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The Rochester New York Integrated Transit Demonstration. Volume II Evaluation Report

Systan, Inc, Los Altos, CA

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16. Abstract

The Rochester Integrated Transit Demonstration (RITD) was designed to assess the roles of demand-responsive transit services in a regionwide transit system that includes an extensive fixed-route bus network. The demonstration extended transit service into suburban areas by using integrated mixes of fixed-route and paratransit services. Four types of innovations were demonstrated: service; system integration; equipment; and fares, marketing, and promotion.

This report describes the conduct of and the impacts resulting from the implementation of a family of demand-responsive transit services and several related innovations in Greece and Irondequoit, New York (two suburbs of Rochester). The report covers the time period beginning with the implementation of PERT (Personal Transit) services in August 1973 through July 1977. The initial Greece project did not become a federally-funded demonstration until after many of the innovations had begun. Nevertheless, this pre-demonstration period has been evaluated to the extent that data were available. The report contains a description of the implementation process and the impacts of individual services and innovations on level of service provided, transit demand, and transit productivity. The implications of the Rochester experience are summarized for the benefit of other localities considering the implementation of similar services. Other volumes of this study are: Volume I: Executive Summary (UMTA-NY-06-0048-78-1); and Volume III: Appendices (UMTA-NY-06-0048-78-3).

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UMTA/TSC Project Evaluation Series

The Rochester New York Integrated Transit Demonstration

Volume II: Evaluation Report

Final Report
March 1979

Service and Methods Demonstration Program

U.S. DEPARTMENT OF TRANSPORTATION
Urban Mass Transportation Administration
and Research and Special Programs Administration
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PREFACE

This report describes the conduct of and the impacts resulting from the implementation of a family of demand-responsive transit services and several related innovations in Greece and Irondequoit, New York, two suburbs of Rochester. The report covers the time period beginning with the implementation of PERT (for Personal Transit) services in August 1973 through July 1977. The initial Greece project did not become a federally-funded demonstration until after many of the innovations had begun. Nevertheless, this pre-demonstration period has been evaluated to the extent that data were available.

The demonstration ended in October 1977; however, the Rochester-Genesee Regional Transportation Authority prepared a request for additional demonstration funding so that additional innovations could be demonstrated in its quest to increase the coverage of transit service at a cost that could be borne in the long run. Specifically, the provision of service through contract with the private sector and modifications of union work rules and job categories were proposed for the extended demonstration. This application was approved by UMTA in December 1977, and PERT services continued to operate under a new demonstration grant. Additional PERT services also began in July 1978.

The demonstration services were operated by the Regional Transit Service, Inc. (RTS), an operating subsidiary of the Rochester-Genesee Regional Transportation Authority (RGRTA). Management assistance to RTS and RGRTA was provided by the Department of Civil Engineering of the Massachusetts Institute of Technology (MIT). Demonstration funding was provided by the Urban Mass Transportation Administration (UMTA) under its Service and Methods Demonstration (SMD) Program (Grant No. NY-06-0048). The SMD Program evaluations are conducted for UMTA by the Transportation Systems Center (TSC) of the U.S. Department of Transportation. The Rochester evaluation was conducted by SYSTAN, Inc. for TSC under Contract No. DOT-TSC-1084.

Mark Abkowitz and Joseph Sturm of the TSC staff, as well as Jim Bautz and Paul Fish of UMTA, were responsible for the evaluation and review of SYSTAN's work. The evaluation was also aided by numerous members of the staffs of the RGRTA, RTS, and MIT, who collected and provided data to SYSTAN for analysis. The report authors were assisted by Debra Newman, Jan Glick, Robert Berry, Andrew Canfield, Robert Bullemer, Carolyn Crow and Richard Morris of the SYSTAN staff. Carole Parker was responsible for production of the report.

GUIDE FOR THE READER

This report consists of an Executive Summary, ten chapters, and twenty appendices; it has been organized into three volumes.

The first volume contains an Executive Summary of the most significant demonstration findings. It should be read with Section 1.5, which summarizes the implications of the Rochester experience for other transit organizations. The first volume also contains Chapter 1, a summary of the entire report. This chapter outlines the major demonstration objectives, services and results, directing the reader to the appropriate sections within the text for more detailed analysis.

