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Integrated Dial-A-Ride and Fixed Route Transit in Ann Arbor, Michigan

Final Report
March 1977

Service And Methods Demonstration Program

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Lance A. Neumann*, James A. Wojno*, Richard D. Juster**	DOT-TSC-UMTA-77-7

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*Cambridge Systematics, Inc.† 238 Main Street Cambridge MA 02142 **Multisystems, Inc.† 1050 Mass. Avenue Cambridge MA 02138	UM727/R7710
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16. Abstract

The implementation and operation of the Teltran system in Ann Arbor MI over the past three years has represented a continuing experiment in transportation innovation. The Ann Arbor Transportation Authority's (AATA) experience with integrated demand responsive and fixed-route service provides some valuable insights for other communities considering major transportation improvements. While the AATA provides a variety of other fixed-route services, subscription and charter services, and special service to the handicapped, this evaluation focuses on the integrated service provided within Ann Arbor.

In particular, the evaluation provides a detailed description of Teltran system configuration (and changes in that configuration by time of day and day of the week), system dispatching and operation, and the effectiveness of an incremental implementation process. In addition, the effect of Teltran on improving transit level of service and ridership is examined as well as the productivities achieved.

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PREFACE

The Ann Arbor Transportation Authority (AATA) operates an integrated fixed-route and dial-a-ride system (Teltran) in the City of Ann Arbor. The schedules of the fixed route buses and dial-a-ride vehicles are synchronized to provide coordinated transfers. During evening and weekend periods the system configuration changes and service is predominantly demand responsive. The AATA also provides fixed-route service in Ypsilanti and service to the elderly and handicapped in rural areas of Washtenaw County.

The major focus of this evaluation is the Teltran system and particularly the dial-a-ride and coordinated transfer aspects of this system. The report describes the development, implementation and current status of the Teltran system as it existed in the spring of 1976. While Teltran is not a Service and Methods Demonstration Program (SMD) project, this evaluation was conducted as part of the SMD program to help disseminate information on an innovative transit system.

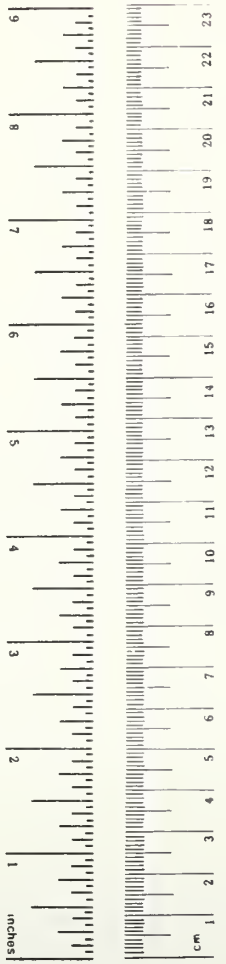
Major contributions to this report were made by Carol Walb, Christine Winquist and Ernest Munch of Cambridge Systematics, Inc., and Larry Englisher of Multisystems. The authors would also like to acknowledge the cooperation and contributions of AATA board members, management, and staff in conducting this evaluation. In particular, Karl Guenther, the Executive Director of the AATA, provided many interesting insights on the implementation and operation of the Teltran system and assisted the authors in many ways during all phases of the evaluation.

In addition, Robert Waksman, the Project Monitor, and Howard Slavin, both of the Transportation Systems Center, provided valuable comments on early drafts of this report. The comments of Paul Fish and Ronald Fisher of the Urban Mass Transportation Administration are also gratefully acknowledged.

METRIC CONVERSION FACTORS

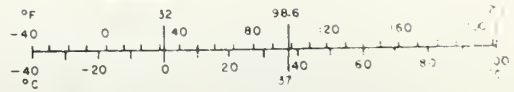
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find
		LENGTH	
mm	millimeters	0.04	[illegible]
cm	centimeters	0.4	[illegible]
m	meters	3.3	[illegible]
m	meters	1.1	[illegible]
km	kilometers	0.6	[illegible]
		AREA	
cm^2	square centimeters	0.16	square [illegible]
m^2	square meters	1.2	[illegible]
km^2	square kilometers	0.4	[illegible]
ha	hectares (10,000 m^2)	2.5	[illegible]
		MASS (weight)	
g	grams	0.035	[illegible]
kg	kilograms	2.2	[illegible]
t	tonnes (1000 kg)	1.1	[illegible]
		VOLUME	
ml	milliliters	0.03	[illegible]
l	liters	2.1	[illegible]
l	liters	1.06	[illegible]
l	liters	0.26	[illegible]
m^3	cubic meters	35	[illegible]
m^3	cubic meters	1.3	[illegible]
		TEMPERATURE (exact)	
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature



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READER'S GUIDE

The sections of this report focus on various aspects of the Teltran system in order to facilitate a selective review by the reader. The Executive Summary provides an overview of the report including the key findings and conclusions of the evaluation.

Section 1 identifies the evaluation issues which provided a focus for this effort and the unique aspects of the Ann Arbor evaluation. Section 2 provides a description of Ann Arbor, including demographic and transportation system characteristics. Section 3 describes the development and current operation of the Teltran system including an analysis of the incremental implementation strategy adopted by the AATA.

The primary results of the evaluation are included in Sections 4 through 6. Section 4 describes the level of service provided by Teltran, including travel time, reliability, and coverage. Section 5 describes the current ridership on the system as well as the growth in ridership over the past three years as system implementation occurred. Section 6 discusses the financial aspects of Teltran and the productivities currently being achieved by the system.

Section 7 provides a summary of the evaluation findings and includes a discussion of the potential transferability of these findings to other communities. Appendices A through D describe the surveys conducted for this evaluation, control room equipment and displays and vehicle operating data. Appendix E is a report of inventions.

EXECUTIVE SUMMARY

OVERVIEW

Since the conclusion of a dial-a-ride pilot project in the fall of 1972, the Ann Arbor Transportation Authority (AATA) has developed and incrementally implemented an integrated dial-a-ride and conventional fixed-route bus transit system which utilizes a computer assisted reservation system and provides the city with 100 percent geographical coverage during all hours of operation. As of the summer of 1976, the final phase of the Teltran system has been implemented. In addition, the AATA operates a many-to-many dial-a-ride service for the handicapped, a number of bus routes in Ypsilanti, and service for the elderly and handicapped in rural areas of the county.

While neither the Teltran system nor the other transit services provided by the AATA are part of the Urban Mass Transportation Administration's (UMTA) Service and Methods Demonstration (SMD) Program, UMTA has decided to conduct an evaluation of transit in Ann Arbor under the aegis of the SMD program. The work was performed for the U.S. Department of Transportation, Transportation Systems Center (TSC) which has the responsibility for monitoring SMD project evaluations. The decision to include an assessment of transit in Ann Arbor within the SMD program has reflected the continuing national attention being given to this innovative transit system. The Teltran system has received substantial local financial support and has resulted in dramatic increases in transit ridership. Thus,

the Ann Arbor experience is both noteworthy and potentially useful to other areas considering major transit innovations in general, and in particular, integrated fixed-route bus and dial-a-ride service.

OBJECTIVES AND EVALUATION ISSUES

The five Service and Methods Demonstration Program objectives are:

1. Reducing travel time for users,
2. Increasing transit coverage,
3. Improving transit reliability,
4. Increasing transit vehicle productivity
5. Improving service to the transit dependent.

While each of these objectives directly applies to the Ann Arbor system, Teltran was implemented to meet two specific local objectives:

1. Providing 100 percent geographic coverage by transit, and
2. Reducing automobile ownership to one car per family and maintaining it at that level.

Provision of 100 percent geographic coverage has strong implications for the level of service that can be provided in terms of travel times and reliability, and the productivities that can be achieved. Although the evaluation has been conducted primarily with existing data, and is constrained to a certain extent as a result, the evaluation focuses on describing the development and operation of the integrated fixed-route bus and dial-a-ride service and, to the extent possible, the level of service provided by a system designed for 100 percent coverage. Other aspects of the system that were examined are:

a. the shift in type of service and system configuration by time of day and day of week,

b. service provided to the transit dependent, and

c. institutional and operational issues involved in implementing integrated services, including the effectiveness of an incremental implementation strategy.

PROJECT DESCRIPTION

Ann Arbor, site of the main campus of the University of Michigan, has a population of 106,000 and is located just outside the Detroit metropolitan area. The city has an area of 23.5 square miles and an average population density of 4,510 persons per square mile. The Ann Arbor transportation Authority operates an integrated dial-a-ride and conventional fixed-route bus system which provides 100 percent geographic coverage within the city during all hours of operation. The Teltran system employs dial-a-ride service within specific geographic zones (the number of zones varies by time period) and connects the zones with fixed-routes serving the downtown area and other major activity centers. Passengers pay a 25 cent fare upon boarding either type of vehicle and all transfers are free. Thus, a rider may be picked up at home by a dial-a-ride vehicle, transfer to a fixed-route bus, and then transfer again to another dial-a-ride vehicle for doorstep delivery if necessary. Special half price fares for regular service are available to low income, handicapped, and elderly citizens, and monthly passes are available to the general public. Transfers between dial-a-ride vans and fixed-route buses are coordinated to minimize wait time. Dial-a-ride vehicles perform flexibly routed tours, with prescheduled arrival times at one or two fixed points within the zone. One or both of these locations, usually situated at existing centers of activity, serve as a transfer point to a fixed-route. The

dial-a-ride vehicle is scheduled to arrive at the transfer point at the same time as the fixed-route bus, but if either vehicle is behind schedule, dispatchers can coordinate transfers by delaying departures from the transfer point. Once passengers transfer between the vehicles, the dial-a-ride van begins its next tour. The driver determines the route for dropping off passengers who have boarded at the transfer point and for picking up new passengers who have telephoned in requests for service. Eventually the van returns to the transfer point to meet another fixed-route bus.

Since fixed-route bus headways during peak periods are 15 minutes, several dial-a-ride vans must operate in each zone to permit coordinated transfers with each fixed-route bus. The city is presently divided into 14 zones for weekday service, 7 zones for weeknight service, and 9 zones on weekends. Four fixed-routes are operated and there are 7 transfer points between dial-a-ride and fixed-route services.

The AATA also provides city-wide dial-a-ride service for the handicapped using special vans equipped with wheelchair lifts. The wheelchair service is being extended to other areas within the county. Five fixed-route bus lines in neighboring Ypsilanti are also operated by the AATA.

A computer assisted system allows three dispatchers to handle the AATA fleet of 32 full-size transit buses and 48 dial-a-ride vans. In addition, a varying number of call takers answer questions and log in telephoned requests for service. Riders may telephone to request immediate or future pickups or place a "standing order" to reserve the same trip on a subscription basis. The computer acts primarily as a bookkeeper, keeping track of reservations, displaying them to call takers and dispatchers,

and facilitating the editing of vehicle tours. The assignment of individual service requests to particular zones and vehicle tours is performed manually. While dispatchers currently radio tour lists to individual drivers, in the future tour lists will be transmitted directly to display screens to be installed in each vehicle. However, there are no plans to automate the decision-making roles of the call takers or dispatchers.

HISTORY AND STATUS

In July of 1968, after the last in a succession of private bus companies had ceased operations, the city of Ann Arbor created the AATA to serve the city and the area in Washtenaw County within 10 miles of the city limits. Initially, service was provided through a short-term operating contract with a private firm. Subsequently, service was expanded as the AATA acquired its own vehicles and operated a fixed-route system which carried 540,000 passengers by 1972.

In April 1968, a citizens' committee met with representatives of Ford Motor Company to explore the feasibility of dial-a-ride service in Ann Arbor. In 1970, the city directed Ford to develop a plan for implementing demand responsive service, and in November the city submitted a proposal for demonstration funding of a pilot project to the State of Michigan. The project began its operation in September 1971. It offered many-to-few service from a residential neighborhood in the southwest part of the city to the downtown, a shopping center, and the university. At the conclusion of the project in September 1972, the service area was 2.4 square miles, after several expansions due to lower ridership than originally anticipated.

By the end of the project, dial-a-ride ridership had reached over 200 passengers per day, and the AATA was very encouraged. Overall transit ridership originating in the zone had doubled from pre-project levels on the fixed-route service and on-board surveys indicated that dial-a-ride service was appealing to a market not reached by regular fixed-route bus service. These results convinced the AATA that demand-responsive transit could play a significant role in Ann Arbor. The plan for the Teltran system was developed by the AATA in the fall of 1972 to provide integrated fixed-route bus and demand responsive service on a city-wide basis.

The first test of the Teltran plan came in April 1973 when the voters were asked to support it by approving a 2.5 mill property tax. The public referendum passed and in the summer of 1973 implementation began. The AATA chose a phased implementation strategy to facilitate fine tuning of system operation and design as experience was gained and to permit adequate time to recruit and train the staff necessary for full scale operation. By the end of 1973, the AATA provided service to the handicapped using a vehicle equipped with a wheelchair lift, and provided weekend and evening dial-a-ride service throughout the city. In 1974, Ypsilanti fixed-route service and integrated dial-a-ride/fixed-route bus service on Saturdays was initiated. During 1975, service expanded considerably with all but three of the weekday dial-a-ride zones in operation. As of June 1976, all zones received integrated service, and annual ridership for fiscal year 1976 was 1.8 million.

FINDINGS

By virtue of its design, Teltran has achieved the city-wide coverage

objective with the implementation of the last remaining dial-a-ride zone. The other local objective, reducing automobile ownership to one car per family, is essentially a long-range goal, and there are insufficient data available at present to determine anything about Teltran's success in achieving this objective.

While telephone associated delays have been a problem, major difficulties appear to have been overcome. Ninety-five percent of all calls are answered within three minutes (mean time is 1.12 minutes) and processed within 2.5 minutes, although this time varies greatly with the type of trip being requested.

For those callers requesting immediate service, the mean elapsed time (after completion of the phone call) before the vehicle has arrived is 22.9 minutes (with a standard deviation of 12.5 minutes). Interestingly, riders have perceived a significantly shorter wait time, perhaps because they can use the time effectively. Typically, the caller is provided with an estimated time of arrival (ETA) for the vehicle, usually a "window" of 10 to 15 minutes. Of those customers surveyed, 59 percent reported that their vehicle arrived "on time" (i.e., within the window).

Dial-a-ride in-vehicle time for daytime trips is found to average 9.5 minutes with a standard deviation of 6.6 minutes. Average dial-a-ride in-vehicle distance for daytime trips is 2.3 miles (with a standard deviation of 1.3 miles), implying an effective speed (including stops) of 14.6 miles per hour. During evening hours, when the service area is divided into fewer but larger zones, the mean travel time is 14.3 minutes.

Coordinated transfers from dial-a-ride vans to line buses or other

vans have averaged 4.1 minutes for nonstanding order (i.e., non-regularly scheduled) trips, with 36 percent of the riders having no wait at all (i.e., the second vehicle is waiting when the van arrives). The transfer time for standing order customers, who dominate AM peak period travel, has averaged 5.4 minutes.

Since 1971, when the first innovations took place, total annual transit ridership in Ann Arbor has increased from 540,000 to 1.8 million for the 1976 fiscal year. About 4,000 trips were served by the special service to the handicapped. Ridership for the fully implemented system should be somewhat more.

From 1975 to 1976, the system carried 10.5 passengers per vehicle hour calculated on a first fare basis. With transfer passengers, the productivities were 35.2 passengers/vehicle hour for line buses and 6 passengers/vehicle hour for dial-a-ride. Operating costs per vehicle hour and vehicle mile (including deadheading) for the entire system were averaging $19.85 and $1.58 respectively. Of the total operating costs, 78 percent were from wages and fringe benefits (including management and administration), 8 percent were for vehicle operating costs, and the remainder were for fixed costs, of which the largest components were for planning and fleet insurance.

The operating cost per passenger was $1.89. With transfer passengers, the cost per passenger was 56¢ for line bus and $3.31 for dial-a-ride. Because of the design of the system, many passengers use both dial-a-ride and line bus service in making a trip. The deficit per passenger was $1.66, of which 93¢ was covered by the millage tax. The

rest of the deficit was funded primarily by both Federal and state operating assistance grants.

TRANSFERABILITY

While it is too early to judge the long term impact of the Teltran system, there are some characteristics of Ann Arbor which have contributed to its success to date. The average family income and median years of education are high for both men and women. The tax base is strong and residents have provided support to public transit by approving a special property tax assessment. In addition, the presence of the University of Michigan has provided a pool of young, educated, and enthusiastic individuals to serve in many staff positions and dedicated to providing high quality public transit service. Finally, the existence of a limited number of major activity centers, with the dominant attraction being the downtown and the adjacent central campus of the university, makes integrated transit combining dial-a-ride feeder service and radial and circumferential fixed-route service an effective choice for Ann Arbor.

Thus, both the ridership and financial support given to Teltran may in part be attributed to the unique nature of Ann Arbor. However, since the University of Michigan operates its own internal transit system free of charge, much of Teltran's ridership and public support does come from individuals with no direct connection to the university. Thus, given a suitable site, popular support, and proper planning, a system like Teltran may have similar success elsewere and Ann Arbor's experience provides some important insights for other communities considering integrated transit.

Integrated dial-a-ride and fixed-route service with coordinated

transfers provides an effective means of providing 100 percent geographic coverage with door-to-door service. However, to maintain reasonable systemwide productivities requires shifting the system configuration during periods of low ridership. Naturally, other communities considering integrated transit may not choose to provide 100 percent geographic coverage, but changes in system configuration may still prove desirable to maintain acceptable productivity levels.

Whether integrated transit is considered for areawide service or only for selected subareas, the Teltran dispatching system provides a very flexible computer assisted dispatching method that could be used by other communities. However, because the computer only performs bookkeeping functions, the Teltran dispatching system requires well trained and experienced staff who are willing to accept major decision-making responsibility.

The incremental implementation strategy adopted by the AATA allows for staff training and adjustments to operating policies before successively more complex system configurations are implemented. However, the Teltran experience also suggests that extensive telephone system planning is desirable and the phone requirements of the final system configuration should be anticipated even if an incremental implementation strategy is adopted. Also, the public acceptability of integrated transit may be increased if public information programs attempt to explain the operating policies used to provide a relatively complex service.

1. OVERVIEW OF THE EVALUATION

1.1 EVALUATION ISSUES

While the AATA provides a variety of transit services to different groups and jurisdictions, the scope of the evaluation is limited to the more innovative aspects of the service provided within the City of Ann Arbor. In particular, the evaluation focuses on the integrated dial-a-ride and line bus Teltran system, the changes in system configuration by time of day (e.g., daytime and evening) and day of week (weekday and weekend), and the incremental strategy used to implement the system. In some cases, it is not possible to disaggregate operating data (e.g., cost data, vehicle fleet utilization, etc.) for the integrated service in Ann Arbor and the line bus routes operated in Ypsilanti; and in these cases evaluation results are presented for AATA services as a whole. However, all transit services provided by the AATA are described in Chapter 3, and a description of the transit services provided in Ann Arbor by other public institutions (e.g., University of Michigan) or private operators is included in Section 2.

In performing an evaluation of an integrated transit system, and especially the Teltran system, a number of issues are of particular interest. First, the SMD program objectives of reducing travel time and increasing coverage are important for Ann Arbor and to some extent are in conflict. With a given amount of resources, movement toward one objective often necessitates some de-emphasis of the other. Early in the campaign for local property tax support of the Teltran system, the AATA made a commit-

ment to provide 100 percent geographic coverage. Thus, the extent to which Teltran also can provide "reasonable" travel times is important both locally and nationally. Because of the importance of this issue and the lack of recent data available in Ann Arbor, a limited surveying effort has been conducted as part of this evaluation to obtain current information on phone service and travel time.

System reliability is an important issue wherever demand responsive transit is implemented. For an integrated system such as Teltran, the reliability of the required transfers between vehicles is an important component of this objective. Similarly, the productivity that an integrated system can achieve is of interest in assessing the effectiveness of using demand responsive service to perform collector/distributor functions for fixed-route bus lines. Of particular concern is the productivity of integrated service compared to either a pure demand responsive system or a conventional bus system.

In addition, the incremental implementation strategy adopted by the AATA and the Authority's operational experience with integrated service provide useful insights for other communities considering innovative transit services. The Ann Arbor experience points out both some of the major strengths of an incremental approach to innovation and the specific elements of the system where more thorough advance planning, and possibly "one-shot" implementation, may be appropriate.

1.2 EVALUATION APPROACH

The Ann Arbor evaluation effort was unique for the following reasons:

a) The system being evaluated was not implemented under the SMD program,

b) The transit system being evaluated was not fully implemented until mid-1976, after completion of this evaluation,

c) The availability of important evaluation data was limited and new data collection efforts were confined to dial-a-ride travel time and phone wait and service time surveys, and

d) The substance of the evaluation including all data collection and analysis was performed within a period of five months.

All of these factors limited the scope of the Ann Arbor evaluation.

Typically, SMD evaluations involve the examination of conditions before and after the implementation of a specific project. Because Ann Arbor is not the site of a SMD project, it is difficult to define a logical "before" period against which to compare the current situation. The lack of consistent time series data further suggests the need for a different emphasis in the evaluation of the Teltran system. Thus rather than statistically testing specific hypotheses about the effects of Teltran, the Ann Arbor evaluation focuses on providing a full and detailed description of the current status and impacts of the Teltran system as it existed during the winter and spring of 1976. To the extent possible, a summary of system implementation and the impacts over time of various stages of the system also is provided.

Since the Teltran system was not completely implemented until mid-1976, the evaluation does not focus on the entire system. The results presented here reflect the Teltran system as it existed in the late spring of 1976, as described in Section 3. Subsequent to the data collection efforts for this evaluation three new dial-a-ride zones have been implemented.

As mentioned earlier, the evaluation depended primarily on data already available in Ann Arbor, and, except for a number of travel time surveys, no new data were collected. The constraint on data collection and the fact that the evaluation was performed over a relatively short time period combined to limit the information generated on several key aspects of the Teltran system. In particular, very little data are available on the travel times (and the variability of travel times) on the line bus portion of the system. The surveys conducted focused on the dial-a-ride component of the system because it was felt that the demand responsive service was the component of the system of most interest to other communities considering integrated service. Time and resource constraints did not allow adequate surveying of the entire daytime integrated system, and thus, little information is presented on the total trip times for riders making transfers to or from line buses.

Similarly, accurate information on total ridership on the dial-a-ride and line bus components of the system was not available. The AATA keeps ridership records for dial-a-ride and fixed-route buses based on the vehicle on which the first fare is paid. Since many riders transfer, an estimate of total ridership on each component of the daytime system has to rely on information on the distribution of transfers generated by the travel time surveys.

2. SITE DESCRIPTION

2.1 OVERVIEW

Ann Arbor is located 38 miles west of Detroit in Washtenaw County and has an area of 23.5 square miles. The 1970 census lists the city's population as 100,035 persons. Currently, the population is estimated at over 106,000 persons, resulting in a density of 4,510 persons per square mile. Ann Arbor is situated along a number of major transportation corridors, including the main east-west highway (Interstate 94) and the rail line between Detroit and Chicago. U.S. Route 23, the major north-south road between Toledo and Flint, runs along the eastern edge of the city.

While Ann Arbor is located on the western fringe of the Detroit metropolitan area, which contains over 4 million people or about 75% of the population of Michigan, the city maintains a strong physical and cultural identify of its own.

The city is fortunate in having a strong tax base made possible by use of its power to annex surrounding land as it developed. During recent years, the rate of annexation has decreased significantly, and currently, the annual rate of expansion is less than one fifth of one percent. The largest community in close proximity to Ann Arbor is Ypsilanti, located directly to the east with a population of 29,502 persons and an area of 4.1 square miles.

The city was first settled in 1823 on the rolling farmland along the Huron River, but was not incorporated until 1851, when its population had reached 4,500. The major reason for Ann Arbor's cultural atmosphere

is the presence of the University of Michigan. The university was founded in Detroit in 1817 but moved to Ann Arbor twenty years later. Currently, the university has an enrollment of 34,695 and employs a research staff of over 5,000. The university owns 10.4 percent of the land in Ann Arbor. One third of the city's population has a direct connection to the University, and indirectly, many others provide services to the university community or indirectly use the resources provided by that community. Over 45 private research firms, employing 3,600 persons, and 8 government research laboratories have located in Ann Arbor. The city has a national reputation as a major research center. The medical center is the city's most significant generator of state and interstate travel.

As shown in Figure 2.1, the university facilities are split between two campuses, one north of the Huron River and the other near the central business district (CBD). The university medical center is located directly north of the central campus.

The university provides the city with many cultural opportunities and contributes to the political climate of the community as well. Ann Arbor was one of several centers of the anti-war movement in the 1960's and early 1970's, and has been a leader in the environmental movement. During the height of the student protest the Human Rights Party (HRP), a student-oriented party, won two seats on the City Council.

The downtown area consists of two commercial areas, one located on State Street at the edge of the University of Michigan campus and the other on Main Street five blocks away. New commercial developments have slowly decreased the separation between these two centers. More recently,

LEGEND

1 North Campus
2 Medical Center
3 Central Campus
4 Commercial Center
5 Stadium

Freeways

Major Arterial Streets

Railroads

SCALE:

0 1

ONE MILE

N

FIGURE 2.1. MAP OF ANN ARBOR

construction of a number of large suburban shopping centers has shifted some retail activity away from the downtown area. The location of major shopping and employment centers and other trip generators is shown in Figure 2.2.

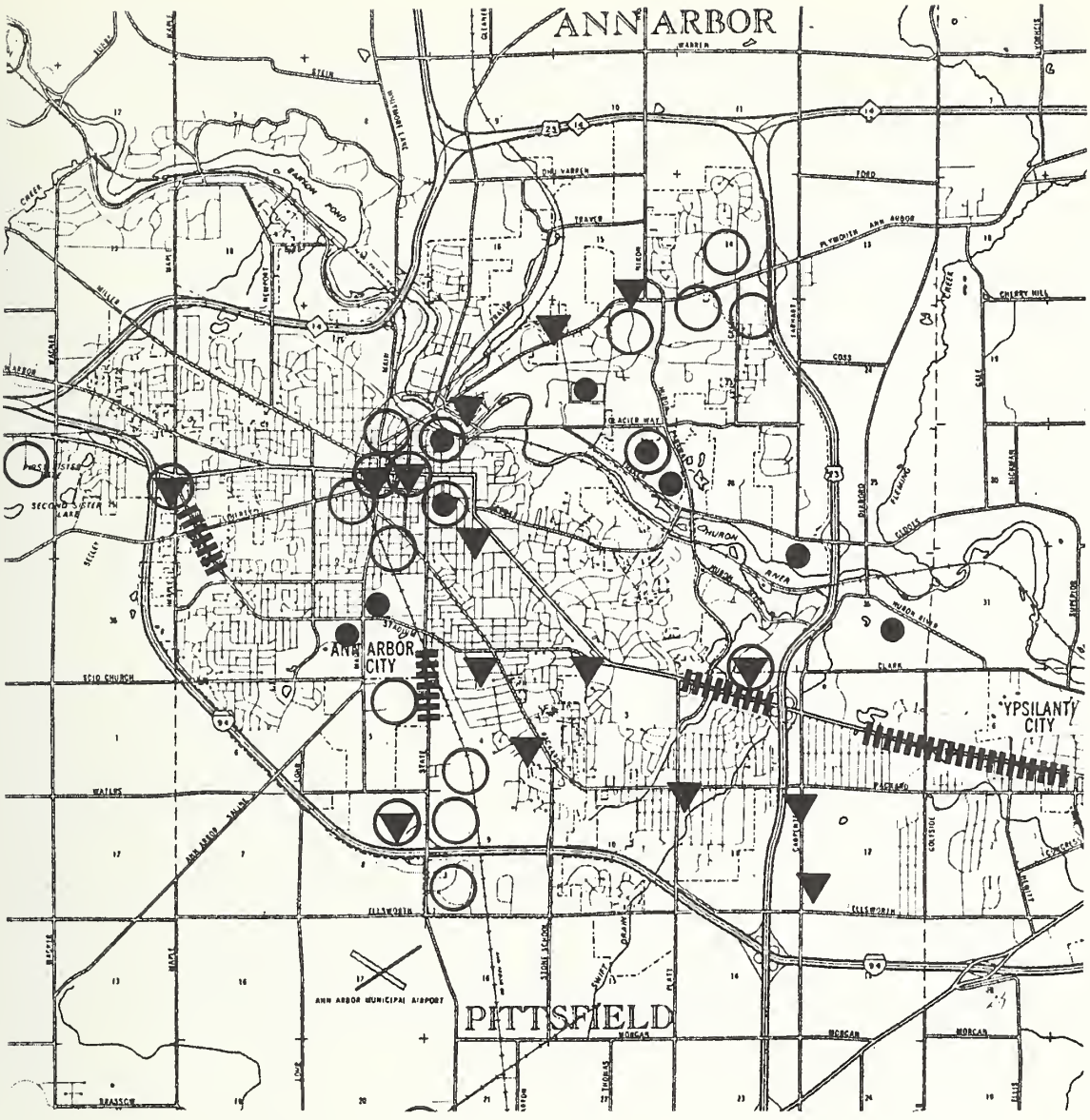
The older residential areas of the city are comprised of single family homes. Near the university campus many of these single family structures have been converted to apartments. In outlying areas, many large apartment and condominium complexes have been constructed.

Meteorological data for Ann Arbor are shown in Table 2.1.

2.2 DEMOGRAPHIC PROFILE

In large part because of the presence of the university, the population of Ann Arbor is younger, better educated, and wealthier than the national averages, as shown in Table 2.2. More detailed data on the sex, age, education and income characteristics of Ann Arbor's population are shown in Table 2.3. The geographic distribution of the population is shown in Figure 2.3. Not surprisingly, the population density is greatest in those tracts close to the downtown area while average family income is lowest in these same tracts. The greatest concentration of elderly individuals is directly northeast of the CBD.

The influence of the university can also be seen in Ann Arbor's employment characteristics. About 70% of Ann Arbor's employment is in the government sector with a rather low proportion, about 11%, in manufacturing and industry. Of the approximately 43,000 employed persons living in Ann Arbor, 72% have their place of work within the city.



LEGEND

- Shopping
- Hospitals, Schools
- Employment
- Strip development

FIGURE 2.2. MAJOR TRIP GENERATORS

TABLE 2.1. METEOROLOGICAL STATISTICS FOR ANN ARBOR (30-yr. average, 1940-1969)

MONTH	AVERAGE DAILY TEMP. °F		AVERAGE MONTHLY TEMP. °F	MEAN PRECIPITATION (water equiv.)(inches)	MEAN SNOWFALL (inches)	MEAN NO. DAYS > 0.10 INCH PRECIPITATION
	Max.	Min.				
J	31.8	17.8	24.8	1.81	7.3	5
F	34.2	19.1	26.7	1.65	6.6	4
M	43.8	26.4	35.1	2.31	5.4	6
A	58.5	37.8	48.2	3.21	1.1	7
M	69.7	48.1	58.9	3.25	0.1	7
J	79.8	58.2	69.0	3.10	0.0	7
J	83.4	62.0	72.7	2.91	0.0	5
A	81.5	60.5	71.0	2.78	0.0	6
S	74.4	53.4	63.9	2.19	0.0	5
O	63.7	43.9	53.8	2.49	0.0	5
N	47.7	32.7	40.2	2.25	3.0	6
D	35.4	22.4	28.9	2.15	6.0	5
TOTAL	NA	NA	NA	30.10	29.5	68

TABLE 2.2. ANN ARBOR COMPARED TO THE NATION

Characteristic	1970 Census Data	
	Ann Arbor	U.S. Totals
Median Income of Families and Unrelated Individuals (Dollars)	$12,819	$9,867
Median Age (Years)	23.6	28.0
Persons 65 Years Old and Over (Percent)	5.4	9.8
Black (Percent)	6.7	11.0
Not Completing High School (Percent)	14.6	47.7

TABLE 2.3. BASIC DEMOGRAPHIC DATA (1970 Census)

Total Population:	100,035
Sex (Percent)	
male	50.05
female	49.95
Age (Percent)	
under 20	34.70
20-44	47.80
45-64	12.10
65 & over	5.40
Race (Percent)	
Black	6.70
Spanish heritage	1.30
Education (Percent)	
no formal schooling	0.30
grade school (1-8)	4.90
some high school (9-11)	9.40
high school diploma (12)	21.30
some college	15.90
college degree or more	48.20
Total Families	20,882
Family Income (Percent)	
less than $5,000	10.90
between $5,000 and $5,999	24.00
between $10,000 and $14,999	26.00
between $15,000 and $24,999	28.00
$25,000 and over	11.10

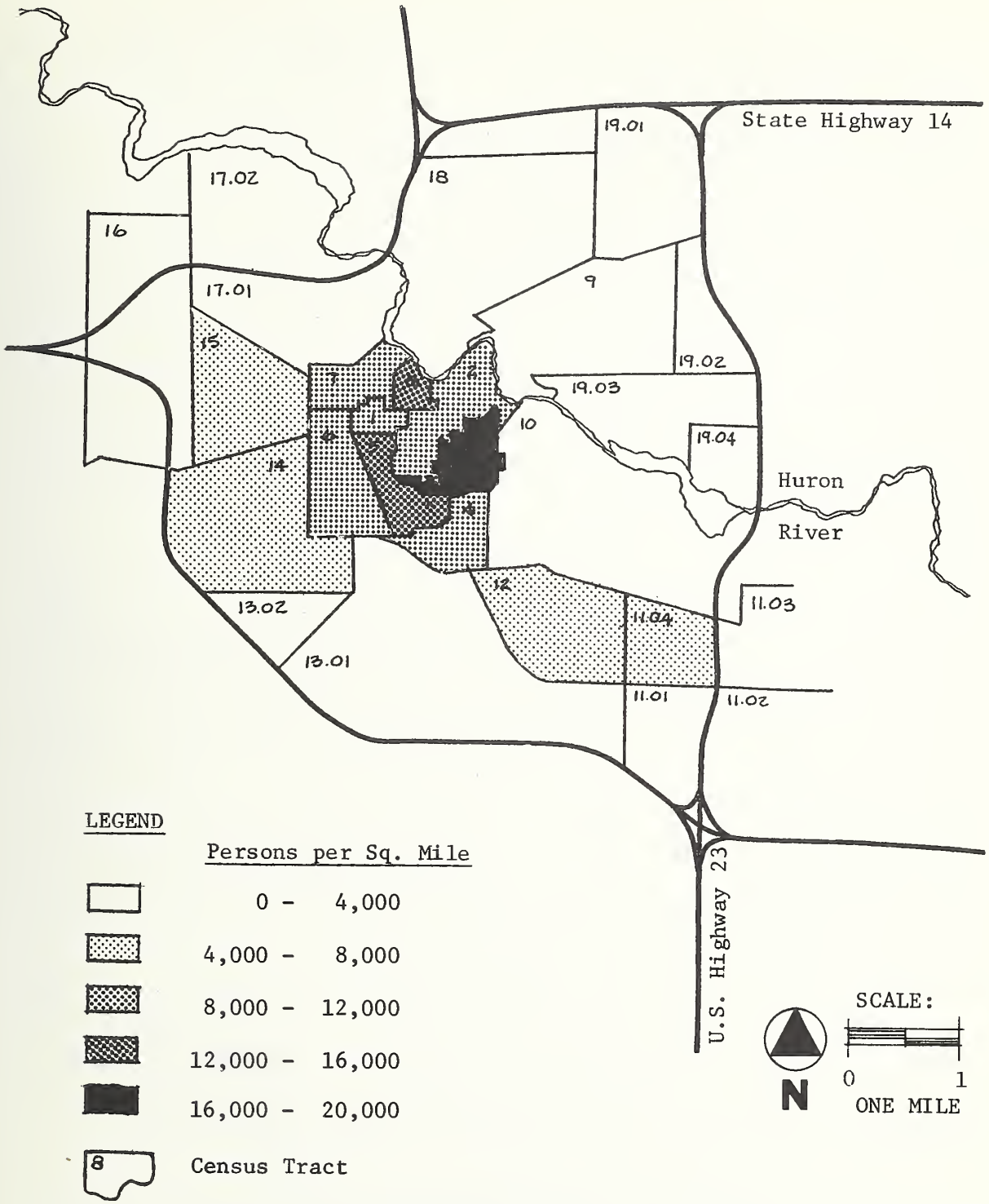


FIGURE 2.3. POPULATION DENSITY

In 1970, Ann Arbor had a total of 31,511 occupied housing units with an average of 3.2 persons per unit. Over 50% of the housing units have had a change of occupancy within the last two years caused in part by the large transient population associated with the university. Table 2.4 provides more detailed data on the city's housing units.

