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THE UNIVERSITY OF ALBERTA

Factors Influencing Bus Passenger Wait Time in Edmonton

by

Marcel Joseph Huculak

A THESIS

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To Dad

I Love You

Abstract

Residential-end waiting times of bus passengers at bus stops in Edmonton, Canada were studied in this research. Previous research gave little attention to the effects of passenger attributes. Thus this study examined the influence of passenger trip purpose, schedule knowledge, and experience catching buses upon waiting time. Also examined were the influences of day to day weather and of persons arriving in groups.

A data collection method was designed to minimize the impact of the observer on bus driver and bus passenger behavior. The method used passenger interviews to link observed wait times with passenger attribute data. Detailed are the successes and failures of this obtrusive observation technique.

Data analysis was guided by statistical procedures. It was found that weather did not have a significant effect on the observed waits, although the range of observed weather was small. In contrast, groups tended to change their arrival behavior during less favorable weather. Although trip purpose did not have a strong effect, both experience and schedule knowledge had significant effects on passenger waits. Applications of these findings and recommendations for further research are given to direct future research.

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the determination to complete this research in the face of personal adversity.

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1. Introduction

1.1 Purpose

The purpose of this research is to gain a better understanding of some factors which affect bus passenger waiting time. Many factors affect wait time. A literature review is used to guide this research, by showing which factors have or have not been studied.

Many types of wait times can be defined. In this research, only waits where passengers are free to choose their bus stop arrival times and where bus arrival times are reliable are studied. A passenger's arrival time must not be controlled by the end-time of another activity, such as another bus arriving (for transfers) or as passengers arriving at a stop immediately after leaving work. Reliable bus arrival times mean that a bus's day to day arrival time does not change during a particular schedule period (eg. Monday to Friday, AM Peak).

Although this research will study "bus" passenger wait time, it is applicable to other similar modes of public transport. The importance of wait time studies, providing motivation for this research, is outlined below.

1.2 Importance of Waiting Time

Rohr (1990), in developing a marketing segmentation method for public transport, referred to the importance of wait time, stating "...two key public transport attributes which affect whether individuals will choose public transport or not are the walk times from their homes to their transit stops and their wait times." Passengers often view wait time as one of the most inconvenient portion of a bus trip. Their goal is to travel, yet they are stationary. Waiting passengers may also experience discomfort due to lack of shelter or place to rest. To reflect this inconvenience, mode split models (calibrated from measured travel behavior) often weight the waiting time portion of a bus trip by two to three times as much as the in-bus travel time (It should be noted that Hunt (1988) developed a mode split model which did not explicitly include origin wait time). A better understanding of wait time may lead to measures which reduce wait time, and improve passenger perceptions of the bus system.

A better understanding of wait time can also help improve wait time models. Such models provide input into mode split models used for transportation planning. Mode split models can be sensitive to relatively small changes in wait time.

Wait time models are also used to evaluate system performance. Often, changes in service will change wait times. An accurate assessment of possible changes in wait time can help evaluate the benefits and costs of a service change.

Wait time is perceived as inconvenient by passengers. Wait time models are important input into mode split models, and into system performance evaluation. A better understanding of some of the factors affecting wait time may help to improve passenger perceptions and wait time models.

1.3 Summary of Contents

Past research on bus passenger waiting time is reviewed, and results pertaining to factors affecting wait time are presented. The review identifies the factors to be studied. A Proposed Data Collection Methodology Section details how data on the factors studied was to be collected. Then the actual data collection procedure is described, attending mostly to problems encountered. The collected data is then analyzed. The Analysis Section describes the analysis techniques used and their results. The Conclusions and Recommendations summarize the results of the research, and recommend applications of the results as well as areas in need of further study.

2. Past Research on Bus Passenger Wait Time

2.1 Introduction

This review of past literature serves two purposes:

1. to summarize the findings of research related to factors affecting bus passenger waiting time
2. to use this summary to formulate the research objective.

The past research is presented in chronological order. Each researcher's findings are summarized with respect to the factors affecting wait time and to the effect of these factors. These findings are summarized at the conclusion of this chapter.

2.2 Holroyd and Scraggs (1966)

These two researchers did not actually measure passenger wait times. Instead, they measured bus headways in Central London, England, and estimated wait times by assuming random passenger arrivals during the observation period. They acknowledged that this assumption would not hold for infrequent services, but did not attempt to determine the headway of an infrequent service. They instead limited the study to average headways of less then 10 minutes.

Their formula for estimating wait times for a given observed set of bus headways was as follows:

$$\bar{w} = \frac{\Sigma_i \; n_i (h_i/2)}{\Sigma_i \; n_i}$$

substituting $n_i = h_i$

$$\bar{w} = \frac{\Sigma_i \; h_i^2}{2\Sigma_i \; h_i}$$

where:

$\bar{w}$ = average wait time

n_i = number of passengers in bus headway i

h_i = length of headway i

In words, the average waiting time for randomly arriving passengers is the sum over all observed headways of the number of passengers in each headway h_i multiplied by their average wait ($h_i/2$), divided by the total number of passengers observed. The number of passengers arriving in bus headway n_i is directly proportional to the length of headway h_i

Holroyd and Scraggs (1966) then applied a correction to the above formula for incomplete headways falling on the "edges" of the observation period. The formula shown above is given by several other researchers, and assumes that passenger arrivals are random and that passengers are able to board the first bus available.

Holroyd and Scraggs (1966) found that for average headways ($\bar{h}$) less than or equal to 2 minutes, the estimated wait time is similar to the case of randomly arriving buses and passengers (i.e. $\bar{w} = \bar{h}$), while for longer headways average wait times approached that of randomly arriving passengers with perfectly regular bus arrivals ($\bar{w} = \bar{h}/2$).

2.3 Gill (1969)

This 1969 thesis dealt mainly with bus routing in Edmonton, Alberta. However, there was some discussion of waiting time.

Gill (1969) recognized that elements of bus excess time such as waiting time "...depend on the frequency of service unless the schedule is known." He implies that some knowledge of the bus system can affect waiting time.

As part of his research, Gill (1969) handed out questionaires to waiting AM peak passengers, which were returned before boarding. He also measured waits for these passengers. One of the questions asked what time the bus arrived at the stop. He found that 98% of the passengers knew the bus arrival time, although he did not state what criterion were used to judge responses. This concurs with the findings of Bowman and Turnquist's (1981) wait time model for AM peak Chicago area bus passengers.

Gill (1969) found that the mean waiting time for these passengers was 3.88 minutes, for a minimum headway of 20 minutes. He stated that for other times of day, wait times may be longer as passengers may be less familiar with schedules.

It appears that Gill's (1969) passengers were basing their questionaire responses upon experience, not a published schedule. Therefore, the question is more likely a measure of experience using the bus, not schedule knowledge. Nonetheless, by using a quesionaire procedure Gill (1969) was able to link wait time data to passenger data.

2.4 O'Flaherty and Mangan (1970)

O'Flaherty and Mangan (1970) examined the relation between average headway and average passenger wait time for PM peak and offpeak conditions in Leeds, England. Wait times were measured for the PM peak conditions. For the offpeak data, actual passenger wait times were not measured, but were estimated by the same formula as Holroyd and Scraggs (1966).

For the PM peak measurements, they found that actual passenger wait times tended to be less than half the headway for headways greater than about 5 minutes. This was a significant finding. They had found a definition of an "infrequent service". Later researchers also defined the headway at which passenger arrivals cease to be random.

O'Flaherty and Mangan (1970) also observed that as the average bus frequency decreased by a factor of ten (from 1.2 minutes to 12 minutes), the measured average wait time increased only by a factor of 1.75 (from 2.0 minutes to 3.5 minutes). This illustrates the inelastic nature of average wait time with respect to service frequency.

2.5 Seddon and Day (1974)

These two researchers observed wait times during AM peak, offpeak and PM peak periods in Manchester, England. Observed headways ranged from 4 to 30 minutes. They wished to determine the headway at which passenger arrivals cease to be random.

For their data, they found passengers do not arrive randomly at headways around 10 to 12 minutes. This differs from O'Flaherty and Mangan (1970). Seddon and Day (1974) did not refer to O'Flaherty and Mangan's (1970) research, although it is likely that the discrepancy is due to the time periods at which the observations were made and the type of stops observed. Seddon and Day (1974) were quite explicit in describing the stop types observed, while it is unknown what stop types O'Flaherty and Mangan (1970) observed.

Seddon and Day (1974) also concluded that using the formula which assumes random passenger arrivals (as given in the Holroyd and Scraggs (1966) section) overestimates the observed wait time, and that in general the overestimation increases as the headway increases.

2.6 Okrent (1974)

The objectives of Okrent's (1974) thesis research were:

1. to determine the condition in which passenger arrivals are uncoordinated with vehicle arrivals.
2. to produce a model of passenger arrivals when

passenger arrivals are not coordinated with vehicles arrivals.

Okrent (1974) formulated a hypothesis of passenger arrival time coordination with vehicle arrivals. He gave the degree of coordination as a function of:

1. System characteristics:
   a. Headway - longer headways have more "coordination" because of greater potential to reduce wait time.
   b. Reliability of Service - more coordination with better reliability.
   c. Easily Known Schedule - either a simple schedule (i.e. clock headways) or one which is well publicized.
2. Trip Characteristics:
   a. Familiarity with the service - a rider's experience with a particular service.
   b. Flexibility - if trip departure and arrival times are unimportant the passenger may not care about time wasted at a stop. Conversely, passengers may not arrive at the stop until the bus is due to arrive. They may pass time "window shopping" or doing some other activity, then rush to the stop when the bus arrives.

Okrent (1974) identified that a passenger's experience "catching the bus" may influence wait time (Note: "Catching the bus" is a colloquial expression meaning that passengers "arrive in time to board" a bus. Because of its relative brevity, "catching the bus" will be used throughout this thesis). Previous researchers mostly considered bus system characteristics only (i.e. headways), and implicitly assumed a homogeneous population of passengers. In a sense, Okrent (1974) turned the tables around. He considers that passengers may influence their own waiting time rather than simply the bus's influence on the passenger's wait.

Unfortunately, Okrent (1974) did not investigate the effect of passenger experience on wait time. Only headway and reliability were studied. Futhermore, he used the standard deviation of headways as a measure of reliability. Although he shows that the standard deviation of headways and of bus arrival times are related, he assumes that each bus at a particular stop has the same degree of day to day reliability. This may not be true, as changing traffic conditions through a day may govern bus reliabilities at a given time of day. Also, different bus drivers may have different reliabilities. Therefore, the standard deviation of headways may not reflect the day to day reliability that a passenger faces (although for some passengers, who may catch different buses on different days at the same stop, an aggregate reliability of all buses may be more appropriate).

Okrent (1974) observed a variety of Chicago, Illinois, area bus stops at a variety of times (AM peak, midday, Saturday, and PM). Locations selected provided a broad range of headways and service reliabilties. Average headways varied from 5.8 minutes to 30 minutes.

He found that as the average headway exceeds 13 minutes, the uniform random passenger arrival assumption must be rejected. For stops where $\bar{h} > 13$ minutes but arrivals were still random, he explained that given the time of day for these observations (Saturday and Noon), trip purpose (i.e. shopping) likely played a role and thus patrons were less familiar with the service. Again Okrent (1974) has an unique perspective. He implies that either trip purpose or experience (or both) influence a passenger's wait time.

Okrent (1974) points out that studying trip purpose or experience is possible. Passengers could be interviewed for experience and trip purpose, and the effects of these variables on waiting time could be analysed. He further recommended that effects upon wait time such as adverse weather, waiting shelters and night time conditions be studied.

2.7 Jolliffe and Hutchinson (1975)

Jolliffe and Hutchinson (1975) used a behavioral approach to explain bus passenger wait time. From some of the above past research they knew that for certain headways passengers did not arrive randomly at stops. They explained this by considering passengers to be one of three possible types:

1. a proportion q whose arrival time is casually

coincidental with the bus

2. a proportion p(1-q) who arrive at the optimal time (the time at which the expected waiting time is a minimum)

3. a proportion (1-p)(1-q) who arrive at random.

Casually coincidental arrivals were defined as passengers who, while perhaps shopping or doing some other activity, see the bus approaching, drop their activity, and run to the bus stop. Expected wait time was defined as the average, over all days observed, of the time elapsing before the next bus departs, for each minute in the observation period.

Jolliffe and Hutchinson (1975) provide support for their hypothesis by arguing that "...if there is a published timetable for the service, or if buses tend to run at certain fixed times rather than at others and there are some passengers who frequently make the same journey, then it may be expected that the bus and passenger arrival times at the stop will be associated so as to reduce the average waiting below that given by..." assuming random passenger arrivals. This argument implies the importance of passenger experience catching the bus. They further state that the gain in reduced waiting time is affected by the extent that buses arrive at the same time from day to day, rather than the regularity of the service from day to day. That is, it is better for buses to arrive at 7:10, 7:15, 7:30, 7:45 on consequetive days rather than arriving at 7:00, 7:15, 7:30, 7:45 one day, 7:10, 7:25, 7:40, 7:55 the next and then 7:05, 7:20, 7:35, 7:50 on the third day.

Jolliffe and Hutchinson (1975) felt that their model of wait time worked well for the data they collected in the south London suburbs, because they felt that the proportions p and q are likely related to:

1. the time of day
2. the socio-economic characteristics of the passengers
3. the type of development near the stop.

in a simpler way than average wait time itself.

2.8 Chapman, Gault and Jenkins (1976)

These researchers did not study passenger wait time, but instead studied urban bus route operations. They did, however, touch upon some aspects of wait time.

They felt that passenger wait time depended on:

1. schedule frequency
2. passengers' knowledge of the timetable and their experience with actual service
3. evenness of headways (for short heaway services).