Volume Two consists of nine chapters. Chapter 2 introduces the demonstration project, Chapter 3 describes the project site and major exogenous events that affected the outcome of the demonstration, and Chapter 4 describes PERT'S innovations, activities, and implementation processes. Each of these chapters covers both Greece and Irondequoit services.

Because of the different transit services offered at various times within Greece and Irondequoit, the evaluation report format diverges to discuss and analyze these results with each service separately; Chapters 5 through 7 focus on Greece services, and Chapters 8 through 10 similarly evaluate PERT operations in Irondequoit. Chapter 5 deals with the changes in the level of service provided to users as a function of the supply and demand levels that resulted from the Greece innovations. The impacts of the Greece demonstration on demand levels are described in Chapter 6, and Chapter 7 describes impacts on system productivity and system economics in Greece. Chapter 8 (Level of Service), 9 (Demand), and 10 (Productivities and Economics) similarly concentrate on PERT activities in Irondequoit. Chapter 5, 6 and 7 generally contain more background material which has been omitted from the Irondequoit analysis. These more detailed sections are therefore referenced throughout the final three chapters.

Volume Three contains the appendices, including a glossary, copies of measurement instruments, and tabulations of survey results.

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VOLUME II: EVALUATION REPORT

EXECUTIVE SUMMARY

The Rochester Integrated Transit program involved a six-year search for a cost-effective combination of paratransit and conventional transit services to extend transit coverage in suburban areas. Few services offered during the course of the program with small buses included door-to-door dial-a-ride, route deviation, point deviation, shuttle, subscription loop routes, and group trips and other special services for the elderly and handicapped. The many services and service changes tested provide a wealth of information for other cities considering the use of paratransit services to complement their fixed-route services.

The extended coverage generated demand levels comparable to those experienced by other demand-responsive systems. Although many of the riders were transit-dependent, a variety of users had acces to an automobile or other form of transportation. Many of the transit-dependent riders took advantage of the services to make trips they otherwise would not have made. As vehicle reliability problems caused service quality to decline, these transit-dependent riders continued to use the service; those who used the services by choice did not, resulting in a higher proportion of transit-dependent users. The total of new trips generally balanced the diversion from automobile use, resulting in a small change in vehicle-miles traveled within the service areas.

The services provided in the suburb of Greece, where little fixed-route service was available, evolved from many-to-many, door-to-door service to combinations of fixed- and flexible-route services. The new services were better tailored to meet demand, and had the potential for higher productivities. The demand patterns revealed by the many-to-many trips provided the information used in redesigning the services, a use that may be made of door-to-door services in other areas.

In the Irondequoit service area, hybrid fixed and flexible routes were initially implemented to replace fixed routes during the off-peak period. The fixed-route services were eventually restored, and DAB service was also retained to complement them. In general, the use of demand-responsive services as a cost-effective substitute for fixed routes was not well received by residents of either service area, and seems to have resulted in reduced transit use.

Several special services for the elderly and handicapped were very successful. Weekly group trip services were provided between elderly housing areas and such activity centers as shopping centers and daycare facilities. In some cases, merchants helped to offset the cost of these services and no fares were charged. These services generally had high load factors, and consequently cost relatively less per passenger.

In addition, a 24-hour advance reservation door-to-door service for the handicapped carried persons to major activity centers throughout the metropolitan area. Although the area served was large, per-passenger costs were relatively low because trips were aggregated to conform to a preestablished bus tour pattern.

Service levels (as measured by such factors as wait time, ride time, and reliability) were comparable to those of other cities offering demand-responsive services. They were not high enough, however, to attract the number of riders anticipated during PERT planning. Therefore, the costs per ride and the required subsidies caused Transit Authority decisionmakers to consider termination of the new services in order to cope with the financial austerity facing both the Transit Authority and the State of New York itself.

Offering new paratransit services through a traditional transit organization strained the operating organization, as the priorities of the Transit Authority and the operating subsidiary differed. This problem may have constrained the effectiveness of the new services. For example, winter-related reliability problems with some of the small buses were an endemic problem that could have been solved if priorities were different.

A computerized dispatching procedure was employed to perform passenger assignment and vehicle dispatching of the dial-a-ride service. This worked well after a period of adjustment and software modifications. Demand levels were not sufficiently high, however, and the number of vehicles involved discouraged testing of the computerized methodology in the large system environment where it is theoretically superior to manual dispatching.