2.3 TRAVEL BEHAVIOR AND THE TRANSPORTATION SYSTEM

While major improvements in public transportation have occurred in Ann Arbor in recent years, transportation in the city is heavily oriented toward the automobile. As seen from Table 2.5, 89% of all households in 1970 had at least one automobile available and over 70% of all workers rode to work in an automobile. The large majority of these workers, almost 75%, had a place of work within Ann Arbor.[1] About one third of Ann Arbor's total employment of 45,000 workers lived outside of the city and commuted into the city from surrounding communities. The highest concentrations of households with no auto were in the CBD and the area directly to the north of the central area. The AATA estimates that the current daily Teltran ridership represents about 2.5% transit mode split for average 24 hour weekday trips within the city.[2]

Ann Arbor is the only city in Michigan that has a complete expressway ring on its periphery. The ring is formed by Interstate 94 to the south and west, U.S. route 23 to the east and State Highway 14 to the north.

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[1] It should be noted that the data, and in particular mode split to work figures, were gathered prior to the implementation of the Teltran system.

[2] Guenther, Karl W., "Report on Demand Responsive Transportation in Ann Arbor," prepared for the 55th Annual Meeting of the Transportation Research Board, January 1976.

TABLE 2.4. HOUSING UNIT DATA (1970 Census)

Number of Housing Units	32,533
Occupancy Type (Percent)	
owner occupied	43.8
renter occupied	53.1
vacant year-round	3.1
Number of Occupied Housing Units	31,511
Occupancy Rate (Percent)	
1 person	21.0
2 person	32.7
3 person	17.0
4 or more	29.3
units with boarders	5.5
Years in Residency (Percent)	
1 to 2 years	55.7
3 to 5 years	16.9
6 to 10 years	10.3
11 to 19 years	10.3
20 or more years	6.8

TABLE 2.5. AUTOMOBILE OWNERSHIP, MODE TO WORK AND PLACE OF WORK DATA (1970 Census)

Number of Automobiles per Household (Percent)	
0	11.3
1	52.3
2 or more	36.4
Total Number of Workers	42,756
Mode to Work (Percent)	
auto driver	60.9
auto passenger	11.2
bus	3.6
walk	17.6
train	.1
other	2.8
work at home	3.8
Place of Work (Percent)	
within Ann Arbor	72.4
within rest of Washtenaw County	11.4
outside SMSA	9.0
not reported	7.2

Nine major arterials connect the expressway ring with the central business district in a radial pattern.[1] The Huron River separates the northeast section of the city from the central business district and other residential areas and has constrained the amount of surface street capacity connecting these segments of the city. Preservation of the environment around the river and its flood plain is a high local priority and an ongoing corridor study analyzing the future travel needs in the river valley is not likely to result in major street expansion.

General traffic conditions in the city are good with relatively uncongested flows even during peak hours. While a number of local streets are in need of resurfacing and street conditions generate numerous citizens' complaints to the city, a recent bond issue for repaving local streets failed to pass.

Limited commuter rail service is provided by Amtrak connecting Jackson and Detroit with stops at Ann Arbor and Ypsilanti. Currently one commuter train is operated in each direction daily though the state may expand the service in the future if ridership increases. Amtrak also operates three trains daily in each direction between Chicago and Detroit with stops in Ann Arbor and other communities in southern Michigan. Regional bus service is provided by the Southeast Michigan Transportation Authority (SEMTA) and five private carriers. The largest of the private carriers is Greyhound which operates eleven buses daily between Ann Arbor and Detroit.

The Detroit Metropolitan airport is located between Detroit and Ann Arbor and is easily accessible via Interstate Route 94. This airport is

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[1]Refer to Figure 2.2.

served by bus and limousine from downtown Ann Arbor and the university. All regional and long-haul flights use this airport, while private craft can use the Ann Arbor airport located on the southern border of the city.

Local bus service, in addition to that provided by the AATA, includes the University of Michigan bus system, the Eastern Michigan University system in Ypsilanti, and the public school system. The University of Michigan system carries approximately 3 million passengers per year making it the single largest carrier in the area. It operates on a free-fare basis for university personnel and students. However, due to a lack of enforcement, in practice anyone travelling around the campus can use the system. The system operates 7 shuttle routes connecting all campus facilities on a fixed schedule and operates all year, though with reduced service levels during the summer months. The AATA system does not provide intra-university service but does have connections to the edge of the main campus from all parts of the city. During evening hours the AATA directly serves portions of the north campus area which do not have good access to the University shuttle. Thus, the university and AATA systems complement each other with the university providing intra-university transit service while AATA connects the campus with the rest of the city. The university's 36 transit vehicles, all with seating capacities of either 41 or 53 passengers, are owned, operated and maintained by the university. The Ann Arbor and Ypsilanti school districts have a combined annual ridership of 3,300,000 and provide service for students living at least 1.5 miles from the school they attend.

Four taxi companies offer service in Ann Arbor and Ypsilanti and carry

approximately 1,500 to 2,000 passengers per day. The taxi rates are $1.10 for the first mile and 60¢ for each additional mile.

In 1973, voters approved an $800,000 bond issue for construction of bikeways. Currently in its early stages, the longest route is located on Packard Road between Ann Arbor and Ypsilanti downtown. There are an estimated 100,000 bicycles in the Ann Arbor-Ypsilanti area.

3. DEVELOPMENT AND OPERATION OF THE TELTRAN SYSTEM

3.1 DIAL-A-RIDE PILOT PROJECT

Public transportation in Ann Arbor began with a streetcar system in the early 1900's. Subsequently, the streetcars were replaced by buses. In the period following World War II the city bus system experienced a dramatic decrease in ridership. In 1946, serving a population of 40,000, the bus system carried 1.7 million passengers. By 1954, while the population had increased to 55,000, the ridership had decreased to 700,000. In May of 1968, the last in a succession of private bus companies ceased operations in the city. After a period with no bus service, interim service was provided by a short-term operating contract between the city and a private firm from June 1968 to February 1969.

The AATA was created by the city in July 1968, in accordance with state enabling legislation. After the private contractor failed to remain within the contract cost, the AATA initiated the city operation in the spring of 1969 with four mini-buses. Subsequently, used transit coaches were purchased as ridership increased. In 1970, the Authority purchased 16 new buses with a grant from the Urban Mass Transportation Administration covering two thirds of the cost. By 1972, the AATA was operating a fixed-route system with a fleet of 18 vehicles. The system consisted of six radial routes which operated from 6:30 AM to 6:15 PM on weekdays only, with half hour headways during peak hours and one hour headways during mid-day. The basic fare was 35¢ with a youth, senior citizen and low income fare of 20¢. Transfers were free and buses for

all routes met at a downtown transfer point each half hour. In fiscal year 1972, ridership on fixed-route buses was approximately 535,000 and operating costs were approximately $450,000. Fifty percent of these costs were covered by fares with the remainder paid for out of the city's general fund.

During the same period from 1968 to 1971 when the AATA assumed the operation of, and expanded, the city's fixed-route service, a series of steps were taken to initiate a dial-a-ride demonstration project. In April 1968, a Citizen's Bus Committee met with representatives of Ford Motor Company to explore the feasibility of dial-a-ride for Ann Arbor. In January 1970, the AATA signed a contract directing Ford's Transportation Research and Planning Office to develop a plan for implementing demand-responsive service. Ford's initial proposal to implement dial-a-ride in the Model Cities neighborhood was abandoned when negotiations between the Model Cities Policy Board and the AATA failed to result in an agreement.

Subsequently, in November 1970, the city submitted a proposal for a dial-a-ride pilot project to the State of Michigan Bureau of Transportation for funding as a demonstration. In August 1971, a contract was signed by the state, and a proposal was submitted to local taxi operators to run the system on behalf of the AATA. The taxi operators did not respond to the proposal and subsequently took legal action which delayed the start of service. The taxi companies in requesting an injunction against the operation of a dial-a-ride system contended that:

1) Dial-a-ride vehicles were really taxis and therefore, were required to obtain licenses under the city's taxicab ordinance,

2) The granting of licenses to existing taxicabs implied that the city had agreed not to offer a competing business, and

3) Ford Motor Company (a co-defendant in the suit) was being enriched by the program without giving adequate consideration in return, thereby defrauding the public.

In response, the City of Ann Arbor filed a motion for a summary judgment and was joined by Ford Motor Company in that motion. The city claimed that:

1) Because dial-a-ride vehicles were not subject to the specific directions of their passengers they were not taxis,

2) The city had the right to further the public interest by improving public transportation and this right had been upheld by earlier U.S. Supreme Court decisions, and

3) While Ford would obtain useful data from the project, the data would be available to all interested parties, and Ford would loan a vehicle for use in the pilot project at no cost to the city.

The Washtenaw County Circuit Court granted the city's motion for a summary judgment, thereby dismissing the case.[1] The taxi companies appealed, but in June 1972, the Michigan Court of Appeals unanimously upheld the decision of the Circuit Court and cleared the way for the start of the pilot project.

The pilot project service area was located in the southwest portion of the city and offered service from anywhere within this residential zone to several destinations outside of the zone including the downtown, a shopping center, the university, and two hospitals. Door-to-door service was also provided for any trips with both an origin and a destination within

[1] A transcript of the court's opinion is included in Lax, Jerold, "Dial-a-Ride Project in Ann Arbor: Legality," in Special Report 136, Transportation Research Board, Washington DC, 1973, pp. 71 to 74.

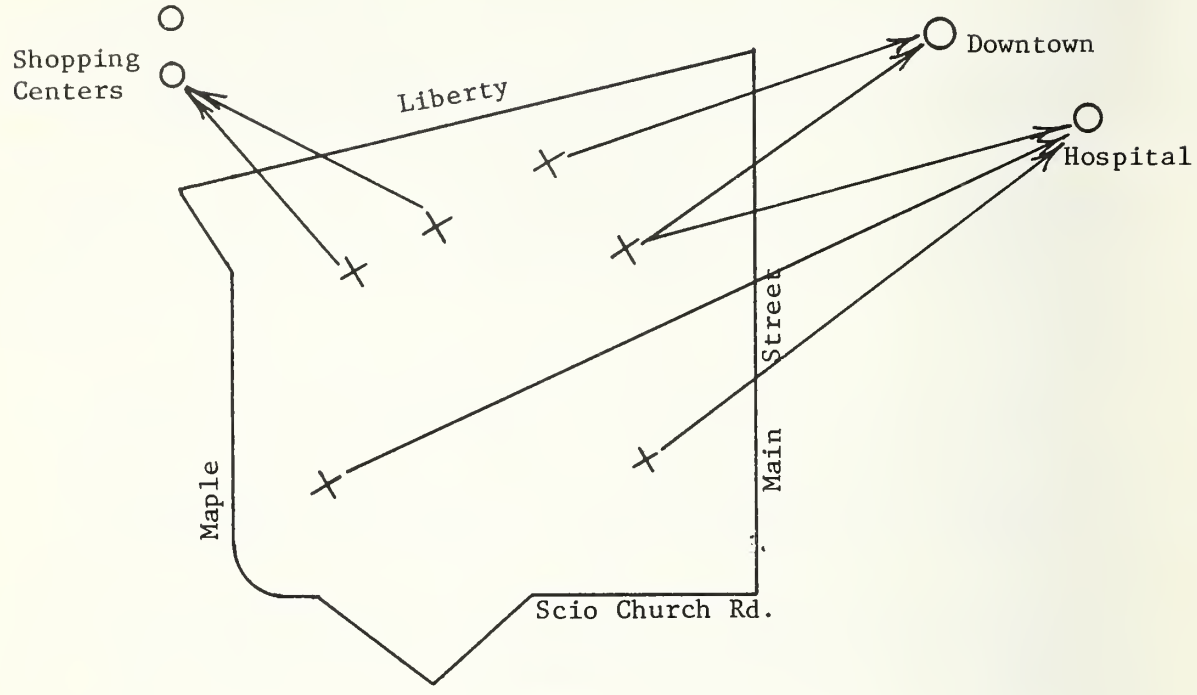
the zone. These intra-zonal trips were given a lower priority and could not always be served during peak periods. Figure 3.1 illustrates these types of service. The project zone, which had an area of 1.3 square miles initially, was expanded several times during the course of the demonstration because of low ridership, and at the conclusion of the project had an area of 2.4 square miles encompassing a population of 16,000 (approximately 16% of the city's population). The average income and automobile ownership in the service area were higher than the averages for the city.

The project utilized three vans and one dispatcher who received all calls, assigned them to vehicles, and answered requests for information as well. Inbound riders called for doorstop pickup. Outbound riders were requested to call for pickup at any of the permitted downtown destinations but could also walk on without calling in advance at these stops. Fares were 60¢ with free transfer to line buses. Line bus riders could transfer to dial-a-ride by paying 25¢ in addition to the basic line bus fare of 35¢.

The pilot project was run from September 1971 until September 1972.[1] Prior to the demonstration, AATA had set a 200 to 300 passenger per day ridership level as the standard for a "moderately successful" project. By the end of the project, ridership had reached over 200 passengers per day. Ridership on the fixed-route passing through the area did not decrease after the introduction of dial-a-ride. Wait times averaged 11 minutes from the time of request for service to the pickup time and in-

[1] In fact, after the state demonstration funding ended in September 1972, the city, at the request of citizens in the pilot project area, continued operating the dial-a-ride service with city appropriations until June 1973 when a special property tax millage was passed and subsequently used to expand the pilot project into the Teltran system.

"Many-to-Few" Service Between Zone and Selected Destinations:



"Many-to-Many" Service Within Zone:

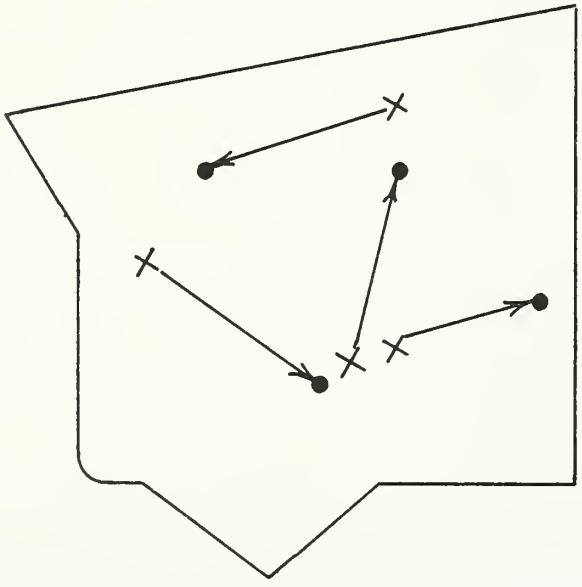


FIGURE 3.1. DIAL-A-RIDE PILOT PROJECT SERVICE

vehicle time averaged 13 minutes.[1]

The total operating cost of the project was $89,000. Capital costs were $10,800, and planning and publicity costs were $24,000. The project generated $24,900 in operating funds and received $61,200 from the State of Michigan. The remaining costs were covered by services and funds totalling $22,500 from the city and $15,200 of services contributed by the Ford Motor Company.

The AATA was very encouraged by the results of the pilot project. Overall transit ridership originating in the southwest zone doubled from the pre-pilot project levels on the fixed route service, and there was evidence from onboard surveys that dial-a-ride was appealing to individuals not reached by regular line bus service. As a result, the pilot project experience provided the major stimulus for the development of the Teltran system. The success of the pilot project also was instrumental in the development of the Michigan Department of State Highways and Transportation Dial-a-Ride Program.[2] The program provides 100% financing for dial-a-ride demonstration projects in small communities and rural areas for one year and up to 33% of the operating costs in subsequent years. Currently 28 communities are participating in this program.

3.2 TELTRAN SYSTEM

3.2.1 Design and Implementation

In April 1971, long after the initial steps had been taken toward

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[1] More detailed documentation of the results of the pilot project are available in AATA, Dial-a-Ride Pilot Project Final Report, April 1973, and numerous other sources.

[2] See Michigan Department of State Highways and Transportation, Michigan Dial-a-Ride Transportation Program Status Report. Revised February 1976.

implementation of the dial-a-ride pilot project, but before that project had begun operating, the AATA adopted a statement of goals and objectives which called for:

1) A coordinated public transportation system for the urbanized area permitting any individual to make any desired trip.

2) A public transportation system of sufficient size and influence to reduce auto ownership to one car per family and to maintain it at that level.

These goals reflected, to some extent, the increasing interest in environmental preservation within the city and an explicit social objective of providing transit to all residents. The pilot project served as a "field test" of the extent to which demand-responsive service could contribute toward meeting these objectives. The results of the pilot project convinced the AATA that demand-responsive transit could have a significant role in increasing transit usage in Ann Arbor and reducing the dependence on the automobile. In retrospect, the pilot project really served as the first phase in the development and incremental implementation of the Teltran system. During the fall of 1972, after considering several alternative system configurations, the AATA, aided by citizen input and their consultants, developed the plan for the Teltran system.[1]

The basic concept embodied in the original Teltran plan was for city-wide transit coverage provided by integrated line bus and demand-responsive service during evening and weekend periods. In peak hours, the plan envisioned eleven dial-a-ride zones, each served by 2 to 4 vehicles,

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[1] See AATA, "Proposal for an Expanded Community-Wide Public Transportation System," prepared for the Ann Arbor City Council and Citizens of Ann Arbor. January 18, 1973.

with coordinated transfers to express line buses.[1] This service was to be supplemented by school and work subscription service where demand and trip patterns made such service feasible. During weekday off-peak periods, the system would collapse to 6 dial-a-ride zones, each with 3 to 5 vehicles, and again with coordinated transfers to line buses. The evening and weekend service was to be provided by 4 dial-a-ride zones with no regularly scheduled line bus service. The plan called for a reduction of basic fare on the system to 25¢ with free transfers.

The first test of the Teltran plan came in April 1973, when the AATA asked the voters in the City of Ann Arbor for financial support for public transportation in the form of a 2.5 mill property tax. The AATA publicly committed itself to using this tax revenue to implement the Teltran plan. While the Republican Party opposed the plan on the grounds that it was too expensive, it did not stress the plan as a campaign issue. Both the Democratic Party and the Human Rights Party, a local student oriented party holding one city council seat at the time of the election, supported both the plan and the tax.

The AATA initiated the founding of a citizens' group to campaign for the millage and the group carried on an extensive media and door-to-door canvassing effort. The plan was also supported by numerous other citizen organizations, the downtown merchants, and the Ann Arbor News. No organized opposition occurred.

The charter amendment authorizing a permanent property tax for public

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[1]The actual system implemented differed from the plan in several respects and is described in the next section.

transportation was passed by 61% of the vote. While the student vote may have helped to pass the amendment, the vote did not represent a confrontation of any sort between the university community and the rest of Ann Arbor. Although the citizens' campaign may have increased the margin of victory, polls taken prior to the establishment of the citizens' committee showed a property tax dedicated to transit passing by a substantial margin. Thus, for a number of reasons (environmental, social, mobility) the residents of Ann Arbor strongly supported a tax for public transportation. The Teltran plan insured that every resident would be provided with door-to-door transit service.

After passage of the millage, the Authority applied for, and received, a Capital Improvement Grant from the Urban Mass Transportation Administration for purchasing additional vehicles and communication equipment, and expanding vehicle maintenance and storage facilities. During the summer of 1973, the AATA explicitly adopted and began a phased implementation of the Teltran system. Fares were reduced to 25¢, and in the fall and winter of 1973, city-wide dial-a-ride service for the handicapped, utilizing specially equipped vehicles, and city-wide evening and weekend dial-a-ride for all residents began. In 1974, the Ypsilanti line bus service was initiated and Saturday service was supplemented by some fixed route bus lines. During 1975, major expansion occurred and daytime dial-a-ride service was extended incrementally to most of the city. The remaining dial-a-ride zones were implemented during the summer of 1976. By following an incremental implementation strategy, the AATA

was able to make modifications to system design and operation based on the operating experience with each new element of the system. In general, new daytime zones were not added until the service in all existing zones was functioning smoothly. Section 3.3 discusses the advantages and disadvantages of this approach to system implementation.

3.2.2 System Description

As of May 1, 1976, the majority of the Teltran system has been implemented. While somewhat different than the system specified in the original plan (e.g., basic system configuration does not change during daytime off-peak periods, the daytime system uses more zones than anticipated, etc.), the existing system does rely heavily upon the coordination of transfers between dial-a-ride and fixed-route vehicles as originally intended.

The weekday Teltran system, operating between 6:30 AM and 6:15 PM, is shown in Figure 3.2. Currently, dial-a-ride service is provided in 11 zones with three additional zones to be added later in 1976.[1] The areas in Figure 3.2 not covered by a dial-a-ride zone are the University of Michigan campus (north and south of the Near Northeast zone), and shopping centers or other trip generators served directly by a line bus (between the Far Southwest and Packard zones). Four fixed-route bus lines are operated during weekday hours. One line is an express loop, with vehicles operating in both directions, routed circumferentially around

[1] In June 1976, daytime dial-a-ride service was initiated in the Burns Park and Devonshire zones. In July, service was initiated in the Near Southeast zone. In addition, the Far Southeast and Medford zones were combined into one zone. However, since all the data used for this evaluation was obtained prior to these system additions, the results presented apply to the system as it existed in May 1976, and as shown in Figure 3.2.

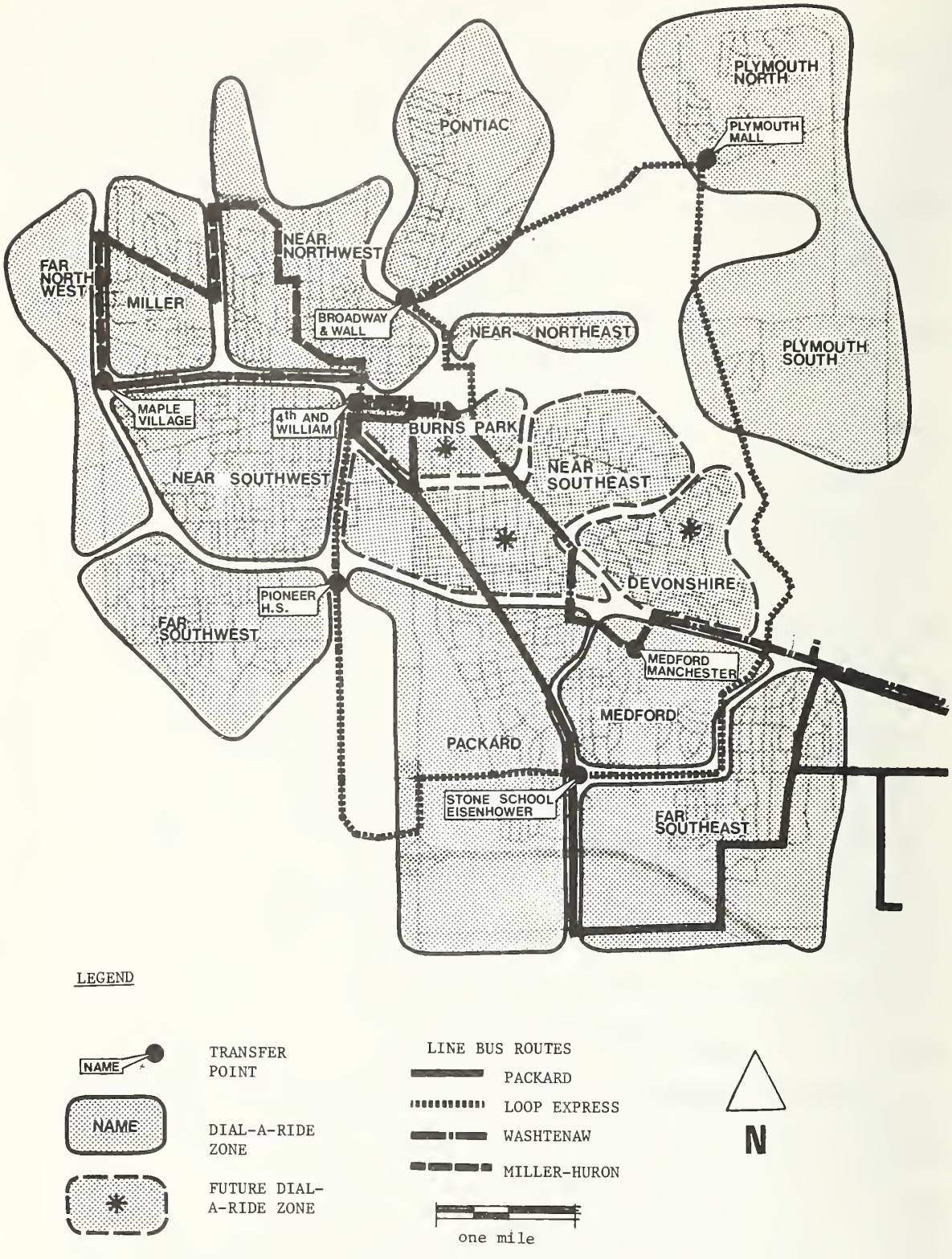


FIGURE 3.2. WEEKDAY TELTRAN SYSTEM

the city and passing through the CBD. The other three lines are radial routes which cross at the CBD.

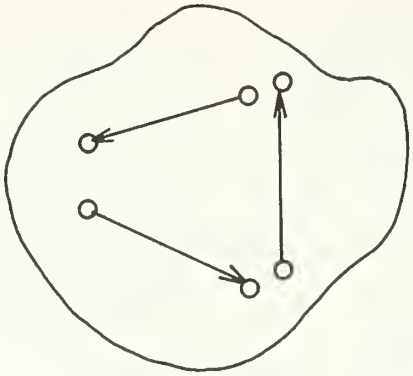
For trips within a particular zone, the dial-a-ride service is many-to-many. For trips between zones, at least one transfer is required. For these inter-zone trips, the dial-a-ride service is many-to-one, collecting riders and taking them to a specific transfer point, and one-to-many, picking riders up at the transfer point and distributing them to destinations within the zone (see Figure 3.3). At a transfer point, depending on their destination, riders board either a fixed route line bus or a dial-a-ride van serving an adjacent zone and the same transfer point. Each zone serves one or two transfer points and the vans in four of the zones (the 3 "near" zones and Miller) provide direct service downtown to the 4th and William transfer point.

In each zone the vehicles operate on a fixed-time tour and tours are generally one half hour in length. Vehicle tours generally begin and end at the same transfer point. However in some zones, vehicle tours are made between two transfer points (where zones serve two transfer points), or between a transfer point and a major activity center within that zone. In these latter two cases, the service provided is a point deviation type of service (see Figure 3.3). There are one to five vehicles serving each zone depending on the time of day, the zone size, and the level of demand. Table 3.1 shows the distribution of vehicles by zone for the weekday service.

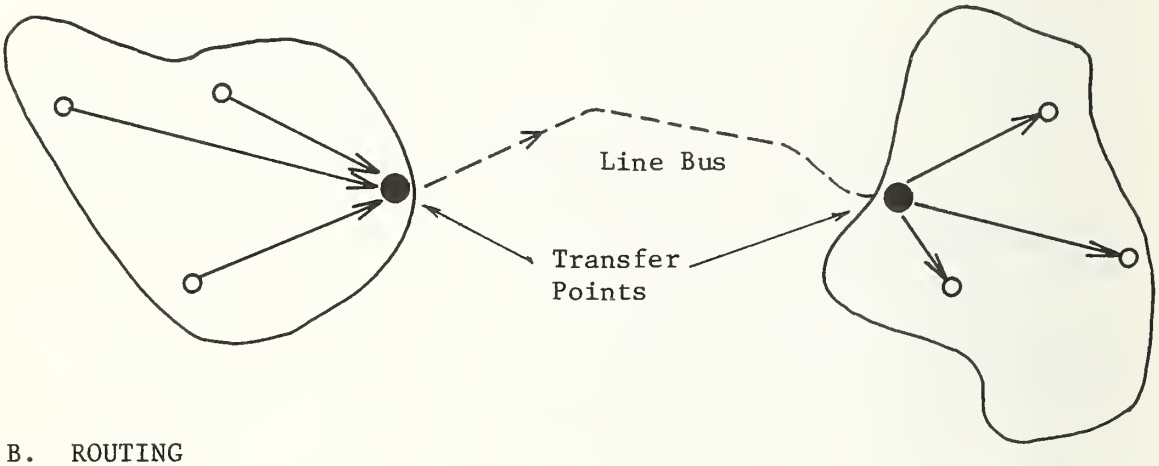
For the most part, all dial-a-ride trips are prescheduled and entire tours are transmitted to each van when it reaches a transfer point. However, a large number of unscheduled riders board at transfer points (both

A. SERVICE

Many-to-Many Service
Within a Zone



Many-to-One and One-to-Many Service
Between Zones



B. ROUTING

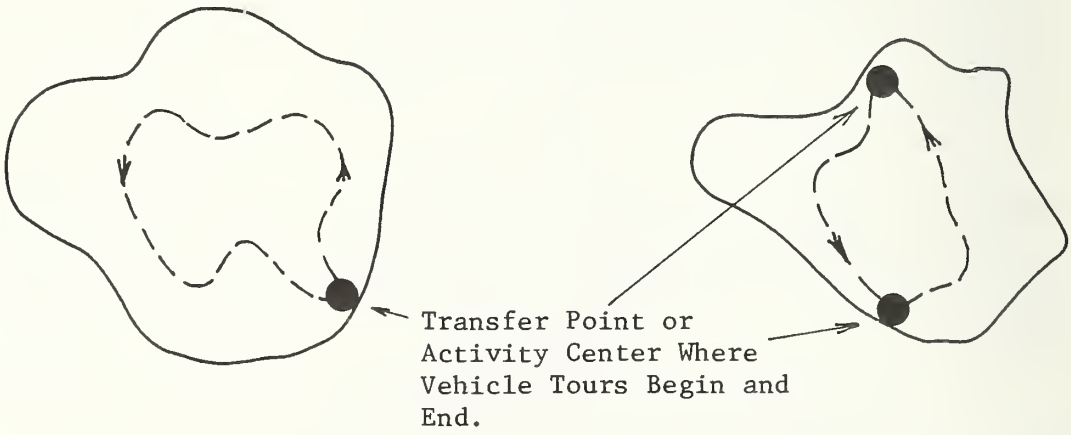


FIGURE 3.3. DIAL-A-RIDE SERVICE AND ROUTING

TABLE 3.1. DAYTIME DIAL-A-RIDE VEHICLE DEPLOYMENT

Zone	Number of Vehicles	
	Peak (7:00-9:30AM, 3:30-5:30PM)	Offpeak
Plymouth (PLY)	4	2
Pontiac (PON)	2	1
Near Northwest (NNW)	3	3
Near Northeast (NNE)	2	1
Near Southwest (NSW)	5	3
Miller (MIL)	2	2
Far Northwest (FNW)	2	1
Far Southwest (FSW)	4	2
Far Southeast (FSE)	4[a]	2
Packard (PAC)	2	1
Medford (MED)	2	1
TOTAL	32	19

[a] 3 during PM peak

walk-ons and transfers from other vehicles) and occasionally dispatchers insert a trip into an ongoing tour.[1]

The fixed-route buses operate generally with 15 minute headways during peak hours and 30 minutes during the offpeak. Table 3.2 summarizes the characteristics of these routes. The Loop Express runs in both directions and connects all major shopping malls, hospitals, the downtown, and the University of Michigan main campus. In addition, the loop connects 5 transfer points which serve six of the outlying dial-a-ride zones. Stops are made at each transfer point and other major trip generators and local service is provided along portions of the route.

The Miller-Huron route runs in a loop through the northwest portion of the city and serves two senior citizen complexes and the Maple Village shopping center. Maple Village also serves as a transfer point for both the Far Northwest and Miller zones. Local stops are made along a portion of the route. The Washtenaw route runs southeast from the Ann Arbor CBD and through the Medford-Manchester transfer point. A continuation of this route provides service to downtown Ypsilanti. Buses make local stops in the center of Ann Arbor and run express with limited stops thereafter. The Packard route also runs southeast from the CBD but through the Stone School and Eisenhower transfer point. It makes local stops and serves a high density corridor, a major low income housing area, Washtenaw Community College and two shopping centers. Finally, during the AM peak period, a line bus follows a fixed route through the Near Southwest zone. This bus was established in response to heavy dial-a-ride ridership and

[1] A more detailed description of the scheduling and dispatching functions is provided in Section 3.2.6.

TABLE 3.2. LINE BUS ROUTE CHARACTERISTICS

Line Route	Peak Period	Headway (min)		Round Trip Route Miles Peak and Offpeak	Transit Coaches Used During Peak Periods
		Peak	Offpeak		
Express Loop (each direction)	7:15AM-9:15AM 3:45PM-5:45PM	15	30	28	10
Washtenaw	7:15AM-8:45AM 3:45PM-5:45PM	15	30	16.6	5
Packard	6:45AM-8:45AM 3:45PM-5:45PM	30 AM 15 PM	60 MID 30 PM	26.0	5
Miller/Huron (both directions)	7:15AM-8:45AM 3:45PM-5:45PM	15	30	6.4	2

currently makes one scheduled inbound trip.

The coordination of transfers between dial-a-ride vans and line buses for six of the outlying zones is keyed to the schedules of the line buses on the express loop. The dial-a-ride tours in the Miller and Far Northwest zones are coordinated with the Miller-Huron fixed route bus schedules. The transfer point for "near-in" zones is the downtown 4th and William transfer point. Dial-a-ride vehicle tours and fixed route buses are scheduled to arrive at the transfer points at the same time. Both dial-a-ride vans and line buses are required to wait for two minutes beyond the scheduled departure time for a late vehicle and can be held longer (for 5 minutes) if a dispatcher requests an additional delay.[1] Informally, van drivers are encouraged to try to arrive at transfer points prior to the scheduled arrival time to minimize transfer wait times for the line buses. Figure 3.4 shows a transfer occurring between a fixed-route bus and a dial-a-ride vehicle.

During weekday evenings, from 6:15 PM to 12:00 PM, city-wide dial-a-ride service is provided by seven dial-a-ride zones. Trips made after 11:00 PM must be scheduled in advance. Each zone provides direct service to the CBD as shown in Figure 3.5, and interzonal trips require a transfer at the 4th and William transfer point. One dial-a-ride van performs downtown circulation and also connects to the 4th and William transfer point. In addition, regular transit coaches provide a route deviation service along Main Street between the downtown and Briarwood Mall with door-to-door pickups made by deviations from the basic route. Callers

[1] Again, see Section 3.2.6 for a detailed description of driver and dispatcher interaction.