Again, experience and schedule knowledge are identified as influences on wait time, but no further investigation is made.

Chapman, et al (1976) went on to critize the analysis procedures of O'Flaherty and Mangan (1970) and Seddon and Day (1974). Chapman, et al (1976) noted that these researchers measured actual arrivals of passengers and buses, calculated an average wait time then compared it to a theoretical average wait time from an appropriate headway distribution. This is a roundabout way of testing for random arrivals; a Chi-Squared test on the wait time distributions would have sufficed.

2.9 Jackson (1977)

Jackson's 1977 thesis studied passenger waiting time in Toronto, Ontario. Much of his research associates individual passenger interview data with wait time data. The interview tested each passenger's knowledge of bus arrival times. Depending on the interviewed passengers' accuracy, they were classified as either a random or non-random arrivals. Jackson (1977) felt that his interview classification method was successful.

Although Jackson (1977) states that he examined passenger schedule knowledge, it appears that he actually measured passenger experience catching buses at the observed stops. He defined schedule knowledge "...as the time difference between a passenger's anticipated bus arrival [as stated in the interview] and the scheduled bus arrival." But since the observed stops were not timing points, he defined scheduled bus arrival as the observed average arrival time of the bus. Thus his schedule knowledge actually measures experience, as a passenger would need to experience bus arrivals on several days to correctly estimate the average bus arrival time. Jackson (1977) even admits that a passenger "...learns the scheduled bus arrival time by observation and trial and error." He concluded that there is evidence to suggest peak users know "schedules" better than offpeak users. In the context of experience, this seems reasonable. During peak periods, trips are more regular and thus experience measured would be higher than during offpeak periods.

In analysing his data, Jackson (1977) found a difference between random and non-random interviewed passenger arrival distributions for 12 and 15 minute headways, but differences for the 5 and 10 minute headways were not as great. Jackson (1977) also tested a stop with a 25 minute headway, but results from it are ignored in the summary. The stop was near an apartment and Jackson (1977) felt that some passengers were waiting inside the building.

Jackson (1977) also found a problem with his interview technique for distinguishing random arrivals. For longer headways, passengers that were defined as random arrivals did not tend to arrive randomly. He explained this by stating that while passengers "...may express ignorance of the bus schedule when interviewed, they, in fact, are not behaving like true random arrivals." Despite this problem, he still felt that "...the hypothesis that passengers who express no knowledge of schedule arrive according to a uniform distribution appears to be reasonable."

Jackson (1977) examined the proportion of random and non-random arrivals for particular headways. Generally he found:

1. that the proportion of random arrivals decreases with increasing headway
2. that, for similar headways, the proportion of random arrivals is higher for offpeak passengers.

The first finding is likely due to a lower proportion of "non-transit captives" avoiding an infrequent service. The second finding is likely a function of trip purpose (i.e. work trips versus shopping trips). Shopping trips are also less frequent, and thus these passengers are relatively less familiar with the service.

Jackson (1977) examined "safety margin" - "The time difference between his [a passenger's] arrival at a stop and his anticipated bus arrival time." He concluded that "...it appears that longer headways elicit greater margins of safety but this increase is small compared to the penalty (the bus headway) for missing the bus." This is consistent with O'Flaherty and Mangan's (1970) finding that wait time is inelastic with headways.

Jackson (1977) also recognized that weather may influence waits. Therefore, he did not survey "...during periods of precipitation or extreme temperature."

2.10 Turnquist (1978)

The objectives of this study were twofold:

1. to produce a wait time model with explicit treatment of non-random passenger arrivals
2. to incorporate the effect of day to day reliability

on passenger wait time.

Turnquist (1978) uses a similar argument as Jolliffe and Hutchinson (1975) to explain non-random arrivals. He states "...if buses tend to adhere to a fixed schedule and there are passengers who make the same trip frequently, it may be expected that some passengers will plan their arrival at the bus stop so as to be there just before the bus comes." Once again, passenger experience (via frequency of use) is implied as a key ingredient to reduce wait time. He differs from Jolliffe and Hutchinson (1975) with regard to casually coincidental arrivals. He feels that they are not a behaviorally distinct group, but rather that they belong to either random or non-random passenger arrival groups. Their behavior is then "...modified slightly as a result of seeing the bus coming."

Turnquist (1978) also differs from Jolliffe and Hutchinson (1975) in the treatment of non-random arrivals in his model. He assumes non-random arrivals minimize expected wait time subject to a constraint which fixes the probability of missing the selected bus. This reflects a more risk-aversive behavior. It appears to be a reasonable behavior mechanism given the findings by Jackson (1977) regarding "safety margin".

In the end, Turnquist (1978) presents a model predicting average passenger wait time at bus stops as a function of the headway distribution between successive buses and of the arrival time distribution of a given bus from day to day. The model provided a means of predicting service change impacts.

2.11 Smith, Soland and Warmoes (1978)

Bus passenger wait times in Montreal, Quebec were observed by Smith, et al (1978) so that they could construct a statistical model of passenger arrival patterns and waiting times for use in evaluating transit operations. Passengers were observed in peak and offpeak conditions. They found that for headways of less than 4 minutes passenger arrivals were random, while for larger headways passenger arrivals were skew towards shorter wait times.

2.12 Bowman and Turnquist (1981)

Citing Okrent (1974), Jolliffe and Hutchinson (1975), Jackson (1977), and Turnquist (1978) as studies which separated passengers into "aware" and "unaware" of bus schedules, Bowman and Turnquist (1981) used this concept to develop a model which evaluates the sensitivity of expected (model predicted) passenger wait time at a bus stop to service frequency and schedule reliability. The model explicitly incorporates a passenger decision making process. It uses a logit formulation to model passengers who are "aware" of the schedule.

They calibrated the model to wait time data collected in Chicago and Evanston, Illinois during AM peak periods. They found that the proportion of "aware" passengers was estimated as 1.0 for nearly all cases. This was attributed to the regular nature of AM peak trips, and matches findings with Gill's (1966) research.

Their model implied that wait time is "...much more sensitive to schedule reliability and much less sensitive to service frequency than previously thought."

2.13 Lam and Morrall (1982)

This is the only research to examine the effect of weather on bus passenger wait time. Lam and Morrall (1982) collected data in Calgary, Alberta during summer and winter seasons, and for a variety of stop types and times of day. They aggregated then analyzed each seasons' data, concluding that the hypothesis that average waiting times in summer are greater than in winter was supported by their data. However, they stated that the passenger populations are also different during these seasons, with more post-secondary and institutional (school) trips in winter, with summer vacations reducing the work force by 20-25%, and with more reliance on transit in winter, especially in very cold weather, when automobiles will not start or roads are hazardous. Thus the measured difference may be due to passenger populations rather than to seasonal weather.

Lam and Morrall (1982) found that using different analysis procedures may lead to differing conclusions regarding the headway at which passenger arrivals cease to be random. They first plotted average wait time against average headway. They concluded that for average headways less than 10 minutes average waiting times were about half the average headway. For longer average headways, the average wait time was less than half the headway. However, when they used a Chi-Squared test procedure, they found that passenger arrivals were not random, but that passengers tended to arrive at the end of the headway. They attributed part of this finding to their observation that passengers were increasing their walking speeds to catch an approaching or waiting bus.

2.14 Hutchinson, Burt, Cuzner and Howell (1986)

Hutchinson, et al (1986) presented the same model of bus passenger wait time as Jolliffe and Hutchinson (1975). New data were collected in suburban Coventry, England, and they found that the model was still adequate. They added that because this model accounts for different passenger behavior, it can examine how policy changes affecting regularity (but not reliability) will impact each modelled passenger group.

2.15 Summary of Bus Passenger Wait Time Research

Generally, the past research has contributed new knowledge to four areas. First is the headway at which passenger arrivals cease to be random. It ranged from 4 to 13 minutes for the research discussed. Discrepancies arise because of the different analysis techniques used, because of the different stop types observed, and because of the different transit systems observed.

The second contribution of the above reasearch is that the average wait time is inelastic with respect to headway.

The third contribution of the past research is identifying factors which affect wait time. Collectively these researchers found that wait time is, or may be, a function of:

1. Bus headway
2. Bus reliability (day to day punctuality of a particular bus)
3. Bus regularity (uniformity of headways)
4. Passenger experience catching the bus
5. Passenger schedule knowledge
6. Passenger trip purpose
7. Passenger socio-economic characteristics
8. Seasonal weather
9. Day to day weather
10. Type of land use near the stop
11. Night/day conditions
12. Shelter at the stop.

The first three factors received the most attention in the past reasearch.

Finally, the past research has contributed to the use of passenger interviews in wait time studies. Such interviews may be used to determine information about passengers, such as passenger trip purpose or schedule knowledge. Interview data can also be linked to observed waits for analysis.

3. Research Objective

The past research has identified many factors which affect bus passenger waiting time. Most studies were directed at how bus operational parameters such as bus headways, reliabilities, and regularities affect average passenger waiting time.

Researchers such as Okrent (1974), Jolliffe and Hutchinson (1975), Jackson (1977), and Bowman and Turnquist (1981), among others, realized that passengers may also affect their waits, particularly if the bus service is reliable. These researchers felt that trip purpose, schedule knowledge, experience catching the bus, and socio-economic characteristics may affect measured wait times. However, limited actual research has been undertaken upon these factors, and often the methodology is unclear.

Other researchers, such as Jolliffe and Hutchinson (1975) and Jackson (1977), implied that time of day (i.e. peak versus offpeak) affects waiting times. However, it would seem that time of day merely describes the trip purpose or experience catching the bus that most passengers may have at that time of day.

During a preliminary study (Edmonton, Canada, June/July 1987, Route 18 at 118 Avenue - 38 Street), both experience catching the bus and schedule knowledge seemed to play a role for some passengers' wait times. The study observed the same stop for twenty nine consecutive weekdays. Passengers were identified by their physical characteristics as remembered by the observed and their arrival times were recorded. Figure 3.1 shows a passenger who seemed to use her experience to catch the bus. She arrived at nearly the same time every day and usually caught the same bus every day.

During this preliminary study, the bus schedules were changed to match reduced summer passenger loads (bus headways were increased from 10 to 15 minutes). However, the newly published route brochures displayed the old schedule. It could be seen that some passengers were confused. Figure 3.2 illustrates one such passenger. His arrival times were very precise. After missing the bus due to the schedule change, his next arrival was his earliest observed arrival. He was trying to adjust his arrival time after "missing" the bus the previous day. Unfortunately this passenger (likely a student) was only observed twice after the schedule change.

Data for this preliminary study were not ideal. It was strongly suspected that the observer's presence affected some of the arrival time observations made. However, the study did tend to indicate that experience catching the bus and schedule knowledge both affect wait time. A better experimental design could help to measure these effects.

The past research emphasises the effects that bus operations may have on waiting time. Little attention has been paid to the passenger's perspective. Passenger trip purpose, schedule knowledge, and experience catching the bus seem to be the most frequently mentioned passenger variables that may affect passenger waiting times. Thus the objective

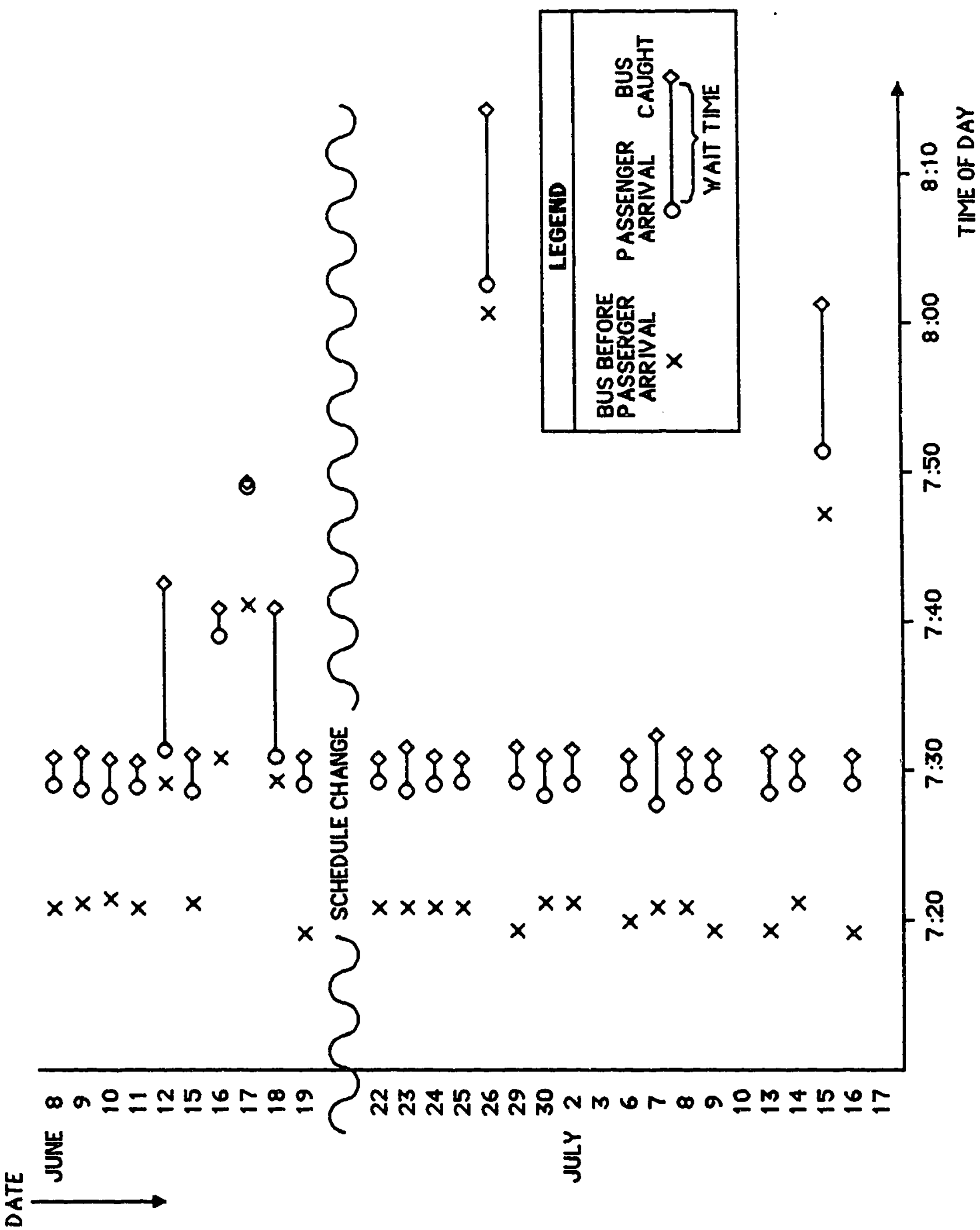

Figure 3.1 An Experienced Bus Passenger's Arrival Times and Wait Times.