The implications of these findings for other cities considering paratransit are summarized in Section 1.5 of the following chapter. This section may be read to complete the Executive Summary.

2. INTRODUCTION

2.1 PURPOSE OF THE DEMONSTRATION

The major objective of the Rochester Integrated Transit Demonstration (RITD) was to establish an effective public transportation system that utilized several types of demand-responsive bus service. The collection of these services, called PERT for PERsonal Transit, was integrated with scheduled, fixed-route bus services.

PERT was intended to meet all the UMTA Service and Methods Demonstration (SMD) program objectives. The most significant effects were anticipated to be in improving coverage, productivity and service to the transit-dependent. In addition, the following local objectives were identified by the Rochester-Genesee Regional Transit Authority (RGRTA):[1]

1. Increase the level and quality of transit service;

2. Balance peak, off-peak and evening services to improve the overall utilization of resources;

3. Increase transit coverage (through system adjustments);

4. Provide meaningful service for the elderly and partially handicapped; and

5. Develop a system for providing easy transfer between the various elements of the overall transit system.

Moreover, the project was intended to test:

1. The use of a computerized dial-a-ride scheduling and dispatching system;

2. The effectiveness of various dial-a-ride operating strategies; and

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[1]Regional Transit Service, Application for Federal Assistance for a Demonstration and Service Development Project Grant entitled "Integrated Adaptable Metropolitan Transit Service Program," November 1974.

3. The effectiveness of various transit promotional and marketing activities.

These local objectives overlap considerably with the five objectives of the SMD program. Almost all the innovations implemented, planned, or considered in Rochester had impacts affecting all of the SMD objectives (see Exhibit 2.1).

The primary emphasis of the demonstration was on the role of demand-responsive transit services as a major component of a regionwide integrated transit system. PERT operated primarily in two low-density suburban areas -- Greece and Irondequoit -- which to a large extent had not been well served by fixed-route service. In these cases, the question was whether PERT could extend the coverage of public transit and attract new riders to the system by providing flexible service. Some areas had been fairly well served by fixed routes, and land use patterns had developed based on these routes. In these cases, the question was whether demand-responsive services provided equivalent services more cost-effectively when used to replace fixed-route services. User acceptance of both the replacement and extension uses of demand-responsive services was a key issue of the demonstration.

Another issue concerned how well a set of special services for the transit-dependent performed, and how often the transit-dependent used the regular service.

The Rochester demonstration was also going to examine integration, including both the institutional and service aspects of a service. PERT services were offered by the Regional Transit Service (RTS) as part of its total operation and subject to its policies and labor contracts. The success of this approach compared to other institutional arrangements was another key evaluation issue.

On the subject of equipment, the question of whether small buses are appropriate for offering demand-responsive services was to be answered. In addition, the demonstration was to help determine the effectiveness of computerized dispatching; its effect on service quality, its success in meeting the needs of the transit-dependent, and its ability to attract automobile drivers to public transit.

EXHIBIT 2.1 OBJECTIVES OF THE DEMONSTRATION'S INNOVATIONS

INNOVATION	Increase Transit Coverage	Decrease Transit Travel Time	Increase Transit Reliability	Increase Transit Vehicle Productivity	Improve Service to Elderly and Handicapped
Service					
DAB	X			X	X
Subscription	X		X	X	X
Transit-Dependent Services	X				X
Route Deviation	X				X
System Integration					
Transfer Coordination		X	X		X
Route Rationalization	X			X	X
Equipment					
Vehicles					X
Communication				X	
Computerized Dispatching		X	X	X	
Fares, Marketing and Promotion					
Reduced Fare Periods	X			X	

2.2 SERVICE AND INNOVATIONS

Before the demonstration, the Rochester suburbs of Greece and Irondequoit were partially served by fixed-route bus lines. Alterations to these lines as well as the various PERT services and equipment were considered as innovations for evaluation. These innovations were grouped into four categories: service; system integration; equipment; and fares, marketing and promotion. The impacts of each innovation on SMD objectives are summarized in Exhibit 2.1. A more complete description of the intent of each innovation, and the evaluation issues considered, are contained in Chapter 4.

2.2.1 Service Innovations

PERT consisted of four sets of services, each designed to serve a particular segment of the population. Each of these services are described below.