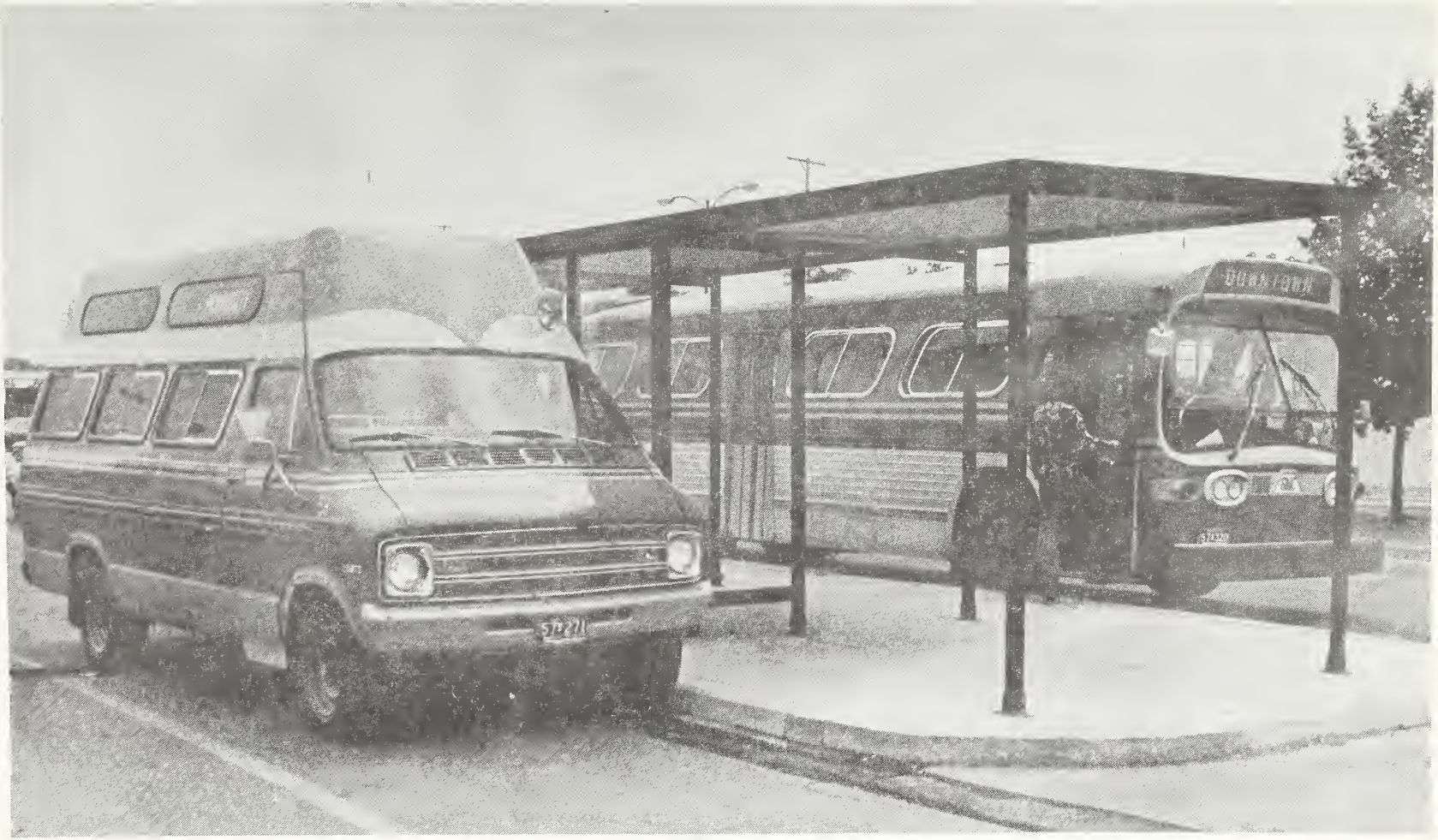


FIGURE 3.4. COORDINATED TRANSFER BETWEEN DIAL-A-RIDE VAN AND FIXED-ROUTE BUS

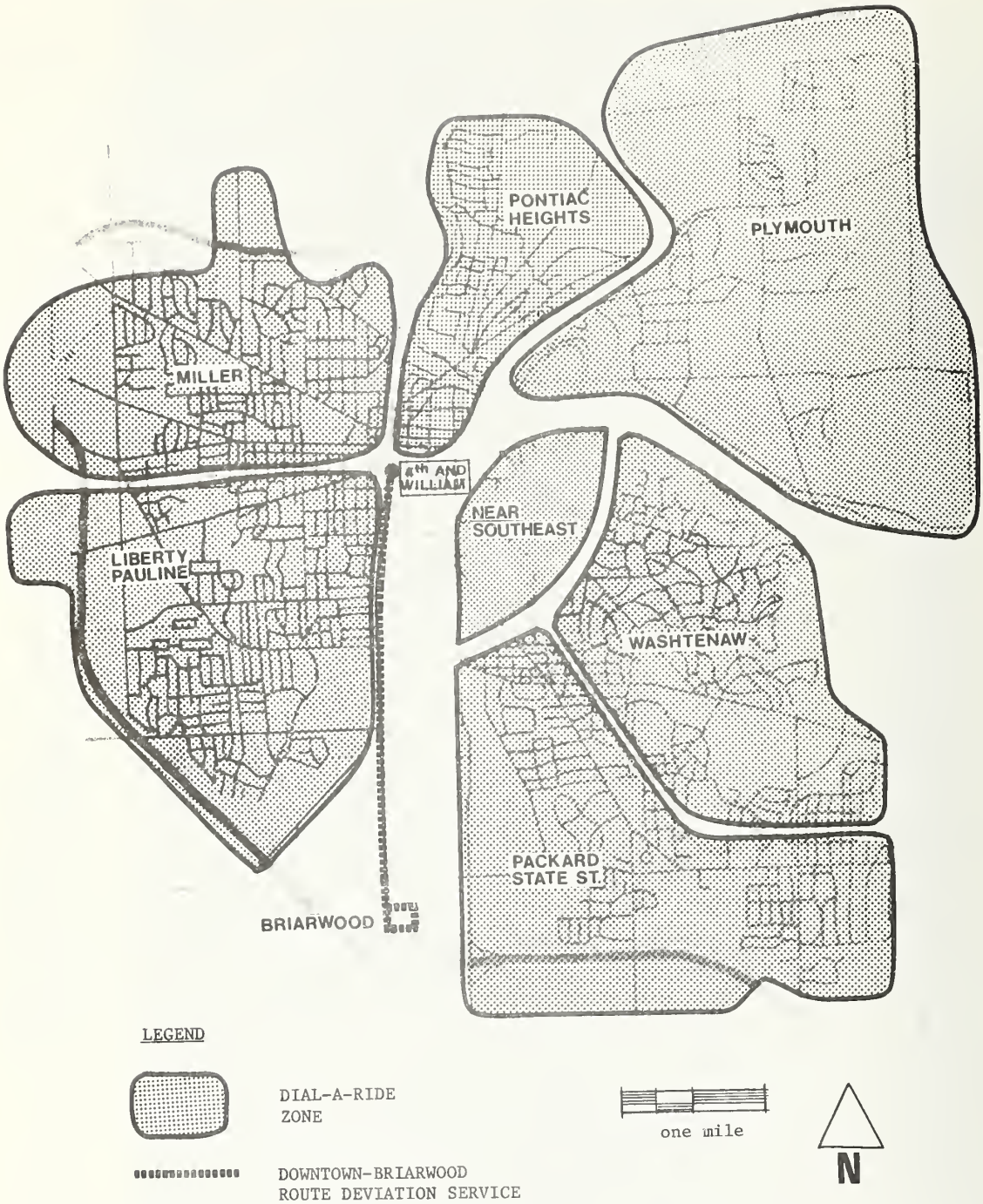


FIGURE 3.5. EVENING TELTRAN SYSTEM

whose trips can best be handled by the buses on this route are encouraged to walk to Main Street to catch the bus. If doorstop pickup is desired, the dispatcher radios the address to the appropriate line bus driver. The evening service is provided by 12 vans and 2 transit coaches. As a safety precaution and unlike daytime service, drivers are obliged to serve only customers who make a telephone reservation.

On weekends, city-wide dial-a-ride service is provided between 8:00 AM and 6:00 PM in nine dial-a-ride zones. In addition, limited line bus service is provided between downtown to Briarwood Mall as shown in Figure 3.6. Again, this is a route-deviation service along Main Street. Another fixed route bus operates in the Huron-Maple Village area. There is also a downtown circulator bus on a fixed schedule.

To obtain door-to-door service, people place a phone call to the dispatching center. Free telephones are located in key downtown locations for return-to-home trips. To facilitate scheduling, riders are encouraged to phone in a trip order in advance. Regular riders can place a standing order reservation for pickup at a scheduled time for a periodic (e.g., daily or weekly, etc.) trip. Riders also can flag a dial-a-ride van or walk on at a transfer point without a telephone reservation if there is a space on that particular tour.

In addition to the services discussed above, the AATA provides city-wide dial-a-ride service for the handicapped. The door-to-door service is provided by vans equipped with wheelchair lifts. Currently two vehicles are used during all hours of operation. The acquisition of additional vans will allow an extension of this service to elderly and handi-

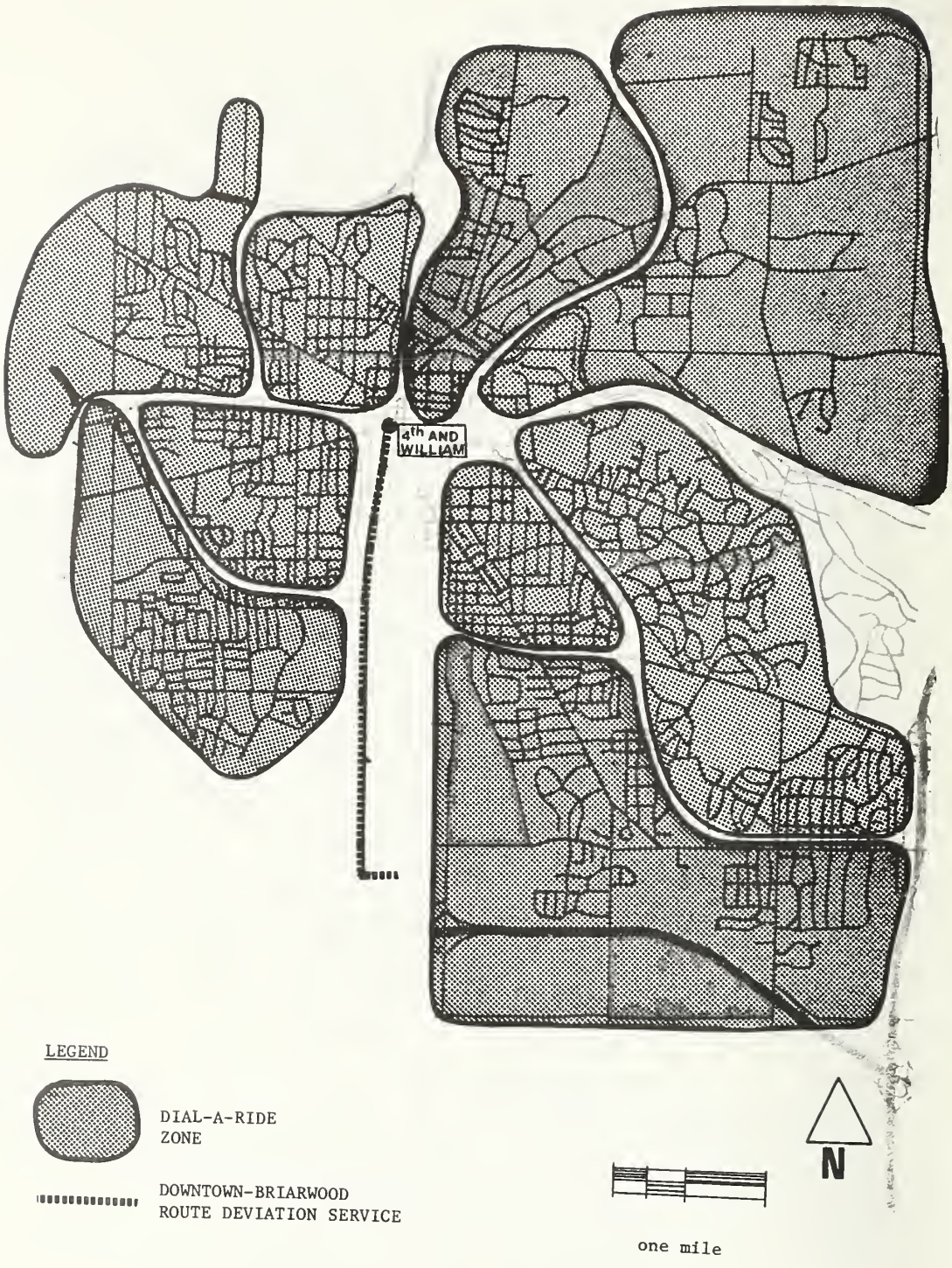


FIGURE 3.6. WEEKEND TELTRAN SYSTEM

capped citizens outside of Ann Arbor but within the AATA service area.[1]

Finally, the AATA operates five fixed-route bus lines in Ypsilanti. Figure 3.7 displays the current configuration of these routes which connect with Ann Arbor service in downtown Ypsilanti via an extension of the Ann Arbor-Washtenaw route. Headways are 30 minutes in the peak periods and 60 minutes in the offpeak. Five full size transit coaches provide service along the 38 miles of fixed routes.

As mentioned previously, the AATA services do not compete with the free shuttle bus service provided by the University of Michigan between its two campuses and various peripheral parking facilities. For the most part, the university system serves intra-university trips but connections to the Teltran system can be made easily from the main campus. Because the system is not policed, the general public also can use the university system for intra-university trips.

3.2.3 Fare Structure

The current AATA fare structure is shown in Table 3.3. The basic fare is 25¢ with free transfers. Individual and monthly passes, good for unlimited rides, also are available. Special fares are available to certain transit dependent groups, as shown. A "self-declaration" policy is in effect to determine the eligibility of low income families defined as follows:

[1] Prior to October 1976, the AATA offered school subscription service to groups of 20 or more students travelling to the same school and living within 1.5 miles of their school. This service was not in competition with the Ann Arbor public school bus program which provides transportation to students living outside of a 1.5 mile radius of their school but insufficient ridership resulted in the cancellation of this service.

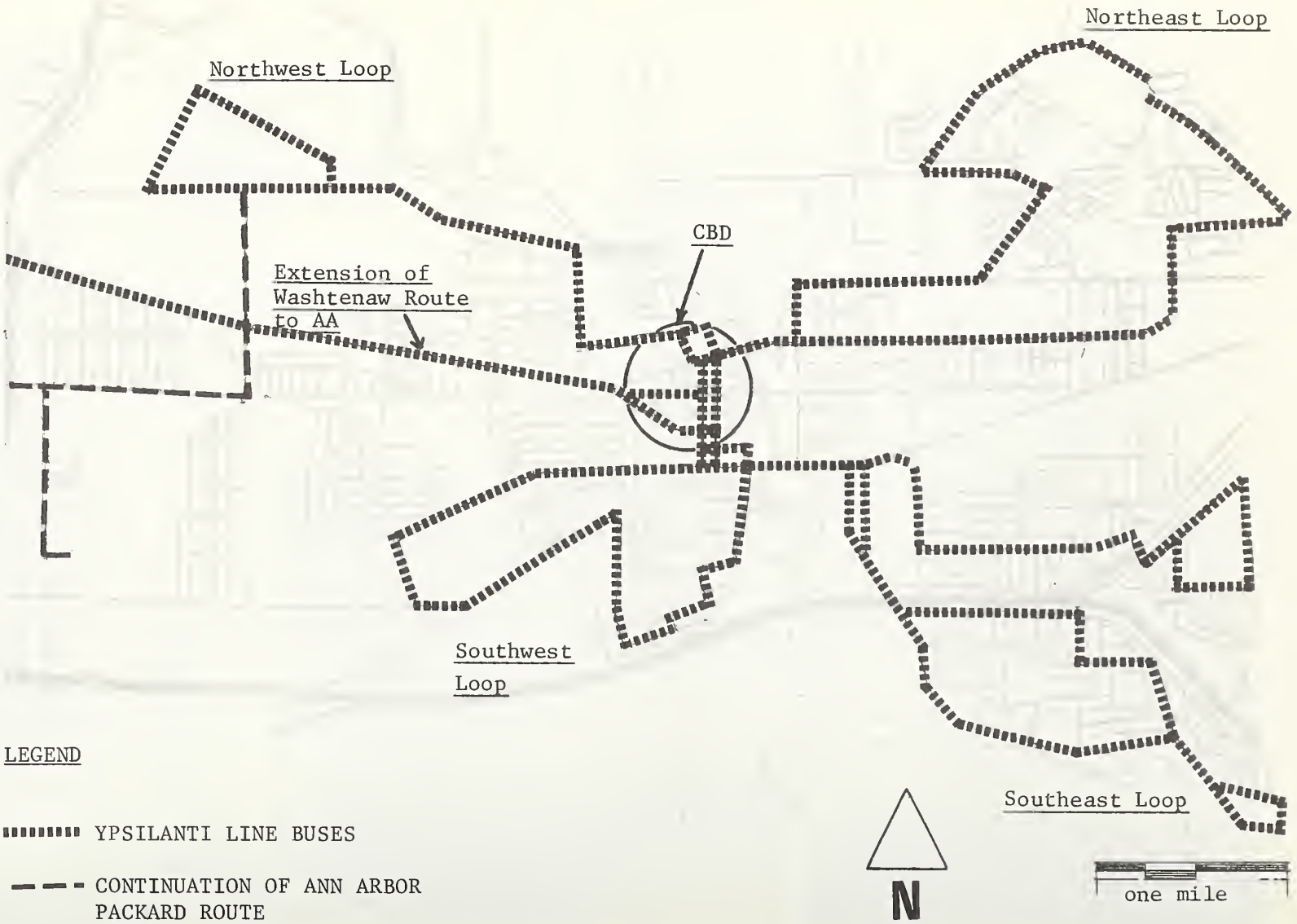


FIGURE 3.7. YPSILANTI LINE BUS ROUTES

TABLE 3.3. AATA FARE POLICY

Service	Regular Fare (dollars)	Fare for Qualified Low Income, Elderly, and Handicapped Riders (dollars)
All service within Ann Arbor	0.25	1.25 for 10 tokens
Ypsilanti to Ann Arbor line bus	0.50	0.25 for 2 tokens
Individual monthly pass for unlimited rides	10.00	5.00
Family monthly pass for unlimited rides for family traveling as a group	15.00	7.50
Transfers	0.0	0.0
Dial-a-ride for handicapped	NA	0.25

Number in Family	Maximum Income (dollars)
1	3,428
2	4,492
3	5,556
4	6,620
5 or more	7,684

Elderly riders are defined as those individuals over 60 years of age. The AATA has also provided free tokens to a number of groups or individuals including those people involved with the Inmate Rehabilitation Program. As a promotional device, coupons redeemable for a free token were included in a printed advertisement which was run in seven local papers during mid-January 1976. By April 1976, a total of 155 of these coupons had been used. This device had been tried a number of times before with similar results.

3.2.4 Vehicles and Fixed Facilities

The Ann Arbor Transportation Authority maintains a fleet of 92 vehicles including vans, transit buses, school buses and service vehicles. The fleet has been rapidly expanding and much of it has been acquired over the last two years. A complete inventory of the fleet is provided in Table 3.4.

The 48 vans and 32 transit buses form the basic fleet for dial-a-ride and line bus service, respectively. Equipment soon to be delivered includes seven wheelchair lift-equipped vans, and grant approval has been obtained for purchases of eight vans and three transit coaches.

TABLE 3.4. AATA VEHICLE FLEET

Fleet Class	Number of Vehicles	Vehicle Type
		VANS
1	4	12-passenger 1973 Dodge B-300
2	10	12-passenger 1974 Dodge B-300
3	34	12-passenger 1975 Dodge B-300 (four with lift for handicapped)
SUBTOTAL	48	
		TRANSIT BUSES
4	5	28-passenger 1970 GMC 3301
5	7	33-passenger 1970 GMC 3301A
6	2	45-passenger 1966 GMC 4519
7	4	45-passenger 1970 GMC 4521A
8	11	40-passenger 1970 GMC 4523A
9	3	53-passenger 1969 GMC 5306A
SUBTOTAL	32	
		SCHOOL BUSES
10	3	54-passenger 1973 Ford B-600
11	4	48-passenger 1973 Ford B-600
	1	54-passenger 1973 Ford B-600
12	3	66-passenger 1966 Ford B-750
SUBTOTAL	11	
		SERVICE VEHICLES
99	1	Ford fork lift, service truck, and parts van
TOTAL	92	

The most recent additions to the AATA fleet reflect the Authority's decision to standardize the fleet on two vehicle sizes, 12-passenger dial-a-ride vans and 40-passenger transit coaches for line and subscription service. The dial-a-ride vehicles are an automotive manufacture compact van with a high quality conversion to provide a higher roof for adult standing headroom (74 inches), a driver-operated passenger door with a very low step (12 inches), and a high quality interior. The base van is the heaviest available with all possible options to make the van better suited to stop-start duty cycles including the highest capacity suspension and the largest brakes. The engine compartment is insulated from the passenger compartment with a minimum 1 inch thick fiberglass material, or equivalent, to minimize interior coach noise, heat, and fumes. The vans have full floor carpeting and 12 foot-candle illumination (minimum) over the entire normal reading position of each two-passenger seat.

The vans for handicapped service are equipped with a curbside hydraulically powered wheelchair lift and appropriate interior hardware to secure at least four wheelchairs, or any combination of wheelchairs and seats (12 seats without wheelchairs). These vans have a single door with a 73 inch high by 24 inch wide opening and stanchions and grab rails in the entrance area. Figure 3.8 shows a lift-equipped van in service.

The most recent purchase prices (early 1976) for the regular 12-passenger vans, lift-equpped vans, and 40-passenger buses are $14,000, $15,700 and $60,000, respectively. However, bus costs vary by as much as $1,700 depending on which options are selected.

FIGURE 3.8. SPECIAL LIFT-EQUIPPED VAN FOR THE HANDICAPPED

New registering fareboxes and vacuum-operated coin handling equipment, with a combined cost of $2,410 each, including installation, are being placed on all vehicles. All dial-a-ride vehicles are being fitted with new three-channel voice radios, which include a "silent alarm" emergency transmitter and cost $3,050 and to which a digital data capability (estimated cost is $2,300) can be added in the future.

The Ann Arbor Transportation Authority presently operates a maintenance and storage facility in Pittsfield Township just outside of the Ann Arbor city limits. Originally occupied on a lease basis in March 1973, the site was purchased as the permanent base of operations in December 1973, after an extensive study of alternatives. Availability of land for expansion and compatible neighboring land use were major factors in selecting a relocation site. The site of a previous facility located in a more residential area had been the subject of numerous public complaints.

The present facility provides 6,000 square feet of office space including the dispatching center, as well as six large garage bays, a machine shop, and a parts storage area.

The AATA is presently implementing a plan for upgrading existing buildings and new construction under a $2.5 million Federal Capital Improvement Grant. A new 45,000 square foot storage building to house the entire AATA fleet is planned at a cost of approximately $1.1 million. Currently, the fleet is stored outdoors on this site. A completely new daily service line, for fueling, maintenance checks, farebox emptying,

bus cleaning, and washing (including an automatic bus washer at $44,000), is scheduled for construction. Funding ($98,600) has been approved for the purchase of the following maintenance equipment: hoists, lubrication equipment, brake drum lathes, benches, testers and tools. The Authority's five year plan calls for construction of more storage facilities on the same site to house additional buses to be procured during fiscal years 1978 and 1980.

3.2.5 Staffing

Since the start of the implementation of the Teltran system, the AATA has acquired a new management team and has grown rapidly. The number of full time equivalent drivers and dispatchers has increased from a total of 25 in 1973, to a total of 180 in 1976. Table 3.5 summarizes the growth in all staff categories from fiscal year 1974 to fiscal year 1976. However, the actual number of individuals working for the AATA is larger since some staff are part time.

Generally, the staff is young and well educated, and many view employment with the AATA as a well paying but transitional job. While the staff is unionized, it has disaffiliated with the national union and formed the independent Transportation Employees Union. During the latest contract negotiations in the fall and winter of 1975, the union stressed many non-financial issues in seeking a broader staff role in the management of the AATA. The current wage rates and those for fiscal year 1975 and 1977 are shown in Table 3.6. The rates reflect a desire on the part of the

TABLE 3.5. STAFFING LEVELS

Staff Category	Fiscal Year[b] (Number of Employees)		
	1974	1975	1976
Drivers[a]	59	82	150
Dispatchers[a]	6	18	30
Bus Counsellors	12	14	13
Maintenance	10	18	25
Administration[a]	13	15.5	17.5
Total Staff	100	137.5	235.5

[a]The figures represent the number of full-time equivalent employees.

[b]July 1-June 30

[c]Prior to the cancellation of school subscription service in October 1976, bus counsellors rode school subscription runs to relive drivers of any disciplinary responsibilities.

TABLE 3.6. HOURLY WAGE LEVELS[a]

Staff Category	Fiscal Year[b] (Dollars)		
	1975	1976	1977
Motor Coach Operator	4.78	5.15	5.40
Dispatcher	4.83	5.15	5.40
Service Employee	4.10	4.96	5.40
Mechanic Helper	4.60	5.09	5.40
Mechanic I	5.55	6.10	6.35
Mechanic II	5.85	6.40	6.65
Counsellors	10.00[c]	5.15	5.40
Clerical	3.96	4.25	4.50
MCO Training	2.60	3.00	3.65
MCO Probationary	2.42	4.75	5.00

[a]Source: Transportation Employees Union AATA Contract Settlement Summary.

[b]July 1-June 30.

[c]Daily.

union to equalize, to the extent possible, wage rates for all staff positions. The rates shown apply to part time as well as full time staff.

Recently, high turnover rates in the driver and dispatching staffs have compounded the problems associated with system expansion and staff training requirements. New staff can be hired and trained at the rate of only three to four persons per week. Dispatchers often require a period of 4 to 5 months before becoming really proficient, while for drivers the orientation period for really becoming familiar with the street system can be from 6 to 7 months.

Drivers are trained to drive both full size coaches and dial-a-ride vans. Since full size coaches are more difficult to operate, driver training starts with these larger buses thereby screening out as quickly as possible individuals who will not be able to operate all the vehicles in the AATA fleet. Bids, assigning drivers to dial-a-ride tours or line bus runs, are cut periodically with drivers choosing assignments in order of years of tenure with the AATA.

3.2.6 Dispatching and Telephone Communication

The Teltran dispatch center, located at AATA headquarters, serves as a clearinghouse for all information flows between the public and the system, and between the dispatch center and drivers. A computer-aided communications and dispatch system assists staff members in storing, organizing, retrieving and transmitting information; it is not fully automated, however, and virtually all decision-making is performed by the staff.

Before the computer-assisted dispatching system was implemented in

August, 1975, all assignment functions were performed manually. A large board was established for each zone and an individual card was produced for each trip request. All cards were mounted on the appropriate board and combined into tours for driver dispatching. While this was an inexpensive way to initiate Teltran services, the complexity and volume of the system made it desirable to provide a more efficient method of handling all the required data. The dispatching system was developed in response to that need. The manual system is still used as backup for the computer assisted dispatch system when major computer failures and "down time" occur.

Figure 3.9 identifies the major flows of information between the dispatch center and users and drivers. Call-takers deal directly with the public, respond to telephoned requests for service, answer questions, choose the best tour to serve the trip, and record all related information. Dispatchers edit tours, communicate with drivers by radio to transmit tours, deal with emergencies and equipment failures, and coordinate the transfers between the line bus and dial-a-ride vehicles. Although these two operating functions are readily distinguishable, a staff member may serve as either dispatcher or call taker, or both, during any shift, depending on the work load. There is no difference in compensation between the two jobs.

The control room houses computer, telephone, and radio equipment designed to increase the efficiency and reliability of the dispatching operation. This equipment includes:[1]

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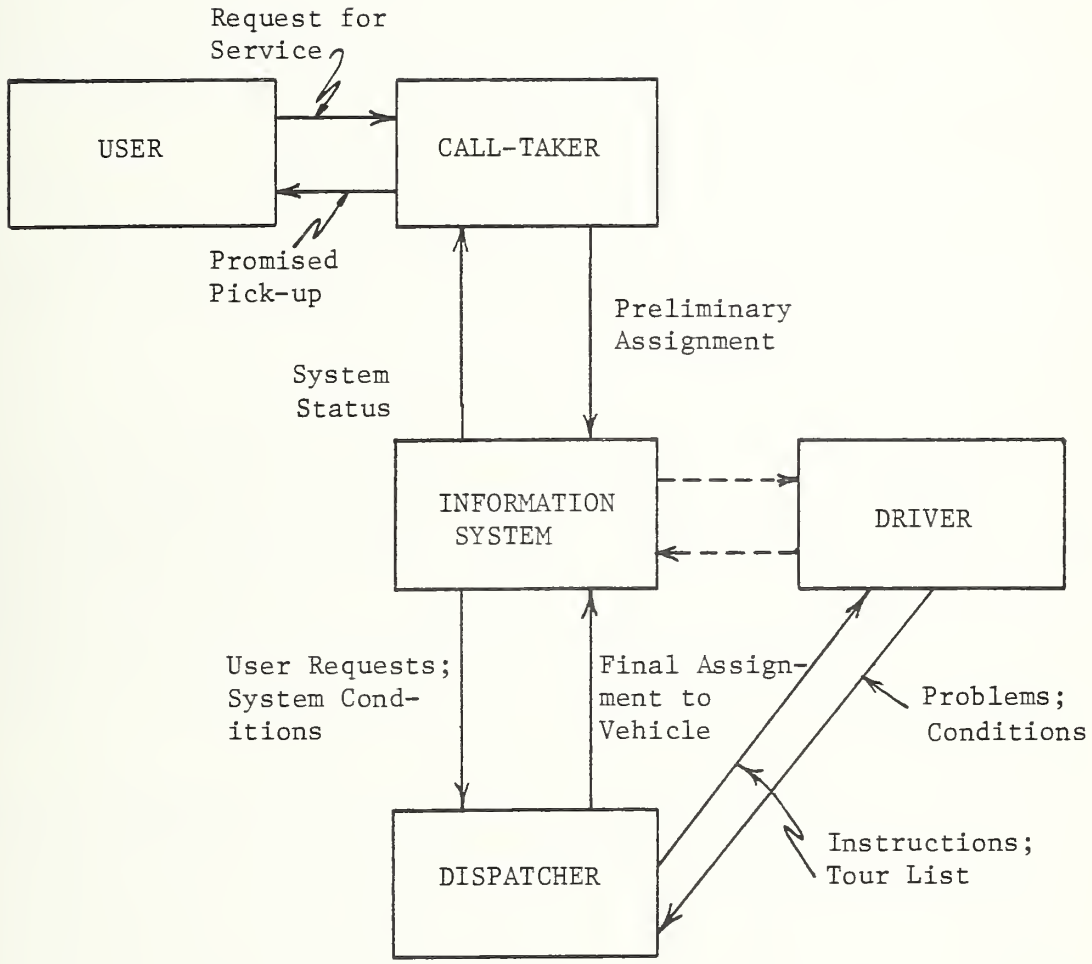
[1]Appendix A contains a more detailed description of control room equipment.



LEGEND

——→ Current Channels of Communication

– – –→ Future Digital Communications (presently manual)

FIGURE 3.9. TELTRAN DISPATCHING SYSTEM

1) a central minicomputer,

2) automatic telephone answering and holding equipment,

3) radio transmitting and receiving equipment, and

4) nine dispatch (or call-taker) terminals equipped with a cathode ray tube display and keyboard input, a phone pad for incoming lines, a radio channel selector, a microphone headset, and a digital clock. A display indicating the next phone line to be answered will be added soon.

The system software serves as the bookkeeper for the transit system. All dial-a-ride tours for all zones are stored in the system for a given day and each tour has an associated zone, transfer point, and time of departure from that point. Calls for dial-a-ride service are logged in through the video terminals and enter a list of pickups associated with each tour. A master file of all daily call-in and standing order trips are stored on disc, for daily tabulation of statistics. The call-taker may access detailed information concerning the entire set of tours for any day within the week using the video display and keyboard at his or her station.[1]

While the computer does not perform any decision-making functions, it facilitates dispatching by increasing the efficiency of a number of call-taker and dispatcher tasks, including the assignment of trip requests to tours, tour editing, and monitoring of system conditions (e.g., number of riders on various vehicle tours). In addition, the system allows a number of call-takers or dispatchers to access system information simultaneously and significantly decreases the risk of "losing" trip requests.

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[1]Appendix B indicates the major types of displays which may be requested of, or provided by, the system.

At present, it takes three dispatchers to cover the system. Two dispatchers, each with a separate geographical domain, handle the dial-a-ride vans and a third is responsible for dispatching all line buses, including instructing them of any actions required to facilitate transfers to or from dial-a-ride vans. Theoretically, a supervisor responsible for such functions as creating or deleting tours and handling bus assignments is on duty at all times, but, in practice, a dispatcher may take on this responsibility. The number of call-takers on duty at any given time varies in response to the expected number of calls. At present, facilities are available for up to six call-takers to work at once.

3.2.6.1 User/Call-Taker Interface

The call-taker is responsible for communications between the public and the dispatch center and thus handles all incoming telephone requests for service. When a user calls requesting service, a recorded message first explains the nature of immediate, advance, and standing order reservations, as well as providing a telephone number for additional information. The caller is then placed on "hold" and hears recorded music until a call-taker is able to answer the call. Call hold times are displayed in the dispatch room to insure that service is on a first-come, first-served basis. The call-taker enters the origin, destination, zone of origin, and desired pickup time into the terminal. The computer automatically supplies three vehicle tours, based on the zone of origin and desired pickup time information. Each of these tours can potentially serve this trip, depending on the rides previously booked. Thus, based upon the number of pickups already assigned to these tours, their spa-

tial distribution, and the caller's desired time of arrival at his or her destination, the call-taker assigns the trip to a particular tour. The call-taker also provides the caller with an estimated time of arrival (ETA) of the dial-a-ride van at the pickup location. Usually, the ETA quoted is a 5 to 15 minute interval. However, wider ranges may be quoted if the system is experiencing problems due to breakdowns, bad weather, or a shortage of staff.

If the caller's request for service involves travel totally within a single zone, the determination of the proper tour is relatively simple. Because the majority of dial-a-ride requests involve travel outside the zone of origin, however, the assignment of a trip to a tour must take into account the need to transfer. Typically, assignments are made by working backward from the desired time of arrival. For example, suppose a caller wishes to travel downtown from an outlying zone, a trip which can only be made by taking a dial-a-ride van to a transfer point and then riding a line bus downtown. The call-taker first determines the line bus which will get the caller downtown at the required time and then checks when this bus will be at the transfer point serving the caller's dial-a-ride zone. The dial-a-ride tours which serve that transfer point at the desired times are then identified and considered for serving the caller's trip. When a suitable tour is found, the trip request is entered into the computer. Depending on how many calls are currently "on hold," the call-taker then tells the customer how to make the transfer(s) and which line bus and dial-a-ride vehicle(s) to ride.

3.2.6.2 Dispatcher/Driver Interface

Dispatchers have full responsibility for the information flows between vehicles and the control system. At the present time, the tour lists, containing the addresses of all pickups, are transmitted to the appropriate driver by voice communication. The transmission occurs approximately five minutes before the start of each tour or whenever the driver can conveniently copy the list. Since each dial-a-ride dispatcher is responsible for up to 20 vans and the typical tour time is 30 minutes during the peak, a new tour must be prepared and transmitted every few minutes.

Prior to transmitting the tour list, the dispatcher reviews it to ensure that the pickup addresses are within the zone boundaries and that the tour is feasible given the scheduled transfer times. The dispatcher retains the flexibility of either moving trip requests from the initially selected tour to another, or rearranging the order of pickups to make the tour more efficient. Since call-takers do not specify exactly which van will pick up a given passenger, the rider is usually oblivious to such changes.

Digital radio transmission of the tour lists is planned for the near future. Lists will then automatically appear on a L.E.D. display screen in the vehicle at the driver's request, but after the dispatcher has determined that the list is properly edited and organized. The list will remain on the screen until the driver requests a new tour. The introduction of display screens into vehicles will greatly expedite the transmission of tours from dispatchers to vehicles. Dispatchers will no lon-

ger have to ask (often repeatedly) if the driver is "ready to copy" and then read a list of addresses. Similarly, a driver can request the next tour at the appropriate time and will not have to manually copy addresses on a piece of paper. Transmission errors and the need to repeat garbled messages will be eliminated. On the negative side, however, the display screens will decrease the direct contact between drivers and dispatchers and may hamper the "spirit of cooperation" required to handle other functions smoothly like inserting new rides in ongoing tours or coordinating transfers between vehicles.

