Southwest Region University Transportation Center

User-Based Location Criteria for Transit Terminal Frequency

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16. Abstract

This research focuses on the development of mathematical models and default parameters that describe the dynamics of relationships between transit terminal frequencies and user travel time. The models and defaults, developed through observations of local bus transit system, supplement a general transit terminal location optimization methodology. Models can be implemented as an aid to development of policies regarding public transportation system terminal frequency and location.

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USER-BASED LOCATION CRITERIA FOR TRANSIT TERMINAL FREQUENCY

by

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Research Report SWUTC 94/721915-2

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EXECUTIVE SUMMARY

This report presents data collection procedures, primary data, and mathematical models describing bus transit passenger access times, as well as, selected bus transit operational characteristics. Data collection activities were conducted in Austin, Texas and all observations involved transit vehicles operated by The Capital Metro Transit Authority.

The data collection and modeling were performed as part of a larger effort developing a methodology for estimating optimal transit terminal location frequency. Tasks that were undertaken included establishing appropriate methods of estimating passenger access/egress walk distances, and wait times, and identifying any relationship between passenger wait time and schedule reliability. Additionally, appropriate model default values for local bus operational parameters were estimated including acceleration, deceleration, and cruise velocities.

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ABSTRACT

This research focuses on the development of mathematical models and default parameters that describe the dynamics of relationships between transit terminal frequencies and user travel time. The models and defaults, developed through observations of a local bus transit system, supplement a general transit terminal location optimization methodology. Models can be implemented as an aid to development of policies regarding public transportation system terminal frequency and location.

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CHAPTER 1 INTRODUCTION

In planning and operating public mass transit systems, the need exists to optimize passenger transit terminal spacing. Optimization can be viewed from multiple, often competing perspectives. The needs of the environment, the community, the transit operator, and the rider may each suggest differing frequencies and spacing of transit terminals, based on differing requirements to conserve resources, optimize land use, and minimize operating costs or travel time, to name only a few potentially competing requirements. Most references on the subject of terminal spacing tend to agree that user travel time is the single most important aspect of transit system network design. Therefore, this research will use this perspective.

The overall objective of this research is to provide estimates of transit system and rider behavior parameters and accompanying mathematical model information to be used in the formulation of a software program that will furnish an optimal transit terminal spacing solution. Such a model will be theory- and empirically-based and can be implemented as an aid in the development of policies regarding public transportation system terminal frequency and location. Although policy decisions are made within the context of a multitude of real constraints, data and analyses provided through this model can provide a basis for those decisions. Optimally locating transit terminal facilities has the potential to reduce costs and to enhance operational efficiency and ridership.

With the above perspective and objective in mind, this research focuses on developing specific default values and models to be built into the software program. In the next chapter, a literature review of this topic will be presented. In Chapter 3, the nature and scope of the research problem will be discussed. In Chapter 4, the data analysis will be presented. Finally, Chapter 5 will provide a summary of the findings and conclusions.

CHAPTER 2 LITERATURE REVIEW

A wide array of literature addresses the concept of optimizing interstation spacing in order to achieve various objectives. Of particular interest are the studies with the objective of minimizing passenger travel time. To this end, relatively recent and comprehensive studies performed by Vukan R. Vuchic form the starting point for this research. Several related studies are also presented.

The study of optimizing interstation spacings to minimize passenger travel time dates back to at least 1915, as was discovered by Vuchic [Ref. 1] in an extensive literature review for his thesis in 1966. He found that several German authors studied the problem of interstation spacings for urban and suburban railways between 1915 and 1930. He cited that, with the exception of one author, the problem was virtually forgotten until the 1960's when, with renewed interest in public transportation in the United States, several studies appeared that either directly or indirectly examined interstation spacings for passenger transportation systems. Within his review, Vuchic presented a brief literature review from the work of one of the early German researchers, Hinze (1930), who was credited for having performed one of the most thorough studies until that time.

To briefly summarize Vuchic's literature review, the 1915 study developed an equation with typical values of parameters for total passenger time as a function of interstation spacings and derived the optimal value of the spacing in numerical form: 637 meters. Mueller (1917) and Bethge (1919) followed a similar procedure and produced interstation distance resulting from minimal aggregate passenger travel time and from average trip length for minimum travel cost, respectively. Hinze pursued Schimpff's (1913) assertion that optimal street car spacings should be a function of the relation between the number of passengers on the vehicle and those along the line waiting to board it, and based his own analytical study. Bendtsen (1938) rederived and simplified some of Hinze's formula for optimal spacing. Schneider (1961) studied a line with cumulative passenger boarding. He made several other assumptions and found optimal interstation spacings. Newell (1962) studied the optimal spacings when access was by bus only and presented a numerical analysis for one case. Overgaard (1965) attempted to find optimal station spacings in order to maximize the number of passengers choosing rapid transit over automobile. His model in order to maximize the number of passengers choosing rapid transit over automobile. His model assumed a radial-circumferential network. In studying problems related to optimizing station spacing, Black (1962) and Creighton (1964) both sought the minimal cost solution to radial corridor scenarios involving multiple transit and commuter modes in different theoretical zones about a city center. The point at which the different modes met for minimum cost was derived.

In the body of his thesis, Vuchic presented graphical, analytical, and numerical examples which minimized aggregate passenger travel time on a line with cumulative boarding. He developed four analytical models covering different combinations of assumptions about population density and interstation spacings:

Case 1: Any population density; no spacing restrictions

Case 2: Uniform population density; no spacing restrictions

Case 3: Any population density; actual spacing ≥ critical spacing (maximum running speed just reached)

Case 4: Uniform population density; actual spacing ≥ critical spacing

In each case, Vuchic performed his analysis in the following order:

a. Location of the passenger shed line (the geometric line which separates the areas from which passengers go to two adjacent stations) was determined;

b. Access time and time on train were computed separately; their sum was total passenger travel time;

c. A set of simultaneous equations determining the optimal locations of stations was derived by either partial differentiation of the total passenger time or by dynamic programming techniques;

d. Expressions for optimal values of distances, interstation spacings, and number of interstation spacings on the line were extracted from the above equations.

In addition to the conclusion that the optimal interstation spacing was a function of the ratio of the number of passengers traveling on the train and those wanting to board or alight, Vuchic also concluded that

> the change of access speed causes considerably greater change in the density and distribution of stations than, for example, change in dynamic characteristics of the train.... It is obvious that accurate prediction of access speeds (modes) is one of the most important factors in planning stations for line-haul passenger transportation [Ref. 1].

Vuchic's minimum time travel thesis was subsequently published with Gordon F. Newell in 1968 [Ref. 2]. Vuchic and Newell's study concentrated on the case in which the population of an area commuted to one central point. Their objective was to identify the number and locations of stations which will minimize the total time of all passengers. They incorporated such parameters as population distribution along the line, access speed, dynamic characteristics of the train, vehicle dwell time in stations, and intermodal transfer time at stations. In general, they found again that spacings were functions of the ratio between the number of passengers traveling on the train and those wanting to board or alight.

In 1974, Kraft and Bergen [Ref. 3] studied how the design of bus terminals and other intermodal transfer facilities was influenced by passenger loading and unloading times. They used the least squares method to analyze and develop equations to predict passenger service time at single transfer facilities when the number of passengers boarding and alighting was known. The factors they determined to be most influential on passenger service time of street transit service were time of day (peak versus non-peak periods); type of service (intercity versus non-intercity service); type of vehicle (physical dimensions of doors, aisles, seating, etc.); method of fare collection (for local service, the exact-fare system saved between 1.4 and 2.6 seconds per passenger); and type of passenger (elderly, handicapped, etc.).

In 1974, Shortreed [Ref. 4] analyzed route structure and researched the disutility or cost of walking, waiting, and riding time. He determined that, in terms of disutility, one minute of in-vehicle riding time was equivalent to 2-3 minutes of out-of-vehicle walking and waiting time. He developed the following model:

$$C_{ij} = a_K(T_1 + T_2) + a_T(T_3 + T_4) + T_5$$

where C_{ij} = weighted travel time from zone i to j

a_K = disutility of walking time relative to riding time (usually 2-3)

a_T = disutility of waiting time relative to riding time (usually 2-3)

T_1 = walking time to transit route

T_2 = walking time from transit route

T_3 = waiting time for transit vehicle

T_4 = transfer time between routes

T_5 = vehicle riding time

In 1973, Feder [Ref. 5] sought to minimize bus running time, bus stop time, passenger access time, and fleet size with respect to bus stop spacing. In his thesis, he recognized the importance of travel time from the financial view of bus transit operations. He developed mathematical models based on data collected in Pittsburgh, Pennsylvania transit buses. He performed computer simulation of bus lines traveling in both synchronized and unsynchronized traffic signal systems to minimize bus running time with respect to near side and far side bus stop locations. His model considered bus spacing affected by three variables:

$$T = T_a + T_s + T_r$$

where T = total passenger travel time

T_a = access time

T_s = time at bus stops

T_r = bus running time between stops

Interestingly, Feder did not consider wait time because it was assumed to be constant. He also did not consider egress time because it was assumed passengers got off closest to their destination and minimized this time.

A study in 1985 by Gleason [Ref. 6] considered the problem of locating bus stops within the context of a set covering problem. He used zero-one integer programming models to locate bus stops on new routes and to locate express bus stops on current routes. The models were used to locate the minimum number of express bus stops required to ensure that a passenger need not walk more than a specified distance (from a given intersection along a route or from another stop along the route) to reach an express bus stop. A modified version of the model was presented which enabled the planner to locate a specified number of express bus stops in such a manner that the total distance walked by all boarders was minimized. In this context, stops were considered to be virtually any point along the route (one dimensional), and the concept of coverage area (two dimensional) was not addressed.

In a 1981 study, Wirasinghe and Ghoneim [Ref. 7] presented a model to locate bus stops that minimized both passenger time and operator costs. The stop spacing increased with lost time (speed), cost of a unit riding time, number of people on the bus, and the operating cost of the system. Spacing decreased with the cost of a walking unit distance and as the demand for boarding and alighting increased. They concluded that the spacing of stops for the minimum travel time for the many to many case (i.e., many boarding points to many alighting points) was inversely proportional to the square root of demand.

In a 1986 study, Abkowitz and Tozzi [Ref. 8] examined characteristics of the transit route to identify the most appropriate conditions under which headway-based control should be exercised. Their research targeted headway-based control as a potentially significant factor in reducing passenger wait time. The paper included an evaluation of several boarding and alighting profiles that typify characteristics of metro-politan bus systems. The results indicated that the profiles with passengers boarding at the middle and alighting at the end of the route produced the most significant savings in passenger wait time when headway control was implemented. Improvements in wait time reduction diminished as more passengers boarded at early stops and were enhanced as the total ridership increased. Their research suggested that headway-based control, most suitable for routes operating with short, uniform headways, was a viable operating strategy. Yet, the ability of headway-based control to reduce passenger wait time varied as it was related to the variability in boarding and alighting rates and locations along the route.

It is exactly this kind of variability that is of interest in this research. As shown by this literature review, some authors considered the variables wait time and access/egress time differently or not at all. Only the last study reviewed considered the effect of reliability (headway-based control) on passenger wait time. Given the information covered in this review as background, the objective of this research is to more fully explore and attempt to capture the variability associated with wait time, walk time, and schedule reliability. The next chapter provides a description of the research scope and approach.

CHAPTER 3 NATURE AND SCOPE OF PROBLEM

BACKGROUND

The starting point of this research was the inverse relationship between passenger travel time and interstation spacing as presented by Vuchic (Ref. 1). A passenger's goal is nearby transit terminal access, but this conflicts with the competing goal of reducing travel time. This conflict of goals suggests an optimum point where both can be accomodated. Figure 1 depicts this inverse relationship where PT_T is overall passenger trip time; PT_t is passenger travel time; PT_a is access time; and s* represents the optimal spacing.

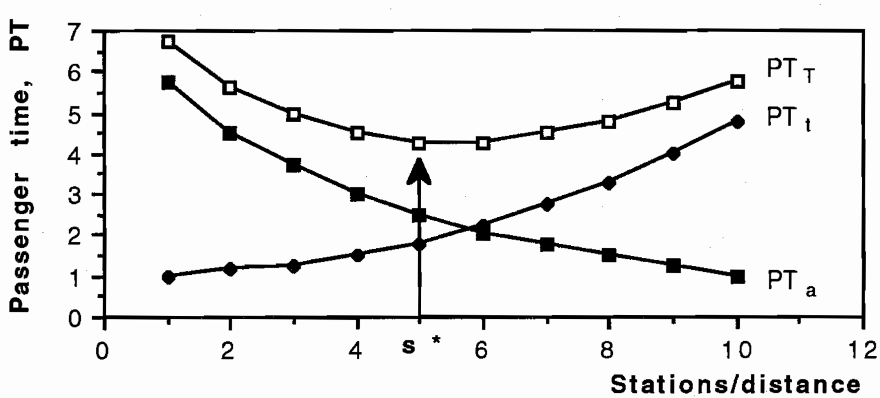

Figure 1. Effect of station spacing on access time and trip time

The corresponding equation for overall passenger trip time is

$$PT_T = PT_a + PT_t$$

The next step was to identify submodels for passenger access time (PT_a) and travel times (PT_t) and parameters to be estimated. The components of overall trip time equation were examined individually.

Research Tasks

Taking the variables in order, PT_a was recognized to consist of access and egress times and wait time. For the purpose of this research, only access by walking was considered, and equal access and equal egress times were assumed. Therefore,

$$PT_a = 2(PT_k) + PT_w$$

where PT_k = walk time
PT_w = wait time

PT_k can be computed by dividing the average access/egress distance by the average access/egress rate. Most studies agree that the average walk distance is about 1/4 mile (Ref. 9) and average walk rate was assumed to be 5 ft/sec (Ref. 5). To provide a reasonable and current default value for walk time and to validate previous research, the first task was to collect and analyze data regarding walk distance.

The examination of wait time, PT_w, indicated that several rules of thumb have been used to estimate PT_w. One rule for headways under 30 minutes is to estimate the wait time as half the headway. Another rule of thumb for headways of 30 minutes or more is to estimate wait time as the square root of the headway (in minutes). Although both rules of thumb are reasonable, it was believed that wait time may be related to schedule reliability. So, to determine if a better estimate of wait time could be developed and to provide a default value, data were collected and analyzed.

Finally, the components of PT_t were considered. Typical, discrete transportation systems were analyzed in depth by Hasse and Holden (Ref. 10), and Vuchic (Ref. 1) presented a slightly more simplified model. Theoretically, between stops a transit vehicle follows a standard trajectory. The vehicle accelerates, cruises, decelerates to a stop, and dwells between stations. If one assumes a constant rate of acceleration, deceleration, and cruise velocity, without other regimes of motion such as coasting, this idealized cycle may be graphed showing travel time as a function of velocity, as in Figure 2:

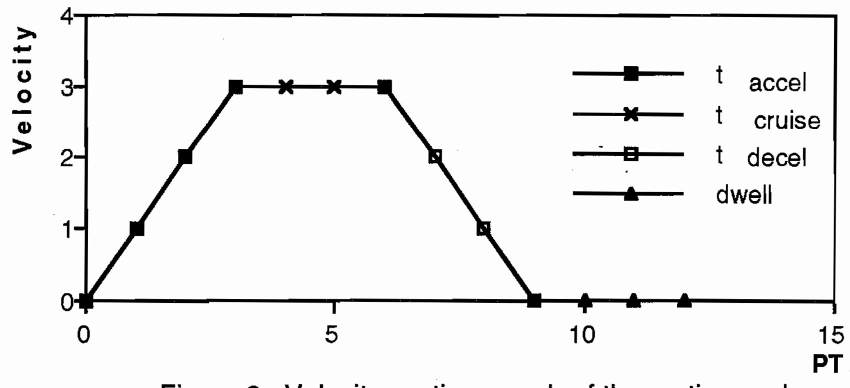

Figure 2. Velocity vs. time graph of the motion cycle

the corresponding mathematical model is

$$PT_t = p[(v/a) + (v/a) + (s - (v^2/2a) - (v^2/2d))/v + dw]$$

where PT_t = travel time (or line haul time)

p = length of route/spacing (or average number of stops per trip)

v = cruise velocity

a = acceleration rate

s = spacing (distance between stops)

d = deceleration rate

dw = dwell time

As noted by Lesley (Ref. 11), in reality, vehicles do not accelerate or decelerate uniformly and they do not cruise at full speed for the full time possible between stops due to traffic signals, turns, etc. Therefore, it is necessary to use average or typical values in models and calculations. To achieve the greatest accuracy in applying this model, optimization program users can specify average values for a, d, and v based on manufacturer specifications or empirical observations of the in-use transit vehicle(s). Likewise, users can furnish values of p and dw that reflect average trip length and dwell time, respectively, based on an existing transit network. In the absence of known average values, default values for each of these parameters are necessary. In addition to providing default values to assist users in optimizing spacings for a specific transit system, by varying the default values, the user can employ the optimization program to evaluate the performance of different vehicles, modes, stops, or routes under consideration.

Data Collection Procedure

Data needed for walking, waiting, and bus schedule reliability parameters were collected in Austin, Texas during a 4 week period from June through July 1992. Three different bus transit stop locations were selected on the basis of their different geographic locations (CBD, center city, and suburb); their relative position along the route (i.e., at the beginning, middle, and end of route); to avoid construction along the route; and to maximize the number of transit lines passing that stop. Data were collected during 2 different times of day: morning non-peak
(9:45 - 11:55 am) and afternoon peak (3:30 - 5:40 pm). It was assumed these 2 time periods would provide a reasonable cross-section of data from which statistical inferences could be generalized, as well as offer a means of explaining the variability expected within the data. At each location for each time period, data were collected on 3-4 non-holiday weekdays. Information regarding each of the data collection locations is shown in Table 1.

TABLE 1. GENERAL CHARACTERISTICS OF THE DATA COLLECTION LOCATIONS

Data Collection Location	Number of Bus Lines	Type Area	Route Position	Average Route Length
6th & Congress	13	CBD	MIddle	8.4 miles
Highland Mall Transit Center	6	Center city	At beginning/end	10.1 miles
Northcross Mall	5	Suburb	Vicinity of beginning/end	8.7 miles

Walk Data

Walk data were collected by asking non-transfer riders waiting at a bus stop bus how far they had walked to the stop and how far they would walk upon alighting to their destination. Responses were recorded in either number of blocks or miles. To assist riders who were not immediately certain of the distance, the questioner prompted by suggesting increments of blocks, such as 0-1 block, 2-3 blocks, etc. It was assumed morning non-peak riders' trip origin was home and trip destination was non-home; the afternoon peak riders' origin was non-home and destination was home.

Wait Data

Wait data were taken by observing and recording when riders arrived at a stop and when the vehicle they boarded departed the stop. Buses were considered to have departed a stop when its tires began rolling. At the Highland Mall Transit Center, when riders boarded a bus prior to the bus' scheduled departure, riders' wait time included wait time on the vehicle. At the 6th & Congress Avenue stop, which was on the near side of a signalized intersection, when the light turned red while boarding riders, wait time included wait time on the bus until the wheels began rolling (after the light turned green). This convention was used because it was observed that the bus would continue to board riders until the light turned green (and sometimes through to the next red light). Additionally, it was assumed that, to the rider, the time spent after boarding but prior to moving was tantamount to wait time.

Bus Schedule Reliability Data

Bus schedule reliability data were collected by recording when buses departed the stop, using the same tires rolling criteria. Once collected, bus data were compared to the most recently published transit schedule, June 7, 1992 (Ref. 12). The transit schedule did not include the actual stop at Northcross Mall, only more significant stops before and after. The transit authority was contacted to obtain exact timetables for this intermediate stop. No such timetable existed; however, using the transit authority's values for the distance to/from the nearest stop with a timetable, average planning speed for that area, and headway, a timetable for that stop was reasonably and effectively interpolated for use in this research. All times were taken to the nearest minute. Standard data recording formats were developed to ensure data accuracy and consistency. Data were then collated and analyzed using the spreadsheet software *EXCEL* and the statistics software *STATISTICA*.

Transit Vehicle and System Default Parameters

To develop the default parameters for the line-haul regimes of motion, data on actual transit vehicles were also needed. Given the extremely large number of vehicle and transit networks in existence in the United States, an attempt to empirically measure vehicle operating characteristics, transit network average trip lengths, and average dwell times exceeded the scope of this research. Therefore, literature was further reviewed to establish appropriate parameter ranges. Several sources presented a wide variety of transit vehicles and systems from different nations and periods. For each parameter, an intermediate value within the identified range was selected to be most representative.

SUMMARY

The specific research tasks at hand were threefold. The first two, which relate to the access portion of the model, were to establish appropriate default values for access/egress walk distance and wait time and to explore any correlation between wait time and schedule reliability. The third task was to establish appropriate default values for the transit vehicle dynamic parameters (i.e., acceleration and deceleration rates, and cruise velocities) and transit system parameters (average trip length and dwell time) by mode. The results of the data collection and analysis are presented in the next chapter.

