metropolis. Retiming of some corridors may affect other corridors significantly. For example, performance on downtown streets is very much interlinked. In such cases, a group of corridors will be considered as a single project and retiming will be done all at once.

Due to limited funds, not all proposed corridors can be retimed at the same time. Corridors should be selected in such a way that funds are used most efficiently. One of the approaches that the NCTCOG uses to come up with a priority list of projects is a ranking model. In another strategy, a group forum approach, each city gives a list of corridors ordered with respect to importance. A group of experts discusses each one and comes up with a priority list. The ranking model method is explained in detail in the next chapter.

5.3 Factors Affecting the Prioritization of Retiming Projects

Various factors that make signal retiming necessary should be considered when prioritizing these projects.

5.3.1 Delay

The reduction of travel time along a corridor is one of the major benefits of signal retiming. Vehicle delay along a corridor occurs when a vehicle's travel time increases above the desired travel time. The desired travel time is the time taken to travel along a corridor at the desired speed, which is normally free flow speed. If the free flow speed is not available, the speed limit can be used as a surrogate. Total corridor delay is the delay of an individual vehicle multiplied by the traffic volume along that corridor. When ranking retiming projects, a project with the potential for a higher reduction in delay should be given more priority.

5.3.2 Number of stops

The number of stops along a corridor is counted as the total number of occasions where the vehicle speed drops below a specified speed, typically five to ten mph. It is represented as number of stops per vehicle-mile. One can multiply this by the total traffic volume along a corridor to get the total number of stops per mile. The number of stops increases the fuel consumption and the emissions because there are accelerations and decelerations associated with the stops. Stopping at more intersections also increases driver frustration. The number of stops along a corridor may be measured by performing travel time runs along the corridor. Projects that are going to have a greater reduction in the number of stops should receive priority.

5.3.3 Fuel consumption

When the variation in speeds after retiming decreases, fuel consumption is expected to decrease. Sunkari (2004) gives examples where fuel consumption reduction related to signal retiming can be as high as nine percent. Fuel consumption can be estimated using travel time measuring instruments or by simulation. Fuel consumption is represented in gallons per vehicle mile. Projects which result in higher reductions in fuel consumption should receive higher priority than other similar projects.

5.3.4 Emissions

Emissions can be measured in real time or they can be estimated through simulation or from traffic signal retiming software. Some of the travel-time measuring instruments may also provide emission estimates. Since signal retiming is expected to reduce emissions and improve the air quality, a project with a greater reduction in emissions should receive higher priority.

5.3.5 Safety

Sunkari (2004) writes that signal retiming indirectly reduces driver frustration, which reduces red light running. Red light running is one of the major causes of crashes (Tindale and Hsu, 2005); therefore, a reduction in red light running improves intersection safety. In a successful example given by Sunkari (2004), adjusting the signal timing in Lexington, Kentucky reduced crashes by thirty-one percent.

However, based on a study of crashes on a coordinated one-way street in Florida, Tindale and Hsu (2005) suggest that signal coordination can be an incentive for red light running. They indicate that drivers may speed or engage in other unsafe behavior to stay in the platoon of the traffic flow. The perception is that this can ensure their passage through the corridor without stopping. Safety may have to be considered as a dis-benefit under some circumstances; its exact impact depends on each particular case.

One should study the crash reports along a corridor to come up with a measure for safety along the corridor. Often, the determination of the cause of a crash is difficult; it may be signal timing or some other reason. Many years of crashes need to be studied to get reasonable data. Every time that signals are retimed, users take a little while to adapt to the new system. Once the system starts to run smoothly, determining the need and specific time for retiming with respect to safety becomes difficult without careful monitoring.

Factors such as delays and emissions can be measured immediately before and after signal retiming, but this is not the case with crashes, unless there is a sudden and statistically significant change in number of accidents. For all of these reasons, safety is not considered in this research.

The ranking model used by NCTCOG is explained in detail in the next chapter.

CHAPTER 6

NCTCOG'S RANKING METHODOLOGY

When arranging the projects in a priority order, the first question that arises is that what should be the basis for ranking. The corridors are being retimed because the traffic conditions have worsened along the corridor. Some preliminary data should be collected to estimate the severity of traffic conditions along each corridor.

6.1 Corridor Data

NCTCOG asked a consultant to perform travel time studies on each of the corridors on the initial list. Because this is only for a preliminary analysis, only one travel time run per direction on each of the corridors was performed. For each run, travel time from one end to the other end of the corridor and the number of stops were measured.

Besides the travel time information, other related data for all the corridors was compiled. This data included the following:

- Length of corridor and the number of signalized intersections to be retimed along the corridor.
- Speed limits and travel time at speed limit.
- Average daily traffic for the current year – this is calculated after applying growth factor to the latest available average daily traffic value.

- System type – whether or not the traffic signals are part of an existing interconnected system.

The entire set of data obtained from the NCTCOG is inserted in Appendix B.

6.2 The Model Used by NCTCOG

The NCTCOG ranking model is based on the existing traffic conditions. The variables used in the model and their weights are discussed in this section.

6.2.1 Variables

6.2.1.1 Total delay

Delay is the most frequently used measure of effectiveness for signalized intersections. Delay can be quantified in many different ways: stopped time delay, approach delay, travel time delay and time-in-queue delay (McShane and Roess, 1998). Travel time delay is used in this research. Travel time delay of an individual vehicle is the difference between the measured travel time and the travel time at the desired speed. Measured travel time is taken as an average of travel time in both directions of travel. The desired speed is taken as the posted speed. In this model, delay is used on an aggregate basis, and it is calculated below:

DPV = delay/vehicle/intersection

= (measured travel time – desired travel time)/ (number of intersections) (6.1)

Total delay/ intersection = DPV x ADT (6.2)

Where ADT is the average daily traffic.

6.2.1.2 Number of stops

The number of stops is taken as the average of the number of stops counted in both directions of travel along the corridor. To get the aggregate value, this average value per intersection is multiplied by the ADT.

Number of stops per intersection =

$$(\text{Number of stops/number of intersections}) \times \text{ADT} \quad (6.3)$$

6.2.1.3 System type

There are three types of existing systems. A value of one indicates that all intersections are part of an existing interconnected system with communications. A value of two indicates that some but not all intersections are part of an existing interconnected system with communications. A value of three indicates that there is no system (currently an isolated operation).

6.2.2 Weightings

The weighting for each factor is allocated by an expert group. The weightings are presented in Table 6.1.

Table 6.1 Variables Used in NCTCOG's Ranking Model and Their Weightings

Variable	**Weighting**
Total Delay (DELAY)	50%
# of stops (STOPS)	30%
System type (SYSTEM_TYPE)	20%

6.3 Calculation of Rank Order

Using the weightings applied by the NCTCOG, the following equation is developed.

$$Total\,Score(S) = \frac{DELAY}{Max(DELAY)} \times 50 + \frac{STOPS}{Max(STOPS)} \times 30 + SYSTEM\_TYPE \times 20 \quad (6.4)$$

Where SYSTEM_TYPE = 1.0 for type 1 (all signals interconnected)

0.5 for type 2 (some signals interconnected)

0 for type 3 (all signals isolated)

Quantitative variables DELAY and STOPS are normalized by dividing by the maximum value from all of the candidate corridors, which precludes any single variable dominating the total score because of its magnitude relative to the other variables. After normalization, each variable is expressed on a zero-to-one scale and the weights are an expression of the relative importance of each criterion. Witkowski (1992) discusses two basic normalization methods and pros and cons of each. For this research, the maximum value of a variable in the given data is used for normalization. The other one is, normalizing using a pre-selected threshold value.

Possible variations of this model may be by separating ADT from DELAY and STOPS. In that case, a different weighting may be applied for ADT. Equation (6.4) is evaluated to the travel time data for all the corridors and their initial ranks are calculated. As previously discussed, higher delay and higher numbers of stops should receive a higher priority. The highest priority goes to the corridor with the maximum total score. The priority decreases with the total score. Table 6.2 shows the first twenty corridors on the priority list based on the NCTCOG ranking model.

Table 6.2 Results of the NCTCOG Ranking Model

Rank	Arterial segment	City	Number of signals	Length (miles)	Score for total delay/per signal	Score for stops/ signal	System type score	Total score
1	Bryant-Irvin	Fort Worth	7	3.0	50.0	30.0	10	90.00
2	Hampton	Dallas	16	4.6	40.8	28.9	20	89.74
3	Belt Line	Dallas	8	3.1	46.2	22.7	20	88.81
4	Harry Hines	Dallas	15	5.9	41.0	25.0	20	85.98
5	Illinois	Dallas	16	5.9	40.5	25.4	20	85.85
6	Abram/Jefferson	Arlington	12	4.0	35.5	26.3	20	81.85
7	FM 1171	Flower Mound	16	4.2	36.5	22.9	20	79.45
8	Northwest Hwy	Dallas	19	7.6	32.6	25.1	20	77.64
9	Jupiter	Garland/Dallas	16	4.6	37.2	19.5	20	76.75
10	Coit	Dallas/Richardson/Dallas	19	5.4	32.1	23.0	20	75.18
11	Jupiter	Richardson	10	4.7	26.9	21.8	20	68.74
12	US 377	Haltom City	19	8.9	41.4	26.7	0	68.04
13	Jupiter	Plano	10	3.5	27.8	19.9	20	67.71
14	Spring Valley	Farmers Branch	8	2.7	27.8	19.1	20	66.88
15	Bryant-Irvin	Fort Worth	10	2.5	37.2	19.0	10	66.21
16	FM 3040/Hebron/ Park Blvd	Lewisville	13	2.4	29.6	26.5	10	66.09
17	Alpha	Dallas	7	2.1	29.2	16.8	20	66.04
18	Oaklawn	Dallas	11	1.5	29.3	16.2	20	65.49
19	Northwest Hwy	Dallas	28	8.9	20.1	25.3	20	65.44
20	University	Fort Worth	4	0.6	29.5	15.1	20	64.63
31	Pioneer Pkwy	Grand Prairie	9	4.2	18.1	19.2	20.0	57.28
58	Great Southwest Pkwy	Grand Prairie	15	5.1	20.4	7.6	20.0	47.99

The results indicate that almost all of the first few on the list belong to system type one; therefore, system type plays a significant role in this ranking. Depending on the available funds, NCTCOG may select the top thirty to forty corridors for executing retiming. In this work, data from before and after studies is available only for two corridors, Pioneer Parkway and Great Southwest Parkway. Their ranks are 31 and 58, respectively. Benefits are estimated for these two corridors.

NCTCOG made some modifications to the original ranking due to non-technical reasons, including overlap of locations funded in the Transportation Improvement Program, distribution of corridors in different regions of DFW metropolitan area, and local match issues.

It is important to estimate the benefits from traffic signal retiming projects to find out how efficiently the funds are spent. Next chapter deals with estimation of benefits through before and after studies.

CHAPTER 7

ESTIMATION OF BENEFITS

Benefits from signal retiming projects can be estimated through before and after studies. These studies are used to document the benefits of signal retiming. They are also used to identify any negative results so that they can be rectified. As an example, before and after studies for two corridors in the City of Arlington are presented.

7.1 Case Study from the City of Arlington

The City of Arlington is part of the DFW Metroplex and is a member of NCTCOG. The city retimed signals along its arterial corridors around three years ago in 2002. At that time, the city's traffic operations officials documented the benefits of retiming major corridors; this thesis considers two retiming case studies. Traffic signals along South Cooper Street, a major arterial, were retimed in 2001. Pioneer Parkway and Arkansas Street are parallel streets with a small distance between them; therefore, the signals along these two corridors were combined for retiming. The traffic operations officials performed ten travel time runs during each time of day in both directions before and after signal retiming. As part of retiming, some of the signals along these corridors were integrated into a coordinated operation. The city calculated travel time savings per year by summing the total reduction in travel times on each weekday. The savings are significant in both delay and number of stops.

Using a $10/hr as the average salary, the annual economic impact of retiming signals is estimated to be $9.8 million on South Cooper Street and $17.3 million on Pioneer Parkway and Arkansas Street.

7.2 Before and After Studies

Usually, after any improvement in transportation infrastructure or policy, the city or the funding agency measures its effectiveness. Before and after studies are performed in such cases. These studies enable the authorities not only to determine how well the improvement solved the problems, but also to document the results for future use. This is better explained through an example.

7.2.1 Before and after studies for signal retiming projects

Before and after studies for signal retiming projects are basically travel time runs. Currently, sophisticated instruments such as the Jamar TDC-12 are available for this purpose. Figure 7.1 shows the Jamar TDC-12 instrument.

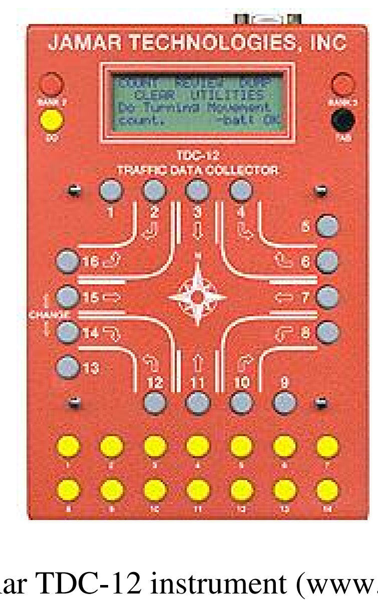


Figure 7.1 Jamar TDC-12 instrument (www.jamartech.com)

While retiming traffic signals, techniques such as signal coordination are used to enable efficient progression of vehicles along the corridor and hence reduce delays. Before doing the improvements, that is when traffic is operating under existing conditions, travel time runs are conducted. At least five runs must be performed from the start to the end of the corridor where the start and end points should be fixed. The intersections are consistently noted at a specific point, for example, the stop line. The Jamar TDC-12 instrument, when connected to an automobile, notes the speed and acceleration information along with the travel time and spacing between each intersection. Beginning and ending points and intersection location are specified.

The data is downloaded into PC-Travel software. PC-Travel estimates delays, fuel consumption and emissions (Carbon Monoxide (CO), Hydrocarbons (HC) and Nitrogen Oxides (NO_x)) from the raw data. In this way, traffic conditions before signal retiming are determined.

Once the traffic signals are retimed, a period of time must pass for the traffic to adjust to the new timing. After allowing enough time for this adjustment, typically at least two weeks, the “after” travel time runs are performed. These runs have the same start and end points and nodes as before. The new conditions are estimated after downloading the data and analyzing. Finally, comparing the conditions before and after retiming, benefits are estimated.

7.2.2 PC-Travel software – an overview

Jamar Technologies developed PC-Travel for Windows, a software program designed to process travel time and delay data. This software is also used in collecting travel time data using a TDC instrument (see Figure 7.1). The start and end points and the nodes between them are input into the software. When a TDC instrument is attached to a vehicle and calibrated, a calibration coefficient is stored with the data file. This is used in calculating the distance between the selected intersections during data collection. At least five runs are performed in each direction along a corridor. The software calculates an average of distances between two subsequent intersections and uses it as current distance. This can also be edited by the user.

For the first run, node names are input. This is called the primary run and the subsequent runs are secondary runs. All the runs performed in one direction and during a specified time of day are stored as one study. Runs performed on a corridor before and after retiming can be stored in the same study. Each of these studies is stored as a study file. Using the "Select Study" menu of PC-Travel, each run that comprises the study is listed. Figure 7.2 shows the window with AM Northbound runs on Great Southwest Parkway before retiming.

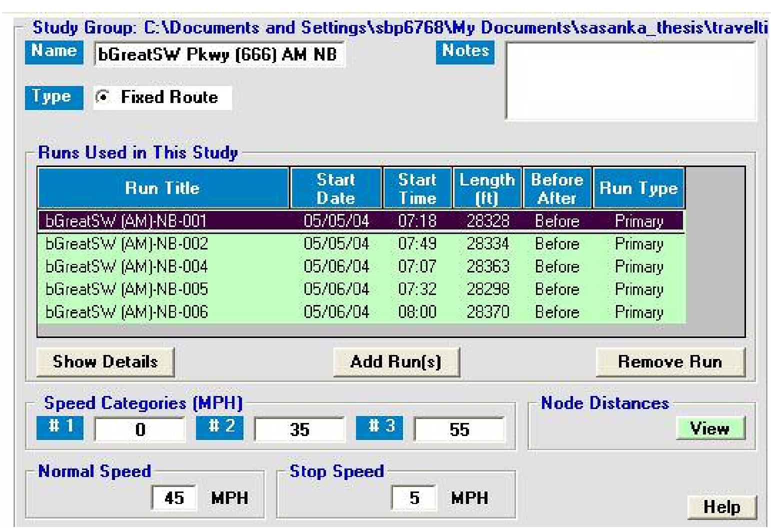
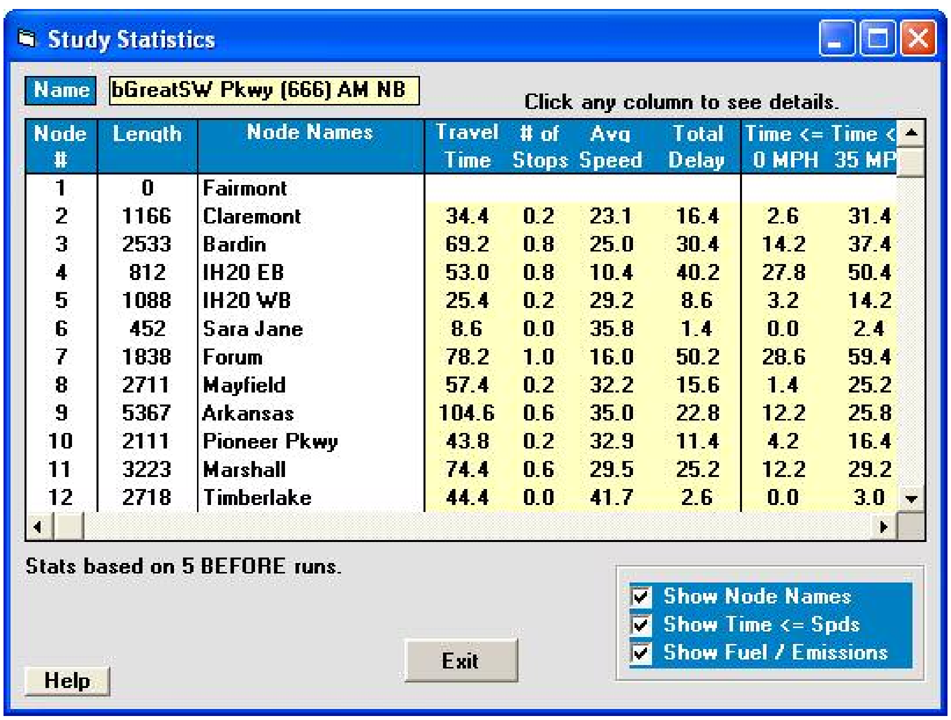


Figure 7.2 PC-Travel window - details for AM NB runs on Great Southwest Pkwy

One can extract run statistics for each run. The software also calculates the averages of all the runs and presents them as study statistics. If both before and after runs are in a study, the software compares the statistics for before and after cases and reports the change between them. Between every two subsequent nodes, the software calculates travel time, number of stops, average speed, total delay and the time during which the speed of the vehicle falls below three different speeds. The total delay is calculated by subtracting the desired travel time, which is at the 'normal speed' specified, from the actual travel time. It also calculates the fuel consumption and emissions. Figure 7.3 shows the window with study statistics.



Node #	Length	Node Names	Travel Time	# of Stops	Avg Speed	Total Delay	Time <= 0 MPH	Time < 35 MP
1	0	Fairmont						
2	1166	Claremont	34.4	0.2	23.1	16.4	2.6	31.4
3	2533	Bardin	69.2	0.8	25.0	30.4	14.2	37.4
4	812	IH20 EB	53.0	0.8	10.4	40.2	27.8	50.4
5	1088	IH20 WB	25.4	0.2	29.2	8.6	3.2	14.2
6	452	Sara Jane	8.6	0.0	35.8	1.4	0.0	2.4
7	1838	Forum	78.2	1.0	16.0	50.2	28.6	59.4
8	2711	Mayfield	57.4	0.2	32.2	15.6	1.4	25.2
9	5367	Arkansas	104.6	0.6	35.0	22.8	12.2	25.8
10	2111	Pioneer Pkwy	43.8	0.2	32.9	11.4	4.2	16.4
11	3223	Marshall	74.4	0.6	29.5	25.2	12.2	29.2
12	2718	Timberlake	44.4	0.0	41.7	2.6	0.0	3.0

Figure 7.3 PC-Travel window showing study statistics

One can also export these statistics to Microsoft Excel for further analysis and presentation. PC-Travel also reports the speeds of the vehicle as a plot.

7.2.3 Estimation of emissions and fuel consumption using PC-Travel

PC-Travel software estimates HC, CO and NO_x emissions from the speed and acceleration data obtained from travel time studies using the TDC-12. It takes the variation in speed as a basis for the estimation. The model used in PC-Travel (Jamar, 2004) is the MICRO2 model developed by the Colorado Department of Highways. The equations used in the PC-Travel for Windows manual (Jamar, 2004) are:

In the following equations, V = velocity in ft/sec, A = acceleration in ft/sec^2

$$\text{Fuel (ml/sec)} = k_1+k_2V+k_3V^3+k_4AV+k_5A^2V \quad (7.1)$$

where

$k_1=0.7$

$k_2=0.00442$

$k_3=0.0000022$

$k_4=0.00762$

$k_5=0.000886$

$$\text{Hydrocarbons (grams/sec)} = hc_1+hc_2AV+hc_3AV^2 \quad (7.2)$$

where

$hc_1 = 0.018$

$hc_2 = 0.0005266$

$hc_3 = 0.0000061296$

$$\text{Carbon Monoxide (grams/sec)} = co_1 + co_2 AV + co_3 AV^2 \quad (7.3)$$

where

$co_1 = 0.182$

$co_2 = 0.0079776$

$co_3 = 0.00036227$

$$\text{Nitrogen Oxides (grams/sec)} = noxa_1 + noxa_2 AV,\ A>0 \quad (7.4)$$

$$\text{or} \quad noxb_1 + noxb_2 AV,\ A<0$$

where

$noxa_1 = 0.00386$

$noxa_2 = 0.00081446$

$noxb_1 = 0.00143$

$noxb_2 = 0.000017005$

7.3 Studies for the Recent Projects

NCTCOG hired a consultant to perform travel time (TT) studies before and after retiming for each of the corridors where signals were retimed. Five runs each were performed during the AM peak, midday and PM peaks before and after retiming. Using the study results summary for each time of day, the average reductions in travel time, delay, number of stops, fuel consumption as well as emissions were calculated by the author. This provides an estimate of the actual benefits per vehicle per mile. The following sections discuss how the benefits of retiming are estimated from the before and after studies for Great Southwest Parkway and Pioneer Parkway corridors.

7.3.1 *Great Southwest Parkway*

Great Southwest Parkway is an arterial in the Cities of Arlington and Grand Prairie running in north-south direction. It is a divided facility with two lanes in each direction. Maximum speed limit along the stretch is 45 mph. Figure 7.4 shows the Great Southwest Parkway corridor. More details about the corridor are presented in Table 7.1.

Table 7.1 Corridor Details for Great Southwest Parkway

Arterial name	**Great Southwest Parkway**
Number of Lanes	4
Length	5.37 mi.
Number of signals	15
North End	E. Division Street
South End	Fairmont
Maximum Speed Limit	45 mph
Average Daily Traffic	20,328

It has two at-grade railway crossings, one between the E Division Street and Abrams Street and the other between Marshall and Pioneer Parkway. Railway crossing between the E Division Street and Abrams Street is more heavily used than the other.

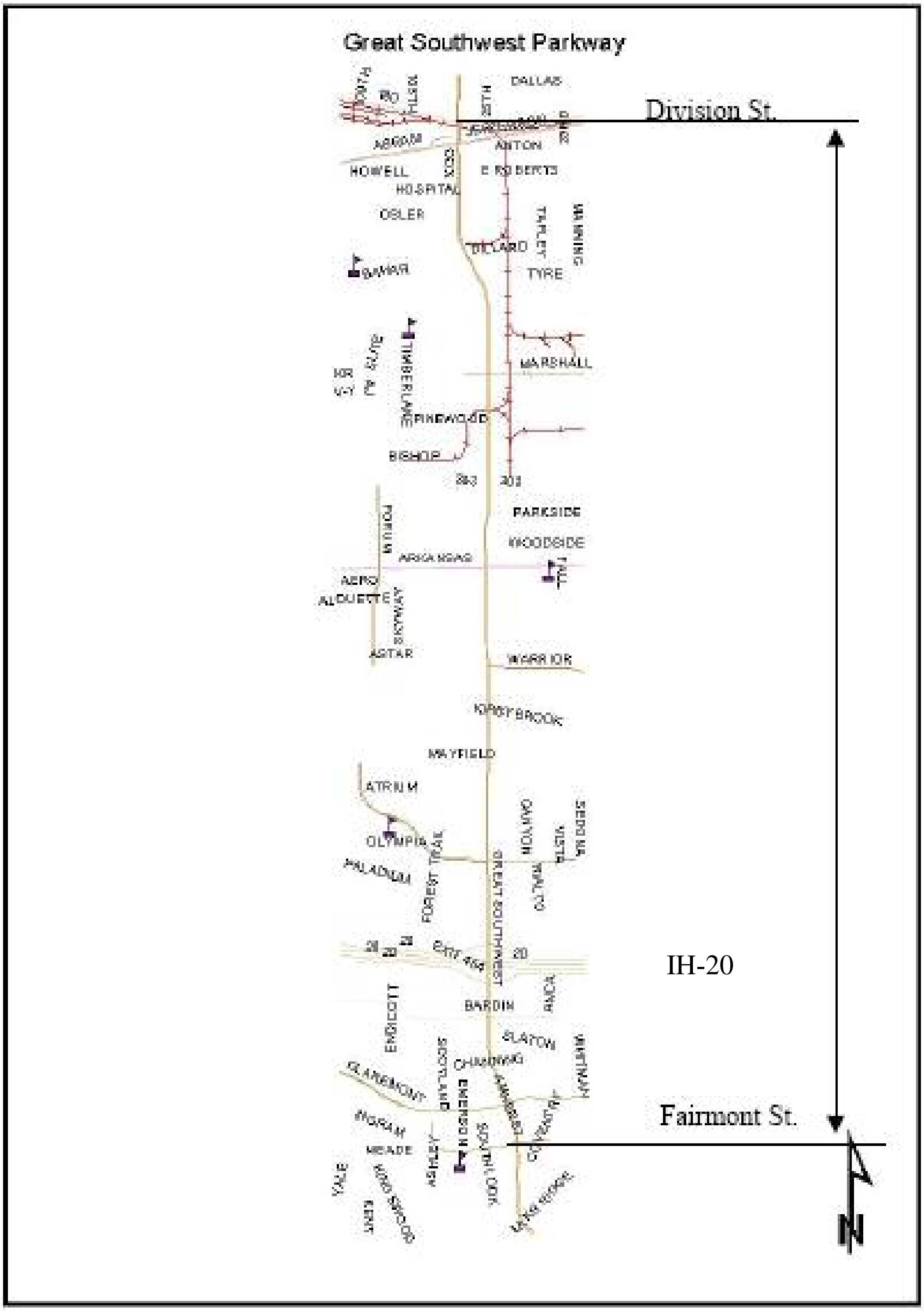


Figure 7.4 Great Southwest Parkway corridor (Source: Rupangi (2005))

Estimates of benefits are presented in Table 7.2. Percentage savings are calculated the formula below:

% Savings = ((Before – After)/Before) x 100 (7.5)

Negative savings in AM peak and PM peak on south bound Great Southwest Parkway indicate that conditions worsened. Especially in the PM peak, total delay increases by more than fifty percent. In the case of the midday period for north bound, though the number of stops decreased by 8.5%, fuel consumption and emissions slightly increased because the proportion of time traveled with speed below 35 mph increased. In the case of PM peak for south bound, the change in fuel and emissions is less than 10% while total delay and number stops increase by around 50%.