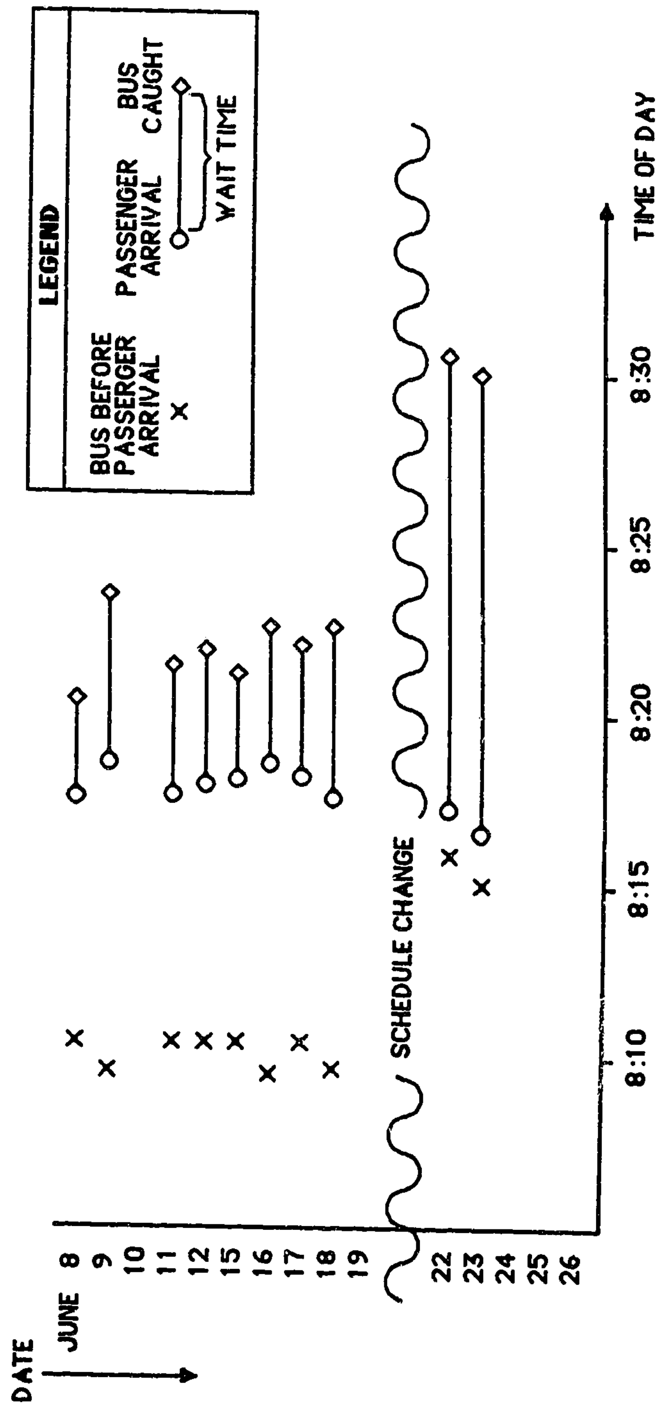

Figure 3.2 A Confused Passengers Arrival Times.

of this research is to examine the effect of passenger trip purpose, schedule knowledge, and experience catching the bus on passenger wait time at bus stops.

4. Proposed Data Collection Mathodology

4.1 Introduction

This chapter's purpose is to address the research objective by identifying the data needs and by proposing a data collection methodology. The proposed data collection methodology explains the intended manner in which the data were to be collected. It was to anticipate practical and theoretical constraints so that data collection could proceed smoothly. Problems encountered by the proposed method, and changes thereby made, are described in the next chapter.

In this chapter the data needs are first identified by considering the research objective. Then the proposed data collection methodology is explained. Finally, the proposed data collection method is summarized.

4.2 Data Needs

The data needs arise from the reseach objective. From Chapter 3, the objective of this research is to examine the effect of passenger schedule knowledge, passenger experience catching the bus, and passenger trip purpose on bus passenger wait time at bus stops.

It is also thought that weather and arrivals of passengers in groups may effect waits. Neither of these variables can be controlled in the experimental design. Also, weather itself is of interest, especially in cities such as Edmonton where weather can vary significantly.

Given the above discussion, data on the following items are required for this research:

1. Wait time- composed of a bus and a passenger arrival time
2. Weather
3. Type of arrival (group or individual)
4. Passenger data
    a. Experience catching buses
    b. Schedule Knowledge
    c. Trip Purpose

Detailed below is the proposed methodology for collecting each of these data items. Each item is described, and the proposed method of collecting that item is presented. Some aspects of this methodology were later modified as described in the following chapter (Data Collection - Execution and Problems).

4.3 Wait Time

Several issues were considered for measuring waiting time. First, there was the "type" of wait to measure, which implied the "type" of stops to observe. Also, several definitions of wait time were possible. Past researchers give guidance here. Finally the actual measurement of time required consideration. Each of these aspects are discussed in the following sections.

4.3.1 Type of Waits

Many past researchers gave little consideration to the type of wait being observed. However, as explained below, the type of wait can have a significant impact on the wait times measured.

For this research, only waits where passengers are free to choose their arrival times within the bus headway are considered. This condition allows observation of waits where passengers may optimize their waits by adjusting their bus stop arrival time. An example of such a wait is a trip starting from a residential area, where the observed stop is the first stop that the passenger started the trip. This condition is violated for trips going home from work, as the passengers bus stop arrival time (and therefore their wait time) is likely constrained by their work quitting time. This "free choice" arrival time condition also rejects transfer trips which arrive at the observed stop by bus. In this case wait times are controlled by the arrival time of the bus that passengers alighted. The effect of transfers was recognized by Smith, et al (1978), Seddon and Day (1974), and Lam and Morrall (1982).

The type of wait desired also imposes some restrictions on the type of stop to be observed, as detailed below.

4.3.2 Type of Stop

In order to observe the type of wait discussed above, it would be necessary to restrict observations to residential areas and to stops where transfers would be unlikely. Several other considerations would be required. Both Seddon and Day (1974) and Jolliffe and Hutchinson (1975) give good guidance for selecting stops to observe. They suggest stops with the following characteristics:

1. service by a single route
2. high passenger usage
3. "open space".

Service by a single route would be required so that the headway that a passenger faces would be known. One could ask passengers which buses they could catch, but it would not be possible to ask passengers with zero waits. As an extension to this rule, it would be possible to observe stops with multiple routes if these routes have either completely common or completely uncommon downstream destinations. For routes with completely common downstream destinations, passengers can catch the first available bus. The headway they face would be the combined headway of all routes at that stop. For routes with completely uncommon downstream destinations, the headway that passengers face would be the headway of the bus caught.

Stops with high (but manageble) passenger usage would be desired so that the amount of time collecting data would be minimized.

The "open space" characteristic would be desired so that passengers wait in clear view. Seddon and Day (1974) found that passengers may hide waits by standing at a corner, waiting for one of two routes, or by walking along the route until they either saw a bus approaching or felt that it was due to arrive. Jackson (1977) found that passengers may wait inside nearby apartments. In Edmonton, it has been observed that some passengers wait inside apartments, especially if they have a vantage point to observe approaching buses well in advance. The "open space" characteristic would help ensure the total passenger wait would be measured, not just the wait at the stop.

In addition to the above guidelines, it was decided to select stops where the service frequency would be one bus every 15 minutes. It was not necessary to collect data for several headways to accomplish the research objective. Also, past research showed that passenger arrivals may be random up to a maximum headway of 13 minutes. This implies that there would be no incentive to optimize waits, and therefore trip purpose, experience catching the bus, and schedule knowledge may be irrelevant explanatory variables under such conditions. A 15 minute headway is a common headway for Edmonton Transit and would imply good passenger usage.

4.3.3 Definitions of Wait Time

Measuring wait time requires observation of passenger arrival times and bus arrival times. Thus definitions for bus and passenger arrival times would be required. A surprising amount of choice exists for such definitions.

Chapman, et al (1976) give a good discussion on three possible measures of wait time:

1. from passenger arrival time to bus arrival time
2. from passenger arrival time to passenger boarding time
3. from passenger arrival time to bus departure time

They note that negative waits are possible with the first definition, unless these are defined as zero.

Chapman, et al (1976) state that the second definition may be closest to perceived wait time, since until the bus is actually boarded the passenger is not sure that there will be no need to wait for the next bus. However, in Edmonton it is rare that passengers are passed-up. Also, from a practical perspective, an observer must remember which passenger belongs to each recorded arrival time. This can be confusing if several passengers board a bus. Also, it would be difficult to simultaneously record precise boarding times for each passenger and correctly match these boarding times to a recorded arrival time. In Edmonton the usual time difference between the first and last passenger boarding is small.

Chapman, et al (1976) state that the third definition of wait time can be related to the headways between buses, as the number of passengers waiting is a function of time since the previous bus departure. This relation is likely true only for close interval services.

Other researchers also discuss how to measure wait time. Seddon and Day (1974) measured wait times using both bus arrival and bus departure times. They found that their regressions of wait time on headways gave better fits when using bus departure times. Lam and Morrall (1982) also used bus departure times to calculate wait times.

Based on the experiences of past researchers, passenger wait time for this research is defined as the difference between bus departure time and passenger arrival time. Definitions for each of these components are given below.

4.3.3.1 Definition of Bus Departure Time

Bus departure time would be defined as the point in time when either the bus doors close (rear or front, whichever is last), or the bus reaches the "Transit Zone" sign (if no passengers are present). Obviously, if no passengers are present then no waits are measured. However, such data could be used to help verify bus schedule adherence.

4.3.3.2 Definition of Passenger Arrival Time

The second component of wait time, the passenger arrival time, is more difficult to define. This is due to the lack of a sharp, definite event in time that defines passenger arrivals as they approach a stop. In the preliminary study conducted in June/July 1987, passenger arrival time was defined as the point in time when the passenger stops walking. However, some passengers slowed their pace as they neared the stop. Lam and Morrall (1982) also noted this behavior. Other passengers would slowly proceed past the stop then turn around or would pace. It was obvious that these passengers had no chance of missing the bus, yet by the definition they had not yet arrived. Thus the definition needed broadening.

This research defines passenger arrival time as the point in time that a passenger is in the "vicinity" of the stop. "Vicinity" here means that the passenger is on the same corner as the stop and cannot miss the bus at his current walking speed. Although this definition required judgement on the observer's part, it was felt that it more closely followed the passengers' perspective of arrival, i.e when they feel that there is no chance of missing the bus.

4.4 Measuring Time

Measurement of bus departure and passenger arrival times would require a watch calibrated to a standard time. Edmonton Transit usually broadcasts the time once every hour on the hour over their bus radio system. This time was used as the standard, as it would help to estimate bus schedule adherence. The calibration procedure would be to periodically listen to the broadcast of Transit time on buses laying over at the University Transit Terminal. To guard against "drift" of the observer's watch, it would be calibrated to another clock at the observer's residence.

4.5 Weather Data

Since the objective of collecting weather data was to determine if passenger arrival behavior changes with weather, it was felt that passenger behavior may provide clues as to the type of weather observed. If passengers were to shift from one foot to another, or to use the passenger shelter more than usual, or to mention that it feels cold, then such behavior could help classify the weather observed.

Additional weather data would include air temperatures from broadcasts on local radio stations immediately prior to the observation period. Also, any precipitation and wind would be noted.

The advantage of using passenger behavior rather than objectively measured values to classify weather is that similar weather conditions may not produce similar passenger behaviors. For example, a 5°C temperature on a winter day may be very comfortable for passengers, and thus may be a "good" weather day. However, a 5°C temperature day on a summer day may be highly uncomfortable and thus passengers may make special efforts either to minimize their waits or to ensure that they will not miss the bus. A "bad" weather day would result.

The main disadvantage of such a method is its subjective nature. The analysis of the data may give some indication as to the method's validity.

In the interests of simplicity, weather would be classified as "good" or "bad" only. Weather classification would take place immediately after the observation period.

Observations would not be taken on days where the weather was so poor that buses would be forced off schedule. Bus arrivals would then tend to be unpredictable, and passenger experience or schedule knowledge would be useless.

4.6 Group Arrivals

A group arrival would be defined as a simultaneous arrival of two or more person walking together and seeming to know one another. Although there was little known effect of group arrivals on wait time, it was thought that there may be some impacts. Passengers that arrived in groups would be noted during data collection. They were assigned common arrival times.