The program user must be cautioned on the use of default values. The defaults are offered as simple estimates of parameters that are affected by many factors which are unique to each transit system and location. Specifically, the defaults presented for vehicle operating characteristics are drawn from a range of values that reflect the design specifications for only a few vehicles that have existed to date. New technology, transit authority policy, and many other factors such as traffic laws, terrain, and road conditions may affect how a transit vehicle actually performs along its route. Similarly, average trip length default values are subject to numerous local considerations. Awareness of the limitations of default values and prudence in their use must be exercised.

CHAPTER 4 DATA ANALYSIS

DATA COLLECTION LOCATIONS

As a first step in analysis, it was necessary to recognize several important characteristics of the data collection locations. Relative observations about the 3 locations were made with respect to land use, level of transit service, daytime population density, and typical rider.

Sixth & Congress land use was primarily Central Business District (CBD) multi-story office/institutional. Daytime population density was the highest of the 3 locations. This location was also served by the highest number of regular bus routes, as well as by a free shuttle service (called the 'Dillo) designed to move riders within the CBD and to/from parking areas just outside the CBD. Shuttle headways were 5 minutes during peak periods and 15 minutes during off-peak periods. The typical rider was observed to be a worker.

Highland Mall Transit Center land use was primarily commercial/retail. Adjacent to the mall were residential and strip development areas. The daytime population density was less than at 6th & Congress but greater than at Northcross Mall. This location was a transit transfer facility and served a moderate number of regular bus routes. The typical riders were a fairly even mix of workers and shoppers.

Northcross Mall land use was primarily commercial/retail. Adjacent to the mall were few residential and strip development areas.This location had the lowest daytime population density and the lowest level of transit service. The typical rider was a shopper. The relative observations are summarized in Table 2.

WALK DATA

The walk distance responses were tabulated and a frequency table developed. Walk data are contained in Appendix A. Table 3 shows the summarized results of the walk distance survey. It was assumed the morning non-peak trip purpose was non-work where the origin was home and the destination was non-home, and the afternoon peak trip purpose was primarily work where the origin was non-home and the destination was home. Blocks were assumed to be an average of 419 feet (Ref 13). From the frequencies and the assumptions regarding trip time and average block length, cumulative percent distribution tables and graphs were prepared. Figure 3 represents the cumulative percent distribution of walk distance at either end for work versus non-work trips. For general comparison purposes, an 85th percentile line was drawn to illustrate the upper limit that most riders would walk. It was observed that work trip walk distance was greater than non-work trip walk distance, which was intuitively reasonable. The 85th percentile work trip walk distance was interpolated to be 2159 feet; the non-work trip walk distance was interpolated to be 1333 feet. Work and non-work trip walk distances were further examined with respect to distance walked from home and distance walked from non-home. Figure 4(a) illustrates the walk distance cumulative percent distribution of trips by purpose from home. Figure 4(b) illustrates the walk distance cumulative percent distribution of trips by purpose from non-home.

TABLE 2. RELATIVE COMPARISON OF DATA COLLECTION LOCATIONS

Data Collection Location	Land Use	Level of Transit Svc	Daytime Pop. Density	Typical Rider
6th & Congress	CBD/office	High	High	Office worker
Highland Mall	Commercial	Medium	Medium	Worker/shopper
Northcross Mall	Commercial	Low	Low	Shopper

TABLE 3. RESULTS OF WALK DISTANCE SURVEY

Trip Time	Total Obsv	Origin (Blocks)						Destination (Blocks)					
		0-1	2-3	4-5	6-7	8-9	10+	0-1	2-3	4-5	6-7	8-9	10+
AM Non-peak	41	23	10	4	2	0	2	25	9	4	1	0	2
PM Peak	76	30	21	9	6	1	9	36	20	9	7	1	3

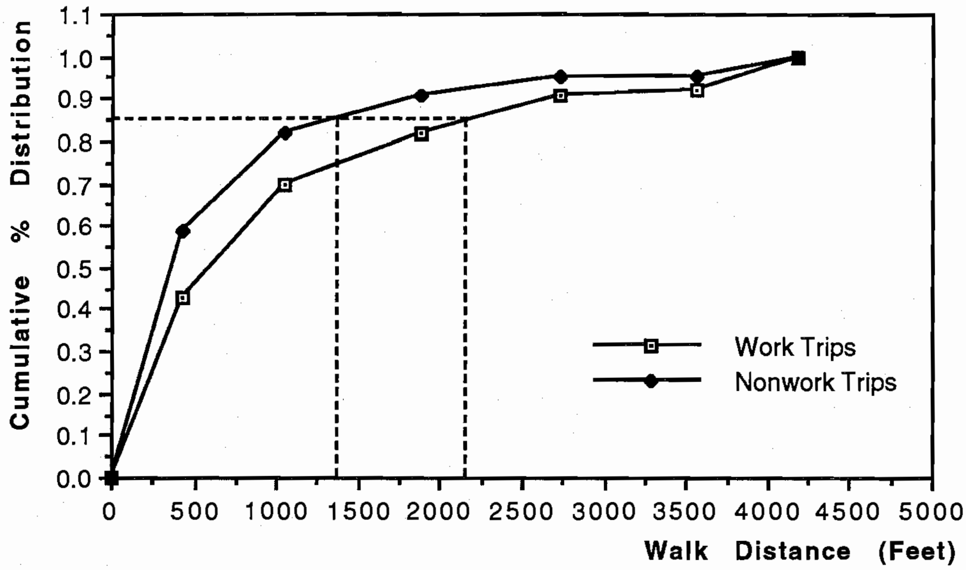

Figure 3. Walk distance by trip purpose

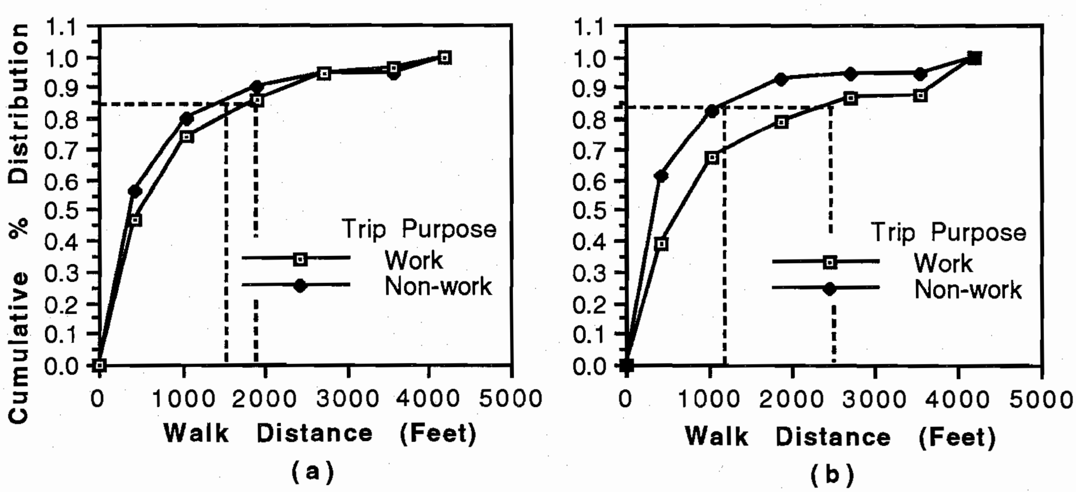

Figure 4. Walk distance from (a) home and (b) non-home for work/non-work trips

These graphs suggest a hierarchy of walk distances by trip purpose and location, as shown in Table 4.

TABLE 4. HIERARCHY OF WALK DISTANCES BY TRIP PURPOSE AND LOCATION

Least to Most Distance	Purpose	Location	50th Percentile Walk Distance	85th Percentile Walk Distance
1	non-work	non-home	343 feet	1228 feet
2	non-work	home	358 feet	1437 feet
3	work	home	481 feet	1850 feet
4	work	non-home	658 feet	2533 feet

Interpreted in terms of transit stop positioning, the 85th percentile walk distances may be considered as upper limits if attempting to attract a certain rider/market. In general, the data suggest that stops in residential areas should not be located farther than 1437 feet from home to attract non-work trips nor farther than 1850 feet to attract work trips. To attract non-work trips, stops in non-work areas (e.g. shopping, recreation, etc.) should be located closest to the non-work trip destination (1228 feet), while stops in primarily work areas may be located the farthest distance (2533 feet) from the work trip destination.

To determine a single value for use as a default parameter, the data were fully aggregated and a cumulative percent distribution graphed, as shown in Figure 5. The aggregated data represent the frequencies of all surveyed riders' walk distances,regardless of trip time and origin and destination

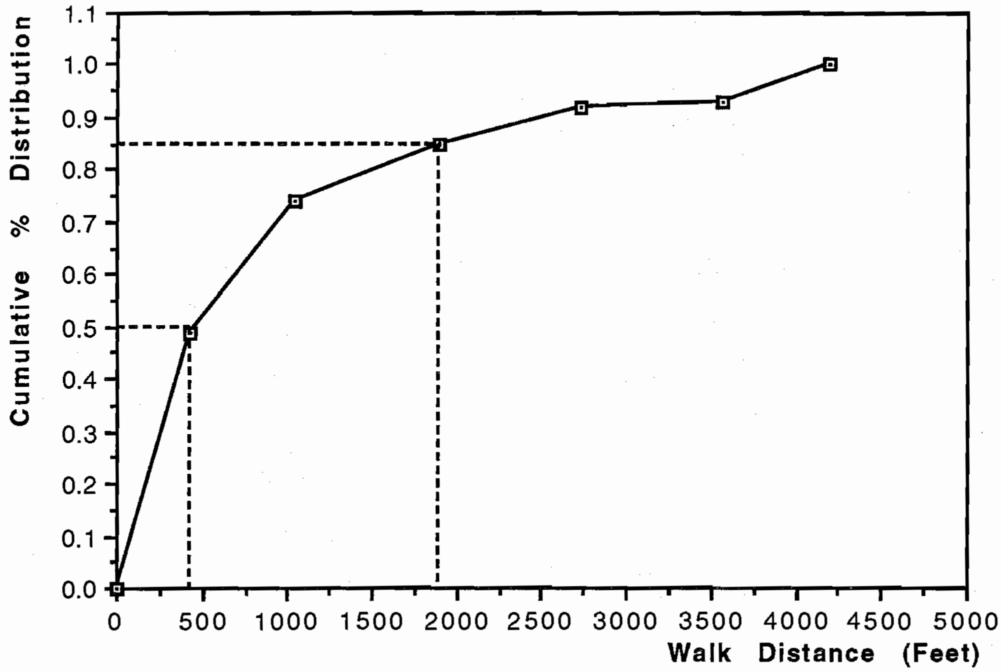

Figure 5. 50th and 85th percentile overall walk distances

percentile maximum distance was interpolated to be 1848 feet. The 1/4 mile rule of thumb distance was at the 78th percentile. For use as a default, it was expected to be closer to the 50th percentile. It was acknowledged that the assumption of a 419 foot average block affected the distances associated with the percentile interpolation. Notwithstanding, this data did not support using 1/4 mile as a default value. The 50th percentile value was selected to represent a typical or average walk distance at either end of a trip, regardless of time of day or location. This value was then divided by an average walk rate of 5ft/sec to yield the default value for average access and egress time of 90.2 seconds, or PT_k = 1.5 minutes.

WAIT DATA

The second research task was to determine a default value for wait time and to test the hypothesis that wait time was related to transit vehicle schedule reliability. To accomplish this, rider wait time data were reduced and analyzed, then bus schedule reliability data were reduced and analyzed. Last, several methods were employed to determine if a correlation between the two existed.

Wait Time Analysis

The rider wait time data set included 517 observations of non-transfer riders (Ref. 14). Appendix B contains wait data information; Tab B1 contains the wait time data set. Descriptive statistics for the overall data and for each location and time period were determined. The results are summarized in Table 5. The overall frequency and cumulative percent distribution are shown in Figure 6.

Overall, the average wait time was about 9.5 minutes with a high standard deviation of about 8 minutes, which suggests a high degree of variability. The mode of 2 minutes suggests a fairly consistent circulation of buses at one extreme, or well conditioned riders at the other. Among locations, 6th & Congress displayed less wait time dispersion than the other two locations. This was possibly explained by the greater number of observations made at 6th & Congress (279)

TABLE 5. WAIT TIME STATISTICS OVERALL AND BY LOCATION AND TIME PERIOD (IN MINUTES)

Time	All	AM Nonpeak			PM Peak		
	Overall	6th & Congress	Highland	North-cross	6th & Congress	Highland	North-cross
Mean	9.52	9.47	13.75	7.41	7.82	9.51	10.50
Median	8.00	8.00	13.00	6.00	6.00	8.00	9.00
Mode	2.00	8.00	5.00	3.00	2.00	4.00	1.00
Std Dev	7.95	6.58	8.71	5.51	7.55	8.08	9.59
Variance	63.22	43.35	75.83	30.38	56.93	65.30	91.93
Range	46.00	30.00	37.00	18.00	42.00	46.00	39.00
Min	0.00	0.00	2.00	2.00	0.00	0.00	0.00
Max	46.00	30.00	39.00	20.00	42.00	46.00	39.00
Sum	4920.00	1184.00	784.00	126.00	1205.00	970.00	651.00
Count	517.00	125.00	57.00	17.00	154.00	102.00	62.00

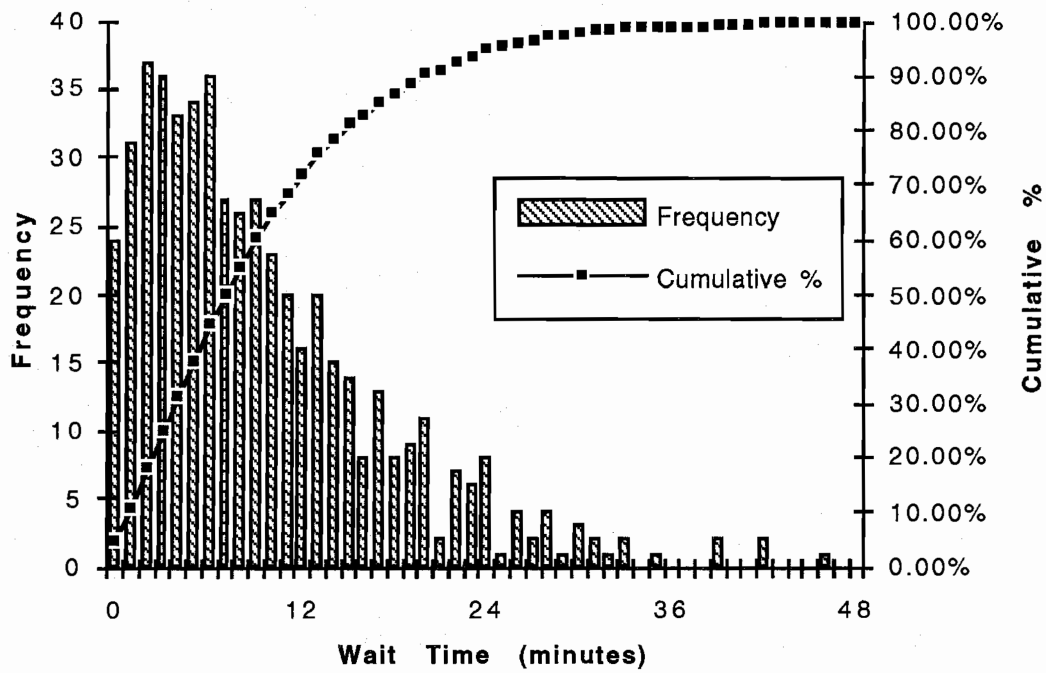

Figure 6. Overall wait time frequency and cumulative percent distribution

than at the other locations combined (238). Between time periods, all measures of central tendency indicated less dispersion of wait time during the peak versus the non-peak periods. This trend was expected as the PM peak headways were generally 15 minutes, while the AM non-peak headways were generally 30 minutes. Within each time period, AM non-peak wait time increased from Northcross Mall to 6th & Congress to Highland Mall; PM peak wait time increased from 6th & Congress to Highland Mall to Northcross Mall. The former trend is not readily explained; the latter may be due to the level of transit service provided at each location (the greater the service, the more choices of bus lines if the trip is short).

The measures of central tendency were evaluated to determine which was the most appropriate and descriptive. The descriptive statistics generally indicated that the mode was much lower than the average or the median; the average was the highest value; and the median was slightly less than the average. A graphical examination of the frequency distributions overall, by location, and by time period revealed that the median and the average appeared to best depict central tendency. Tab B2, contains the wait time frequency distribution graphs. For the purpose of this analysis, general or typical values were sought; therefore, the median was selected as the primary measure of central tendency.

A variable added after the data were collected was "expected wait time." Expected wait time was defined as the amount of time riders *would have* waited had they planned their wait time with perfect information about the transit schedule and had the bus departed exactly on schedule. Descriptive statistics were calculated on this variable to provide a baseline, if not, insight, to the data. For example, if actual wait time was less than expected wait time, one might infer that the bus schedule tended to be more reliable than not. Conversely, if actual wait time was greater than expected wait time, one might infer the bus schedule tended to be less reliable. Table 6 summarizes the expected wait time descriptive statistics. The overall frequency and cumulative percent distribution are shown in Figure 7.

TABLE 6. EXPECTED WAIT TIME STATISTICS OVERALL AND BY LOCATION AND TIME PERIOD

Time	All	AM Nonpeak			PM Peak		
	Overall	6th & Congress	Highland	North-cross	6th & Congress	Highland	North-cross
Mean	9.92	9.26	14.60	11.24	8.66	9.25	10.81
Median	8.00	8.00	14.00	9.00	7.00	8.00	7.00
Mode	5.00	5.00	6.00	1.00	0.00	3.00	1.00
Std Dev	8.32	6.94	8.86	8.84	8.16	7.72	10.09
Variance	69.24	48.16	78.57	78.07	66.65	59.63	101.90
Range	48.00	33.00	38.00	27.00	48.00	40.00	33.00
Min	0.00	0.00	3.00	1.00	0.00	0.00	0.00
Max	48.00	33.00	41.00	28.00	48.00	40.00	33.00
Sum	5127.00	1158.00	832.00	191.00	1333.00	943.00	670.00
Count	517.00	125.00	57.00	17.00	154.00	102.00	62.00

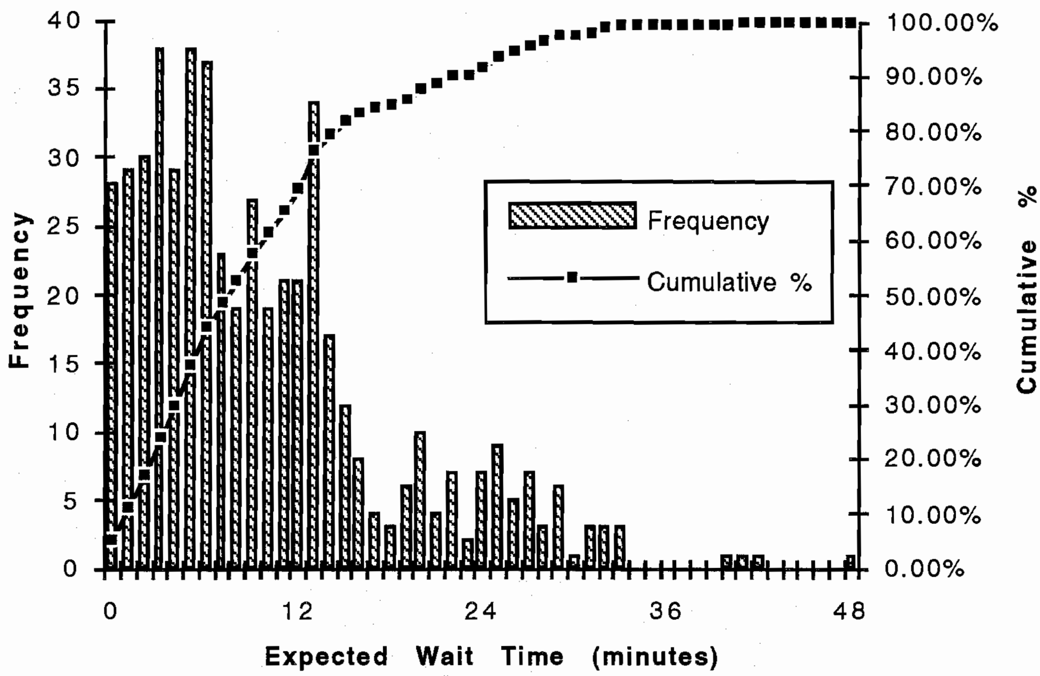

Figure 7. Overall expected wait time frequency and cumulative percent distribution

Interestingly, the overall average expected wait time was less than a half minute longer than overall actual average wait time. The median was the same, and the mode 3 minutes more. Though descriptive statistical trends similar to the wait time variable were observed among locations, between time periods, and within time periods, the frequency distribution graphs were different from the wait time variable. Tab B3 contains the expected wait time frequency distributions overall, by location, and by time period. A t-test was performed on the two variables and indicated that, at a 95% confidence level, their overall and by location and time period mean differences were statistically insignificant (Tab B4). An F-test indicated that the variance differences were statistically insignificant overall and at 4 of the 6 locations (Tab B5). The 2 locations where wait time variances differed significantly were Highland Mall (peak period) and Northcross Mall (non-peak period). The different variances may be due to the typical rider being a shopper and, therefore, on a less demanding schedule than a worker. However, there is no apparent explanation for the different time periods.