Table 7.2 Estimated Benefits per Vehicle for Great Southwest Parkway

	Travel Time (sec/mi)	Number of stops /mile	Total Delay (sec/mile)	Fuel (gal/mile)	Emissions		
					HC (gm/mile)	CO (gm/mile)	NOx (gm/mile)
North Bound – Savings per vehicle per mile							
AM	21.5	0.11	20.9	4.1E-03	0.42	3.85	0.04
MD	2.6	0.08	2.4	-2.8E-04	-0.15	-2.20	-0.19
PM	18.8	0.15	18.4	3.2E-03	0.46	3.06	0.18
North Bound - %Savings							
AM	14.2	10.2	29.5	6.9	7.6	6.5	1.2
MD	2.3	8.5	7.5	-0.5	-3.2	-4.4	-7.0
PM	14.0	14.2	34.2	5.7	8.7	5.4	5.9
South Bound – Savings per vehicle per mile							
AM	-4.06	0.04	-3.8	-7.6E-04	-0.05	-1.26	0.04
MD	3.5	0.08	3.3	5.7E-05	0.10	0.21	0.06
PM	-23.92	-0.49	-24.0	-2.9E-03	-0.11	0.57	0.28
South Bound - %Savings							
AM	-3.2	3.3	-8.3	-1.4	-0.9	-2.3	1.3
MD	3.0	8.8	9.5	0.1	2.1	0.4	2.0
PM	-19.1	-48.3	-53.8	-5.3	-2.2	1.0	9.0

Detailed study statistics for Great Southwest Parkway corridor are shown in Appendix C.

7.3.2 *Pioneer Parkway*

Pioneer Parkway is a major east-west arterial. It is a divided facility with three lanes in each direction. Maximum speed limit along the stretch is 45 mph. Figure 7.5 shows Pioneer Parkway corridor. More details about the corridor are presented in Table 7.3.

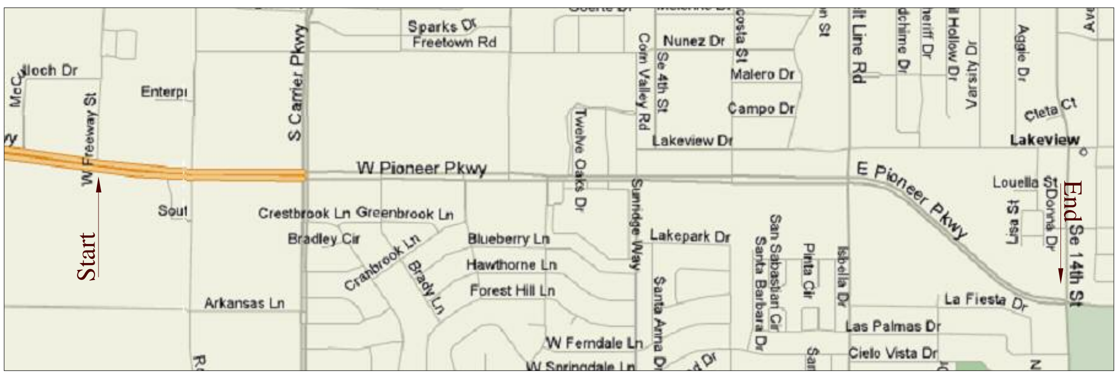


Figure 7.5 Pioneer Parkway corridor (Source: www.mapquest.com)

Table 7.3 Corridor Details for Pioneer Parkway

Arterial name	**Pioneer Parkway**
Number of Lanes	6
Length	2.33 mi
Number of signals	8
West End	W. Freeway
North End	SE 14th
Maximum Speed Limit	45 mph
Average Daily Traffic	35,351

Estimated benefits per vehicle-mile are presented in Table 7.4. There is a considerable improvement in conditions in all the periods of the day along east bound Pioneer Parkway. But AM peak conditions along west bound Pioneer Parkway are more severe.

Table 7.4 Estimated Benefits per Vehicle for Pioneer Parkway

	Travel Time (sec/mile)	**Number of stops /mile**	**Total Delay (sec/mile)**	**Fuel (gal/mile)**	**Emissions**		
					HC (gm/mile)	**CO (gm/mile)**	**NO_x (gm/mile)**
East Bound – Savings per vehicle per mile							
AM	53.8	1.4	54.0	0.02	3.03	25.31	2.37
MD	36.4	1.0	36.5	0.01	1.69	9.16	1.34
PM	55.0	1.5	54.0	0.01	2.86	17.36	2.32
East Bound – %Savings							
AM	37.9	94.0	88.2	27.0	48.8	38.5	59.3
MD	26.9	74.4	66.8	16.3	31.7	16.8	41.0
PM	39.4	94.3	92.0	24.5	47.0	28.5	57.7
West Bound – Savings per vehicle per mile							
AM	-10.6	-0.3	-10.4	-4.6E-03	-0.67	-4.51	-0.56
MD	0.9	-0.01	1.0	-3.0E-03	-0.50	-7.64	-0.48
PM	32.0	0.85	32.0	3.3E-03	0.31	-5.51	-0.01
West Bound – %Savings							
AM	-10.2	-81.2	-47.2	-9.0	-14.3	-8.1	-18.8
MD	0.7	-1.0	2.3	-5.6	-9.5	-13.5	-14.4
PM	21.2	52.3	45.8	5.5	5.1	-8.9	-0.3

Detailed study statistics for Pioneer Parkway are shown in Appendix C.

7.4 Total Corridor Benefits

Assuming retiming is done every three years, the total corridor benefits from a retiming project are those that are achieved in three years of time starting from the date when retiming is done. These are to be calculated and used in prioritization. Turning movements for all the intersections along the corridor are available for the AM, midday and PM cases. Traffic volumes along Great Southwest Parkway and Pioneer parkway are calculated and are shown in Table 7.5 and Table 7.6, respectively. These are calculated from the approach volumes given in the Synchro networks prepared by the consultant while analysis.

Table 7.5 Traffic Volumes for Great Southwest Parkway

	NB			**SB**		
	AM	**MID**	**PM**	**AM**	**MID**	**PM**
Hourly	1151	572	629	459	556	1145
Total Peak	2877	4573	1886	1147	4446	3435

Table 7.6 Traffic Volumes for Pioneer Parkway

	EB			**WB**		
	AM	**MID**	**PM**	**AM**	**MID**	**PM**
Hourly	1103	857	1261	809	888	1350
Total Peak	2758	6856	3783	2021	7103	4049

The final recommended operating schedule for Great Southwest Parkway and Pioneer Parkway by the consultant is given in Table 7.7. Because some time after PM peak also has same characteristics as mid day, it is also operated at mid day timing. Total savings in three years of operation for Great Southwest Parkway and Pioneer Parkway are given in Table 7.8 and Table 7.9, respectively.

Table 7.7 Recommended Signal Timing Operating Schedule for Weekday

	AM Peak	**Midday**	**PM Peak**
Monday-Thursday	7AM to 9:30AM	11AM to 4 PM and 7PM to 9:30PM	4 PM to 7 PM
Friday	7AM to 9:30AM	11AM to 3 PM and 7PM to 11PM	3 PM to 7 PM

Table 7.8 Savings in Three Years from Signal Retiming along Great Southwest Parkway

	# of stops	Total Delay (Hours)	Fuel (gal)	HC (Tons)	CO (Tons)	NOx (Tons)
North Bound - Total savings in three years						
AM	1380709	69905	49172	5.1	46.5	0.5
MD	1385555	12354	-5071	-2.7	-40.0	-3.4
PM	1251522	43114	27069	3.9	25.8	1.5
South Bound - Total savings in three years						
AM	188325	-5115	-3675	-0.2	-6.0	0.2
MD	1330829	16070	1010	1.8	3.7	1.0
PM	-7470092	-102292	-44152	-1.8	8.7	4.4

Table 7.9 Savings in Three Years from Signal Retiming along Pioneer Parkway

	# of stops	Total Delay (Hours)	Fuel (gal)	HC (Tons)	CO (Tons)	NOx (Tons)
East Bound - Total savings in three years						
AM	6829098	75172	81744	15.2	126.9	11.9
MD	12006250	119936	106784	20.0	108.5	15.9
PM	10656691	109995	105745	21.0	127.3	17.0
West Bound - Total savings in three years						
AM	-1276598	-10611	-16717	-2.5	-16.6	-2.0
MD	-129280	3468	-36974	-6.2	-93.7	-5.9
PM	6681687	69659	25896	2.5	-43.3	-0.1

By adding the savings in both directions and for all the times of day, the overall weekday daytime savings for a corridor for the next three years can be obtained. Table 7.10 gives the total weekday daytime (7:00 am – 9:30 pm) corridor savings for both the corridors over the next three years.

Table 7.10 Total Weekday Daytime Corridor Savings

	# of stops	Total Delay (Hours)	Fuel (gal)	HC (Tons)	CO (Tons)	NOx (Tons)
Great Southwest Pkwy	-1933152	34036	24353	6.1	38.6	4.1
Pioneer Pkwy	34767848	367620	266479	50.0	209.1	36.7

7.5 Comparison of Benefits with Estimates from SimTraffic

Traffic simulation software, Synchro plus SimTraffic, can simulate the traffic conditions along a corridor both before and after retiming. It estimates various measures of effectiveness (MOEs) at each intersection including total delay, control delay, number of stops, fuel consumption and emissions. It also outputs arterial performance and total network performance. As part of arterial performance, SimTraffic provides travel time, delay and arterial speed between any two subsequent intersections along the arterial. This delay is comparable to the delay calculated using PC-Travel. While optimizing the timing on Great Southwest Parkway and Pioneer Parkway, the consultant used Synchro. The Synchro networks with both before and after signal timings are simulated using SimTraffic and MOEs are obtained. Table 7.11 and Table 7.12 compare delays estimated by SimTraffic and that are obtained by travel time runs.

Table 7.11 Comparison of Delays for Great Southwest Parkway

Delay (sec)						
	Synchro plus SimTraffic			Travel Time Study		
NB	**Before**	**After**	**%reduction**	**Before**	**After**	**%reduction**
AM	190	170	10.2	379	268	29.3
MD	164	105	36.1	176	163	7.4
PM	252	212	16.1	289	190	34.3
SB						
AM	185	181	2.2	247	268	-8.5
MD	178	79	55.6	184	166	9.8
PM	289	250	13.7	239	367	-53.6

Table 7.12 Comparison of Delays for Pioneer Parkway

Delay (sec)						
	Synchro plus SimTraffic			Travel Time Study		
EB	**Before**	**After**	**%reduction**	**Before**	**After**	**%reduction**
AM	127	133	-5.5	144	17	88.2
MD	130	74	42.8	128	42	67.2
PM	224	180	19.6	137	11	92.0
WB						
AM	147	111	24.5	51	75	-47.1
MD	117	118	-0.4	102	99	2.9
PM	249	139	43.9	163	88	46.0

Delay estimates from SimTraffic are very much different from those from the travel time studies. In the case of Great Southwest Parkway, SimTraffic underestimates the delay in all the cases except for two. But in the case of Pioneer Parkway, delay is overestimated in all the cases except one. The reduction percentages estimated by the SimTraffic are different from what are estimated from travel time studies. The author recommends that SimTraffic should be calibrated to represent existing conditions more accurately or any other more reliable software should be used.

A new methodology based on the benefits from signal retiming projects is proposed in the next chapter.

CHAPTER 8

PROPOSED METHODOLOGY

As previously discussed, NCTCOG's model is built on the severity of existing traffic flow conditions. However, a reasonable objective for any infrastructure project is to improve societal benefits. Poor traffic flow conditions along a corridor may not indicate that retiming signals along that corridor will produce a good benefit to cost ratio. Therefore, a new prioritization strategy must take into consideration greater overall societal benefits.

8.1 Modeling Benefits

In this research, an effort is made to relate the benefits to current conditions of the corridors. Regression analysis can be used for this purpose. All six benefits quantified in the previous chapter can be used. However, for the reasons given below, some of them are not taken into consideration.

8.1.1 Dependents and predictors in the model

The following benefits are considered:

S_D = Saving in delay (in sec)

S_F = Saving in fuel consumption (in gallons)

S_E = Saving in NO_x emissions (in tons)

Reducing the number of stops indirectly reduces fuel consumption and emissions and driver frustration, which is difficult to quantify. Also, it is difficult to convert the number of stops into a monetary value. Hence, savings in the number of stops is not considered. With respect to emissions, NO_x is the only pollutant considered, as explained by Rupangi (2005).

> *The precursors of ozone are NO_x and VOCs. Since DFW is declared as a NO_x limited zone, overall reductions in NO_x would highly reduce the formation of ozone. (Rupangi, 2005)*

At this time, safety is not included because of its long time horizons and stochastic characteristics. All the benefits are converted into a dollar amount so that the relative importance of any one benefit may be compared with the other benefits.

Many factors can influence the overall corridor benefits. In the first effort to relate benefits to corridor characteristics, many possible qualitative and quantitative variables must be considered. The variables can be divided into two categories, physical characteristics and traffic characteristics. Table 8.1 lists all the variables to be used. Each variable can be used in a number of forms.

Table 8.1 Predictors Considered in Modeling Benefits

Symbol	Description
Physical characteristics	
L	Length
SIG	Number of signals
NL	Number of lanes
l	Spacing between the intersections
Z	System type
Traffic Characteristics	
ADT	Average Daily Traffic
FRTIME	Free flow travel time
TT	Measured travel time
D	Delay
NS	Number of stops
M	Turning movements as a percentage of total volumes

8.1.2 Discussion of predictors

First consideration in selecting the independent variables is that they should be easily available or can be obtained at the start of the prioritization process.

The total corridor length and the number of signals along the section may affect the benefits. Number of signals can be used separately or as signal density, the number of signalized intersections per mile. A corridor with intersections at short intervals, which are suffering from queue spillbacks, may get greater improvement after signal coordination than a corridor with fewer intersections.

Number of lanes on the arterial may affect the benefits. It is used as a qualitative variable.

Achievement of maximum progression and minimum delay timing is dependent on how uniform the spacing between each intersection is. Spacings are obtained with the help of NCTCOG road network and from aerial maps. Standard deviation of spacings is the parameter that indicates the non-uniformity of the spacings along a corridor. However, the distribution of standard deviations may be skewed, which may produce errors in the analysis. To overcome this, the logarithm of standard deviations can be used.

As discussed in the sixth chapter, system type is the variable that shows how the intersections along the corridors are connected. This can also affect the overall benefits.

Estimates of ADT, the average daily traffic, are available for each of the corridors considered. Traffic volumes may affect the overall benefits directly because this is going to be multiplied by the per vehicle benefits calculated from the before and after travel time studies.

The FRTIME, free flow travel time, is taken from the Dallas/Fort Worth Regional Transportation Model, abbreviated as DFWRTM, (NCTCOG, 2000) and prepared by the NCTCOG. Free flow travel time from any node to any other node is a basis for travel times between these nodes. In the DFWRTM, the intersection delay as well as delay due to intervening controls is incorporated into the free speed. Free flow travel time is the time taken to travel along a corridor at free speed.

As discussed in chapter six, one travel time run on each corridor was conducted by the NCTCOG's consultants. Measured travel time is the average of travel times on both directions. The number of stops and delay from this data are taken as independent variables. Delay may be represented as total delay per vehicle, delay/veh/signal or delay/veh/mile. Similarly, number of stops may be represented as total number of stops/vehicle, number of stops/veh/signal or number of stops/veh/mile. After thorough analysis, one can use the significant variables for the regression.

Finally, higher turning-in or turning-out volumes at the intersections decrease the benefits associated with signal coordination (McShane and Roess, 1998). Basically, signal coordination works on the basis of offsets, the time taken for a vehicle to travel from one intersection to the next intersection. Heavy turn-out volumes may impede platoons or destroy their structure by the loss of vehicles from the middle of the platoon. Heavy turn-in volumes cause more unexpected reductions in speeds and reduce the benefit to setting the offset to a particular value. Hence, the turning movements as a percentage of the total volume may be a significant variable; however, this variable may be difficult to accurately quantify beforehand. So, engineering judgment may be used to at least give a qualitative value for this variable or an estimate may be based on historical turning movements.

8.1.3 Model development

Multi-linear regression is used to estimate coefficients for the model. At present, very few corridors have been retimed and the benefits must be calculated after the before and after studies. NCTCOG is in the process of retiming another thirty to forty corridors in the near future. When these projects are finished and travel time studies are conducted, there will be enough data for applying regression. However, the values of predictors are available. Data is compiled for fifty-one corridors and uni-variate analysis is done. Correlation matrix for these data is calculated and presented in section 8.1.3.3.

8.1.3.1 Uni-variate analysis - Qualitative variables

Histograms of the two qualitative variables, Number of lanes (NL) and System type (Z) are shown in Figure 8.1 and Figure 8.2 respectively. About 75% of the corridors analyzed belong to system type 1.

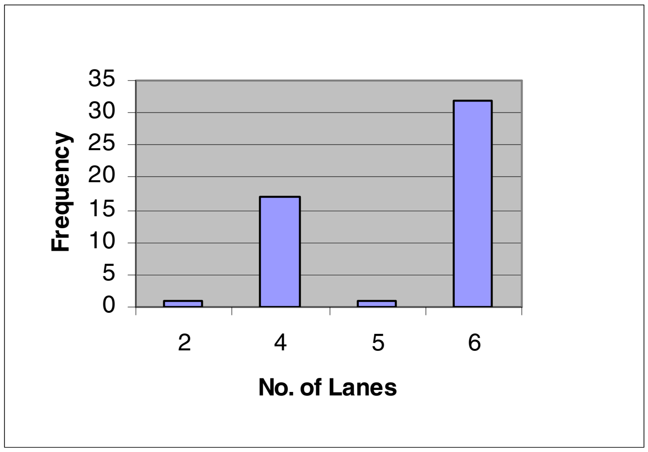


Figure 8.1 Histogram for Number of lanes (NL)

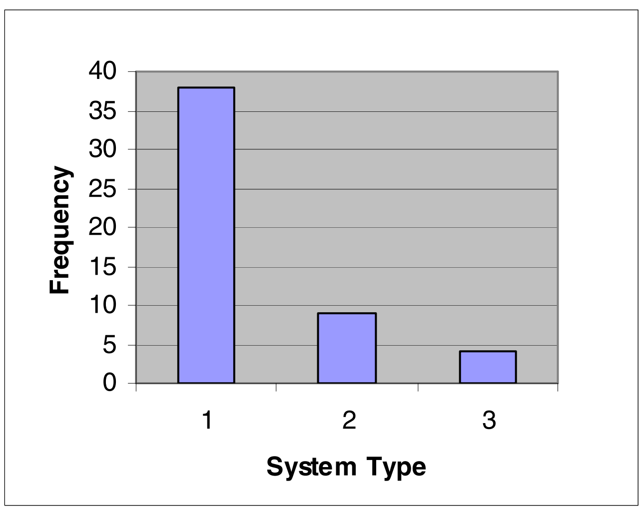


Figure 8.2 Histogram for System type (Z)

8.1.3.2 Uni-variate analysis - Quantitative variables

Results of uni-variate analysis of quantitative variables are presented in Table 8.2.

Table 8.2 Uni-variate Analysis of Quantitative Variables

S. No.	Variable	Min	Max	Mean	Median	St.Dev
1	Length (miles)	0.56	9.12	4.01	3.99	2.00
2	No. of signals	4	21	11.2	10	4.36
3	Signal density (signals/mile)	1.6	7.1	3.2	2.8	1.2
4	Log(Signal density)	0.19	0.85	0.47	0.44	0.15
5	St dev (Spacing) (mi)	0.03	0.43	0.25	0.25	0.09
6	Average daily traffic	20328	68356	39858	40627	11424
7	Free flow travel time (sec)	79.8	908.4	445.1	387.6	202.9
8	Measured travel time (sec)	157	1094	531	497	232
9	Total delay/veh (sec)	42.0	401.3	178.9	171.0	78.6
10	Delay/veh/signal (sec)	5.6	35.9	16.1	15.5	5.7
11	Delay/veh/mile (sec)	12.9	172.1	52.7	45.1	29.3
12	Number of stops/veh	0.8	8.6	3.9	3.5	1.7
13	Number of stops/veh/mile	0.4	3.1	1.1	0.9	0.5
14	Number of stops/veh/signal	0.2	0.7	0.4	0.4	0.1

Figure 8.3 to Figure 8.16 show the density histograms for each of the qualitative variables mentioned in Table 8.2. Standard deviation of signal spacing in this case is not skewed. So logarithm is not used. As shown in Figure 8.5, distribution of Signal Density is skewed. So logarithm of Signal Density can be used.