4.7 Passenger Data - Use of Interviews

Collecting passengers' trip purpose, schedule knowledge, and experience would require interaction with passengers. A good practical method to obtain the required passenger data was to interview passengers at bus stops. A post-back questionaire could have been used, but Hunt (1984) states that interviews usually have higher response rates and that the interviewer can clarify questions. Also, post back questionaires have higher monetary costs.

Hunt (1984) also stated that test interviews can be conducted to help design the exact wording of questions. This study's questions were based on the preliminary study conducted in June/July 1987. Interviews also present an opportunity for good public relations. A "Thank-you" letter would be given to participants, aiding future Transportation studies.

Interviews were also used by Jackson (1977) to classify passenger arrivals as random or non-random. He felt that his interviews were successful in this respect.

Thus the interview would be used as the means of obtaining passenger data. However, the decision to use the interview format to collect the data would raise two concerns:

1. Possible mental harm to passengers caused by the interview process
2. Obtrusive observations - i.e. the interviewer's presence affecting the data he would be measuring.

These concerns are each addressed in the following two sections.

4.7.1 Mental Harm Concerns

Because interviews would require the researcher to initiate contact with members of the public, University of Alberta regulations required that an Ethics Review Committee approve the intended interview. These regulations required that the passengers understand that they are being used for research purposes. Thus the interviewer commenced each interview by stating:

"Hi! I'm a university student conducting research on the time people wait for buses, and I was wondering if you could help me out by answering four non-personal questions?"

The Department of Civil Engineering Ethics Review Committee required that the interviewer carry his student identification card while conducting interviews. Futhermore, each interviewed passenger would receive a "Thank-you" letter. It would contain the supervisor's name, mailing address, and phone number. This would provide members of the public an opportunity to comment on the interviewer's conduct and on the interview itself. Figure 4.1 shows the first version of the "Thank-you" letter.

To further justify his presence at bus stops, the interviewer would carry a generic letter from his supervisor. This letter would explain the interviewer's purpose, and give a contact address and phone number. A copy of this letter is shown in Figure 4.2. It would be intended for persistent members of the public who doubted the interviewer's presence, and for police officers who may have been called to the stop by members of the public.

4.7.2 Obtrusive Observation Concerns

Obstrusive observations were of concern to other researchers. Hill (1986) observed the route choice of

Dear Passenger,

Thank-you for participating in this research. If you have any questions or concerns regarding this study, you may contact:

Marcel Huculak (Interviewer)
Room 219J
Civil Engineering Building
University of Alberta
EDMONTON, Alberta
T6G 2G7
ph. 432-2795

Professor J.J. Bakker (Supervisor)
Department of Civil Engineering
Civil Engineering Building
University of Alberta
EDMONTON, Alberta
T6G 2G7
ph. 432-5112

Yours sincerely,

Marcel Huculak

Figure 4.1 A copy of the "Thank-you" Letter, First Version.

University of Alberta
Edmonton
Canada T6G 2G7

Department of Civil Engineering
220 Civil/Electrical Engineering Building,
Telephone (403) 432-4235

Oct. 29/88

To whom it may concern:

The bearer of this letter, Mr. Marcel Huculak, is collecting data concerning the time bus passengers wait for buses. These data are for research being conducted in the Department of Civil Engineering at the University of Alberta. These data do not compromise the privacy of the bus passengers.

If you have any concerns or questions, please call me at 432-5112.

Thank-you.

Sincerely,

J.J. Bakker
Professor of Civil Engineering

Figure 4.2 Generic letter to legitimize interviewer's presence.

elementary school children walking home from school by following them home. He used a rule that if a child were to turn around and see him on two occassions, then that observation would be discarded.

Monnette, et al (1986) give an excellent discussion on research observation techniques. They state that, with respect to validity of data, the Researcher-Participant relation has two critical issues:

1. the extent to which the observer changes the setting that is being observed
2. the extent to which people should be informed that they are being used for research purposes.

Issue number two was addressed in the previous section. Clearly the research method would be entirely up-front and open to the passengers. It is issue number one that would be important here.

Because of the observer's presence, passengers may try to optimize their arrival times so as to appear more rational in the eyes of the observer. Bus operators may also become more conscious of their arrival times if they know that they are being observed.

Thus some strategies would be introduced to help minimize the observer's impact on the arrival time data. First, since passengers cannot predict the observer's first appearance, their arrival behavior would not be affected by the observer's first presence. Thus stops would only be observed once so that the possibility of observing a passenger more than once would be minimized.

Second, the observation period at a stop would be limited to the round trip time of buses on that route. Thus, drivers would only see the observer no more than twice at the observed stop - once in the observed direction and once in the opposite direction (for stops not on one way route loops). This strategy is likely adequate. If a driver sees the observer before going through the observed stop, he would likely think that the observer is a passenger. When driving through the observed stop, the driver may notice the observer recording data, and that the observer never boarded. But by this point it is too late for the driver to alter his arrival time.

Third, stops on the same route would not be observed on consecutive days. This would make it more difficult for drivers and passengers to predict the observer's presence.

Despite these strategies it is still possible for drivers on a route to fore-warn other drivers on that route of the observer's presence. It would be impossible to prove or prevent this, but some data from the preliminary study (June/July 1987) discredits this possibility.

During the preliminary study an observer stationed himself across the street from a stop (Route 18 westbound at 118 Avenue - 38 Street) for nineteen consecutive weekdays. The observer was in plain view (i.e. he was not in a car). Although he tried to diguise the fact that he was collecting bus arrival data, it was clear that at least one driver grew suspicious of the observer's continued presence.

Notwithstanding this obtrusive observation method, bus departure time distributions were constructed from the data collected. Two distributions for the same bus runs (observed twice per day at the observed stop) are shown in Figure 4.3. It is likely that only one or two drivers who regularly drive this route are responsible for each bus run. It is clear that Set "A" of drivers is highly unreliable compared to Set "B" of drivers. It is likely that this difference is due to the drivers alone. Traffic conditions are similar for both bus runs, and because they were both observed twice per day, differences due to one bus possibly originating from the garage should not be present. Further, some of Set "A" drivers' arrival times fail to meet Edmonton Transit standards, and would be subject to disciplinary action. Monnette, et al (1986) state that if people behave strangely (for example, do something illegal), one may assume that they are not affected by the observer's presence. Therefore this particular observation technique, which was highly obtrusive compared to the present technique, was still effective for at least some observations.

Therefore, this research assumes that the observer's presence does not alter the arrival time behavior of passengers and drivers. It is believed that the proposed strategies to minimize the impact of the observer's presence on passengers and drivers will validate this assumption. During data collection, the observer would note events that

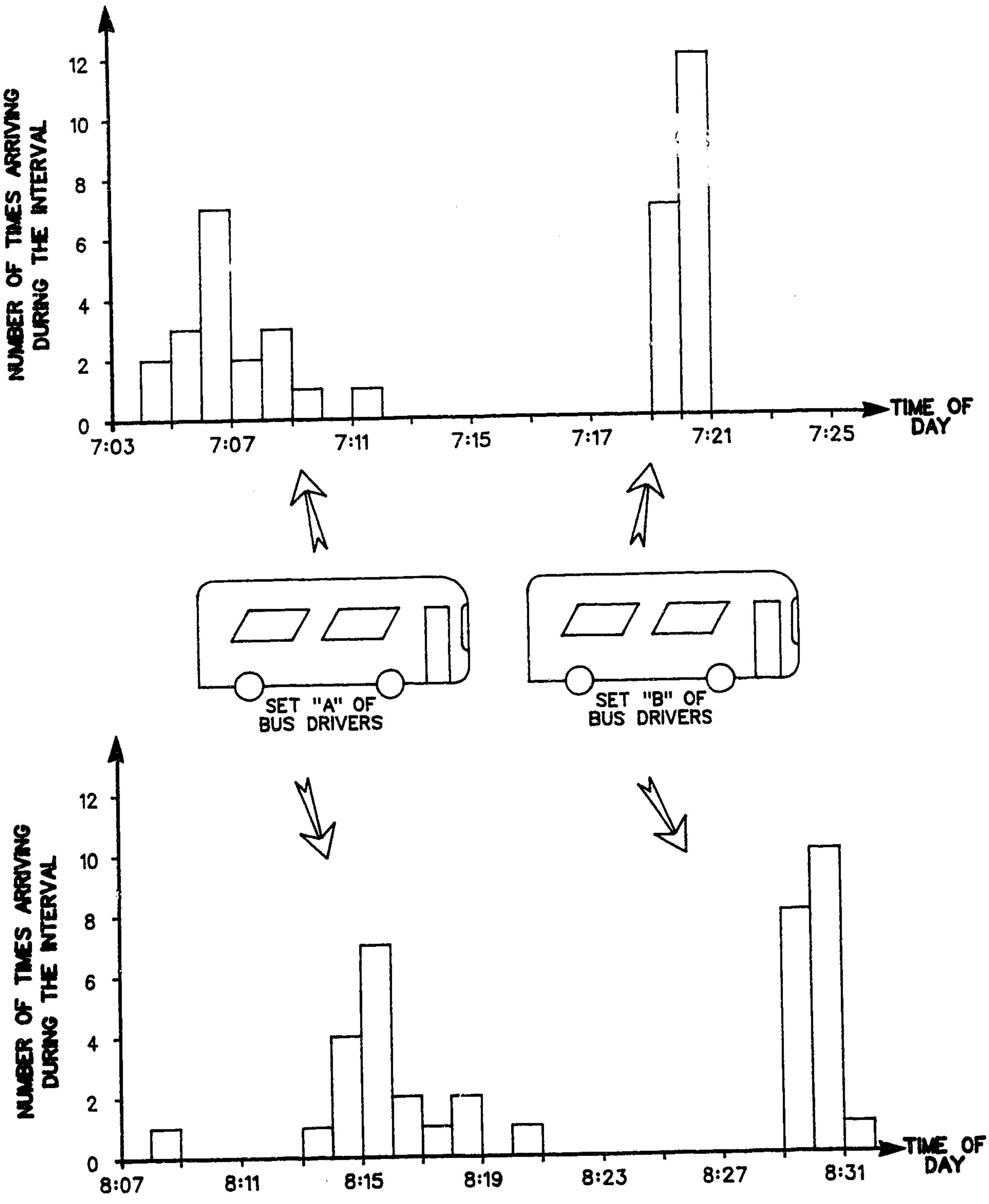

Figure 4.3 Bus departure distributions for two sets of drivers, from the preliminary study (Route 18 westbound at 118 Avenue - 38 Street.

indicate the level of success of the observation method.

4.8 Design of Interview Questions

The original design of each interview question is presented in this section. General considerations are discussed first. Then each interview question is presented, and the rational behind each question is explained. Wording for the first three interview questions was based on the preliminary study of June/July 1987.

4.8.1 General Interview Considerations

Passenger interviews would be required to determine trip purpose, experience catching the bus, and schedule knowledge. To determine each of these precisely would require many questions. However, there are practical constraints which limit the depth of questioning.

One constraint is that there would be a need to interview as many passengers as possible. If the interview were too long, many passengers could not be interviewed before the bus arrived.

A longer interview would introduce a heavier sampling bias. The proportion of interviewed passengers with short waits would be less than those with long waits. Jackson (1977) found such a interview sampling bias in his data despite his interview having only two questions. The preliminary study showed that the passenger arrival rate is greatest in the last five minutes of the headway. If this arrival rate exceeds the rate at which passengers are interviewed then a queue of non-interviewed passengers would form. Once the bus arrives this potential pool of data would be lost.

Thus the interview design would become a trade-off of level of detail versus the number of interviews and the lengths of waits associated with interview data. The interview would be kept as short as possible. It would then not be possible to precisely determine the information required in the interview. Therefore, the interview responses would become surrogates for the true values of passenger trip purpose, experience, and schedule knowledge.

4.8.2 Interview Question 1, Trip Purpose

The trip purpose question would be the first interview question. It would be worded as:

> "What is the purpose of your trip? (What are you going to do?)"

The bracketed portion would be optional. It would be asked only to clarify the question for puzzled looking passengers. Response options would include "work", "school", "shopping", "recreational", and "other".

The trip purpose question appeared first on the interview for several reasons. First, it would be simple. Second, answers could be coached out of passengers with little chance of biasing the result. Coaching would promote a cooperative spirit between the interviewer and passenger.

It also would help gain a passenger's trust. Finally, the passenger's confidence would be boosted by correctly answering the question.

The level of detail provided by this question would be satisfactory. However, persons who chain trips would not be detected.

4.8.3 Interview Question 2, Experience

Interview question 2 would attempt to determine passenger experience catching the bus. It would be worded as:

> "How many times did you catch the bus to make this trip at this stop last week?"

Response options would include zero through five individually and greater than five.

The underlying assumption would be that passenger frequency of use (at that stop, for that trip purpose) would be a resonable measure of their experience. Any experience gained at other stops, or from other trips purposes or passengers would not be detected. However, the degree to which such other experiences would help a passenger catch the bus at the observed stop could only be determined through additional questions.

Passengers may have experience catching the bus at the observed stop during different schedule periods or times of the day. Again, this kind of experience would be assumed irrelevant. The question thus would ask for experience "to make this trip", assuming that different trips would be made at different times of the day.

Passenger experience would be limited to a time frame including only "last week". It would be likely easy for passengers to remember their trip behavior over the last week, as compared to a longer time period. This would represent a passenger's most recent experience and passengers who would be just learning when to catch the bus probably compiled enough experience in one week to become experienced users.

Generally, this question is more difficult than interview question 1 as some memory recall would be required. But passengers would likely provide a response to their satisfaction.

4.8.4 Interview Question 3, Schedule Knowledge

This question would determine a passenger's schedule knowledge. It would be worded as:

> "What time does this bus depart (the nearest upstream timing point)?"