The fact that wait time and expected wait time were relatively similar suggested several interpretations. One possibility was that rider wait time behavior was not affected by knowledge of the bus schedule or reliability expectations, but was perhaps more closely related to habit. Additionally, expected wait time could be viewed as a way of quantifying user cost (as it measured the difference between wait time under actual conditions and wait time under theoretically perfect conditions). However, as it related to rider wait behavior, the variable's hypothetical nature presented difficulty in interpretion and use.

Based on an analysis of wait time alone, prior to exploring a correlation with bus schedule reliability, the data suggest a default value of about 9.5 minutes as a typical wait time.

Bus Schedule Reliability Analysis

To reduce the bus data set, each observation of actual departure time from a stop was compared to the scheduled departure time, and the difference in minutes recorded. To reduce the data range, the differences in minutes were aggregated into 3 variables: "early," "on-time", and "late." Buses were considered early if they departed any time prior to scheduled departure; on-time if they departed 0-3 minutes after scheduled departure; and late if they departed 4 or more minutes after scheduled departure. The convention for early was based on the assumption that riders generally tend to avoid excessive waiting and that many will arrive at a stop close to the scheduled departure time. (This tendency was validated by the overall expected wait time cumulative distribution data at Tab B6; over 50% of the riders showed up within 8 minutes of scheduled departure.) Consequently, it was assumed that transit vehicle operators generally avoid departing early. The convention of 0-3 minutes after scheduled departure was used to define on-time because it represented what the author subjectively considered a rider's reasonable expectation of reliability, given the effects of congestion, signalization, road and weather conditions, etc. on a transit vehicle adhering to a fixed schedule. The convention of 4 minutes after scheduled departure defining late followed.

For each bus line, location, and time period, the frequency of early, on-time, and late buses were recorded, and a probability calculated for each. Bus reliability data are contained in Appendix C, and are summarized on the next page in Table 7.

Given these probabilities, it was assumed that rider behavior would be most influenced by the schedule inconsistencies, that is, when the bus was early or late. Therefore, a variable developed from the probabilities to quantify schedule unreliability was the combined early and late probabilities, called "unreliability" (or "1-P(on-time)").

An additional variable developed to quantify schedule unreliability was "average minutes late," for each bus line by location and time period. It was assumed that riders would not generally know how early a bus tended to be, but experience with late departures may influence rider wait behavior. This variable was developed by calculating the average of the times the bus departed 4 or more minutes after scheduled departure time. Average late times were plotted against the unreliability for each bus and indicated a generally positive trend (Figure 8).

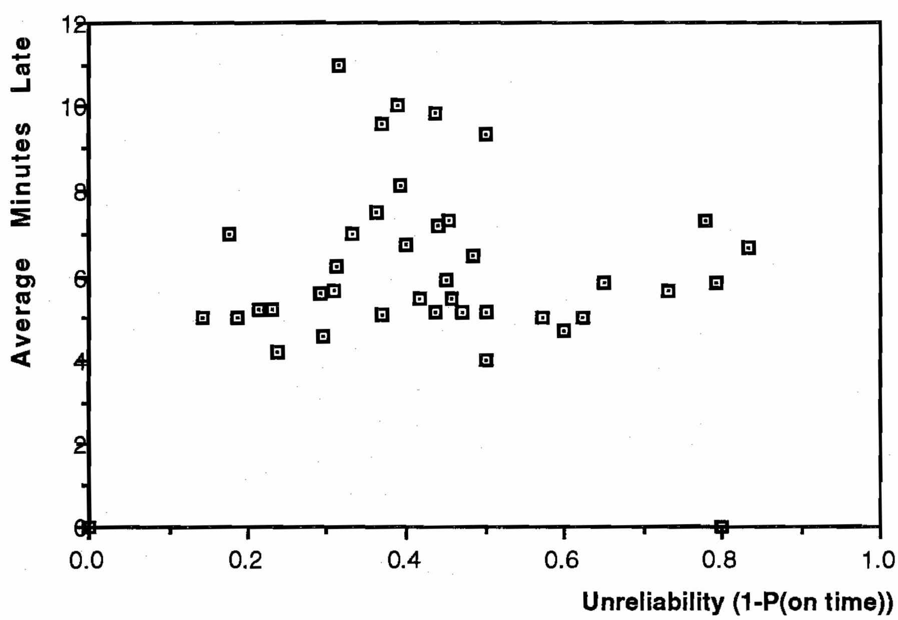

Figure 8. Schedule unreliability versus average minutes late

This positive relationship indicated that the greater a bus' unreliability, the later it was, and supported the use of the variable, average minutes late, as a measure of unreliability.

Correlation Analysis

To test the hypothesis that wait time was a function of schedule unreliability, it was necessary to pair median wait times for each bus line, by location and time period, with the corresponding unreliability variables. The median wait time and unreliability variables used in this pairing were not aggregated by location or time period, but rather, specific to each bus line at that location and time period, since an underlying assumption of the hypothesis was that wait behavior was linked to specific bus lines. Initial scatter plots of all median wait times versus each unreliability variable indicated little correlation, as shown in Figure 9.

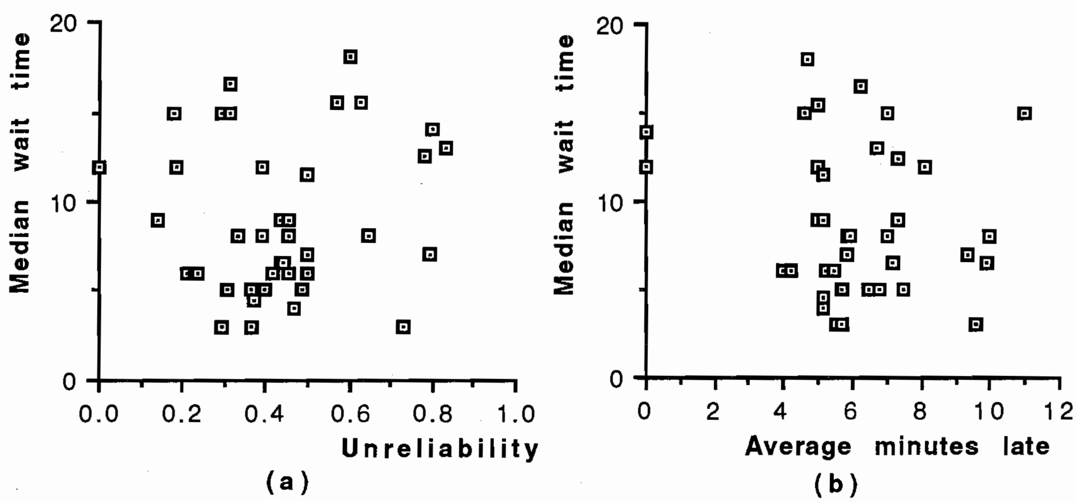

Figure 9. Scatter plots of (a) unreliability and (b) average minutes late vs. median wait time

As an additional way to explore correlation, peak and non-peak median wait times were separately plotted versus unreliability. The peak scatter plot was expected to show better correlation than non-peak due to the generally shorter headways; Figure 10 contains the scatter plots. As graphically observed, peak trends did not appear significantly more correlated than non-peak trends. Since outlying data points were possibly contributing to the scatter, peak and non-peak variables were reduced to bus lines with 15-20 and 30-35 minute headways (Figure 11). The unreliability vs. peak median wait time scatter plot (Figure 11a) appeared somewhat less dispersed than non-peak (Figure 11b) and may be useful to establish a peak wait time default. However, its usefulness for this research was limited as overall defaults were sought.

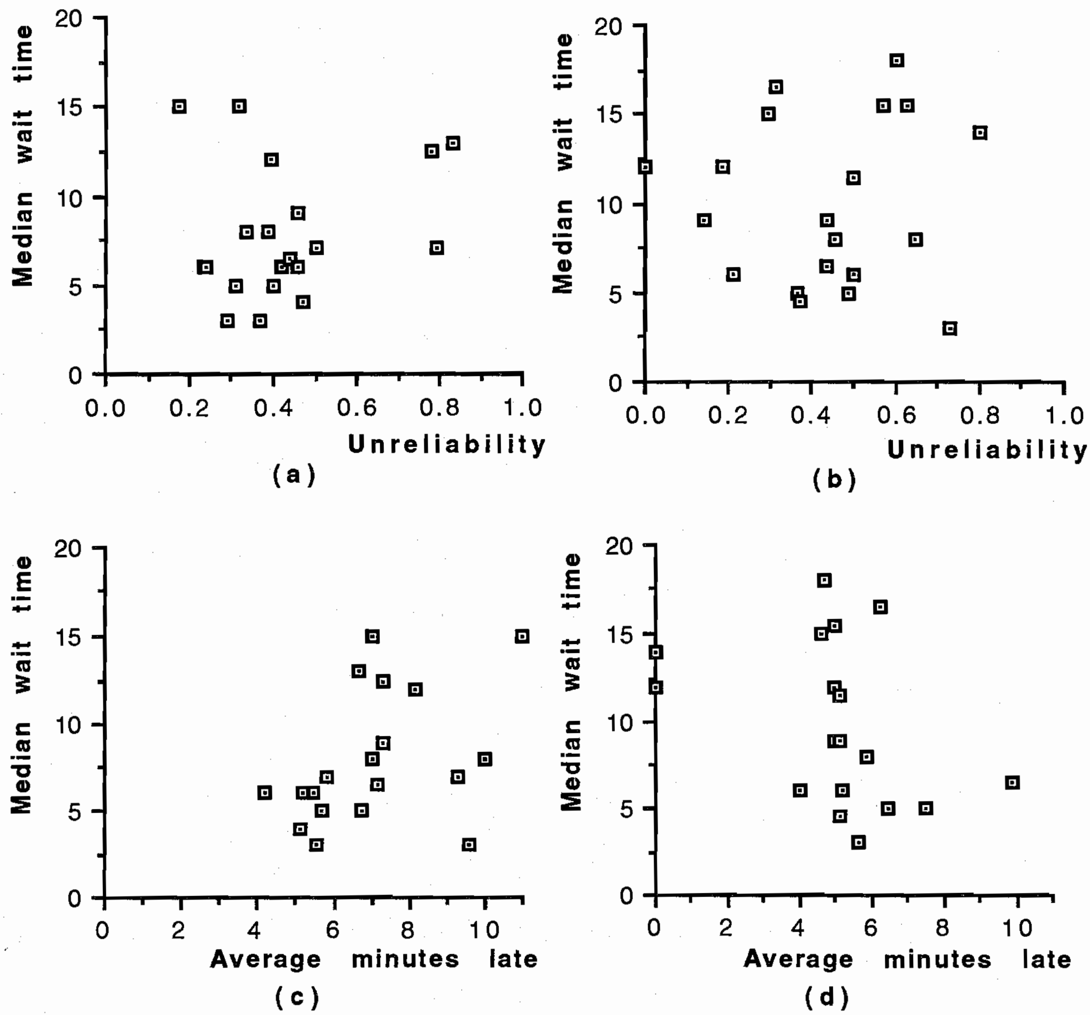

Figure 10. Scatter plots of unreliability vs. median wait time for (a) peak and (b) non-peak and average minutes late vs. median wait time for (c) peak and (d) non-peak

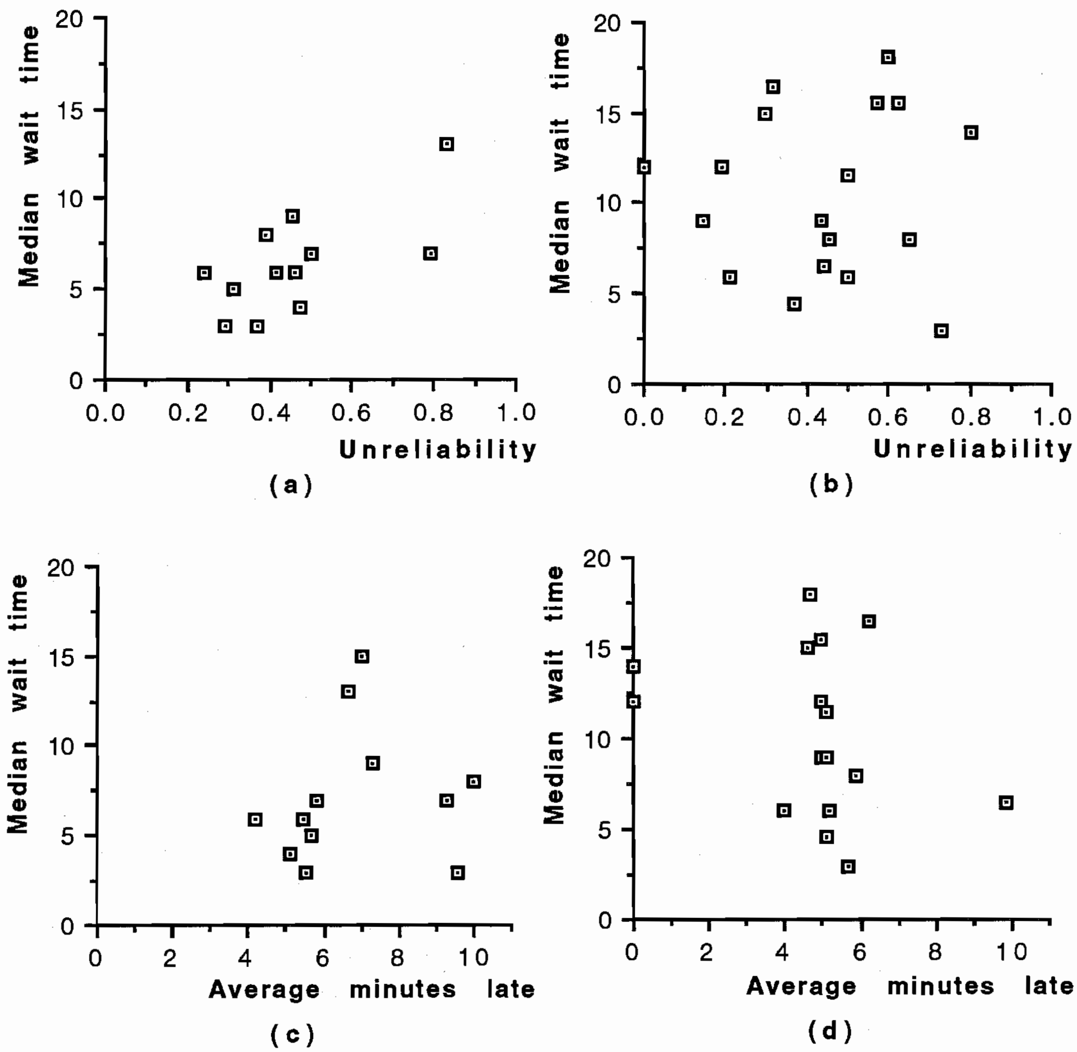

Figure 11. Scatter plots of unreliability vs. median wait time for (a) 15 minute and (b) 30 minute headways and average minute late vs. median wait time for (c) 15 minute and (d) 30 minute headways

A further step was to logarithmically transform all variables related to time, in order that their ranges were more compatible with the unreliability variable. The data were transformed into both natural and base 10 logs; plots again showed little correlation. Average wait time (a secondary wait time variable) was plotted in place of median wait time, but yielded no better graphical correlations.

Aside from the previously discussed trend that peak period median wait times displayed less variability than non-peak period, as shown in Figure 10, there appeared no overall indication that median wait time increased with schedule unreliability. One observation regarding median wait time was that for the majority of bus lines, the median wait time was less than half the headway. That is, 75% of the peak

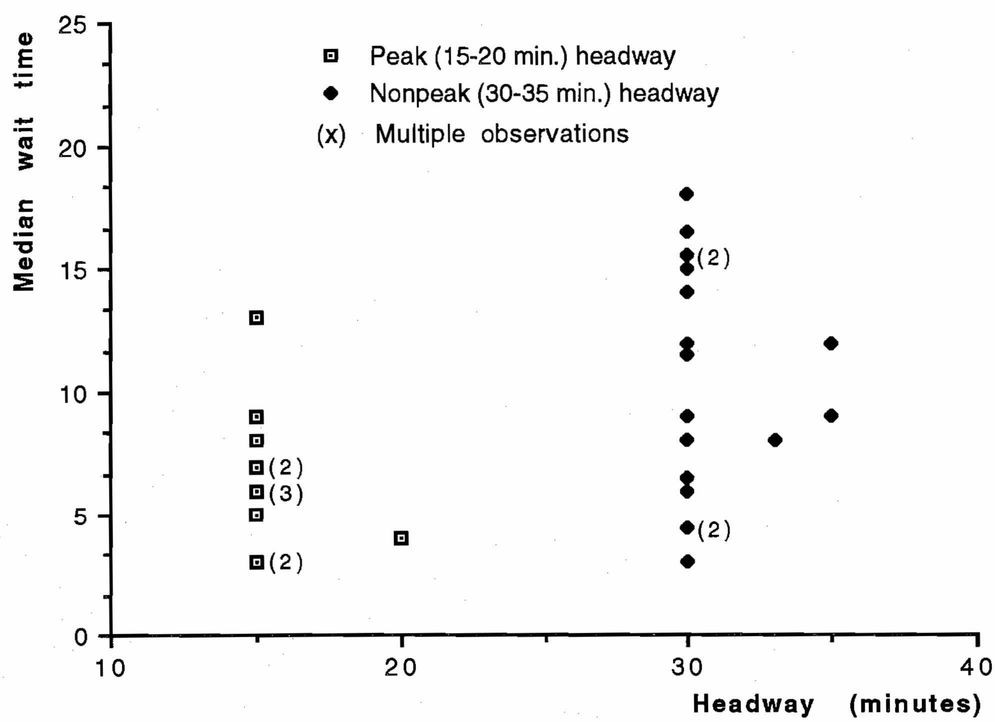

Figure 12. Headway vs. median wait time

median is, 75% of the peak median wait times were less than 7.5 minutes, and 78% of the non-peak median wait times were less than 15 minutes. This observation offered an explanation of why wait time did *not* significantly increase when unreliability was high: simply put, riders generally *won't* wait excessively long. This suggested that wait time outliers played an important interpretation role. If a riders waited excessively long once, they were not likely to do it again. To avoid waiting excessively long again, it was possible that they either gained and acted on more accurate information regarding the bus schedule (by consulting the published schedule, other riders, the bus driver, etc.) or they found a different means of transportation.

From this analysis, the variables developed for wait time and schedule unreliability from the data do not support the hypothesis that wait time was a function of unreliability. There was support, however, that wait time was related to headway. A cumulative percent distribution of median wait time data indicated that for 15-20 minute headways the 50th percentile value was 6 minutes and the 85th percentile value was 8 minutes; for 30-35 minute headways, the 50th percentile value was 9 minutes, and the 85th percentile value was 15 minutes, as shown on the next page in Table 8. If one considered the 85th percentile values as representative of the majority of riders, the data supported the rule of thumb that wait time was half the headway. Since a typical wait time was sought, the 50th percentile value (or median) was selected. Assuming a linear relationship between headways and using 50th percentile median wait times yielded the wait time default equation $PT_W = 3 + 0.2(x)$ where (x) was headway in minutes.

Linearity cannot be assumed outside the 15-35 minute headway range for which data were collected. Therefore, the default equation was recommended only for headways ranging from 10-35 minutes.

Transit Vehicle and System Default Parameters

The final research task was to define the default parameters required for the line haul time model: acceleration (a), deceleration (d), velocity (v), average trip length (p), and dwell time (dw). Defaults were required for each of the 4 transit modes the optimization program will include: regular bus (RB), semi-rapid bus (SRB), light rail transit (LRT), and rapid rail transit (RRT). For each mode, the vehicle characteristics of several U.S. models were reviewed to establish reasonable ranges for transit vehicle dynamic characteristics. Several U.S. cities' transit system characteristics were also reviewed to determine average or typical trip length and dwell times.