Dial-A-Bus

Dial-A-Bus (DAB) was a demand-activated, door-to-door service. Customers used DAB by telephoning the PERT control room and giving the order processor the relevant trip information: name and telephone number, origin, destination, and desired time of departure. Requests were classified into "immediate" (the customer wanted to travel as soon as possible) and "advance" requests (the customer booked a trip for later in the day or week). DAB could be used in three ways: for direct service from any origin to any destination in the Greece or Irondequoit service area, as a means of access to a fixed route for travel outside the service area, or as a means of access to the adjacent DAB service area in Greece (i.e., Irondequoit to Greece or Greece to Irondequoit).

Subscription Service

Subscription service was a many-to-one or many-to-few PERT service, including work, school, day care, and subscription feeder services. These services accepted reservations on a weekly basis. Subscription service was intended to serve recurring demand which could be aggregated in order to provide high reliability and high productivity levels.

Transit-Dependent Service

Transit-dependent service included a number of many-to-few and many-to-one services characterized by exclusive use of the vehicle, advance booking and special fares. Shoppers' Specials provided point-to-point service between elderly housing sites and shopping centers. In one case, a grocery store paid the cost of this service, providing an opportunity for evaluation of third-party financing innovations. Special PERT services for handicapped users were also offered.

Route Deviation

Route deviation is a flexible service mode in which buses follow a nominal fixed route and deviate from the route in a defined area upon user requests for either pick-up or discharge. Point deviation is a similar service in which buses serve designated checkpoints and deviate to other points upon request, but do not follow a predetermined route. These services were offered at an increased fare. The purpose of route deviation was to provide coverage approaching that of a full many-to-many, demand-responsive system while maintaining the productivity and reliability of a fixed-route system.

2.2.2 System Integration Innovations

PERT services were primarily designed to extend transit coverage to new geographic areas, in new time periods, and to new users by providing convenient service comparable to alternative modes in both service quality and price. Integration of PERT and fixed-route service was an important means of extending coverage and, hence, was a major demonstration objective. Integration was accomplished by transfer timing, the provision of convenient transfer locations, coordinated fares, and special feeder services. "Transfer coordination" and "route rationalization" were treated as separate innovations, as the experimental conditions differed sufficiently from each other to make this a desirable evaluation distinction.

Route Rationalization

Route rationalization refers to the replacement of fixed-route services with demand-responsive services in areas and at times of day when the latter are hypothesized to be more efficient. The evaluation of this concept was designed to determine the changes in service quality and cost-effectiveness resulting from this substitution.

Transfer Coordination

Transfer coordination included the dispatching of DAB buses and scheduling of other PERT services (such as subscription feed-a-bus) to provide acceptable transfer waiting times at points on the fixed routes. In addition, transfer stations and information centers were installed at major transfer points with the intent of making each transfer comfortable and convenient.

2.2.3 Equipment Innovations

The equipment category includes several innovations, the impacts of which are likely to be primarily of interest to management. In some cases (e.g., the introduction of computerized dispatching), users may not perceive that a change has taken place, except insofar as service levels are changed. An exception to this is the case of vehicles, where the attitudes of users toward the equipment were surveyed.

Over the course of the PERT service period, buses of eight different manufacturers were added to the fleet. Thus, the Rochester demonstration provided an opportunity to compare buses made by various manufacturers with regard to performance and user preference within the same environment. Due to the small number of buses of each type, generalizable statements cannot be made; however, the evaluation does provide information on probable problems that operators of small bus fleets will face.

Three modes of communication between the dispatching center and the bus drivers were used during the demonstration: voice, printer-digital, and video-digital. These are described and compared.

Computerized scheduling and dispatching refers to the use of a computerized algorithm for the assignment of passengers to buses, the routing of buses, and the generation of promised pick-up times. As such, the innovation was not properly a hardware innovation, but rather consisted of the computerized concept. The system is evaluated by assessing its ability to improve the level of service provided and increase system productivity compared to the manual dispatching system used prior to computerization. For several reasons, the comparisons made are imperfect, but some insights are possible.

2.2.4 Fares, Marketing and Promotion

Several fare promotional techniques were used during the demonstration to enhance community awareness of PERT services and to attract new ridership. These consisted of reduced fare periods to introduce PERT service to new users, DAB half-fare coupons distributed through various media forms, and subscription service discounts.