The bracketed portion would quote the column heading description of the nearest upstream timing point printed in the publically available route schedule pamphlets. An example of Edmonton Transit's published schedule information is shown in Figure 4.3. In Edmonton Transit's published schedule information, this would be the best schedule information a passenger may obtain. Bus arrival times are

Weekdays

18 Kingsway - Abbottsfield - Kingsway

	Ⓐ Kingsway Transit Centre Depart Northbound	Ⓑ 106 Street 118 Avenue Eastbound	Ⓒ 76 Street 118 Avenue Arrive Eastbound	Ⓒ 76 Street 118 Avenue Depart Eastbound	Ⓓ 66 Street 118 Avenue Eastbound	Ⓔ 50 Street 118 Avenue Eastbound	Ⓕ Abbottsfield Transit Centre Arrive Westbound	Ⓕ Abbottsfield Transit Centre Depart Westbound	Ⓔ 50 Street 118 Avenue Westbound	Ⓓ 66 Street 118 Avenue Westbound	Ⓒ 76 Street 118 Avenue Westbound	Ⓖ 105 Street 118 Avenue Westbound	Ⓐ Kingsway Transit Centre Arrive Northbound
AM								5:47	5:52	5:56	6:01	6:11	6:14
		6:49	6:01	6:03	6:06	6:10	6:16	6:17	6:22	6:26	6:31	6:41	6:44
								6:32	6:37	6:41	6:46	6:56	6:59
	6:15	6:18	6:31	6:33	6:36	6:40	6:46	6:47	6:54	6:58	7:04	7:15	7:19
								6:57	7:04	7:08	7:14	7:25	7:29
								7:07	7:14	7:18	7:24	7:35	7:39
	6:45	6:49	7:01	7:03	7:06	7:10	7:16	7:17	7:24	7:28	7:34	7:45	7:49
								7:27	7:34	7:38	7:44	7:55	7:59
	7:05	7:09	7:21	7:23	7:26	7:30	7:36	7:37	7:44	7:48	7:54	8:05	8:09
	7:15	7:19	7:31	7:33	7:36	7:40	7:46	7:47	7:54	7:58	8:04	8:15	8:19
	7:25	7:29	7:41	7:43	7:46	7:50	7:56	7:57	8:04	8:08	8:14	8:25	8:29
	7:35	7:39	7:51	7:53	7:56	8:00	8:06	8:07	8:14	8:18	8:24	8:35	8:39
	7:45	7:49	8:01	8:03	8:06	8:10	8:16	8:17	8:24	8:28	8:34	8:45	8:49G
	7:55	7:59	8:11	8:13	8:16	8:20	8:26	8:27	8:34	8:38	8:44	8:55	8:59G
	8:05	8:09	8:21	8:23	8:26	8:30	8:36	8:36	8:42	8:46	8:52	9:03	9:06
	8:15	8:19	8:31	8:33	8:36	8:40	8:46	8:47	8:54	8:58	9:04	9:16	9:19
	8:25	8:29	8:41	8:43	8:45	8:50	8:56	8:57	9:04	9:08	9:14	9:25	9:29
	8:35	8:39	8:51	8:53	8:56	9:00	9:06	9:12	9:19	9:23	9:29	9:40	9:44
	8:50	8:54	9:06	9:08	9:11	9:15	9:21	9:27	9:34	9:38	9:44	9:55	9:59
	9:07	9:10	9:21	9:23	9:26	9:30	9:36	9:42	9:49	9:53	9:59	10:10	10:14
	9:20	9:24	9:36	9:38	9:41	9:45	9:51	9:57	10:04	10:08	10:14	10:25	10:29
	and every 15 minutes until												
PM	1:50	1:54	2:06	2:08	2:11	2:15	2:21	2:27	2:34	2:38	2:44	2:55	2:59
	2:05	2:08	2:21	2:23	2:26	2:30	2:36	2:38	2:45	2:49	2:55	3:06	3:12
	2:20	2:24	2:36	2:38	2:41	2:45	2:51	2:53	3:00	3:04	3:10	3:21	3:25
	2:35	2:39	2:51	2:53	2:56	3:00	3:06	3:08	3:16	3:19	3:25	3:36	3:42
	2:50	2:54	3:06	3:08	3:11	3:15	3:21	3:23	3:30	3:34	3:40	3:51	3:55
	3:01	3:05	3:17	3:19	3:22	3:26	3:32	3:33	3:40	3:44	3:50	4:01	4:05
	and every 10 minutes until												
	4:41	[illegible]	[illegible]	[illegible]	5:02	5:06	5:12	5:13	5:20	5:24	5:30	5:41	5:45G
	4:51	4:55	5:07	5:09	5:12	5:16	5:22	5:23	5:29	5:33	5:37	5:47	5:50
	5:01	[illegible]	5:17	[illegible]	5:22	5:26	5:32	5:33	5:39	5:43	5:47	5:57	6:00G
	5:11	5:15	5:27	5:29	5:32	5:36	5:42	5:43	5:49	5:53	5:57	6:07	6:10
	[illegible]	[illegible]	[illegible]	[illegible]	5:44	5:48	5:54	5:56	6:02	6:06	6:10	6:20	6:23
	5:41	5:44	5:54	5:56	5:59	6:03	6:09	6:11	6:17	6:21	6:25	6:35	6:38
	[illegible]	[illegible]	[illegible]	[illegible]	6:14	6:18	6:24	6:26	6:32	6:36	6:40	6:50	6:53
	6:11	6:14	6:24	6:26	6:29	6:33	6:39	6:41	6:47	6:51	6:55	7:05	7:08G
	6:23	6:26	[illegible]	[illegible]	6:44	6:48	6:54	6:56	7:02	7:06	7:10	7:20	7:23
	6:38	6:41	6:51	6:54	6:59	7:03	7:09G						
	6:53	6:56	7:06	[illegible]	7:14	7:18	7:24	7:26	7:32	7:36	7:4	7:50	7:53
	7:23	7:26	7:36	7:39	7:44	7:48	7:54	7:56	8:02	8:06	8:10	8:20	8:23
	7:53	7:56	8:06	8:09	8:14	8:18	8:24	8:26	8:32	8:36	8:40	8:50	8:53
	8:23	8:26	8:36	8:39	8:44	8:48	8:54	8:56	9:02	9:06	9:10	9:20	9:23
	8:53	8:56	9:06	9:09	9:14	9:18	9:24	9:26	9:32	9:36	9:40	9:50	9:53
	9:23	9:26	9:36	9:39	9:44	9:48	9:54	9:56	10:02	10:06	10:10	10:20	10:23
	9:53	9:56	10:06	10:09	10:14	10:18	10:24	10:26	10:32	10:36	10:40	10:50	10:53
	10:23	10:26	10:36	10:39	10:44	10:48	10:54	10:56	11:02	11:06	11:10	11:20	11:23
	10:53	10:56	11:06	11:09	11:14	11:18	11:24	11:26	11:32	11:36	11:40	11:50	11:53
	11:23	11:26	11:36	11:39	11:44	11:48	11:54	11 54	12:00	12:04	12:08	12:18	12:21
	11:57	12:00		12:10	12:15	12:19	12:25	12:25	12:31	12:36	12:39	12:48	12:51
	12:21	12:24		12:34	12:39	12:43	12:49G						
	12:51	12:54		1:15	1:20	1:24	1:30G						

LAST BUS

Subject to change without notice.

G = Garage

Figure 4.4 Example of Edmonton Transit's published schedule information.

not available for most stops in Edmonton.

It would be possible that passengers may have other useful schedule knowledge. For example, a downstream timing point may be closer. However, buses may arrive early at this timing point and then lay over. Thus extrapolating bus stop arrival times from this information would be more difficult.

This interview question is the most difficult as it requires a specific answer. Passengers may suffer the embarassment of not knowing the answer. Since it may be a discouraging question, it would be placed near the end of the interview, after other data has already been extracted.

4.8.5 Interview Question 4, Method of Payment

Interview question 4 would confirm the passenger's experience, and check the validity of the reponses provided. It would be worded as:

"How will you pay for your trip?"

Response options included "pass", "cash", "ticket", or "transfer".

Passengers claiming frequent use (from interview question 2) should respond "pass", while infrequent users should respond "cash" or "ticket". "Transfer" would be included as a response to help prevent the possibility of including such passengers in the data. Responses inconsistent with the experience question would negate interview results for that passenger.

This question would be included because the experience interview question may be the least reliable, as passengers may not be precise. This question is short, and would not significantly lengthen the interview.

Interview question 4 ends the interview on a positive note. Passengers can be happy that they would provide another response to their satisfaction.

4.9 Data Collection Method - Summary

The end result of the preceeding discussions was the data collection form, shown in Figure 4.5. This form was used for recording arrival time data and interview data.

To summarize, the proposed data collection method was to first find stops which satisfy the stop selection criterion. At these stops the data would be collected. First the objective weather data would be noted, then arrival time data and interview data would be collected after the departure of the first observed bus. After the last bus departs the stop, notes regarding the weather behavior of passengers are made, and any other relevant events could be recorded. After enough data were collected, the in field data collection experiences could be summarized and data analysis could commence.

DATE:____________ DAY:________ ROUTE:______

LOCATION:____

ARRIVAL TIME:______________ BUS ARRIVAL TIME:_______________

1. What is the purpose of your trip? (What are you going to do?)

   __WORK __SCHOOL __SHOPPING __RECREATION __OTHER______________
   __JR HIGH
   __HIGH SCHOOL
   __UNIVERSITY OR COLLEGE

2. How many times did you catch the bus to make this trip at this stop last week?

   __1 __2 __3 __4 __5 __5+_____

3. Do you know what time this bus is scheduled to depart ____?

   __NO __YES; WHAT IS THAT TIME?______

4. How will you pay for this trip?

   __CASH __PASS __TICKET __TRANSFER

ARRIVAL TIME:______________ BUS ARRIVAL TIME:_____________

1. What is the purpose of your trip? (What are you going to do?)

   __WORK __SCHOOL __SHOPPING __RECREATION __OTHER______________
   __JR HIGH
   __HIGH SCHOOL
   __UNIVERSITY OR COLLEGE

2. How many times did you catch the bus to make this trip at this stop last week?

   __1 __2 __3 __4 __5 __5+

3. Do you know what time this bus is scheduled to depart ____?

   __NO __YES; WHAT IS THAT TIME?______

4. How will you pay for this trip?

   __CASH __PASS __TICKET __TRANSFER

Figure 4.5 Data collection form, initial version.

5. Data Collection - Execution and Problems

The pratical execution of the proposed data collection is described in the following sections. Variations from the intended data collection methodology and problems encountered are detailed. These variations and problems impact the data analysis, and provide some guidelines for similar future research.

5.1 Background Information

The data were collected on Saturdays, Mondays, and Tuesdays, beginning on Saturday October 29, 1988 and ending on Tuesday, November 30, 1988. Most data were obtained in the AM hours, especially the AM peak (06:00 to 08:00). The remainder of the data were collected in the early afternoon.

Only one observer/interviewer (the author) was used. He had been a frequent user of Edmonton Transit from September 1978 to July 1988. Approximately 230 wait times were observed and 160 interviews were conducted at 18 stops on seven routes.

5.2 Bus Stop Selection

Before any data could be collected, bus stops which met the bus stop criterion were sought. To start, an Edmonton Transit network bus route map was reviewed. All route segments with a 15 minute service interval in a residential area during either the AM Peak or Midday Schedule Period were identified. Then site investigations along these route segments identified suitable stops, usually close to higher density housing.

The stops actually used in the study are listed in Table 5.1. Given are the location of the surveyed stop, the direction of the route surveyed, the date and time of the survey, the number of wait times recorded, and the number of interviews completed for each stop. Their locations are shown on copies of Edmonton Transit route brochure maps (Figures 5.1 through 5.7).

While most of the surveyed stops did fit the stop criterion for this research, there were some exceptions. These are discussed below.

5.2.1 Route 39, 64 Avenue - 178 Street Northbound

This stop produced the most serious problems with the intended data collection method. Because of the stop's close proximity to the one way loop at the Route's southern end (see Figure 5.6), a southbound bus on 178 Street near the observed stop becomes the next northbound bus at the observed stop.

It was observed that many passengers, especially Junior High School students (ages 12 - 15), would catch the first available bus regardless of its direction. Compounding the problem were the cool temperature (about −1 °C) and noticeable wind chill. This gave passengers more incentive to catch southbound buses, as at least they would be warm on the bus while it looped around. Two passengers who started

Table 5.1 List of Surveyed Stops.