Dispatchers have a number of additional functions, including:

a) Last-minute requests - When a request for service occurs near the start time of an appropriate tour, the call-taker usually asks the dispatcher if the pickup is possible. The dispatcher communicates with the driver who determines whether to accept or refuse the additional pickup, depending on the likelihood of its jeopardizing his or her scheduled arrival at the transfer point.

b) Coordination with a late vehicle - If a line bus or van is going to be late in arriving at a transfer point, the dispatcher often notifies the waiting vehicle. He or she may instruct a line bus to wait up to 5 minutes beyond the scheduled departure time to effect the transfer. Line buses will wait up to two minutes without dispatcher instructions if the dial-a-ride van is late.

c) Emergency calls - Dispatchers handle emergency calls from drivers including vehicle breakdowns and accidents, notify the maintenance crew of any vehicle problems, and dispatch replacement vehicles.

d) Recording of "no-shows" - If no one appears at a pickup address within one minute of the arrival of the van and the horn being sounded, the driver notifies the dispatcher of a "no-show." The dispatcher records the address so that repeated occurrences at a given address can be identified, checked, and refused service in the future. The dispatcher can relay the no-show information to the call-taker to clear up any error in case the customer calls back.

e) Scheduling "extra" dial-a-ride vans - Extra vans, not assigned to any particular tours, are used to assist with breakdowns and overloads in demand. Scheduling these extra vans is the re-

sponsibility of the dispatcher. In some cases, dispatchers detect overloads when tour lists are reviewed before transmission. However, overloads also occur unexpectedly if a large number of riders walk-on at a transfer point. In such cases, the driver alerts the dispatcher of the situation so that another vehicle may cover some of the overloaded van's pickups.

3.3 TELTRAN IMPLEMENTATION

When the original plan for the Teltran system was developed, the AATA explicitly decided to phase the system into full operation incrementally. The rationale for adopting an incremental implementation strategy was to gain operating experience with each successive system addition and, where necessary, to make adjustments to both the services provided and internal operations as expansion continued. From a more pragmatic point of view, such a strategy also allowed a smaller and continuous staff recruiting and training program which could respond to the unpredictable delays in the delivery of new vehicles and equipment. Thus, the incremental implementation process has served as a method for learning about, and subsequently modifying, the operation of an innovative service, while at the same time maintaining a given quality of service as system expansion proceeds.

The implementation process began in the summer of 1973, soon after the passage of the millage to support public transit, and the last daytime dial-a-ride zones were phased into the system in the summer of 1976. However, even despite the slow pace of implementation for the Teltran system, it was very difficult at times for the AATA to maintain service quality in the face of both system expansion and relatively high staff turnover rates. The staff training problem was exacerbated by underestimating the

training and on-the-job experience required to produce skilled drivers and dispatchers. It is interesting to note that the operating staff and union generally have desired to delay each implementation step as long as possible in the interest of maintaining service quality.

One of the major reasons that implementation was slow was the unpredictable delivery time for equipment and the time required to process grant applications. Although the initial Teltran capital grant was filed the day after the property tax passed, the actual contract was executed over a year later. Equipment specification approvals often required 6 to 8 weeks and bids for equipment had to be advertised for a 45-day period. Vehicle and some telephone equipment delivery took up to 9 months, and up to a month often was needed for acceptance tests.

There has been some impatience on the part of the public with the slow pace of implementation. At the time of the millage election the public endorsed a citywide transit system providing 100% coverage and expectations were raised. Subsequently enthusiasm waned as inequities in the provision of service remained as implemention proceeded. While all citizens have contributed taxes to transit since the date of the millage vote, some did not receive daytime dial-a-ride service until 3 years later. While the AATA felt a slow and careful phased implementation would provide the best systemwide service in the long run, public pressure increased as implementation proceeded more slowly than expected.

A primary advantage of an incremental implementation strategy was the ability to learn from experience and make modifications. However, some of the changes and adjustments made during Teltran implementation

evoked both staff and public criticism. At the most general level, too many adjustments in service levels or type seemed to create a perception on the part of the public that the AATA was "experimenting" and lacked the expertise to do the job right from the beginning. Thus, the AATA had to walk a tight rope of sorts. On one hand, management recognized the uncertainties involved in developing an innovative service and freely admitted to errors. Yet, on the other hand, they constantly had to explain why in hindsight specific problems were not anticipated.

Perhaps the most vocal group of individuals with reservations about Teltran are former line bus users whose previous fixed-route service has been replaced by dial-a-ride service often involving a transfer to line bus. Clearly, some of these individuals are receiving worse service with Teltran than with the pre-pilot fixed-route service. A number of these people currently serve on the AATA Citizens' Committee which is pushing for the establishment of "service standards" to evaluate the Teltran system.

In the Pontiac Heights area the elimination of a fixed-route bus line caused substantial public reaction prompting the AATA to reinstitute fixed route shuttle service on a trial basis. Subsequently, the shuttle service was terminated due to lack of ridership. Residents often request that it be established again, and there are plans to reinstate this service. A previous direct line bus between downtown and the VA hospital is being replicated to some extent by having the start and finish of dial-a-ride tours in the Near Northeast zone alternate between downtown and the hospital on a regularly scheduled basis.

Numerous less visible operational changes also have occurred as a result of the experience gained during incremental implementation. These changes include adjustments in zone configurations, tour schedules, and vehicle deployment. In the Plymouth zone, for example, a transfer point at Huron High School was eliminated when suitable usage rates did not develop. The AATA feels that many of these modifications would have been much more difficult to accomplish if one shot systemwide implementation had occurred.

In addition to the user reactions to changes, some of the modifications to Teltran system operation or equipment have also created staff problems. Perhaps the most notable example of such internal reactions occurred when the Teltran system reached a size where computer aided dispatching was required. Many dispatchers comfortable with, and skilled at, the manual dispatching procedure resisted the switch over to the current dispatching operation. There may be similar resistance from both drivers and dispatchers when L.E.D. display screens are installed in dial-a-ride vehicles to facilitate the communication of vehicle tours from dispatcher to the driver. Also, some of the changes to system configuration or operation, which were clearly desirable from an overall system management point of view, were not readily apparent to drivers working in a particular zone.

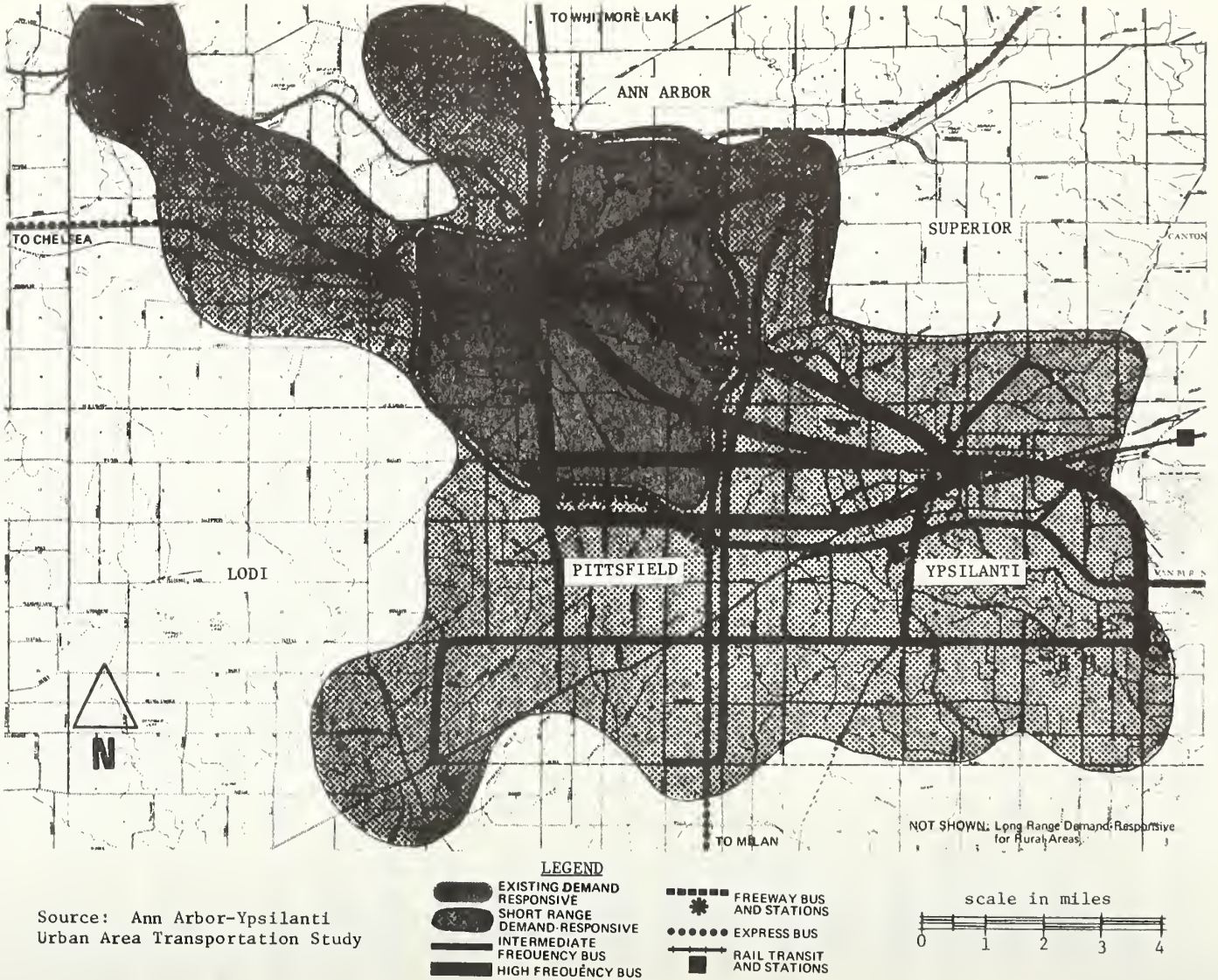
While the implementation process in Ann Arbor has generated some problems, it is the strong feeling of AATA management that the implementation strategy adopted was extremely beneficial.

3.4 FUTURE SYSTEM EXPANSION

With implementation of the Teltran system completed during the summer of 1976, there are a number of different perspectives on how the system should be modified or expanded in the future. AATA management feels that Teltran clearly has established a role for dial-a-ride service in Ann Arbor. Both the AATA's 1975-80 Transit Development Program and the Ann Arbor-Ypsilanti Urban Area Transportation Committee's (UATC) 1990 Plan propose major expansions to both the fixed route and dial-a-ride portions of the Teltran system (see Figure 3.10).[1] Dial-a-ride service is planned to be extended to many rural areas currently with no public transit. Additional line routes are planned for some areas currently served directly only by dial-a-ride, while others are proposed for areas currently with little or no public transit.

Whether and how the system actually expands in the future depends on a number of key financial and political factors. First, future expansion may hinge upon the continued increase in Federal and state funds for transit operations. There is some feeling in Ann Arbor that AATA should focus on providing service to the City where the local commitment to transit has been demonstrated by property tax support. The UAT Committee, representing the entire urbanized area, is likely to push for expansion of AATA services outside of Ann Arbor. However, even with continued state and Federal operating assistance, any significant expansion of

[1] More recently, the City of Ann Arbor has completed a circulation study for the central area which is consistent with the UATC plan and details central area transit improvements.



Source: Ann Arbor-Ypsilanti
Urban Area Transportation Study

FIGURE 3.10 FUTURE SYSTEM EXPANSION

dial-a-ride service may require additional tax support from local communities.

Within the City of Ann Arbor there is some evidence of a growing fixed-route versus dial-a-ride debate. Some individuals, including some members of the AATA board and the AATA Citizens' Committee, feel that resources currently allocated to dial-a-ride service could be better spent in improving and expanding fixed-route bus service. Some members of the Citizens' Committee in cooperation with the AATA have developed interim service standards for evaluating the Teltran system.

It is impossible to draw any conclusions about overall public sentiment concerning the Teltran system. However, even many of these individuals questioning the current commitment to dial-a-ride recognize some role for demand responsive service, particularly for specific transit dependent groups. AATA management recognizes that some shift in emphasis to line bus service in "mature" dial-a-ride zones (e.g., those with high demand levels) may be desirable. Currently, one daily line bus run in the morning has been instituted in the Near Southwest zone as a response to high dial-a-ride ridership. Similar service may be instituted in the Pontiac Heights, Far Southwest, and Far Southeast zones in response to high peak hour dial-a-ride ridership in those zones. Such shifts in service could change the relative distribution of resources between dial-a-ride and fixed route service.

The AATA management feels very strongly that the continued evolution of the Teltran system is required and the ability to adapt has been, and will continue to be, a major strength of the AATA's approach to system

operation and management.[1] The AATA feels a number of factors dictate the need for the system to evolve including changes in the public need for transit, as well as changes in ridership (levels or patterns) and the resources available for transit. Currently, the AATA in cooperation with the Institute of Survey Research of the University of Michigan is developing, and conducting the first phase of what is viewed as an on-going approach to system evaluation including user and non-user attitude surveys. This evaluation effort is viewed as one means to identify the directions in which system evolution should occur. Naturally, the actual direction that transit in Ann Arbor takes over the next few years may depend on many factors. One key element may be the shifts in consensus on the AATA board as new members are appointed.

[1] Since completion of this evaluation effort, the AATA has combined two of the daytime dial-a-ride zones (Medford and Far Southeast) to improve internal operations and has experimented with a change in the downtown transfer point to provide more convenient downtown service.

4. TELTRAN LEVEL OF SERVICE

4.1 COVERAGE

A major local objective for the Teltran system is to provide 100% geographical coverage during all hours of service. By the summer of 1976, the AATA met this objective fully by implementing daytime dial-a-ride service in the one remaining zone without service. The coverage objective has been met since December 1973 for the weekend and evening service.

There is no question that by providing 100% geographic coverage, the Teltran system allows all residents of Ann Arbor to make any trip within the city by transit. It is also clear from informal interviews conducted during the onboard survey which was performed for this evaluation that door-to-door service and low fares allows many transit dependents to make trips they otherwise could not make. However, the provision of 100% geographic coverage generally involves a tradeoff with the level of service that can be provided and does not imply equality in the level of service provided to different subareas or types of trips.

Section 3 described in detail the type of service provided by the Teltran system during different time periods including the system configuration, vehicle utilization rates, headways, tour times, route miles, and vehicle density. Table 4.1 summarizes these coverage characteristics. The discussion here focuses on the differences in the level of service provided to different groups and for different trip types.

Table 4.2 compares the distributions of dial-a-ride vehicle hours

TABLE 4.1. COVERAGE CHARACTERISTICS

Service Type (Ann Arbor)	Operating Hours		Headway Tour Length (minutes)		Route Miles or Service Area[a]	Number of Vehicles		Dial-a-Ride[a] Vehicles/sq. mile		Weekday In-service Vehicle Hours[b]
	Weekday	Weekend	Peak	Off-peak		Peak	Off-Peak	Peak	Offpeak	
Dial-a-Ride	6:30AM-11:00PM[c]	8:00AM-6:00PM	15	30	23.5 sq.mi.	32	19	1.36	0.81	373
Line Bus	6:45AM-6:15PM	limited 8:00AM-6:00PM	15	30	77 miles	22	10	--	--	148.5
Handicapped Service	6:45AM-11:00PM	8:00AM-6:00PM	--	--	23.5 sq.mi.	2	2	0.09	0.09	16

[a]Based on total area of Ann Arbor; actual service area is smaller.

[b]In-service vehicle hours, not including deadheading, from run sheets. Total vehicle hours are about 10 percent higher.

[c]Pickups are made until 12:00 PM but trip reservations must be made prior to 11:00 PM.

TABLE 4.2. DIAL-A-RIDE VEHICLE HOURS

VERSUS RIDERSHIP (December 1975)

Service	Total Ridership (percent)	Dial-a-Ride Vehicle Hours (percent)
Weekday	66	72
Weeknight	16	15
Weekend	18	12

and ridership for different time periods. The table shows that weekend service, in contrast to weekday service, generates a higher proportion of total dial-a-ride ridership than the percentage of total vehicle hours allocated to that service. However, given the different system configurations and the different types of trips being made during these two periods, it is difficult to conclude whether the level of service, even for intra-zonal trips, is higher during weekday hours. In fact, weekday service includes many relatively unproductive dial-a-ride vehicle hours during mid-day periods which alone could explain the figures in Table 4.2

During weekday daytime periods, dial-a-ride tours which are filled mostly by standing orders receive a higher level of service than regular tours. The service provided to tours filled with standing orders is similar to subscription service, with less variability in pickup times and in-vehicle times than for non-standing order trips. Not surprisingly, because of the popularity of the service, many AM peak period tours are filled with standing orders. Since PM peak period trips from downtown often start on a line bus, a standing order for the return trip is not required.

The results of the onboard survey, discussed in detail in the following section, indicate that average dial-a-ride wait, in-vehicle and transfer times do not vary significantly by zone for the non-standing order weekday service. This suggests that vehicles are deployed, depending on the zone size and the level of demand, in order to give approximately the same level of service within each zone. However, the level of service for inter-zonal trips varies markedly. The daytime Teltran system provides the best service for trips going from outer zones to downtown or

vice versa and for trips between major activity centers (e.g., a number of shopping centers, hospitals, and the downtown are served directly by the express loop line bus). As the standing order survey indicated, travel time increases proportionally with the number of transfers made, and a trip downtown from any zone involves no more than one transfer. Four zones have direct service downtown. Since dial-a-ride vans generally arrive at transfer points prior to the line bus, an outbound trip from the downtown to an outer zone receives somewhat better service than the same trip inbound since no transfer wait time is involved.

Trips involving two transfers are generally crosstown trips, though in some cases trips between adjacent zones require two transfers and may have very circuitous routings resulting in travel times even higher than for crosstown trips. For example, where adjacent zones are not served by the same transfer point, an inter-zonal trip would involve taking dial-a-ride to a transfer point, transferring to a line bus to get to another transfer point, and finally using dial-a-ride again to get to the final destination.

As mentioned in the previous section, while there is public concern with the poor surface condition of many local roads, it is unlikely that major street improvements will occur within the city inside the freeway ring. However, in general, traffic conditions are good and parking within a reasonable distance (10 minute walk) of the downtown is usually available and low priced. As a result, Teltran generally is not competitive

(in terms of travel times) with auto for a large number of trips within Ann Arbor. The AATA's interim service standards state that in-vehicle time including transfer time should not exceed 30 minutes, 40 minutes, and 60 minutes for intra-zonal trips, trips to the downtown, and cross-town trips, respectively. While often intra-zonal and downtown trips on Teltran probably take only 2 to 3 times the direct auto driving time, crosstown trips, as the executive director of the AATA notes, may have travel times which are 4 to 5 times the direct auto driving time.[1] It should be noted, however, that in some cases for peak period trips from outlying zones to the downtown, Teltran is competitive with the auto.

Despite these travel time differences, however, there is evidence from AATA onboard surveys that Teltran is attracting trips previously made by auto. One factor encouraging such trips is the low fare charged. The basic fare is 25¢ and transfers are free. Reduced fare passes are available for qualified handicapped, elderly, and low income individuals, and monthly passes available to the general public may result in reduced fares, depending on the number of trips taken (more than 44 trips per month would result in a reduced fare). The low fares are consistent with the provision of 100% geographic coverage in supporting the AATA's desire to make public transit available to everyone. The AATA estimates that 500 passes are sold each month. Thus, for an extremely low fare, door-to-door service can be obtained and some auto trips are being attracted to Teltran. With an average in-vehicle distance of 2.3 miles on daytime dial-a-ride, a similar trip by taxi at the current rates in Ann Arbor would cost $1.78 for the dial-a-ride portion alone. While direct

[1]Guenther, Karl W., op. cit.

routing by taxi would decrease trip distance somewhat, it is clear that taxi service is significantly more expensive than transit for most trips in Ann Arbor.

Finally, while the AATA provides 100% geographic coverage during all hours of operation, it is clear that some individuals receive worse transit service today for at least some trips than they did prior to the implementation of Teltran. The individuals receiving worse service are former fixed-route users whose previous line bus service was terminated or rerouted during Teltran implementation. In general, it has been former line bus users who are now forced, due to the system configuration, to take dial-a-ride to a transfer point or directly to their destinations, who are the most vocal opponents of the Teltran system. While new fixed-route service is likely to be established in zones with increasing dial-a-ride ridership, it was inevitable that the system configuration required to shift from exclusively fixed-route to integrated service would leave some individuals with worse transit service. Subsequent service modifications are unlikely to restore the previous level of service enjoyed by some line bus riders.

4.2 TRAVEL TIME AND RELIABILITY

In order to obtain up to date information on the travel times and the phone wait and service times provided by the Teltran system, a limited data collection effort was undertaken. While it would have been desirable to obtain travel time information on both the fixed-route and dial-a-ride components of the system, due to time and resource limitations, the surveys which were conducted focused, for the most part, on

the dial-a-ride portion of the system.

Figure 4.1 illustrates the various components of telephone, wait, and travel time for a trip originating on dial-a-ride and involving a transfer to a second vehicle. If the trip involves more than one transfer, additional transfer time and in-vehicle time components will extend the line. If the trip originates on a line bus, the time components of interest begin with the wait time for the first vehicle. In fact, as a result of the design of the Teltran system, different trips may involve the following sequences of vehicles:

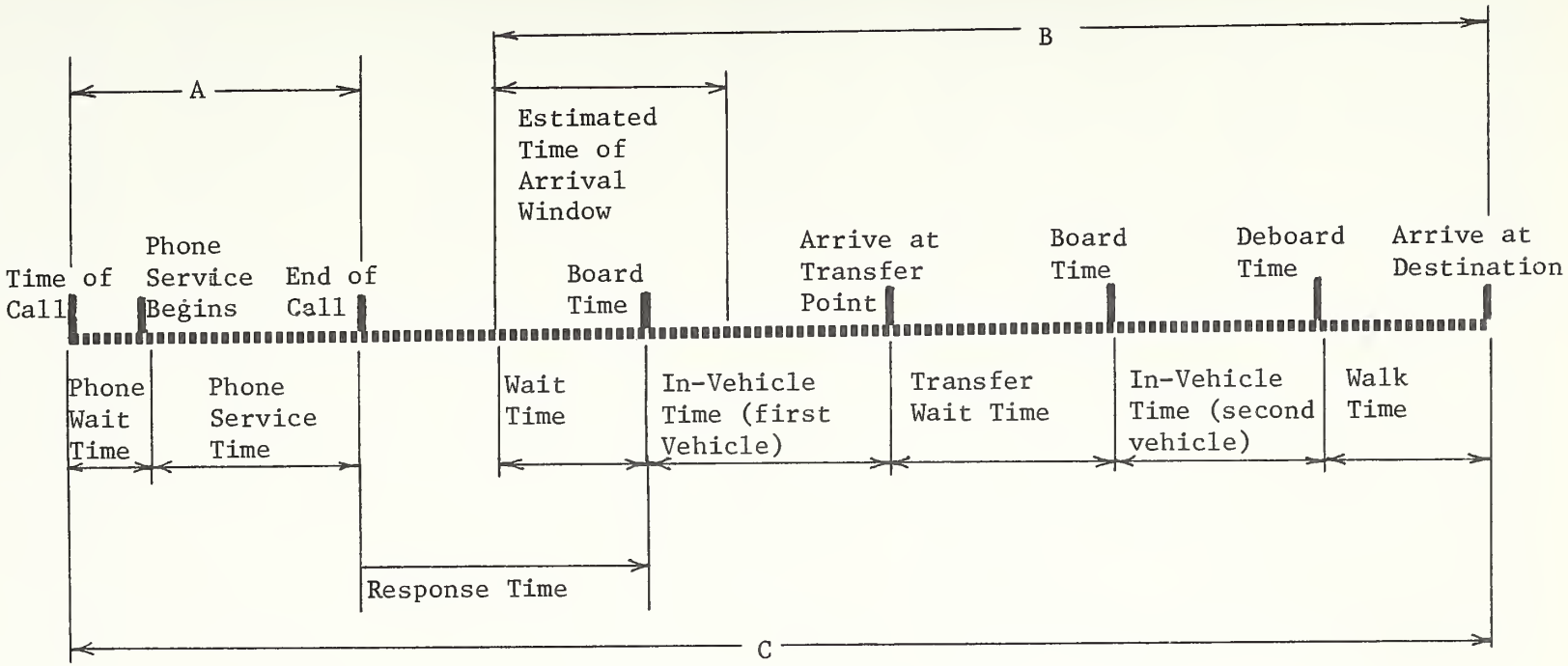
a) One transfer trips: dial-a-ride (DAR) or Line bus,

b) Two transfer trips: DAR-Line; Line-DAR; DAR-DAR,

c) Three transfer trips: DAR-Line-Line; DAR-Line-DAR; Line-Line-DAR.

Naturally, the time components involved in each of these trips varies.

For trips originating on dial-a-ride, the time components of interest also vary depending on when service is desired and how the reservation is made. For all phone in trips for dial-a-ride service, the telephone hold and service times are important. If the caller wants immediate service, then all the time components, from the "end of call" point on, are of interest. If the caller is making a trip reservation in advance for pickup at a later time, the response time is not relevant and only the time components from the wait time on are important. Finally, for individuals who have standing orders or regular prescheduled trips (e.g., daily, weekly, etc.), only the wait time and subsequent times are relevant since



Time Intervals Involved in Different Trip Types:

1.	Phone in for Immediate Service:	Interval C
2.	Phone in for Service at Another Time:	Intervals A and B
3.	Regularly Scheduled "Standing Order":	Interval B
4.	Walk on:	Interval B

FIGURE 4.1. TIME LINE FOR INTEGRATED DIAL-A-RIDE AND LINE BUS SERVICE

(For a one transfer trip originating on dial-a-ride)

a phone call is not required each time the standing order trip is made.

The three surveys that were conducted collected data on various phone and trip time components (both perceived and actual) for a number of trip types. The surveys that were conducted include:[1]

1) Dispatch room surveys: telephone hold and service time data was collected on a number of days and during different time periods by direct observation in the dispatch room.

2) Onboard survey: a one week (5 weekdays) survey was conducted on dial-a-ride vans. Data was collected on actual response time, in-vehicle time and transfer time as well as perceived telephone hold time, response time and wait time. All daytime dial-a-ride zones were surveyed and the distribution of responses by zone was approximately the same as the distribution of total dial-a-ride phone-in ridership.[2] All dial-a-ride users except standing orders were included in the onboard survey.

3) Mail-out survey: A separate survey of individuals with daily (e.g., 5 weekdays) standing orders was conducted by mail. These individuals were asked to keep a one week record of their travel times, including in-vehicle time on the second vehicle if a transfer was made.

Both the onboard and standing order surveys were conducted during the week of April 5 to 9, 1976. The dispatch room surveys were conducted on four different days during late March and early April 1976. The results of these surveys are discussed below for each of the phone service and travel time components included in Figure 4.1.

4.2.1 Telephone Service

Information on current phone level of service in terms of the frequency of occurrence of busy signals, hold times, and processing times

[1] A more detailed discussion of these surveys in terms of their design, pretest, execution, and data processing can be found in Appendix C.

[2] Again, refer to Appendix C for the exact percentages of survey responses and ridership by zone.

was obtained from the surveys conducted for this evaluation and from a phone company busy signal study. The discussion of the issues and problems associated with telephone access and equipment was a direct result of extensive discussions with AATA staff.

4.2.1.1 Telephone Hold Time

One of the most frequent complaints about the Teltran system is that telephone waiting times for requesting dial-a-ride service are too long. Some customers have complained that they were on hold so long that vans actually have gone by their house while they were waiting for a call-taker. Long telephone hold times can both limit the use of dial-a-ride and discourage people from cancelling an unwanted but previously scheduled trip.

Hold time data was collected by direct observation of the hold time display board in the dispatching room and the results are shown in Table 4.3. Because there is a recorded message played for every call regardless of whether a call-taker is immediately available, the minimum hold time for any call is .3 minutes. On all three days during which data was collected, the weather was clear and warm and no major system breakdowns occurred. As a result, dispatchers on duty felt the load of calls was lighter than usual and, due to the relatively small number of observations in each period, the results may not represent an accurate measure of system hold time.

The survey results show that the longest hold times occured during the AM peak hours, the period with the highest concentration of

TABLE 4.3. TELEPHONE HOLD TIME (Spring 1976)

Time Period	Hold Time (minutes)				Number of Calls Observed
	Mean	Maximum	90 percent Answered Within	95 percent Answered Within	
7:20 AM - 12:15 PM (4/9/76)	1.75	6.50	3.6	5.1	202
9:50 AM - 1:30 PM (3/24/76)	0.60	1.90	1.0	1.4	102
3:00 PM - 6:30 PM (3/23/76)	0.70	2.20	1.4	1.7	183
ALL CALLS	1.12	6.50	2.2	2.9	487

calls.[1] During 1975, dial-a-ride service was greatly expanded and numerous telephone related problems (including some very long hold times) occurred as phone capacity was being increased. The survey results suggest that phone hold times are now approaching levels which are consistent with the AATA's Interim Service Standards, which require that 95% of all calls be answered within 3 minutes[2]. The survey indicates that such a goal may have been reached already with 95% of all observed hold times being within 2.9 minutes. However, more sampling during each time period (including weekday evenings and weekends) is required to verify that Teltran is satisfying this standard on a system-wide basis.

As part of the onboard survey, riders were asked how long they had waited on hold in order to make their current trip reservation. The distribution of responses to this interval choice question (1 minute intervals) is shown in Figure 4.2. Not surprisingly, the perceived hold times reported in the onboard survey are significantly larger than those observed directly in the dispatch room.[3]

When all 15 phone lines are in use, a customer encounters a busy signal. As part of the onboard survey, riders who telephoned for service were asked how many times busy signals were encountered as they made the reservation for their current trip. The results are presented in Figure 4.3. The distribution did not vary significantly in different time per-

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[1] It should be noted that phone hold times also vary with the individual call-takers and dispatchers on duty at any given time.

[2] AATA "AATA Interim Policy on Service Standards," August 4, 1976.

[3] Assuming the midpoint of each interval is the mean hold time for all observations in that interval (and assuming a 4.5 minute mean for the last interval), the mean perceived hold time is 2.2 minutes or approximately twice the mean observed hold time of 1.12 minutes for all observations.

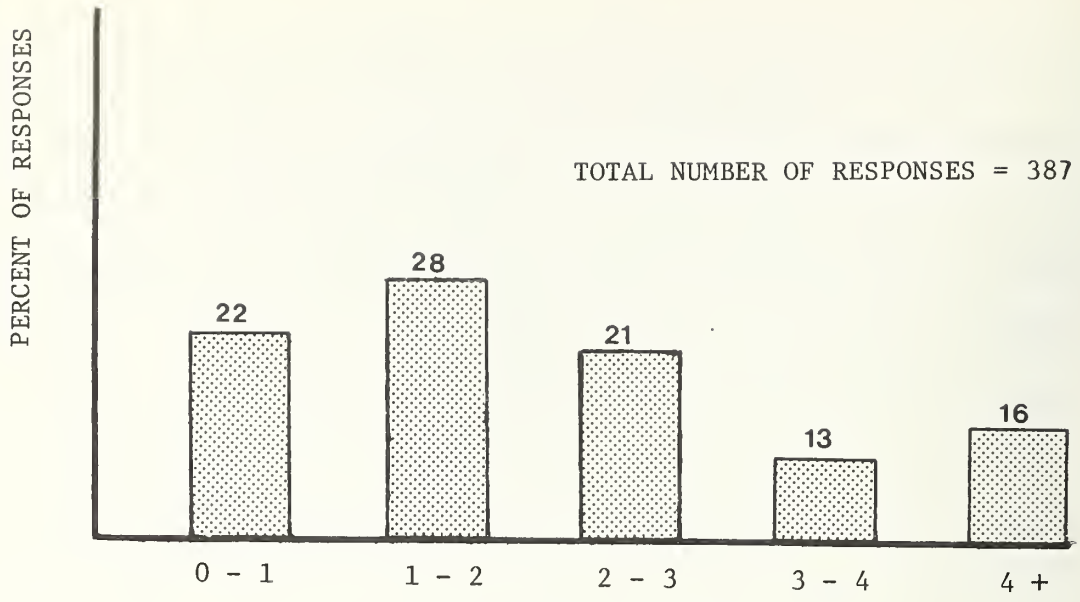

FIGURE 4.2. DISTRIBUTION OF PERCEIVED TELEPHONE HOLD TIME (April 1976)

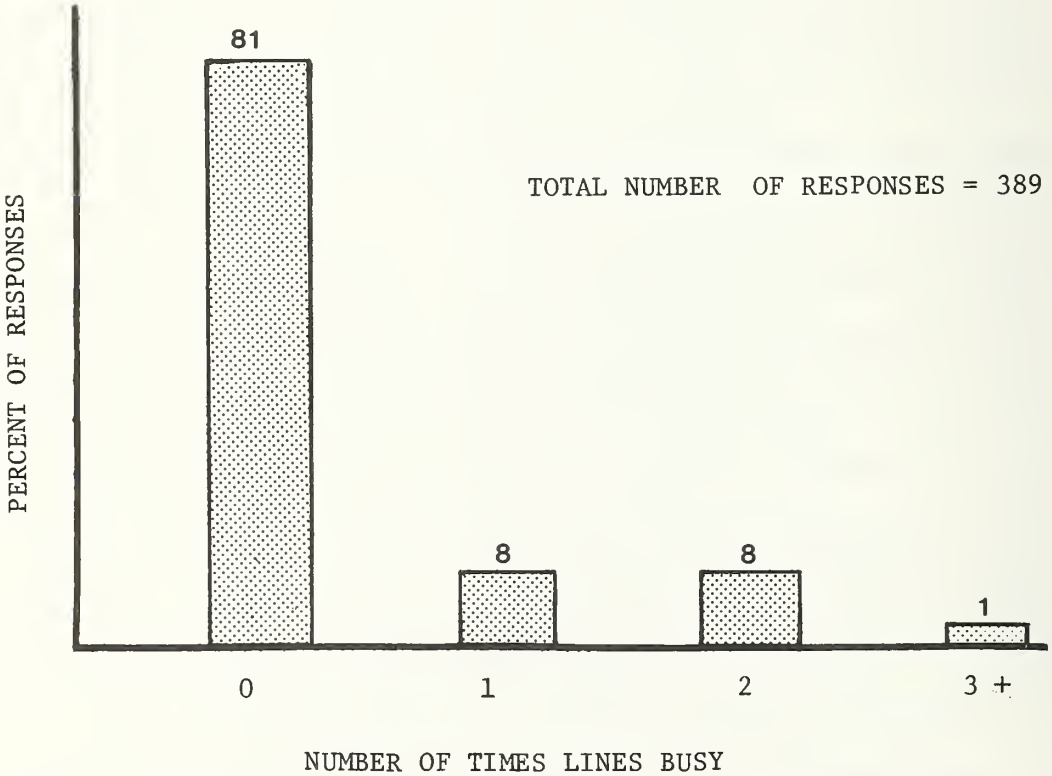

FIGURE 4.3. PERCEIVED NUMBER OF TIMES BUSY SIGNALS WERE ENCOUNTERED (April 1976)

iods and 80% of the respondents reported encountering no busy signal, while 90% reported one or less. However, there is no way of knowing the number of callers who gave up upon encountering a busy signal, except through special Bell Telephone monitoring.[1] During the dispatch room surveying, however, all lines were observed to be in use only a few times. During the initial phases of the implementation of Teltran, busy phones were a major customer complaint. In a February 1975, onboard survey conducted by AATA only 8% of the riders listed "busy phones" as a reason for dissatisfaction with the service.

4.2.1.2 Call Processing Time

Although call processing time is not perceived by the customer to be as onerous as hold time, the actual length of the conversation between customer and call-taker often is greater than hold time. Call processing time varies both by the type of call being made (e.g. immediate service, one or more advance orders, trip reservation and information) and the individual call-takers and dispatchers on duty. Because consultations between call-taker, dispatcher, and driver are sometimes required, an inexperienced call-taker or dispatcher can significantly increase call processing times. During periods of heavy demand, call processing times tend to increase because the communication between the dispatch staff and drivers generally is slower irrespective of the experience of the staff performing each function. The increase in call processing times during heavy demand periods also increases telephone hold times.