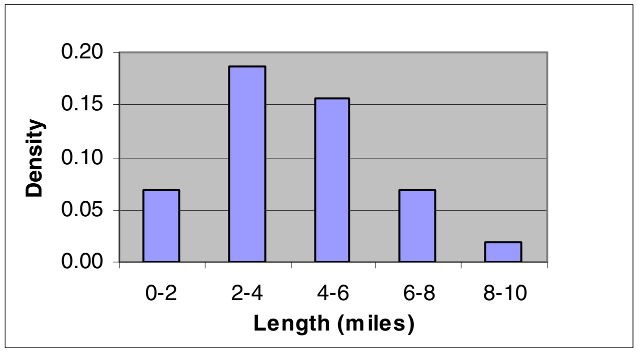


Figure 8.3 Density histogram for Length

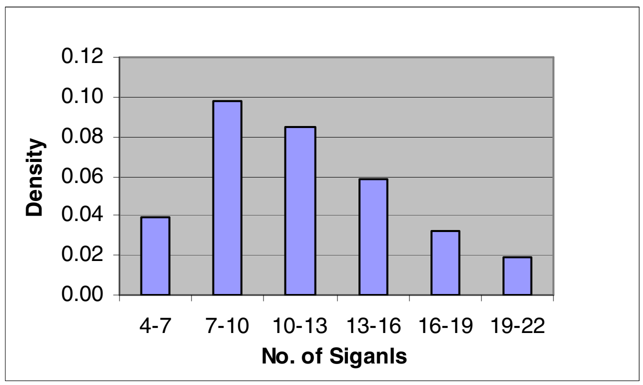


Figure 8.4 Density histogram for No. of signals

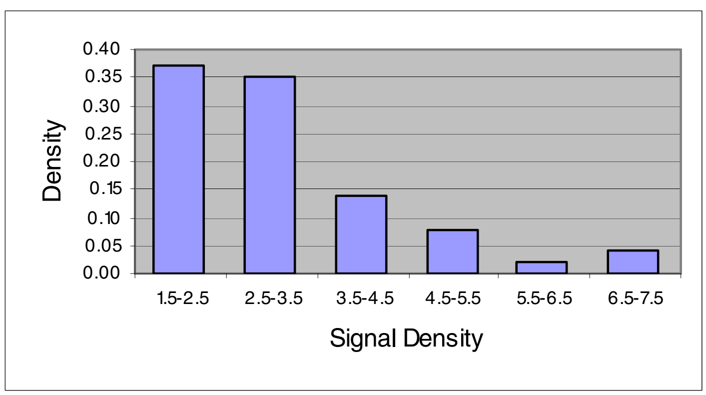


Figure 8.5 Density histogram for Signal density

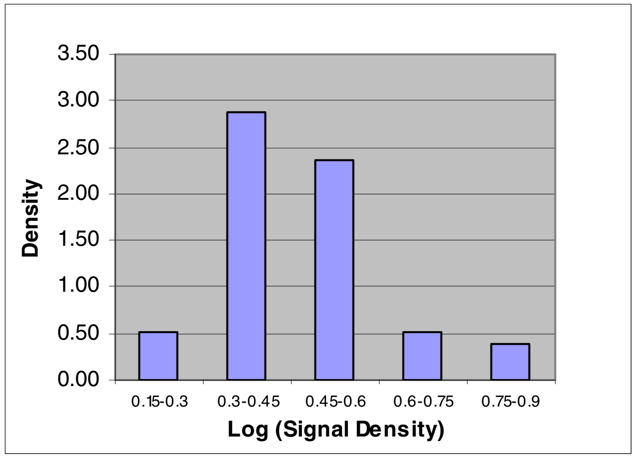


Figure 8.6 Density histogram for Log (Signal density)

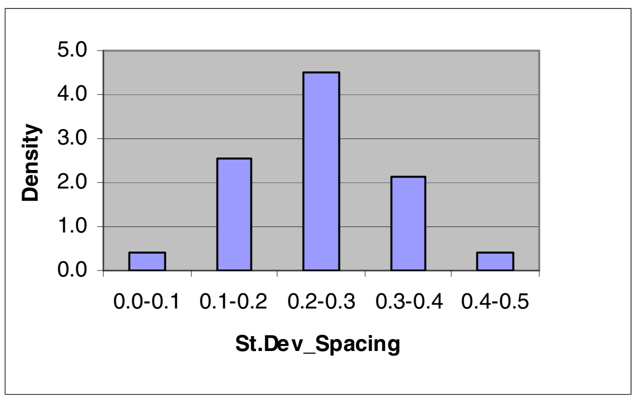


Figure 8.7 Density histogram for St. dev of spacing

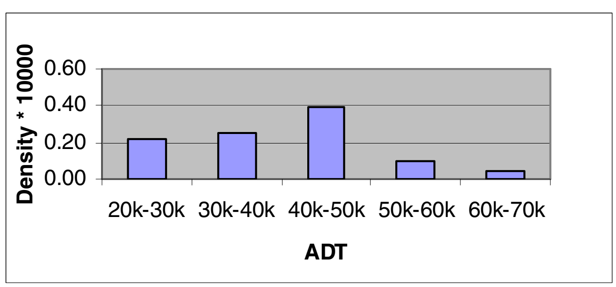


Figure 8.8 Density histogram for Average daily traffic

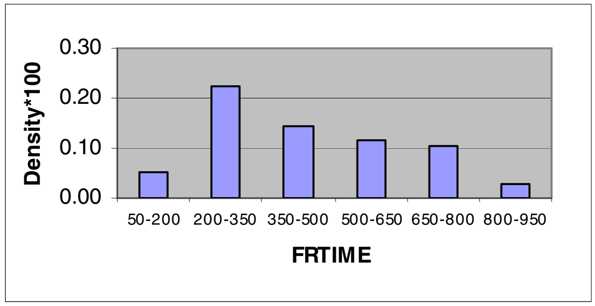


Figure 8.9 Density histogram for Free flow travel time

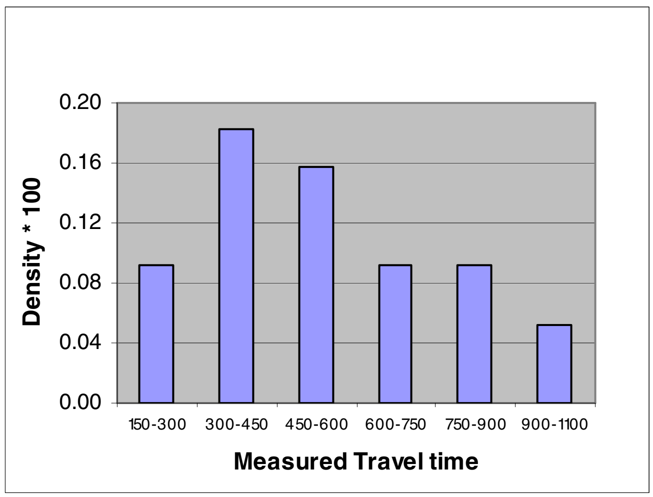


Figure 8.10 Density histogram for Measured travel time

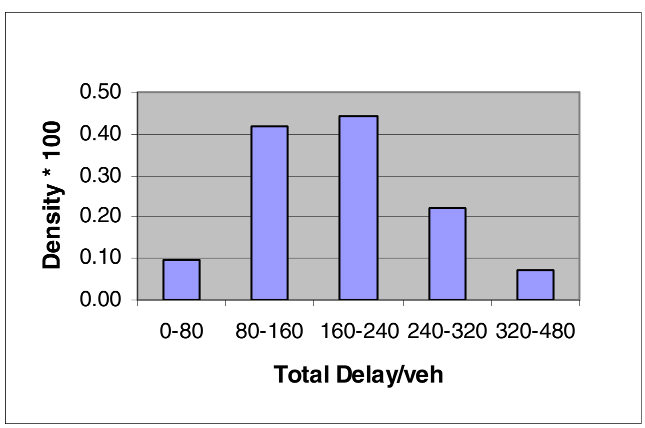


Figure 8.11 Density histogram for Total delay/vehicle

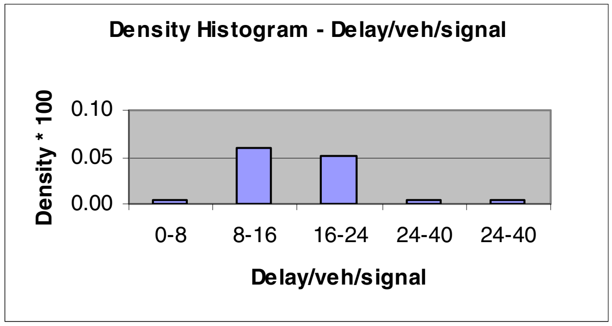


Figure 8.12 Density histogram for Delay/veh/signal

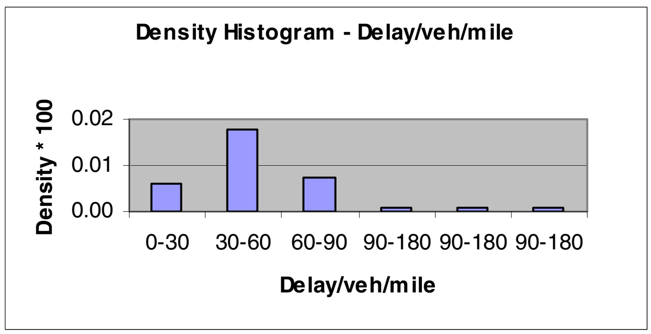


Figure 8.13 Density histogram for Delay/veh/mile

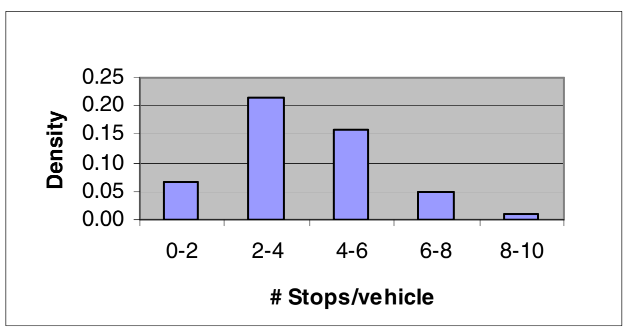


Figure 8.14 Density histogram for Number of stops/veh

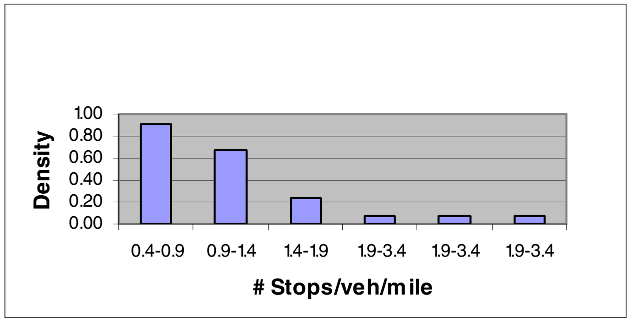


Figure 8.15 Density histogram for Number of stops/veh/mile

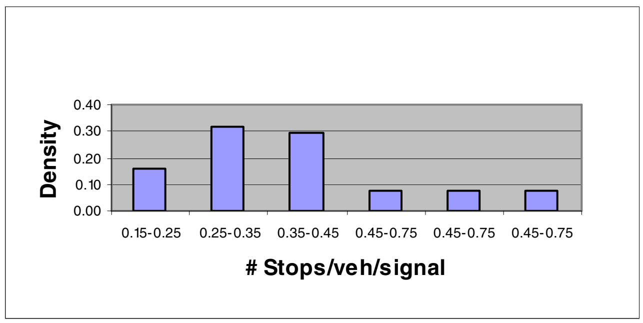


Figure 8.16 Density histogram for Number of stops/veh/signal

8.1.3.3 Correlation matrix

Correlation matrix including all the quantitative variables is calculated and presented in Table 8.3. Correlation matrix is the best way to identify the relation between any two of the variables. From Table 8.3, one can see that Length, FRTIME and Measured TT are highly correlated to each other. The most significant variable from these can be used for modeling. Similarly, there is a high correlation between Delay/veh and Number of stops/veh; Delay/veh/signal and Number of stops/veh/signal; and Delay/veh/mile and Number of stops/veh/mile. Hence any one of these six variables may be used in the regression. Once the data for dependent variables is compiled, one can proceed with further analysis.

Table 8.3 Correlation Matrix for the Independent Variables

	Length	Number of signals	Signal density	Log (Signal den)	St dev_ Spacing	ADT	FRTIME	Measured TT	Delay/ veh	delay/veh/signal	delay/ veh/mile	# Stops/ veh	# Stops/ veh/mile	# Stops/ veh/ signal
Length	1.00													
Number of signals	**0.82**	1.00												
Signal density	**-0.63**	-0.22	1.00											
Log(Signal den)	**-0.64**	-0.16	**0.98**	1.00										
St dev_Spacing	0.41	0.08	**-0.61**	**-0.62**	1.00									
ADT	0.25	0.40	-0.11	-0.04	-0.06	1.00								
FRTIME	**0.89**	**0.87**	-0.47	-0.45	0.29	0.21	1.00							
Measured TT	**0.94**	**0.86**	**-0.51**	**-0.50**	0.36	0.14	**0.91**	1.00						
Delay/veh	**0.63**	**0.65**	-0.24	-0.23	0.25	-0.10	**0.62**	**0.83**	1.00					
Delay/veh/signal	-0.11	-0.27	0.03	-0.06	0.21	**-0.63**	-0.17	0.07	0.46	1.00				
Delay/veh/mile	**-0.54**	-0.34	**0.78**	**0.71**	-0.35	-0.44	-0.49	-0.35	0.08	**0.58**	1.00			
# Stops/veh	**0.71**	**0.69**	-0.31	-0.30	-0.09	0.03	**0.70**	**0.85**	**0.88**	0.25	-0.10	1.00		
# Stops/veh/mile	**-0.50**	-0.29	**0.76**	**0.70**	-0.35	-0.38	-0.43	-0.32	0.06	0.47	**0.89**	0.07	1.00	
# Stops/veh/ signal	0.05	-0.15	-0.13	-0.20	0.34	-0.47	-0.02	0.20	0.46	**0.75**	0.35	**0.55**	**0.51**	1.00

Note: Correlation values equal or more than 0.5 are bold

8.2 Monetary Benefits

To convert the benefits into monetary values, benefits must be multiplied by their respective value of benefits.

8.2.1 Value of time

Mattingly *et al*. (2004) analyzed a stated preference survey conducted in the DFW region to find out the value of time in the context of HOT lanes and HOV lanes. They concluded that the respondents' value of time is $8.39 per hour. Though the present research is concerned with time savings of a few seconds, which poses some aggregation concerns, this value of time is still reasonable for comparison purposes. Further surveys may indicate how to address the aggregation difficulties for this particular case.

8.2.2 Fuel price

According to the American Automobile Association (2006), $2.57 per gallon was the regional average gasoline price in southwest USA on April 6, 2006.

8.2.3 Value of NO_x emissions

Trading of NO_x emissions is still an emerging topic. NO_x trading is considered by Evolution Markets LLC. In a personal communication with the author, Peter Zabrowsky (2006), who is the managing director of the Environmental Markets of Evolution Markets LLC, specified a rough estimate of NO_x value as $2500 per short ton, which is $2756 per a metric ton. This number may be a national average. For the DFW area, two different values are given in the Texas Commission on Environmental Quality (TCEQ, 2006) based on earlier NO_x trading in this area. They are $6500/ton and

$3000/ton of NO_x. An average of the two values is applied in this research as a reasonable value.

8.3 Application of Methodology

Once the model is developed, it can be applied to the data collected for the candidate corridors. Benefits in delay, fuel consumption and emissions are calculated using the model. In order to obtain a single score for each corridor, these three benefits are added. This score is named the Project Benefit Score.

$$\text{Project Benefit Score (PBS)} = V_D * S_D + V_F * S_F + V_E * S_E \quad (8.1)$$

where,

V_D = value of time = $8.39/hour

V_F = Value of fuel = $2.57/gallon and

V_E = value of NO_x emissions = $4750/ton for the existing condition.

S_D = Saving in delay (in sec)

S_F = Saving in fuel consumption (in gallons)

S_E = Saving in NO_x emissions (in tons)

The PBS is calculated assuming that equal importance is given to all the benefits, but the funding organization may establish a different importance to each of these benefits. In that case, their relative importance has to be quantified according to the organization's policies. If the weightings for delay, fuel consumption and emissions are W_D, W_F, W_E respectively,

$$\text{Weighted Project Benefit Score (WPBS)} = W_D V_D S_D + W_F V_F S_F + W_E V_E S_E \quad (8.2)$$

Sorting WPBS for all the candidate projects, a priority list is obtained. The actual performance of this methodology will be known after it is applied at least once to prioritize corridors and then benefits are calculated. The author recommends the model may be periodically updated after a large number of corridors are retimed and before and after studies are completed.

CHAPTER 9

CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

The U.S. Department of Transportation's Federal Highway Administration (FHWA) started a campaign on retiming traffic signals with the video "It's About Time, Traffic Signal Management: Cost-Effective Street Capacity and Safety" in 2001. Inspired by this, more and more cities and regional planning authorities are going to retime signals because retiming traffic signals is one of the most cost-effective techniques available for improving operations.

The prioritization of signal retiming projects, like any other project, is necessary to maximize the benefits with limited funds. This thesis addresses this issue by explaining the benefits provided of traffic signal retiming and the steps involved in such projects before studying the necessity of prioritizing such projects.

The author considers current methods used by various cities and planning agencies in the United States in selecting retiming projects. Based on the responses from these agencies, many regions undertake signal retiming projects on a regular basis; however, there is no common methodology for prioritizing signal retiming projects except at the NCTCOG. Recently, NCTCOG used a sophisticated ranking model methodology for ranking retiming projects.

NCTCOG's ranking methodology is based on the severity of the existing traffic conditions, but the traffic conditions being severe may not assure high benefits from retiming signals on that corridor. Benefits from signal coordination, a technique used in signal retiming to achieve progression of vehicles along the corridor, depend on various features such as uniformity of intersection spacing, and speeds along the corridor.

Hence, a new and more efficient methodology is proposed. In this methodology, regression analysis will be used to estimate the benefits based on existing corridor characteristics, both physical and traffic related. The benefits in delay, fuel consumption and emissions are all dependent variables. The overall corridor benefits for a period until the next retiming in the future are calculated using the data from before and after studies.

Using such a model, corridor benefits can be forecasted before implementation. This model can be used in the future to estimate the benefits associated with any signal retiming project. An overall benefit score called the weighted project benefit score is calculated using dollar rates and weighting for each of benefits. Priority order of these projects is the decreasing order of this overall benefit score.

9.2 Recommendations for Further Research

As there is not enough available data from before and after studies, the methodology is only proposed. NCTCOG is conducting retiming projects along another thirty to forty corridors during 2006. Before and after studies have to be conducted along each of these corridors. Once this data is available, model coefficients can be estimated.

This research considers the uniformity in intersection spacing as a variable on which benefits from retiming may depend. Intersection spacing has important role in coordinated signals. But, all the intersections along a corridor may not be coordinated while retiming. In that case, standard deviation of spacings between every two consecutive intersections may not be meaningful. Hence, groups of intersections may be decided to be coordinated and an average of standard deviations calculated for each group of corridors may be used as a variable. More research is needed in this respect.

Further research is needed in selecting the value of benefits. Research must be done to identify a more accurate dollar value associated with benefits in NO_x from vehicular emissions. Similarly, the value of time should also be examined again to see if any other appropriate value can be obtained for city travel in DFW region. This thesis applies a value of time which was calculated through stated preference surveys. The time savings on the arterials are typically a few seconds rather than a few minutes. Application of value of time which was calculated for HOV or HOT lanes to the savings on arterials may cause some aggregation errors. More research is needed to solve these potential problems.

APPENDIX A

RESPONSES OF VARIOUS TRANSPORTATION ORGANIZATIONS ON SIGNAL REITMING PROJECTS AND THEIR PRIORITIZATION

Recipient Organizations of the E mail Survey

S. No.	Name of the Organization
1	New York State Dept of Transportation
2	New Jersey Transportation Planning Authority
3	Mid-America Regional Council, Kansas
4	East-West Gateway Council of Governments, Saint Louis
5	South East Michigan Council of Governments / Michigan Department of Transportation
6	Metropolitan Orlando
7	Santa Barbara County Association of Governments
8	S.California Association of Governments
9	Sacramento Council of Governments
10	Elmira-Chemung Transportation Council
11	Capital District Transportation Committee, NY
12	Palm Beach County Government
13	City of Indianapolis
14	Miami Dade County Government
15	Knoxville Regional Transportation Planning Organization (TPO)
16	Yuma Metropolitan Planning Organization
17	San Antonio-Bexar County Metropolitan Planning Organization
18	Boston Metropolitan Planning Organization
19	Capital Area Metropolitan Planning Organization, Austin

Reply from City of Indianapolis:

City of Indianapolis has neither staff nor budget to accomplish retiming in regular intervals. Typically corridors are retimed if the corridor is being upgraded or when complaints about the corridors are received. Corridors with the most traffic are concentrated upon.

Reply from Knoxville Regional TPO:

A formal process for prioritization of signal retiming projects is currently not there. Corridors that have been identified as a "congested corridor" in their Congestion Management System (CMS) plan are concentrated upon. The TPO is in the process of updating their CMS plan with new travel time data, which could possibly be used to develop criteria for prioritization for signal retiming projects. Right now they just ask the local jurisdictions in the area to propose re-timing projects that they feel are needed. A good source of funding is available from the Congestion Mitigation and Air Quality Improvement (CMAQ) program, since the area is as a non-attainment area.

Reply from Miami-Dade Public Works:

Usually they do not have time or funding for scheduled traffic signal retiming projects. Instead, they solve signal timing problems on a "fire-fighting" basis. On the rare occasions when they have funding for such projects, they pick the corridors based on engineering judgment, which is in turn based on the following questions:

- How long has it been since the corridor was re-timed?
- How much has traffic flow changed since then?
- How many complaints are we getting about the timing on that corridor?

Reply from S. California Association of Governments - Ventura County:

In Ventura County the only regional prioritization affecting traffic signals would be the CMAQ project selection process. The screening criteria are divided into three categories: project eligibility, planning consistency and financial feasibility. Proposed projects must meet all of these screening criteria in order to move to the next phase of the process. There may also be signal synchronization projects done by individual jurisdictions, but if that is the case, the prioritization would be done by the individual jurisdiction.

Reply from S. California Association of Governments - Riverside County:

Typically they have a "call for projects" per fund type, not project type. Projects are scored for various criteria before being selected.

Reply from Metropolitan Orlando, Florida:

No criteria available at this time. Because there are 21 cities under this organization, the prioritization process can be complex and political. Recently their Board requested that they should look at retiming signals to achieve a regional standard for safety and efficiency. Recently, a corridor has been identified, which serves many of their counties and cities in their region, for their first region retiming project.

Reply from Michigan Department of Transportation:

They do not have a priority set up for what locations. In their view, the best method would be based on volumes and complaints. They started with the Detroit area but now are in the process of retiming the entire state. They are doing entire counties at a time to get better prices on their projects. They are not selecting individual corridors.

APPENDIX B

ORIGINAL DATA OBTAINED FROM NCTCOG

Row No.	Arterial	West or North Limit "A"	East or South Limit "B"	City	Arterial Segment: No. of Signals	Arterial Segment: Length (Miles)	Other Signals That Would Have To Be Retimed	Less Signals Counted Twice	Travel Time (Seconds): Measured Travel Time (Seconds) A-B	Measured Travel Time (Seconds) B-A	Travel Time at Posted Speed (Seconds)	Average Measured Travel Time (As Percentage of Travel	Stops: Average Measured A-B	Average Measured B-A	Average Stops Per Mile	Average Stops Per Signal	No. of Lanes
1	Illinois	Duncanville	SH 342	Dallas	16	5.9			859.5	1,000.5	570	163%	5.5	9.5	1.27	0.47	6
2	Hampton	Leath	Illinois	Dallas	16	4.6			841.0	642.5	455	163%	9.5	4.0	1.47	0.42	6
3	Harry Hines	IH-635	Empire Central	Dallas	15	5.9			832.0	652.0	483	154%	8.0	2.5	0.89	0.35	6
4	FM 1171	Churchill	IH-35E	Flower Mound, Lewisville	16	4.2			622.0	682.0	376	173%	4.5	7.0	1.37	0.36	2
5	Coit	Pres. George Bush	Churchill	Dallas/Richardson/Dallas	19	5.4			709.0	704.0	486	145%	6.0	4.5	0.97	0.28	6
6	Northwest Hwy	US 75	Saturn	Dallas	19	7.6			768.0	849.5	613	132%	5.0	5.0	0.66	0.26	6
7	Richardson-Garland Group 1	N/A	N/A	Richardson/Garland	133	50.5	14	15	6,039.5	5,960.5	4,252	141%	35.0	34.0	0.68	0.26	N/A
8	Jupiter	Spring Creek Pkwy	PGBT EBFR	Plano	10	3.5			496.0	450.0	347	136%	3.0	3.0	0.86	0.30	6
9	SH 190 (PGBT Frontage Roads)	Jupiter Road	Brand	Richardson/Garland	7	4.4			509.5	475.0	314	157%	4.0	2.5	0.74	0.46	6
10	FM 3040/Hebron/Park Blvd	Edmonds	Lakepointe	Lewisville	13	2.4			323.5	434.5	186	204%	5.0	6.5	2.40	0.44	6
11	Dallas Group 3 (Royal E of US 75, etc.)	N/A	N/A	Dallas	17	5.6	9	0	772.5	802.5	541	146%	5.0	3.5	0.76	0.25	N/A
12	Pioneer Pkwy (Spur 303)	Susan	SE 14th	Grand Prairie	9	4.2			440.5	411.0	326	131%	3.0	4.0	0.83	0.39	6
13	Pleasant Run	Hampton	IH-35E	Desoto	7	1.9			283.0	392.0	170	199%	2.0	4.0	1.58	0.43	4
14	Dallas Group 2 (Preston,Royal, etc.)	N/A	N/A	Dallas	140	47.6	26	12	6,255.5	6,020.5	4,646	132%	41.5	32.0	0.77	0.26	N/A
15	SH 78	Naaman School	Castle	Garland	4	1.7			173.5	174.0	124	140%	1.0	0.5	0.44	0.19	6
16	SH 78	Brown (FM 3412)	Murphy Road	Wylie/Sachse	6	5.5			527.0	495.0	424	121%	3.0	2.5	0.50	0.46	4
17	Rowlett Road	Castle	Roan	Rowlett	7	5.0			543.0	546.5	426	128%	2.5	3.5	0.60	0.43	4
18	Irving Blvd	Willowcreek	Norwood	Irving	17	6.2			726.0	968.0	555	153%	4.5	7.0	0.93	0.34	4
19	Denton Tap/Belt Line	Lakeshore	Oakdale	Irving	28	9.4			1,048.0	1,122.5	834	130%	8.0	6.5	0.77	0.26	6
20	Frankford	Campbell	Coit	Dallas	6	2.1			278.0	221.5	191	131%	1.5	1.5	0.71	0.25	6
21	Valley View Ln	Senlac	Alpha	Farmers Branch	14	3.7			501.5	492.0	360	138%	4.0	3.5	1.01	0.27	4
22	Preston	PGBT	Arapaho	Dallas	8	3.5			272.0	366.0	274	116%	1.5	2.0	0.50	0.22	6
23	Dallas Group 1 (Oaklawn, etc.)	N/A	N/A	Dallas	91	21.8	29	7	2,964.0	2,730.0	2,117	134%	19.5	17.0	0.84	0.20	N/A
24	Marsh/Lemmon	Hebron Pkwy	Country Square	Dallas/Carrollton	12	4.4			488.0	540.0	420	122%	2.5	3.5	0.68	0.25	6
25	MacArthur	SH 114	SH 183	Irving	16	3.5			533.0	512.0	360	145%	3.5	5.0	1.21	0.27	6
26	FM 407	Chinn Chapel	IH-35E	Flower Mound, Lewisville	10	3.6			440.0	468.0	313	145%	3.5	4.0	1.04	0.38	2