TABLE 8. CUMULATIVE % DISTRIBUTION OF MEDIAN WAIT TIMES FOR BUSES WITH 15-20 AND 30-35 MINUTE HEADWAYS

15-20 Minute Headways

Bus No.	Head-way	Median Wait Time	Cum. %
1 (Peak)	15	3.0	0.071
3 (Peak)	15	3.0	0.143
5 (Peak)	20	4.0	0.214
7DT (Peak)	15	5.0	0.286
1	15	5.0	0.357
13	15	5.0	0.428
6 (Peak)	15	*6.0	0.500
16 (Peak)	15	6.0	0.571
27 (Peak)	15	6.0	0.643
13 (Peak)	15	7.0	0.714
5 (Peak)	15	7.0	0.786
15 (Peak)	15	* 8.0	0.857
15 (Peak)	15	9.0	0.928
7 (Peak)	15	13.0	1.000

30-35 Minute Headways

Bus No.	Head-way	Median Wait Time	Cum. %
27	30	3.0	0.038
3	30	4.5	0.077
7 N'cape	30	5.0	0.115
7 D'town	30	6.0	0.154
5	30	6.0	0.192
9 (Peak)	33	6.0	0.231
26	30	6.5	0.269
30 (Peak)	30	6.5	0.308
9	33	8.0	0.346
8	30	8.0	0.385
26 (Peak)	30	8.0	0.423
6	35	9.0	0.461
30	30	* 9.0	0.500
7	30	11.5	0.538
15	30	12.0	0.577
32	35	12.0	0.615
8 (Peak)	30	12.0	0.654
8 (Peak)	30	12.5	0.692
15	30	14.0	0.731
5	30	15.0	0.769
32 (Peak)	35	15.0	0.808
39 (Peak)	30	* 15.0	0.846
7 N'Cape	30	15.5	0.884
8	30	15.5	0.923
16	30	16.5	0.961
39	30	18.0	1.000

Vehicle Dynamic Parameters

Each of the modes for which parameter values were sought first needed to be defined. Regular bus service was characterized by single unit buses operating along fixed routes on fixed schedules. Semi-rapid bus service was characterized by similar vehicles as RB operating along routes that included partial or exclusive right-of-way (ROW) and/or limited stop service. LRT service utilized predominantly reserved but not necessarily grade separated ROW. It consisted of electrically powered rail vehicles that operated singly or in trains. RRT consisted of large rail vehicles operating on fully exclusive ROW. The vehicles were characterized by a high degree of automated control.

In order for the optimization model to generate realistic estimates of user travel time, normal operating characteristics, not maximum ratings for each of the vehicle dynamic characteristics were identified. Various factors that influence those characteristics were also identified. Acceleration was most affected by vehicle loading, gradients present on the route, and use of air conditioning. Although constant acceleration cannot be assumed each time a vehicle begins a motion cycle, acceleration was assumed to average out over the long run (i.e., in the analysis of many vehicles operating over many routes). Deceleration was not as affected by loading or gradients as acceleration and "with a well trained driver [was] approximately uniform" (Ref. 15). Maximum deceleration rates were known to exceed what standing passengers can safely tolerate. Normal operating or cruising velocity was significantly less than maximum velocity due to traffic conditions, safety considerations, and legal speed limits. Cruising velocity cannot be assumed constant due to vehicle loading, signalization, access to partial or exclusive ROW, and number and radius of turns along the route. Cruising velocity was assumed to average out in the long run. Default parameter ranges (from Ref. 15) and values are presented in Table 9.

Transit System Parameters

The diversity of the transit systems reviewed mirrored the diversity within U.S. cities and regions. One source identified LRT average trip lengths from U.S. cities that ranged from 2.2 - 8.5 miles, with a non-weighted average of 4.9 miles and a median of 4.5 miles (Ref. 16). One would expect average trip lengths to be most closely related to the spatial orientation and type of activity centers along a route. A 1968 report published by NCHRP (Ref. 17) cited that, based on an analysis of various trips in U.S. and

Canadian cities, the most important factors related to trip length are the size and physical structure of the urban area; the transportation system; and the social and economic patterns. In the NCHRP report, work trip lengths ranged from 2.0 to 8.8 miles and shop trips ranged from 2.4 to 6.3 miles. Table 10 is an extract

TABLE 9. RANGES AND PROPOSED DEFAULT VALUES FOR VEHICLE DYNAMIC PARAMETERS BY MODE

Parameter		RB	SRB	LRT	RRT
a (ft/sec^2)	Range	2.30-2.95	2.30-2.95	5.50-5.58	3.28-4.59
	Default	2.63	2.63	5.54	3.94
d (ft/sec^2)	Range	2.30-2.95	2.30-2.95	4.26-5.58	3.28-4.59
	Default	2.63	2.63	4.92	3.94
v (mph)	Range	9.32-15.54	12.4-24.86	12.43-27.97	15.54-37.29
	Default	12.43	18.65	20.20	26.42

TABLE 10. TRIP LENGTHS AND MAJOR INFLUENCING FACTORS

City	Population (1000s)	Average Trip Length (Miles) Work	Shop	Avg. Network Speed (mph)
Los Angeles, CA	6,489	8.8	-	31.0
Washington, DC	1,808	5.9	2.9	24.7
Pittsburgh, PA	1,804	4.2	3.8	20.7
Baltimore, MD	1,419	7.0	2.7	24.6
Fort Worth, TX	503	8.1	3.6	30.9
Worcester, MA	281	4.9	3.9	27.3
Erie, PA	177	3.4	2.4	21.7
Waterbury, CN	142	5.9	4.5	35.0
Springfield, IL	134	3.6	2.5	29.2
Greensboro, NC	123	4.3	4.7	29.0

from the NCHRP report. The report cited that the average lengths of work, social-recreation, and non-home-based trips were related to population, while shopping trip lengths were not highly related to the development pattern of the city. It suggested that trip length characteristics were depicted more accurately when dispersion around the mean trip length (variance) was considered. Finally, it suggested that work and non-work trips be stratified by income to further understand travel behavior. Given the wide range of average trip lengths empirically determined and the number of influencing factors on that range, the most accurate average trip length default value to use will be that furnished by the optimization program user based on a specific transit network. Therefore, what follows is a discussion of the rationale used to define a general default parameter set.

Considering the different natures of the transit services, specifically, their access to partial or exclusive ROW and their operating characteristics, it was generally expected that SRB routes were longer than RB routes and that RRT routes were longer than LRT routes. RB and LRT route lengths were expected to be compatible, as were SRB and RRT route lengths. Next, it was assumed that average trip lengths were some fraction of route lengths. Because RB and LRT services were generally expected to have more stops and cover geographically smaller areas than SRB or RRT, their average trip lengths were assumed to be a smaller fraction of their route lengths than SRB and RRT average trip lengths. RB and LRT trip lengths were assumed to be .5 of the route length; SRB and RRT average route lengths were assumed to be .75 of the route length. As a starting point, the routes that served the 3 Austin data collection locations were calculated to establish an average RB route length. The route lengths varied from 5.5 to 13.75 miles. The average length was 9.04, rounded to 9 miles. SRB and RRT routes were expected to average 50% longer, or 13.5 miles. From these assumptions, RB and LRT average route length was theoretically calculated to be $p = 4.5$ miles, and SRB and RRT average route length was calculated to be $p = 10.1$ miles. These default values do not reflect an average value based on empirical observations, merely a theoretically reasonable value.

Most of the dwell time research addressed passenger boarding and alighting rates. The rates were affected by channel-to-door width ratios, fare collection methods, signalization and traffic delays, station configuration and access, and passenger arrival rates. For RB and SRB, boarding/alighting rates were found to range from 1-4 sec/passenger; for LRT, 6-30 passengers/sec; and for RRT, 40-80 passengers/sec. Given such wide ranges, the discussion of the rationale to define a single default value was limited to general observations.

Rail modes were expected to have fixed dwell times established by policy; bus modes were expected to have variable dwell times primarily due to low boarding/alighting rates and traffic conditions. From observation, typical LRT and RRT dwell times were assumed to be $dw_r = 30$ seconds and, for RB and SRB, dwell times were $dw_b = 1.5$ minutes.

SUMMARY

Important land use and transit service characteristics were recognized between each of the 3 data collection locations. Relative to the others, 6th & Congress had the highest daytime population and level of transit service. Northcross Mall had the lowest daytime population and transit service level. The typical rider at 6th & Congress was a worker; at Highland Mall Transit Center, a mix of workers and shoppers; and at Northcross Mall, a shopper.

Walk data analysis suggested a hierarchy of walk distances by trip purpose and location. Recognition of this hierarchy may provide useful insight when positioning transit stops near activity centers. The proposed default value for access/egress time based on walk distance data was $PT_k = 1.5$ minutes.

Wait data was analyzed to determine if a correlation existed with bus schedule unreliability. The wait time variable was the "median wait time" for each bus line. The variable "expected wait time" was created to provide insight to wait behavior. Two variables were developed to define bus schedule unreliability. The bus data range was reduced by categorizing each bus departure as early, on-time, or late. Observations for each bus line were converted into early, on-time, and late probabilities. "Unreliability" was defined as the combined early and late probabilities (or 1-P(On-time)). "Average minutes late" was the average time a bus departed 4 or more minutes after scheduled departure time. Scatter plots of the data overall, by peak and non-peak, by headway, and with the time variables logarithmatically transformed showed little graphical correlation between wait time and unreliability. Wait time trends appeared more closely related to headway. The proposed default equation for headways between 10-35 minutes was $PT_w = 3 + 0.2(x)$, where (x), the headway, and PT_w were in minutes.

Parameter default values for transit vehicles and system characteristics were developed for 4 modes: regular bus (RB), semi-rapid bus (SRB), light rail transit (LRT), and rapid rail transit (RRT). Given the wide ranges for each parameter, the most accurate results from the optimization program will be based on user-furnished parameter values.

The last chapter contains a summary of the findings and conclusions.

CHAPTER 5 SUMMARY AND CONCLUSIONS

SUMMARY

The user-based terminal spacing optimization program was based on the following models:

$$PT_T = PT_a + PT_t$$

where PT_T = overall passenger trip time

PT_a = passenger access time = $2(PT_k) + PT_w$, and

PT_t = passenger travel time

$$= p[(v/a) + (v/a) + (s - (v^2/2a) - (v^2/2d))/v + dw]$$

As identified in Chapter 3, there were three basic research tasks. The first two, related to the access portion of the model, were to establish appropriate default values for access/egress time (PT_k) and wait time (PT_w) and to explore any correlation between wait time and schedule reliability. The third task was to establish appropriate default values for the vehicle dynamic parameters (a, d, v) and transit system parameters (p and dw). The goal of this research was to develop default values for each parameter for 4 transit modes: RB, SRB, LRT, and RRT. Data on bus rider walk distance and wait time and on bus schedule reliability were collected in Austin, Texas, and analyzed to develop mathematical models and/or default values for PT_k and PT_w. The walk data indicated a hierarchy of walk distances by trip purpose and location and may be an aid to development of terminal positioning policies. The hypothesis that wait time was related to bus schedule reliability was explored using the variables "median wait time" and "expected wait time" and the bus variables "unreliability" and "average minutes late," and indicated no overall correlation but possible correlation for bus lines operating with 15 minute headways. The data yielded an expected correlation between median wait time and headway. Transit vehicle and system characteristics were reviewed to identify appropriate default values for transit vehicle dynamic parameters (a, d, and v) and system parameters (p and dw). The default values proposed as a result of this research are summarized in Table 11.

TABLE 11. SUMMARY OF PROPOSED DEFAULT VALUES

Mode	PT_k (minutes)	PT_w* (minutes)	a (ft/sec^2)	d (ft/sec^2)	v (mph)	p (miles)	dw (minutes)
RB	1.5	3 + 0.2(x)	2.63	2.63	12.43	4.5	1.5
SRB	1.5	3 + 0.2(x)	2.63	2.63	18.65	10.1	1.5
LRT	1.5	3 + 0.2(x)	5.54	4.92	20.20	4.5	1.0
RRT	1.5	3 + 0.2(x)	3.94	3.94	26.42	10.1	1.0

(* x = headway (min.); equation recommended only for 10-35 min. headways)

CONCLUSIONS

This research has offered insight into the process of establishing appropriate values for user travel time mathematical model default parameters. The advantage of having optimization program furnished default values must be weighed against the disadvantage of using single, deterministic values for parameters which, in reality, are stochastic. The data analysis indicated parameter values which were within the ranges of general rules of thumb. However, before the values can be generalized, they must be viewed within the context of the data collection procedure and analysis.

It must be noted that Austin had only a single, RB-dominated transit system. Overall, its bus service was fairly reliable. It would be difficult to predict the impact the presence of alternative transit modes may have on rider walk and wait behavior, if any. In a region with multiple transit alternatives, it is even possible that rider behavior may not be a function of the mode used, but perhaps more a function of the mode avoided.

Regarding the first 2 research tasks, the 3 data collection locations were geographically and demographically selected to enable the walk distance and wait time findings to be generalized. They represented a mix of land uses, levels of transit service, daytime population densities, and typical riders. Walking was the dominant access mode for Austin riders to the bus stop. However, in regions with rail transit modes, it is expected that access by private auto and bus transit is significant and perhaps dominant. The assumed walk rate of 5 ft/sec may not be appropriate for communities with a large elderly or mobility-impaired population. The walk survey was subject to errors associated with verbal survey methods. Some riders had difficulty expressing their walk distance in terms of blocks. The assumed block length of 419 feet may not be appropriate to all communities. The use of the 50th percentile or median value as the walk distance and wait time measures of central tendency helped to mitigate the effect of having substantially more data from the 6th & Congress location than the other data collection locations. Use of the average would have given more weight to outlying data points, which may have impacted the smaller data sets. Additional research on other access modes to transit and related access distance/time is needed to fully and realistically depict the range of access options and enable the optimization program user to generate more refined results.

Bus schedule reliability data was initially categorized as "early," "on-time," or "late." The conventions used to define each category may have biased the "average minutes late" variable and obscured its correlation with wait time. Austin's transit system operated with generally only 2 headways, 15 and 30 minutes. The "unreliability" variable developed from the data may have been more meaningful if the bus lines operated over a range of more than 2 headways. Due to Austin's fairly reliable bus system, there were few examples of high unreliability with which to test a correlation with wait time. Though no significant correlation was determined by this research, further research on the correlation between schedule unreliability and wait time is recommended.

Regarding the third research task, it must be recognized that, though transit vehicle and system parameter ranges were identified, the wide diversity within modes and systems made the selection of a single default value, like any "average," too high half the time, too low half the time, and seldom accurate. The values, however, will serve the intended purpose of providing a reasonable default.

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13. Average block length research was performed by Dr. Machemehl in 1978. Based on the cities considered in the research, which included Austin, Texas, the average block length was determined to be 419 feet.

14. Sixty-five transfer rider wait time observations were made but not included in the analysis. It was assumed that their wait time was not dependent on their own behavioral choices but rather on the schedule of the connecting bus. These 65 observations appear at the end of Appendix B, Tab B1.

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APPENDIX A

Walk Data

Actual Observations

Location	Total	Origin (Blocks)						Destination (Blocks)					
		0-1	2-3	4-5	6-7	8-9	10+	0-1	2-3	4-5	6-7	8-9	10+
6th & Congress - Peak	48	19	14	6	2	1	6	21	12	7	5	1	2
6th & Congress - Non-peak	26	16	7	2	1	0	0	14	5	4	1	0	2
Highland Mall - Non-peak	15	7	3	2	1	0	2	11	4	0	0	0	0
Northcross Mall - Peak	28	11	7	3	4	0	3	15	8	2	2	0	1
Total	117	53	31	13	8	1	11	61	29	13	8	1	5
Total Origin + Destination	234	114	60	26	16	2	16						

Additive Distribution

Location	Origin (Blocks)						Destination (Blocks)					
	0-1	2-3	4-5	6-7	8-9	10+	0-1	2-3	4-5	6-7	8-9	10+
6th & Congress - Peak	19	33	39	41	42	48	21	33	40	45	46	48
6th & Congress - Non-peak	16	23	25	26	26	26	14	19	23	24	24	26
Highland Mall - Non-peak	7	10	12	13	13	15	11	15	15	15	15	15
Northcross Mall - Peak	11	18	21	25	25	28	15	23	25	27	27	28
Total	53	84	97	105	106	117	61	90	103	111	112	117
Total Origin + Destination	114	174	200	216	218	234						

Cumulative Percent Distribution

Location	Origin (Blocks)						Destination (Blocks)					
	0-1	2-3	4-5	6-7	8-9	10+	0-1	2-3	4-5	6-7	8-9	10+
6th & Congress - Peak	0.396	0.688	0.813	0.854	0.875	1.000	0.438	0.688	0.833	0.938	0.958	1.000
6th & Congress - Non-peak	0.615	0.885	0.962	1.000	1.000	1.000	0.538	0.731	0.885	0.923	0.923	1.000
Highland Mall - Non-peak	0.467	0.667	0.800	0.867	0.867	1.000	0.733	1.000	1.000	1.000	1.000	1.000
Northcross Mall - Peak	0.393	0.643	0.750	0.893	0.893	1.000	0.536	0.821	0.893	0.964	0.964	1.000
Total	0.453	0.718	0.829	0.897	0.906	1.000	0.521	0.769	0.880	0.949	0.957	1.000
Total Origin + Destination	0.487	0.744	0.855	0.923	0.932	1.000						

APPENDIX B

WAIT TIME DATA

Location Code:
1- 6th & Congress (Non-peak)
2- 6th & Congress (Peak)
3- Highland Mall Transit Center (Non-peak)
4- Highland Mall Transit Center (Peak)
5- Northcross Mall (Non-peak)
6- Northcross Mall (Peak)

Non-transfer Riders

Observation No.	Bus No.	Wait Time (Minutes)	Expected Wait Time (Minutes)	Bus Headway (Minutes)	Location
1	1	1	13	15	1
2	1	4	5	15	1
3	1	10	11	15	1
4	1	8	4	15	1
5	1	10	6	15	1
6	1	5	1	15	1
7	5	8	7	30	1
8	5	5	4	30	1
9	6	9	7	35	1
10	6	0	33	35	1
11	7	12	13	30	1
12	13	5	5	15	1
13	13	9	10	15	1
14	13	8	9	15	1
15	15	13	10	30	1
16	15	14	13	30	1
17	15	6	5	30	1
18	15	24	22	30	1
19	27	3	4	30	1
20	30	6	5	30	1
21	30	7	6	30	1
22	1	1	13	15	1
23	1	10	10	15	1
24	1	9	9	15	1
25	1	0	0	15	1
26	1	4	5	15	1
27	1	3	4	15	1
28	1	14	13	15	1
29	1	14	13	15	1
30	1	11	10	15	1

Non-transfer Riders (cont.)

Observation No.	Bus No.	Wait Time (Minutes)	Expected Wait Time (Minutes)	Bus Headway (Minutes)	Location
31	1	13	13	15	1
32	1	4	5	15	1
33	1	2	3	15	1
34	5	5	3	30	1
35	5	15	10	30	1
36	5	10	10	30	1
37	6	18	17	35	1
38	6	8	8	35	1
39	6	8	8	35	1
40	6	3	3	35	1
41	7	11	11	30	1
42	9	3	32	33	1
43	9	9	5	33	1
44	13	1	2	15	1
45	13	5	5	15	1
46	13	4	4	15	1
47	13	6	5	15	1
48	13	7	6	15	1
49	13	2	2	15	1
50	13	26	22	15	1
51	15	4	2	30	1
52	15	26	25	30	1
53	15	14	13	30	1
54	16	20	19	30	1
55	16	13	12	30	1
56	27	1	28	30	1
57	27	3	5	30	1
58	30	5	6	30	1
59	30	24	24	30	1
60	30	6	4	30	1
61	30	10	8	30	1
62	1	1	3	15	1
63	1	4	5	15	1
64	1	2	3	15	1
65	1	20	13	15	1
66	1	17	10	15	1
67	5	19	15	30	1
68	5	18	14	30	1
69	5	23	20	30	1
70	6	9	6	35	1

Non-transfer Riders (cont.)

Observation No.	Bus No.	Wait Time (Minutes)	Expected Wait Time (Minutes)	Bus Headway (Minutes)	Location
71	6	17	16	35	1
72	7	8	4	30	1
73	7	5	1	30	1
74	7	15	13	30	1
75	9	8	6	33	1
76	13	6	7	15	1
77	13	16	14	15	1
78	13	5	3	15	1
79	15	10	9	30	1
80	15	3	2	30	1
81	15	23	22	30	1
82	15	14	13	30	1
83	15	12	11	30	1
84	15	12	11	30	1
85	26	10	9	30	1
86	27	11	5	30	1
87	27	5	6	30	1
88	30	13	12	30	1
89	30	9	9	30	1
90	30	9	8	30	1
91	1	4	3	15	1
92	1	2	1	15	1
93	1	8	6	15	1
94	1	4	3	15	1
95	1	13	11	15	1
96	1	11	9	15	1
97	1	6	3	15	1
98	1	5	2	15	1
99	1	1	13	15	1
100	5	23	19	30	1
101	6	30	25	35	1
102	6	20	17	35	1
103	6	8	5	35	1
104	6	18	15	35	1
105	6	13	10	35	1
106	7	16	9	30	1
107	9	10	5	33	1
108	9	8	3	33	1
109	9	4	3	33	1
110	13	2	1	15	1

Non-transfer Riders (cont.)