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[1] A telephone company study during the 5-day period from February 23 to 27, 1976, indicated that busy signals were encountered by 50 callers. During the period March 23-26, 1976, the phone company reported 306 callers encountered busy signals (191 occurred within a one hour period and raised questions about the validity of the data).

The data on call processing time was collected during the busiest time period, from 7:45 AM to 12 PM on a weekday (April 1976). Seven different call-takers were observed randomly to reduce any individual bias but it was not possible to distinguish the different types of calls being serviced. The weather on the day of the survey was clear and warm, resulting in a relatively light volume of calls but two minor computer failures occurred and caused several long processing times.

A total of 141 calls were observed and the mean processing time was 1.0 minutes. As reported previously, the mean phone hold time for the same time period but for a different day of the same week was 1.75 minutes. The maximum processing time observed was 6.1 minutes. Approximately 95% of all calls were less than 2.5 minutes in length, and 90% were under 2.2 minutes.

4.2.1.3 Telephone Access and Equipment

The AATA staff feels that the importance of telephone system planning was not clearly understood in the design and implementation stages of Teltran. Further, the assumption that telephone system design and implementation details were straightforward because the equipment was provided by Michigan Bell proved inaccurate. Some problems encountered have been related to system size and capacity, while others have related to the design and procurement of equipment not available through the phone company.

In February 1974, almost 50% of the complaints registered about the Teltran system during an onboard survey were directed at the inconvenience of busy phone lines. In Feburary 1975, a similar survey yielded a smaller number of complaints and busy phones represented only 21.6% of

the complaints registered. Too long wait times had replaced busy phones as the most common complaint. While busy phones may no longer be a priority problem for the Teltran system, phone related problems do continue to generate adverse user reaction and AATA is re-examining all aspects of their phone system design. Phone wait times have been the focus of numerous complaints about the quality of service and are one of the factors for which the AATA Citizens' Committee and staff are developing standards.

The telephone equipment used by AATA started out in 1971 as a series of call directors (key sets) answering a sequence of three group hunt lines accessed by a single telephone number. As the system expanded, this simple concept was expanded. A move of AATA's offices and garages from central Ann Arbor to a suburban location in 1974 introduced a new problem. No further capacity expansion could be undertaken on the existing phone number and a new series of dial-a-ride telephone lines was introduced and accessed by a second number. The telephone company refused to expand the number of lines accessed by the original number because the new location was serviced out of a different central office. The phone company repeatedly requested that the AATA delete the old series of lines. This was finally accomplished in the spring of 1976, and there is now a single dial-a-ride telephone number again.

On several occasions during the 1974-76 period, delays were encountered in ordering new phone lines. As phone volumes grew, there were times when callers encountered many busy signals due to inadequate line capacity. Further problems occurred even after the installation of additional lines when, for a period of time, callers would hear the phone ring, yet the lines

were not ringing in the AATA dispatch room because the installation was not properly completed.

Early in 1974, it became apparent that call volume required some automatic handling and it was determined that an "airline reservation" type automatic answer and hold system should be procured. While the AATA's computer dispatching and communications hardware and software were supplied by a single vendor, the telephone equipment was not. The phone company did not have automatic answer/hold equipment suited to the dial-a-ride system and the equipment was custom built by a local vendor and was connected through "couplers" provided by the phone company. While the automatic answer/hold equipment has performed adequately, routine service and repair have been a major problem. Some of the most difficult reliability problems have been associated with the interface between the phone company and the private equipment.

The Authority staff is now undertaking further revisions and refinements of its telephone system. The information lines and dial-a-ride lines will be combined into a single number, and all will be answered in the AATA dispatch center. This will extend the hours of coverage, allow better utilization of personnel, and remove a source of possible customer confusion. Test results with new "second generation" automatic answer/hold equipment, recently made available as an off the shelf item, appear good. This simpler and more serviceable equipment is likely to be employed system-wide. "Piped in" music has replaced the in-house music sources, further eliminating a reliability problem area. A read-out on each individual operator's console will show which caller has waited

longest and will provide better customer service. The two master readout displays are difficult to monitor which results in some abnormally long hold times. In retrospect, the AATA staff feels that implementing the telephone system turned out to be more complex than initially assumed, and that a more carefully thought out phone system design and monitoring strategy should have been developed at the start. Where special equipment was required, it should have been procured only with a clear commitment from the vendor for after-sales service and parts support.

Any community considering dial-a-ride service should at least consider the alternative of installing and debugging the final configuration of equipment either before operations begin or on a small service area. This would allow apparent malfunctions, design errors, and staff familiarization to occur before large volumes of demand for service developed. In this way, fewer people would experience the frustration of long waits, busy signals, lost calls, and other inconveniences caused by telephone communication problems. Although this alternative involves idle capacity during system implementation and implies additional costs, it may well prove effective in the long run in delivering more reliable service and in capturing higher ridership.

4.2.2 Response Time for Requests for Immediate Service

The response time, as shown in Figure 4.1, is the interval between the end of a customer's call and the time at which the customer boards a dial-a-ride van. Response time is only relevant for customers requesting immediate pickup, since for advance order requests the time between

placing an order and pickup can be arbitrarily large. For customers requesting immediate pickup, the response time provides a measure of how quickly the system can accomodate their desire for travel "as soon as possible." Alternatively, for the experienced rider, the response time represents the amount of time which must be allowed between calling in an order for immediate service and expecting a van to arrive.

Actual response time data was obtained by matching observed board times from the onboard survey with computer logs which record the time a trip order is entered into a tour (presumably at the end of the customer call). The onboard survey included 236 riders who had called for immediate service. However, only 88 observations of calls for immediate service were successfully matched up with computer logs.[1] For these observations the average response time was 22.9 minutes with a standard deviation of 12.5. While one would expect the response time during the peak period to be greater than the overall average, there were too few observations in the peak periods to draw any conclusions about the relative magnitudes of response time during different time periods.

Perceived response time was obtained from an interval choice question on the onboard survey. The distribution of the responses to this question, for the same 88 individuals for which actual response time was obtained, are shown in Figure 4.4. The results suggest that the perceived

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[1] During the week of the onboard survey, portions of computer logs were lost during computer "down time." In other cases, addresses were not filled in on survey cards or did not correspond to any address on the logs.

response time is lower than the actual response time.[1] Thus, the relationship between perceived and actual time for response time is opposite to the relationship discussed earlier for phone hold time.

The fact that perceived response time is lower than actual response time is not surprising considering that individuals can utilize the time between the end of their call for service until the beginning of the estimated time of arrival (ETA) internal (refer again to Figure 4.1) for the dial-a-ride van, assuming early arrival of vans is an infrequent occurrence.[2] Figure 4.5 shows the distribution of the length of the intervals between the end of the call to the beginning of the ETA window for 84 of the individuals for which actual and perceived response times were obtained.[3] The intervals shown in the figure are the portion of total response time which ideally individuals can use without worrying about the arrival of the van. The mean of the distribution is 16 minutes with a standard deviation of 9.5.

4.2.3 Dial-a-Ride Wait Time and ETA Accuracy

Two important aspects of the level of service provided by dial-a-ride to all users are the accuracy of the estimated time of arrival (ETA) windows quoted to customers and the time spent waiting for the van to arrive. Data on each of these factors was obtained from the onboard survey.

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[1] Calculating a mean for the distribution in Figure 4.4 by assuming the midpoint of each interval (32.5 minutes for the last interval) is the response time for all observations in that interval, the average perceived response time is 17.3 minutes with a standard deviation of 10.6. Using these statistics for the distribution of perceived response time, one would conclude that perceived response time is less than actual response time at the 95% confidence level.

[2] Frequency of early and late arrivals is discussed in the next section on dial-a-ride wait times.

[3] Four of the original 88 individuals reported no ETA on their survey cards.

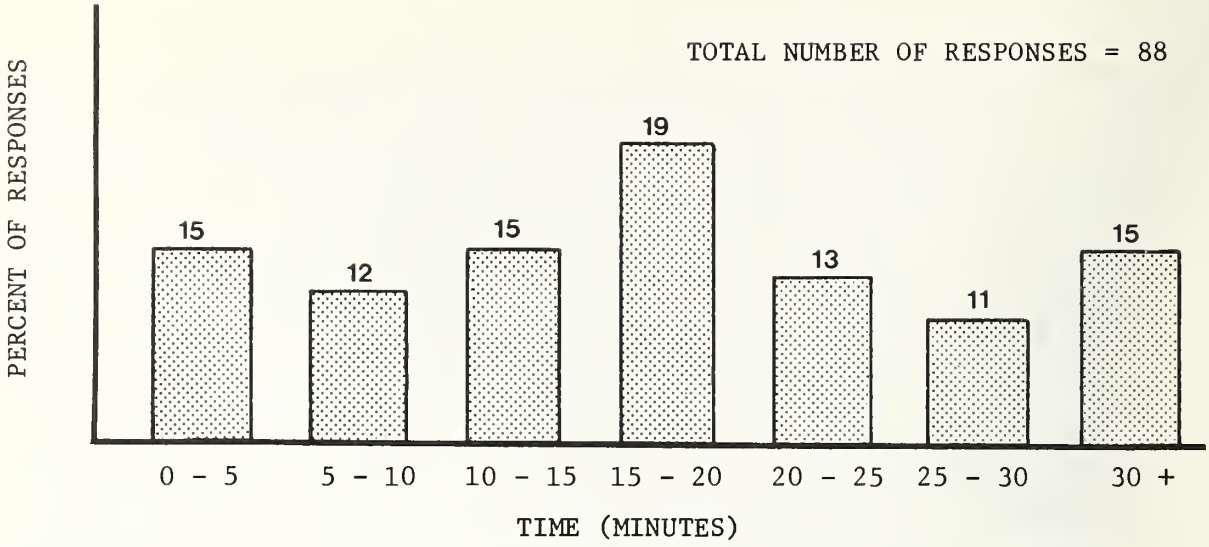

FIGURE 4.4 PERCEIVED RESPONSE TIME FOR RIDERS REQUESTING IMMEDIATE SERVICE (April 1976)

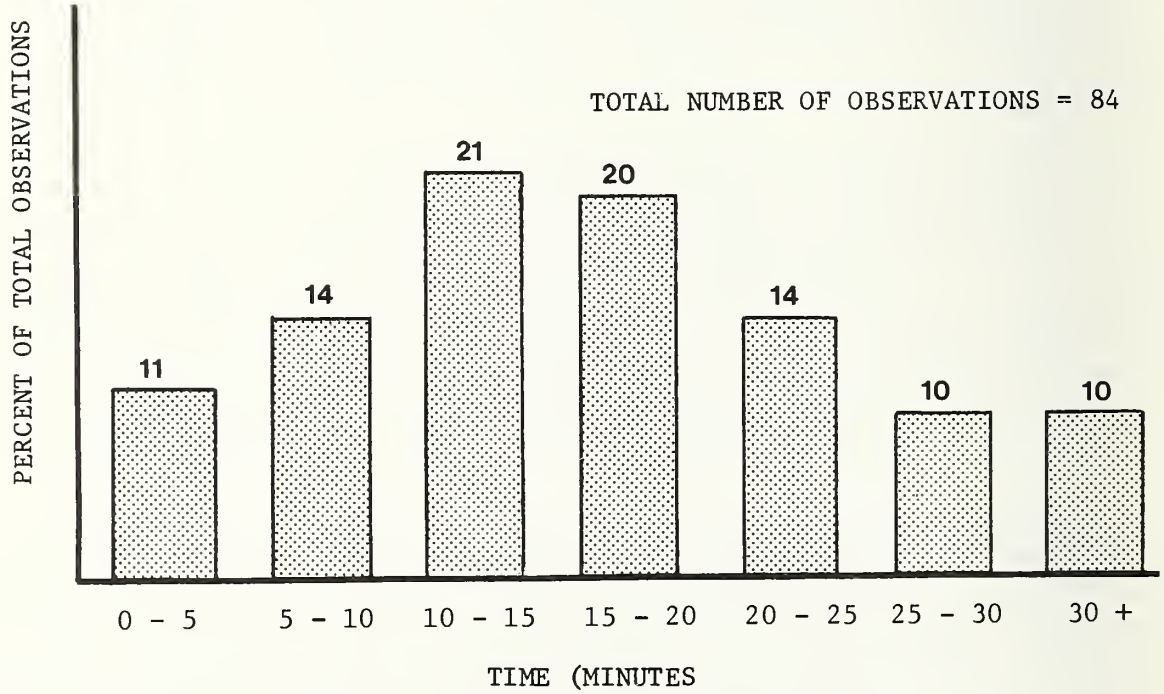

FIGURE 4.5. TIME FROM THE END OF CALL TO BEGINNING OF ESTIMATED TIME OF ARRIVAL WINDOW (April 1976)

Wait time is defined as the interval from the start of the ETA window until the van is boarded (refer to Figure 4.1).[1] It is the time period during which the customer must be prepared for the arrival of the van and cannot be preoccupied by other activities. In some sense, actual wait time for customers wishing immediate service is the response time discussed in the previous section. However, as the comparison of perceived and actual response time suggested, customers may perceive some of the response time interval as productive time.

Based on 296 observations, including both advance order and immediate service calls but not standing orders, the average wait time was 11.5 minutes with a standard deviation of 9.8. This does not include riders picked up early (i.e., prior to the beginning of the ETA window). The highest wait times were reported in the Pontiac zone, which due to some over-sampling, increases the system averages reported here. There were 46 riders who reported an early pickup with an average early time (e.g., the interval between boarding and the beginning of the ETA window) of 6.3 minutes with a standard deviation of 7.3.[2] It should be emphasized that the estimates of the ETA windows used for these calculations were those reported by the riders, and there was no way to check the relationship between the actual ETA's quoted and those reported on the onboard survey.

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[1] When a point estimate rather than an ETA window was quoted, wait time was defined as the interval from the point estimate to the time of boarding. Nineteen percent of all riders who quoted an ETA on their survey cards reported a point estimate. Also, since call takers do not record the ETA's they quote, there was no way to check the accuracy of the ETA's reported by riders.

[2] There were 15 observations of riders with 0 wait time which were included in the statistics for wait time but not for early time.

A precise estimate of wait times for customers with standing orders was not possible due to the inconsistency between the ETA's quoted in the mail out survey and those contained in AATA records and the long term nature of many standing order trips. Irrespective of the original ETA quoted for a regular standing order, the customer soon perceives a small interval around the usual pickup time as the ETA. In general, wait times would be expected to be smaller for standing order customers than for phone-in orders. Many AM peak period tours are completely filled with standing orders. Thus, drivers soon become familiar with what is essentially a subscription service run and follow a regular route and sequence of pickups providing customers with a very reliable service. This hypothesis is verified to some extent by the results of the standing order survey. For 45 individuals with standing orders, who recorded their pickup time for at least four of the five survey days, the standard deviation about the mean pickup times was computed and then averaged for all individuals. The average variation was 2.4 minutes, indicating a very reliable pickup time for the standing order trips surveyed. However, it must be noted that over 700 standing orders were served each weekday and most of the responses to the mail out surveys were concentrated in two relatively small geographic areas.

As mentioned earlier, the accuracy of the ETA's given to customers is an important factor in determining the level of service provided by dial-a-ride. Specifically, if ETA's are accurate (e.g., vans arrive within the ETA window), customers can make full use of the time prior to the start of the ETA interval. Naturally, by making ETA's arbitrarily large,

accuracy can approach 100%, but then the time during which a customer must be prepared to board a van (e.g., wait time, as defined here) increases as well. Ideally, ETA windows should be both accurate and relatively short in duration.

In Ann Arbor, the AATA policy is to give customers a ten minute ETA window. However, for a variety of reasons, including inexperience on the part of call-takers, weather, or staff shortages, quoted ETA's are sometimes as large as 30 minutes. Also, in some cases, point estimates rather than windows are quoted. Table 4.4 shows the distribution of the length of the windows quoted and their accuracy for 277 phone-in customers (i.e., not standing orders) included in the onboard survey.[1] The ETA windows shown are those reported by the customer, while board times were observed by surveyors on the dial-a-ride vans.

Almost half of the ETA's reported by customers were 10 to 15 minutes in length. For all observations, 59% of the customers were served "on time" (i.e., within the window), while 10% were early and 31% were late. There were no significant differences in the distribution of customers served early, on time, and late, either by zone or time of day.

While it would appear from these results that the AATA is far from reaching a proposed service standard of 93% of all trips served on time with ten minute windows, there may be some discrepancy between customer reported ETA's and the ETA's quoted by call-takers. As mentioned earlier, the actual ETA's quoted by call-takers are not recorded and

[1] Of a total of 342 customers quoting ETA's, 65, or 19%, reported point estimates rather than windows.

TABLE 4.4. ESTIMATED TIME OF ARRIVAL WINDOW LENGTHS AND ACCURACY (April 1977)

ETA Window Length (minutes)	Early	Per-cent	On Time	Per-cent	Late	Per-cent	Total	Percent
0 to 5	7	16	15	33	23	51	45	16
5 to 10	8	10	43	51	33	39	84	31
10 to 15	13	10	92	70	26	20	131	47
15+	1	6	13	76	3	18	17	6
ALL OBSERVATIONS	29	10	163	59	85	31	277	100

thus were unavailable for a comparison.

4.2.4 Dial-a-Ride In-Vehicle and Transfer Times

Estimates of dial-a-ride in-vehicle time and distance and transfer time were obtained for 776 invididuals participating in the onboard survey as well as for 485 additional riders who either refused the questionnaire or were making a standing order trip but who were observed for ride and transfer time. The average in-vehicle time for daytime dial-a-ride was 9.5 minutes with a standard deviation of 6.6, based on 1,043 observations. In-vehicle time did not vary significantly by time of day except during evening service hours when the average in-vehicle time was 14.3 minutes. While evening zones are larger than daytime zones and longer in-vehicle times are not surprising, only a few evening tours were surveyed.

The average in-vehicle time also did not vary significantly by zone in most cases. The zones with much lower in-vehicle times than the system average all had small sample sizes and were neither the smallest zones nor the zones serving the CBD where average trip lengths and in-vehicle times might be expected to be lower. As a result these variations are probably due to under sampling.

The average in-vehicle trip distance on daytime dial-a-ride was 2.3 miles with a standard deviation of 1.3, based on 1,043 observation. In-vehicle trip distance was calculated from odometer readings recorded by surveyors. Trip distance did not vary significantly by time of day but smaller zones, as expected, had lower average trip distances. Average

speed aboard dial-a-ride computed to 14.6 miles per hour.[1] Typical van speeds were higher, however, since dwell time at each stop is included in this figure.

For riders transferring from a dial-a-ride van to a line bus (or to another dial-a-ride vehicle) in the outer zones, transfer wait time was recorded.[2] The average transfer time was 4.1 minutes based on 175 observations. Of the total number of individuals who made a transfer, 36% had no transfer wait time (i.e., the second vehicle was at the transfer point when the van arrived). The average transfer time for individuals with a positive transfer time was 6.5 minutes. In almost all cases, transfer wait time is spent onboard the dial-a-ride van and thus may be less onerous to the customer than wait time spent outside a vehicle.

The average transfer time for standing orders, from the mail-out survey, was 5.4 minutes based on 185 observations. While transfer time should not vary between standing order and phone-in trips, most of the standing order responses were for AM peak period trips when transfer times were observed to be longest. Often, the transfer wait time for riders transferring from line buses to dial-a-ride is zero since dial-a-ride vans usually arrive at transfer points prior to line buses.

Transfer wait time is caused by late line bus or early dial-a-ride van arrival at transfer points. The latter occurs most often when tours have only a few riders and the pickups are made too early. A long trans-

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[1] Speed was calculated as the individual in-vehicle distance divided by in-vehicle time.

[2] Because of the number of vehicles serving the downtown (4th and William) transfer point, and because the downtown is a major destination, it was impossible to keep an accurate record of transfers for inner zones.

fer wait time can occur if the dial-a-ride vehicle arrives late and the line bus does not wait for the coordinated transfer, and dial-a-ride transfer riders must wait for the next line bus. Generally speaking, the transfer coordination works well. Often dispatcher-driver radio communication is required to hold vans and line buses in order to make transfers, or to arrange a different point of transfer in a few cases where a van "chased" a line bus to make the transfer. In a number of cases, while transfers were made successfully, the pressure of heavy demand tours and tight schedule coordination required that dial-a-ride vans exceed the posted speed limits in order to arrive at a transfer point prior to the line bus.

While actual transfer time was observed for riders going from dial-a-ride to a line bus, data on perceived transfer time (or wait time for walk ons) was collected for riders boarding dial-a-ride at a transfer point. The majority of these riders were transfers from a line bus. Perceived transfer time was asked in the form of an interval choice question, and the results are shown in Figure 4.6. The figure reveals that 80% of all respondents perceived transfer (or wait) times as 5 minutes or less and 90% reported transfer times of 10 minutes or less. About 1% of the respondents reported transfer or wait times of 30 minutes or more.[1]

[1] Again using the midpoint of each interval as the wait time for all responses in that interval, the average perceived transfer time for riders going from line bus to dial-a-ride is 4.45 minutes. However, it is likely that a large number of responses in the 0 to 5 minute interval actually had a zero transfer time, implying a lower average.

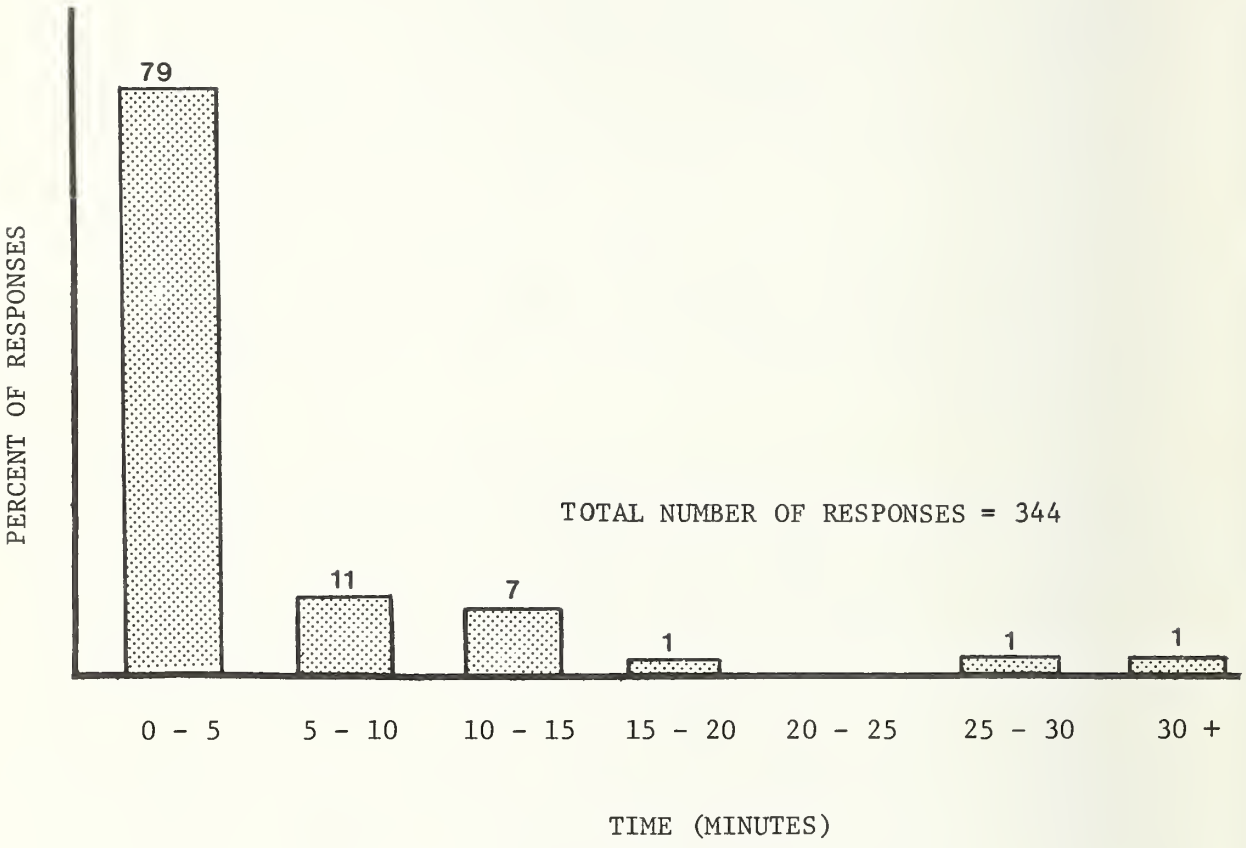

FIGURE 4.6. DISTRIBUTION OF PERCEIVED WAIT TIME FOR DIAL-A-RIDE TRANSFERS AND WALK-ONS (April 1976)

4.2.5 Total Trip Time for Dial-a-Ride Standing Orders

There are approximately 700 standing order (i.e., regularly scheduled) trips on dial-a-ride each day. About half of these standing orders are for a daily weekday trip. A mail-out survey was sent to all individuals with daily (5 day) standing orders requesting that they keep a diary of each component of their total trip times for a one week period.[1] Sixty-five usable responses were obtained, each with up to 5 observations of total trip time.[2]

Ninety-one percent of the reported trips were made in the AM peak period, 7% during the mid-day period and 2% in the PM peak. Although this does not reflect the actual distribution of all standing order trips over the day, there are far more standing order trips in the AM than the PM, and most are for daily trips. Many standing order trips in the AM peak have return trips in the PM peak which originate on fixed route bus and hence do not require a trip reservation in advance. Over 81% of the respondents had a trip origin in one of three zones (Far Southwest, Near Southwest, and Plymouth). The high response rate from the two southwest zones is not surprising since they encompass the area served longest by dial-a-ride which includes many strong supporters of the Teltran system.

The standing order survey provides some insight into the total trip

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[1] Walk time from deboarding point to final destination was assumed not to vary and was asked for only once on the survey form.

[2] Of 266 survey forms mailed out, 249 were delivered to an individual with a current standing order. The 65 survey cards which were returned represented a response rate of 26%.

time for users of an integrated dial-a-ride and fixed-route bus system and the relative magnitudes of various components of trip time. However, given the geographical concentration of trip origins and destinations, the results cannot really be interpreted as representing system averages.[1]

Approximately 34% of the responses were for intra-zonal trips (i.e., no transfer), while 51% made 1 transfer, 14% made 2 transfers, and 1% (i.e., one response) made 3 transfers. Of all the trips involving only one transfer, 94% were trips involving a transfer from a dial-a-ride vehicle to a line bus. The average total trip time, including walk time, for all trips was 26.9 minutes with a standard deviation of 12.9, based on 230 observations. As mentioned previously, the average transfer time was 5.4 minutes with a standard deviation of 8.0, based on 185 observations.[2] The average walk time from the deboarding point to the final destination was 2.74 minutes with a standard deviation of 2.84. Table 4.5 shows the average total trip time for trips with different numbers of transfers. Not surprisingly, average trip time increases proportionately as the number of transfers increases.

Although no other questions were asked on the diary, 5% of the respondents reported one incidence of a dial-a-ride van missing them com-

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[1] As discussed in an earlier section, the wait time for standing orders (i.e., the variance around expected pickup time) is significantly lower than for phone-in customers and is the major reason why standing order service in general is better than phone-in service. However, the calculation of total trip time for standing orders began with the boarding time on the first vehicle. Thus, the components of travel time discussed in this section would not be expected to vary by type of service and it is the temporal and geographical distribution of the responses which make the results unrepresentative of the system as a whole.

[2] Trips with 2 transfers provided 2 observations for the calculation of average transfer time.

TABLE 4.5. TRAVEL TIME FOR STANDING ORDERS (April 1976)

Number of Transfers	Total Trip Time		Number of Observations
	Mean	Standard Deviation	
0	15.5	5.9	94
1	33.4	8.8	122
2	46.3	14.3	14
All	26.9	12.9	230

pletely, and 3% of the respondents reported one occurrence of the van being excessively late and had to call in. Thus, missed vans occurred on less than 2% of the standing order trips reported and late vans were reported for 1% of the trips. Naturally the reports of missed vans may in fact have been late vans but the standing order rider made alternative transportation arrangements prior to van arrival. In addition, 3% of the respondents reported one incidence of an early pickup. Many other respondents, however, had very positive compliments for the service. During the AM peak period, many tours are booked completely by standing orders and consequently not all new requests for this type of service can be satisfied at this time.

4.3 OPERATIONAL ISSUES

In addition to the aspects of level of service discussed in the previous sections, there are a number of additional areas which affect the actual or perceived level of service of Teltran and provide valuable insights for other communities considering transit innovations and particularly integrated dial-a-ride and fixed-route service. These areas are:

a) Driver and Dispatcher Operations,
b) Service Shifts, and
c) Public Information.

The objective of the discussion is to identify some of the issues faced by the AATA during the evolution of the Teltran system. The point is not to attempt a definitive assessment of the particular design and operating decisions made for Teltran, but rather to examine the tradeoffs implied by some of those decisions. While some of the issues encountered

by Teltran may be unique to Ann Arbor, many are likely to be faced by other communities implementing integrated transit services.

The major sources of information for this portion of the evaluation were extended discussions with AATA staff; interviews with selected AATA board members and other individuals involved with transit in Ann Arbor; a review of newspaper files and board meeting minutes available at AATA; and the first hand observation of the individuals who conducted the on-board surveys as part of this evaluation effort.

4.3.1 Driver and Dispatcher Operations

The Teltran system relies heavily on coordinated transfers between dial-a-ride vans and fixed route buses for weekday daytime service. The result is a system which provides good transit service for many trips in Ann Arbor but whose dial-a-ride and fixed-route components are necessarily more complex operationally than either component would be if operated as an independent system.

Dial-a-ride tours are scheduled to arrive at transfer points at the same time as line buses, but line bus schedules must allow for some variability in dial-a-ride van arrivals.[1] If an inexperienced dispatcher overloads a tour or an inexperienced driver makes an inefficient series of drop offs and pickups, the van may have to speed toward the end of the tour to make the transfer, radio to hold the line bus, "chase" the line bus to an appointed rendezvous point, or leave the passengers at the

[1] Naturally, line bus schedules have some variability as well, and in some cases, vans must wait for late line buses.

transfer point to wait for the next line bus. Similarly, missed communication between driver and dispatcher (e.g., a wrong address or building entrance, etc.) or the insertion of riders into ongoing tours also can create tight schedules.

Thus, depending on the level of dial-a-ride demands, the coordination of transfers can create additional pressures on the driver and dispatcher which are not present in a "pure" dial-a-ride system. To some extent AATA management felt they underestimated the staff training task for such a system and have recently moved to increase and improve the training function. For effective call-taking and dispatching, the key requirements are automatically making the transformation from an address to a dial-a-ride zone; managing the vehicle fleet and particularly the "extra" buses used to relieve system overloads; learning to deal with the public; and fulfilling a leadership role in obtaining cooperation from drivers. It often takes 4 to 5 months for a new dispatcher or call-taker to become proficient at this task. Drivers must become very familiar with the street system and learn to schedule tours to meet line bus arrivals. The time required for producing a good driver is often 6 to 7 months. System expansion and staff turnover have placed additional demands on the AATA training program. Currently, staff turnover is roughly 30% per year, making it difficult to maintain a work force completely knowledgeable of the city.

Even with experienced staff, the successful operation of the Teltran system requires the mutual respect of drivers and dispatchers and a high quality of on-line management to deal with the variety of human and equipment failures which necessitate some departure from standard operating

procedures. The degree of cooperation between drivers and dispatchers has an important impact upon system operation. Both AATA staff and management agree that an effective method for fostering a climate of cooperation is to have drivers and dispatchers perform both functions in order to have a feeling for what is happening on the other end of the radio. Unfortunately, such a policy would have exacerbated the already acute staff training problem during the winter and early spring of 1976, and only a few staff members have been both drivers and dispatchers. With implementation of the entire system completed, the staff training problems have decreased.

One situation requiring cooperation between drivers and dispatchers occurs during periods with high demands for service. To accomodate demand variations, a small number of "extra" dial-a-ride vans are scheduled to assist overloaded tours as they occur. The dispatcher must anticipate these occasional peaks and deploy the extra vans, as well as any regular vans with light tours that may be close by. Often, however, the extra vans are either too far from an overflow or else in use, sometimes unnecessarily. While good dispatchers can position these vehicles to aid overloaded tours, drivers must be prepared to accept the dispatcher's judgment on the most effective overall vehicle utilization strategy and refrain from running his or her vehicle under his or her own "system rules."

Because drivers are the only Teltran personnel that passengers see, they have a number of important responsibilities beyond simply operating the vehicle fleet. Often, drivers must listen to customer complaints and attempt to respond tactfully and, where possible, solve particular

problems. For example, if a passenger receives incorrect information from the call-taker on how to make the transfers on his or her trip, the driver must know the routes, the schedules, and the zone structure in order to give the proper instructions.

The dispatchers generally radio the pickup addresses to drivers in the most logical order. However, the driver often re-orders the list to make the tour less circuitous. In particular, the order in which the dispatcher gives the addresses may not be optimal when the destinations of those who boarded the van at a transfer point are taken into account. During afternoon hours there are a large number of walk-ons and transfers from line buses and drivers must ask these riders for their destinations and decide on a logical order for making drop-offs. Drivers normally make drop-offs first and then pick up the new customers. On tours with a large number of both drop-offs and pickups, a driver often intermingles the stops in order to reduce backtracking and travel time for that particular tour. Although it takes careful thought to order a tour in this fashion, it can reduce the average ride time for the passengers aboard, and also give the driver a better chance of completing a heavy tour on schedule.

Often, drivers perform duties which promote excellent public relations. For example, very young children use the system unaided by an adult and drivers generally make certain that the children get to their destination, sometimes escorting them to the door. Some parents pin a note on their child giving the destination, which demonstrates a great deal of trust in the drivers. Elderly people are often helped aboard.

It is clear from this discussion and the earlier description con-

tained in Section 3 that the Teltran dispatching system, while computer-aided, relies exclusively on call-takers, dispatchers, and drivers to perform all the decision-making functions. The AATA feels that such a system provides the flexibility to respond to daily fluctuations in ridership levels and patterns, vehicle breakdowns, and computer failures,[1] while at the same time providing a good level of service during periods of "normal" operations. Such a system is also readily adaptable to the changes in system configuration occurring during evening and weekend periods and can be modified easily as the expected system evolution continues. However, the Teltran dispatching system requires good personnel to fill call-taking, dispatching, and driver positions, and the level of service provided varies by the quality and experience of the staff on duty.

4.3.2 Service Shifts

To provide weekday evening service (after 6:15 PM), the Teltran system shifts from an integrated fixed-route and demand responsive system to a completely demand responsive system.[2] The daytime dial-a-ride zones are consolidated into six zones during the evening period. During weekends a third system configuration is formed by using 7 dial-a-ride zones and some limited line bus service. These changes in system configuration make servicing the varying levels and patterns of trips more efficient from an operational point of view. However, they also generate some additional

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[1] The backup system for computer failures involves the same decision-making roles, but with a more cumbersome manual accounting system; refer to Section 3 for a description.

[2] The only exception is the route deviation service along Main Street.

user and public information problems. Public information is discussed in the following section.

From the users' point of view there are a number of ramifications from shifts in service. First, while access to the system can always be obtained via the phone, at different times of the day or on different days of the week (e.g., weekday vs. weekend), the same trip may involve a different sequence of vehicles. For example, a trip which requires a dial-a-ride to line bus transfer during weekdays may be serviced by a single dial-a-ride (DAR) trip or a DAR to DAR transfer during evenings or weekends. The result is that users perceive some additional variability in a system which, because of its integrated demand-responsive and fixed-route components, already has a certain level of variablility associated with it.

Variability in service also arises from the discretion of different drivers in a given zone. Some drivers, for example, will take regular riders a small distance outside their zone or make a special drop-off in order to eliminate a transfer, if time permits. However, a different driver on the same run may not deliver this special service which confuses and displeases the customer in spite of the fact that the special service is not part of normal system operation.