		Volume Data									Cumulative No. of Signals and Miles of Corridor		
		From NCTCOG 1999 Volumes Unless Later Year is Noted			More Recent Count If Available				ADT Volume Used For Ranking				
Row No.	Arterial	ADT Volume	Year	Volume Adjusted to 2003	Newer ADT Volume	Year	Source	Volume Adjusted to 2003		Existing System Type	No. of Signals	Length (Miles)	Comments
1	Illinois	32,640	1999	35,331	38,113	2002	C of D	38,875	38,875	1	16	5.9	
2	Hampton	43,030	1999	46,577	47,316	2001	C of D	49,228	49,228	1	32	10.5	
3	Harry Hines	47,390	1999	51,296	46,029	2002	C of D	46,950	51,296	1	47	16.4	
4	FM 1171	44,000	2001	45,778	32,501	2002	C of L	33,151	45,778	1	63	20.6	
5	Coit	52,910	1999	57,271	58,690	2002	C of R	59,864	59,864	1	82	26.0	
6	Northwest Hwy	58,930	1999	63,788	67,016	2002	C of D	68,356	68,356	1	101	33.6	
7	Richardson-Garland Group 1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	529,891	1	233	84.1	
8	Jupiter	35,430	1999	38,351	46,738	2002	C of P	47,673	47,673	1	243	87.6	
9	SH 190 (PGBT Frontage Roads)	6,400	1999	6,928	24,520	2001	C of G	25,511	25,511	2	250	92.0	
10	FM 3040/Hebron/Park Blvd	39,770	1999	43,048				0	43,048	2	263	94.4	
11	Dallas Group 3 (Royal E of US 75, etc.)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	76,847	1	289	100.0	
12	Pioneer Pkwy (Spur 303)	31,680	1999	34,291	34,658	2002	C of GP	35,351	35,351	1	298	104.2	
13	Pleasant Run	20,750	1999	22,460				0	22,460	2	305	106.1	
14	Dallas Group 2 (Preston,Royal, etc.)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	402,855	1	459	153.7	
15	SH 78	34,160	1999	36,976	37,533	1999	C of G	40,627	40,627	1	463	155.4	
16	SH 78	29,000	1999	31,391				0	31,391	2	469	160.9	
17	Rowlett Road	37,520	1999	40,613				0	40,613	3	476	165.9	
18	Irving Blvd	28,260	1999	30,590				0	30,590	2	493	172.1	Excellent progression during PM peak
19	Denton Tap/Belt Line	60,670	1999	65,671				0	65,671	2	521	181.5	
20	Frankford	35,180	1999	38,080	N/A			0	38,080	1	527	183.6	
21	Valley View Ln	22,650	1999	24,517	33,037	2000	C of FB	35,059	35,059	1	541	187.3	
22	Preston	60,350	1999	65,325	60,837	2001	C of D	63,295	65,325	1	549	190.8	Excellent progression during AM peak
23	Dallas Group 1 (Oaklawn, etc.)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	280,415	1	662	212.6	
24	Marsh/Lemmon	38,080	1999	41,219	N/A			0	41,219	1	674	217.0	
25	MacArthur	45,230	1999	48,958	49,400	2001	C of Irv	51,396	51,396	2	690	220.5	
26	FM 407	25,000	2001	26,010	27,428	2000	C of L	29,107	29,107	2	700	224.1	

	Arterial	West or North Limit "A"	East or South Limit "B"	City	Arterial Segment		Other Signals That Would Have To Be Retimed	Less Signals Counted Twice	Travel Time (Seconds)				Stops				No. of Lanes
									Measured Travel Time (Seconds)		Travel Time at Posted Speed (Seconds)	Average Measured Travel Time (As Percentage of Travel	Average Measured		Average Stops Per Mile	Average Stops Per Signal	
					No. of Signals	Length (Miles)			A-B	B-A			A-B	B-A			
27	First/Broadway	Avenue D	Centerville	Garland	7	2.3			249.0	248.5	205	121%	1.5	1.5	0.65	0.21	6
28	Buckner	Northcliff	Mercer	Dallas	7	1.8			219.0	223.5	162	137%	1.0	1.5	0.69	0.18	6
29	Hampton	Illinois	IH-20	Dallas	10	5.0			542.0	555.0	452	121%	2.5	2.5	0.50	0.25	6
30	MacArthur	Belt Line	SH 114	Irving	19	4.6			723.0	577.0	474	137%	5.5	3.0	0.92	0.22	6
31	Belt Line	Marsh	DNT SBFR	Addison	9	1.9			277.5	164.0	166	133%	2.0	0.5	0.66	0.14	6
32	Belt Line	Luna	Marsh	Carrollton	16	3.9			411.5	466.5	350	125%	1.0	5.5	0.83	0.20	6
33	US 380	IH-35	Cooper Creek	Denton	16	5.3			740.5	626.5	486	141%	6.0	5.0	1.04	0.34	4
34	Carrier Pkwy	Conover	Bardin	Grand Prairie	15	4.5			490.0	618.5	401	138%	2.5	6.0	0.94	0.28	4
35	Abram/Jefferson	Great SW Pkwy	Camden	Grand Prairie	15	5.1			622.0	520.0	464	123%	4.5	3.0	0.74	0.25	4
36	MacArthur	FM 3040	Belt Line	Coppell	9	3.8			429.5	544.0	372	131%	2.0	3.0	0.66	0.28	4
37	Denton Tap/Belt Line	Oakdale	IH-20	Grand Prairie	24	8.0			1,033.5	801.0	671	137%	6.0	4.0	0.63	0.21	4
38	Campbell	Preston	Meandering Way	Dallas	5	1.6			185.5	202.0	166	117%	1.0	1.5	0.78	0.25	6
39	FM 3040/Hebron/Park Blvd	Marchant	Marsh	Carrollton	13	5.7			578.5	582.5	455	128%	2.0	3.0	0.44	0.19	6
40	Marsh/Lemmon	Country Square	IH-635	Addison/Farmers Branch	12	2.8			321.5	353.0	287	118%	1.0	3.5	0.80	0.19	6
41	Royal	MacArthur	IH-35E	Irving/Dallas	8	3.5			340.5	365.5	273	129%	2.0	3.5	0.79	0.34	6
42	Preston	FM 720	SH 121	Frisco	9	3.7			344.5	324.0	297	113%	2.0	0.5	0.34	0.14	6
43	Broadway	Centerville	Guthrie	Garland	11	3.3			294.0	341.5	261	122%	1.5	1.0	0.38	0.11	6
44	US 380	Skyline	SH 5	McKinney	11	2.2			358.0	247.0	195	155%	4.5	1.0			6
45	Denton Tap/Belt Line	SH 121	Lakeshore	Lewisville/Coppell	12	4.1			479.5	422.5	362	125%	3.0	3.5	0.79	0.27	6
46	Hampton	Wheatland	Parkerville	Dallas/Desoto	12	4.7			555.5	607.0	426	136%	3.5	4.5	0.85	0.33	4
47	SH 66	Centerville	Dalrock	Rowlett	7	4.6			411.0	374.0	345	114%	1.0	0.5	0.16	0.11	6
48	Bethany	US 75	Cheyenne		8	2.7			350.5	377.0	251	145%	3.0	2.5	1.02	0.34	4
49	Camp Wisdom	Cedar Ridge	US 67	Duncanville/Dallas	12	3.2			354.0	566.5	291	158%	0.5	6.5	1.09	0.29	6
50	Garland Rd	Jupiter	La Vista	Dallas	13	3.8			369.0	422.0	347	114%	1.0	1.5	0.33	0.10	6
51	Division/Main	Great SW Pkwy	MacArthur	Grand Prairie	16	4.8			557.5	488.0	436	120%	1.5	2.5	0.42	0.13	4
52	Galloway	Oates	Gross	Mesquite	20	5.7			809.5	772.5	587	135%	6.5	5.5	1.05	0.30	4
53	Northeast Parkway	Crist	Castle	Garland	5	2.3			238.5	215.0	188	121%	2.0	0.5	0.54	0.25	6

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		Volume Data									Existing System Type	Cumulative No. of Signals and Miles of Corridor		
		From NCTCOG 1999 Volumes Unless Later Year is Noted			More Recent Count If Available				ADT Volume Used For Ranking					
	Arterial	ADT Volume	Year	Volume Adjusted to 2003	Newer ADT Volume	Year	Source	Volume Adjusted to 2003			No. of Signals	Length (Miles)	Comments
27	First/Broadway	43,610	1999	47,205	47,673	1999	C of G	51,603	51,603	1	707	226.4	
28	Buckner	35,650	1999	38,589	39,760	2001	C of D	41,366	41,366	1	714	228.2	
29	Hampton	26,230	1999	28,392	27,310	2001	C of D	28,413	28,413	1	724	233.2	
30	MacArthur	43,940	1999	47,562	51,000	2001	C of Irv	53,060	53,060	2	743	237.8	
31	Belt Line	51,150	1999	55,366	55,382	2002	C of A	56,490	56,490	1	752	239.7	
32	Belt Line	45,970	1999	49,759				0	49,759	1	768	243.6	
33	US 380	24,000	2001	24,970	25,970	1999	C of Den	28,111	28,111	2	784	248.9	
34	Carrier Pkwy	26,879	1998	29,677	36,095	2002	C of GP	36,817	36,817	2	799	253.4	6 lanes wide from Crossland to Westchester
35	Abram/Jefferson	15,940	1999	17,254	24,247	2002	C of GP	24,732	24,732	1	814	258.5	
36	MacArthur	26,250	1999	28,414				0	28,414	2	823	262.3	
37	Denton Tap/Belt Line	37,170	1999	40,234	40,384	2002	C of GP	41,192	41,192	2	847	270.3	Northern portion is under construction
38	Campbell	27,630	1999	29,908	23,048	2001	C of D	23,979	29,908	1	852	271.9	
39	FM 3040/Hebron/Park Blvd	38,720	1999	41,912	42,400	2001	C of C	44,113	44,113	2	865	277.6	
40	Marsh/Lemmon	43,970	1999	47,595	43,090	2002	C of A	43,952	47,595	1	877	280.4	Actual speeds well in excess of posted
41	Royal	24,120	1999	26,108	21,495	2000	C of D	22,811	26,108	2	885	283.9	Irving intersections do not have comm; signals being added at Love and at Los Colinas
42	Preston	32,000	2001	33,293	52,128	2001	C of F	54,234	54,234	1	894	287.6	
43	Broadway	41,770	1999	45,213				0	45,213	1	905	290.9	
44	US 380	31,740	1999	34,356	31,932	2000	C of M	33,886	34,356	1	916	293	
45	Denton Tap/Belt Line	35,160	1999	38,058				0	38,058	2	928	297.2	
46	Hampton	28,670	1999	31,033	32,392	2001	C of D	33,701	33,701	3	940	301.9	
47	SH 66	27,360	1999	29,615	29,000	2001	TxDOT	30,172	30,172	1	947	306.5	
48	Bethany	25,360	1999	27,450	27,613	2003	C of A	27,613	27,613	3	955	309.2	
49	Camp Wisdom	27,090	1999	29,323	29,022	2001	C of D	30,194	30,194	3	967	312.4	
50	Garland Rd	38,990	1999	42,204	40,755	2002	C of D	41,570	42,204	1	980	316.2	
51	Division/Main	17,360	1999	18,791	22,098	2002	C of GP	22,540	22,540	1	996	321.0	
52	Galloway	34,760	1999	37,625				0	37,625	3	1,016	326.7	
53	Northeast Parkway	33,330	1999	36,077	51,043	2001	C of G	53,105	53,105	3	1,021	329	The signal at Crist is installed but not yet operational

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									Measured Travel Time (Seconds)		Travel Time at Posted Speed (Seconds)	Average Measured Travel Time (As Percentage of Travel	Average Measured		Average Stops Per Mile	Average Stops Per Signal	
					No. of Signals	Length (Miles)			A-B	B-A			A-B	B-A			
54	Miller	First	Centerville	Garland	4	1.6			229.5	199.5	145	148%	2.0	1.0	0.94	0.38	4
55	Main/McDermott	Suncreek/Twin Creeks	Malone		14	4.2			558.0	556.0	469	119%	2.0	3.5	0.65	0.20	6
56	Carrier Pkwy	SH 360	Conover	Grand Prairie	14	5.3			569.5	571.5	487	117%	4.0	3.0	0.66	0.25	4
57	Pleasant Run	IH-35E	SH 342	Lancaster	7	3.7			431.5	470.5	373	121%	2.5	2.5	0.68	0.36	4
58	Rowlett Road	Roan	Broadway	Garland	5	1.7			171.0	200.5	130	143%	1.0	2.0	0.88	0.30	4
59	Main Street	Dallas North Tollway	County	Frisco	3	1.2			170.5	163.5	113	148%	1.0	1.0	0.83	0.33	2
60	Virginia Pkwy	Jordan	Wilson Creek Pkwy	McKinney	5	1.1			141.5	159.0	83	181%	1.0	1.0	0.91	0.20	4
61	Cedar Ridge	IH-20	Santa Fe	Duncanville	8	2.2			231.5	268.5	200	125%	1.5	3.5	1.14	0.31	6
62	Buckner	Samuell	Elam	Dallas	15	5.0			490.0	481.0	505	96%	1.0	1.0	0.20	0.07	6
63	Jupiter	McDermott/Main	Spring Creek Pkwy	Allen	5	3.4			373.0	453.5	330	125%	1.0	2.0	0.44	0.30	2
64	Eldorado	Lake Forest	Craig	McKinney	4	2.5			239.0	258.5	222	112%	0.5	1.5	0.40	0.25	4
65	Stacy Road	CR 196	Angel Pkwy	Allen	5	2.1			207.0	204.0	143	144%	1.0	1.5	0.60	0.25	4
66	Wheatland	Clark	Hampton	Duncanville	17	4.8			563.5	547.5	415	134%	3.5	4.0	0.78	0.22	6
67	Carroll/Fort Worth Dr	Sherman	IH-35E	Denton	13	2.5			279.5	253.5	252	106%	2.0	2.0	0.80	0.15	2
68	Belt Line	Guthrie	Bruton	Sunnyvale/Mesquite	16	6.0			670.5	611.5	551	116%	4.5	2.5	0.58	0.22	6
69	Bryant-Irvin	IH-30	Southwest Pkwy	Fort Worth	7	3.0			560.0	534.0	296	185%	5.5	4.5	N/A	0.71	4
70	Abram/Jefferson	Cooper	Great SW Pkwy	Arlington	12	4.0			525.5	604.0	372	152%	5.0	4.5	1.19	0.40	6
71	Green Oaks SE/SW	Kelly-Elliott	SH 360	Arlington, Grand Prairie	12	6.6			748.5	804.0	530	146%	6.0	6.5	0.95	0.52	4
72	Fort Worth Group 3 (Camp Bowie, etc.)	N/A	N/A	Fort Worth	17	3.3	1	2	657.0	643.5	283	230%	6.5	7.0	2.05	0.40	N/A
73	Camp Bowie	SH 183	IH-30	Fort Worth	8	2.2			294.5	397.0	224	154%	2.5	4.5	1.59	0.44	6
74	US 377	Keller-Hicks	Broadway	Haltom City, Watauga, Kel	19	8.9			1,109.5	1,079.0	693	158%	9.2	8.0	0.97	0.45	4
75	Bryant-Irvin	Southwest Pkwy	Mira Vista	Fort Worth	10	2.5			294.0	504.0	222	180%	1.5	4.5	N/A	0.30	6
76	Belknap/Grapevine Hwy	Sylvania	Rufe Snow	Fort Worth, Haltom City, NRH	10	5.2			742.0	799.0	493	156%	6.5	5.5	1.15	0.60	4
77	Collins	Abram	Bardin	Arlington	12	4.4			583.0	521.5	381	145%	5.5	5.5	1.25	0.46	6
78	Great Southwest Pkwy	Division/Main	Fairmont	Grand Prairie	15	5.1			919.0	581.0	424	177%	4.5	3.5	0.78	0.27	4
79	Division/Main	Bowen	Great SW Pkwy	Arlington	16	6.2			782.0	772.5	570	136%	5.0	7.0	0.97	0.38	4
80	Belknap/Grapevine Hwy	Rufe Snow	Precinct Line	Haltom City, NRH	13	4.1			627.0	533.5	338	172%	7.5	4.0	1.40	0.44	4

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		From NCTCOG 1999 Volumes Unless Later Year is Noted			More Recent Count If Available				ADT Volume Used For Ranking				
		ADT Volume	Year	Volume Adjusted to 2003	Newer ADT Volume	Year	Source	Volume Adjusted to 2003			No. of Signals	Length (Miles)	
54	Miller	15,160	1999	16,410				0	16,410	3	1,025	330.6	
55	Main/McDermott	35,618	2003	35,618	34,773	2003	C of A	34,773	35,618	2	1,039	334.8	
56	Carrier Pkwy	26,190	1999	28,349	27,684	2002	C of GP	28,238	28,349	2	1,053	340.1	
57	Pleasant Run	19,900	1999	21,540				0	21,540	3	1,060	343.8	
58	Rowlett Road	23,920	1999	25,892				0	25,892	3	1,065	345.5	
59	Main Street	13,697	2001	14,250				0	14,250	3	1,068	346.7	Signals widely spaced
60	Virginia Pkwy	23,520	1999	25,459				0	25,459	3	1,073	347.8	
61	Cedar Ridge	26,610	1999	28,804				0	28,804	3	1,081	350.0	
62	Buckner	15,690	1999	16,983	40,986	2001	C of D	42,642	42,642	1	1,096	355.0	Actual speeds well in excess of posted
63	Jupiter	9,140	2002	9,323				0	9,323	3	1,101	358.4	
64	Eldorado	27,510	1999	29,778	27,631	2002	C of M	28,184	29,778	3	1,105	360.9	
65	Stacy Road	9,900	2001	10,300	14,767	2002	City of A	15,062	15,062	3	1,110	363.0	
66	Wheatland	23,450	1999	25,383				0	25,383	3	1,127	367.8	
67	Carroll/Fort Worth Dr	20,400	1999	22,082	32,274	1999	C of Den	34,934	34,934	2	1,140	370.3	Actual speeds well in excess of posted
68	Belt Line	30,420	1999	32,928				0	32,928	3	1,156	376.3	
69	Bryant-Irvin	27,850	1999	30,146				0	30,146	2	7	7.0	
70	Abram/Jefferson	44,140	1999	47,779				0	47,779	1	19	13.6	New system under other TIP project
71	Green Oaks SE/SW	23,280	1999	25,199				0	25,199	1	31	16.9	
72	Fort Worth Group 3 (Camp Bowie, etc.)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	73,833	1	47	19.1	
73	Camp Bowie	29,670	1999	32,116				0	32,116	1	55	28.0	
74	US 377	42,330	2003	42,330				0	42,330	3	74	30.5	Retimed as West Pilot Project; consider for upgrade to closed-loop system
75	Bryant-Irvin	41,990	1999	45,451				0	45,451	2	84	35.7	
76	Belknap/Grapevine Hwy	23,790	1999	25,751				0	25,751	3	94	40.1	
77	Collins	38,780	1999	41,977				0	41,977	2	106	45.2	
78	Great Southwest Pkwy	18,780	1999	20,328				0	20,328	1	121	51.4	
79	Division/Main	22,259	1999	24,094				0	24,094	1	137	55.5	New system under other TIP project
80	Belknap/Grapevine Hwy	32,990	1999	35,709				0	35,709	3	150	64.5	

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									Measured Travel Time (Seconds)		Travel Time at Posted Speed (Seconds)	Average Measured Travel Time (As Percentage of Travel	Average Measured		Average Stops Per Mile	Average Stops Per Signal	
					No. of Signals	Length (Miles)			A-B	B-A			A-B	B-A			
81	FM 1709	US 377	SH 114	Keller, Southlake	21	9.0			999.0	894.0	757	125%	5.5	4.0	0.53	0.23	4
82	SH 183	Ridgmar Mall	SH 199	Fort Worth	11	4.5			523.0	499.0	340	150%	4.0	2.5	0.72	0.30	4
83	Weatherford Hwy	IH-820	SH 183	Fort Worth	8	2.3			324.0	329.0	205	159%	3.0	3.0	1.30	0.38	6
84	Fort Worth Group 1 (Granbury-Wabash)	N/A	N/A	Fort Worth	13	3.0	1	0	489.5	507.5	272	183%	4.0	5.0	1.50	0.35	N/A
85	Little Rd/Green Oaks W	Treepoint	Pleasant Ridge	Arlington	10	1.3			246.5	176.0	120	176%	3.0	1.0	1.54	0.20	4
86	Pioneer Pkwy (Spur 303)	Oakridge	Susan	Arlington	20	8.2			771.0	903.5	644	130%	3.5	5.5	0.55	0.23	4
87	Oakland/Miller	Meadowbrook	Martin	Fort Worth	10	3.7			517.5	472.0	314	158%	4.0	3.0	0.95	0.35	4
88	Matlock	Pioneer	Debbie	Arlington, Mansfield	17	7.3			781.0	720.0	593	127%	5.5	4.5	0.68	0.29	4
89	Collins	Green Oaks NW	Abram	Arlington	11	3.2			418.0	432.0	326	130%	3.0	3.0	0.94	0.27	6
90	SH 183	SH 199	IH-35W	Fort Worth	11	3.8			480.0	539.0	413	123%	3.5	4.5	1.05	0.36	6
91	Crowley Rd	IH-20	Sycamore School	Fort Worth	6	2.0			272.0	231.0	174	145%	2.0	1.5	0.88	0.29	6
92	Watauga/ Mid Cities	US 377	FM 1938	Watauga, NRH	7	3.2			498.0	334.5	298	140%	3.0	2.0	0.78	0.36	4
93	Fort Worth Group 1 (N of IH-820)	N/A	N/A	Fort Worth	29	9.0	0	2	1,333.5	1,277.5	816	160%	9.0	6.0	0.83	0.26	N/A
94	Harwood	Norwood	FM 157	Bedford	13	4.1			579.5	575.0	353	164%	5.5	5.0	1.28	0.40	4
95	Cooper	UTA Blvd	Turner-Warnell	Arlington	22	8.9			917.0	1,117.5	715	142%	6.0	10.5	0.93	0.38	4
96	Central	Cummings	SH 183	Bedford	6	1.5			251.0	224.5	136	175%	2.0	2.0	1.33	0.33	6
97	Cooper	Turner-Warnell	Debbie	Mansfield	3	1.5			183.5	150.0	109	153%	0.5	0.5	0.33	0.17	4
98	FM 157	Mid Cities	US 183 EBFR	Bedford/Euless	7	2.0			266.0	222.5	160	153%	2.0	1.5	0.88	0.25	4
99	Beach	IH-820	East 1st	Fort Worth	9	4.9			640.0	496.0	469	121%	2.5	4.5	0.71	0.39	4
100	Bridge St	Oakland	IH-820	Fort Worth	10	3.0			383.5	327.5	262	136%	4.5	2.0	1.08	0.33	4
101	FM 1938	FM 1709	IH-820	NRH, Keller, Southlake	15	7.2			617.5	681.5	530	123%	4.0	5.0	0.63	0.30	4
102	Bedford-Euless Rd	Strummer	Brown Trail	Hurst	9	2.6			445.0	409.0	263	162%	3.0	4.0	1.35	0.39	4
103	SH 10	Raider	Main	Euless	8	3.4			316.0	383.5	249	140%	0.5	2.5	0.44	0.19	4
104	Bedford Rd	Brown Trail	Martin	Bedford	7	2.6			291.5	329.0	204	152%	1.5	0.5	0.38	0.14	4
105	SH 199	Tenderfoot	Love Circle	Fort Worth	4	4.3			275.0	319.5	259	115%	0.0	0.5	0.06	0.06	4
106	Lancaster	Riverside	Handley	Fort Worth	12	4.9			578.0	573.5	443	130%	3.0	2.5	0.56	0.23	4
107	Summit/8th/Cleburne	Rio Grande	Benbrook Blvd	Fort Worth	15	3.0			647.0	604.5	327	191%	8.5	8.0	2.75	0.55	4
108	Cooper	Lamar	Division	Arlington	6	1.4			N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
109	Cooper	Division	UTA Blvd		3	0.4			N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6

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	Arterial	Volume Data: From NCTCOG 1999 Volumes Unless Later Year is Noted: ADT Volume	Year	Volume Adjusted to 2003	More Recent Count If Available: Newer ADT Volume	Year	Source	Volume Adjusted to 2003	ADT Volume Used For Ranking	Existing System Type	Cumulative No. of Signals and Miles of Corridor: No. of Signals	Length (Miles)	Comments
81	FM 1709	43,570	1999	47,162				0	47,162	1	171	69.0	
82	SH 183	32,560	1999	35,244				0	35,244	2	182	71.3	
83	Weatherford Hwy	26,560	1999	28,749				0	28,749	2	190	74.3	
84	Fort Worth Group 1 (Granbury-Wabash)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	45,365	2	204	75.6	
85	Little Rd/Green Oaks W	34,910	1999	37,788				0	37,788	1	214	83.8	New system under other TIP project
86	Pioneer Pkwy (Spur 303)	29,160	1999	31,564				0	31,564	1	234	87.5	New system under other TIP project
87	Oakland/Miller	18,090	1999	19,581				0	19,581	2	244	94.8	
88	Matlock	33,410	1999	36,164				0	36,164	2	261	98.0	New system under other TIP project
89	Collins	35,320	1999	38,232				0	38,232	2	272	101.8	New system under other TIP project
90	SH 183	26,560	1999	28,749				0	28,749	2	283	103.8	
91	Crowley Rd	22,540	1999	24,398				0	24,398	2	289	107.0	
92	Watauga/ Mid Cities	25,430	1999	27,526				0	27,526	3	296	129.0	Split into 2 segments
93	Fort Worth Group 1 (N of IH-820)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	94,042	3	323	120.1	
94	Harwood	22,282	1999	24,119	22,282	1999	C of Bed	24,119	24,119		336	129.0	Combination of segments 11-1 and 11-2
95	Cooper	29,560	1999	31,997				0	31,997	3	358	130.5	
96	Central	18,347	2002	18,714	27,300	2002	C of Bed	27,846	27,846	3	364	132.0	
97	Cooper	29,560	1999	31,997	30,134	2002	C of M	30,737	31,997	3	367	134.0	
98	FM 157	17,610	1999	19,062				0	19,062	2	374	138.9	
99	Beach	25,590	1999	27,699				0	27,699	3	383	141.9	
100	Bridge St	8,910	1999	9,644				0	9,644	2	393	149.1	
101	FM 1938	30,160	1999	32,646				0	32,646	3	408	151.7	
102	Bedford-Euless Rd	8,900	1999	9,634				0	9,634	3	417	155.1	New system under other TIP project
103	SH 10	23,200	1999	25,112				0	25,112	3	425	157.7	
104	Bedford Rd	21,302	2000	22,606	19,030	2000	C of Bed	20,195	22,606	3	432	162.0	
105	SH 199	38,790	1999	41,988				0	41,988	3	436	166.9	
106	Lancaster	20,550	1999	22,244				0	22,244	3	448	169.9	
107	Summit/8th/Cleburne	25,540	1999	27,645				0	27,645	2	463	15.3	Utility construction adversely affected TT runs
108	Cooper	37,010	1999	40,061				0	40,061	1			New system under other TIP project; TT data unavailable due to roadway construction (currently being widened to 6 lanes)
109	Cooper	61,420	1999	66,483				0	66,483	1			TT data unavailable due to roadway construction (currently being widened to 6 lanes)