Stop Description	Date and Time Surveyed	Waits Recorded	Interviews Completed
Route 29 SBD, 152 Ave - 118 St	Sat, Oct 29, 1100-1235	3	3
	Sat, Nov 12, 1220-1310	0	0
Route 30 NBD, 179 Ave - 95 St	Mon, Oct 31, 0640-0755	31	19
Route 18 WBD, 118 Ave - 34 St	Mon, Oct 31, 0915-1015	12	10
Route 43 EBD, 47 Ave - 106A St	Tues, Nov 1, 0555-0810	8	6
Route 5 EBD, 114 Ave - 131 St	Tues, Nov 1, 0930-1010	0	0
Route 29 WBD, 152 Ave - 114 St	Sat, Nov 5, 1005-1050	1	1
Route 39 NBD, 64 Ave - 178 St	Mon, Nov 7, 0645-0810	24	17
Route 5 WBD, 114 Ave - 124 St	Mon, Nov 7, 0850-0955	5	5
	Mon, Nov 14, 1145-1345	5	3
Route 43 EBD, 47 Ave - 106 St	Tues, Nov 8 0555-0840	26	19
Route 29 SBD, 147 Ave - 118 St	Tues, Nov 8, 1055-1125	0	0
Route 30 NBD, 174 Ave - 95 St	Mon, Nov 14, 0640-0755	31	20
Route 3 SBD, 117 Ave - 124 St	Tues, Nov 15, 0625-0740	8	4
Route 29 SBD, 145 Ave - 118 St	Tues, Nov 15, 0825-0925	6	4
Route 5 EBD, 114 Ave - Groat Rd	Sat, Nov 19, 1100-1145	0	0
Route 30 NBD, 171 Ave - 95 St	Mon, Nov 21, 0640-0755	18	12
Route 43 WBD, 47 Ave - 106 St	Tues, Nov 22, 0655-0830	17	9
Route 30 NBD, 176 Ave - 95 St	Mon, Nov 28, 0625-0755	16	10
Route 43 WBD, 47 Ave - 106A St	Tues, Nov 29, 0700-0830	17	14
		SUM = 228	SUM = 156

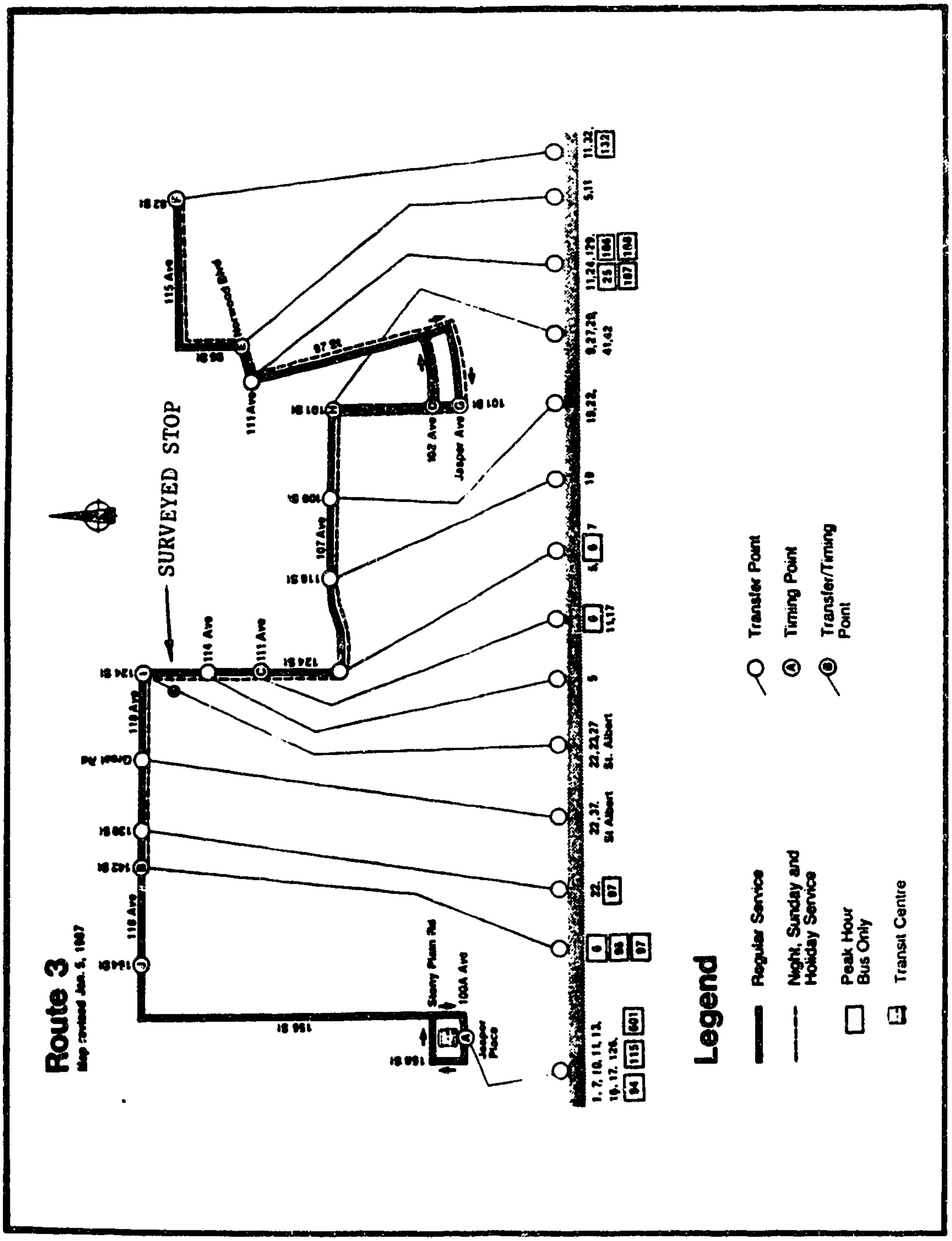

Figure 5.1 Route 3 Surveyed Stop.

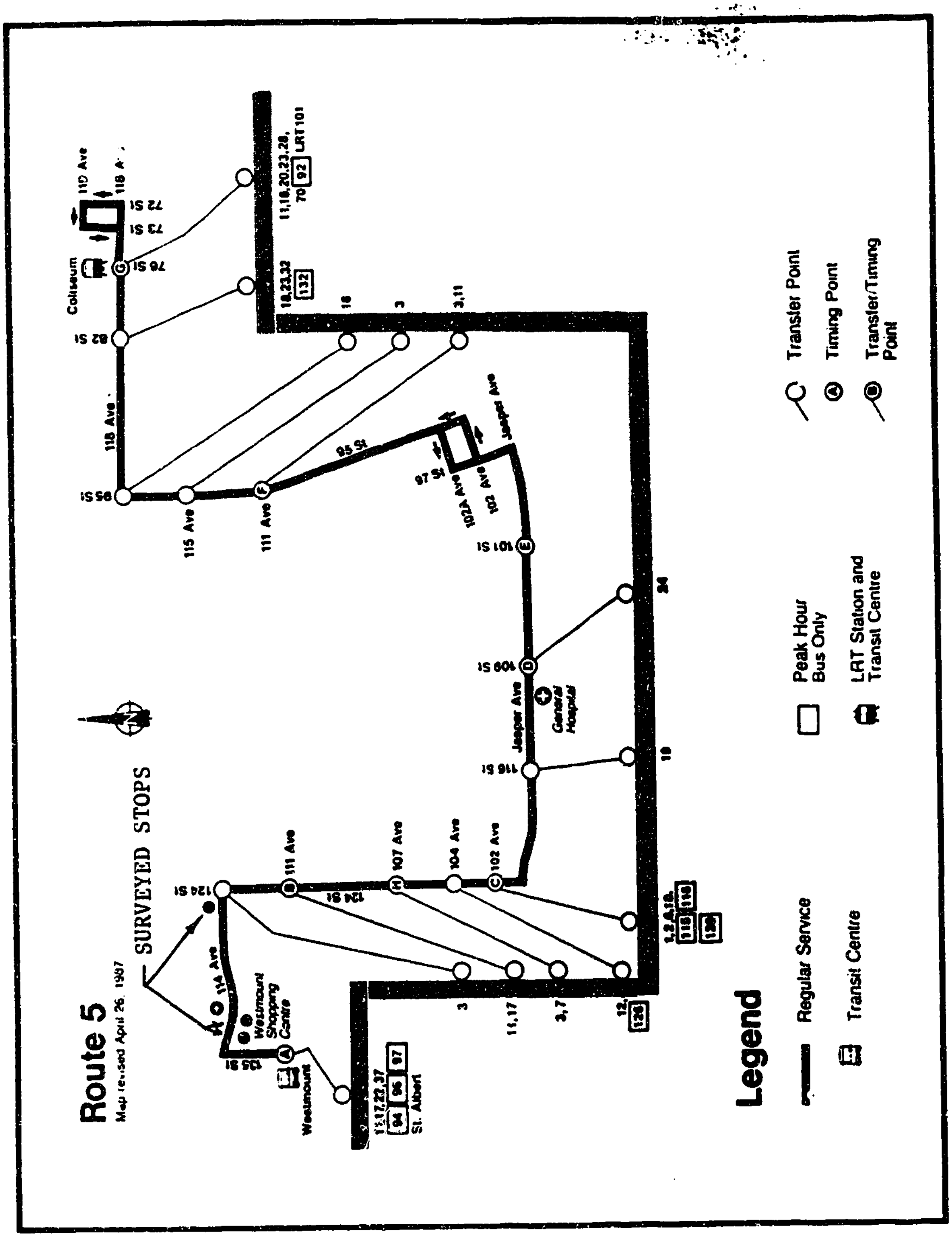

Figure 5.2 Route 5 Surveyed Stops.

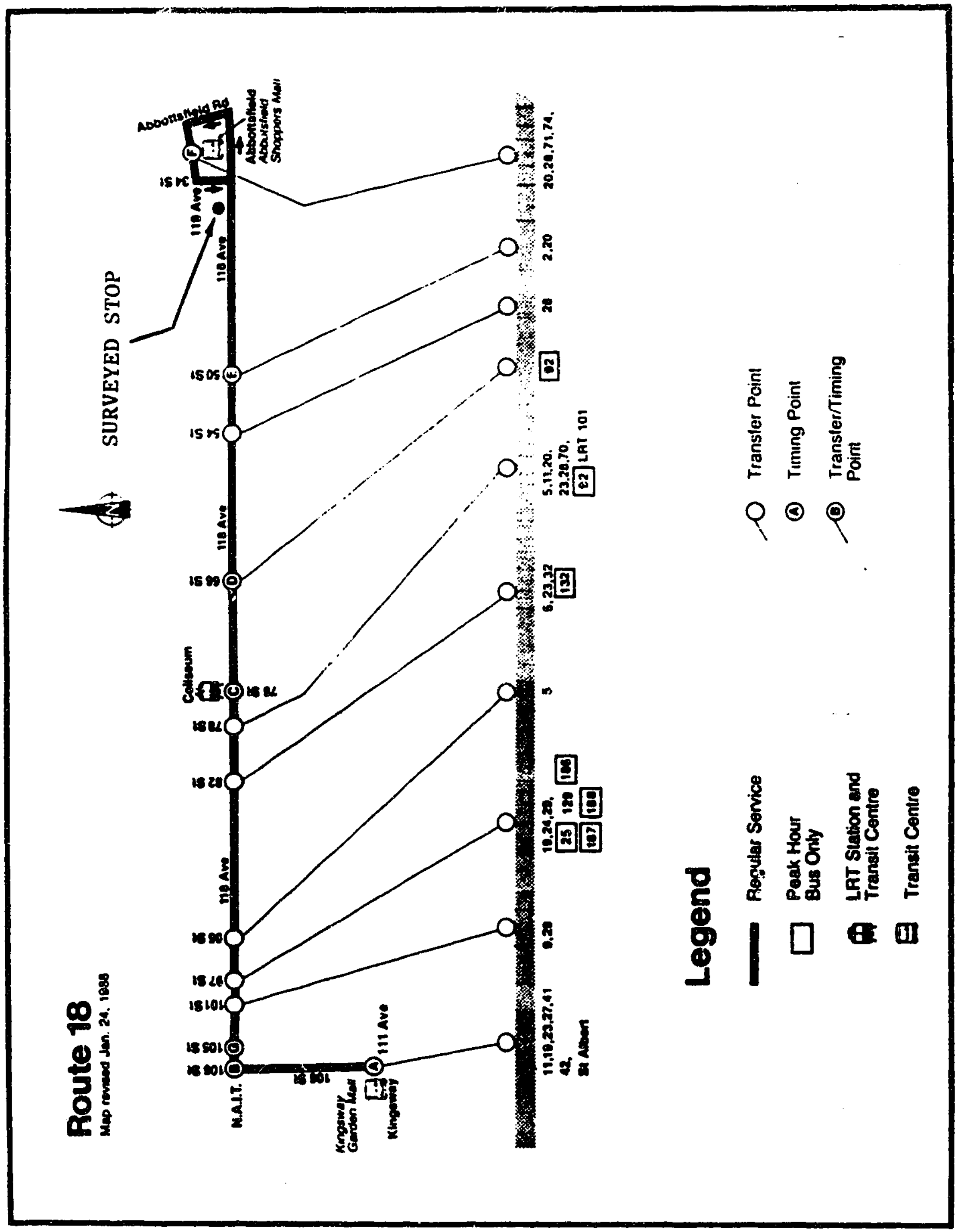

Figure 5.3 Route 18 Surveyed Stop.