Observation No.	Bus No.	Wait Time (Minutes)	Expected Wait Time (Minutes)	Bus Headway (Minutes)	Location
111	13	1	13	15	1
112	15	17	13	30	1
113	15	9	5	30	1
114	15	19	14	30	1
115	15	11	6	30	1
116	15	8	3	30	1
117	15	4	1	30	1
118	26	3	1	30	1
119	27	3	1	30	1
120	27	1	29	30	1
121	27	14	14	30	1
122	30	10	7	30	1
123	30	8	5	30	1
124	30	5	2	30	1
125	30	22	21	30	1
126	1	7	5	15	2
127	1	7	5	15	2
128	1	8	8	15	2
129	1	3	3	15	2
130	1	3	3	15	2
131	1	4	0	15	2
132	1	0	14	15	2
133	5	7	3	20	2
134	5	5	1	20	2
135	6	0	16	15	2
136	6	1	15	15	2
137	6	28	26	15	2
138	7	9	6	15	2
139	7	13	9	15	2
140	9	17	13	33	2
141	9	3	32	33	2
142	9	42	42	33	2
143	9	0	31	33	2
144	9	7	7	33	2
145	9	6	6	33	2
146	9	6	6	33	2
147	9	4	4	33	2
148	13	22	12	15	2
149	13	18	8	15	2
150	13	5	11	15	2

Non-transfer Riders (cont.)

Observation No.	Bus No.	Wait Time (Minutes)	Expected Wait Time (Minutes)	Bus Headway (Minutes)	Location
151	13	3	9	15	2
152	13	16	20	15	2
153	13	16	20	15	2
154	13	33	32	15	2
155	13	0	6	15	2
156	13	14	4	15	2
157	13	11	1	15	2
158	13	2	6	15	2
159	13	10	2	15	2
160	13	0	0	15	2
161	13	11	8	15	2
162	13	42	48	15	2
163	15	2	0	15	2
164	15	2	0	15	2
165	15	10	6	15	2
166	15	0	11	15	2
167	16	3	0	15	2
168	16	14	11	15	2
169	26	9	9	30	2
170	26	9	9	30	2
171	26	7	7	30	2
172	26	3	3	30	2
173	26	29	26	30	2
174	26	23	20	30	2
175	26	5	2	30	2
176	26	5	2	30	2
177	27	2	14	15	2
178	27	7	6	15	2
179	27	3	2	15	2
180	27	3	12	15	2
181	30	6	3	30	2
182	30	6	3	30	2
183	30	8	6	30	2
184	1	5	0	15	2
185	1	3	2	15	2
186	1	4	0	15	2
187	1	0	12	15	2
188	1	2	14	15	2
189	1	1	13	15	2
190	5	11	5	30	2

Non-transfer Riders (cont.)

Observation No.	Bus No.	Wait Time (Minutes)	Expected Wait Time (Minutes)	Bus Headway (Minutes)	Location
191	5	4	27	30	2
192	5	4	27	30	2
193	5	2	25	30	2
194	5	3	0	20	2
195	5	4	2	20	2
196	5	8	7	20	2
197	5	10	9	20	2
198	5	2	1	20	2
199	5	1	0	20	2
200	5	1	0	20	2
201	6	10	7	15	2
202	6	13	13	15	2
203	6	2	15	15	2
204	6	7	4	15	2
205	7	20	5	15	2
206	9	7	6	33	2
207	9	2	0	33	2
208	13	15	11	15	2
209	13	8	4	15	2
210	13	7	3	15	2
211	13	1	13	15	2
212	13	0	12	15	2
213	13	17	10	15	2
214	13	2	10	15	2
215	13	6	2	15	2
216	13	18	6	15	2
217	13	7	9	15	2
218	13	7	9	15	2
219	13	6	8	15	2
220	13	4	6	15	2
221	13	6	14	15	2
222	13	5	13	15	2
223	13	2	10	15	2
224	15	15	12	15	2
225	15	9	7	15	2
226	15	12	9	15	2
227	16	11	5	15	2
228	16	0	10	15	2
229	16	7	4	15	2
230	16	3	1	15	2

Non-transfer Riders (cont.)

Observation No.	Bus No.	Wait Time (Minutes)	Expected Wait Time (Minutes)	Bus Headway (Minutes)	Location
231	16	0	12	15	2
232	16	7	1	15	2
233	16	1	10	15	2
234	26	8	6	30	2
235	27	13	12	15	2
236	27	7	6	15	2
237	27	9	7	15	2
238	27	2	0	15	2
239	27	3	2	15	2
240	27	15	9	15	2
241	27	8	2	15	2
242	30	0	0	30	2
243	30	23	20	30	2
244	30	5	2	30	2
245	30	2	1	30	2
246	1	11	9	15	2
247	1	2	2	15	2
248	1	6	6	15	2
249	1	2	2	15	2
250	1	1	1	15	2
251	5	1	17	30	2
252	6	5	4	15	2
253	7	6	2	30	2
254	7	6	2	30	2
255	7	24	22	30	2
256	7	13	11	15	2
257	9	0	0	33	2
258	9	15	13	33	2
259	9	6	4	33	2
260	13	2	14	15	2
261	13	1	13	15	2
262	13	23	20	15	2
263	13	16	13	15	2
264	13	12	9	15	2
265	13	0	11	15	2
266	13	12	9	15	2
267	16	12	9	15	2
268	16	11	9	15	2
269	16	8	6	15	2
270	16	6	4	15	2

Non-transfer Riders (cont.)

Observation No.	Bus No.	Wait Time (Minutes)	Expected Wait Time (Minutes)	Bus Headway (Minutes)	Location
271	16	1	0	15	2
272	16	6	3	15	2
273	27	3	0	15	2
274	27	6	5	15	2
275	30	7	6	30	2
276	30	17	16	30	2
277	30	14	13	30	2
278	30	9	8	30	2
279	30	5	4	30	2
280	7 Downtown	28	27	30	3
281	7 Downtown	30	30	30	3
282	7 Northcape	27	29	30	3
283	8	19	18	30	3
284	8	14	16	30	3
285	8	4	6	30	3
286	15	2	9	30	3
287	15	14	18	30	3
288	15	20	25	30	3
289	32	13	22	35	3
290	7 Downtown	5	6	30	3
291	7 Downtown	5	6	30	3
292	7 Downtown	10	7	30	3
293	7 Downtown	6	6	30	3
294	7 Northcape	12	14	30	3
295	8	6	5	30	3
296	8	5	4	30	3
297	8	24	24	30	3
298	8	28	24	30	3
299	15	3	4	30	3
300	15	24	24	30	3
301	32	9	9	35	3
302	32	10	10	35	3
303	32	28	29	35	3
304	32	19	20	35	3
305	39	12	13	30	3
306	7 Downtown	5	5	30	3
307	7 Downtown	4	4	30	3
308	7 Downtown	22	24	30	3
309	7 Northcape	19	19	30	3
310	7 Northcape	4	4	30	3

Non-transfer Riders (cont.)

Observation No.	Bus No.	Wait Time (Minutes)	Expected Wait Time (Minutes)	Bus Headway (Minutes)	Location
311	8	20	20	30	3
312	8	3	3	30	3
313	8	17	15	30	3
314	8	10	4	30	3
315	15	14	15	30	3
316	15	19	20	30	3
317	15	16	17	30	3
318	15	13	14	30	3
319	15	11	12	30	3
320	15	11	12	30	3
321	15	2	3	30	3
322	7 Downtown	6	6	30	3
323	7 Northcape	39	41	30	3
324	7 Northcape	5	7	30	3
325	8	20	21	30	3
326	8	18	11	30	3
327	8	2	25	30	3
328	15	18	19	30	3
329	15	7	8	30	3
330	15	22	24	30	3
331	15	20	22	30	3
332	15	4	6	30	3
333	32	6	4	35	3
334	32	11	8	35	3
335	32	15	13	35	3
336	39	24	21	30	3
337	7 Downtown	1	3	15	4
338	7 Northcape	1	0	30	4
339	7 Downtown	5	6	15	4
340	7 Downtown	7	8	15	4
341	7 Downtown	6	7	15	4
342	7 Downtown	17	8	15	4
343	7 Downtown	6	6	15	4
344	7 Downtown	3	3	15	4
345	7 Downtown	12	12	15	4
346	7 Downtown	3	2	15	4
347	7 Northcape	16	13	30	4
348	7 Northcape	4	4	15	4
349	7 Northcape	6	6	15	4
350	7 Northcape	10	9	15	4

Non-transfer Riders (cont.)

Observation No.	Bus No.	Wait Time (Minutes)	Expected Wait Time (Minutes)	Bus Headway (Minutes)	Location
351	7 Northcape	4	3	15	4
352	8	22	11	30	4
353	8	18	15	30	4
354	8	15	12	30	4
355	8	19	12	30	4
356	8	17	13	30	4
357	8	7	3	30	4
358	15	24	26	15	4
359	15	2	2	15	4
360	15	2	3	15	4
361	15	13	11	15	4
362	15	24	25	15	4
363	15	5	5	15	4
364	15	9	10	15	4
365	15	0	1	15	4
366	32	14	14	35	4
367	32	2	2	35	4
368	39	26	25	30	4
369	7 Downtown	9	8	15	4
370	7 Downtown	13	14	15	4
371	7 Downtown	3	3	15	4
372	7 Downtown	7	7	15	4
373	7 Downtown	4	4	15	4
374	7 Downtown	1	1	15	4
375	7 Downtown	13	14	15	4
376	7 Northcape	10	10	15	4
377	7 Northcape	46	40	15	4
378	8	15	12	30	4
379	8	10	7	30	4
380	8	8	5	30	4
381	8	8	0	30	4
382	15	11	10	15	4
383	15	4	1	15	4
384	15	10	12	15	4
385	32	13	12	35	4
386	32	31	28	35	4
387	32	27	26	35	4
388	39	15	15	30	4
389	7 Downtown	12	11	15	4
390	7 Downtown	1	0	15	4

Non-transfer Riders (cont.)

Observation No.	Bus No.	Wait Time (Minutes)	Expected Wait Time (Minutes)	Bus Headway (Minutes)	Location
391	7 Downtown	7	5	15	4
392	7 Downtown	5	3	15	4
393	7 Downtown	1	14	15	4
394	7 Downtown	7	7	15	4
395	7 Downtown	4	4	15	4
396	7 Downtown	4	1	15	4
397	7 Downtown	4	1	15	4
398	7 Downtown	5	3	15	4
399	7 Downtown	2	0	15	4
400	7 Downtown	2	0	15	4
401	7 Downtown	4	5	15	4
402	7 Northcape	0	10	30	4
403	7 Northcape	2	0	15	4
404	7 Northcape	13	7	15	4
405	7 Northcape	4	13	15	4
406	8	20	5	30	4
407	8	1	16	30	4
408	8	0	15	30	4
409	8	17	11	30	4
410	8	15	11	30	4
411	8	9	5	30	4
412	8	8	4	30	4
413	8	0	27	30	4
414	15	3	2	15	4
415	15	4	4	15	4
416	15	12	11	15	4
417	15	6	5	15	4
418	15	8	8	15	4
419	15	2	2	15	4
420	15	14	14	15	4
421	15	12	13	15	4
422	15	11	12	15	4
423	15	6	7	15	4
424	15	11	10	15	4
425	15	4	3	15	4
426	15	2	1	15	4
427	15	9	9	15	4
428	15	8	8	15	4
429	15	3	3	15	4
430	15	11	11	15	4

Non-transfer Riders (cont.)

Observation No.	Bus No.	Wait Time (Minutes)	Expected Wait Time (Minutes)	Bus Headway (Minutes)	Location
431	32	2	31	35	4
432	32	33	22	35	4
433	32	16	5	35	4
434	39	5	6	30	4
435	39	19	19	30	4
436	39	9	9	30	4
437	39	22	25	30	4
438	39	13	16	30	4
439	3	6	1	30	5
440	5	7	2	30	5
441	5	3	28	30	5
442	8	3	15	30	5
443	8	2	14	30	5
444	8	5	19	30	5
445	5	6	3	30	5
446	5	6	3	30	5
447	8	9	5	30	5
448	3	19	18	30	5
449	5	2	15	30	5
450	8	20	20	30	5
451	8	8	7	30	5
452	3	3	1	30	5
453	3	3	26	30	5
454	5	12	9	30	5
455	8	12	5	30	5
456	3	17	13	15	6
457	3	11	7	15	6
458	3	3	1	15	6
459	3	1	11	15	6
460	5	10	4	15	6
461	5	9	3	15	6
462	5	6	0	15	6
463	5	9	7	30	6
464	5	7	5	30	6
465	5	3	1	30	6
466	5	22	21	30	6
467	5	7	6	30	6
468	5	6	5	30	6
469	5	1	0	30	6
470	5	25	23	30	6

Non-transfer Riders (cont.)

Observation No.	Bus No.	Wait Time (Minutes)	Expected Wait Time (Minutes)	Bus Headway (Minutes)	Location
471	5	20	16	30	6
472	5	5	3	30	6
473	8	3	2	30	6
474	8	2	1	30	6
475	8	1	0	30	6
476	8	26	29	30	6
477	8	21	24	30	6
478	8	5	8	30	6
479	8	39	1	30	6
480	8	35	33	36	6
481	8	31	29	36	6
482	8	13	11	36	6
483	8	9	7	36	6
484	5	12	2	30	6
485	8	21	3	30	6
486	8	15	33	36	6
487	8	11	5	31	6
488	8	6	0	31	6
489	3	7	3	15	6
490	3	4	0	15	6
491	3	1	13	15	6
492	3	2	1	17	6
493	3	0	12	13	6
494	3	9	4	30	6
495	5	17	15	30	6
496	5	9	5	30	6
497	5	5	1	30	6
498	8	15	23	30	6
499	8	10	8	30	6
500	8	30	29	36	6
501	8	17	16	36	6
502	8	14	13	36	6
503	8	13	12	36	6
504	8	8	7	36	6
505	8	3	2	36	6
506	8	15	12	31	6
507	3	1	13	15	6
508	3	9	6	15	6
509	3	1	13	15	6
510	5	1	2	30	6

Non-transfer Riders (cont.)

Observation No.	Bus No.	Wait Time (Minutes)	Expected Wait Time (Minutes)	Bus Headway (Minutes)	Location
511	5	6	1	30	6
512	8	0	25	30	6
513	8	0	27	30	6
514	8	0	27	30	6
515	8	0	27	30	6
516	8	32	31	36	6
517	8	10	8	36	6

Transfer Riders

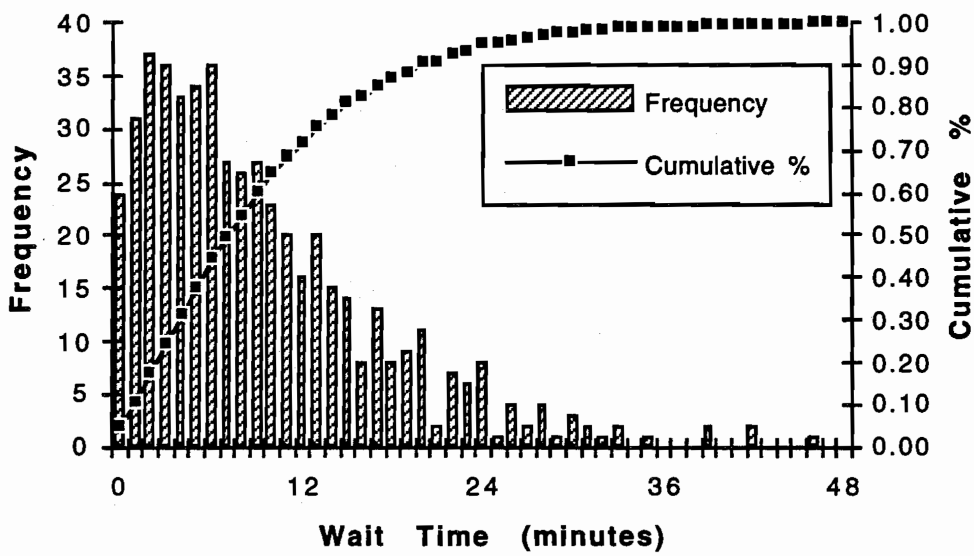
Observation No.	Bus No.	Wait Time (Minutes)	Expected Wait Time (Minutes)	Bus Headway (Minutes)	Location
1	7 Northcape	11	13	30	3
2	7 Northcape	26	24	30	3
3	7 Northcape	26	24	30	3
4	7 Northcape	26	24	30	3
5	7 Northcape	26	24	30	3
6	8	21	23	30	3
7	8	14	16	30	3
8	8	2	4	30	3
9	8	1	26	30	3
10	15	2	9	30	3
11	32	7	9	35	3
12	32	4	6	35	3
13	7 Downtown	14	11	30	3
14	7 Downtown	14	11	30	3
15	8	7	6	30	3
16	8	20	16	30	3
17	15	15	17	30	3
18	15	15	17	30	3
19	15	30	29	30	3
20	32	12	14	35	3
21	32	11	12	35	3
22	39	17	17	30	3
23	7 Downtown	8	8	30	3
24	7 Downtown	16	12	30	3
25	8	28	28	30	3
26	8	6	0	30	3
27	8	23	23	30	3

Transfer Riders (cont.)

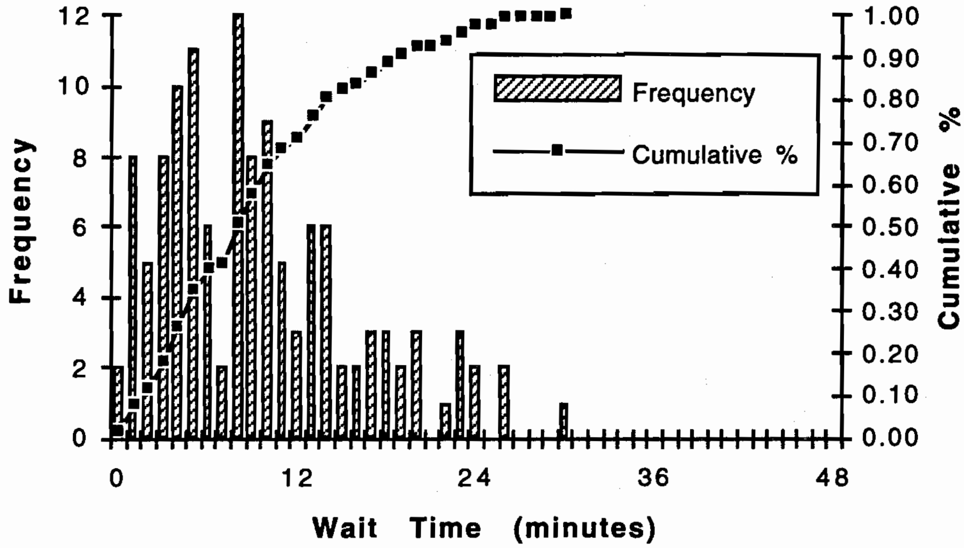
Observation No.	Bus No.	Wait Time (Minutes)	Expected Wait Time (Minutes)	Bus Headway (Minutes)	Location
28	15	29	30	30	3
29	15	8	9	30	3
30	32	13	12	35	3
31	39	33	29	30	3
32	39	25	26	30	3
33	7 Downtown	15	14	30	3
34	7 Downtown	15	14	30	3
35	7 Downtown	4	3	30	3
36	7 Downtown	4	3	30	3
37	7 Northcape	32	34	30	3
38	7 Northcape	14	9	30	3
39	15	20	18	30	3
40	32	22	20	35	3
41	32	24	21	35	3
42	32	33	36	35	3
43	39	6	3	30	3
44	39	6	3	30	3
45	7 Downtown	3	3	15	4
46	7 Downtown	3	3	15	4
47	7 Downtown	3	3	15	4
48	7 Northcape	10	9	30	4
49	7 Northcape	6	5	30	4
50	39	3	2	30	4
51	7 Downtown	23	21	15	4
52	7 Northcape	34	28	15	4
53	7 Northcape	19	13	15	4
54	8	29	22	30	4
55	8	19	12	30	4
56	8	8	1	30	4
57	8	6	2	30	4
58	8	10	35	30	4
59	15	10	7	15	4
60	32	15	14	35	4
61	32	13	10	35	4
62	39	20	22	30	4
63	7 Downtown	14	13	15	4
64	8	17	35	36	6
65	8	17	35	36	6