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	Arterial	West or North Limit "A"	East or South Limit "B"	City	Arterial Segment		Other Signals That Would Have To Be Retimed	Less Signals Counted Twice	Travel Time (Seconds)				Stops				No. of Lanes
									Measured Travel Time (Seconds)		Travel Time at Posted Speed (Seconds)	Average Measured Travel Time (As Percentage of Travel	Average Measured		Average Stops Per Mile	Average Stops Per Signal	
					No. of Signals	Length (Miles)			A-B	B-A			A-B	B-A			
110	Belt Line	DNT SBFR	Coit	Dallas	8	3.1			452.0	463.5	289	158%	2.5	3.0	0.89	0.34	6
111	Jupiter	Buckingham	Northwest Hwy	Garland/Dallas	16	4.6			618.0	616.5	388	159%	4.0	4.0	0.87	0.25	6
112	Spring Valley	Inwood	Meandering Way	Farmers Branch/Dallas	8	2.7			403.5	427.5	273	152%	3.5	3.0	1.20	0.41	6
113	Alpha	Dallas North Tollway	Hillcrest	Dallas	7	2.1			376.5	309.5	212	162%	2.5	2.5	1.19	0.36	5
114	Jupiter	PBGT EBFR	Buckingham	Richardson	10	4.7			553.5	569.5	422	133%	3.5	4.0	0.80	0.38	6
115	Oaklawn	Blackburn	Highline	Dallas	11	1.5			323.5	362.5	179	192%	3.0	3.0	2.00	0.27	4
116	Forest	US 75	IH-635	Dallas	9	2.2			304.5	312.5	195	158%	2.5	1.5	0.91	0.22	6
117	Harry Hines	Empire Central	Wycliff	Dallas	9	2.3			325.5	285.0	188	162%	3.0	2.5	1.20	0.31	6
118	Forest	Harry Hines	US 75	Dallas	21	7.1			971.5	869.5	669	138%	6.5	4.5	0.77	0.26	6
119	Belt Line	Coit	Jupiter	Richardson	16	5.1			785.0	682.5	527	139%	3.5	4.5	0.78	0.25	6
120	Preston	Arapaho	IH-635	Dallas	10	2.6			378.0	352.5	204	179%	2.0	1.5	0.67	0.18	6
121	Inwood	Alpha	Mockingbird	Dallas	15	6.3			775.0	878.0	622	133%	4.5	5.0	0.75	0.32	4
122	FM 3040/Hebron/Park Blvd	Marsh	Alma	Plano	23	7.6			853.5	927.0	675	132%	7.5	5.5	0.86	0.28	6
123	First	Buckingham	Avenue D	Garland	4	1.5			158.0	180.0	127	133%	1.5	0.5	0.67	0.25	6
124	Preston	SH 121	PBGT	Plano	16	5.7			520.5	724.5	468	133%	2.0	5.0	0.61	0.22	6
125	Royal	US 75	IH-635	Dallas	8	3.4			468.0	490.0	346	138%	2.5	2.0	0.66	0.28	6
126	Northwest Hwy	Newkirk	US 75	Dallas	28	8.9			1,106.0	1,019.0	871	122%	10.0	6.0	0.90	0.29	6
127	SH 121	Denton Tap	IH-35E	Lewisville	5	2.4			235.5	230.5	147	159%	1.5	1.5	0.63	0.30	6
128	Marsh/Lemmon	Almazon	US 75	Dallas	21	5.4			711.5	715.5	536	133%	3.0	4.0	0.65	0.17	6
129	Arapaho	US 75	Jupiter	Richardson	10	2.5			285.5	359.0	226	143%	1.5	2.0	0.70	0.18	6
130	Inwood	Mockingbird	Conveyor	Dallas	13	2.7			399.0	294.0	264	131%	4.0	2.0	1.11	0.23	6
131	Belt Line/First	Jupiter	Buckingham	Garland	11	3.5			446.0	361.5	303	133%	4.5	0.5	0.71	0.23	6
132	Arapaho/Garland Ave	Jupiter	Avenue F	Garland	13	5.0			595.0	493.0	414	131%	4.5	3.0	0.75	0.29	4
133	Skillman/Forest	Audelia	State	Dallas/Garland	16	3.7			396.5	446.5	295	143%	1.5	2.5	0.54	0.13	6
134	Shiloh	Pres. George Bush	Northwest Hwy	Garland/Dallas	18	8.0			984.0	915.5	703	135%	6.0	6.0	0.75	0.33	4
135	Irving Blvd/Industrial	Norwood	Reunion	Dallas	17	5.7			648.5	602.0	504	124%	4.5	4.5	0.79	0.26	6
136	Spring Valley/Centennial	Meandering Way	College Park	Richardson	13	4.0			442.5	478.5	385	120%	2.5	4.0	0.81	0.25	6
137	FM 3040/Hebron/Park Blvd	Alma	Los Rios	Plano	8	3.9			493.0	542.0	443	117%	3.5	4.0	0.96	0.47	4
138	Royal	IH-35E	US 75	Dallas	20	7.2			924.5	795.0	745	115%	6.0	3.0	0.63	0.23	6
139	Preston	IH-635	Northwest Hwy	Dallas	16	4.0			508.5	511.0	411	124%	3.5	2.0	0.69	0.17	6
140	Buckingham	College Park	SH 78	Garland	12	4.6			457.5	493.5	396	120%	1.0	1.0	0.22	0.08	6

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	Arterial	Volume Data								Existing System Type	Cumulative No. of Signals and Miles of Corridor		Comments
		From NCTCOG 1999 Volumes Unless Later Year is Noted			More Recent Count If Available				ADT Volume Used For Ranking				
		ADT Volume	Year	Volume Adjusted to 2003	Newer ADT Volume	Year	Source	Volume Adjusted to 2003			No. of Signals	Length (Miles)	
110	Belt Line	43,700	1999	47,302	N/A			0	47,302	1	8	3.1	
111	Jupiter	39,930	1999	43,222	51,854	1999	C of G	56,128	56,128	1	24	7.7	
112	Spring Valley	31,160	1999	33,729	N/A			0	33,729	1	32	10.4	
113	Alpha	31,200	1999	33,772	N/A			0	33,772	1	39	12.5	
114	Jupiter	34,670	1999	37,528	40,920	2002	C of R	41,738	41,738	1	49	17.2	
115	Oaklawn	39,290	1999	42,529	N/A			0	42,529	1	60	18.7	
116	Forest	46,000	1999	49,792	48,545	2002	C of D	49,516	49,792	1	69	20.9	
117	Harry Hines	37,770	1999	40,883				0	40,883	1	78	23.2	
118	Forest	43,960	1999	47,584	38,750	2001	C of D	40,316	47,584	1	99	30.3	
119	Belt Line	40,390	1999	43,719	40,900	2002	C of R	41,718	43,719	1	115	35.4	
120	Preston	34,190	1999	37,008	34,614	2002	Cof D	35,306	37,008	1	125	38.0	
121	Inwood	24,280	1999	26,281	30,529	1998	C of D	33,706	33,706	1	140	44.3	
122	FM 3040/Hebron/Park Blvd	47,150	1999	51,037				0	51,037	1	163	51.9	Not considered at City request (TT runs for regional assessment only)
123	First	43,610	1999	47,205				0	47,205	1	167	53.4	
124	Preston	52,000	2001	54,101				0	54,101	1	183	59.1	Not considered at City request (TT runs for regional assessment only)
125	Royal	24,390	1999	26,401	26,525	2002	C of D	27,056	27,056	1	191	62.5	
126	Northwest Hwy	53,000	1999	57,369	62,353	2002	C of D	63,600	63,600	1	219	71.4	
127	SH 121	32,200	1999	34,854				0	34,854	2	224	73.8	Deleted -- mainlanes now under construction
128	Marsh/Lemmon	51,730	1999	55,994	N/A			0	55,994	1	245	79.2	
129	Arapaho	40,690	1999	44,044	41,270	2002	C of R	42,095	44,044	1	255	81.7	
130	Inwood	53,650	1999	58,072	41,374	2002	C of D	42,201	58,072	1	268	84.4	
131	Belt Line/First	34,550	1999	37,398				0	37,398	1	279	87.9	
132	Arapaho/Garland Ave	25,930	1999	28,067				0	28,067	1	292	92.9	
133	Skillman/Forest	50,040	1999	54,165	50,748	2001	C of D	52,798	54,165	1	308	96.6	
134	Shiloh	28,980	1999	31,369	30,183	1999	C of G	32,671	32,671	2	326	104.6	
135	Irving Blvd/Industrial	31,560	1999	34,162	N/A			0	34,162	1	343	110.3	
136	Spring Valley/Centennial	40,680	1999	44,033	44,150	2003	C of R	44,150	44,150	1	356	114.3	
137	FM 3040/Hebron/Park Blvd	21,740	1999	23,532				0	23,532	2	364	118.2	Delete at City request --TT runs for regional assessment only
138	Royal	34,450	1999	37,290	35,657	2001	C of D	37,098	37,290	1	384	125.4	Actual speeds well in excess of posted
139	Preston	31,580	1999	34,183				0	34,183	1	400	129.4	
140	Buckingham	37,090	1999	40,147				0	40,147	1	412	134.0	

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									Measured Travel Time (Seconds)		Travel Time at Posted Speed (Seconds)	Average Measured Travel Time (As Percentage of Travel	Average Measured		Average Stops Per Mile	Average Stops Per Signal	
					No. of Signals	Length (Miles)			A-B	B-A			A-B	B-A			
141	Mockingbird	Dallas North Tollway	Irving Blvd	Dallas	20	4.2			556.0	471.0	446	115%	2.0	1.0	0.36	0.08	6
142	Forest/Ave B & D/SH 66	State	Centerville	Garland	10	3.3			318.0	364.5	290	118%	1.0	2.0	0.45	0.15	6
143	Marsh/Lemmon	IH-635	Almazon	Dallas	7	3.6			360.0	395.0	362	104%	0.5	1.5	0.28	0.14	6
144	FM 1382	Clark Rd N	IH-35E														
145	Loop 288	McKinney	Southridge	Denton													
146	Custer	Pres. George Bush	McDermott	Plano													
147	SH 121	Alma	Hardin	Allen, McKinney													
148	University	Camp Bowie	Crestline/Harley	Fort Worth	4	0.6			113.0	201.5	54	291%	2.0	1.5	2.92	0.44	6
149	Camp Bowie/7th	Montgomery	Stayton	Fort Worth	6	1.5			246.0	228.5	115	206%	2.0	2.5	1.50	0.38	6
150	Montgomery	Camp Bowie	Vickery	Fort Worth	7	1.2			298.0	213.5	114	224%	2.5	3.0	2.29	0.39	4
151	Wabash/Granbury	Seminary	Gorman/Wedgemont	Fort Worth	8	1.3			253.5	294.0	114	240%	2.5	3.0	2.12	0.34	4
152	Basswood	Riverside	US 377	Fort Worth	7	2.4			400.5	273.0	213	158%	3.5	1.0	0.94	0.32	4
153	Western Center	IH-35W	US 377	Fort Worth	10	3.0			444.5	462.5	279	163%	3.0	2.5	0.92	0.28	4
154	McCart/Granbury	Benbrook Blvd	Trail Lake	Fort Worth	5	1.7			236.0	213.5	158	142%	1.5	2.0	1.03	0.35	4
155	Beach	Tarrant Pkwy N	IH-820	Fort Worth	12	3.6			488.5	542.0	324	159%	2.5	2.5	0.69	0.21	4
156	Main Street	Northwest	Mustang	Grapevine													
157	Dallas Rd (SH 26)	New Wal-Mart Signal	Main	Grapevine													
158	William D. Tate/Bass	Northwest	Mustang	Grapevine													
159	Northwest Hwy	SH 114	Gridiron	Grapevine													
160	Mockingbird	Dallas North Tollway	Irving Blvd	Dallas	20	4.2			556.0	471.0	446	115%	2.0	1.0	0.36	0.08	6
161	Harry Hines	Empire Central	Wycliff	Dallas	9	2.3			325.5	285.0	188	162%	3.0	2.5	1.20	0.31	6
162	Inwood	Mockingbird	Conveyor	Dallas	13	2.7			399.0	294.0	264	131%	4.0	2.0	1.11	0.23	6
163	Oaklawn	Blackburn	Highline	Dallas	11	1.5			323.5	362.5	179	192%	3.0	3.0	2.00	0.27	4
164	Marsh/Lemmon	Almazon	US 75	Dallas	21	5.4			711.5	715.5	536	133%	3.0	4.0	0.65	0.17	6
165	Irving Blvd/Industrial	Norwood	Reunion	Dallas	17	5.7			648.5	602.0	504	124%	4.5	4.5	0.79	0.26	6
166	Dallas Group 1 (Oaklawn, etc.)				91	21.8	29	7	2,964.0	2,730.0	2,117	134%	19.5	17.0	0.84	0.20	

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		Volume Data									Cumulative No. of Signals and Miles of Corridor		
		From NCTCOG 1999 Volumes Unless Later Year is Noted			More Recent Count If Available				ADT Volume Used For Ranking	Existing System Type			
	Arterial	ADT Volume	Year	Volume Adjusted to 2003	Newer ADT Volume	Year	Source	Volume Adjusted to 2003			No. of Signals	Length (Miles)	Comments
141	Mockingbird	45,060	1999	48,774	40,716	2002	C of D	41,530	48,774	1	432	138.2	
142	Forest/Ave B & D/SH 66	51,790	1999	56,059				0	56,059	2	442	141.5	
143	Marsh/Lemmon	32,040	1999	34,681	30,872	2001	C of D	32,119	34,681	1	449	145.1	Actual speeds well in excess of posted
144	FM 1382												Deleted due to roadway construction
145	Loop 288												Deleted due to roadway construction
146	Custer												Deleted at City request
147	SH 121												Deleted due to roadway construction
148	University	22,860	1999	24,744				0	24,744	1	4	0.6	
149	Camp Bowie/7th	23,710	1999	25,664				0	25,664	1	10	2.1	
150	Montgomery	21,640	1999	23,424				0	23,424	1	17	3.3	
151	Wabash/Granbury	25,540	1999	27,645				0	27,645	2	25	4.6	
152	Basswood	24,120	1999	26,108				0	26,108	2	32	7.0	
153	Western Center	31,040	1999	33,599				0	33,599	3	42	10.0	Split into 2 segments
154	McCart/Granbury	16,370	1999	17,719				0	17,719	2	47	11.7	
155	Beach	31,720	1999	34,335				0	34,335	3	59	15.3	
156	Main Street												Deleted (currently being retimed as City project)
157	Dallas Rd (SH 26)												Deleted (currently being retimed as City project)
158	William D. Tate/Bass												Deleted (currently being retimed as City project)
159	Northwest Hwy												Deleted (currently being retimed as City project)
160	Mockingbird	45,060	1999	48,774	40,716	2002	C of D	41,530	48,774	1	2,114	712.6	
161	Harry Hines	37,770	1999	40,883				0	40,883	1			
162	Inwood	53,650	1999	58,072	41,374	2002	C of D	42,201	58,072	1	2,136	717.6	
163	Oaklawn	39,290	1999	42,529	N/A			0	42,529	1	2,147	719.1	
164	Marsh/Lemmon	51,730	1999	55,994	N/A			0	55,994	1	2,168	724.5	
165	Irving Blvd/Industrial	31,560	1999	34,162	N/A			0	34,162	1	2,185	730.2	
166	Dallas Group 1 (Oaklawn, etc.)								280,415	1			

Key to Existing System Type: 1 = all intersections are part of an existing system with communications; 2 = some but not all intersections are part of an existing system with communications; 3 = No system (currently isolated operation)

	Arterial	West or North Limit "A"	East or South Limit "B"	City	Arterial Segment: No. of Signals	Arterial Segment: Length (Miles)	Other Signals That Would Have To Be Retimed	Less Signals Counted Twice	Travel Time (Seconds): Measured Travel Time (Seconds) A-B	Measured Travel Time (Seconds) B-A	Travel Time at Posted Speed (Seconds)	Average Measured Travel Time (As Percentage of Travel	Stops: Average Measured A-B	Average Measured B-A	Average Stops Per Mile	Average Stops Per Signal	No. of Lanes
167	Belt Line	DNT SBFR	Coit	Dallas	8	3.1			452.0	463.5	277	165%	2.5	3.0	0.89	0.34	6
168	Inwood	Alpha	Mockingbird	Dallas	15	6.3			775.0	878.0	622	133%	4.5	5.0	0.75	0.32	4
169	Marsh/Lemmon	IH-635	Almazon	Dallas	7	3.6			360.0	395.0	362	104%	0.5	1.5	0.28	0.14	6
170	Alpha	Dallas North Tollway	Hillcrest	Dallas	7	2.1			376.5	309.5	212	162%	2.5	2.5	1.19	0.36	5
171	Forest	Harry Hines	US 75	Dallas	21	7.1			971.5	869.5	669	138%	6.5	4.5	0.77	0.26	6
172	Royal	IH-35E	US 75	Dallas	20	7.2			924.5	795.0	745	115%	6.0	3.0	0.63	0.23	6
173	Northwest Hwy	Newkirk	US 75	Dallas	28	8.9			1106.0	1019.0	871	122%	10.0	6.0	0.90	0.29	6
174	Spring Valley	Inwood	Meandering Way	Farmers Branch/Dallas	8	2.7			403.5	427.5	273	152%	3.5	3.0	1.20	0.41	6
175	Preston	IH-635	Northwest Hwy	Dallas	16	4.0			508.5	511.0	411	124%	3.5	2.0	0.69	0.17	6
176	Preston	Arapaho	IH-635	Dallas	10	2.6			378.0	352.5	204	179%	2.0	1.5	0.67	0.18	6
177	Dallas Group 2 (Preston,Royal, etc.)				140	47.6	26	12	6,255.5	6,020.5	4,646	132%	41.5	32.0	0.77	0.26	
178	Forest	US 75	IH-635	Dallas	9	2.2			304.5	312.5	195	158%	2.5	1.5	0.91	0.22	6
179	Royal	US 75	IH-635	Dallas	8	3.4			468.0	490.0	346	138%	2.5	2.0	0.66	0.28	6
180	Dallas Group 3 (Royal E of US 75, etc.)				17	5.6	9	0	772.5	802.5	541	146%	5.0	3.5	0.76	0.25	
181	Beach	Tarrant Pkwy N	IH-820	Fort Worth	12	3.6			488.5	542.0	324	159%	2.5	2.5	0.69	0.21	4
182	Basswood	Riverside	US 377	Fort Worth	7	2.4			400.5	273.0	213	158%	3.5	1.0	0.94	0.32	4
183	Western Center	IH-35W	US 377	Fort Worth	10	3.0			444.5	462.5	279	163%	3.0	2.5	0.92	0.28	4
184	Fort Worth Group 1 (N of IH-820)				29	9.0	0	2	1333.5	1277.5	816	160%	9.0	6.0	0.83	0.26	
185	McCart/Granbury	Benbrook Blvd	Trail Lake	Fort Worth	5	1.7			236.0	213.5	158	142%	1.5	2.0	1.03	0.35	4
186	Wabash/Granbury	Seminary	Gorman/Wedgemont	Fort Worth	8	1.3			253.5	294.0	114	240%	2.5	3.0	2.12	0.34	4
187	Fort Worth Group 2 (Granbury-Wabash)				13	3.0	1	0	489.5	507.5	272	183%	4.0	5.0	1.50	0.35	
188	Camp Bowie/7th	Montgomery	Stayton	Fort Worth	6	1.5			246.0	228.5	115	206%	2.0	2.5	1.50	0.38	6
189	Montgomery	Camp Bowie	Vickery	Fort Worth	7	1.2		21	298.0	213.5	114	224%	2.5	3.0	2.29	0.39	4
190	University	Camp Bowie	Crestline/Harley	Fort Worth	4	0.6		4	113.0	201.5	54	291%	2.0	1.5	2.92	0.44	6
191	Fort Worth Group 3 (Camp Bowie, etc.)				17	3.3	1	2	657.0	643.5	283	230%	6.5	7.0	2.05	0.40	
192	Belt Line	Coit	Jupiter	Richardson	16	5.1			785.0	682.5	325	226%	3.5	4.5	0.78	0.25	6
193	Belt Line/First	Jupiter	Buckingham	Garland	11	3.5			446.0	361.5	303	133%	4.5	0.5	0.71	0.23	6
194	First	Buckingham	Avenue D	Garland	4	1.5			158.0	180.0	105	161%	1.5	0.5	0.67	0.25	6
195	Jupiter	PBGT EBFR	Buckingham	Richardson	10	4.7			553.5	569.5	422	133%	3.5	4.0	0.80	0.38	6
196	Jupiter	Buckingham	Northwest Hwy	Garland/Dallas	16	4.6			618.0	616.5	388	159%	4.0	4.0	0.87	0.25	6
197	Shiloh	Pres. George Bush	Northwest Hwy	Garland/Dallas	18	8.0			984.0	915.5	703	135%	6.0	6.0	0.75	0.33	4
198	Spring Valley/Centennial	Meandering Way	College Park	Richardson	13	4.0			442.5	478.5	385	120%	2.5	4.0	0.81	0.25	6
199	Buckingham	College Park	SH 78	Garland	12	4.6			457.5	493.5	396	120%	1.0	1.0	0.22	0.08	6
200	Skillman/Forest	Audelia	State	Dallas/Garland	16	3.7			396.5	446.5	295	143%	1.5	2.5	0.54	0.13	6
201	Forest/Ave B & D/SH 66	State	Centerville	Garland	10	3.3			318.0	364.5	290	118%	1.0	2.0	0.45	0.15	6
202	Arapaho	US 75	Jupiter	Richardson	10	2.5			285.5	359.0	226	143%	1.5	2.0	0.70	0.18	6
203	Arapaho/Garland Ave	Jupiter	Avenue F	Garland	13	5.0			595.0	493.0	414	131%	4.5	3.0	0.75	0.29	4
204	Richardson-Garland Group 1				133	50.5	14	15	6,039.5	5,960.5	4,252	141%	35.0	34.0	0.68	0.26	

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		Volume Data									Cumulative No. of Signals and Miles of Corridor		
		From NCTCOG 1999 Volumes Unless Later Year is Noted			More Recent Count If Available				ADT Volume Used For Ranking	Existing System Type			
	Arterial	ADT Volume	Year	Volume Adjusted to 2003	Newer ADT Volume	Year	Source	Volume Adjusted to 2003			No. of Signals	Length (Miles)	Comments
167	Belt Line	43,700	1999	47,302	N/A			0	47,302	1	2,284	755.1	
168	Inwood	24,280	1999	26,281	30,529	1998	C of D	33,706	33,706	1	2,299	761.4	
169	Marsh/Lemmon	32,040	1999	34,681	30,872	2001	C of D	32,119	34,681	1	2,306	765.0	Actual speeds well in excess of posted
170	Alpha	31,200	1999	33,772	N/A			0	33,772	1	2,313	767.1	
171	Forest	43,960	1999	47,584	38,750	2001	C of D	40,316	47,584	1	2,334	774.2	
172	Royal	34,450	1999	37,290	35,657	2001	C of D	37,098	37,290	1	2,354	781.4	Actual speeds well in excess of posted
173	Northwest Hwy	53,000	1999	57,369	62,353	2002	C of D	63,600	63,600	1	2,382	790.3	
174	Spring Valley	31,160	1999	33,729	N/A			0	33,729	1	2,390	793.0	
175	Preston	31,580	1999	34,183				0	34,183	1	2,406	797.0	
176	Preston	34,190	1999	37,008	34,614	2002	Cof D	35,306	37,008	1			
177	Dallas Group 2 (Preston,Royal, etc.)								402,855	1			
178	Forest	46,000	1999	49,792	48,545	2002	C of D	49,516	49,792	1	2,565	849.4	
179	Royal	24,390	1999	26,401	26,525	2002	C of D	27,056	27,056	1	2,573	852.8	
180	Dallas Group 3 (Royal E of US 75, etc.)								76,847	1			
181	Beach	31,720	1999	34,335				0	34,335	3	2,602	862.0	
182	Basswood	24,120	1999	26,108				0	26,108	3	2,609	864.4	
183	Western Center	31,040	1999	33,599				0	33,599	3	2,619	867.4	Split into 2 segments
184	Fort Worth Group 1 (N of IH-820)								94,042	3			
185	McCart/Granbury	16,370	1999	17,719				0	17,719	2	2,653	878.1	
186	Wabash/Granbury	25,540	1999	27,645				0	27,645	2	2,661	879.4	
187	Fort Worth Group 2 (Granbury-Wabash)								45,365	2			
188	Camp Bowie/7th	23,710	1999	25,664				0	25,664	1	2,680	883.9	
189	Montgomery	21,640	1999	23,424				0	23,424	1	2,687	885.1	
190	University	22,860	1999	24,744				0	24,744	1	2,990	990.0	
191	Fort Worth Group 3 (Camp Bowie, etc.)								73,833	1			
192	Belt Line	40,390	1999	43,719	40,900	2002	C of R	41,718	43,719	1	2,724	894.1	
193	Belt Line/First	34,550	1999	37,398				0	37,398	1	2,735	897.6	
194	First	43,610	1999	47,205	47,673	1999	C of G	51,603	51,603	1	2,739	899.1	
195	Jupiter	34,670	1999	37,528	40,920	2002	C of R	41,738	41,738	1	2,749	903.8	
196	Jupiter	39,930	1999	43,222	51,854	1999	C of G	56,128	56,128	1	2,765	908.4	
197	Shiloh	28,980	1999	31,369	30,183	1999	C of G	32,671	32,671	2	2,783	916.4	
198	Spring Valley/Centennial	40,680	1999	44,033	44,150	2003	C of R	44,150	44,150	1	2,796	920.4	
199	Buckingham	37,090	1999	40,147				0	40,147	1	2,808	925.0	
200	Skillman/Forest	50,040	1999	54,165	50,748	2001	C of D	52,798	54,165	1	2,824	928.7	
201	Forest/Ave B & D/SH 66	51,790	1999	56,059				0	56,059	2	2,834	932.0	
202	Arapaho	40,690	1999	44,044	41,270	2002	C of R	42,095	44,044	1	2,844	934.5	
203	Arapaho/Garland Ave	25,930	1999	28,067				0	28,067	1	2,857	939.5	
204	Richardson-Garland Group 1								529,891	1			