In addition to fare promotion, marketing was done through the media and through publication of brochures, etc. The PERT staff also met with several community groups to discuss the nature of demonstration services and to give community members an opportunity to express their views. These marketing activities are described but not evaluated.

2.3 EVALUATION OVERVIEW

The evaluation documents the implementation process and includes analyses to determine if significant[2] changes resulted from the introduction of demonstration innovations. Where significant changes are identified, the magnitude and causes of these changes are addressed. Whenever possible, an attempt is made to determine the transferability of these results to other sites. The analysis will be conducted in a step-wide fashion, similar to the procedure outlined in Exhibit 2.2.

Each innovation effects a change in the transportation supply available to Rochester area residents. Of particular interest are the service and system innovations; however,

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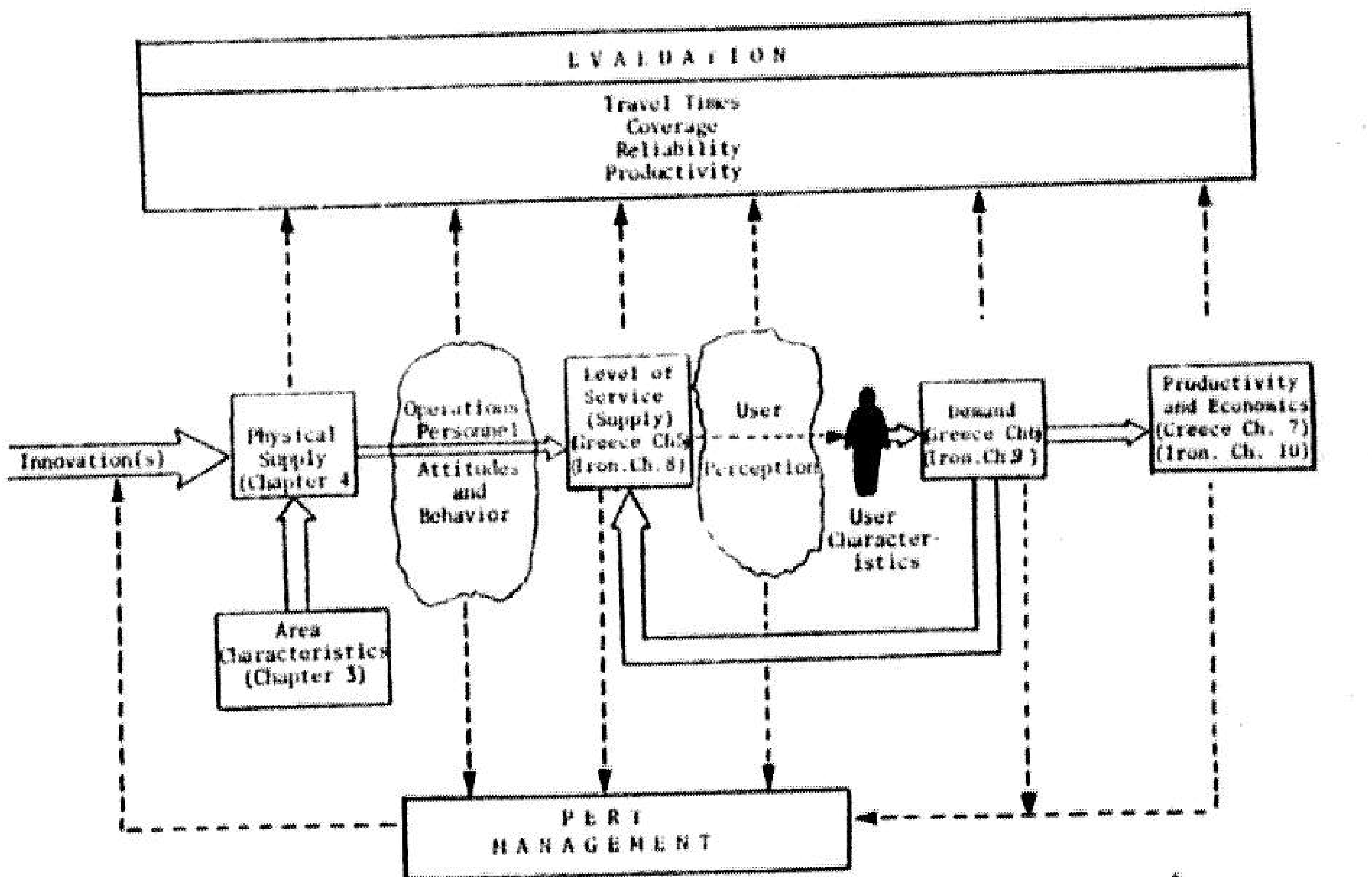
[2]"Significant" is used throughout this report in the usual statistical sense, that is, as a probability measure of how likely an outcome is based on chance rather than due to a specific cause. If two statistics are said to be different at a significance level of .10, it means that under the measurement methods used there is a 10% chance of obtaining the measurements if the real values of the underlying variables are the same. For example, if weekly ridership during a defined period following a service change is greater than ridership during a period preceding the change at the .10 level, it means that there is a 10% chance that the observed difference in ridership between the two periods reflects only the normal fluctuation in ridership between weeks rather than some fundamental difference between the two periods (such as that caused by the service change). Statistical significance in observed variable changes depends upon the magnitude of the change, the sample sizes, and the variation of the variable. In most cases, a significance level is reported with each finding in the report. The lower the number, the stronger the empirical evidence for whatever assertion is being made. If the word "significant" is used without the corresponding value, it means the significance level is less than .05.