WAIT TIME FREQUENCY GRAPHS

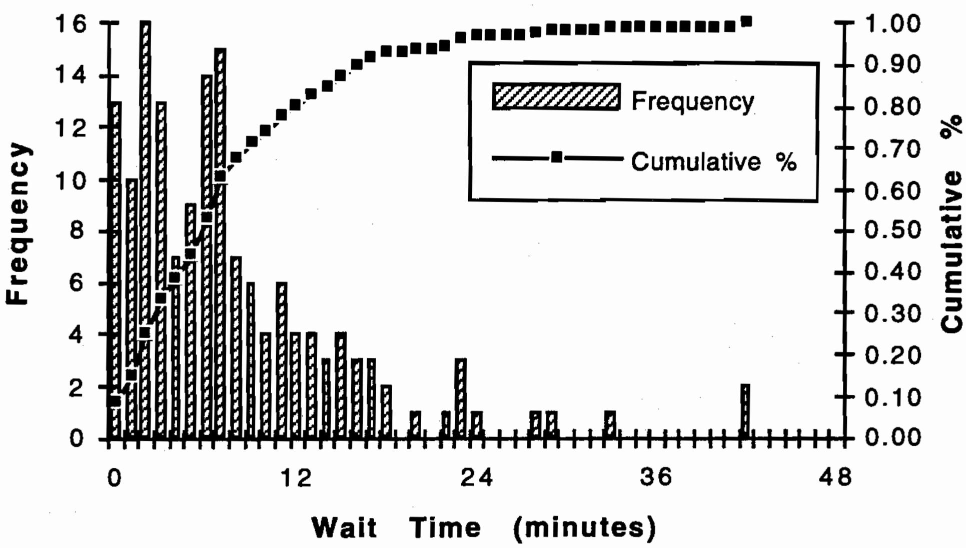
Overall Wait Time



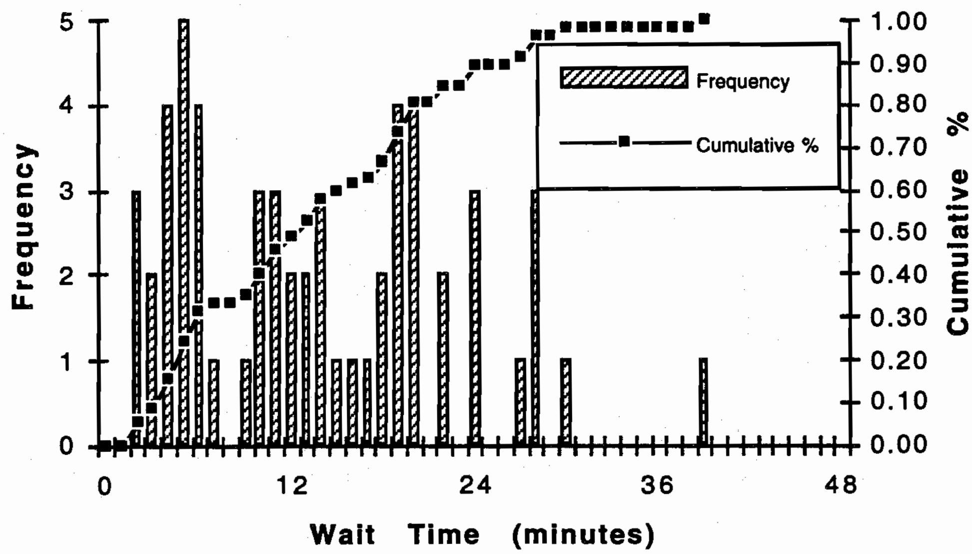
6th & Congress - Non-peak



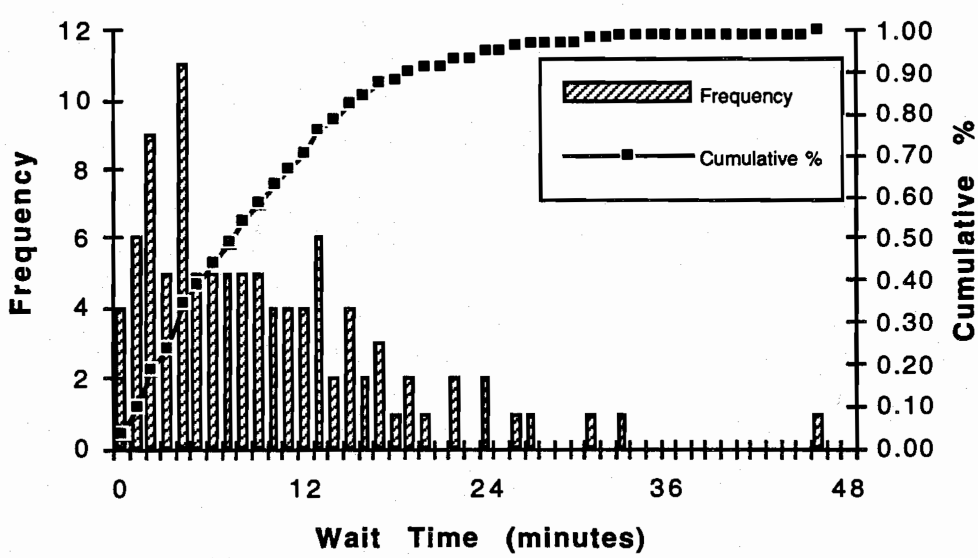
6th & Congress - Peak



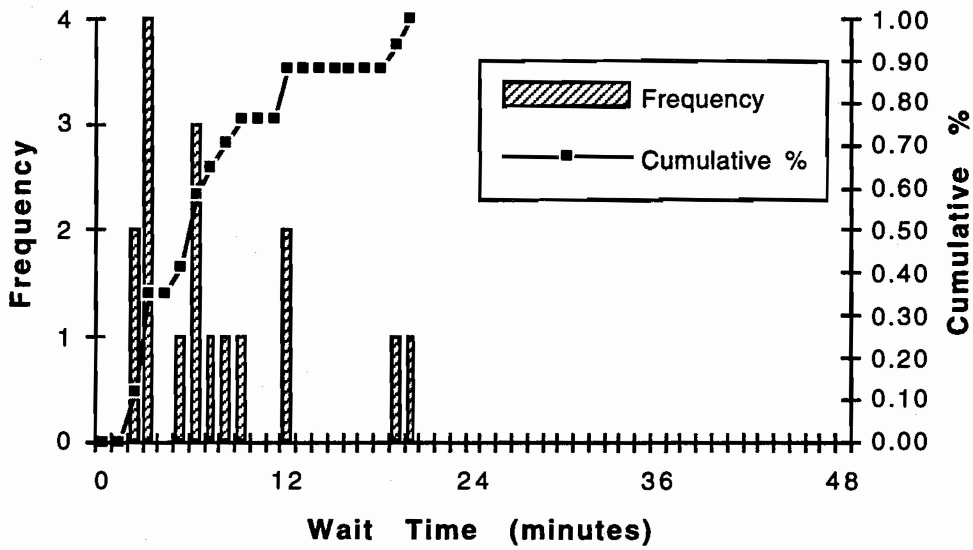
Highland Mall Transit Center - Non-peak



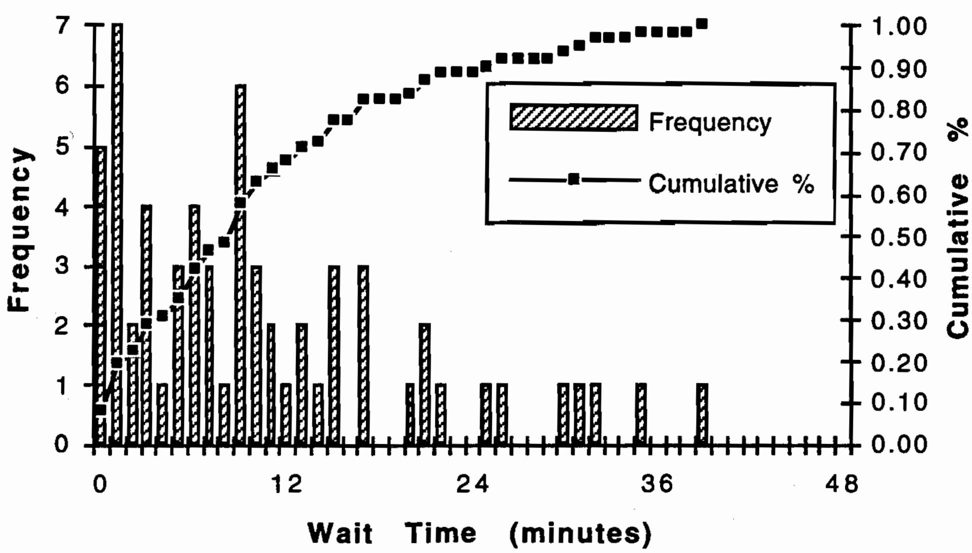
Highland Mall Transit Center - Peak



Northcross Mall - Non-peak



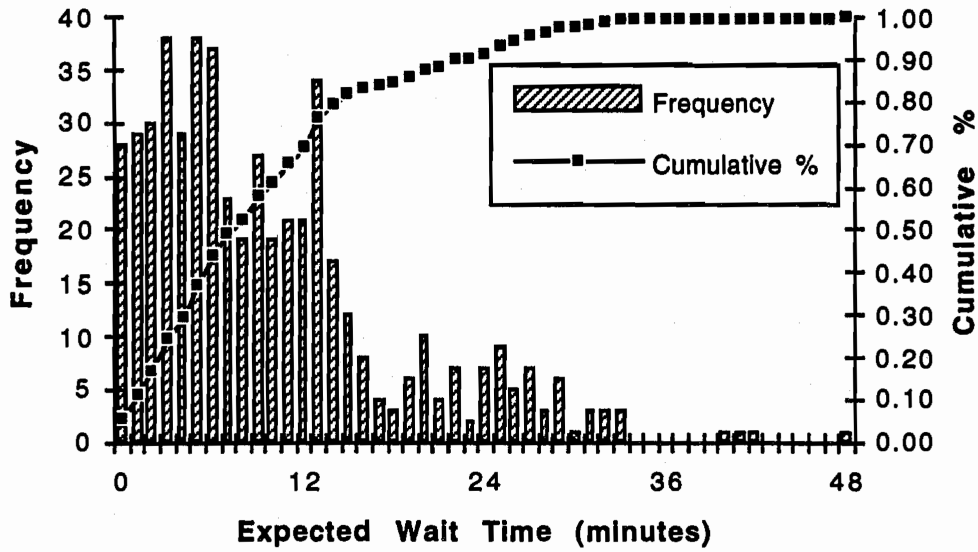
Northcross Mall - Peak



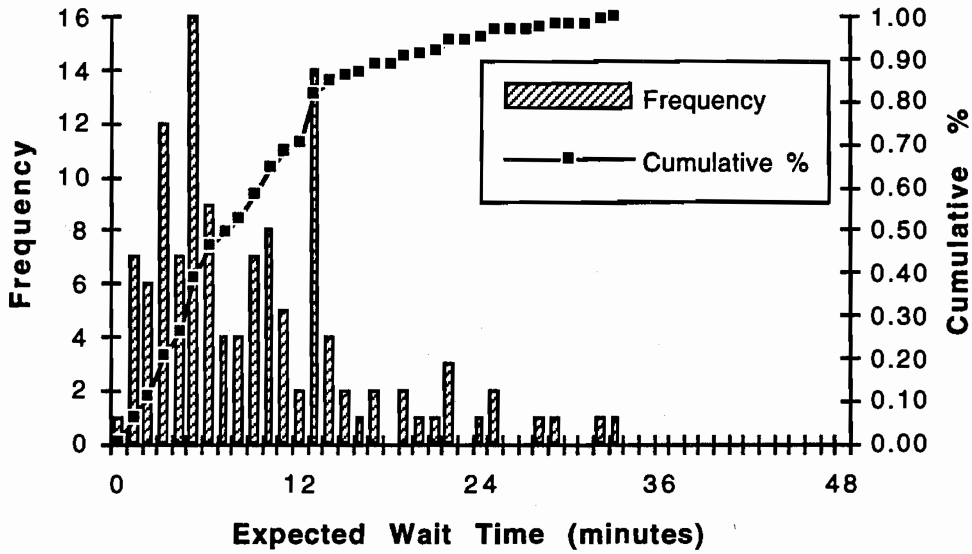
EXPECTED WAIT TIME

FREQUENCY GRAPHS

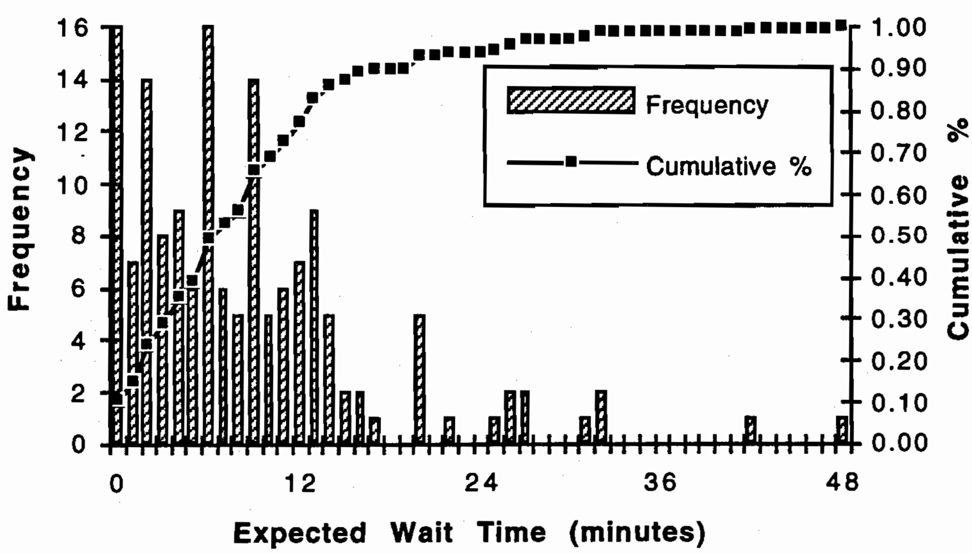
Overall Expected Wait Time



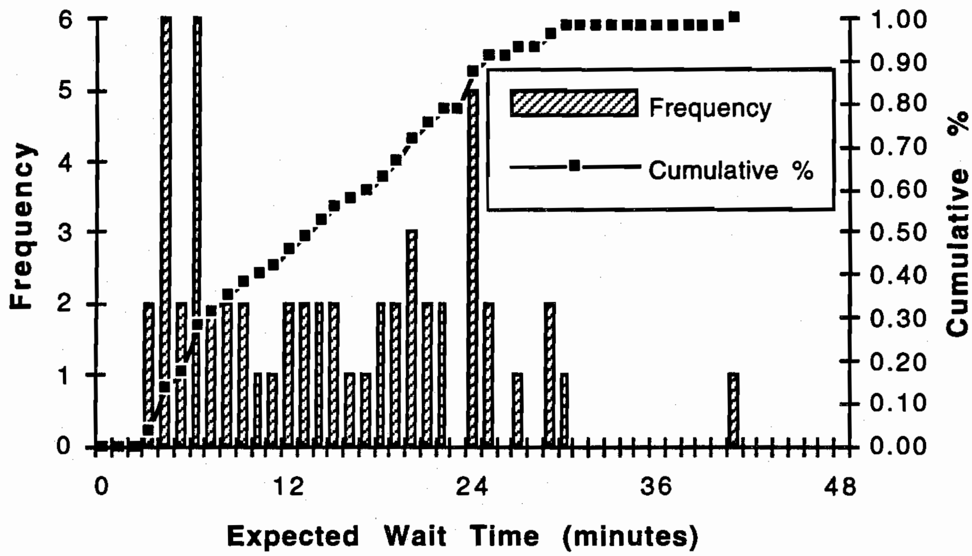
6th & Congress - Non-peak



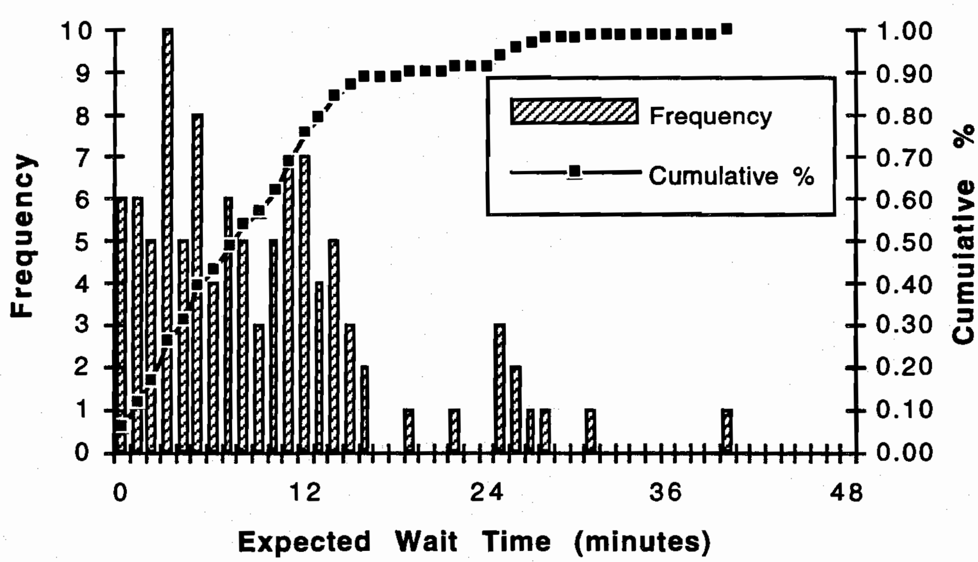
6th & Congress - Peak

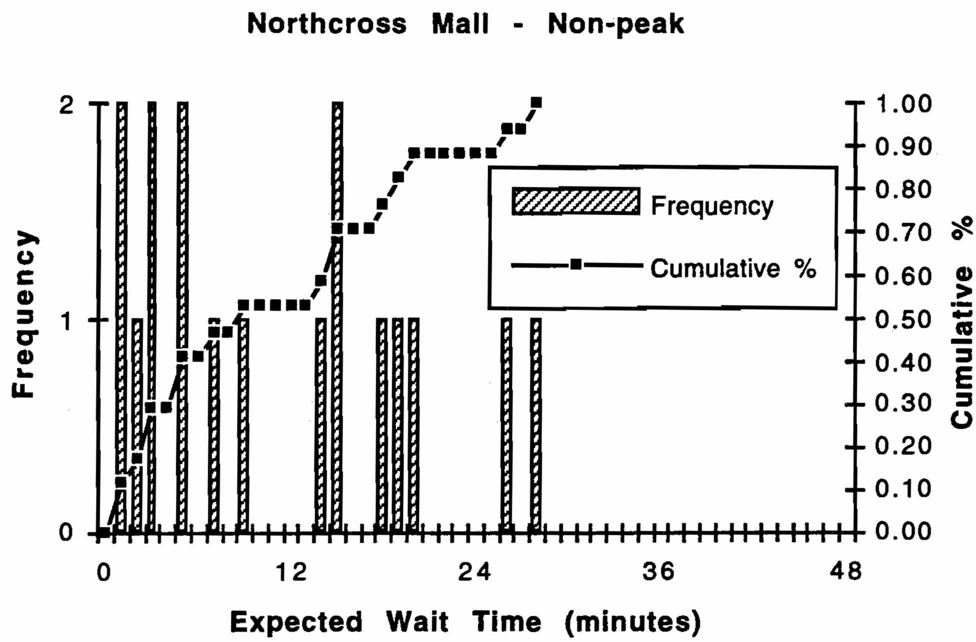


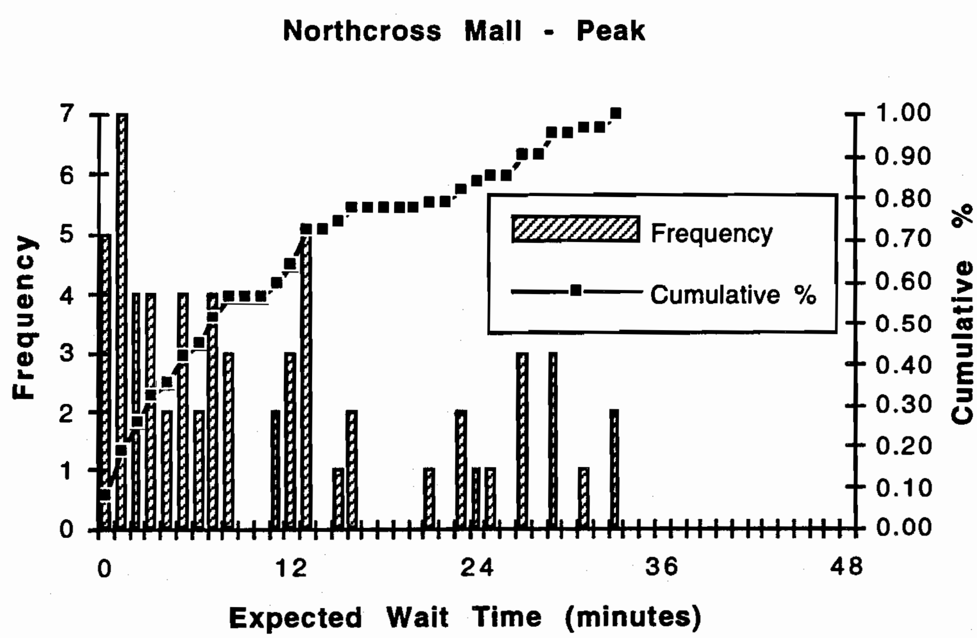
Highland Mall Transit Center - Nonpeak



Highland Mall Transit Center - Peak




Northcross Mall - Non-peak
Frequency
Cumulative %
2
1
0
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
12
24
36
48
Expected Wait Time (minutes)


Northcross Mall - Peak
Frequency
Cumulative %
7
6
5
4
3
2
1
0
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
12
24
36
48
Expected Wait Time (minutes)

T-TEST STATISTICS

t-Test Paired Two-Sample for Means

Statistics	Overall	
	Wait Time	Expected Wait Time
Mean	9.52	9.92
Variance	63.22	69.24
Observations	517.00	517.00
Pearson Correlation	0.63	
Pooled Variance	41.38	
Hypothesized Mean Diff.	0.00	
df	516.00	
t	-1.29	(NOT SIGNIF.)
P(T<=t) one-tail	0.10	
t Critical one-tail	1.65	
P(T<=t) two-tail	0.20	
t Critical two-tail	1.96	

t-Test Paired Two-Sample for Means (cont.)