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APPENDIX C

DETAILED STUDY STATISTICS FROM BEFORE AND AFTER TRAVELTIME STUDIES

Detailed Study Statistics for Great Southwest Parkway Corridor

AM Northbound Before Retiming														
Node Number	**Length (ft)**	**Node Names**	**Travel time (s)**	**# of Stops**	**Avg Speed (mph)**	**Total Delay (s)**	**Time <= 0 MPH**	**Time <= 35 MPH**	**Time <= 55 MPH**	**Fuel (gal)**	**HC (gm)**	**CO (gm)**	**NO_x (gm)**
1	0	Fairmont											
2	1166	Claremont	34	0.2	23	16	3	31	34	0.01	1.47	13.11	0.99
3	2533	Bardin	69	0.8	25	30	14	37	69	0.03	2.66	25.98	1.62
4	812	IH20 EB	53	0.8	10	40	28	50	53	0.02	1.82	14.86	1.04
5	1088	IH20 WB	25	0.2	29	9	3	14	25	0.01	1.31	14.00	0.92
6	452	Sara Jane	9	0.0	36	1	0	2	9	0.01	0.75	9.36	0.59
7	1838	Forum	78	1.0	16	50	29	59	78	0.02	2.13	20.68	0.88
8	2711	Mayfield	57	0.2	32	16	1	25	57	0.03	2.93	32.50	2.02
9	5367	Arkansas	105	0.6	35	23	12	26	105	0.05	3.76	44.22	2.01
10	2111	Pioneer Pkwy	44	0.2	33	11	4	16	44	0.02	2.13	24.48	1.42
11	3223	Marshall	74	0.6	30	25	12	29	74	0.03	3.26	36.72	2.06
12	2718	Timberlake	44	0.0	42	3	0	3	44	0.02	2.14	27.12	1.36
13	2771	W.E. Roberts/Sherman	44	0.0	43	2	0	0	44	0.02	1.54	19.99	0.75
14	1001	Jefferson/Abram	125	0.6	5	110	94	119	125	0.03	2.80	24.84	0.73
15	547	SH 180/Main	50	0.8	8	42	26	49	49	0.01	1.32	10.36	0.58
Total	28338		813	6.0	24	379	226	463	813	0.32	30.03	318.23	16.96
	Total per mile		152	1.1		71	42	86	151	0.06	5.60	59.29	3.16

AM Northbound After Retiming													
Node Number	**Length (ft)**	**Node Names**	**Travel time (s)**	**# of Stops**	**Avg Speed (mph)**	**Total Delay (s)**	**Time <= 0 MPH**	**Time <= 35 MPH**	**Time <= 55 MPH**	**Fuel (gal)**	**HC (gm)**	**CO (gm)**	**NO_x (gm)**
1	0	Fairmont											
2	1187	Claremont	30	0.0	27	12	0	23	30	0.01	1.62	15.83	1.18
3	2441	Bardin	83	1.0	20	46	30	52	83	0.03	2.49	23.94	1.19
4	898	IH-20 EBFR	42	0.8	15	28	12	42	42	0.01	1.68	12.49	1.14
5	1102	IH-20 WBFR	22	0.0	34	5	0	13	22	0.01	1.42	16.21	1.08
6	446	Sara Jane Pkwy	8	0.0	39	1	0	1	8	0.00	0.52	6.77	0.38
7	1829	Forum	56	0.4	22	28	10	40	56	0.02	1.44	13.93	0.57
8	2729	Mayfield	64	0.4	29	22	5	35	64	0.03	3.14	33.92	2.15
9	5393	Arkansas	100	0.4	37	19	13	26	100	0.05	3.99	49.03	2.25
10	2081	Pioneer	52	0.4	27	20	12	26	52	0.02	1.94	21.05	1.11
11	3246	Marshall	69	0.2	32	20	8	26	69	0.03	2.91	33.29	1.78
12	2715	Timberlake	48	0.2	38	7	1	14	48	0.03	2.30	27.89	1.50
13	2800	W.E. Roberts / Sherman	47	0.0	41	4	0	9	47	0.02	1.98	25.21	1.18
14	1007	Jefferson / Abram	52	1.4	13	37	18	45	52	0.02	1.54	11.44	0.80
15	537	Main St / Division	26	0.2	14	18	8	25	26	0.01	0.86	7.30	0.49
Total	28411		700	5.4	28	268	117	378	699	0.30	27.83	298.30	16.80
	Total per mile		130	1.0		50	22	70	130	0.06	5.17	55.44	3.12

Reductions for AM Northbound (Before-After)													
Node Number	Length (ft)	Node Names	Travel time (s)	# of Stops	Avg Speed (mph)	Total Delay (s)	Time <= 0 MPH	Time <= 35 MPH	Time <= 55 MPH	Fuel (gal)	HC (gm)	CO (gm)	NO_x (gm)
1	0	Fairmont											
2	1187	Claremont	4	0.2		4	3	8	4	-1E-04	-1E-01	-3E+00	-2E-01
3	2441	Bardin	-13	-0.2		-15	-15	-15	-13	-7E-04	2E-01	2E+00	4E-01
4	898	IH-20 EBFR	11	0.0		12	16	8	11	2E-03	1E-01	2E+00	-1E-01
5	1102	IH-20 WBFR	3	0.2		3	3	2	3	3E-04	-1E-01	-2E+00	-2E-01
6	446	Sara Jane Pkwy	1	0.0		1	0	1	1	1E-03	2E-01	3E+00	2E-01
7	1829	Forum	22	0.6		22	18	19	22	6E-03	7E-01	7E+00	3E-01
8	2729	Mayfield	-7	-0.2		-7	-4	-10	-7	-1E-03	-2E-01	-1E+00	-1E-01
9	5393	Arkansas	5	0.2		3	-1	0	5	-2E-03	-2E-01	-5E+00	-2E-01
10	2081	Pioneer	-8	-0.2		-9	-8	-9	-8	-3E-04	2E-01	3E+00	3E-01
11	3246	Marshall	6	0.4		6	4	4	6	2E-03	4E-01	3E+00	3E-01
12	2715	Timberlake	-4	-0.2		-4	-1	-11	-4	-1E-03	-2E-01	-8E-01	-1E-01
13	2800	W.E. Roberts / Sherman	-2	0.0		-2	0	-9	-2	-2E-03	-4E-01	-5E+00	-4E-01
14	1007	Jefferson / Abram	73	-0.8		74	76	73	73	1E-02	1E+00	1E+01	-7E-02
15	537	Main St / Division	24	0.6		23	18	24	24	5E-03	5E-01	3E+00	9E-02
Total	28411		114	0.6		111	109	85	113	2E-02	2E+00	2E+01	2E-01
	Reduction per mile		22	0.1		21	20	16	21	0.00	0.42	3.85	0.04
	% Reduction		14	10		30	49	19	14	7	8	7	1

Mid Day Northbound Before Retiming													
Node Number	Length (ft)	Node Names	Travel time (s)	# of Stops	Avg Speed (mph)	Total Delay (s)	Time <= 0 MPH	Time <= 35 MPH	Time <= 55 MPH	Fuel (gal)	HC (gm)	CO (gm)	NO_x (gm)
1	0	Fairmont											
2	1158	Claremont	31	0.4	26	13	3	21	31	0.01	1.48	13.93	1.06
3	2440	Bardin	55	0.6	30	18	6	19	55	0.02	2.09	20.92	1.24
4	927	IH20 EB	46	0.8	14	32	18	40	46	0.02	1.70	13.81	1.05
5	1071	IH20 WB	21	0.0	34	4	0	10	21	0.01	1.14	12.81	0.81
6	463	Sara Jane	9	0.0	37	2	0	4	9	0.00	0.54	6.23	0.40
7	1840	Forum	44	0.8	29	16	6	18	44	0.02	1.68	17.32	1.02
8	2706	Mayfield	45	0.0	41	4	0	5	45	0.03	2.34	28.86	1.56
9	5378	Arkansas	93	0.2	40	11	4	9	93	0.04	2.90	34.81	1.32
10	2086	Pioneer Pkwy	57	0.8	25	25	13	28	57	0.02	2.18	22.66	1.29
11	3241	Marshall	58	0.2	38	9	0	12	58	0.03	2.95	35.01	1.99
12	2706	Timberlake	45	0.0	41	3	0	2	45	0.02	1.87	23.57	1.08
13	2784	W.E. Roberts/Sherman	45	0.0	42	2	0	0	45	0.02	1.57	20.30	0.78
14	1014	Jefferson/Abram	29	0.4	24	14	6	16	29	0.01	0.84	8.22	0.40
15	532	SH 180/Main	33	0.6	11	25	13	32	32	0.01	0.93	6.88	0.47
Total	28346		610	4.8	32	176	68	215	610	0.27	24.23	265.33	14.48
	Total per mile		114	0.9		33	13	40	114	0.0511	4.51	49.42	2.70

Mid Day Northbound After Retiming														
Node Number	Length (ft)	Node Names	Travel time (s)	# of Stops	Avg Speed (mph)	Total Delay (s)	Time <= 0 MPH	Time <= 35 MPH	Time <= 55 MPH	Fuel (gal)	HC (gm)	CO (gm)	NO_x (gm)
1	0	Fairmont											
2	1156	Claremont	38	0.6	21	20	5	33	38	0.02	1.77	14.64	1.28
3	2467	Bardin	70	0.6	24	32	13	50	70	0.03	2.71	25.79	1.68
4	913	IH 20 EBFR	28	0.6	22	14	3	26	28	0.01	1.56	13.27	1.22
5	1089	IH 20 WBFR	20	0.0	37	3	0	6	20	0.01	1.00	12.11	0.67
6	437	Sara Jane Pkwy	8	0.0	36	1	0	4	8	0.00	0.52	6.51	0.38
7	1840	Forum	47	0.6	27	19	13	21	47	0.02	1.68	19.53	0.89
8	2707	Mayfield	52	0.2	35	11	5	15	52	0.03	2.34	26.77	1.48
9	5392	Arkansas	91	0.2	40	9	6	10	91	0.05	3.36	42.82	1.75
10	2101	Pioneer	41	0.4	35	9	2	13	41	0.02	1.53	16.13	0.89
11	3254	Marshall	63	0.6	35	14	2	21	63	0.03	2.88	33.12	1.87
12	2688	Timberlake	49	0.2	38	7	1	11	49	0.03	2.57	31.23	1.75
13	2797	W.E. Roberts / Sherman	46	0.0	42	3	0	3	46	0.02	1.85	23.75	1.06
14	1037	Jefferson / Abram	27	0.2	26	11	7	12	27	0.01	0.80	8.23	0.37
15	520	Main St / Division	17	0.2	21	9	0	16	16	0.01	0.48	3.72	0.26
Total	28398		597	4.4	32	163	56	240	597	0.28	25.06	277.63	15.52
	Total per mile		111	0.8		30	10	45	111	0.0514	4.66	51.62	2.89

Reductions for Mid Day Northbound (Before-After)													
Node Number	Length (ft)	Node Names	Travel time (s)	# of Stops	Avg Speed (mph)	Total Delay (s)	Time <= 0 MPH	Time <= 35 MPH	Time <= 55 MPH	Fuel (gal)	HC (gm)	CO (gm)	NO_x (gm)
1	0	Fairmont											
2	1187	Claremont	-7	-0.2		-7	-2	-12	-7	-2E-03	-3E-01	-7E-01	-2E-01
3	2441	Bardin	-15	0.0		-14	-7	-31	-15	-4E-03	-6E-01	-5E+00	-4E-01
4	898	IH 20 EBFR	18	0.2		18	15	15	18	3E-03	1E-01	5E-01	-2E-01
5	1102	IH 20 WBFR	1	0.0		1	0	4	1	6E-04	1E-01	7E-01	1E-01
6	446	Sara Jane Pkwy	0	0.0		0	0	0	0	1E-04	2E-02	-3E-01	3E-02
7	1829	Forum	-4	0.2		-4	-7	-4	-4	-4E-04	-4E-03	-2E+00	1E-01
8	2729	Mayfield	-7	-0.2		-8	-5	-10	-7	-1E-03	-2E-03	2E+00	8E-02
9	5393	Arkansas	2	0.0		2	-2	-2	2	-3E-03	-5E-01	-8E+00	-4E-01
10	2081	Pioneer	16	0.4		16	11	16	16	4E-03	7E-01	7E+00	4E-01
11	3246	Marshall	-5	-0.4		-5	-2	-8	-5	-1E-04	8E-02	2E+00	1E-01
12	2715	Timberlake	-4	-0.2		-4	-1	-9	-4	-3E-03	-7E-01	-8E+00	-7E-01
13	2800	W.E. Roberts / Sherman	0	0.0		-1	0	-3	0	-1E-03	-3E-01	-3E+00	-3E-01
14	1007	Jefferson / Abram	2	0.2		3	-1	4	2	4E-04	5E-02	-9E-03	3E-02
15	537	Main St / Division	16	0.4		16	13	16	16	4E-03	5E-01	3E+00	2E-01
Total	28411		13	0.4		13	12	-24	13	-2E-03	-8E-01	-1E+01	-1E+00
	Reduction per mile		3	0.1		2	2	-4	3	0.00	-0.15	-2.20	-0.19
	% Reduction		2	9		7	17	-11	2	-1	-3	-4	-7

PM Northbound Before Retiming													
Node Number	Length (ft)	Node Names	Travel time (s)	# of Stops	Avg Speed (mph)	Total Delay (s)	Time <= 0 MPH	Time <= 35 MPH	Time <= 55 MPH	Fuel (gal)	HC (gm)	CO (gm)	NO_x (gm)
1	0	Fairmont											
2	1180	Claremont	35	0.2	23	17	8	22	35	0.01	1.50	15.32	0.96
3	2429	Bardin	63	0.4	26	26	15	27	63	0.02	2.15	22.85	1.13
4	906	IH20 EB	82	1.4	8	68	40	80	82	0.02	2.43	18.66	1.24
5	1080	IH20 WB	22	0.0	34	5	0	12	22	0.01	1.39	15.50	1.06
6	459	Sara Jane	8	0.0	37	1	0	2	8	0.00	0.42	5.28	0.28
7	1842	Forum	40	0.4	32	12	6	13	40	0.02	1.53	17.68	0.87
8	2691	Mayfield	49	0.2	37	8	3	10	49	0.03	2.08	24.78	1.25
9	5386	Arkansas	103	0.6	36	21	9	23	103	0.05	3.53	40.68	1.81
10	2088	Pioneer Pkwy	89	0.8	16	57	39	60	89	0.03	3.14	32.97	1.70
11	3238	Marshall	63	0.2	35	14	2	18	63	0.03	3.14	36.78	2.11
12	2711	Timberlake	46	0.0	41	4	0	6	46	0.02	2.07	26.06	1.27
13	2787	W.E. Roberts/Sherman	48	0.0	39	5	0	8	48	0.03	2.21	27.10	1.39
14	1013	Jefferson/Abram	52	1.0	13	37	22	42	52	0.02	1.46	12.23	0.69
15	538	SH 180/Main	23	0.4	16	15	7	22	22	0.01	1.11	9.90	0.80
Total	28348		723	5.6	27	289	149	345	723	0.30	28.16	305.77	16.57
	Total per mile		135	1.0	1.0	54	28	64	134	0.06	5.24	56.85	3.08

PM Northbound After Retiming													
Node Number	Length (ft)	Node Names	Travel time (s)	# of Stops	Avg Speed (mph)	Total Delay (s)	Time <= 0 MPH	Time <= 35 MPH	Time <= 55 MPH	Fuel (gal)	HC (gm)	CO (gm)	NO_x (gm)
1	0	Fairmont											
2	1182	Claremont	25	0.0	32	7	0	17	25	0.01	1.49	15.24	1.11
3	2439	Bardin	62	0.6	27	25	14	29	62	0.02	2.09	22.70	1.09
4	926	IH 20 EBFR	45	0.4	14	31	23	35	45	0.01	1.53	15.71	0.80
5	1073	IH 20 WBFR	24	0.4	30	8	0	14	24	0.01	1.16	11.96	0.81
6	472	Sara Jane Pkwy	9	0.0	37	1	0	3	9	0.01	0.69	8.53	0.54
7	1822	Forum	39	0.4	32	11	7	12	39	0.02	1.36	15.61	0.73
8	2719	Mayfield	57	0.6	33	16	10	20	57	0.03	2.51	29.33	1.56
9	5368	Arkansas	83	0.0	44	3	0	7	83	0.05	3.50	44.85	2.01
10	2090	Pioneer	60	1.0	24	28	18	34	60	0.02	1.85	17.82	0.93
11	3261	Marshall	63	0.2	35	13	2	22	63	0.03	3.16	35.85	2.15
12	2694	Timberlake	56	0.6	33	15	7	19	56	0.03	2.54	29.87	1.62
13	2787	W.E. Roberts / Sherman	45	0.0	43	2	0	5	45	0.02	2.05	26.35	1.27
14	1028	Jefferson / Abram	39	0.4	18	23	15	27	39	0.01	1.13	10.33	0.54
15	522	Main St / Division	17	0.2	21	9	0	16	17	0.01	0.64	5.04	0.43
Total	28383		622	4.8	31	190	96	261	622	0.29	25.70	289.19	15.59
	Total per mile		116	0.9	6	35	18	48	116	0.05	4.78	53.80	2.90

Reductions for PM Northbound (Before-After)														
Node Number	Length (ft)	Node Names	Travel time (s)	# of Stops	Avg Speed (mph)	Total Delay (s)	Time <= 0 MPH	Time <= 35 MPH	Time <= 55 MPH	Fuel (gal)	HC (gm)	CO (gm)	NO_x (gm)
1	0	Fairmont											
2	1187	Claremont	9	0.2		9	8	5	9	1E-03	1E-02	8E-02	-2E-01
3	2441	Bardin	2	-0.2		2	0	-1	2	-1E-04	6E-02	2E-01	5E-02
4	898	IH 20 EBFR	37	1.0		37	16	45	37	8E-03	9E-01	3E+00	4E-01
5	1102	IH 20 WBFR	-3	-0.4		-3	0	-2	-3	1E-04	2E-01	4E+00	2E-01
6	446	Sara Jane Pkwy	0	0.0		0	0	-2	0	-1E-03	-3E-01	-3E+00	-3E-01
7	1829	Forum	1	0.0		1	-1	0	1	6E-04	2E-01	2E+00	1E-01
8	2729	Mayfield	-7	-0.4		-7	-7	-10	-7	-3E-03	-4E-01	-5E+00	-3E-01
9	5393	Arkansas	20	0.6		18	9	16	20	4E-04	3E-02	-4E+00	-2E-01
10	2081	Pioneer	29	-0.2		29	21	27	29	8E-03	1E+00	2E+01	8E-01
11	3246	Marshall	0	0.0		0	1	-4	0	5E-04	-2E-02	9E-01	-3E-02
12	2715	Timberlake	-10	-0.6		-11	-7	-13	-10	-4E-03	-5E-01	-4E+00	-4E-01
13	2800	W.E. Roberts / Sherman	4	0.0		3	0	3	4	1E-04	2E-01	8E-01	1E-01
14	1007	Jefferson / Abram	13	0.6		14	7	15	13	3E-03	3E-01	2E+00	2E-01
15	537	Main St / Division	6	0.2		6	6	6	6	3E-03	5E-01	5E+00	4E-01
Total	28411		101	0.80		99	53	85	101	2E-02	2E+00	2E+01	1E+00
Reduction per mile			19	0.15		18	10	16	19	0.00	0.46	3.06	0.18
% Reduction			14	14		34	35	24	14	6	9	5	6

AM Southbound Before Retiming													
Node Number	Length (ft)	Node Names	Travel time (s)	# of Stops	Avg Speed (mph)	Total Delay (s)	Time <= 0 MPH	Time <= 35 MPH	Time <= 55 MPH	Fuel (gal)	HC (gm)	CO (gm)	NO_x (gm)
1	0	SH 180/Main											
2	596	Jefferson/Abram	44	1.0	9	34	19	43	44	0.01	1.65	11.42	1.07
3	1032	W.E. Roberts/Sherman	24	0.4	29	8	2	14	24	0.01	1.56	15.79	1.22
4	2796	Timberlake	47	0.0	41	4	0	3	47	0.02	2.06	25.27	1.26
5	2683	Marshall	49	0.2	38	8	1	9	49	0.02	1.70	19.55	0.90
6	3224	Pioneer Pkwy	72	0.4	31	23	11	27	72	0.03	2.92	33.54	1.74
7	2125	Arkansas	56	0.6	26	24	12	27	56	0.02	2.29	24.43	1.42
8	5371	Mayfield	106	0.8	35	24	11	27	106	0.05	4.27	49.08	2.51
9	2705	Forum	64	0.2	29	23	1	39	64	0.03	2.49	27.04	1.49
10	1845	Sara Jane	53	0.6	24	24	5	36	53	0.02	2.60	25.74	1.83
11	442	IH20 WB	37	0.8	8	30	19	36	37	0.01	1.18	8.57	0.65
12	1076	IH20 EB	25	0.4	29	8	1	15	25	0.01	1.47	13.98	1.13
13	934	Bardin	20	0.0	32	5	0	11	20	0.01	1.08	11.01	0.79
14	2456	Claremont	54	0.6	31	16	4	18	54	0.02	1.81	18.72	0.96
15	1079	Fairmont	31	0.4	24	14	1	25	30	0.01	1.17	11.11	0.73
Total	28364		680	6.4	28	247	88	329	680	0.30	28.25	295.25	17.71
	Total per mile		127	1.2	5	46	16	61	127	0.06	5.26	54.96	3.30

AM Southbound After Retiming														
Node Number	Length (ft)	Node Names	Travel time (s)	# of Stops	Avg Speed (mph)	Total Delay (s)	Time <= 0 MPH	Time <= 35 MPH	Time <= 55 MPH	Fuel (gal)	HC (gm)	CO (gm)	NO_x (gm)
1	0	Main St / Division											
2	625	Jefferson / Abram	28	0.4	15	18	4	28	28	0.01	1.17	8.58	0.82
3	1023	W.E. Roberts / Sherman	33	0.4	21	17	8	26	33	0.01	1.61	15.95	1.13
4	2821	Timberlake	47	0.0	41	4	0	7	47	0.03	2.43	30.38	1.60
5	2661	Marshall	59	0.8	31	18	9	23	59	0.03	1.79	18.36	0.87
6	3230	Pioneer	76	0.6	29	27	12	37	76	0.03	3.14	32.98	1.95
7	2108	Arkansas	66	1.0	22	34	20	41	66	0.03	2.73	27.23	1.74
8	5394	Mayfield	112	0.8	33	30	21	39	112	0.06	4.74	55.57	2.85
9	2720	Forum	56	0.0	33	15	0	27	56	0.03	2.49	28.74	1.58
10	1852	Sara Jane Pkwy	65	0.8	19	37	21	47	65	0.02	2.68	26.59	1.69
11	453	IH 20 WBFR	11	0.0	28	4	0	9	11	0.01	0.64	5.75	0.50
12	1093	IH 20 EBFR	19	0.0	39	2	0	3	19	0.01	0.98	12.23	0.64
13	887	Bardin	46	1.0	13	32	22	39	46	0.01	1.17	8.68	0.49
14	2504	Claremont	47	0.0	37	9	0	11	47	0.02	2.19	23.92	1.44
15	1040	Fairmont	38	0.4	19	22	11	29	38	0.01	0.81	7.54	0.21
Total	28411		703	6.2	28	268	129	367	703	0.30	28.56	302.49	17.50
	Total per mile		131	1.2	5	50	24	68	131	0.06	5.31	56.22	3.25

Reductions for AM Southbound (Before-After)													
Node Number	Length (ft)	Node Names	Travel time (s)	# of Stops	Avg Speed (mph)	Total Delay (s)	Time <= 0 MPH	Time <= 35 MPH	Time <= 55 MPH	Fuel (gal)	HC (gm)	CO (gm)	NO_x (gm)
1	0	Fairmont											
2	1187	Claremont	16	0.6		17	14	15	16	4E-03	5E-01	3E+00	3E-01
3	2441	Bardin	-9	0.0		-9	-6	-12	-9	-6E-04	-5E-02	-2E-01	9E-02
4	898	IH 20 EBFR	0	0.0		0	0	-5	0	-2E-03	-4E-01	-5E+00	-3E-01
5	1102	IH 20 WBFR	-10	-0.6		-10	-8	-14	-10	-2E-03	-8E-02	1E+00	4E-02
6	446	Sara Jane Pkwy	-5	-0.2		-5	-1	-10	-5	-8E-04	-2E-01	6E-01	-2E-01
7	1829	Forum	-10	-0.4		-10	-8	-14	-10	-3E-03	-4E-01	-3E+00	-3E-01
8	2729	Mayfield	-6	0.0		-6	-10	-11	-6	-4E-03	-5E-01	-6E+00	-3E-01
9	5393	Arkansas	8	0.2		9	1	12	8	1E-04	7E-03	-2E+00	-9E-02
10	2081	Pioneer	-12	-0.2		-12	-16	-11	-12	-2E-03	-8E-02	-8E-01	1E-01
11	3246	Marshall	26	0.8		27	19	26	26	6E-03	5E-01	3E+00	1E-01
12	2715	Timberlake	6	0.4		6	1	13	6	3E-03	5E-01	2E+00	5E-01
13	2800	W.E. Roberts / Sherman	-26	-1.0		-27	-22	-28	-26	-4E-03	-9E-02	2E+00	3E-01
14	1007	Jefferson / Abram	7	0.6		8	4	6	7	-7E-04	-4E-01	-5E+00	-5E-01
15	537	Main St / Division	-8	0.0		-8	-10	-5	-7	5E-04	4E-01	4E+00	5E-01
Total	28411		-23	0.2		-21	-41	-38	-23	-5E-03	-3E-01	-7E+00	2E-01
	Reduction per mile		-4	0.0		-4	-8	-7	-4	0.00	-0.05	-1.26	0.04
	% Reduction		-3	3		-8	-46	-11	-3	-1	-1	-2	1