Naturally, to some extent, the disorientation caused by such service shifts can be mitigated by public information programs and will decrease, in any event, as users become more experienced at using the system. However, the original plan to have an additional shift in dial-a-ride zone configuration during daytime off-peak hours has been abandoned. This

decision was made, at least partially, in anticipation of the user reaction to taking the same trip during peak and off-peak periods and being routed through two different transfer points. While some internal shifts in system operation occur during off-peak hours, they do not require any users to use a different transfer point than they would during the peak period. The AATA feels that the lack of a major change in zone configuration during the off-peak period requires expending more resources during the mid-day period than is necessary. In the future a more major off-peak system reconfiguration may be instituted.

Another user related problem associated with the shift from weekday daytime to evening service is the occasional transfer or walk-on passenger who is stranded at a transfer point as evening service begins. Again, as users become more familiar with the system such occurrences should decrease.

4.3.3 Public Information

The original concept for introducing the Teltran system to the public was to provide information on the user access points to the system (e.g., telephone, walk-on points, fixed-route locations and schedules), but not to describe in any detail the operational complexity of the demand-responsive and coordinated transfer aspects of the system. The hope was that the public would accept the fact that they can make any trip within the city by transit by simply phoning for service and waiting for a van.

There appear to have been four major reasons for adopting such a public information strategy. First, at a time when most staff attention was

focused on implementing and operating an innovative service, a more extensive public information program would have been a drain on scarce staff resources. Second, the complexity of the system itself defies any simple graphic or verbal description, thus increasing the resources required to present a good description of system operation and use (e.g., the specific transfers required and estimated travel times for various trips). Third, by not describing system operation in detail, the AATA maintained the maximum flexibility to shift zone configurations, tour times, etc., as experience was gained during the implementation process. Finally, unlike the Santa Clara dial-a-ride project,[1] the AATA chose not to undertake a large advertising campaign in order not to stimulate more demand than the system could accomodate at any given stage in its development.

While these factors suggested a limited public information program initially, as the executive director of the AATA notes, the system is not "transparent" enough for some citizens.[2] People want to know what to expect and the combination of demand-responsive service for some trips, and coordinated transfers with line buses for others, confuses some individuals. To some extent, as users' experience with the system increases, the requests for more thorough system descriptions may decrease.

Now that the Teltran system is completely implemented, the Authority intends to expand its public information program. There are plans to paint the dial-a-ride telephone numbers along with an identifying logo on

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[1] See "Dial-a-Ride...Failure in Santa Clara," an article in Metro. Volume 72, No. 3, May/June 1976, pp. 15-22.

[2] See Karl Guenther, "Report on Demand-Responsive Transportation in Ann Arbor," prepared for the 55th Annual Meeting of the Transportation Research Board, January 1976.

the vans. Presently, vans have no information on them. Also, more bus stop signs will be put up and schedules will be posted at all transfer points. The AATA is also planning to develop a manual to provide more complete information on how to use the system.

Finally, because dial-a-ride vans serving different zones use the same transfer points, all vans are scheduled to be equipped with signs designating the service zone of each vehicle. The lack of such signs has generated some complaints by users who must request service zone information from drivers. These constant requests for information can provide an aggrevation to drivers as well, though AATA management feels the key to better public information may be a well-informed and experienced work force.

5. TELTRAN RIDERSHIP

5.1 RIDERSHIP GROWTH

Since the Ann Arbor Transportation Authority began operating transit services, ridership has increased steadily. During the past 5 years, the AATA has achieved a 3-fold increase in total ridership.[1] Table 5.1 shows the growth in annual first fare ridership (i.e. not including transfers) for the AATA. The total ridership for the period from May 1975 through April 1976, was 1,706,136. The large variance in the annual percentage increases in ridership is due to the schedule of the major service improvements made as part of the implementation of the Teltran system. Figure 5.1 shows the growth in monthly ridership and the corresponding schedule of fleet size improvements. Monthly ridership peaks during the late winter and early spring. Ridership is lowest during the summer months due to both mild weather and the exodus of University students during this period.

The growth in dial-a-ride ridership can be seen by examining the average weekday ridership on each type of service provided by the AATA. Table 5.2 shows the average weekday ridership achieved at different points in time during the past three years for each type of service except school subscription service.[2] The figures represent the number of passengers paying their first fare on each type of service and thus do not account

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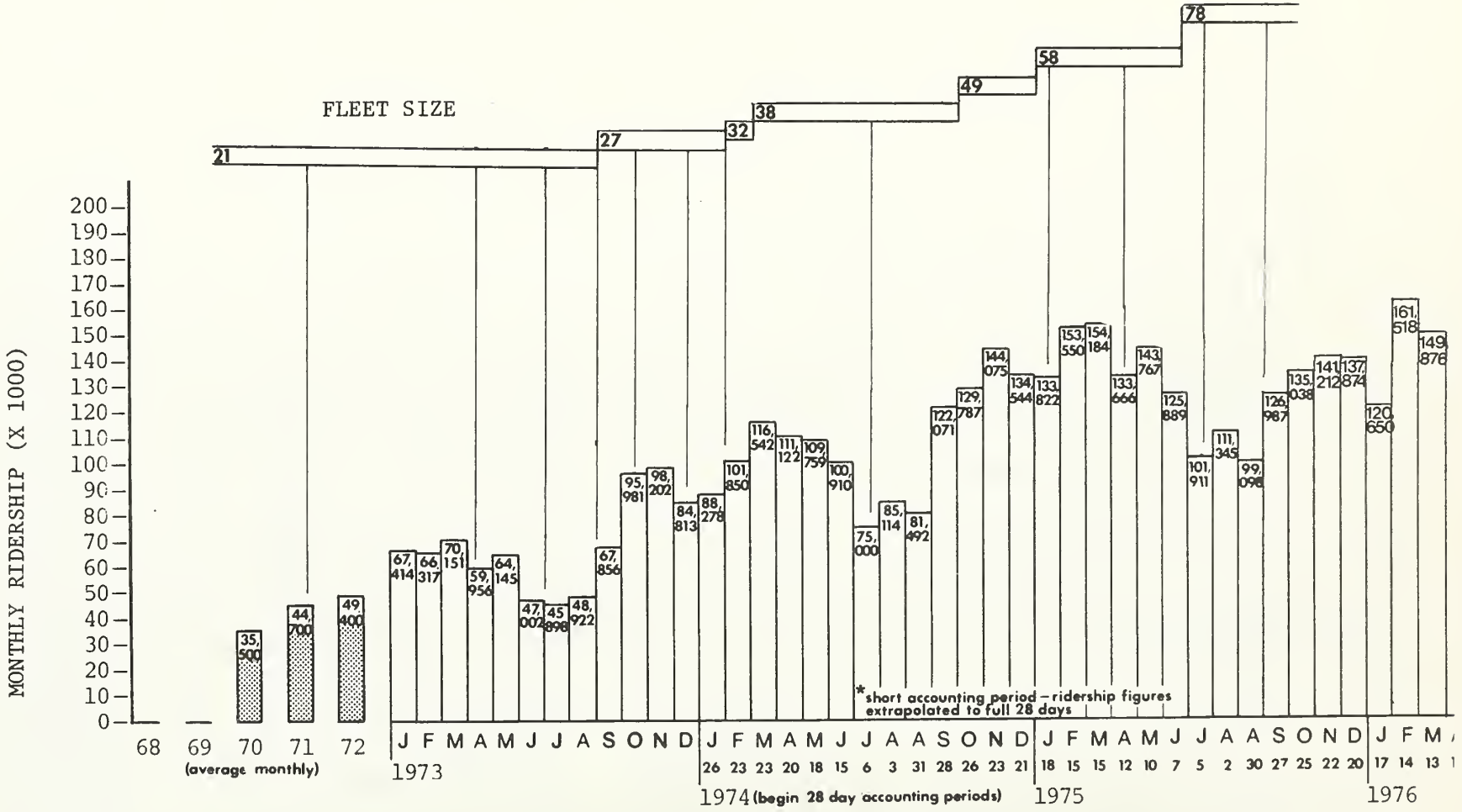
[1] Guenther, Karl, op. cit.

[2] For the same time periods as shown in the table, the average weekday school subscription ridership was 1,200, 1,470 and 300, respectively. The dramatic decrease in ridership on this service was due to the provision of free school bus service by the Ann Arbor Public Schools starting in 1975. The free service is available to students living more than 1.5 miles from their school.

TABLE 5.1. TOTAL ANNUAL RIDERSHIP FOR ALL AATA SERVICES

Fiscal Year	Number of Passengers	Increase Over Previous Year (percent)	Service
1971	540,941	-	6 fixed routes
1972	582,240	7.6	fixed-routes, pilot dial-a-ride
1973	677,500	16.4	fares lowered
1974	1,110,135	63.9	beginning of Teltran
1975	1,613,746	45.4	expansion of Teltran
1976	1,814,600	9.8	completion of Teltran



Source: 1975-1980 Transit Development Program for the Ann Arbor/ Ypsilanti Urban Area

FIGURE 5.1. MONTHLY RIDERSHIP AND FLEET SIZE IMPROVEMENTS

TABLE 5.2. WEEKDAY RIDERSHIP GROWTH BY TYPE OF SERVICE

Type of Service	Average Weekday Ridership		
	December 1973	January 1975	March 1976
Ann Arbor and Ypsilanti Line Bus	3,000	4,700	4,788
Dial-a-Ride	600	935	1,650
Handicapped	20	25	30
Total	3,620	5,660	6,468

for transfers.[1] The implementation of the Teltran system has increased the percentage of total first fare ridership using dial-a-ride from 17% to 25%.

5.2 WEEKDAY RIDERSHIP ESTIMATES AND TRANSFER PATTERNS

The ridership figures presented in the previous section for the fixed-route and dial-a-ride components of the weekday Teltran system represent the number of passengers paying their first fare on a particular vehicle type and do not account for transfers.[2] Given the design of the weekday system, many passengers must make transfers, and thus the total volume of riders on both the fixed-route and dial-a-ride components is considerably larger than the first fare ridership.

Based on the onboard survey conducted on dial-a-ride vehicles as part of this evaluation (April 5-9, 1976), 68% of all respondents on dial-a-ride made one or more transfers. Table 5.3 shows the distribution of the sequence of vehicles used by respondents to the survey. Table 5.4 shows the distribution of the number of transfers used by zone for respondents.[3]

The survey respondents included both phone-in riders to dial-a-ride and "extra-ons" (e.g., walk-ons and transfers) but not standing orders. Of the 776 total responses, 47% were "extra-ons" while 53% were phone-in requests for service. As expected, the survey results showed a higher

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[1] Estimates of the current total passenger volume on line buses and dial-a-ride, including transfers, are discussed in the following section.

[2] While the AATA uses transfer slips, no record is kept of the number of transfers, and often, the slips are not used at outlying transfer points.

[3] The figures shown are for the zone in which the survey was administered, which may be the zone of origin or destination.

TABLE 5.3. DISTRIBUTION OF TRANSFERS FROM ONBOARD SURVEY (April 1976)

Sequence of Vehicles Used [a]	Number of Trips [b]	Percent of Total
ISA	246	32
L-D	219	28
D-L	164	21
D-D	25	3
D-L-L	27	3
L-L-D	32	4
D-L-D	57	8
D-L-L-D	6	1
Total	776	100

[a] D = Dial-a-Ride
L = Line Bus
ISA = Intra-zonal trip on dial-a-ride

[b] does not include standing orders

TABLE 5.4. TRANSFERS BY ZONE FROM ONBOARD SURVEY (April, 1976)

Number of Transfers	Zone												Total	Percent of Total
	PON	NSW	FSW	FSE	NNE	MIL	PAC	PLY	MED	FNW	NNW	Evening Service		
0	27	87	36	12	13	6	2	22	3	11	15	12	246	32
1	162	22	78	31	13	2	2	63	9	6	12	9	409	52
2	44	1	29	15	4	0	1	18	0	1	3	0	116	15
3	0	1	0	1	0	0	0	3	0	1	0	0	6	1

percentage of intra-zonal trips in zones directly serving the downtown.

The AATA report programs for the week of March 15, 1976, which include all phone-in and standing order trips logged onto a dial-a-ride tour, showed that 88% of all trips which began on dial-a-ride involved at least one transfer.[1] The discrepancy between the report programs and onboard survey in the percent of rides involving a transfer suggests that standing order trips (not included in the onboard survey) involve a transfer more frequently than phone-in trips.[2] Standing orders represented about 43% of the total trips logged into dial-a-ride tours during the week of March 15. The daily and daytime distribution of phone-in rides by time of day are shown in Figure 5.2. The highest phone-in volumes occur from 7 to 8:00 AM with another smaller peak in the afternoon from 3 to 4:00 PM. However, the volume of transfers from line buses to dial-a-ride is greatest during the late afternoon. During this period, many commuters take the reverse of their AM inbound trip by boarding line buses downtown and then transferring to dial-a-ride in outer zones.

In order to get estimates of the average weekday total volume of riders on dial-a-ride and line buses, the results of both the onboard survey and report programs for the week of March 15 to 19 were utilized.[3] The on-

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[1] Phone-in orders which are placed onto an ongoing tour are often not logged into the computer, and thus, do not show up on the daily report programs.

[2] The results of the mail-out survey of standing orders conducted during the same week as the onboard survey showed only 67% of the respondents making at least one transfer. However, there were only 65 responses to this survey and a disproportionate share of the responses came from near-in zones which require no transfer to get downtown.

[3] The onboard survey was conducted the week of April 5-9, 1976. Because of computer problems, complete report programs were not available for that week.

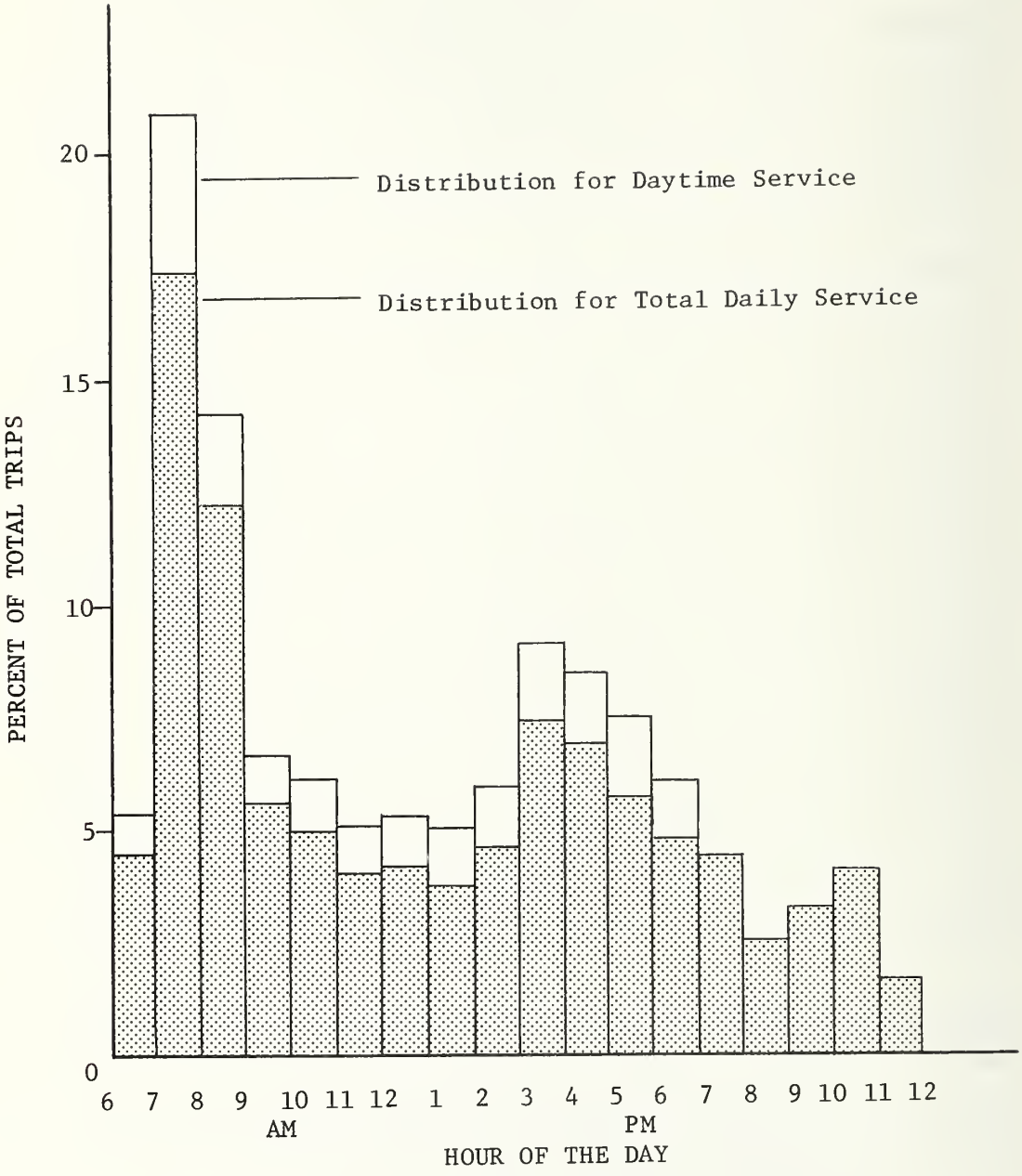

FIGURE 5.2: DISTRIBUTION OF DIAL-A-RIDE PHONE-IN TRIPS

board survey indicated that 47% of all non-standing order trips on dial-a-ride are either walk-ons or transfers (i.e., "extra-ons"). These trips (or segments of trips) do not appear in the daily report programs which record only the total phone-in and standing order trips by zone of origin. From the report programs, the average daily number of phone-in requests was 942. If these trips are factored up to account for walk-ons and transfers, based on the onboard survey results, the average daily non-standing order ridership on dial-a-ride becomes 1,777. The average daily number of standing orders from the report programs was 708, resulting in a total average daily dial-a-ride ridership of approximately 2,500.[1] The AATA executive director estimates that the average daily dial-a-ride ridership during the winter of 1975-76 was about 3,000 riders. The estimate developed here is consistent with this figure given that some phone-in trips do not get logged into the computer and that overall ridership is lower in the spring due to seasonal factors.

The onboard survey also indicated that approximately 9% of all calls for service result in a "no show" (i.e., a rider does not appear at the address given by the call taker). The percentage is probably high due to oversampling in the Pontiac zone,generally a lower income area, where a higher than average frequency of no-shows occur. While some of the no shows are due to driver and call-taker errors, many are also due to the fact that the AATA has made the procedure for cancelling trips difficult (i.e., the procedure involves several steps and is time consuming) in order to minimize the chances of losing a valid trip from the computer

[1]Since phone-in trips which are not logged into the computer are not included in this figure, the estimate is probably somewhat conservative. In addition, some standing order trips involve transfers to a second dial-a-ride vehicle and these are not included in the transfer estimate. However return trips (e.g. CBD to home) for standing orders are included in the estimated 47% of "extra ons".

record. As a result, many standing order riders have an informal agreement with their drivers not to officially cancel their trips and simply do not "show" when they are not making the trip.

An estimate of average weekday line bus ridership was developed from the distribution of transfers obtained from the onboard survey. Based on the survey, 55% of riders paying their first fare on dial-a-ride transfer to line buses. Also, based on the onboard survey, 68% of all phone-in and "extra-on" riders and all standing orders pay their first fare on dial-a-ride. For the last two weeks in March, average weekday first fare ridership on line buses was 4,788. For the week of March 15, the average first fare ridership on dial-a-ride was 1,916. Thus, total weekday line bus ridership was approximately 5,800.

5.3 RIDERSHIP PROFILES

In February of 1974 and 1975, the AATA conducted onboard surveys on weekday and weekend dial-a-ride and in March 1975, an onboard survey was conducted on several line bus routes. The results of these surveys provide some information on the profiles of AATA users at that time and their attitudes about the Teltran system.[1] The majority of the Teltran system was implemented after the 1975 survey, however, AATA management feels that a survey conducted now would probably not produce significantly different results.

The 1975 survey (based on 1,251 responses) indicated that the majority of riders were female (63%) and under 24 years of age (60%). About

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[1]The AATA is currently undertaking a more comprehensive attitudinal survey of both users and non-users in order to make the Teltran system more attractive to both groups. The survey will be conducted by the Survey Research Institute of the University of Michigan and is funded by a Technical Studies Grant from the Urban Mass Transportation Administration.

20% of all riders were under 16 years of age, while only 5% were more than 64 years old. The distribution of ridership by age is shown in Table 5.5 and is roughly proportional to the age structure of the total population of Ann Arbor based on the 1970 Census.

Approximately 50% of all respondents used dial-a-ride on a daily basis, and about 56% of all respondents intended to use AATA service for a round-trip. About 7% of those surveyed were riding for the first time. Work trips represented the predominant trip purpose for both dial-a-ride and the two line bus routes surveyed as shown in Table 5.6.

According to the 1975 survey, 37% of the dial-a-ride respondents had access to at least one car and possessed a driver's license. However, 26% of the respondents came from an auto-less household, while 45% had no driver's license as shown in Table 5.7. About 60% of the respondents indicated that they were replacing an auto trip (either as driver or passenger) with their transit trip. Approximately 3% of the respondents indicated that they have sold, or not bought, an automobile as a result of the Teltran system and 24% indicated that the system had influenced their household location decision.

About 76% of the dial-a-ride respondents said that they were "basically satisfied" with AATA service. The most frequent complaints registered by all respondents were "wait time too long" (12%), "phones too busy" (8%), and "inaccurate estimated time of arrival" (7%).

TABLE 5.5. AGE OF TELTRAN USERS (March 1975)

Age	Percent of Respondents
under 15	20
16-20	23
21-24	17
25-34	18
35-44	6
45-54	3
55-64	4
65 and more	4
no reply	4

TABLE 5.6. TRIP PURPOSE OF TELTRANS USERS (March 1975)

Trip Purpose	Dial-a-Ride (percent)	Washtenaw Line Bus (percent)	Briarwood Line Bus (percent)
Work	30	34	27
University	7	26	4
Shop	16	11	47
Elementary School or Secondary School	11	10	10
Personal Business	12	9	4
Social or Recreational	12	8	7
Other	12	2	1
Total	100	100	100

TABLE 5.7. AUTOMOBILE OWNERSHIP AND DRIVER'S LICENSE DATA FOR TELTRAN USERS (March 1975)

Automobiles Per Household	Percent of Respondents
0	26
1	35
2 or more	32
no reply	7
Drivers License	**Percent of Respondents**
yes	52
no	45
no reply	3

6. FINANCIAL DATA AND PRODUCTIVITY

6.1 INTRODUCTION

With the aid of substantial local support in the form of a dedicated property tax millage, the AATA has been able to greatly expand transit service within the City of Ann Arbor during a period when many transit operators have faced a severe financial crisis requiring service cutbacks. During this same period the AATA also has been very successful in securing capital and operating grants from Federal and State sources. However, during the past winter, unusually bad weather created many vehicle delays and breakdowns requiring the allocation of additional vehicle hours to maintain service levels and forced a reduction and reallocation of vehicle hours originally budgeted for the latter part of fiscal year 1976. Whether more permanent cuts are required in the future may depend greatly on the continued growth of Federal and State operating assistance programs.

This section presents the basic cost and revenue data for all AATA services, as well as various productivity measures.

6.2 COSTS

Table 6.1 shows the distribution of the AATA's actual operating and capital costs among various categories for the fiscal years 1974, 1975, and the estimated costs for fiscal year 1976.[1] In fiscal year 1973, which

[1]The 1976 cost estimates do not include the cost of providing some new service to the rural areas of Washtenaw County and thus are comparable to the cost figures shown for 1974 and 1975. The AATA fiscal year runs from July 1 to June 30.

TABLE 6.1 COSTS

Cost Category	Fiscal Year (dollars) 1974	1975	1976
Operating Costs			
Wages and Salaries			
Operations	620,780	1,117,171	2,063,976
Maintenance	141,109	211,010	373,359
Administrative	103,675	189,792	253,851
	865,564	1,517,973	2,691,186
Fleet Costs			
Parts	68,117	138,825	119,430
Fuel	44,490	108,409	117,415
Outside Repairs	13,477	20,408	-
Tires	8,222	2,047	-
Other	2,808	5,095	43,086
	137,114	274,784	279,931
Administrative Costs			
Building Maintenance	9,841	35,798	33,500
Rent	56,869	61,640	0
Office Expense	23,557	97,775	87,409
Insurance	19,225	39,680	84,100
Other	114,300	195,079	264,036
	223,792	429,972	469,045
Total Operating Cost	1,226,470	2,222,729	3,440,162
Capital Costs			
Land and Building	-	600,000	185,000
Building Improvements	8,839	94,338	40,500
Vehicles	211,055	902,223	282,932
Equipment	21,090	453,951	136,065
Total Capital Cost	240,984	2,050,512	644,497
TOTAL COST	1,467,454	4,273,241	4,084,659

was prior to the start of the implementation of Teltran, total operating costs were $513,632 of which 66% was for wages and salaries. Total capital costs were $167,480 of which 91% was for payment of long term debt.

As the Teltran system has been implemented during the past three years, both operating and capital expenditures have increased dramatically. From fiscal year 1974 to fiscal year 1975, operating costs increased by 180%, while capital expenditures increased by more than 800% as large additions were made to the vehicle fleet and the current AATA headquarters was purchased. The estimated operating costs for fiscal 1976 represent over a 150% increase from the previous year. Wages and salaries, which represented about 70% of the total operating costs in fiscal years 1974 and 1975, are estimated to be almost 80% of the total operating cost for fiscal year 1976 and are the fastest growing component of operating cost. The increase in wage and salary expenditures results from increases in both total staff and wage rates. From fiscal year 1975 to fiscal year 1976, the staff increased by 70%. The current union contract provides for an average increase of 7% in wage rates for each staff position for fiscal year 1977. The contract must be renegotiated during the current fiscal year.

Table 6.2 shows the average maintenance costs per vehicle mile by cause.[1] Unscheduled maintenance is the major component of such costs. The ratio of unscheduled to scheduled maintenance costs is in the range

[1]Additional information on vehicle utilization rates, maintenance, and accident data is contained in Appendix D.

TABLE 6.2. AVERAGE COST OF MAINTENANCE (July 1975-March 1976)

FLEET CLASS	Vehicle Miles	Cost of Maintenance/Repairs by Type (dollars/vehicle-mile)					
		Scheduled	Un-Scheduled	Accident	Vehicle Improvements	Road Call	No Cause
VANS							
1	50,921	0.0324	0.0963	0.0008	0.0063	0.0143	-
2	191,651	0.0203	0.0482	0.0057	0.0037	0.0046	0.0003
3	573,509	0.0129	0.0234	0.0035	0.0015	0.0027	0.0001
Total	816,081	0.0116	0.0338	0.0038	0.0023	0.0038	0.0001
BUSES							
4	100,773	0.0293	0.0695	0.0202	0.0189	0.0089	-
5	84,805	0.0346	0.0868	0.0166	0.0140	0.0151	0.0003
6	20,043	0.0184	0.0663	-	0.0576	0.0075	-
7	59,129	0.0191	0.0341	0.0044	0.0339	0.0046	0.0001
8	299,951	0.0151	0.0161	0.0229	-	0.0027	0.0001
9	26,704	0.0205	0.1321	0.0079	0.-724	0.0060	0.0066
Total	591,405	0.0211	0.0441	0.0182	0.0109	0.0060	0.0004
All Vehicles	1,407,486	0.0156	0.0381	0.0099	0.0059	0.0047	0.0002

of 2.5-3.0 to 1.0. This may indicate that better preventive maintenance is in order. A review of the AATA vehicle inspection log for the period February to March, 1976, revealed that of 144 inspections that were due, 62 inspections were completed for an average of 42% of the fleet receiving scheduled inspections.

Costs per vehicle-mile for repairs and maintenance and fuel and oil costs are summaried in Table 6.3 for the various fleet segments for the year to date (March 1976). Costs for vans are somewhat lower on a vehicle-mile basis. In addition, newer vehicles have lower maintenance and operating costs, as would be expected. It is difficult to compare van and bus fleets since the buses are generally older but tend to have longer "lives." For vehicles of equal age (fleet segments 2 and 8), the larger buses seem more reliable in terms of maintenance. However, the sample is small and few conclusions can actually be made on this data regarding the superiority of vans or buses in terms of per vehicle-mile operating and maintenance costs.

While it is difficult to allocate operating costs among the various services offered by the AATA, some indication of the relative costs is provided by the vehicle service hours allocated to each service type. Of a total of 173,335 vehicle hours estimated to be provided in fiscal year 1976, 103,980 hours (59%) were budgeted to dial-a-ride service, while 41,647 hours (24%) were budgeted for Ann Arbor line bus service.[1] The Ypsilanti line bus service was allocated 18,434 hours (11%).[2]

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[1]The dial-a-ride allocation includes all 15,801 hours budgeted for providing weekend service.

[2]The remaining hours were allocated to the school subscription, handicap, and charter services.

TABLE 6.3 DIRECT OPERATING AND MAINTENANCE COSTS (January to March 1976)

FLEET CLASS	Maintenance Cost Per Vehicle-Mile (dollars)	Direct Operating Cost Per Vehicle-Mile (dollars)
VANS		
1 (1973)	0.1501	0.0592
2 (1974)	0.0828	0.0588
3 (1975)	0.0441	0.0472
Total Van	0.0598	0.0507
BUSES		
4 (1970)	0.1467	0.0563
5 (1970)	0.1673	0.0681
6 (1966)	0.1499	0.0916
7 (1970)	0.0962	0.0898
8 (1974)	0.0570	0.0817
9 (1969)	0.2455	0.1125
Total Bus	0.1486	0.0780
TOTAL FLEET	0.0971	0.0622

For budgeting purposes the AATA assumes that the cost of providing an hour of dial-a-ride service or line bus service is the same. The estimated cost per vehicle hour for fiscal year 1976 is $19.85, based on total vehicle hours and operating cost estimates. The local communities supporting the Ypsilanti service are billed on a service hour basis.[1]

6.3 REVENUE

Table 6.4 shows the distribution of the AATA's revenue among various sources for fiscal years 1974 and 1975, as well as the estimated revenues for fiscal year 1976.[2] In fiscal 1973, the last year in which there was no property tax revenue, total revenues were $482,107 with 46% coming from fares and 47% coming from City of Ann Arbor general funds.

Over the past three years fare box revenues have decreased from 22% of total operating cost in 1974 to an estimated 12% for 1976. The average fare per passenger for fiscal year 1976 is estimated to be about 23¢. The largest single revenue source is the Ann Arbor property tax assessment which can only be used for providing service within the City. In fiscal year 1976, property taxes are estimated to account for 45% of all revenues and over 53% of all revenues applicable to operating costs. The property tax represents a $15 per capita local contribution for transit in Ann Arbor. The property tax revenue increased by 8% from

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[1] Prior to the budget revision in early 1976, which resulted in a decrease in estimated total service hours, the billing rate for Ypsilanti service was $17.48 per service hour.

[2] The estimated revenues for fiscal year 1976 do not include a grant for $206,000 from the State of Michigan to provide service to rural areas of Washtenaw County.

TABLE 6.4 REVENUES

REVENUE SOURCE	Fiscal Year (Dollars) 1974	1975	1976
Regular Fares	270,058	379,045	424,075[b]
Charter Fares	5,953	5,780	-
AA Property Tax	1,413,799	1,553,125	1,678,815
Other Governmental Contributions[a]	70,000	66,202	72,986
Interest on Investments	56,206	54,156	27,000
Other Income	3,068	32,124	32,500
State Transportation Fund	264,142	256,307	416,200
Federal Operating	-	-	438,424
UMTA Technical Study	-	-	23,000
Comprehensive Employment Training Act	-	-	8,140
	2,083,226	2,344,239	3,121,140
State Capital Grants	149,125	261,785	92,536
Federal Capital Grants	-	1,430,978	503,598
Total Revenue	2,232,351	4,039,502	3,717,274

[a] Ypsilanti, Pittsfield, Superior and Ann Arbor Townships and City of Ypsilanti

[b] all fare box revenue

fiscal year 1975 to 1976.[1]

In fiscal year 1976, the Townships of Ypsilanti, Pittsfield, Superior and Ann Arbor and the City of Ypsilanti contributed over $70,000 in general funds to help support the Ypsilanti fixed-route service.

Over the past three years, the AATA has received over $2.4 million in capital grants from Federal and State sources. These grants represent over 80% of the total capital expenditures made during the same period with the remainder of the revenue coming from local sources. Fiscal year 1976 was the first year that Federal operating assistance was available (based on 1975 operating data). Federal operating funds represented about 13% of total estimated operating costs.

6.4 PRODUCTIVITY

Because the design of the Teltran system reflects the AATA's objective of providing 100% geographic coverage, the productivities achieved by the system are of particular interest. While productivities are calculated for the fixed-route and dial-a-ride services as well as the system as a whole, it must be remembered that a large proportion of trips involve using both fixed-route and dial-a-ride vehicles. Due to the large number of transfers, weekday productivities in terms of passenger per vehicle-hour of service were calculated for dial-a-ride and the Ann Arbor line buses using both first fare and total ridership estimates.

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[1] The City of Ann Arbor collects the tax and receives 1% of the revenue to pay for this and other services. The total Ann Arbor property tax is 70 mils of which the AATA portion represents 3.6%. Property taxes provide 41% of the City of Ann Arbor's total revenue (not including the public schools' budget) and the AATA property tax support represents about 6% of the city's total expenses (again excluding public schools).

Table 6.5 shows these figures and the weekday total productivity for both services achieved during late March 1976.

These results can be compared with productivities reported by the AATA. Table 6.6 shows the average productivities for each service for fiscal year 1976. The dial-a-ride productivity, as estimated for the entire fiscal year, represents a decrease from the 1975 levels of 9.5 and 5.9 passengers per vehicle hour for the daytime and evening periods respectively.[1] The decrease is due to the implementation of several new dial-a-ride zones during late 1975 and early 1976. Some of these new zones, as expected, are currently experiencing lower than average ridership.

Cost per vehicle-mile, per vehicle-hour and per passenger were calculated for all AATA services. Since the same vehicles and staff provide all services, it is difficult to disaggregate costs by type of service. Table 6.7 summarizes the estimated fiscal year 1976 operating data for the AATA. The cost per passenger of $1.89 is somewhat higher than an earlier estimate made by AATA of $1.67. The operating deficit per passenger of $1.66 represents the non-fare box revenue required to just cover total operating costs. By subtracting the revenue from the property tax, it can be seen that the AATA must receive $.73 per passenger from other local, state, or Federal sources to cover operating costs.

Estimates of the operating cost per passenger for both dial-a-ride

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[1] See Guenther, Karl W., op. cit.

TABLE 6.5. WEEKDAY PRODUCTIVITIES (March 1976)

Data Item	Ann Arbor Line Bus	Dial-a-Ride	Total
Weekday vehicle hours[a]	165	414	579
Weekday first fare ridership	4,788[b]	1,916	6,704
Weekday total ridership (including transfers)	5,800	2,500	--
First fare passengers per vehicle-hour	29	4.6	11.6
Total passengers per vehicle-hour	35.2	6.0	--

[a]Based on the run sheets for March 1976. These figures include deadheading which is estimated to account for about 10 percent of total vehicle hours.

[b]The last two weeks in March had a fairly high line bus ridership (47,884). The following two two-week periods showed 39,280 and 33,728 respectively, with corresponding first-fare productivities of 23.5 and 20.14.

TABLE 6.6. ANNUAL PRODUCTIVITIES

Type of Service	Estimated Total for Fiscal Year 1976
AA Lines Weekday	
passenger trips	881,510
vehicle hours	41,647
productivity	21.2
AA DAR Weekday	
passenger trips	495,710
vehicle hours	88,179
productivity	5.6
AA Handicapped	
passenger trips	4,080
vehicle hours	5,546
productivity	.74
AA Weekend	
passenger trips	97,400
vehicle hours	15,801
productivity	6.2
AA School Subscription	
passenger trips	70,600
vehicle hours	3,728
productivity	18.9
Ypsilanti Line, AA-Ypsi	
passenger trips	265,600
vehicle hours	18,434
productivity	14.4
Total (not including charters)	
passenger trips	1,814,900
vehicle hours	173,335
productivity	10.5

TABLE 6.7 AATA OPERATING DATA

Data Category	System Total Fiscal Year 1976
Total Vehicle Miles[a]	2,184,000
Total Vehicle Hours[a]	173,335
Operating Cost (dollars)	3,440,162
Operating Revenue[b] (dollars)	3,121,140
Fare Box Revenue (dollars)	424,075
Total Passengers	1,814,600
Operating Cost/Vehicle Mile (dollars)	1.58
Operating Cost/Vehicle Hour (dollars)	19.85
Operating Cost/Passenger (dollars)	1.89
Revenue/Passenger (dollars)	0.23
Operating Deficit/Passenger (dollars)	1.66
Operating Cost/Operating Revenue (dollars)	1.10
Operating Cost/Fare Box Revenue (dollars)	8.11

[a]In-service vehicle miles and vehicle hours are about 10% less than total vehicle miles and vehicle hours due to deadheading.