Statistics	Location 1 Wait Time	Location 1 Expected Wait Time	Location 2 Wait Time	Location 2 Expected Wait Time	Location 3 Wait Time	Location 3 Expected Wait Time
Mean	9.47	9.26	7.82	8.66	13.75	14.60
Variance	43.35	48.16	56.93	66.65	75.83	78.57
Observations	125.00	125.00	154.00	154.00	57.00	57.00
Pearson Correlation	0.58		0.57		0.90	
Pooled Variance	26.41		34.84		69.52	
Hypothesized Mean Diff.	0.00		0.00		0.00	
df	124.00		153.00		56.00	
t	0.37	(NOT SIGNIF.)	-1.41	(NOT SIGNIF.)	-1.62	(NOT SIGNIF.)
P(T<=t) one-tail	0.35		0.08		0.06	
t Critical one-tail	1.66		1.65		1.67	
P(T<=t) two-tail	0.71		0.16		0.11	
t Critical two-tail	1.98		1.98		2.00	

	Location 4		Location 5		Location 6	
Mean	9.51	9.25	7.41	11.24	10.50	10.81
Variance	65.30	59.63	30.38	78.07	91.93	101.90
Observations	102.00	102.00	17.00	17.00	62.00	62.00
Pearson Correlation	0.72		0.02		0.48	
Pooled Variance	45.08		0.90		46.15	
Hypothesized Mean Diff.	0.00		0.00		0.00	
df	101.00		16.00		61.00	
t	0.45	(NOT SIGNIF.)	-1.53	(NOT SIGNIF.)	-0.24	(NOT SIGNIF.)
P(T<=t) one-tail	0.33		0.07		0.41	
t Critical one-tail	1.66		1.75		1.67	
P(T<=t) two-tail	0.65		0.15		0.81	
t Critical two-tail	1.98		2.12		2.00	

F-TEST STATISTICS

F-Test: Two-Sample for Variances

Statistics	Location 1		Location 2		Location 3	
	Wait Time	Exp. Wait Time	Wait Time	Exp. Wait Time	Wait Time	Exp. Wait Time
Mean	9.47	9.26	7.82	8.66	13.75	14.60
Variance	43.35	48.16	56.93	66.65	75.83	78.57
Observations	125.00	125.00	154.00	154.00	57.00	57.00
df	124.00	124.00	153.00	153.00	56.00	56.00
F	1.11		1.17		1.04	
P(F<=f) one-tail	0.28	(NOT SIGNIFICANT	0.17	(NOT SIGNIFICAN	0.45	(NOT SIGNIFICANT)
F Critical one-tail	1.26		1.23		1.41	

Statistics	Location 4		Location 5		Location 6	
	Wait Time	Exp. Wait Time	Wait Time	Exp. Wait Time	Wait Time	Exp. Wait Time
Mean	9.51	6.00	7.41	11.24	10.50	10.81
Variance	65.30	15.27	30.38	78.07	91.93	101.90
Observations	102.00	12.00	17.00	17.00	62.00	62.00
df	101.00	11.00	16.00	16.00	61.00	61.00
F	4.28		2.57		1.11	
P(F<=f) one-tail	0.01	(SIGNIFICANT)	0.03	(SIGNIFICANT)	0.34	(NOT SIGNIFICANT)
F Critical one-tail	2.46		1.93		1.39	

Statistics	Overall	
	Wait Time	Exp. Wait Time
Mean	9.52	9.92
Variance	63.22	69.24
Observations	517.00	517.00
df	516.00	516.00
F	1.10	
P(F<=f) one-tail	0.15	(NOT SIGNIFICANT)
F Critical one-tail	1.12	

WAIT TIME AND EXPECTED WAIT TIME FREQUENCY DISTRIBUTIONS

Overall

Minutes	Wait		Expected Wait	
	Frequency	Cumulative %	Frequency	Cumulative %
0	24	4.64%	28	5.42%
1	31	10.64%	29	11.03%
2	37	17.79%	30	16.83%
3	36	24.76%	38	24.18%
4	33	31.14%	29	29.79%
5	34	37.72%	38	37.14%
6	36	44.68%	37	44.29%
7	27	49.90%	23	48.74%
8	26	54.93%	19	52.42%
9	27	60.15%	27	57.64%
10	23	64.60%	19	61.32%
11	20	68.47%	21	65.38%
12	16	71.57%	21	69.44%
13	20	75.44%	34	76.02%
14	15	78.34%	17	79.30%
15	14	81.04%	12	81.62%
16	8	82.59%	8	83.17%
17	13	85.11%	4	83.95%
18	8	86.65%	3	84.53%
19	9	88.39%	6	85.69%
20	11	90.52%	10	87.62%
21	2	90.91%	4	88.39%
22	7	92.26%	7	89.75%
23	6	93.42%	2	90.14%
24	8	94.97%	7	91.49%
25	1	95.16%	9	93.23%
26	4	95.94%	5	94.20%
27	2	96.32%	7	95.55%
28	4	97.10%	3	96.13%
29	1	97.29%	6	97.29%
30	3	97.87%	1	97.49%
31	2	98.26%	3	98.07%
32	1	98.45%	3	98.65%
33-34	2	98.84%	3	99.23%
35	1	99.03%	0	99.23%
36-38	0	99.03%	0	99.23%
39	2	99.42%	0	99.23%
40	0	99.42%	1	99.42%
41	0	99.42%	1	99.61%
42	2	99.81%	1	99.81%
43-45	0	99.81%	0	99.81%
46	1	100.00%	0	99.81%
47	0	100.00%	0	99.81%
48	0	100.00%	1	100.00%

Location 1 - 6th & Congress (Non-peak)

Minutes	Wait		Expected Wait	
	Frequency	Cumulative %	Frequency	Cumulative %
0	2	1.60%	1	0.80%
1	8	8.00%	7	6.40%
2	5	12.00%	6	11.20%
3	8	18.40%	12	20.80%
4	10	26.40%	7	26.40%
5	11	35.20%	16	39.20%
6	6	40.00%	9	46.40%
7	2	41.60%	4	49.60%
8	12	51.20%	4	52.80%
9	8	57.60%	7	58.40%
10	9	64.80%	8	64.80%
11	5	68.80%	5	68.80%
12	3	71.20%	2	70.40%
13	6	76.00%	14	81.60%
14	6	80.80%	4	84.80%
15	2	82.40%	2	86.40%
16	2	84.00%	1	87.20%
17	3	86.40%	2	88.80%
18	3	88.80%	0	88.80%
19	2	90.40%	2	90.40%
20	3	92.80%	1	91.20%
21	0	92.80%	1	92.00%
22	1	93.60%	3	94.40%
23	3	96.00%	0	94.40%
24	2	97.60%	1	95.20%
25	0	97.60%	2	96.80%
26	2	99.20%	0	96.80%
27	0	99.20%	0	96.80%
28	0	99.20%	1	97.60%
29	0	99.20%	1	98.40%
30	1	100.00%	0	98.40%
31			0	98.40%
32			1	99.20%
33			1	100.00%

Location 2 - 6th & Congress (Peak)

Minutes	Wait Frequency	Wait Cumulative %	Expected Wait Frequency	Expected Wait Cumulative %
0	13	8.44%	16	10.39%
1	10	14.94%	7	14.94%
2	16	25.32%	14	24.03%
3	13	33.77%	8	29.22%
4	7	38.31%	9	35.06%
5	9	44.16%	6	38.96%
6	14	53.25%	16	49.35%
7	15	62.99%	6	53.25%
8	7	67.53%	5	56.49%
9	6	71.43%	14	65.58%
10	4	74.03%	5	68.83%
11	6	77.92%	6	72.73%
12	4	80.52%	7	77.27%
13	4	83.12%	9	83.12%
14	3	85.06%	5	86.36%
15	4	87.66%	2	87.66%
16	3	89.61%	2	88.96%
17	3	91.56%	1	89.61%
18	2	92.86%	0	89.61%
20	1	93.51%	5	92.86%
21	0	93.51%	0	92.86%
22	1	94.16%	1	93.51%
23	3	96.10%	0	93.51%
24	1	96.75%	0	93.51%
25	0	96.75%	1	94.16%
26	0	96.75%	2	95.45%
27	0	96.75%	2	96.75%
28	1	97.40%	0	96.75%
29	1	98.05%	0	96.75%
30	0	98.05%	0	96.75%
31	0	98.05%	1	97.40%
32	0	98.05%	2	98.70%
33	1	98.70%	0	98.70%
34-41	0	98.70%	0	98.70%
42	2	100.00%	1	99.35%
43			0	99.35%
44			0	99.35%
45			0	99.35%
46			0	99.35%
47			0	99.35%
48			1	100.00%

Location 3 - Highland Mall Transit Center (Non-peak)

Minutes	Wait		Expected Wait	
	Frequency	Cumulative %	Frequency	Cumulative %
0	0	0.00%	0	0.00%
1	0	0.00%	0	0.00%
2	3	5.26%	0	0.00%
3	2	8.77%	2	3.51%
4	4	15.79%	6	14.04%
5	5	24.56%	2	17.54%
6	4	31.58%	6	28.07%
7	1	33.33%	2	31.58%
8	0	33.33%	2	35.09%
9	1	35.09%	2	38.60%
10	3	40.35%	1	40.35%
11	3	45.61%	1	42.11%
12	2	49.12%	2	45.61%
13	2	52.63%	2	49.12%
14	3	57.89%	2	52.63%
15	1	59.65%	2	56.14%
16	1	61.40%	1	57.89%
17	1	63.16%	1	59.65%
18	2	66.67%	2	63.16%
19	4	73.68%	2	66.67%
20	4	80.70%	3	71.93%
21	0	80.70%	2	75.44%
22	2	84.21%	2	78.95%
23	0	84.21%	0	78.95%
24	3	89.47%	5	87.72%
25	0	89.47%	2	91.23%
26	0	89.47%	0	91.23%
27	1	91.23%	1	92.98%
28	3	96.49%	0	92.98%
29	0	96.49%	2	96.49%
30	1	98.25%	1	98.25%
31	0	98.25%	0	98.25%
32	0	98.25%	0	98.25%
33	0	98.25%	0	98.25%
34	0	98.25%	0	98.25%
35	0	98.25%	0	98.25%
36	0	98.25%	0	98.25%
37	0	98.25%	0	98.25%
38	0	98.25%	0	98.25%
39	1	100.00%	0	98.25%
40			0	98.25%
41			1	100.00%

Location 4 - Highland Mall Transit Center (Peak)

Minutes	Wait		Expected Wait	
	Frequency	Cumulative %	Frequency	Cumulative %
0	4	3.92%	6	5.88%
1	6	9.80%	6	11.76%
2	9	18.63%	5	16.67%
3	5	23.53%	10	26.47%
4	11	34.31%	5	31.37%
5	5	39.22%	8	39.22%
6	5	44.12%	4	43.14%
7	5	49.02%	6	49.02%
8	5	53.92%	5	53.92%
9	5	58.82%	3	56.86%
10	4	62.75%	5	61.76%
11	4	66.67%	7	68.63%
12	4	70.59%	7	75.49%
13	6	76.47%	4	79.41%
14	2	78.43%	5	84.31%
15	4	82.35%	3	87.25%
16	2	84.31%	2	89.22%
17	3	87.25%	0	89.22%
18	1	88.24%	0	89.22%
19	2	90.20%	1	90.20%
20	1	91.18%	0	90.20%
21	0	91.18%	0	90.20%
22	2	93.14%	1	91.18%
23	0	93.14%	0	91.18%
24	2	95.10%	0	91.18%
25	0	95.10%	3	94.12%
26	1	96.08%	2	96.08%
27	1	97.06%	1	97.06%
28	0	97.06%	1	98.04%
29	0	97.06%	0	98.04%
30	0	97.06%	0	98.04%
31	1	98.04%	1	99.02%
32	0	98.04%	0	99.02%
33	1	99.02%	0	99.02%
34-39	0	99.02%	0	99.02%
40	0	99.02%	1	100.00%
41	0	99.02%		
42	0	99.02%		
43	0	99.02%		
44	0	99.02%		
45	0	99.02%		
46	1	100.00%		

Location 5 - Northcross Mall (Non-peak)

Minutes	Wait		Expected Wait	
	Frequency	Cumulative %	Frequency	Cumulative %
0	0	0.00%	0	0.00%
1	0	0.00%	2	11.76%
2	2	11.76%	1	17.65%
3	4	35.29%	2	29.41%
4	0	35.29%	0	29.41%
5	1	41.18%	2	41.18%
6	3	58.82%	0	41.18%
7	1	64.71%	1	47.06%
8	1	70.59%	0	47.06%
9	1	76.47%	1	52.94%
10	0	76.47%	0	52.94%
11	0	76.47%	0	52.94%
12	2	88.24%	0	52.94%
13	0	88.24%	0	52.94%
14	0	88.24%	1	58.82%
15	0	88.24%	2	70.59%
16	0	88.24%	0	70.59%
17	0	88.24%	0	70.59%
18	0	88.24%	1	76.47%
19	1	94.12%	1	82.35%
20	1	100.00%	1	88.24%
21			0	88.24%
22			0	88.24%
23			0	88.24%
24			0	88.24%
25			0	88.24%
26			1	94.12%
27			0	94.12%
28			1	100.00%

Location 6 - Northcross Mall (Peak)

Minutes	Wait		Expected Wait	
	Frequency	Cumulative %	Frequency	Cumulative %
0	5	8.06%	5	8.06%
1	7	19.35%	7	19.35%
2	2	22.58%	4	25.81%
3	4	29.03%	4	32.26%
4	1	30.65%	2	35.48%
5	3	35.48%	4	41.94%
6	4	41.94%	2	45.16%
7	3	46.77%	4	51.61%
8	1	48.39%	3	56.45%
9	6	58.06%	0	56.45%
10	3	62.90%	0	56.45%
11	2	66.13%	2	59.68%
12	1	67.74%	3	64.52%
13	2	70.97%	5	72.58%
14	1	72.58%	0	72.58%
15	3	77.42%	1	74.19%
16	0	77.42%	2	77.42%
17	3	82.26%	0	77.42%
18	0	82.26%	0	77.42%
19	0	82.26%	0	77.42%
20	1	83.87%	0	77.42%
21	2	87.10%	1	79.03%
22	1	88.71%	0	79.03%
23	0	88.71%	2	82.26%
24	0	88.71%	1	83.87%
25	1	90.32%	1	85.48%
26	1	91.94%	0	85.48%
27	0	91.94%	3	90.32%
28	0	91.94%	0	90.32%
29	0	91.94%	3	95.16%
30	1	93.55%	0	95.16%
31	1	95.16%	1	96.77%
32	1	96.77%	0	96.77%
33	0	96.77%	2	100.00%
34	0	96.77%		
35	1	98.39%		
36	0	98.39%		
37	0	98.39%		
38	0	98.39%		
39	1	100.00%		

APPENDIX C

Overall Bus Observations

Location	Bus No.	N	Peak			N	Non-peak			N	Total		
			Early	On-Time	Late		Early	On-Time	Late		Early	On-Time	Late
6th & Congress	1	24	0	17	7	31	9	16	6	55	9	33	13
	5	17	1	9	7	17	0	12	5	34	1	21	12
	6	21	0	16	5	14	1	12	1	35	1	28	6
	7	18	2	3	13	16	1	8	7	34	3	11	20
	9 IB	12	0	11	1	14	5	4	5	26	5	15	6
	9 OB	10	0	6	4	17	8	7	2	27	8	13	6
	9	22	0	17	5	31	13	11	7	53	13	28	12
	13	24	7	5	12	33	8	21	4	57	15	26	16
	15	22	3	12	7	16	0	13	3	38	3	25	10
	16	24	2	13	9	16	1	11	4	40	3	24	13
	26	12	0	8	4	16	0	9	7	28	0	17	11
	27	24	1	14	9	15	8	4	3	39	9	18	12
	30 IB	12	0	2	10	17	4	9	4	29	4	11	14
	30-OB	13	1	12	0	15	3	9	3	28	4	21	3
	30	25	1	14	10	32	7	18	7	57	8	32	17
Highland Mall Transit Center	7 DT	39	9	27	3	20	9	10	1	59	18	37	4
	7 NC	25	6	15	4	24	12	9	3	49	18	24	7
	8	18	1	4	13	21	9	9	3	39	10	13	16
	15	36	12	22	2	5	4	1	0	41	16	23	2
	32	17	0	14	3	4	0	4	0	21	0	18	3
	39	19	5	13	1	20	9	8	3	39	14	21	4
North-cross Mall	3 IB	26	0	21	5	17	0	11	6	43	0	32	11
	3 OB	12	1	3	8	10	1	6	3	22	2	9	11
	3	38	1	24	13	27	1	17	9	65	2	41	22
	5 IB	20	0	14	6	17	0	14	3	37	0	28	9
	5 OB	18	10	5	3	16	2	12	2	34	12	17	5
	5	38	10	19	9	33	2	26	5	71	12	45	14
	8 IB	14	1	11	2	17	0	10	7	31	1	21	9
	8 OB	14	2	6	6	14	5	7	2	28	7	13	8
	8	28	3	17	8	31	5	17	9	59	8	34	17
	25 IB	6	6	0	0	5	0	2	3	11	6	2	3
	25 OB	16	0	14	2	18	2	14	2	34	2	28	4
	25	22	6	14	2	23	2	16	5	45	8	30	7
	44	8	5	1	2	7	1	6	0	15	6	7	2

(IB = inbound; OB = outbound; DT = Downtown, NC = Northcape)

Bus Observations By Location and Time Period

6th & Congress

Min.	Peak			Off-Peak			Total		
	Early	On-Time	Late	Early	On-Time	Late	Early	On-Time	Late
0		19			37			56	
1	5	38		32	45		37	83	
2	1	42		7	28		8	70	
3	4	29		1	25		5	54	
4	2		27	6		19	8		46
5			14			10			24
6	2		16			6	2		22
7	1		13	1		8	2		21
8	2		9			2	2		11
9			4			3			7
10			4			1			5
11						2			2
12									
13									
14									
15			1			2			3
16				1			1		
17						1			1
Tot.	17	128	88	48	135	54	65	263	142

Highland Mall

Min.	Peak			Off-Peak			Total		
	Early	On-Time	Late	Early	On-Time	Late	Early	On-Time	Late
0		46			10			56	
1	15	27		10	8		25	35	
2	9	13		13	8		22	21	
3	4	9		2	6		6	15	
4	2		6	7		3	9		9
5			4	1		2	1		6
6	2		4			2	2		6
7				1			1		
8			2						2
9			3						3
10	1		2				1		2
11			3						3
12			1						1
13									
14									
15			1						1
Tot.	33	95	26	34	32	7	67	127	33

Bus Observations By Location and Time Period (cont.)

Northcross Mall

Min.	Peak			Off-Peak			Total		
	Early	On-Time	Late	Early	On-Time	Late	Early	On-Time	Late
0		11			16			27	
1	9	13		4	18		13	31	
2	3	17		5	10		8	27	
3	3	19			22		3	41	
4	1		8			7	1		15
5	1		5			6	1		11
6			3			6			9
7			2			2			4
8			1			1			2
9						1			1
10			2						2
11									
12									
13			4						4
14	1						1		
15			2						2
16									
17			1						1
18			2						2
19			1						1
20									
21									
22									
23									
24			1						1
Tot.	18	60	32	9	66	23	27	126	55

Bus Observations By Location and Time Period (cont.)