Mid Day Southbound Before Retiming													
Node Number	Length (ft)	Node Names	Travel time (s)	# of Stops	Avg Speed (mph)	Total Delay (s)	Time <= 0 MPH	Time <= 35 MPH	Time <= 55 MPH	Fuel (gal)	HC (gm)	CO (gm)	NO_x (gm)
1	0	SH 180/Main											
2	613	Jefferson/Abram	43	0.8	10	34	17	43	43	0.01	1.50	10.11	0.92
3	1030	W.E. Roberts/ Sherman	20	0.0	35	4	0	7	20	0.01	1.54	17.14	1.23
4	2795	Timberlake	50	0.2	38	7	1	8	50	0.03	2.08	25.01	1.24
5	2682	Marshall	55	0.4	33	14	6	16	55	0.02	2.01	22.91	1.11
6	3210	Pioneer Pkwy	83	1.0	27	34	16	41	83	0.03	3.25	34.34	1.96
7	2129	Arkansas	40	0.0	37	7	0	14	40	0.02	2.20	25.15	1.55
8	5363	Mayfield	93	0.2	39	11	1	13	93	0.05	3.81	47.35	2.19
9	2699	Forum	54	0.6	34	13	3	15	54	0.03	2.19	24.60	1.33
10	1849	Sara Jane	34	0.0	37	6	0	9	34	0.02	1.63	18.42	1.09
11	447	IH20 WB	36	0.8	8	29	20	35	36	0.01	1.03	7.50	0.51
12	1076	IH20 EB	21	0.0	35	4	0	8	21	0.01	1.26	13.86	0.94
13	915	Bardin	16	0.0	38	2	0	1	16	0.01	0.66	8.19	0.38
14	2483	Claremont	49	0.2	35	11	2	7	49	0.02	1.40	15.44	0.60
15	1054	Fairmont	24	0.4	30	8	2	11	24	0.01	0.94	10.12	0.57
Total	28345		618	4.6	31	184	68	229	618	0.28	25.50	280.14	15.60
	Total per mile		115	0.9	6	34	13	43	115	0.05	4.75	52.18	2.91

Mid Day Southbound After Retiming													
Node Number	Length (ft)	Node Names	Travel time (s)	# of Stops	Avg Speed (mph)	Total Delay (s)	Time <= 0 MPH	Time <= 35 MPH	Time <= 55 MPH	Fuel (gal)	HC (gm)	CO (gm)	NO_x (gm)
1	0	Main St / Division											
2	621	Jefferson / Abram	22	0.2	19	12	3	21	22	0.01	1.22	9.91	0.94
3	1036	W.E. Roberts / Sherman	32	0.6	22	16	7	21	32	0.01	1.31	13.15	0.84
4	2789	Timberlake	47	0.0	41	4	0	7	47	0.03	2.56	31.83	1.74
5	2679	Marshall	72	0.6	26	31	23	34	72	0.03	2.04	21.86	0.86
6	3234	Pioneer	85	0.6	26	36	24	44	85	0.04	3.34	37.28	1.94
7	2111	Arkansas	60	1.0	24	28	10	37	60	0.02	2.58	25.12	1.71
8	5412	Mayfield	87	0.0	43	4	0	9	87	0.05	4.03	51.68	2.49
9	2701	Forum	41	0.0	45	0	0	0	41	0.02	1.49	19.85	0.74
10	1838	Sara Jane Pkwy	31	0.2	40	3	0	5	31	0.01	0.92	10.63	0.42
11	452	IH 20 WBFR	15	0.4	21	8	2	12	15	0.01	0.73	5.89	0.55
12	1070	IH 20 EBFR	19	0.0	38	2	0	5	19	0.01	1.04	12.96	0.71
13	926	Bardin	20	0.2	31	6	0	11	20	0.01	0.70	6.36	0.41
14	2465	Claremont	48	0.4	35	11	0	11	48	0.02	1.92	20.67	1.17
15	1032	Fairmont	20	0.0	35	4	0	8	20	0.01	1.10	12.06	0.79
Total	28366		600	4.2	32	166	69	226	600	0.28	24.98	279.23	15.30
	Total per mile		112	0.8	6	31	13	42	112	0.05	4.65	51.98	2.85

Reductions for Mid Day Southbound (Before-After)														
Node Number	Length (ft)	Node Names	Travel time (s)	# of Stops	Avg Speed (mph)	Total Delay (s)	Time <= 0 MPH	Time <= 35 MPH	Time <= 55 MPH	Fuel (gal)	HC (gm)	CO (gm)	NO_x (gm)
1	0	Fairmont											
2	1187	Claremont	21	0.6		21	14	22	21	4E-03	3E-01	2E-01	-2E-02
3	2441	Bardin	-12	-0.6		-12	-7	-14	-12	-3E-04	2E-01	4E+00	4E-01
4	898	IH 20 EBFR	3	0.2		3	1	1	3	-2E-03	-5E-01	-7E+00	-5E-01
5	1102	IH 20 WBFR	-16	-0.2		-17	-17	-18	-16	-3E-03	-2E-02	1E+00	3E-01
6	446	Sara Jane Pkwy	-3	0.4		-3	-8	-3	-3	-1E-03	-9E-02	-3E+00	2E-02
7	1829	Forum	-21	-1.0		-21	-10	-24	-21	-4E-03	-4E-01	3E-02	-2E-01
8	2729	Mayfield	7	0.2		7	1	4	7	-1E-03	-2E-01	-4E+00	-3E-01
9	5393	Arkansas	13	0.6		13	3	15	13	3E-03	7E-01	5E+00	6E-01
10	2081	Pioneer	3	-0.2		3	0	4	3	2E-03	7E-01	8E+00	7E-01
11	3246	Marshall	21	0.4		22	18	23	21	4E-03	3E-01	2E+00	-5E-02
12	2715	Timberlake	2	0.0		2	0	3	2	9E-04	2E-01	9E-01	2E-01
13	2800	W.E. Roberts / Sherman	-4	-0.2		-4	0	-10	-4	-5E-04	-4E-02	2E+00	-3E-02
14	1007	Jefferson / Abram	0	-0.2		0	2	-4	0	-2E-03	-5E-01	-5E+00	-6E-01
15	537	Main St / Division	4	0.4		4	2	3	4	0E+00	-2E-01	-2E+00	-2E-01
Total	28411		18	0.4		17	-1	3	18	1E-04	5E-01	9E-01	3E-01
		Reduction per mile	4	0.1		3	0	1	4	0.00	0.10	0.21	0.06
		% Reduction	3	8.8		10	-2	1	3	0	2	0	2

PM Southbound Before Retiming													
Node Number	Length (ft)	Node Names	Travel time (s)	# of Stops	Avg Speed (mph)	Total Delay (s)	Time <= 0 MPH	Time <= 35 MPH	Time <= 55 MPH	Fuel (gal)	HC (gm)	CO (gm)	NO_x (gm)
1	0	SH 180/Main											
2	620	Jefferson/Abram	21	0.0	20	11	0	20	21	0.01	1.24	9.90	1.00
3	1029	W.E. Roberts/ Sherman	19	0.0	38	3	0	5	19	0.01	1.16	14.85	0.83
4	2796	Timberlake	51	0.2	37	9	3	10	51	0.02	1.94	23.91	1.06
5	2671	Marshall	59	0.4	31	19	9	23	59	0.03	2.44	26.86	1.48
6	3224	Pioneer Pkwy	93	0.8	24	44	18	53	93	0.04	3.89	41.55	2.43
7	2128	Arkansas	55	0.4	26	23	10	31	55	0.02	2.36	25.59	1.49
8	5373	Mayfield	99	0.4	37	17	5	20	99	0.05	3.84	46.61	2.15
9	2705	Forum	44	0.0	42	3	0	2	44	0.02	2.00	25.64	1.21
10	1826	Sara Jane	57	1.0	22	29	10	37	57	0.02	1.62	13.91	0.78
11	464	IH20 WB	18	0.6	18	11	2	18	18	0.01	1.11	7.77	0.93
12	1074	IH20 EB	20	0.0	37	3	0	5	20	0.01	1.03	12.61	0.70
13	900	Bardin	34	0.6	18	20	8	24	34	0.01	1.19	11.07	0.69
14	2478	Claremont	78	0.6	22	40	24	41	78	0.03	2.51	26.06	1.25
15	1059	Fairmont	25	0.4	29	8	1	11	24	0.01	1.23	12.81	0.86
Total	28347		673	5.4	29	239	91	299	672	0.29	27.55	299.14	16.87
		Total per mile	125	1.0	5	44	17	56	125	0.05	5.13	55.72	3.14

PM Southbound After Retiming													
Node Number	Length (ft)	Node Names	Travel time (s)	# of Stops	Avg Speed (mph)	Total Delay (s)	Time <= 0 MPH	Time <= 35 MPH	Time <= 55 MPH	Fuel (gal)	HC (gm)	CO (gm)	NO_x (gm)
1	0	Main St / Division											
2	640	Jefferson / Abram	20	0.0	22	10	0	20	20	0.01	1.07	8.58	0.83
3	1031	W.E. Roberts / Sherman	20	0.0	35	4	0	13	20	0.01	0.95	11.12	0.63
4	2784	Timberlake	46	0.0	41	4	0	6	46	0.02	2.01	26.08	1.20
5	2692	Marshall	61	0.4	30	20	14	22	61	0.03	2.00	22.71	1.00
6	3190	Pioneer	185	2.2	12	136	91	158	185	0.05	5.30	48.41	2.37
7	2126	Arkansas	44	0.4	33	11	1	17	44	0.02	2.21	23.43	1.55
8	5409	Mayfield	84	0.0	44	1	0	1	84	0.05	3.37	45.91	1.84
9	2693	Forum	42	0.0	43	2	0	1	42	0.02	1.27	16.27	0.53
10	1809	Sara Jane Pkwy	120	3.4	10	92	47	107	120	0.03	3.06	25.30	1.24
11	444	IH 20 WBFR	33	0.4	9	26	18	33	33	0.01	1.19	9.86	0.70
12	1078	IH 20 EBFR	29	0.2	26	12	7	17	29	0.01	1.22	13.67	0.75
13	924	Bardin	45	0.6	14	31	21	39	45	0.01	1.44	12.15	0.76
14	2461	Claremont	51	0.4	33	14	3	15	51	0.02	1.98	21.08	1.18
15	1037	Fairmont	20	0.0	35	4	0	7	20	0.01	1.05	11.23	0.76
Total	28318		800	8.0	24	367	201	456	800	0.31	28.14	295.80	15.33
	Total per mile		149	1.5	4	68	38	85	149	0.06	5.25	55.15	2.86

Reductions for PM Southbound (Before-After)													
Node Number	Length (ft)	Node Names	Travel time (s)	# of Stops	Avg Speed (mph)	Total Delay (s)	Time <= 0 MPH	Time <= 35 MPH	Time <= 55 MPH	Fuel (gal)	HC (gm)	CO (gm)	NO_x (gm)
1	0	Fairmont											
2	1187	Claremont	1	0.0		1	0	0	1	1E-03	2E-01	1E+00	2E-01
3	2441	Bardin	-2	0.0		-2	0	-8	-2	1E-03	2E-01	4E+00	2E-01
4	898	IH 20 EBFR	5	0.2		5	3	4	5	6E-04	-7E-02	-2E+00	-1E-01
5	1102	IH 20 WBFR	-1	0.0		-1	-5	1	-1	1E-03	4E-01	4E+00	5E-01
6	446	Sara Jane Pkwy	-92	-1.4		-93	-73	-105	-92	-2E-02	-1E+00	-7E+00	6E-02
7	1829	Forum	11	0.0		11	9	14	11	2E-03	2E-01	2E+00	-6E-02
8	2729	Mayfield	15	0.4		16	5	19	15	2E-03	5E-01	7E-01	3E-01
9	5393	Arkansas	2	0.0		1	0	0	2	3E-03	7E-01	9E+00	7E-01
10	2081	Pioneer	-62	-2.4		-62	-37	-71	-62	-1E-02	-1E+00	-1E+01	-5E-01
11	3246	Marshall	-15	0.2		-16	-16	-15	-15	-2E-03	-8E-02	-2E+00	2E-01
12	2715	Timberlake	-9	-0.2		-8	-7	-12	-9	-2E-03	-2E-01	-1E+00	-5E-02
13	2800	W.E. Roberts / Sherman	-11	0.0		-11	-13	-14	-11	-2E-03	-3E-01	-1E+00	-8E-02
14	1007	Jefferson / Abram	27	0.2		26	21	26	27	5E-03	5E-01	5E+00	7E-02
15	537	Main St / Division	5	0.4		4	1	4	5	2E-03	2E-01	2E+00	1E-01
Total	28411		-128	-2.6		-128	-111	-157	-128	-2E-02	-6E-01	3E+00	2E+00
Reduction per mile			-24	0		-24	-21	-29	-24	0.00	-0.11	0.57	0.28
% Reduction			-19	-48		-54	-123	-53	-19	-5	-2	1	9

Detailed Study Statistics for Pioneer Parkway Corridor

AM Eastbound Before Retiming

Node No.	Length (ft)	Node Names	Travel Time (s)	No. of Stops	Total Delay (s)	Time<= 0 MPH (s)	Time<=35 MPH (s)	Time<=55 MPH (s)	Fuel (gals)	HC (gm)	CO (gm)	NO_x (gm)
1	0	West Frwy										
2	1425	Robinson	46	0.8	24	13	31	46	0.02	1.84	17.42	1.15
3	1349	Carrier	46	0.4	26	16	35	46	0.02	1.89	18.34	1.18
4	2490	SW 3rd	44	0.0	6	0	6	44	0.02	2.39	29.13	1.65
5	1534	Corn Valley	67	0.8	43	33	48	67	0.02	1.99	19.06	0.94
6	1153	Acosta	24	0.0	6	0	14	24	0.01	1.69	18.45	1.34
7	1410	Beltline	40	0.6	18	6	25	40	0.02	1.73	16.08	1.17
8	3024	SE 14th	66	0.8	20	9	26	66	0.03	3.03	35.60	1.95
Total	12385		334	3.4	144	77	185	333	0.14	14.55	154.07	9.37
	Total per mile		142	1.4	61	33	79	142	0.06	6.20	65.68	4.00

AM Eastbound After Retiming

Node No.	Length (ft)	Node Names	Travel Time (s)	No. of Stops	Total Delay (s)	Time<= 0 MPH (s)	Time<=35 MPH (s)	Time<=55 MPH (s)	Fuel (gals)	HC (gm)	CO (gm)	NO_x (gm)
1	0	W Freeway										
2	1379	Robinson	23	0.0	2	0	4	23	0.01	1.04	12.74	0.65
3	1310	Carrier	23	0.0	3	0	6	23	0.01	1.01	12.45	0.61
4	2437	SW 3rd	38	0.0	0	0	0	38	0.02	1.44	19.42	0.75
5	1505	Corn Valley	23	0.0	0	0	0	23	0.01	0.79	10.49	0.37
6	1147	Acosta	17	0.0	0	0	0	17	0.01	0.54	7.01	0.23
7	1389	Belt Line	22	0.0	1	0	1	22	0.01	0.65	8.21	0.27
8	2949	SE 14th	56	0.2	11	5	11	56	0.03	1.81	22.33	0.86
Total	12116		203	0.2	17	5	23	203	0.10	7.29	92.65	3.73
	Total per mile		88	0.1	7	2	10	88	0.04	3.18	40.38	1.63

Reductions for AM Eastbound

Node No.	Length (ft)	Node Names	Travel Time (s)	No. of Stops	Total Delay (s)	Time<= 0 MPH (s)	Time<=35 MPH (s)	Time<=55 MPH (s)	Fuel (gals)	HC (gm)	CO (gm)	NO_x (gm)
1		W Freeway										
2		Robinson	23	0.8	22	13	26	23	0.01	0.79	4.68	0.50
3		Carrier	23	0.4	23	16	29	23	0.01	0.88	5.88	0.57
4		SW 3rd	6	0.0	5	0	6	6	0.00	0.95	9.71	0.90
5		Corn Valley	43	0.8	43	33	48	43	0.01	1.19	8.57	0.56
6		Acosta	7	0.0	6	0	14	7	0.00	1.15	11.45	1.11
7		Belt Line	18	0.6	17	6	24	18	0.01	1.08	7.87	0.90
8		SE 14th	11	0.6	10	3	15	10	0.01	1.22	13.27	1.10
Total			131	3.2	127	71	162	130	0.04	7.27	61.42	5.64
Reduction per mile			54	1.4	54	30	69	54	0.02	3.03	25.31	2.37
%reduction			38	94.0	88	93	88	38	26.98	48.83	38.53	59.32

MD Eastbound Before Retiming

Node No.	Length (ft)	Node Names	Travel Time (s)	No. of Stops	Total Delay (s)	Time<= 0 MPH (s)	Time<=35 MPH (s)	Time<=55 MPH (s)	Fuel (gals)	HC (gm)	CO (gm)	NO_x (gm)
1	0	West Frwy										
2	1419	Robinson	42	0.6	20	8	28	42	0.0169	1.8098	17.6198	1.1941
3	1379	Carrier	51	0.4	29	9	38	51	0.0184	1.9616	18.8663	1.2098
4	2475	SW 3rd	48	0.2	10	0	17	48	0.0215	1.8941	21.0153	1.1239
5	1536	Corn Valley	38	0.4	14	3	23	38	0.0149	1.3044	11.9813	0.7431
6	1126	Acosta	28	0.4	10	2	14	28	0.0122	1.2735	12.5487	0.8758
7	1455	Beltline	47	0.6	25	8	29	47	0.0182	1.8611	19.0654	1.1428
8	3009	SE 14th	64	0.6	19	2	20	64	0.0281	2.4187	27.1604	1.3935
Total	12399		318	3.2	128	31	169	317	0.1301	12.523	128.257	7.6829
	Total per mile		135	1.4	55	13	72	135	0.06	5.33	54.62	3.27

MD Eastbound After Retiming

Node No.	Length (ft)	Node Names	Travel Time (s)	No. of Stops	Total Delay (s)	Time<= 0 MPH (s)	Time<=35 MPH (s)	Time<=55 MPH (s)	Fuel (gals)	HC (gm)	CO (gm)	NO_x (gm)
1	5999	W Freeway										
2	1380	Robinson	23	0.0	2	0	0	23	0.0119	0.9711	12.8925	0.5589
3	1334	Carrier	22	0.0	1	0	3	22	0.0109	0.807	10.5349	0.4263
4	2442	SW 3rd	40	0.0	3	0	3	40	0.0208	1.6821	21.7385	0.9735
5	1504	Corn Valley	25	0.0	2	0	1	25	0.0125	0.9392	12.3329	0.4969
6	1116	Acosta	18	0.0	1	0	0	18	0.0092	0.6668	8.7199	0.3417
7	1390	Belt Line	42	0.4	20	13	22	42	0.0149	1.1163	11.4884	0.4408
8	2958	SE 14th	58	0.4	13	5	18	58	0.0263	2.1833	26.6668	1.1972
Total	12124		227	0.8	42	18	46	227	0.11	8.37	104.37	4.44
	Total per mile		99	0.3	18	8	20	99	0.05	3.64	45.45	1.93

Reductions for MID Eastbound

Node No.	Length (ft)	Node Names	Travel Time (s)	No. of Stops	Total Delay (s)	Time<= 0 MPH (s)	Time<=35 MPH (s)	Time<=55 MPH (s)	Fuel (gals)	HC (gm)	CO (gm)	NO_x (gm)
1		W Freeway										
2		Robinson	19	0.6	18	8	28	19	0.01	0.84	4.73	0.64
3		Carrier	29	0.4	28	9	35	29	0.01	1.15	8.33	0.78
4		SW 3rd	8	0.2	7	0	14	8	0.00	0.21	-0.72	0.15
5		Corn Valley	13	0.4	13	3	22	13	0.00	0.37	-0.35	0.25
6		Acosta	10	0.4	10	2	14	10	0.00	0.61	3.83	0.53
7		Belt Line	5	0.2	5	-5	8	5	0.00	0.74	7.58	0.70
8		SE 14th	6	0.2	6	-4	2	6	0.00	0.24	0.49	0.20
Total			91	2.4	87	13	123	90	0.02	4.16	23.88	3.25
Reduction per mile			36	1.0	36	5	52	36	0.01	1.69	9.16	1.34
%reduction			27	74.4	67	39	72	27	16.28	31.68	16.78	40.96

PM Eastbound Before Retiming

Node No.	Length (ft)	Node Names	Travel Time (s)	No. of Stops	Total Delay (s)	Time<= 0 MPH (s)	Time<=35 MPH (s)	Time<=55 MPH (s)	Fuel (gals)	HC (gm)	CO (gm)	NO_x (gm)
1	0	West Frwy										
2	1409	Robinson	56	0.8	34	13	43	56	0.0194	2.0344	18.4846	1.2278
3	1365	Carrier	51	0.8	30	8	42	51	0.0191	2.1954	19.0334	1.5108
4	2451	SW 3rd	66	1.0	29	5	37	66	0.0276	2.8155	27.5099	1.8527
5	1545	Corn Valley	47	0.6	23	5	35	47	0.0197	2.2656	21.5607	1.611
6	1139	Acosta	25	0.2	7	0	12	25	0.0125	1.427	15.5806	1.0491
7	1435	Beltline	28	0.0	6	0	10	28	0.0134	1.2309	12.947	0.8035
8	2995	SE 14th	54	0.2	8	0	9	53	0.0257	2.2242	27.2218	1.3294
Total	12339		326	3.6	137	32	189	325	0.1374	14.193	142.338	9.3844
	Total per mile		140	1.5	59	14	81	139	0.06	6.07	60.91	4.02

PM Eastbound After Retiming

Node No.	Length (ft)	Node Names	Travel Time (s)	No. of Stops	Total Delay (s)	Time<= 0 MPH (s)	Time<=35 MPH (s)	Time<=55 MPH (s)	Fuel (gals)	HC (gm)	CO (gm)	NO_x (gm)
1	5987	W Freeway										
2	1365	Robinson	21	0.0	0	0	2	21	0.0112	0.7064	9.5522	0.3379
3	1349	Carrier	21	0.0	0	0	1	21	0.0114	0.8742	11.8536	0.4966
4	2420	SW 3rd	37	0.0	0	0	0	37	0.0204	1.452	20.2955	0.766
5	1520	Corn Valley	23	0.0	0	0	0	23	0.0126	0.8611	11.9248	0.4353
6	1136	Acosta	17	0.0	0	0	0	17	0.0099	0.7549	10.8576	0.4232
7	1369	Belt Line	22	0.0	1	0	1	22	0.0106	0.6491	8.0326	0.2829
8	2954	SE 14th	53	0.2	9	2	10	53	0.0257	2.0801	27.3972	1.1526
Total	12113		194	0.2	11	2	14	193	0.10	7.38	99.91	3.89
	Total per mile		85	0.1	5	1	6	84	0.04	3.22	43.55	1.70

Reductions for PM Eastbound

Node No.	Length (ft)	Node Names	Travel Time (s)	No. of Stops	Total Delay (s)	Time<= 0 MPH (s)	Time<=35 MPH (s)	Time<=55 MPH (s)	Fuel (gals)	HC (gm)	CO (gm)	NO_x (gm)
1		W Freeway										
2		Robinson	35	0.8	34	13	41	35	0.01	1.33	8.93	0.89
3		Carrier	30	0.8	29	8	41	30	0.01	1.32	7.18	1.01
4		SW 3rd	29	1.0	28	5	37	29	0.01	1.36	7.21	1.09
5		Corn Valley	24	0.6	23	5	35	24	0.01	1.40	9.64	1.18
6		Acosta	7	0.2	7	0	12	7	0.00	0.67	4.72	0.63
7		Belt Line	6	0.0	5	0	9	6	0.00	0.58	4.91	0.52
8		SE 14th	0	0.0	-1	-2	-1	0	0.00	0.14	-0.18	0.18
Total			132	3.4	126	30	175	132	0.04	6.82	42.42	5.49
Reduction per mile			55	1.5	54	13	75	55	0.01	2.86	17.36	2.32
%reduction			39	94.3	92	94	92	39	24.53	47.05	28.50	57.73

AM Westbound Before Retiming

Node No.	Length (ft)	Node Names	Travel Time (s)	No. of Stops	Total Delay (s)	Time<= 0 MPH (s)	Time<=35 MPH (s)	Time<=55 MPH (s)	Fuel (gals)	HC (gm)	CO (gm)	NO_x (gm)
1	0	West Frwy										
2	1287	Robinson	21	0.0	1	0	1	20	0.0109	0.8913	12.2921	0.5203
3	1355	Carrier	23	0.0	2	0	0	23	0.0115	0.9593	12.6846	0.5602
4	2491	SW 3rd	41	0.0	2	0	1	41	0.02	1.4011	18.1756	0.6823
5	1531	Corn Valley	27	0.0	3	0	2	27	0.0132	1.1863	14.3223	0.73
6	1174	Acosta	21	0.0	3	0	6	21	0.0092	0.6358	7.3566	0.2935
7	1419	Beltline	25	0.0	3	0	5	25	0.0162	1.9352	24.1096	1.4987
8	3075	SE 14th	84	1.0	37	22	45	84	0.0377	3.9134	41.4243	2.6103
Total	12332		241	1.0	51	22	59	240	0.1186	10.922	130.365	6.8954
	Total per mile		103	0.4	22	9	25	103	0.05	4.68	55.82	2.95