[b]Includes Federal and state operating assistance grants.

and the Ann Arbor line buses can be obtained from the productivities reported earlier. Using the productivities of 6.0 and 35.2 passengers (including transfers) per vehicle hour for dial-a-ride and line bus respectively, calculated earlier in this section, and assuming the $19.85 cost per vehicle hour is the same for both dial-a-ride vans and line buses, the operating cost per passenger is $3.31 for dial-a-ride and $.56 for line buses.[1] These productivities include transfer passengers. Using the average trip length on dial-a-ride of 2.3 miles obtained from the onboard survey, the operating cost per dial-a-ride passenger mile is $1.44.

[1]The AATA assumes the operating costs of vans and line buses are the same for purposes of developing service hour budgets and for billing the communities which provide support for the Ypsilanti line buses.

7. FINDINGS AND CONCLUSIONS

7.1 FINDINGS

The AATA is operating an integrated dial-a-ride and fixed-route bus system which, with the implementation of the last dial-a-ride zone, is providing one hundred percent geographic coverage within Ann Arbor during all hours of system operation. Providing city-wide coverage was a major local objective of the Teltran system and it is still too early to determine if Teltran will have any success in meeting the second major local objective of reducing automobile ownership.

During weekday hours the Teltran system is composed of fourteen dial-a-ride zones and four fixed-route bus lines (three radial routes and a circumferential route). Transfers between line buses and dial-a-ride vans are coordinated and during peak hours the system uses 32 vans (12-passenger) and 22 transit coaches (varying in size from 28 to 53 passenger vehicles). During weekend and evening periods the system is composed of fewer and larger dial-a-ride zones with little, or no, fixed-route service.

While telephone associated delays have been a problem, major difficulties appear to have been overcome. Ninety-five percent of all calls are answered within three minutes (mean time is 1.12 minutes) and processed within 2.5 minutes, although this time varies greatly with the type of trip being requested.

For those callers requesting immediate service, the mean elapsed time (after completion of the phone call) before the vehicle has arrived is 22.9

minutes (with a standard deviation of 12.5 minutes). Interestingly, riders have perceived a significantly shorter wait time, perhaps because they can use the time effectively. Typically, the caller is provided with an estimated time of arrival (ETA) for the vehicle, usually a "window" of 10 to 15 minutes. Of those customers surveyed, 59 percent reported that their vehicle arrived "on time" (i.e., within the window).

Dial-a-ride in-vehicle time for daytime trips is found to average 9.5 minutes with a standard deviation of 6.6 minutes. Average dial-a-ride in-vehicle distance for daytime trips is 2.3 miles (with a standard deviation of 1.3 miles), implying an effective speed (including stops) of 14.6 miles per hour. During evening hours, when the service area is divided into fewer but larger zones, the mean travel time is 14.3 minutes.

Coordinated transfers from dial-a-ride vans to line buses or other vans have averaged 4.1 minutes for nonstanding order (i.e., non-regularly scheduled) trips, with 36 percent of the riders having no wait at all (i.e., the second vehicle is waiting when the van arrives). The transfer time for standing order customers, who dominate A.M. peak period travel, has averaged 5.4 minutes.

Because of the design of the Teltran system and the coordination of transfers between vans and line buses, many riders use both dial-a-ride and fixed-route service in making a trip. The survey (not including riders with a regularly scheduled trip) suggested that almost 70 percent of dial-a-ride trips involve at least one transfer. AATA computer report programs suggest that almost 90 percent of all dial-a-ride users make at least one transfer when standing order customers (regularly scheduled

trips) are included. From the survey, about 32 percent of dial-a-ride users originated their trip on fixed-route service.

In fiscal year 1976, the system carried 10.5 passengers per vehicle hour calculated on a first fare basis. With transfer passengers, the productivities were 35.2 passengers/vehicle hour for line buses and 6 passengers/vehicle hour for dial-a-ride. Operating costs per vehicle hour and vehicle mile (including deadheading) for the entire system were averaging $19.85 and $1.58 respectively. Of the total operating costs, 78 percent were for wages and fringe benefits (including management and administration), 8 percent were for vehicle operating costs, and the remainder were for fixed costs, of which the largest components were for planning and fleet insurance.

The operating cost per passenger was $1.89. With transfer passengers, the cost per passenger was 56¢ for line bus and $3.31 for dial-a-ride. The deficit per passenger was $1.66 of which 93¢ was covered by the millage tax. The rest of the deficit was funded primarily by both Federal and state operating assistance grants.

7.2 CONCLUSIONS

The implementation and operation of Teltran has been an evolving experiment in transportation innovation and the AATA's experience provides some valuable lessons for other communities considering major transit improvements.

7.2.1 Phased Implementation

A significant feature of Teltran implementation was the incremental expansion strategy adopted by the AATA to implement the system. In a

sense, this began with the pilot project demonstration which, while not identical to Teltran, provided the public with a taste of demand-responsive service and gave the AATA operating experience and feedback on the public's response. Once the Teltran plan was approved by the voters, implementation proceeded very slowly. Addition of new services was timed to allow adequate debugging of each operation before another was introduced. Furthermore, phased implementation permitted the time necessary to train new staff members as the need for additional personnel grew.

While no segment of the population was forced to pay a higher fare, some people did receive a lower level of service due to replacement of line bus routes with dial-a-ride service plus transfers. Both former line bus users who now had to use dial-a-ride and residents of the last zones to receive daytime dial-a-ride service voiced complaints during the implementation process. In some cases, line bus service was reinstituted on a temporary basis in response to complaints. In addition, the AATA has initiated additional fixed-route service in dial-a-ride zones generating high ridership and fully expects the Teltran system to continue to evolve in response to changing ridership patterns and levels.

One shortcoming of Teltran's growth plan was a serious underestimation of its need for telephone equipment and facilities. Since people place orders for service by telephone, a shortage of lines (with attendant busy signals for callers) can cause people to become disgruntled about the system. Teltran began with only three telephone lines on group hunt and the growth in demand quickly outstripped their capacity. Since the AATA had not reserved additional continguous lines, they were forced to

add lines accessed by another telephone number. Thus, two different telephone numbers were being used by the public to obtain the same service, resulting in some confusion. Proper planning (e.g., securing a reasonably large number of contiguous phone numbers at the outset) might have avoided this problem and suggests that incremental implementation in this area may have more disadvantages than advantages.

7.2.2 Public Information

Teltran is a relatively complicated service designed to be used by individuals without requiring a detailed understanding of how it is operated. In fact, AATA has been somewhat reluctant to publish much information on system operation, partly because it may restrict operating flexibility and partly because management believes the public may be confused by the details. However, the public in Ann Arbor has shown a clear desire to understand more about the workings of the system and the AATA is planning to develop a user's manual as well as expanding their program of audio-visual presentations.

In short, a system which is not "transparent" to users is very likely to generate requests for more information about system operation. Not providing detailed information or operating policies right from the start of implementation may have little effect on the public response to the service in the long run. However, because dial-a-ride service and coordinated transfers have some inherent variability associated with them, information on system operation may help gain public acceptance of the integrated service concept, particularly in the early stages of implementation.

Also, while during the initial stages of implementation the public was

willing to accept a minimum of signs and posted schedules at line bus stops and transfer points, as implementation proceeded, more and more complaints were received about inadequate signage at stops and on dial-a-ride vehicles. Thus, while a limited public information program might be possible, and desirable, during early stages of implementation, the need to increase public information as a new service becomes more established should be anticipated.

7.2.3 System Design and Performance

Several major design decisions have been greatly influenced by the operations and impacts of the Teltran system to date. First, the commitment to 100 percent coverage at all hours of system operation implies a tradeoff with other aspects of the level of service provided and particularly travel time. During weekday service hours, most trips require one transfer and many crosstown trips require two or more transfers. Also, while the system provides 100 percent coverage to the city, this does not imply equality in the level of service provided to different subareas or types of trips. In particular, trips to the CBD are served best while crosstown trips generally receive the worst service. The provision of door-to-door service has improved the mobility of many transit dependents but the reconfiguration in line bus routes that was desirable for providing integrated transit also lowered the level of service provided to some former fixed-route bus users.

To provide 100 percent coverage and maintain an effective vehicle utilization strategy during evening and weekend periods, major shifts in system configuration have been required. While the weekend and evening

systems are operated essentially like the dial-a-ride component of the weekday service, with little or no line bus service, the change in zone sizes requires that dispatchers and drivers adjust to different tour lengths and coverage patterns. To improve overall system productivity a shift to fewer and larger zones is probably desirable during off-peak daytime hours (e.g., 10AM to 3 PM) as well. However, anticipation of adverse public reaction has kept the AATA from introducing a midday shift in system configuration to date.

The coordination of transfers between line buses and dial-a-ride vans is designed to minimize the wait time required at transfer points. However, coordinated transfers increase the pressure on dispatchers and dial-a-ride van drivers to maintain fixed tour schedules and sometimes result in vans exceeding posted speed limits. Also, while the Teltran dispatching system requires only the transmittal of tour rosters to dial-a-ride vans, a substantial amount of driver-dispatcher communication is required to ensure successful coordination of transfers and to insert a new request for service into an ongoing tour.

The Teltran dispatching system is computer assisted but basically is a manual operation. The computer keeps track of the rides assigned to each tour, facilitates efficient tour editing, and provides some daily ridership statistics, but all decision-making functions are performed by call takers, dispatchers, and drivers. The AATA feels that a manual dispatching method is important for making adjustments in system operating policies and provides the flexibility for shifting system configurations during evening hours and weekends. The AATA also feels that the basic

dispatching method can be used on a greatly expanded service area without increasing the functions performed by the computer. While, in general, the dispatching system works well, it requires an experienced staff to operate smoothly and the level of service provided can vary depending on the quality of the dispatchers and drivers on duty.

The productivity achieved by the dial-a-ride component of the Teltran system (i.e., total passengers per vehicle hour) exceeds the productivity achieved by many "pure" dial-a-ride systems. However, since the fare for all trips is 25 cents, the operating deficit per passenger is relatively high. The majority of this deficit is offset by the local property tax revenues dedicated to transit.

7.3 IMPLICATIONS REGARDING TRANSFERABILITY

The Teltran system is a rather unique approach to the provision of public transportation. While specific operating policies may be a locally debated issue, there appears to be a growing concensus among the community that the system works, and that both dial-a-ride and fixed-route service have a role in providing transit to the city. Ann Arbor's experience with Teltran raises the question of whether a similar transit system could be implemented in other cities with similar results.

To some extent, Ann Arbor's experience with Teltran can be attributed to certain characteristics of the city which are typical of only a small number of communities. The average family income and the median years of education for both men and women are high. The tax base is strong and residents have traditionally been very involved in social issues and civic organizations. Strong support has been given to public transit in general

and specifically the Teltran system. There is no question that without local property tax support the Teltran concept would have to be revised and that a substantial decrease in service would occur.

The influence of the University of Michigan cannot be underestimated in explaining the local support given to public transit in Ann Arbor. There has been a significant amount of interaction among the AATA board and staff, the university community, and the staffs of various research and consulting firms in the area. Faculty members have served on the AATA board and students and former students have held a significant number of positions as drivers, dispatchers and call-takers. The availability of a pool of young, educated, and enthusiastic individuals to serve in many staff positions has created a work force dedicated to providing good transit service and is an important factor in the results achieved by Teltran, particularly in the early stages of implementation and innovation.

Another factor which contributes to making integrated service an effective choice for Ann Arbor is the existence of a limited number of major activity centers within the city. The central business district, adjacent to the main campus of the university, is the dominant center and a high percentage of peak hour trips are oriented toward the CBD. These trips are well served by Teltran's primarily radial fixed-route bus services. Fixed-route buses also directly serve the major shopping centers outside of the CBD. Although many-to-many service is available within each zone, dial-a-ride vans are used primarily for feeder service. With more dispersed trip patterns, more many-to-many service will be required and the

the integration of line and dial-a-ride vehicles may be harder to achieve. Furthermore, with more scattered trip patterns, there will be some advantage to large zone sizes to reduce transfers and this may adversely affect dial-a-ride productivity and travel time.

Notwithstanding these special characteristics of Ann Arbor, the AATA's experience with the Teltran system provides some important insights for other communities considering integrated transit. First, integrated dial-a-ride and fixed-route service with coordinated transfers provides an effective means of providing 100 percent coverage with door-to-door service. However, to maintain reasonable systemwide productivities will probably require shifting the system configuration during periods of low ridership. Naturally, other communities considering integrated transit may also choose to increase productivities by not providing 100 percent geographic coverage. Thus, areas yielding low ridership could be excluded from receiving dial-a-ride service during some, or all, hours of system operation.

Whether integrated transit is considered for areawide service or only for selected subareas, the Teltran dispatching system provides a very flexible dispatching method that could be used by other communities. In the early stages of implementation, dispatching can be completely manual as in the early phase of Teltran operation. As the system expands and experience is gained, computer assistance can be phased in without either changing the basic functions of call takers, dispatchers, and drivers, or disrupting system operation. The Teltran dispatching system does require well trained and experienced staff who are willing to accept major decision-

making responsibility.

The AATA's experience with the phased implementation of Teltran may also prove valuable to other communities considering integrated transit. In particular, incremental implementation allows for staff training and adjustments to operating policies before successively more complex system configurations are implemented. The Teltran experience also suggests that extensive telephone system planning is desirable and the phone requirements of the final system configuration should be anticipated even if an incremental implementation strategy is adopted. Also, the public acceptability of integrated transit may be increased if public information programs attempt to explain the operating policies used to provide a relatively complex service.

In summary, both the ridership and financial support given to Teltran may in part be attributed to the unique nature of Ann Arbor. However, since the University of Michigan operates its own internal transit system free of charge, much of Teltran's ridership and public support does come from individuals with no direct connection to the university. In considering integrated service, other communities may wish to consider applying the concept without a commitment to provide 100 percent coverage. Both the Teltran dispatching system and the AATA's approach to system implementation may prove useful to other communities studying the potential for integrated transit.

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APPENDIX A

Control Room Equipment Specifications

The Teltran control room, located at AATA headquarters in Ypsilanti, houses the following computer, telephone and radio equipment necessary for system operation:

1) A Data General, Nova 820 computer with 48,000 words of primary memory, two disk drives located in the console, two Tally Industries line printers, and a TTY Teletype for input of computer commands.

2) Nine dispatch (or call-taker) terminals equipped with one each of the following:

   a) a Cathode Ray Tube display by Ann Arbor Terminals, Inc.,
   b) a 30-button phone pad for all incoming lines,
   c) an intercom connecting all dispatch terminals,
   d) a microphone headset for either telephone or radio communications,
   e) a channel selector for accessing one of the radio channels,
   f) a digital clock, and
   g) a device which displays the telephone line which has been kept on hold the longest is scheduled to be installed at each terminal.

3) Automatic telephone answering and holding equipment designed specifically for AATA and consisting of:

   a) one Communications Unlimited, Inc. answering device capable of answering up to 10 telephone lines. It actually incorporates one answering machine per line so that any single failure affects only one line.

   b) one Panasonic 8-track tape player which provides music (following completion of message) for those lines answered by the Communications Unlimited device.

   c) one Nationwide Communications answering machine capable of handling up to 5 lines. This machine puts the caller into the middle of a repeating, pre-recorded message but stays on for the next complete cycle. This unit then supplies background music.

   d) a digital display board (custom made by Communications Unlimited) which indicates the length of time for which each line has been on hold.

4) Radio transmitting and receiving equipment consisting of the following:

   a) three radio stations providing 3 frequencies of UHF-type duplex pairs so that talk and receive can be accomplished simultaneously. One of the three channels is shared with a Detroit trucking firm and there is often some interference from their transmission.

   b) a 250 foot tower transmitter (located at AATA headquarters) broadcasting with an effective power of 5 watts. The tower provides 98% coverage of the AATA service area with 98% reliability of a successful first transmission.

The control room itself is 20 feet by 38 feet and is equipped with temperature and humidity controls. A glass enclosure around the computer equipment is currently under construction to eliminate static caused by passing personnel.

APPENDIX B

Teltran Call-Taking and Dispatching Displays

The following figures indicate the content and format of several major computer displays used in the Teltran Communications and Dispatching System.[1] The uses of these displays are detailed below:

Figure B.1: Trip Entry - The call-taker supplies the information requested in this display to obtain the list of three alternative tours to serve the present caller. Call-takers may then choose one of the tours.

Figure B.2: Tour Roster - The call-taker may decide to check the assignments to a particular tour before making a choice. The system gives the call-taker the opportunity to enter the present caller's request and assign an estimated pickup time if the tour is acceptable.

Figure B.3: Standing Order Entry - If the caller wishes to travel on a regular basis, the call-taker may arrange for the system to repeatedly enter the caller's trip in the proper tours without the need to call each trip in. The call-taker enters the request using this display.

Figure B.4: Advance Order Entry - The caller may wish to make one or more (non-repeating) trips on a future date. The call-taker uses this display to enter the request.

Figure B.5: Tour Roster Edit - A call-taker or dispatcher may wish to remove a trip from one tour and move it to another. This display indicates the tour roster and asks the call-taker which trips are to be shifted.

Figure B.6: Tour Roster Organize - The dispatcher must review tours before transmitting them (or releasing for transmission when digital equipment is introduced). This display provides the dispatcher with the opportunity to reorder, declare organized, and store or transmit the tour roster.

Figure B.7: Bus Status - This display will appear at the bottom of each dispatcher's screen (in addition to other displays) once the digital communications equipment is installed. The display, which will be updated automatically by the system, will indicate which vehicles are on or awaiting voice communications, as well as the operational status of particular vehicles in the fleet.

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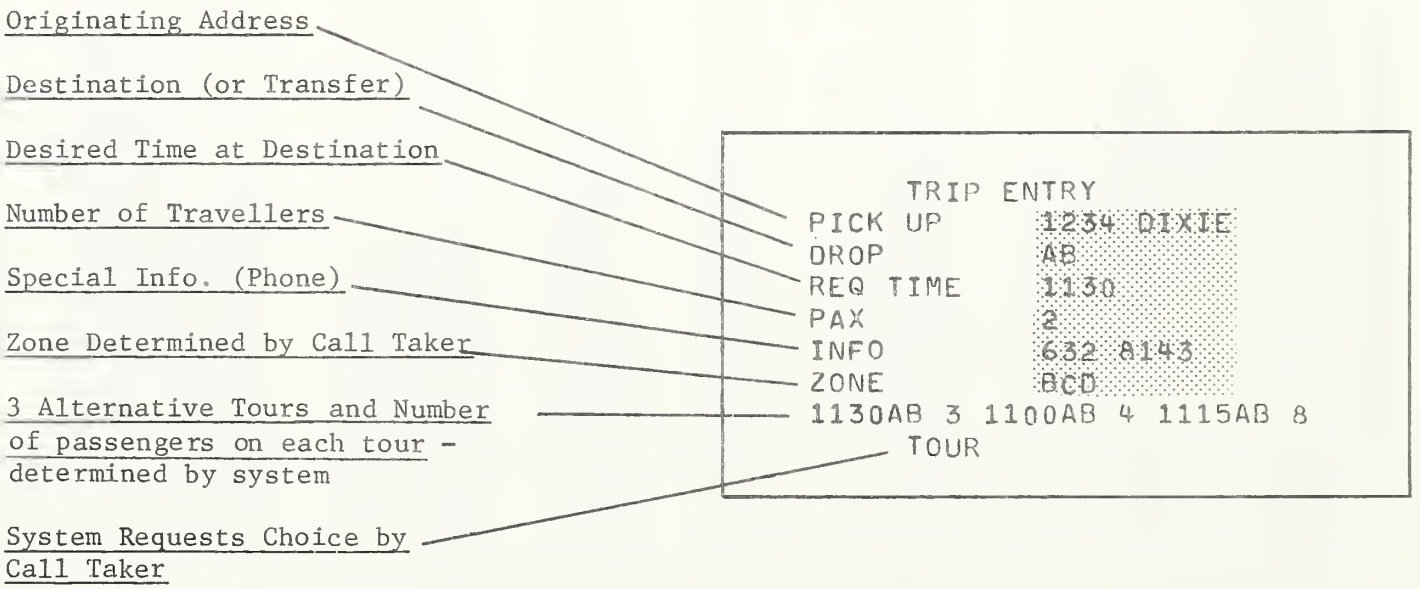
[1] Note: Dial-a-ride tours are identified by their departure time and their destination. Thus, Tour 0637 departs at 6:37 AM for transfer point PH (Pioneer High School).



Note: Shading indicates input keyed in by call-taker or dispatcher.

FIGURE B.1. TRIP ENTRY

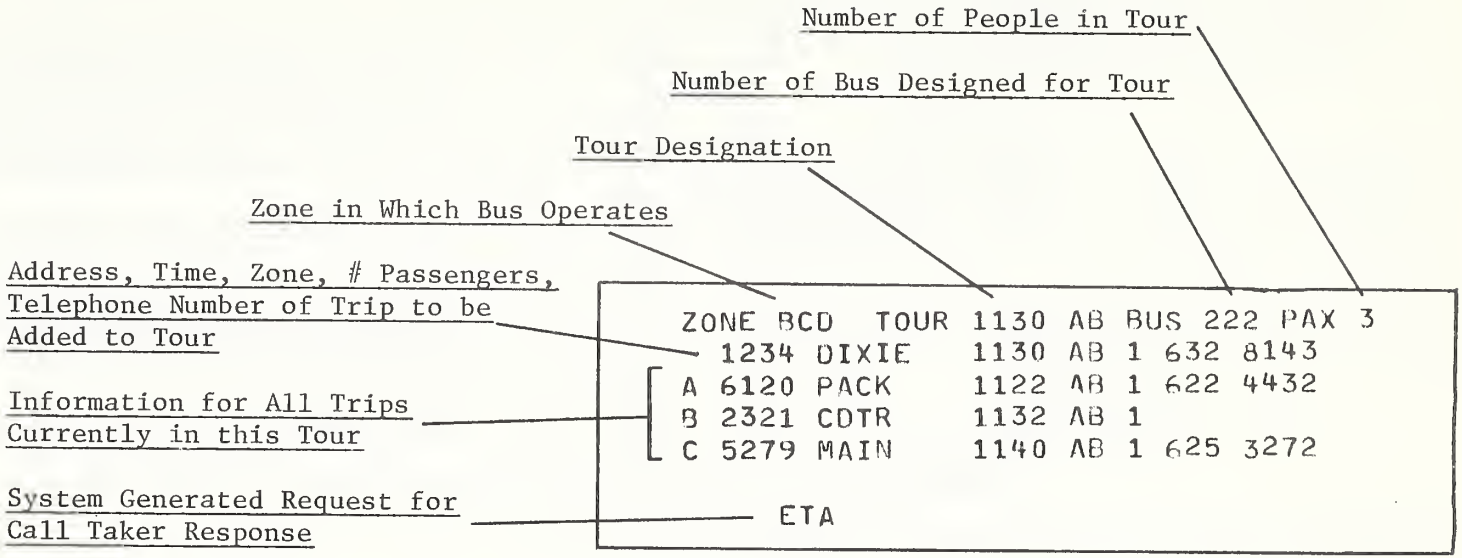
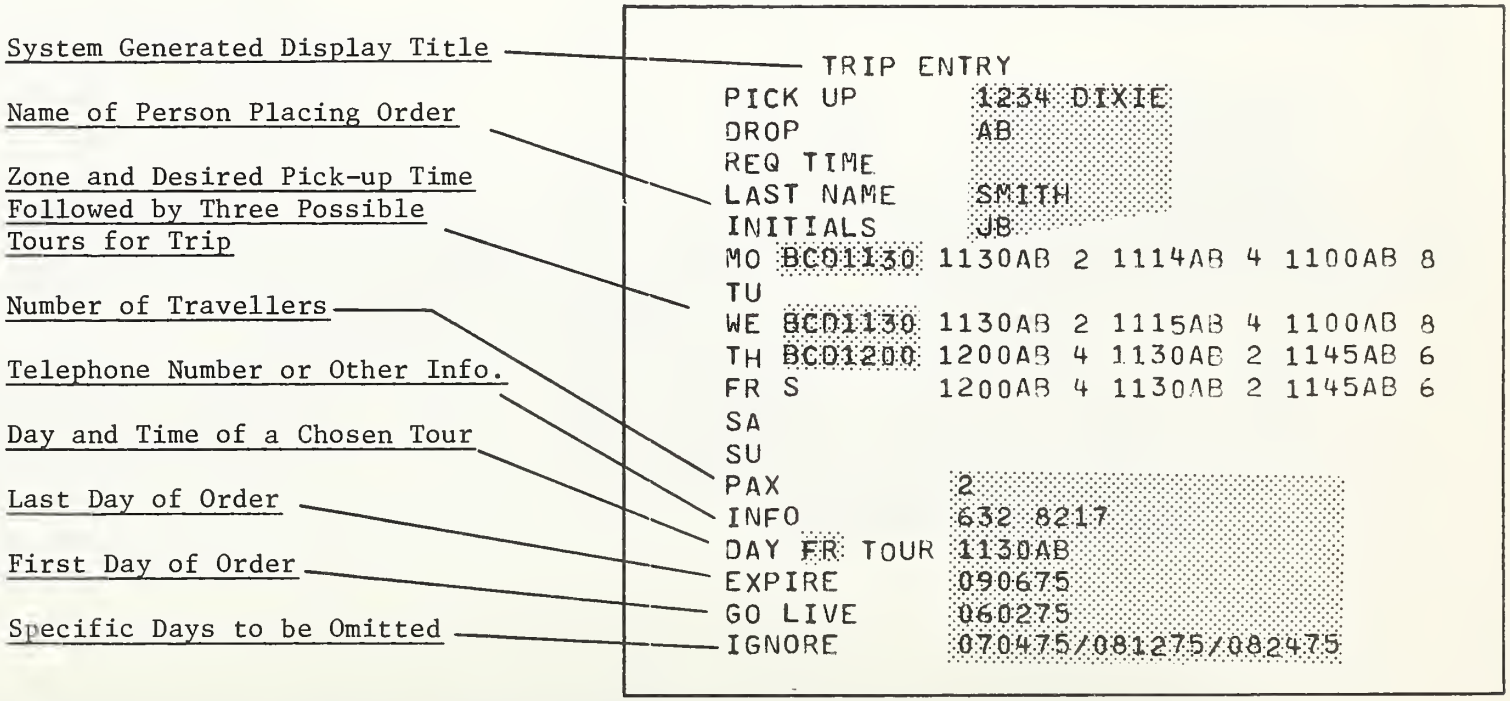
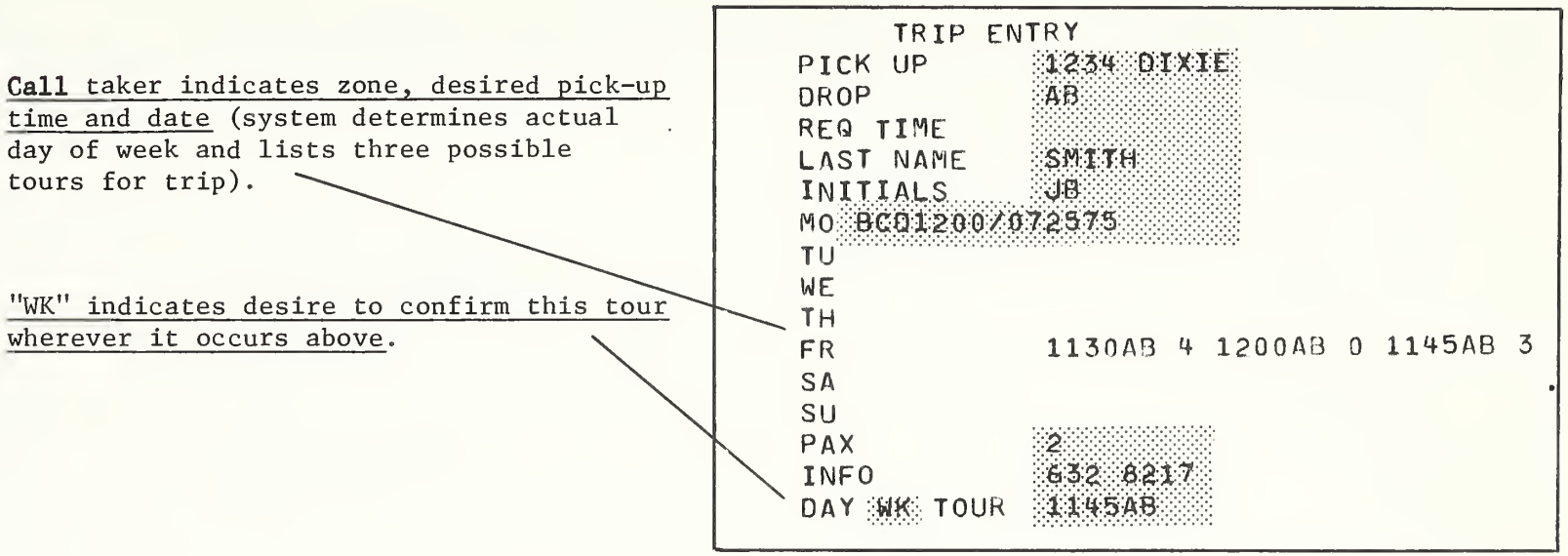


FIGURE B.2. TOUR ROSTER



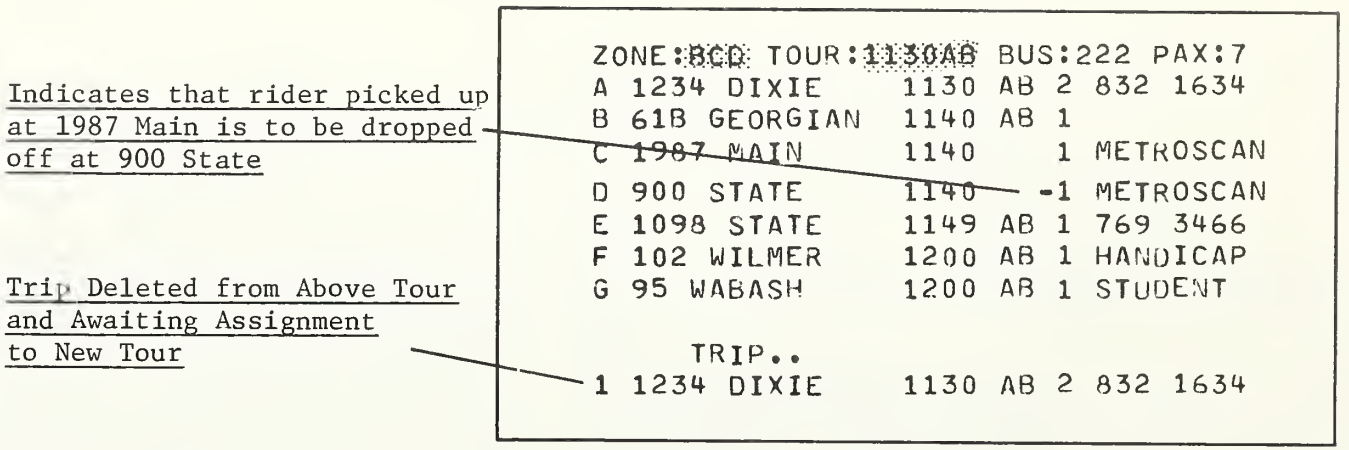
Note: Shading indicates input keyed in by call-taker or dispatcher.

FIGURE B.3. STANDING ORDER ENTRY



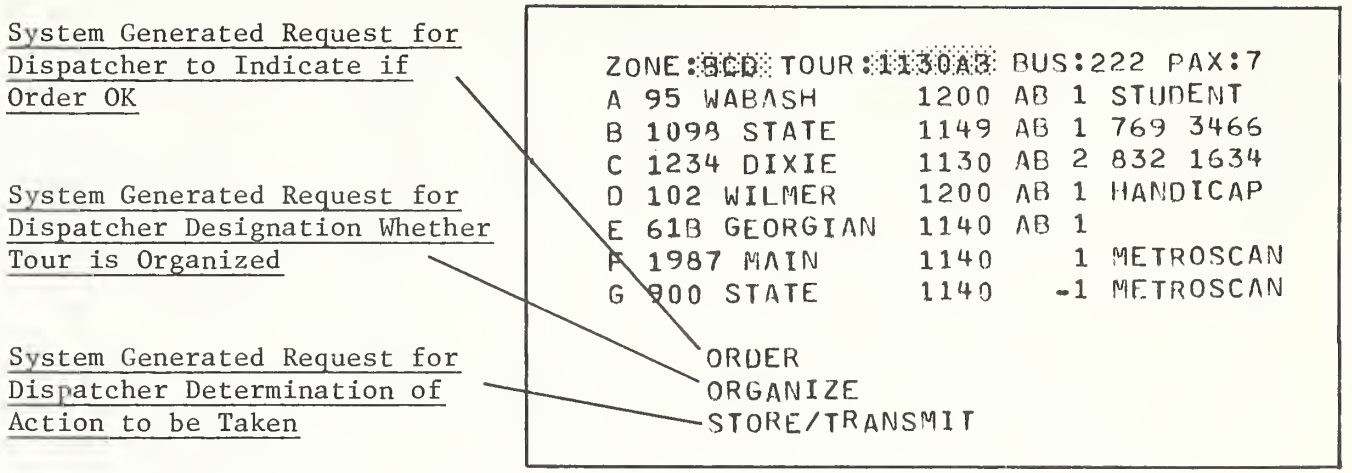
Note: Shading indicates input keyed in by call-taker or dispatcher.

FIGURE B.4. ADVANCE ORDER ENTRY



Note: Shading indicates input keyed in by call-taker or dispatcher

FIGURE B.5. TOUR ROSTER EDIT



Note: Shading indicates input keyed in by call-taker or dispatcher

FIGURE B.6. TOUR ROSTER ORGANIZE

Indicates Dispatcher 2 communicating with Bus 111, Dispatcher 3 communicating with Bus 456; All numbers to right indicate buses awaiting voice communication and channel, in order of entry to queue.

Bus Numbers alternately followed by code indicating such information as:
- Ready for Next Tour
- No Show
- Request for Repeated Message
- Etc.

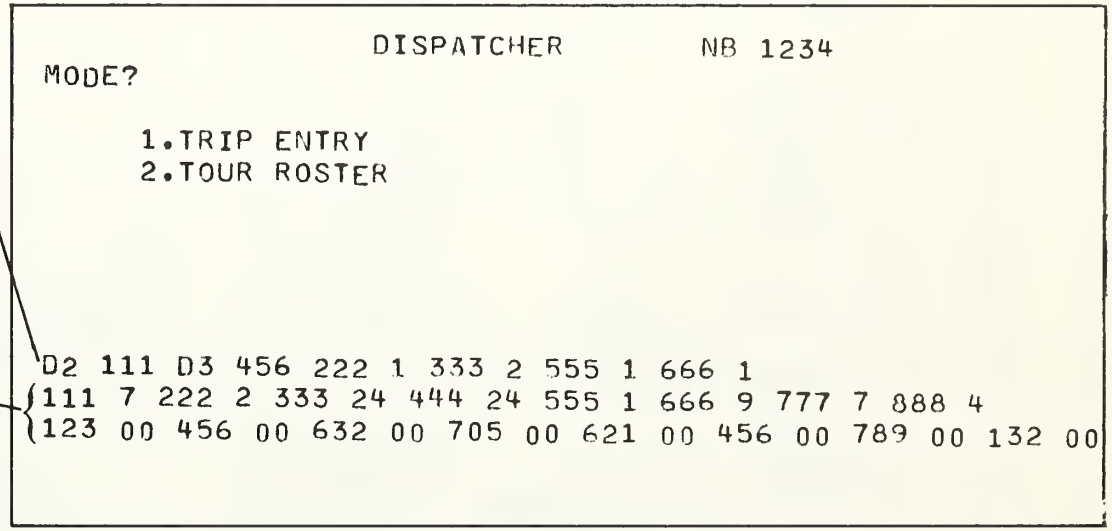


FIGURE B.7. BUS STATUS

APPENDIX C

Travel Time and Telephone Service Surveys

The need for new information on the travel times and phone service times provided by the Teltran system became apparent very early in the Ann Arbor evaluation effort. Previous surveys have been performed in March 1975, prior to the establishment of daytime dial-a-ride service in many areas of the City. Thus, a limited data collection effort was authorized and two travel time surveys were performed to collect wait, ride, and transfer time data on the present Teltran system. In addition, telephone service data was collected both from riders and from dispatch room observations.