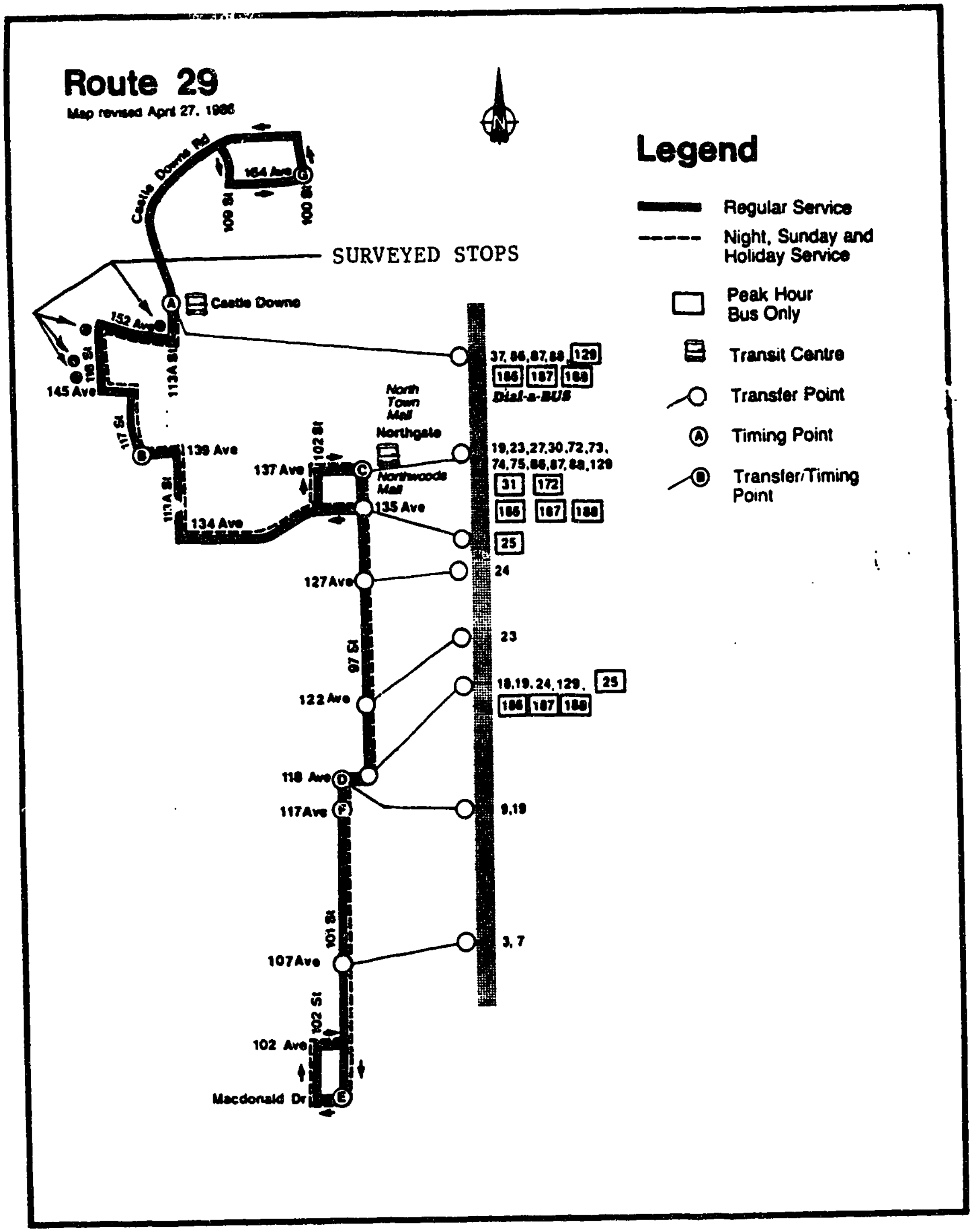

Figure 5.4 Route 29 Surveyed Stops.

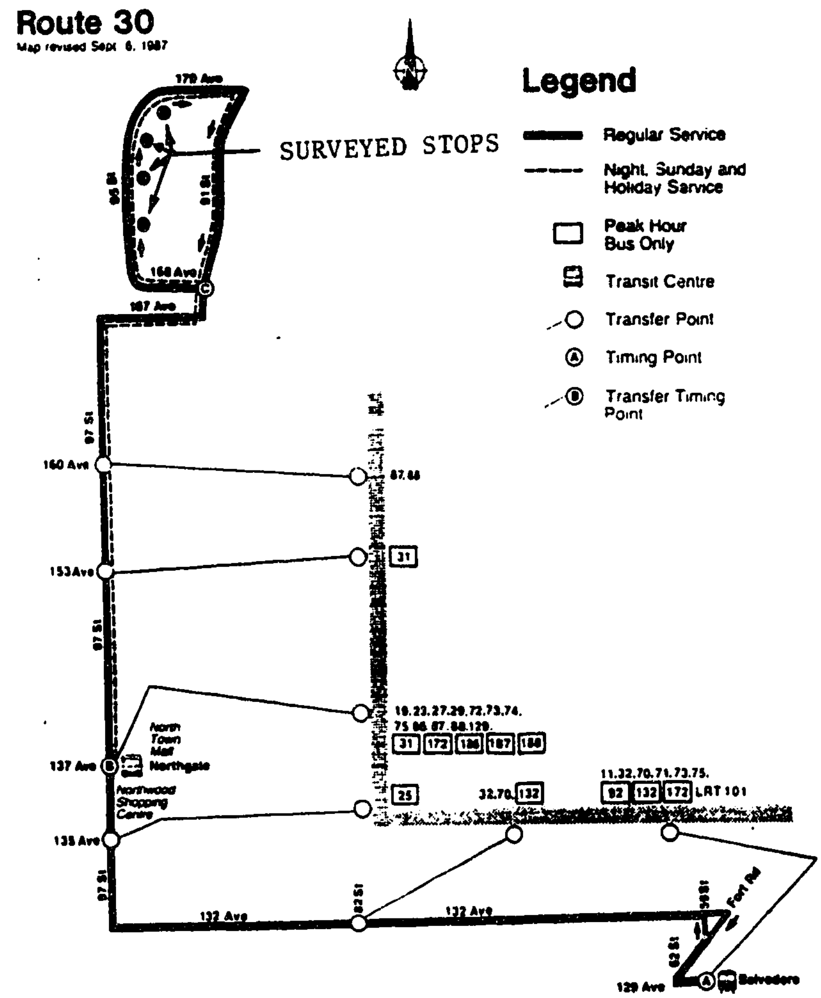

Figure 5.5 Route 30 Surveyed Stops.

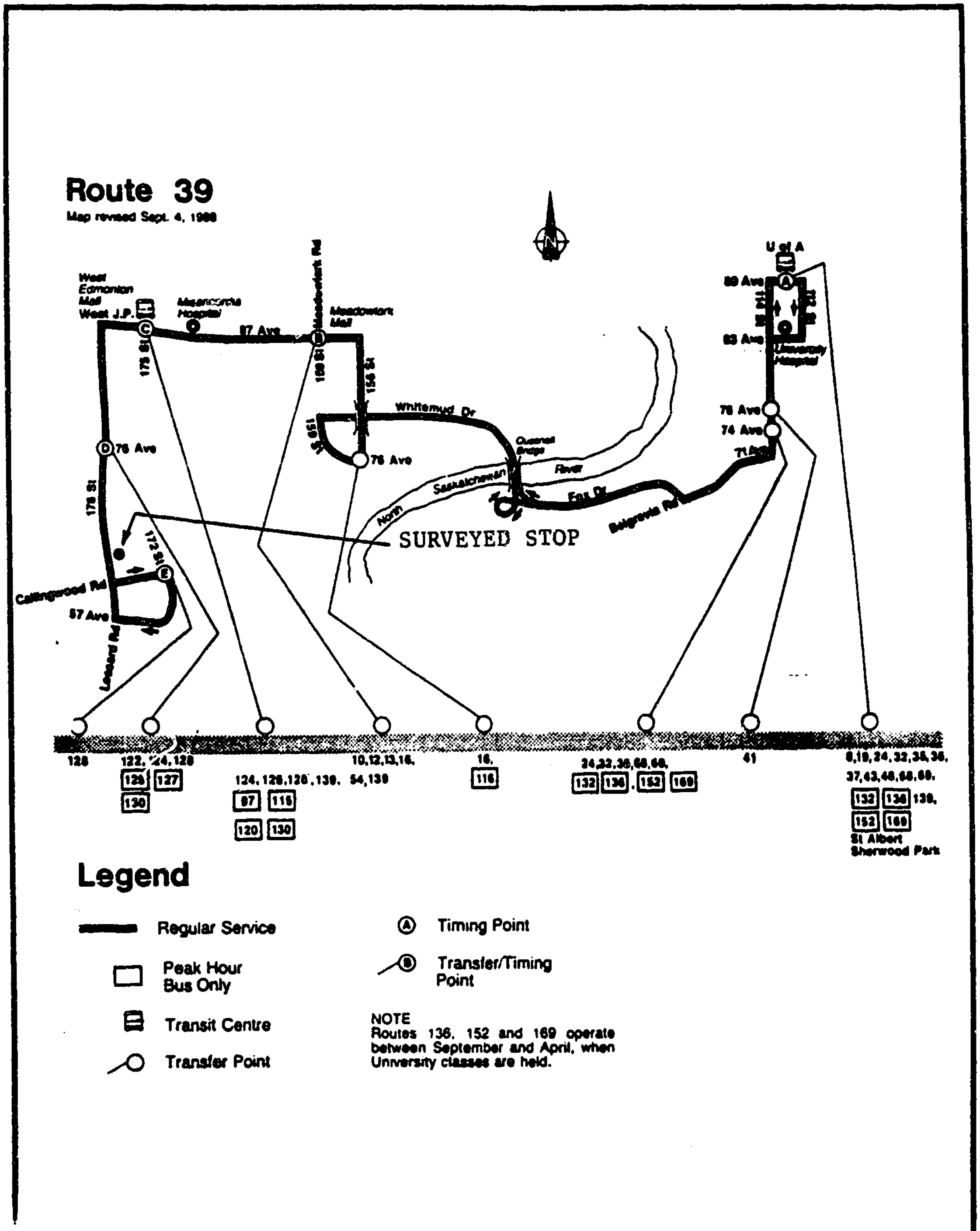

Figure 5.6 Route 39 Surveyed Stop.

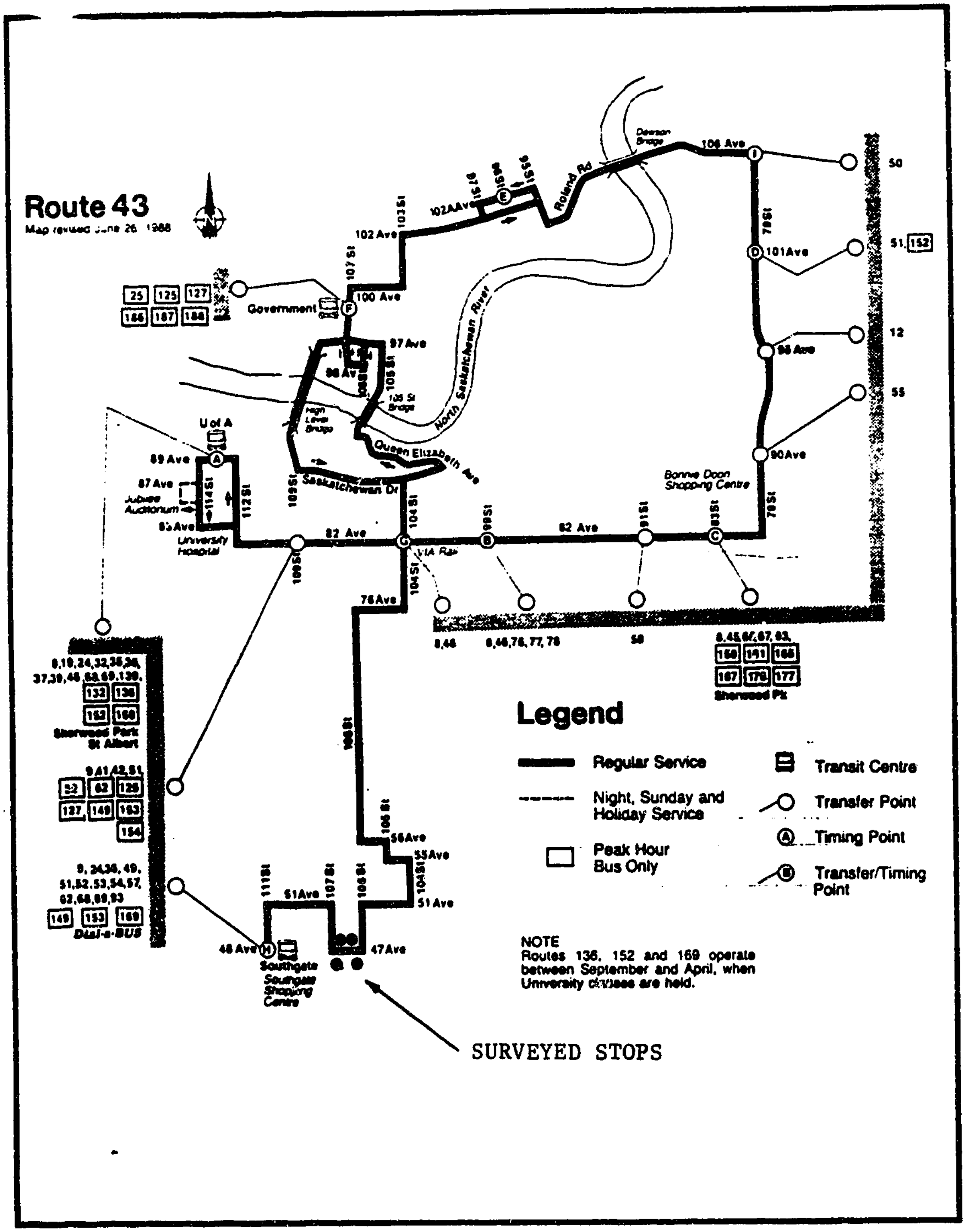

Figure 5.7 Route 43 Surveyed Stops.

their waits at the observed stop crossed the street to board an oncoming southbound bus.

Another incentive to board southbound buses was noticed. Some of the northbound buses had significant seated loads. Thus in order to get a desired seat, one could board a southbound bus. This "desired seat incentive" seems most prevelant in Junior High School students who, in the author's experiences, seem to prefer rear bus seats.

Because the service was being used on both sides of the street, the effective average headway became less than 15 minutes. Thus, data from this stop were not included in subsequent analysis.

5.2.2 Route 5, 114 Ave - 124 St

Because this stop was close to a stop for Route 3 transfers were possible. Thus the interviewer carefully watched for passengers approaching from the Route 3 stop. If a transfer was suspected, then passengers were asked, "Did you just get off from the 3?". About three observed passengers were transfering and as a result they were not included in any data analysis.