equipment and promotional innovations affect the impacts of service changes. Supply changes are also reflected in levels of service as perceived by the users. The user or potential user reacts in some manner to the supply change, and this reaction may lead to a change in travel behavior, referred to as demand in Exhibit 2.2. The supply and demand changes together will effect changes in productivity and economics. Demand changes may also have a feedback effect on levels of service. Where appropriate, the impacts of supply changes are disaggregated by service type, market group, trip purpose, and time of day.

The most effective technique for determining changes in demand and productivities is to make a direct comparison of operating statistics and travel behavior before an innovation is implemented with similar data elements collected after the innovation has been in operation and effects have stabilized. Unfortunately, innovations and policy changes often coincided in Rochester during the course of the demonstration, making it difficult to disaggregate cause and effect relationships. Direct before/after evaluation in Rochester was further complicated by the fact that fixed-route and demand-responsive services are inherently different, giving rise to conceptual problems in making comparisons. Whenever possible, direct before/after comparisons have been made. In many cases, this approach has been inconclusive. Nevertheless, before/after results are reported, but which supply changes were responsible for the changes can only be speculated.

EXHIBIT 2.2

CONCEPTUAL FRAMEWORK OF DEMONSTRATION RELATIONSHIPS



2.4 ORGANIZATIONAL ROLES

Several organizations were involved in the implementation and evaluation of the Rochester demonstration (Exhibit 2.3). The demonstration was part of the Urban Mass Transportation Administration (UMTA) Service and Methods Demonstration (SMD) program, and was executed under two grants from UMTA (NY-06-0048 and NY-03-0075) to the Regional Transit Service, Inc. (RTS). RTS operates the transit system in the Rochester area; it is a subsidiary of the Rochester-Genesee Regional Transportation Authority (RGRTA), which is responsible for coordinating and improving transportation services within the Rochester metropolitan area. RGRTA is directed by ten commissioners from the City of Rochester and Monroe, Genesee, Livingston and Wayne Counties.

For developing and managing the PERT demand-responsive transit system, RGRTA contracted for assistance from the Massachusetts Institute of Technology (MIT). RTS and MIT implemented the demonstration and carried out most of the data collection required for management and evaluation. The implementation was under the policy direction of a Demonstration Project Committee comprised of RGRTA commissioners.

The Transportation Systems Center (TSC) of the U.S. Department of Transportation conducts evaluation of SMD projects and other innovative transit projects under the sponsorship of UMTA. The Transportation Systems Center retained SYSTAN, Inc. to perform this evaluation under its technical supervision. The demonstration began on April 1, 1975, was scheduled to end on June 30, 1977, but was extended through October 1977. Although not covered in this report, a new demonstration will continue PERT operations in Greece and Irondequoit until the summer of 1979. PERT services actually started on August 6, 1973 in the suburb of Greece, prior to the demonstration. Irondequoit PERT services began on April 12, 1976. The following table identifies the sources of demonstration[3] funding and their share of total demonstration costs.