Ideally, the surveys would have collected travel time data for an individual's entire trip on Teltran including both dial-a-ride and line bus segments if a transfer(s) was made. However, time and resource constraints did not allow such a data collection effort and the surveys focussed, for the most part, on the daytime dial-a-ride service. An onboard survey was conducted on dial-a-ride vans and provided information on perceived telephone service and perceived wait time and response times, as well as actual response, in-vehicle, and transfer times. A mail-out survey of customers with daily, regularly scheduled, standing orders provided some information on total trip times and the reliability of dial-a-ride pickup times. Data collected in the dispatching control room included actual telephone service and hold times. The design, execution, and data processing for each of these surveys is discussed below.

C.1 ONBOARD SURVEY

C.1.1 Survey Design and Pretest

For the dial-a-ride portion of a trip, the following time components were measured by an onboard survey:

1) call-in riders picked up at origin:

   a) type of call, immediate or advanced order,
   b) number of busy signals encountered when making service call,
   c) length of time on hold,
   d) response time, or time from end of call to pickup,
   e) wait or early time,
   f) ride time,
   g) transfer time to line bus, if any,
   h) distance travelled on dial-a-ride, and
   i) number and pattern of transfers.

2) riders not calling for ride or "walk-ons"

   a) wait time for dial-a-ride van,
   b) ride time and distance, and
   c) transfer information.

The questionnaire used for this survey is shown in Figure C.1. The actual survey form was a 6" x 9" card printed on one side only. It contained 12 short questions most of which required checking a box or writing a line. The card was stiff enough to allow riders to write on them using felt-tipped pens without needing a book, clipboard, etc., for backing.

The first two questions provide information on the trip origin and final destination (e.g., not the transfer point if a transfer is made). Using the origin and destination information, together with questions 3 and 4, it was possible to identify the number and pattern (e.g., dial-a-ride van to line bus versus van to van, etc.) of transfers made. Question 5 separated phone in riders from walk-ons and transfers from line

HELLO THERE!! IN EXCHANGE FOR A FEW MINUTES OF YOUR TIME, WOULD YOU HELP THE ANN ARBOR TRANSPORTATION AUTHORITY IMPROVE ITS BUS SERVICE TO YOU? YOUR COOPERATION IS GREATLY APPRECIATED.

1. Where did you begin this trip?

_____
(specify address, building, store, etc)

2. What is your final destination?

_____
(specify address, building, store, etc)

3. How many vehicles (city buses plus Dial-a-Ride vans) are you riding on this trip?

☐ one ☐ two ☐ three ☐ four

4. What is the next vehicle you will ride on this trip? (check one)

☐ a city bus
☐ another Dial-a-Ride van
☐ none -- this van will drop me at my destination.

5. If you telephoned for this ride, check here ☐ and answer questions 7 through 12.
If you did not telephone for this ride, check here ☐ and answer question 6 only.

6. How long did you wait for this van to come by?

☐ 0-5 minutes ☐ 10-15 minutes ☐ 20-25 minutes ☐ 30 minutes or more
☐ 5-10 minutes ☐ 15-20 minutes ☐ 25-30 minutes

PLEASE RETURN THIS CARD WHEN YOU EXIT THE VAN. THANK YOU FOR YOUR COOPERATION!!

7. At what time did you place your telephone call to Dial-a-Ride? _____ AM / PM

8. How many times did you get a "busy" signal before you got your call through?

☐ none ☐ once ☐ twice ☐ three or more times

9. How long did you wait on "hold" for a call-taker to answer you?

☐ 0-1 minute ☐ 2-3 minutes ☐ 4 minutes or more
☐ 1-2 minutes ☐ 3-4 minutes

10. When you called in to request Dial-a-Ride service, did you call --

A. ☐ for immediate pickup.
B. ☐ for pickup at a later time. If so, what was that time? _____ AM / PM

11. What time did the call-taker tell you the van would pick you up?

Between _____ and _____ AM / PM

12. Answer only if you marked A in question 10: How long was it from the end of your call to the arrival of the van?

☐ 0-5 minutes ☐ 10-15 minutes ☐ 20-25 minutes ☐ 30 minutes or more
☐ 5-10 minutes ☐ 15-20 minutes ☐ 25-30 minutes

PLEASE RETURN THIS CARD TO THE SURVEYOR WHEN YOU EXIT THE VAN. THANKS VERY MUCH !!!

FIGURE C.1. ONBOARD SURVEY CARD

buses. The latter two groups were asked for their wait time in question 6, while phone-in riders were asked for dial-a-ride phone and wait time information in questions 7 to 12. Question 10 identified riders wanting immediate pickup versus those making trip reservations in advance. Question 12, requesting information on response time, was asked only of riders who wanted immediate service since for advance orders this time can be arbitrarily large.

Actual ride and transfer time was obtained by surveyors who recorded each rider's boarding and deboarding time on a separate form. When a passenger made a transfer from a dial-a-ride van to a line bus, the passenger's wait time for line bus also was observed by recording the arrival time at the transfer point (in general, riders remain on the van until the line bus arrives so that deboard time minus transfer point time is the transfer wait time). The distance travelled also was recorded by the surveyor for each rider by observing odometer readings, when driver cooperation permitted. An average "speed" on dial-a-ride could thus be computed.

Wait and early time was obtained by taking the difference between the observed boarding time and the beginning of the estimated time of arrival window quoted by the call-taker (question 11). Often a point estimate rather than an interval or window was quoted and in these cases the point time was used as the start of the waiting period. Call takers do not record the actual ETA's quoted and thus there was no way to check the accuracy of the riders' responses.

Response time, a measure of how fast a van comes after the call

placement for immediate pickup, was collected in two ways. Perceived response time was asked in question 12. Actual response time was obtained from the difference between observed boarding time and the end-of-call time as recorded on the computer log. The survey forms were matched to the log by using question 1, trip origin, and question 7, time of call placement, as identifiers. The log time is recorded when the order is entered into the computer system which generally occurs just after the call is complete.

After several revisions based on discussions with Authority staff, an initial onboard survey was tested in two zones on March 22 and 23, 1976. The respondents were very willing to offer suggestions and to point out areas of confusion on the survey form and the pretest proved to be extremely helpful in reworking questions more clearly.

C.1.2 Survey Procedure

During the week of April 5 to 9 1976, 6 individuals conducted the survey aboard dial-a-ride vans. Scheduling surveyors to specific vans and zones was done to maximize the number of responses and to approximate the distribution of responses over zones to the actual ridership over zones. The schedule was developed by using tour rosters for a previous week which contained each vehicle tour by zone and the number of phone-in and standing order passengers. While tour rosters do not indicate the walk-ons, they do provide the information about which vehicles and tours are not efficient to survey. In some zones, the average rider-

ship per van was very low, even though total demand in the zone was relatively high. Some vehicle tours carry higher loads than others in a given zone and where possible these vans were chosen for the survey. Nearly all surveying was done between the hours of 7:00 AM and 6:30 PM corresponding to weekday service. One run of evening service was surveyed from 7:00 PM to 11:00 PM.

Each boarding passenger was asked whether their current trip was a standing order. If the trip was not a standing order, the rider was asked to fill out a questionnaire. Thus, phone-in, walk-on and transferring riders were surveyed. Standing orders were surveyed in the separate mail-out survey. Those people who refused to fill out the form, children too young, or people unable for any reason to complete the survey form were sometimes asked the questions orally with the surveyor filling in the card.

The surveyor recorded boarding, deboarding and arrival at transfer point times on a separate sheet for everyone who rode the van. Usually good driver cooperation permitted the surveyor to record odometer readings at each stop to obtain each rider's trip distance and the overall tour distance. Except when the vehicle was full (12-14 riders), all information was gathered with ease by the surveyors. However, on full runs it was often difficult to record mileage. Boarding and deboarding time and mileage was recorded even if a rider did not fill out the questionnaire. This was intended to enrich the sample for average ride time and distance.

Cooperation from the drivers in survey administration was excellent. They helped the surveyors locate their vehicles, occasionally went out

of their way to drop or pickup a surveyor at a special place, and suggested other vans and tours that would carry heavier ridership. Although the surveyors were instructed not to solicit opinions from the drivers concerning the Teltran system, many comments were volunteered. The riders also gladly provided their opinions to the surveyors. Both of these inputs provided non-quantitative, but useful perspectives on the system and its operation.

C.1.3 Response Rate

The total number of useful responses over the week was 776. An additional 485 riders who either refused the questionnaire or were making a standing order trip were observed for ride and transfer time. Of those who responded, 53% had telephoned for their rides and 47% were walk-ons. Of the 414 respondents who phoned in, 60% requested immediate pickup, while 40% requested pickup at a later time.

All dial-a-ride zones were surveyed and Table C.1 compares the distribution of ridership to the distribution of survey response by zone. Although the response distribution only approximates the ridership distribution, the latter does not include riders who walked on at transfer points without calling, while the former includes walk-ons. Except for over-surveying in Pontiac Heights, the surveyors were deployed roughly proportionately to ridership by zone.

C.1.4 Data Reduction

The survey forms were coded along with the zone of observation, observed boarding and deboarding times and odometer readings, and the actual

TABLE C.1. DISTRIBUTION OF ONBOARD RESPONSES BY DIAL-A-RIDE ZONE

Zone	Percent Ridership	Percent of Responses
Pontiac Heights	14	30
Near Southwest	19	15
Far Southwest	12	18
Far Southeast	11	10
Near Northeast	10	5
Miller	7	1
Packard	5	1
Plymouth	12	14
Medford	4	2
Far Northwest	1	2
Near Northwest	5	2
Total	100	100

time of call from the computer log for respondents who telephoned for pickup. This data set was then processed through four FORTRAN programs which calculated the following groups of statistics:

a) Transfers and number/types of vehicles used on each trip tabulated by zone; call-ins vs. walk-ons by zone; immediate vs. advanced pickup by zone.

b) Average in-vehicle time, transfer waiting time, average trip length and speed on dial-a-ride portion of trip for each respondent tabulated by four time periods (AM peak, mid-day, PM peak, night).

c) Same as b) tabulated by zone.

d) Perceived wait time (for dial-a-ride walk-on respondents) tabulated by zone and time period; busy signals and telephone hold time (perceived) by time of day; wait and early times for telephone respondents; percent arrivals on time, early or late by zone and time of day for telephone respondents; actual and perceived response time for immediate pickup telephone respondents.

The statistics in b) and c) above were computed on the total observed sample. This included all riders, regardless of whether they agreed to fill out a questionnaire or not, or were making a standing order trip. Because it was not always possible to record odometer readings, the trip length statistic includes only observations where mileage was recorded. The mean value and standard deviation about the mean were calculated for each variable by zone and time period, where applicable. The speed statistic is only an indication of route circuity on the dial-a-ride portion of each trip. It was calculated by dividing dial-a-ride in-vehicle time, excluding transfer time.

For wait time and telephone call statistics some respondents again randomly left questions unanswered. Systemwide statistics are based upon the total valid responses for each question and corresponding variable. Because respondents were asked to check ranges of wait times, only dis-

crete distributions were available.

Wait and early time for immediate pickup calls were calculated as the difference between the observed boarding time and the estimated time of arrival (ETA) given by the call-taker. If the respondent recorded a promised pickup "window," wait time was calculated from the beginning of the window. If board time was earlier than the beginning of the window, early time was calculated as the difference between the beginning of the window and the board time. Zero wait time responses were included in the wait time, but not early time, statistics. If the respondent reported only a single promised time, the wait time is the difference between it and the board time. If the respondent reported a promised time as "in 5 minutes," this was added to the time of call placement as recorded in the computer log to get an ETA window. If no promised time was reported, no wait/early time was calculated for that observation.

Actual response time was calculated as the interval between the end of the call for service and the actual boarding time. The latter was obtained from the computer log of daily calls. Many responses could not be matched to the log because of inadequate recording of either trip origin or the time of call placement. In addition, some calls never are logged into the computer if they occur close to the time that a van actually picks up the respondent. Because of a computer crash, one day's log was not available, and another day's log was not located by AATA staff. Actual and perceived response time was tabulated only if the computer log time was matched and the respondent answered question 12 on perceived response time. For the comparison of actual and perceived response time there were some errors in clock synchronization. It is estimated that

the surveyors' watches were not more than ± 3 minutes from the computer log clock, but part of the variance in response time can be attributable to clock error. For wait, in-vehicle and transfer times, this error is irrelevant because the calculation of these times was dependent only on the surveyor's clock.

A few respondents rode two dial-a-ride vehicles on one trip and were surveyed on the second van. Most of these people incorrectly filled out the survey form for the first van and not for the one they were riding while being surveyed. Since the telephone information concerning the earlier ride does not match the observed times of the ride being surveyed, questions 7 to 12 were ignored and the response treated as a walk-on for these respondents.

C.1.5 Assessment of Survey Procedure

Overall, the onboard survey produced the desired data and statistics. However, in spite of numerous revisions, the questionnaire could still have been improved to clarify some questions. Although it was intended that the survey concern itself with the current one-way origin-to-destination trip, some respondents replied in terms of a round trip, or part of a trip. Usually these errors could be corrected since origin and destination were specified. Reported transfer information, along with system maps, were used to verify the exact number of type and vehicles used on a trip. A statement on the questionnaire concerning the definition of a trip could have been added.

Since there were eight possible types of trips (i.e., the sequence of vehicles used), they were not enumerated on the form because of length and

confusion. Questions 3 and 4, which asked the number of vehicles ridden and the type of vehicle the respondent rode next, did not distinguish among all eight trip types, but with the origin and destination information from questions 1 and 2, any ambiguities could be clarified. A more suitable question structure concerning transfers was attempted in the design but enumeration may have been adequate.

For advance telephone order respondents, question 11-B was intended to show for what time the person requested later pickup. Most respondents repeated the promised pickup window for this question, which was the closest time the system could accomodate the request. The question could have been worded more clearly.

The riders themselves were very cooperative in filling out the card and very few people refused. Many riders viewed the survey as an opportunity to provide input to AATA management. Although no space was designated for comments, about 25% of the respondents wrote comments on the back or in margins. The opportunity to comment added an incentive to filling out the card. Toward the end of the week, however, some riders had filled out the form 3 or 4 times and the refusal rate increased as the week progressed. As a result, the productivity of each surveyor decreased sharply on the fourth and fifth days. If possible, it would have been better to have surveyed on more vans for fewer days, capturing a greater number of different riders. The questions on origin and destination (1 and 2) took the longest to fill out and some riders did complain about the size of the print on the cards.

The weather during the survey was warm and clear. Only one serious computer crash occurred. Therefore, ridership was lighter than usual and service better than average. Ideally, it would have been better to include a rainy day(s) and day(s) during winter when more service problems occur and ridership is higher.

C.2 STANDING ORDER SURVEY

C.2.1 Survey Design

Unlike the onboard survey, the standing order survey was intended to measure the variability and duration of the same trip over 5 days for each respondent. The form asked respondents to record boarding and deboarding times for each vehicle ridden for each day of the week that the standing order was made. Thus, as many as five observations of the same trip could be obtained. Some consideration was given to increasing the length of the diary to 2 to 3 weeks to improve the validity of the statistics computed. However, it was felt that the response rate to even a one week survey would be quite low and any increase in the duration of the survey might be counterproductive.

A cover letter, instruction sheet and 6" x 9" survey card were sent to standing order customers making daily trips (see Figures C.2 and C.3). The survey form was a mail-back card with postage pre-paid. The instructions urged strongly that the rider carry a watch and the card with him or her and the card was folded in half for convenience. This was intended to yield accurate time recording as opposed to recollection or perception of times. Specific times of occurrence were asked instead of time intervals in order to avoid rider "guessing" at the time

STANDING ORDER TRAVEL TIME SURVEY

APRIL 5 - APRIL 9, 1976

1. What is the final destination of your pre-scheduled transit trip? (check one)

Downtown/State Street	Main Street/4th and William
Pioneer High	Westgate
Plymouth Mall	St. Joseph's Hospital
Briarwood	Veteran's Hospital
Arborland	Maple Village
Huron High	University/Union Area
University Hospital	University/Church & Geddes
	University/North Campus

Other _____
(specify address; nearest cross streets; building)

2. Do you make a transfer on this trip? (check one)

YES - to another Dial-a-Ride van

YES - to a city bus

NO

3. At what time are you scheduled to be picked up each day? _____

4. How long a walk, if any, it it from your last bus stop to your final destination? _____minutes

5. For each trip you make going to your destination, please fill in your pickup and drop off times. If no trip is made on a given day, leave that day's line blank.

DAY OF WEEK	DIAL-A-RIDE VAN		2nd VEHICLE IF YOU TRANSFER	
	time you were picked up	time your van arrived at destination or transfer point	time you on 2nd vehicle	time you got off 2nd vehicle
EXAMPLE	9:14 AM	9:37 AM	9:41 AM	9:56 AM
MONDAY				
TUESDAY				
WEDNESDAY				
THURDSAY				
FRIDAY				

Please promptly mail this card free of charge after completing your last trip of the week.

THANK YOU!!!

FIGURE C.2. STANDING ORDER SURVEY CARD

We are interested in just how long it takes for you to ride, wait and transfer on your prescheduled transit trips during next week, April 5 through April 9, 1976. (If you have cancelled your daily reservation, please ignore all questions, write "CANCELLED" across card, and mail it free of charge.) All information requested refers to your prescheduled trip from home (or other starting point) to the place you are going each day of the week. Refer to the card as you read:

Question 1: Check the one box which best describes the ultimate destination of your daily trip. If it is not listed, please write in the address, building, nearest two cross streets, etc. in the space entitled "OTHER".

Question 2: Check whether you make a transfer to either a line bus or to another Dial-a-Ride van, or make no transfers at all.

Question 3: Mark the time of day that you are scheduled to be picked up each day.

Question 4: Mark how long a walk you have from the point where the last transit vehicle drops you off to the doorstep of your ultimate destination. Mark "0" if the vehicle drops you off at the doorstep of your destination.

Question 5: One line for each day of next week is provided for you to mark the time of day when the Dial-a-Ride van picks you up and the time it arrives at your destination, or transfer point, if you transfer to another vehicle.

If you do make a transfer, fill in the times that you got on and got off the second vehicle in the spaces provided under the heading "2ND VEHICLE IF YOU TRANSFER". If you make no transfer, leave these spaces blank. An example is provided.

It would be most helpful to carry a watch and the card with you on your pre-arranged trips next week. This will make it easy for you to jot down your daily pickup and dropoff times as they occur. If you do not have a watch, it is best you not participate in this survey. If you forget to mark your times or bring a watch one day, leave that day blank in Question 5. Please do not guess at the times.

After recording all the times for the week, please staple and fold the card and mail it free of charge promptly. Or if you prefer, you can leave it with your Dial-a-Ride driver the following week. All information you provide will be held strictly confidential, and no names or personal information will be used.

WE GREATLY APPRECIATE YOUR TIME AND EFFORT. ONCE AGAIN, THANK YOU!!!

FIGURE C.3. INSTRUCTIONS FOR FILLING OUT CARD

intervals and to encourage the use of a watch. Riders without watches were urged not to participate.

The same transfer information was obtained as in the onboard survey. In addition, the 15 most heavily used destinations, provided by the AATA, were listed for respondents to check.

Because of time constraints, it was not possible to pretest the mail-out survey. Suggestions were given by AATA staff for clarifying the instructions and the survey card itself was fairly short and straightforward.

C.2.2 Survey Procedure

The survey materials were mailed out a week in advance to all daily standing order customers. AATA records provided the names and addresses. During the week of April 5 to 9, the same week as the onboard survey, the respondents filled in their boarding and deboarding times on their pre-scheduled daily trip. The cards were mailed to the AATA free of charge to the rider and were collected by an AATA staff member at the Ypsilanti Post Office.

C.2.3 Response Rate

Of 266 riders who were sent the standing order survey, 65 usable responses, each with up to 5 trip records were obtained. Of the total number of forms mailed, 17 were returned either undelivered or because the trip order had subsequently been cancelled, yielding a response rate of 26%. Although not enough responses were obtained to compute good statistically reliable averages, it was a larger response than anticipated in light of the diary aspect of the questionnaire.

Of those who responded, there was no apparent confusion in the survey procedure. People who rode 3 vehicles made space on the form to report times for the third vehicle, although it was not asked. A few people kept track of both AM and PM standing order trips they made. A majority of the responses (82%) were concentrated in three zones, Near and Far Southwest and Plymouth.

C.2.4 Data Reduction

Unlike the onboard survey, the standing order form provided information on total trip time, including in-vehicle transfer and walk times for the same trip over a one week period. The following variables were tabulated:

a) transfers and number/type of vehicles used tabulated by zone of origin,

b) distribution of the most common destinations; distribution of trips by time period, and

c) average total trip time by number of transfers; variation in pickup time; average transfer wait time.

Although the sample of standing orders included only individuals who made 5 trips per week, not every respondent rode or filled out the forms each day. If a respondent reported boarding and deboarding times for only part of his or her total one-way trip, total time was not computed. The average total trip for each trip recorded was calculated, as well as the average trip time for trips involving 0, 1, or 2 transfers.

Variation in pickup time was computed only for respondents reporting 4 or more trips. The variance about the mean pickup time was computed, then averaged over all valid respondents for this variable. This variance has a rather low statistical confidence since there are a maxi-

mum of 5 observations per individual.

C.2.5 Assessment of Survey Procedure

Although the response rate was expected to be quite low because it was both mail-back and time-consuming, the actual response rate was surprisingly high. No apparent misunderstanding of instructions occurred, except for a few who completed it by filling in the same times for each day before the actual week of the survey. The enthusiasm and high educational level of Ann Arbor residents probably accounts for this unusual cooperation. It may well have failed altogether in another location.

If more resources and time had been available, total trip time data could have been gathered in a better way by conducting surveys on line buses and dial-a-ride simultaneously. Similarly, better data on the reliability of the service provided for one individual's daily trip could have been generated by lengthening the duration of the trip diary and using telephone contact to try to increase the response rate.

C.3 DISPATCH ROOM SURVEYS

Both phone hold and service times were observed directly in the dispatch room. The method of data collection was the observation of the hold time board in the dispatch room. This device has a digital timer, indicating in tenths of minutes for each of the first ten lines. The last five lines were calibrated in units of 16 seconds and were therefore not readily usable. However, being at the low end of the line group hunt, they were seldom busy. Observations were made by having one person watch the line with the longest hold time until it was answered. The counter on the

first ten lines was randomly malfunctioning, but erroneous observations were easily detected and discarded. There is a .3 minute recorded message played for every call regardless of whether a call-taker is immediately available. Although some of the counters began after the message and some before, all data was corrected to include the message time.

Phone service times were observed by one individual using a stop watch to time calls and randomly observing 7 different call-takers.

For the hold time survey, time allowed for only one observation of the AM peak, mid-day and PM peak periods. The call-takers were aware of the surveyor's presence which may have provided an incentive for answering waiting calls faster than usual. It was unavoidable, however, because the hold time read-out board was located in the dispatch room. The presence of the surveyor in the processing survey made no difference because length of call was dependent on the person calling for service, his or her request and the system status. Again, it would have been desirable to have had more periods of observation. Dispatch room personnel were very cooperative during both surveys.

APPENDIX D

Vehicle Utilization, Maintenance, and Accident Data

There are 80 vehicles in the AATA transit fleet; 48 vans for dial-a-ride service and 32 buses for fixed-route service. Table D.1 summarizes the utilization of various segments of the fleet in terms of average monthly vehicle-miles travelled. It is evident that newer vehicles are being used to a greater extent and that dial-a-ride vans are experiencing greater monthly mileage than are line buses. According to AATA estimates, average fleet availability is in the vicinity of 92-94%. The use of spare vehicles in the event of breakdowns has enabled service levels to be maintained and kept delays to a minimum.

The frequency of road calls and total repairs is summarized in Table D.2. As might be expected, newer vehicles, particularly among the vans, break down less frequently and require fewer repairs. In addition, the bus fleet appears less reliable than the van fleet partly due to the fact that the van fleet is newer.

Table D.3 shows the distribution of repair types for the van and bus fleets. The figures reveal that the average number of repairs per vehicle for the year to date, regardless of type, was approximately the same for the van fleet (35.2) and the bus fleet (34). Vans required more repairs to the electrical system, steering mechanism and propeller shaft, while buses required more repairs to the cooling system, clutch, brakes, and engine.

An AATA study of accidents which occurred in 1974 revealed that there were 142 total accidents during the year. The results are summarized in Figures D.1 and D.2. The greatest proportions of accidents occurred during the winter and during peak hours. Neither result is surprising given Ann Arbor's winter weather and the higher utilization of transit vehicles and higher traffic volumes during the peak periods. The accident rate was somewhat higher for vans (.135 per thousand vehicle-miles) than for buses (.101 per thousand vehicle-mile). The difference in rates is probably due to the different type of driving required for dial-a-ride including many turns, frequent backing up required, the use of small streets, and bursts of higher speeds while trying to keep to tour schedule. Also, as a result of the bid process, less experienced drivers are often assigned to "extra" vans on the dial-a-ride system.

TABLE D.1. VEHICLE UTILIZATION (February 1976)

FLEET CLASS	Number of Vehicles	Total Miles	Average Miles/ Vehicle/Month
1 (1973)	4	3,440	860
2 (1974)	10	11,755	1,176
3 (1975)	30	45,288	1,510
ALL VANS	44	60,483	1,375
4 (1970)	5	7,541	1,508
5 (1970)	7	3,447	492
6 (1966)	2	1,387	694
7 (1970)	4	4,667	1,167
8 (1974)	11	18,925	1,720
9 (1969)	3	1,087	362
ALL TRANSIT BUSES	32	37,054	1,158

TABLE D.2. ROAD CALLS AND REPAIRS (Year to date, March, 1976)

FLEET CLASS	# Road Calls/1000 Vehicle-Miles	# Repairs/1000 Vehicle-Miles
VANS		
1 (1973)	0.33	4.2
2 (1974)	0.16	2.9
3 (1975)	0.18	2.1
ALL VANS	0.18	2.5
BUSES		
4 (1970)	0.35	2.9
5 (1970)	0.65	4.8
6 (1966)	0.50	3.8
7 (1970)	0.42	3.1
8 (1974)	0.14	1.6
9 (1969)	0.37	5.0
ALL TRANSIT BUSES	0.30	2.6

TABLE D.3. DISTRIBUTION OF REPAIR TYPES

Year-to-Date (March 1976)

TYPE OF REPAIR	VANS (51 Vehicles) Number of Repairs	BUSES (41 Vehicles) Number of Repairs
Front/Rear Axle	13	14
Brakes	231	251
Clutch	2	4
Cooling	45	79
Electrical	482	343
Engine	80	88
Frame	3	4
Fuel System	103	46
Suspension	40	24
Steering	101	24
Transmission	75	62
Prop Shaft	18	3
Wheels/Tires	168	116
Body Parts	207	164
Air Conditioning	14	14
Radio	88	48
Accessories	5	2
Fare Collection	111	106
Other	11	5
TOTAL	1,797	1,397

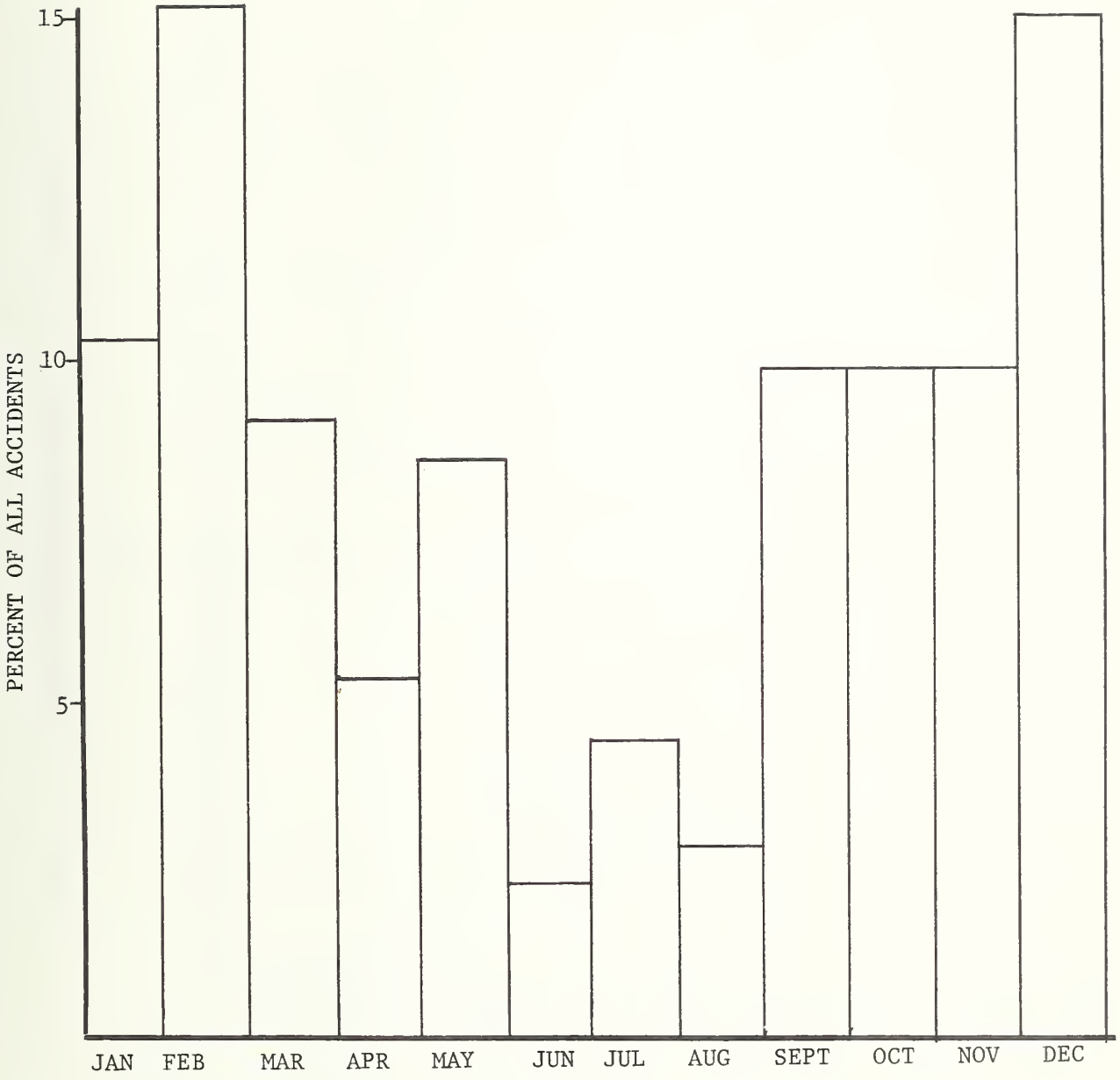


FIGURE D.1. MONTHLY ACCIDENT RATES (1974)

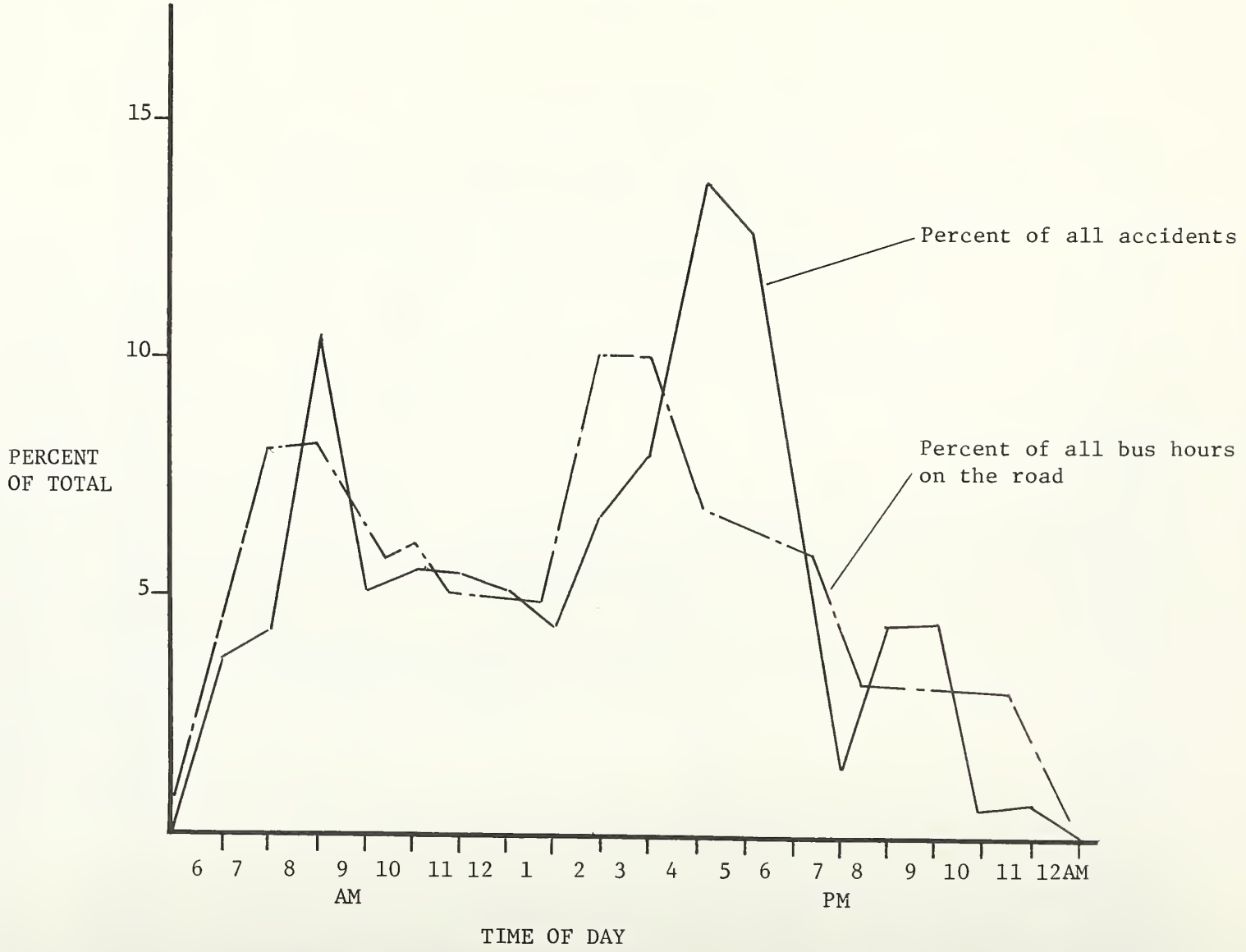


FIGURE D.2. ACCIDENT RATES AND VEHICLE UTILIZATION BY TIME OF DAY

APPENDIX E

Report of Inventions

A thorough review of the work performed under this contract has revealed no significant innovations, discoveries, or inventions at this time. In addition all methodologies employed are available in the open literature. However, the findings in this document do represent an improvement and they will be useful throughout the United States in designing and evaluating integrated demand-responsive and fixed-route transit systems.

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