Overall

Min.	Peak			Off-Peak			Total		
	Early	On-Time	Late	Early	On-Time	Late	Early	On-Time	Late
0		76			63			139	
1	29	78		46	71		75	149	
2	13	72		25	46		38	118	
3	11	57		3	53		14	110	
4	5		41	13		29	18		70
5	1		23	1		18	2		41
6	4		23			14	4		37
7	1		15	2		10	3		25
8	2		12			3	2		15
9			7			4			11
10	1		8			1	1		9
11			3			2			5
12			1						1
13			4						4
14	1						1		
15			4			2			6
16				1			1		
17			1			1			2
18			2						2
19			1						1
20									
21									
22									
23									
24			1						1
Total	68	283	146	91	233	84	159	516	230

BUS OBSERVATIONS

BY BUS LINE

BUS RELIABILITY - 6TH & CONGRESS (PEAK)
BUS #1 LAMAR
OBSERVER: B

SCHEDULED	23-Jun (B)			24-Jun (B)			25-Jun (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:40			3			6			1
3:55			6			1			1
4:10			1		0				3
4:25			1			4			2
4:40			5			5			3
4:55			2			2			3
5:10			2		0				1
5:25			6						1
5:35			7						

BUS RELIABILITY - 6TH & CONGRESS (OFF-PEAK)
BUS #1 LAMAR
OBSERVER: J & S

SCHEDULED	23-Jun (J)			24-Jun (J)			26-Jun (S)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
9:53						3			7
10:08				1			2		
10:23					0				1
10:38			3	1			1		
10:53	1			1					7
11:08	1					1			4
11:23		0			0			0	
11:38			4	1					1
11:53		0							
12:08		0							

BUS RELIABILITY - 6TH & CONGRESS (PEAK)
BUS #5 WOODROW
OBSERVER: B

SCHEDULED	23-Jun (B)			24-Jun (B)			25-Jun (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:49			3			6			5
4:19			4			3			2
4:34			4		0				6
4:49			1			2			6
5:04		0				1			1
5:22	1								5

BUS RELIABILITY - 6TH & CONGRESS (OFF-PEAK)
BUS #5 WOODROW
OBSERVER: J & S

SCHEDULED	23-Jun (J)			24-Jun (J)			26-Jun (S)			29-Jun (S)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
9:52					0							2
10:20						5			2			4
10:50			1			2			4			5
11:20			1		0			0				1
11:50			5			2			3			2

BUS RELIABILITY - 6TH & CONGRESS (PEAK)
BUS #6 E 12TH
OBSERVER: B

SCHEDULED	23-Jun (B)			24-Jun (B)			25-Jun (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:31						4			3
3:48			5			3			2
4:05			2		0				4
4:22			2			4			2
4:39			4			3			2
4:56			1			3			3
5:13			2			1			1
5:30		0							

BUS RELIABILITY - 6TH & CONGRESS (OFF-PEAK)
BUS #6 E 12TH
OBSERVER: J & S

SCHEDULED	23-Jun (J)			24-Jun (J)			26-Jun (S)			29-Jun (S)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
10:00						1			2			2
10:35	1					1						5
11:10			2			1			3			3
11:45			2		0				1			3

BUS RELIABILITY - 6TH & CONGRESS (PEAK)
BUS #7 DUVAL
OBSERVER: B

SCHEDULED	23-Jun	(B)		24-Jun	(B)		25-Jun	(B)	
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:37			6			4			5
4:07			4			15			3
4:22			6			1			2
4:37			5			8			6
4:52			5						5
5:07			8			10			
5:22	1								
5:37	8								

BUS RELIABILITY - 6TH & CONGRESS (OFF-PEAK)
BUS #7 DUVAL
OBSERVER: J & S

SCHEDULED	23-Jun	(J)		24-Jun	(J)		26-Jun	(S)		29-Jun	(S)	
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
10:05						4		0				4
10:35			6			1			7			4
11:05		0				2			4			2
11:35	1				0				2			7
12:05			1									

BUS RELIABILITY - 6TH & CONGRESS (PEAK)
BUS #9 ENFIELD - INBOUND
OBSERVER: B

SCHEDULED	23-Jun (B)			24-Jun (B)			25-Jun (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:44			1		0				1
4:17			9			2			2
4:50			3			2			3
5:23			1			2			2

BUS #9 ENFIELD - OUTBOUND

SCHEDULED	23-Jun (B)			24-Jun (B)			25-Jun (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:57			5			4			4
4:30			1			1			3
5:03		0				3			4
5:37			1						

BUS RELIABILITY - 6TH & CONGRESS (OFF-PEAK)
BUS #9 ENFIELD - INBOUND
OBSERVER: J & S

SCHEDULED	23-Jun (J)			24-Jun (J)			26-Jun (S)			29-Jun (S)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
10:14	2					3			6			9
10:47				1				0				4
11:20		0				4			2			9
11:53	4			4						4		

BUS #9 ENFIELD - OUTBOUND

SCHEDULED	23-Jun (J)			24-Jun (J)			26-Jun (S)			29-Jun (S)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
9:55				2				0				1
10:28	1					4			1			5
11:01	2			4			1				0	
11:34	4					1			3			3
12:07	1						16					

BUS RELIABILITY - 6TH & CONGRESS (PEAK)
BUS #13 S CONGRESS
OBSERVER: B

SCHEDULED	23-Jun (B)			24-Jun (B)			25-Jun (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:32						4			4
3:47			1			4			4
4:02			7			7		0	
4:17			10			5			3
4:32						4			5
4:47	3								3
5:02			1	2					7
5:17	6			8					9
5:32	4			7					
5:47	6								

BUS RELIABILITY - 6TH & CONGRESS (OFF-PEAK)
BUS #13 S CONGRESS
OBSERVER: J & S

SCHEDULED	23-Jun (J)			24-Jun (J)			26-Jun (S)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
10:02	1				0				1
10:17		0				2	1		
10:32	1			1			1		
10:47		0			0				2
11:02	1					1		0	
11:17			3		0				1
11:32	1					3			13
11:47	2					4			5
12:02			1						

BUS RELIABILITY - 6TH & CONGRESS (PEAK)
BUS #15 RED RIVER
OBSERVER: B

SCHEDULED	23-Jun (B)			24-Jun (B)			25-Jun (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:37			2		0			0	
3:48			3						7
4:07			5			3	1		
4:22	3				0		3		
4:37			1			2			1
4:52			7			9			8
5:07			8						1
5:22			7						2
5:37		0							

BUS RELIABILITY - 6TH & CONGRESS (OFF-PEAK)
BUS #15 RED RIVER
OBSERVER: J & S

SCHEDULED	23-Jun (J)			24-Jun (J)			26-Jun (S)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
9:54						1			3
10:24			2			1			1
10:54			1		0				1
11:24			1			2			1
11:54			2						

BUS RELIABILITY - 6TH & CONGRESS (PEAK)
BUS #16 WESTGATE
OBSERVER: B

SCHEDULED	23-Jun	(B)		24-Jun	(B)		25-Jun	(B)	
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:40			2			4			2
3:53			2			3			7
4:10			3			2			1
4:23			6			6			3
4:38			3			2			6
4:53			2			2			1
5:08			4			6			6
5:23	3						1		
5:38			4						

BUS RELIABILITY - 6TH & CONGRESS (OFF-PEAK)
BUS #16 WESTGATE
OBSERVER: J & S

SCHEDULED	23-Jun	(J)		24-Jun	(J)		26-Jun	(S)	
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
9:51									5
10:21			2			1		0	
10:51			3			4			1
11:21			1		0		1		
11:51			3		0				

BUS RELIABILITY - 6TH & CONGRESS (PEAK)
BUS #26 BERGSTROM
OBSERVER: B

SCHEDULED	23-Jun (B)			24-Jun (B)			25-Jun (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:54			1			2			1
4:24			2			1			2
4:54			4			2		0	
5:24			4			10			10

BUS RELIABILITY - 6TH & CONGRESS (OFF-PEAK)
BUS #26 BERGSTROM
OBSERVER: J & S

SCHEDULED	23-Jun (J)			24-Jun (J)			26-Jun (S)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
9:50						4			
10:20			1			3		0	
10:50					0				1
11:20			7		0				2
11:50			6			1			3

BUS RELIABILITY - 6TH & CONGRESS (PEAK)
BUS #27 DOVE SPRINGS
OBSERVER: B

SCHEDULED	23-Jun (B)			24-Jun (B)			25-Jun (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:27									2
3:42		0			0				8
4:02		0				1			4
4:19			4			2			2
4:32	4					2			1
4:47			4			2			4
5:02			1			1			3
5:17			8			6			4
5:32			7						2

BUS RELIABILITY - 6TH & CONGRESS (OFF-PEAK)
BUS #27 DOVE SPRINGS
OBSERVER: J & S

SCHEDULED	23-Jun (J)			24-Jun (J)			26-Jun (S)			29-Jun (S)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
9:46												7
10:01			1			3			6			
10:31	1						1			3		
11:01	1			2			1			7		
11:31			3			4				1		
12:01		0										

BUS RELIABILITY - 6TH & CONGRESS (PEAK)
BUS #30 BARTON CREEK - INBOUND
OBSERVER: B

SCHEDULED	23-Jun (B)			24-Jun (B)			25-Jun (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:50			5			3			7
4:20			8			8			7
4:50			7			7			6
5:22			9			2			8

BUS #30 BARTON CREEK - OUTBOUND

SCHEDULED	23-Jun (B)			24-Jun (B)			25-Jun (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:46			1			1			1
4:16			3			3			1
4:44			2			2			1
5:14			3			1	1		
5:47			2						

BUS RELIABILITY - 6TH & CONGRESS (OFF-PEAK)
BUS #30 BARTON CREEK - INBOUND
OBSERVER: J & S

SCHEDULED	23-Jun (J)			24-Jun (J)			26-Jun (S)			29-Jun (S)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
9:50									5			
10:20	1			1				0				1
10:50		0		2				0				4
11:20			1			5			8		0	
11:50			1			1	4				0	

BUS #30 BARTON CREEK - OUTBOUND

SCHEDULED	23-Jun (J)			24-Jun (J)			26-Jun (S)			29-Jun (S)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
10:15			4			2			1	1		
10:45			4			1			1			3
11:15			6	1					1			1
11:45	1				0							3

BUS RELIABILITY - HIGHLAND MALL (PEAK)
BUS #7 DUVAL/DOWNTOWN
OBSERVER: B & S

SCHEDULED	9-Jul (B)			13-Jul (S)			14-Jul (S)			15-Jul (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
2:59			4									
3:14			1									
3:34		0								1		
3:51	1								1			1
4:04			4	1				0				1
4:19			1	1			3					2
4:34			1			3	2				0	
4:49		0				9		0				3
5:04		0			0			0				2
5:21		0			0		2			1		
5:34		0			0		1				0	
5:49			2			1		0				
6:00						1						

BUS RELIABILITY - HIGHLAND MALL (OFF-PEAK)
BUS #7 DUVAL/DOWNTOWN
OBSERVER: J & S

SCHEDULED	8-Jul (J)			9-Jul (J)			10-Jul (J)			13-Jul (S)		
TIMES	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
10:04	1			2				0				1
10:34	4			4				0				1
11:04			1			2			4		0	
11:34	2				0		2				0	
12:04		0		2			1			5		

BUS RELIABILITY - HIGHLAND MALL (PEAK)

BUS #7 NORTHCAPE

OBSERVER: B & S

SCHEDULED	9-Jul (B)			13-Jul (S)			14-Jul (S)			15-Jul (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:38			2									10
4:09		0				3			2			1
4:39			2	1			3					1
4:54			2	2			2					2
5:09			6			5			3			6
5:24			1		0		1					1
5:39			2		0		1					

BUS RELIABILITY - HIGHLAND MALL (OFF-PEAK)

BUS #7 NORTHCAPE

OBSERVER: J & S

SCHEDULED	8-Jul (J)			9-Jul (J)			10-Jul (J)			13-Jul (S)		
TIMES	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
9:50			2			4			6		0	
10:05	4			2			4			4		
10:35	2				0		3			2		
11:05			3			3		0				5
11:35			2	4			1					2
12:05	2			2			7					3

BUS RELIABILITY - HIGHLAND MALL (PEAK)
BUS #8 GOVALLE
OBSERVER: B & S

SCHEDULED	9-Jul (B)			13-Jul (S)			14-Jul (S)			15-Jul (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:21			10									11
3:51			1				2					4
4:21			3			9			3			15
4:51			5			2			9			6
5:27			5			5			8			4
5:58						4						

BUS RELIABILITY - HIGHLAND MALL (OFF-PEAK)
BUS #8 GOVALLE
OBSERVER: J & S

SCHEDULED	8-Jul (J)			9-Jul (J)			10-Jul (J)			13-Jul (S)		
TIMES	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
9:54	3					2	1			4		
10:24	2				0		1				0	
10:54			1	1					1	2		2
11:24			4			3			5			6
11:54	2					1	1					1

BUS RELIABILITY - HIGHLAND MALL (PEAK)
BUS #15 RED RIVER*
OBSERVER: B & S

SCHEDULED	9-Jul (B)			13-Jul (S)			14-Jul (S)			15-Jul (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
2:55	10											
3:25		0										12
3:55			8			1			3		0	
4:10		0			0				1			1
4:25		0		2			4				0	
4:40		0		1			4				0	
4:55	1					1	6			1		
5:10			2		0				1			1
5:25			2			1	6				0	
5:40		0			0		2					
5:55				1			2					

*ALL ACTUAL DEPARTURE TIMES

BUS RELIABILITY - HIGHLAND MALL (0FF-PEAK)
BUS #15 RED RIVER
OBSERVER: J & S

SCHEDULED	8-Jul (J)			9-Jul (J)			10-Jul (J)			13-Jul (S)		
TIMES	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
9:55			3	5			3			5		
10:25	5			7			1*			7		
10:55	7			6			7			1*		
11:25	4			5			1*			2*		
11:55	5			4			4			5		

*ACTUAL DEPARTURE TIMES

BUS RELIABILITY - HIGHLAND MALL (PEAK)
BUS #32 AIRPORT BLVD *
OBSERVER: B & S

SCHEDULED	9-Jul (B)			13-Jul (S)			14-Jul (S)			15-Jul (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
2:50		0										
3:25		0										
4:00		0			0				1			6
4:35		0			0				1			11
5:10			2		0				3			4
5:45		0				1			1			

*ALL ACTUAL DEPARTURE TIMES

BUS RELIABILITY - HIGHLAND MALL (0FF-PEAK)
BUS #32 AIRPORT BLVD
OBSERVER: J & S

SCHEDULED	8-Jul (J)			9-Jul (J)			10-Jul (J)			13-Jul (S)		
TIMES	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
10:10			8			8			3			2*
10:45			5			2			1*			3*
11:20			1			4			6			2*
11:55			3			6			7			4

*ACTUAL DEPARTURE TIMES

BUS RELIABILITY - HIGHLAND MALL (PEAK)
BUS #39 WALNUT CREEK
OBSERVER: B & S

SCHEDULED	9-Jul (B)			13-Jul (S)			14-Jul (S)			15-Jul (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:25			1									
3:55			3		0		3			1		
4:25		0				1	1				0	
4:55		0			0			0			0	
5:25		0				11	2			3		
5:55						1		0				

BUS RELIABILITY - HIGHLAND MALL (OFF-PEAK)
BUS #39 WALNUT CREEK
OBSERVER: J & S

SCHEDULED	8-Jul (J)			9-Jul (J)			10-Jul (J)			13-Jul (S)		
TIMES	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
9:55	5				0			0		4		
10:25	1				0				4	5		
10:55	3				0		3					3
11:25			2	1			1				0	
11:55			2			4	1					6

BUS RELIABILTITY - NORTHCROSS MALL (PEAK)

BUS #3 BURNET - MALL STOP - INBOUND

OBSERVER: J & B

SCHEDULED	16-Jul (J)			21-Jul (J)			22-Jul (B)			23-Jul (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:26			3									
3:41			2						3			
3:56									4			3
4:11			4			2			3			3
4:26			2			2			3			3
4:41			3			3			3			1
4:58			3			3			1			4
5:11			2						2			1
5:41									5			4

BUS #3 BURNET - MALL STOP - OUTBOUND

SCHEDULED	16-Jul (J)			21-Jul (J)			22-Jul (B)			23-Jul (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:31									18			
4:01			15			18			2			17
4:31			3			4	14					3
4:41												
4:56												
5:11						10						
5:26									13			13

BUS RELIABILITY - NORTHCROSS MALL (OFF-PEAK)

BUS #3 BURNET - MALL STOP - INBOUND

OBSERVER: J & B

SCHEDULED	17-Jul (J)			20-Jul (J)			21-Jul (B)			22-Jul (J)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
9:41									1			
10:11		0				3		0				3
10:41			6			1		0				2
11:11			4			5			1			5
11:41			4			3			1			6

BUS #3 BURNET - MALL STOP - OUTBOUND

SCHEDULED	17-Jul (J)			20-Jul (J)			21-Jul (B)			22-Jul (J)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
9:58			4			4			3			
10:28					0		2				0	
10:58						1			1			1
11:28						8						

BUS RELIABILITY - NORTHCROSS MALL (PEAK)

BUS #5 WOODROW - INBOUND

OBSERVER: J & B

SCHEDULED	16-Jul (J)			21-Jul (J)			22-Jul (B)			23-Jul (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:27			5									
3:42		0						0				
3:57			6						2			3
4:12			2			3		0			0	
4:42			1			24			2		0	
5:12			2			10			4			5
5:42									1		0	

BUS #5 WOODROW - OUTBOUND

SCHEDULED	16-Jul (J)			21-Jul (J)			22-Jul (B)			23-Jul (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:27			5									
3:42		0						0				
3:57			6						2			3
4:12			2			3		0			0	
4:42			1			24			2		0	
5:12			2			10			4			5
5:42									1		0	

BUS RELIABILITY - NORTHCROSS MALL (OFF-PEAK)

BUS #5 WOODROW - INBOUND

OBSERVER: J & B

SCHEDULED	17-Jul (J)			20-Jul (J)			21-Jul (B)			22-Jul (J)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
9:42								0				
10:12			2			6			3			4
10:42			5			3			1			3
11:12			1			3		0				3
11:42			2			3		0				3

BUS #5 WOODROW - OUTBOUND

SCHEDULED	17-Jul (J)			20-Jul (J)			21-Jul (B)			22-Jul (J)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
10:05			3			6			3			5
10:33	2					1			1			3
11:01			2			3	2				0	
11:31			3			1		0				2

BUS RELIABILITY - NORTHCROSS MALL (PEAK)
BUS #44 ARBORETUM
OBSERVER: J & B

SCHEDULED	16-Jul (J)			21-Jul (J)			22-Jul (B)			23-Jul (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:36			7									
4:36	2			1			4			1		
5:36				5					3			4

BUS RELIABILITY - NORTHCROSS MALL (OFF-PEAK)
BUS #44 ARBORETUM
OBSERVER: J, B & S

SCHEDULED	17-Jul (J)			20-Jul (J)			21-Jul (B)			22-Jul (S)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
10:33			3		0		1					2
11:33						3		0				1

BUS RELIABILITY - NORTHCROSS MALL (PEAK)

BUS #25 OHLEN - WESTBOUND

OBSERVER: J & B

SCHEDULED	16-Jul (J)			21-Jul (J)			22-Jul (B)			23-Jul (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
4:03	2											
4:36							1					
5:06	3			3			3			2		

BUS #25 OHLEN - EASTBOUND

SCHEDULED	16-Jul (J)			21-Jul (J)			22-Jul (B)			23-Jul (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:43			1						2			
4:13			1			2		0			0	
4:43			1			1			1		0	
5:13			2			4			2		0	
5:43									4		0	

BUS RELIABILITY - NORTHCROSS MALL (OFF-PEAK)

BUS #25 OHLEN - WESTBOUND

OBSERVER: J, S, & B

SCHEDULED	17-Jul (J)			20-Jul (J)			21-Jul (B)			22-Jul (S)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
10:27			11									
10:57		0										4
11:27			2									4

BUS #25 OHLEN - EASTBOUND

SCHEDULED	17-Jul (J)			20-Jul (J)			21-Jul (B)			22-Jul (S)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
9:43			8						2			
10:13			1			1	2					2
10:43			3			2			7			3
11:13			2			3	1					3
11:43			2			3			2			3

BUS RELIABILITY - NORTHCROSS MALL (PEAK)

BUS #8 GOVALLE - NORTHBOUND

OBSERVER: J & B

SCHEDULED	16-Jul (J)			21-Jul (J)			22-Jul (B)			23-Jul (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:58			2						4			5
4:28	3					15			1	1		
4:58		0				13			1			2
5:28			1						8			7

BUS #8 GOVALLE - SOUTHBOUND

SCHEDULED	16-Jul (J)			21-Jul (J)			22-Jul (B)			23-Jul (B)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
3:35			1									
4:05		0							2			3
4:35	3					19			2			1
5:11			2			6			1			1
5:42									3			2

BUS RELIABILITY - NORTHCROSS MALL (OFF-PEAK)

BUS #8 GOVALLE - NORTHBOUND

OBSERVER: J, S, & B

SCHEDULED	17-Jul (J)			20-Jul (J)			21-Jul (B)			22-Jul (S)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
9:53			3				2					
10:23	1					1	2				0	
10:53			5			3			9			
11:23	1					1	1				0	
11:53								0				

BUS #8 GOVALLE - SOUTHBOUND

SCHEDULED	17-Jul (J)			20-Jul (J)			21-Jul (B)			22-Jul (S)		
TIME	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE	EARLY	ON TIME	LATE
9:38									2			
10:08			1			4			2			2
10:38			3			4		0				2
11:08			7			6			5			7
11:38			1			3			1			6