AM Westbound After Retiming

Node No.	Length (ft)	Node Names	Travel Time (s)	No. of Stops	Total Delay (s)	Time<= 0 MPH (s)	Time<=35 MPH (s)	Time<=55 MPH (s)	Fuel (gals)	HC (gm)	CO (gm)	NO_x (gm)
1	5900	W Freeway										
2	1369	Robinson	21	0.0	0	0	0	21	0.0109	0.6949	9.1323	0.3172
3	1346	Carrier	22	0.0	1	0	1	22	0.0132	1.3474	18.0037	0.9331
4	2411	SW 3rd	42	0.2	5	0	6	42	0.0201	1.3964	16.4295	0.7053
5	1540	Corn Valley	27	0.0	3	0	7	27	0.0168	1.9601	24.4702	1.4756
6	1130	Acosta	32	0.6	15	1	21	32	0.0121	1.0195	7.6168	0.5983
7	1398	Belt Line	25	0.0	3	0	7	25	0.0159	1.9371	23.8974	1.501
8	3059	SE 14th	94	1.0	48	24	58	94	0.0394	4.0456	40.4532	2.6087
Total	12253		264	1.8	75	26	101	264	0.13	12.40	140.00	8.14
Total per mile			114	0.8	32	11	43	114	0.06	5.34	60.33	3.51

Reductions for AM Westbound

Node No.	Length (ft)	Node Names	Travel Time (s)	No. of Stops	Total Delay (s)	Time<= 0 MPH (s)	Time<=35 MPH (s)	Time<=55 MPH (s)	Fuel (gals)	HC (gm)	CO (gm)	NO_x (gm)
1		W Freeway										
2		Robinson	0	0.0	1	0	1	-1	0.00	0.20	3.16	0.20
3		Carrier	0	0.0	0	0	-1	0	0.00	-0.39	-5.32	-0.37
4		SW 3rd	-1	-0.2	-2	0	-6	-1	0.00	0.00	1.75	-0.02
5		Corn Valley	0	0.0	0	0	-5	0	0.00	-0.77	-10.15	-0.75
6		Acosta	-11	-0.6	-12	-1	-15	-11	0.00	-0.38	-0.26	-0.30
7		Belt Line	0	0.0	0	0	-2	0	0.00	0.00	0.21	0.00
8		SE 14th	-11	0.0	-11	-2	-13	-11	0.00	-0.13	0.97	0.00
Total			-23	-0.8	-24	-4	-41	-24	-0.01	-1.48	-9.64	-1.24
Reduction per mile			-11	-0.3	-10	-2	-18	-11	0.00	-0.67	-4.51	-0.56
	%reduction		-10	-81.2	-47	-19	-71	-11	-8.96	-14.27	-8.09	-18.80

MID Westbound Before Retiming

Node No.	Length (ft)	Node Names	Travel Time (s)	No. of Stops	Total Delay (s)	Time<= 0 MPH (s)	Time<=35 MPH (s)	Time<=55 MPH (s)	Fuel (gals)	HC (gm)	CO (gm)	NO_x (gm)
1	0	West Frwy										
2	1326	Robinson	41	0.6	21	11	22	41	0.0157	1.5467	17.3815	0.8894
3	1362	Carrier	27	0.0	6	0	10	27	0.0123	1.1195	12.0919	0.7052
4	2473	SW 3rd	46	0.2	8	0	9	46	0.0219	1.9254	21.6552	1.1723
5	1544	Corn Valley	36	0.4	13	1	21	36	0.0154	1.5678	15.8152	1.0314
6	1132	Acosta	25	0.2	8	0	14	25	0.0106	0.9583	8.8317	0.5979
7	1442	Beltline	30	0.2	7	0	10	30	0.0156	1.79	19.7866	1.3368
8	3091	SE 14th	87	0.8	40	21	49	87	0.0354	3.4755	36.9014	2.1122
Total	12370		292	2.4	102	34	135	292	0.1268	12.383	132.464	7.8452
	Total per mile		125	1.0	44	14	58	124	0.05	5.29	56.54	3.35

MID Westbound After Retiming

Node No.	Length (ft)	Node Names	Travel Time (s)	No. of Stops	Total Delay (s)	Time<= 0 MPH (s)	Time<=35 MPH (s)	Time<=55 MPH (s)	Fuel (gals)	HC (gm)	CO (gm)	NO_x (gm)
1	5878	W Freeway										
2	1358	Robinson	25	0.2	4	2	5	25	0.0125	1.0278	12.947	0.5965
3	1357	Carrier	25	0.0	3	0	6	25	0.014	1.6188	20.5857	1.1896
4	2410	SW 3rd	49	0.4	12	2	18	49	0.0215	1.6627	17.558	0.9135
5	1533	Corn Valley	27	0.0	4	0	9	27	0.0167	2.0001	24.4666	1.5278
6	1129	Acosta	38	1.0	21	5	27	38	0.0135	1.1802	8.8251	0.6658
7	1391	Belt Line	25	0.0	4	0	7	25	0.0157	1.9473	23.9188	1.512
8	3066	SE 14th	98	0.8	51	28	63	98	0.0386	3.9862	40.5226	2.4778
Total	12244		287	2.4	99	37	135	287	0.13	13.42	148.82	8.88
	Total per mile		124	1.0	43	16	58	124	0.06	5.79	64.18	3.83

Reductions for MID Westbound

Node No.	Length (ft)	Node Names	Travel Time (s)	No. of Stops	Total Delay (s)	Time<=0 MPH (s)	Time<=35 MPH (s)	Time<=55 MPH (s)	Fuel (gals)	HC (gm)	CO (gm)	NO_x (gm)
1		W Freeway										
2		Robinson	16	0.4	17	9	18	16	0.00	0.52	4.43	0.29
3		Carrier	2	0.0	2	0	4	2	0.00	-0.50	-8.49	-0.48
4		SW 3rd	-2	-0.2	-3	-2	-9	-2	0.00	0.26	4.10	0.26
5		Corn Valley	9	0.4	9	1	12	9	0.00	-0.43	-8.65	-0.50
6		Acosta	-13	-0.8	-13	-5	-13	-13	0.00	-0.22	0.01	-0.07
7		Belt Line	4	0.2	4	0	3	4	0.00	-0.16	-4.13	-0.18
8		SE 14th	-11	0.0	-11	-7	-14	-11	0.00	-0.51	-3.62	-0.37
Total			5	0.0	3	-3	1	5	-0.01	-1.04	-16.36	-1.04
Reduction per mile			1	0.0	1	-1	0	1	0.00	-0.50	-7.64	-0.48
	%reduction		1	-1.0	2	-10	-1	1	-5.57	-9.51	-13.51	-14.39

PM Westbound Before Retiming

Node No.	Length (ft)	Node Names	Travel Time (s)	No. of Stops	Total Delay (s)	Time<=0 MPH (s)	Time<=35 MPH (s)	Time<=55 MPH (s)	Fuel (gals)	HC (gm)	CO (gm)	NO_x (gm)
1	0	West Frwy										
2	1317	Robinson	26	0.2	6	0	12	26	0.0134	1.5029	16.386	1.1116
3	1363	Carrier	62	0.8	41	18	53	62	0.0207	2.2967	20.8133	1.3895
4	2452	SW 3rd	86	1.0	48	18	58	86	0.0302	2.941	28.0392	1.6457
5	1561	Corn Valley	42	0.6	18	5	26	42	0.0168	1.6424	15.3106	1.0384
6	1143	Acosta	21	0.2	4	0	4	21	0.0097	0.761	8.3103	0.4216
7	1412	Beltline	26	0.0	4	0	5	26	0.0139	1.526	18.3896	1.0952
8	3082	SE 14th	89	1.0	42	11	51	89	0.0361	3.6521	37.2159	2.3111
Total	12330		353	3.8	163	52	209	352	0.1408	14.322	144.465	9.0131
	Total per mile		151	1.6	70	22	90	151	0.06	6.13	61.86	3.86

PM Westbound After Retiming

Node No.	Length (ft)	Node Names	Travel Time (s)	No. of Stops	Total Delay (s)	Time<= 0 MPH (s)	Time<=35 MPH (s)	Time<=55 MPH (s)	Fuel (gals)	HC (gm)	CO (gm)	NO_x (gm)
1	5862	W Freeway										
2	1391	Robinson	21	0.0	0	0	0	21	0.0125	1.0724	15.4556	0.6665
3	1339	Carrier	24	0.0	3	0	7	24	0.0144	1.7234	21.9662	1.2872
4	2425	SW 3rd	50	0.4	13	1	19	50	0.0224	1.891	20.7157	1.1078
5	1522	Corn Valley	26	0.0	2	0	2	26	0.0154	1.6722	22.176	1.1928
6	1141	Acosta	29	0.4	11	0	20	29	0.0118	1.1286	9.0337	0.764
7	1375	Belt Line	24	0.0	3	0	6	24	0.016	1.9399	24.7729	1.4944
8	3054	SE 14th	102	1.0	55	32	68	102	0.0397	4.0684	42.1634	2.466
Total	12247		276	1.8	88	33	123	276	0.13	13.50	156.28	8.98
	Total per mile		119	0.8	38	14	53	119	0.06	5.82	67.38	3.87

Reductions for PM Westbound

Node No.	Length (ft)	Node Names	Travel Time (s)	No. of Stops	Total Delay (s)	Time<= 0 MPH (s)	Time<=35 MPH (s)	Time<=55 MPH (s)	Fuel (gals)	HC (gm)	CO (gm)	NO_x (gm)
1		W Freeway										
2		Robinson	5	0.2	6	0	11	5	0.00	0.43	0.93	0.45
3		Carrier	38	0.8	37	18	46	38	0.01	0.57	-1.15	0.10
4		SW 3rd	36	0.6	35	17	39	36	0.01	1.05	7.32	0.54
5		Corn Valley	16	0.6	16	5	23	16	0.00	-0.03	-6.87	-0.15
6		Acosta	-7	-0.2	-7	0	-16	-7	0.00	-0.37	-0.72	-0.34
7		Belt Line	1	0.0	1	0	-2	1	0.00	-0.41	-6.38	-0.40
8		SE 14th	-13	0.0	-13	-21	-16	-13	0.00	-0.42	-4.95	-0.15
Total			77	2.0	75	18	86	76	0.01	0.83	-11.82	0.03
Reduction per mile			32	0.9	32	8	36	32	0.00	0.31	-5.51	-0.01
%reduction			21	52.3	46	35	41	21	5.47	5.13	-8.91	-0.29

APPENDIX D

DATA COMPILED FOR INDEPENDENT VARIABLES

Data compiled for independent variables

Arterial	Start	End	City	Length	Number of signals	Signal density	Log (Signal density)	No. of lanes	Mean spacing	St dev	ADT	FRTIME
Bryant-Irvin	IH-30	Southwest Pkwy	Fort Worth	3.1	7	2.26	0.35	4	0.52	0.43	30146	301
Belt Line	DNT SBFR	Coit	Dallas	3.22	8	2.48	0.40	6	0.46	0.17	47302	353
Illinois	Duncanville	SH 342	Dallas	6.11	17	2.78	0.44	6	0.38	0.23	38875	698
Hampton	Leath	Illinois	Dallas	4.75	15	3.16	0.50	6	0.34	0.14	49228	626
Harry Hines	IH-635	Empire Central	Dallas	6.17	15	2.43	0.39	6	0.44	0.26	51296	596
Abram/Jefferson	Cooper	Great SW Pkwy	Arlington	3.99	13	3.26	0.51	6	0.33	0.28	47779	528
FM 1171	Churchill	IH-35E	Flower Mound, Lewisville	4.16	15	3.61	0.56	2	0.3	0.28	45778	500
University	Camp Bowie	Crestline/Harley	Fort Worth	0.56	4	7.14	0.85	6	0.19	0.12	24744	80
Jupiter	Buckingham	Northwest Hwy	Garland/Dallas	4.61	11	2.39	0.38	6	0.46	0.33	56128	538
Green Oaks SE/SW	Kelly-Elliott	SH 360	Arlington, Grand Prairie	6.91	12	1.74	0.24	4	0.63	0.34	25199	723
Spring Valley	Inwood	Meandering Way	Farmers Branch/Dallas	2.78	7	2.52	0.40	6	0.46	0.33	33729	358
Alpha	Dallas North Tollway	Hillcrest	Dallas	2.05	6	2.93	0.47	5	0.41	0.34	33772	269
Coit	Pres. George Bush	Churchill	Dallas/Richardson/Dallas	5.64	15	2.66	0.42	6	0.4	0.28	59864	347
Northwest Hwy	US 75	Saturn	Dallas	7.56	18	2.38	0.38	6	0.44	0.33	68356	719
Jupiter	PBGT EBFR	Buckingham	Richardson	4.86	11	2.26	0.35	6	0.49	0.27	41738	495
Camp Bowie	SH 183	IH-30	Fort Worth	2.07	7	3.38	0.53	6	0.35	0.23	32116	264
Oaklawn	Blackburn	Highline	Dallas	1.65	11	6.67	0.82	4	0.17	0.14	42529	329
Jupiter	Spring Creek Pkwy	PGBT EBFR	Plano	3.72	9	2.42	0.38	6	0.47	0.29	47673	415
US 377	Keller-Hicks	Broadway	Haltom City, Watauga, Keller	8.46	18	2.13	0.33	4	0.5	0.38	42330	757
Camp Bowie/7th	Montgomery	Stayton	Fort Worth	1.18	6	5.08	0.71	6	0.24	0.08	25664	214
Bryant-Irvin	Southwest Pkwy	Mira Vista	Fort Worth	2.59	10	3.86	0.59	6	0.29	0.23	45451	296
SH 190 (PGBT Frontage Road(EB))	Jupiter Road	Brand	Richardson/Garland	4.5	7	1.56	0.19	6	0.75	0.36	25511	387
Montgomery	Camp Bowie	Vickery	Fort Worth	1.22	7	5.74	0.76	4	0.2	0.22	23424	179

Arterial	Start	End	City	System type	Measured TT	TT at SP Limit	Delay/veh	Delay/ veh/signal	Delay/ veh/mile	#Stops/ veh	# Stops/ veh/ mile	# Stops/ veh/ signal
Bryant-Irvin	IH-30	Southwest Pkwy	Fort Worth	2	547	296	251	35.9	83.7	5.0	1.6	0.7
Belt Line	DNT SBFR	Coit	Dallas	1	458	289	169	21.1	54.4	2.8	0.9	0.3
Illinois	Duncanville	SH 342	Dallas	1	930	570	360	22.5	61.0	7.5	1.2	0.4
Hampton	Leath	Illinois	Dallas	1	742	455	287	17.9	62.3	6.8	1.4	0.5
Harry Hines	IH-635	Empire Central	Dallas	1	742	483	259	17.3	43.9	5.3	0.9	0.4
Abram/Jefferson	Cooper	Great SW Pkwy	Arlington	1	565	372	193	16.1	48.2	4.8	1.2	0.4
FM 1171	Churchill	IH-35E	Flower Mound, Lewisville	1	652	376	276	17.3	65.7	5.8	1.4	0.4
University	Camp Bowie	Crestline/Harley	Fort Worth	1	157	54	103	25.8	172.1	1.8	3.1	0.4
Jupiter	Buckingham	Northwest Hwy	Garland/Dallas	1	617	388	229	14.3	49.8	4.0	0.9	0.4
Green Oaks SE/SW	Kelly-Elliott	SH 360	Arlington, Grand Prairie	1	776	530	246	20.5	37.3	6.3	0.9	0.5
Spring Valley	Inwood	Meandering Way	Farmers Branch/Dallas	1	416	273	143	17.8	52.8	3.3	1.2	0.5
Alpha	Dallas North Tollway	Hillcrest	Dallas	1	343	212	131	18.7	62.4	2.5	1.2	0.4
Coit	Pres. George Bush	Churchill	Dallas/Richardson/Dallas	1	707	486	221	11.6	40.8	5.3	0.9	0.4
Northwest Hwy	US 75	Saturn	Dallas	1	809	613	196	10.3	25.8	5.0	0.7	0.3
Jupiter	PBGT EBFR	Buckingham	Richardson	1	562	422	140	14.0	29.7	3.8	0.8	0.3
Camp Bowie	SH 183	IH-30	Fort Worth	1	346	224	122	15.2	55.3	3.5	1.7	0.5
Oaklawn	Blackburn	Highline	Dallas	1	343	179	164	14.9	109.3	3.0	1.8	0.3
Jupiter	Spring Creek Pkwy	PGBT EBFR	Plano	1	473	347	126	12.6	36.0	3.0	0.8	0.3
US 377	Keller-Hicks	Broadway	Haltom City, Watauga, Keller	3	1094	693	401	21.1	45.1	8.6	1.0	0.5
Camp Bowie/7th	Montgomery	Stayton	Fort Worth	1	237	115	122	20.4	81.5	2.3	1.9	0.4
Bryant-Irvin	Southwest Pkwy	Mira Vista	Fort Worth	2	399	222	177	17.7	70.8	3.0	1.2	0.3
SH 190 (PGBT Frontage Road(EB))	Jupiter Road	Brand	Richardson/Garland	2	492	314	178	25.5	40.5	3.3	0.7	0.5
Montgomery	Camp Bowie	Vickery	Fort Worth	1	256	114	142	20.3	118.1	2.8	2.3	0.4

Arterial	Start	End	City	Length	Number of signals	Signal density	Log (Signal density)	No. of lanes	Mean spacing	St dev	ADT	FRTIME
Forest	US 75	IH-635	Dallas	2.21	10	4.52	0.66	6	0.25	0.16	49792	274
Belknap/Grapevine Hwy	Sylvania	Rufe Snow	Fort Worth, Haltom City, NRH	5.18	10	1.93	0.29	4	0.58	0.34	25751	540
FM 3040/Hebron/Park Blvd	Edmonds	Lakepointe	Lewisville	2.37	12	5.06	0.70	6	0.22	0.1	43048	310
Harry Hines	Empire Central	Wycliff	Dallas	2.29	9	3.93	0.59	6	0.29	0.25	40883	299
Forest	Harry Hines	US 75	Dallas	7.37	20	2.71	0.43	6	0.39	0.26	47584	908
Collins	Abram	Bardin	Arlington	4.45	12	2.70	0.43	6	0.4	0.22	41977	486
Belt Line	Coit	Jupiter	Richardson	5.09	16	3.14	0.50	6	0.34	0.17	43719	631
Preston	Arapaho	IH-635	Dallas	2.56	10	3.91	0.59	6	0.28	0.18	37008	262
Inwood	Alpha	Mockingbird	Dallas	6.67	15	2.25	0.35	4	0.48	0.28	33706	808
Pioneer Pkwy (Spur 303)	Susan	SE 14th	Grand Prairie	4.25	10	2.35	0.37	6	0.47	0.32	35351	388
First	Buckingham	Avenue D	Garland	1.51	5	3.31	0.52	6	0.38	0.4	47205	235
Pleasant Run	Hampton	IH-35E	Desoto	2.02	7	3.47	0.54	4	0.34	0.2	22460	235
Royal	US 75	IH-635	Dallas	3.45	8	2.32	0.37	6	0.49	0.29	27056	476
Great Southwest Pkwy	Division/Main	Fairmont	Grand Prairie	5.3	15	2.83	0.45	4	0.38	0.25	20328	560
SH 78	Naaman School	Castle	Garland	1.8	4	2.22	0.35	6	0.6	0.03	40627	147
Division/Main	Bowen	Great SW Pkwy	Arlington	6.09	13	2.13	0.33	4	0.51	0.29	24094	703
Wabash/Granbury	Seminary	Gorman/Wedgemont	Fort Worth	1.39	7	5.04	0.70	4	0.23	0.11	27645	136
Rowlett Road	Castle	Roan	Rowlett	5.54	9	1.62	0.21	4	0.69	0.32	40613	464
Belknap/Grapevine Hwy	Rufe Snow	Precinct Line	Haltom City, NRH	4.1	12	2.93	0.47	4	0.37	0.26	35709	301
FM 1709	US 377	SH 114	Keller, Southlake	9.12	21	2.30	0.36	4	0.46	0.24	47162	750
Marsh/Lemmon	Almazon	US 75	Dallas	5.75	21	3.65	0.56	6	0.29	0.19	55994	766
Irving Blvd	Willowcreek	Norwood	Irving	4.81	16	3.33	0.52	4	0.32	0.19	30590	782
SH 183	Ridgmar Mall	SH 199	Fort Worth	4.31	9	2.09	0.32	4	0.54	0.34	35244	361
Frankford	Campbell	Coit	Dallas	2.18	6	2.75	0.44	6	0.44	0.23	38080	269
Valley View Ln	Senlac	Alpha	Farmers Branch	3.69	14	3.79	0.58	4	0.28	0.25	35059	560
Arapaho	US 75	Jupiter	Richardson	2.66	9	3.38	0.53	6	0.33	0.28	44044	320
Inwood	Mockingbird	Conveyor	Dallas	2.78	11	3.96	0.60	6	0.28	0.14	58072	419
Preston	PGBT	Arapaho	Dallas	3.47	9	2.59	0.41	6	0.43	0.17	65325	342

Arterial	Start	End	City	System type	Measured TT	TT at SP Limit	Delay/ veh	Delay/ veh/ signal	Delay/ veh/ mile	#Stops/ veh	# Stops/ veh/ mile	# Stops/ veh/ signal
Forest	US 75	IH-635	Dallas	1	309	195	114	12.6	51.6	2.0	0.9	0.2
Belknap/Grapevine Hwy	Sylvania	Rufe Snow	Fort Worth, Haltom City	3	771	493	278	27.8	53.4	6.0	1.2	0.6
FM 3040/Park Blvd	Edmonds	Lakepointe	Lewisville	2	379	186	193	14.8	80.4	5.8	2.4	0.5
Harry Hines	Empire Central	Wycliff	Dallas	1	305	188	117	13.0	51.0	2.8	1.2	0.3
Forest	Harry Hines	US 75	Dallas	1	921	669	252	12.0	35.4	5.5	0.7	0.3
Collins	Abram	Bardin	Arlington	2	552	381	171	14.3	38.9	5.5	1.2	0.5
Belt Line	Coit	Jupiter	Richardson	1	734	527	207	12.9	40.5	4.0	0.8	0.3
Preston	Arapaho	IH-635	Dallas	1	365	204	161	16.1	62.0	1.8	0.7	0.2
Inwood	Alpha	Mockingbird	Dallas	1	827	622	205	13.6	32.5	4.8	0.7	0.3
Pioneer Pkwy	Susan	SE 14th	Grand Prairie	1	426	326	100	11.1	23.8	3.5	0.8	0.4
First	Buckingham	Avenue D	Garland	1	169	127	42	10.5	28.0	1.0	0.7	0.2
Pleasant Run	Hampton	IH-35E	Desoto	2	338	170	168	23.9	88.2	3.0	1.5	0.4
Royal	US 75	IH-635	Dallas	1	479	346	133	16.6	39.1	2.3	0.7	0.3
Great Southwest Pkwy	Division/Main	Fairmont	Grand Prairie	1	750	424	326	21.7	63.9	4.0	0.8	0.3
SH 78	Naaman School	Castle	Garland	1	174	124	50	12.4	29.3	0.8	0.4	0.2
Division/Main	Bowen	Great SW Pkwy	Arlington	1	777	570	207	13.0	33.4	6.0	1.0	0.5
Wabash/Granbury	Seminary	Gorman/Wedgemont	Fort Worth	2	274	114	160	20.0	122.9	2.8	2.0	0.4
Rowlett Road	Castle	Roan	Rowlett	3	545	426	119	17.0	23.8	3.0	0.5	0.3
Belknap/Grapevine Hwy	Rufe Snow	Precinct Line	Haltom City, NRH	3	580	338	242	18.6	59.1	5.8	1.4	0.5
FM 1709	US 377	SH 114	Keller, Southlake	1	947	757	190	9.0	21.1	4.8	0.5	0.2
Marsh/Lemmon	Almazon	US 75	Dallas	1	714	536	178	8.5	32.9	3.5	0.6	0.2
Irving Blvd	Willowcreek	Norwood	Irving	2	847	555	292	17.2	47.1	5.8	1.2	0.4
SH 183	Ridgmar Mall	SH 199	Fort Worth	2	511	340	171	15.5	38.0	3.3	0.8	0.4
Frankford	Campbell	Coit	Dallas	1	250	191	59	9.8	28.0	1.5	0.7	0.3
Valley View Ln	Senlac	Alpha	Farmers Branch	1	497	360	137	9.8	37.0	3.8	1.0	0.3
Arapaho	US 75	Jupiter	Richardson	1	322	226	96	9.6	38.5	1.8	0.7	0.2
Inwood	Mockingbird	Conveyor	Dallas	1	347	264	83	6.3	30.6	3.0	1.1	0.3
Preston	PGBT	Arapaho	Dallas	1	319	274	45	5.6	12.9	1.8	0.5	0.2

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BIOGRAPHICAL INFORMATION

Pulipati Sasanka Bhushan was born in Andhra Pradesh state in India on 25th May 1981. He obtained his Bachelor's degree in Civil Engineering from Birla Institute of Technology and Science (BITS), Pilani, Rajasthan, India. He worked as a Highway Engineer with RITES Ltd, New Delhi, India for two years (2002-2004).

During his stay at RITES Ltd, he took part in one of the prestigious highway projects in India, the North – South – East – West Corridor project. He also worked in Afghanistan for the detailed field survey and soil investigation for transmission line between Kabul and Phul-E-Khumri, a rehabilitation project.

Sasanka earned his Master of Science in Civil Engineering from the University of Texas Arlington. Transportation Engineering was his specialization. During his study at UT Arlington, he served as a Graduate Teaching Assistant in the Department of Civil and Environmental Engineering where he taught Geodesy Lab.

Pulipati's research interests are in the field of transportation planning. His master's research is focused on the "Regional prioritization of corridors for traffic signal retiming". He proposes a new methodology based on estimated benefits to prioritize retiming projects.

As the president of ITE (Institute of Transportation Engineers) Student Chapter at UTA, he made the chapter to be recognized as an active student chapter in Texas. He received the "Outstanding student award" by the TexITE (Texas Institute of

Transportation Engineers) at the summer meeting, 2005. He was also initiated to Tau Beta Pi, an all engineering honors society in November, 2005.

Pulipati aims at returning to research in Transportation Engineering after a few years of experience in the field.