5.2.3 Route 43

Two passengers, interviewed together at a westbound Route 43 stop, mentioned that if they miss the bus they walk (about 500m) to the Southgate Transit Terminal. Therefore, long waits at this stop may be less frequent as passengers have an alternative transportation choice. Both observed westbound stops could be competing with the Southgate Transit Terminal, as passengers may be willing to walk a longer distance in order to receive better (more frequent and diverse) service.

Despite these possible problems the data were kept. The walking distance is long (minimum of 600m) and circuitous, as AM Peak passengers must walk around Southgate Mall.

All Route 43 stops observed were close together (see Figure 5.6). As a result one passenger was interviewed twice, once in each direction. However, due to the "random" appearances made by the observer at these stops, it is unlikely that she could have predicted the observer's presence. Thus both observed wait times for this passenger were kept.

5.2.4 Route 18, 118 Avenue - 34 Street, Westbound

This was the only stop that was not in a residential location. Medium density housing is on the opposite corner from the observed stop. All other corners have commercial development. The stop was surveyed from 9:15 - 10:15, when it was less likely that shopping or work trips would be ending. However, the interviewer was aware of this possibility and discovered two such trips. They were not included in any data analysis.

5.2.5 Routes 5 and 29, Stops Surveyed Twice

Table 5.1 shows that stops on Route 29 and on Route 5 were surveyed twice. To minimize the chance of surveying passengers twice, they were observed at different times of the day. Also the passenger usage was low, and the observer remembered the passengers previously interviewed. These stops were observed twice to collect more Midday and Saturday schedule period data, where trip purposes other that work or school were more likely to be observed.

5.3 Wait Time Data

No problems were found with the watch calibration procedure. However, the bus departure time and passenger arrival time definitions were well tested.

5.3.1 Bus Departure Times

Departure times for buses were measured as previously defined, to the nearest five seconds. However, on two occasions the bus doors closed, the bus pulled about two bus lengths away from the curb, and then the bus stopped for another passenger. For one of these cases (Route 3, 117 Avenue - 124 Street, Southbound), the bus was delayed about 25 seconds while waiting for a passenger to cross the street.

For both cases the second door closing time was used to define the bus departure time.

5.3.2 Passenger Arrival Times

Passenger arrival times were measured to the nearest five seconds. The passenger arrival time definition was upheld as closely as possible, but there were problems. When interviewing, passenger arrivals and/or arrival times were missed. The observer tried to watch for such arrivals, and even recorded arrival times during interviews. But some arrivals were not noticed until the completion of an interview. In this case, the arrival time was noted as the time that the passenger was first noticed. Thus, since the interview took from one to two minutes to complete, the largest possible error in the measured wait time is one to two minutes. This procedure may skew measured wait times for busy buses, where more than about five passengers boarded a bus at the observed stop.

For some passengers who arrived during interviews but were not noticed until later, no attempt was made to estimate their arrival time. This occurred at very busy stops, where the interviewer was constantly interviewing. This procedure was followed because:

1. The observer felt that such passengers may have been waiting longer than one interview. Thus the measured wait time error may be large.
2. In some cases, the observer was uncertain as to if their arrival times had been previously recorded.

This procedure was not used frequently. About five passenger arrival times may not have been recorded.

One possible procedure to confirm the number of observed passengers is to count passengers boarding. However, the observer did not think of this immediately and sometimes the observer was still recording data during the boarding period.

5.4 Weather Data

Observations for this study were made in the Fall, when temperatures were generally declining as the weeks passed. Air temperatures ranged from approximately +3 ^{o}C to -8 ^{o}C. No precipitation occurred during passenger arrivals. Passenger behavior seemed to be sensitive to the declining temperatures, as more "bad" weather days were recorded as the weeks passed. However, as the temperatures began a slight increase, more "good" weather behavior was displayed. This occurred despite recorded temperatures that gave bad weather behavior a few weeks earlier. Thus it seemed that similar weather conditions did not produce similar passenger behaviors.

On some days it was difficult to classify the weather as "good" or "bad", as passenger response to the weather seemed to vary between individuals. For these days, "ok to bad" and "ok to good" categories were created.

A summary of the subjective weather classification data and the objectively measured data is given in Appendix E.

5.5 Group Arrival Data

Thirteen group arrivals were observed. No problems were encountered collecting these data.

5.6 Passenger Interview Data

Of the 230 passenger wait times observed, only 136 had complete interview data associated. Most of those missed waited less than five minutes, thus inducing a sampling bias for the interview data. This bias will be examined more closely in the Analysis section. The bias could have been significantly reduced if two interviewers/observers were present, although some degree of coordination between the two observers would be required so that no waits are duplicated or missed.

Often, before introducing himself as a university student conducting research on waiting time and asking passengers if they were willing to participate in such research, the interviewer would ask:

"Are you going to catch the bus here?"

Usually the answer was a fore-gone conclusion, but this question served as a better starting point for the interview.

Also, to help passengers with the interview, the interview form was usually made visible to them, and the interviewer pointed to the questions/answers as they were read.

The "Thank-you" letter was slightly altered. Also, each of the interview questions had some problems. As a result three were re-worded after the first week of observations (Oct 29, 1989 to Nov 1, 1989). These changes are discussed below.

5.6.1 Interview Question 1, Trip Purpose

Some persons thought that this question was too personal until the interviewer clarified the level of detail required by reading the list of possible responses. Therefore, interview question 1 was changed to read:

"Are you going to:

Work? School? Shopping? Recreation? Other?"

Usually after the work and school options were stated, passengers indicated their trip purpose and the remaining options were not read. This wording leads directly into the level of detail required, and passengers no longer found the question personal.

The new wording also dropped the type of school trip. For the purposes of this research it was felt that more detail of school trips was not required. It also helped to speed up interviews for the numerous school trips encountered.

5.6.2 Interview Question 2, Experience

This question was changed to read:

"How many times did you catch the bus at this stop in the last week?"

The trip purpose condition was dropped. Any experience at the stop, regardless of trip purpose or time of day, was thought to be relevant. This also simplified the question for passengers as they no longer had to recall their trip purpose for each bus trip made in the last week. There were some indications that passengers were not paying close attention to this level of detail. For example, for the data collected on November 14 and 15, 1988, there were only four working days "in the last week". Yet most passengers gave the typical response of "five" times caught "in the last week."

Keeping the trip purpose condition would likely confuse passengers, and produce variations in the data due to differences in the level of understanding each passenger had of the question. Data from the original wording were kept, as it was felt that this change would not alter many passenger responses.

With respect to the "in the last week" condition, the words "in the" were explicitly added. They had already been pencilled in on the original interview forms. It was hoped that adding these words would help prevent passengers from thinking of trips made during weekdays only. However there was still some confusion. Some persons counted the interview day. The interviewer clarified the question if passengers seemed confused by stating "Not counting today." Other persons counted the current work week only. They stated, "This is Monday, its my first time this week." Again the interviewer clarified the question, this time by stating "...in the last seven days." Using "...in the last seven days." may have been the best wording for this question.

Another problem with the trip purpose question is that a frequent user may not have used the bus "... in the last week." For example, one gentleman stated that he was on holidays during the previous week. Two such cases were encountered, and both were classified as frequent (i.e. five times in the last week) users for the purposes of the data analysis.

5.6.3 Interview Question 3, Schedule Knowledge

Some passengers may not have been completely familiar with the nearest upstream timing point's location, or the direction that the bus departed this timing point (which usually was not included in the question). To help orient passengers, the interviewer usually pointed in the general direction of the timing point.

An interesting reaction to the schedule knowledge question by some passengers was noticed by the interviewer. They seemed to be puzzled that the interviewer was asking what time the bus left some stop other than the one they were using. The look on their faces seemed to say "Why are you asking me what time the bus leaves that stop?" or "What good is that to me?" or "That location seems rather arbitrary!". This was especially noticeable for the westbound stops surveyed on Route 43, as the nearest upstream timing point is about 14 minutes distant by bus travel time. Very few passengers at these two stops correctly answered the schedule knowledge question. Such reactions by passengers probably indicate limited understanding of using timing points to estimate the bus's arrival time, or the difficulty in estimating the bus travel times from distant timing points.

For the surveyed stops along Route 30, a few passengers seemed to believe that they were being asked what time the bus departs their neighborhood, not the timing point. This is likely due to the bus actually passing the timing point's street address twice, as the route is looped (see Figure 5.4). Giving the bus's direction may have reduced the confusion.

Whether passengers are confused about the direction the bus departs a timing point or about the location of a timing point is not damaging to the research question. In fact, it shows that they have limited schedule knowledge. Passengers who were familiar with the schedule understood the question. Many persons correctly and confidently answered this question.

5.6.4 Interview Question 4, Method of Payment

It was found that some passengers claiming to use the bus five or more times per week paid for their trip by cash. At first this seemed surprising. However, this result was confirmed by a fare survey conducted by Edmonton Transit in October and November 1988.

There were good reasons for such behavior. At the time of the surveys, a low price differential existed between monthly pass and cash payments. A monthly pass cost $36, while the cash fare was $1 per trip. For twenty one-way trips per month, the cash fare would be $40. However, if some passengers are able to get some rides during the course of the month, or if they go on holidays, or if they work compressed work weeks, then it becomes more economical to pay by cash. In addition to economic reasons, there is also the risk of losing the pass and having to pay cash fares for the remainder of the month. Thus the incentive to purchase a monthly pass was low.

As a result of this peculiarity, interview question 4 was not used as a check on passenger response to frequency of use (interview question 2), or to validate responses.

5.6.5 Interview Form and Thank-you Letter

Final versions of the "Thank-you" letter and the interview form are shown in Figures 5.8 and 5.9 respectively. These versions were used from Saturday, November 5, 1988 to Tuesday, November 29, 1988.

The "Thank-you" letter was placed on University of Alberta Department of Civil Engineering letterhead, to help legitimitize the interviewer's presence. Neither version of the "Thank-you" letter had problems. No post-interview

University of Alberta
Edmonton
Canada T6G 2G7

Department of Civil Engineering
220 Civil/Electrical Engineering Building,
Telephone (403) 432-4235

Dear Passenger,

Thank-you for participating in this research. If you have any questions or concerns regarding this study, you may contact:

Marcel Huculak (Interviewer)
Room 219J
Civil Engineering Building
University of Alberta
EDMONTON, Alberta
T6G 2G7
ph. 432-2795

Professor J.J. Bakker (Supervisor)
Department of Civil Engineering
Civil Engineering Building
University of Alberta
EDMONTON, Alberta
T6G 2G7
ph. 432-5112

Yours sincerely,

Marcel Huculak

Marcel Huculak

Figure 5.8 Final Version of the "Thank-you" Letter.

DATE:______________ DAY:_________ ROUTE:_______

LOCATION:____

ARRIVAL TIME:____________ BUS ARRIVAL TIME:_______________

1. Are you going to:

__WORK __SCHOOL __SHOPPING __RECREATION __OTHER_______________

2. How many times did you catch the bus at this stop in the last week?

__0 __1 __2 __3 __4 __5 __5+_____

3. Do you know what time this bus is scheduled to depart ____?

__NO __YES; WHAT IS THAT TIME?______

4. How will you pay for your trip?

__CASH __PASS __TICKET __TRANSFER

ARRIVAL TIME:______________ BUS ARRIVAL TIME:______________

1. Are you going to:

__WORK __SCHOOL __SHOPPING __RECREATION __OTHER_______________

2. How many times did you catch the bus at this stop in the last week?

__0 __1 __2 __3 __4 __5 __5+_____

3. Do you know what time this bus is scheduled to depart ____?

__NO __YES; WHAT IS THAT TIME?______

4. How will you pay for your trip?

__CASH __PASS __TICKET __TRANSFER

Figure 5.9 Final Version of the Interview Form.

contact was received from any interviewed passengers.

The interview form served an additional function of providing room for notes that the observer would scrawl in margins. These notes included passenger arrival times during interviews, peculiar passenger bahaviors and problem descriptions for any data collected. This helped the observer to recall experiences, leading to an appropriate treatment of data for analysis.

5.6.6 Interviewing Groups

Many persons arrived in groups, usually of two. In most cases they were interviewed together. It was more convenient for them, and it was feared that asking them to split up would arouse suspicions.

This procedure is not ideal. One passenger's response to a question may influence the remaining passenger's response. This is also a problem when separate passengers are within ear shot of each other, especially in passenger shelters. In one case (Route 43, 47 Avenue - 106 Street, Eastbound) a passenger seemed to "agree" with the scheduled departure given by a previously interviewed passenger. He responded "Ahhh...yeah, 7:22." His resonse was correct, but it was decided that for the purposes of the analysis, his schedule knowledge was classified as "not perfect".

5.6.7 Interview Refusals

Two persons refused an interview. One may not have been able to speak English. The second appeared to be mentally handicapped and perhaps did not understand the interviewer's purpose, thus becoming suspicious of the interview. In both cases, once the passenger said "No", no further attempts were made to obtain an interview. Also, the interviewer should have offered these persons the "Thank-you" letter, providing an opportunity to express their concerns to the interviewer's supervisor. This was not done. It was not considered until after the data were collected.

One other person may have intentionally avoided an interview by stating that he was catching the bus across the street from the observed stop (Route 43, 47 Avenue - 106 Street, Eastbound). He said that he does this when he feels that he missed the eastbound bus. However, he did catch the bus at the observed stop. His wait was recorded.

Finally, some persons seemed reluctant to participate in the interview. They expressed reservations by not responding immediately to the interview request but seeming to decide, or by asking the interviewer "What do you mean by non-personal questions?". In these cases the interviewer asked:

> "How about I ask the questions, and if you don't want to answer, just say so."

None of these persons refused to answer any interview questions, and one expressed relief when she saw that the