Planning and Operations

UMTA (Grant #NY-06-0048)	$2,598,200	71%
RGRTA	1,048,400	29%
Total	$3,646,600	100%

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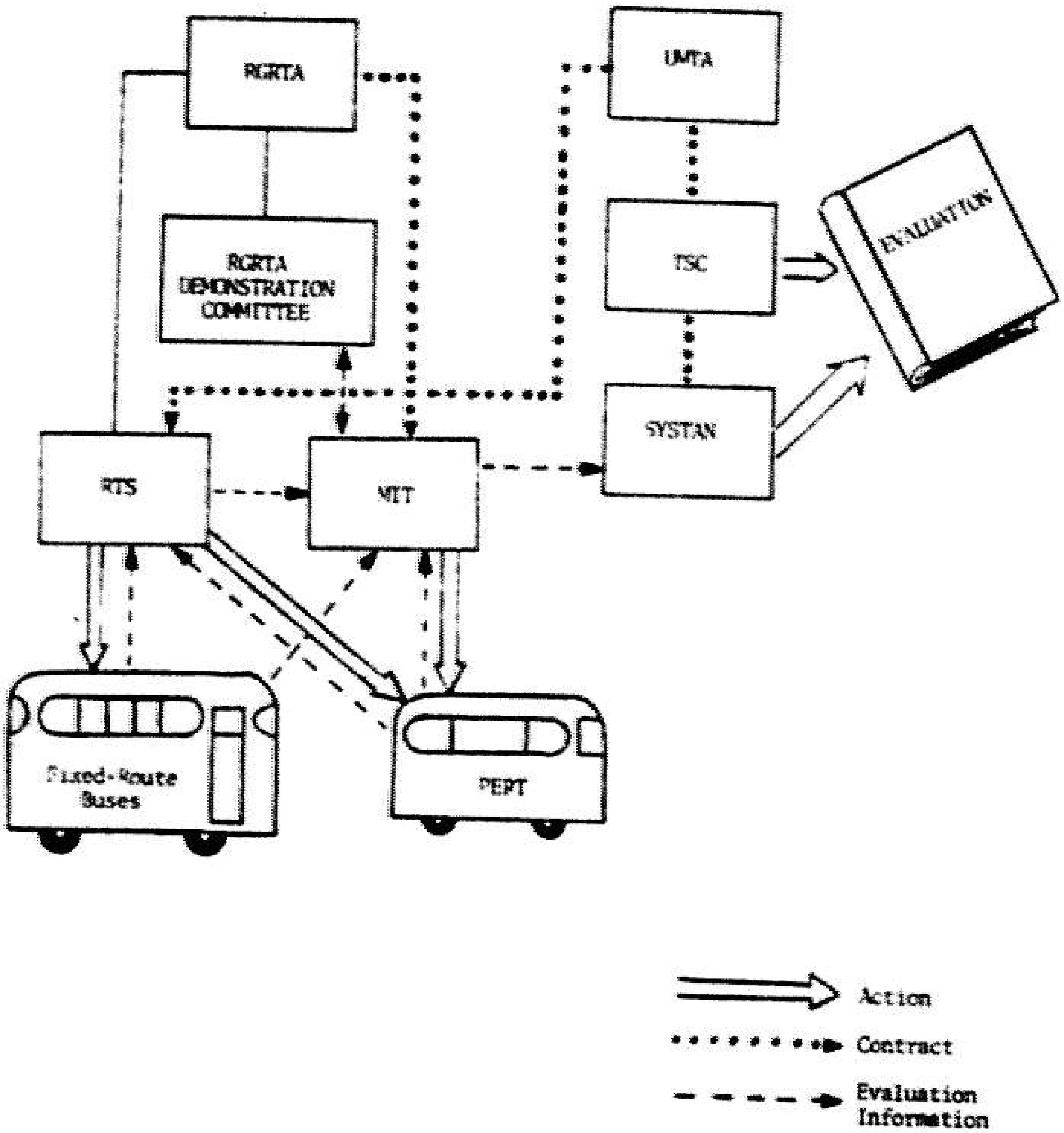
[3]UMTA initially granted 80% of the demonstration funds, but then reduced the federal share and increased the local commitment. For a complete breakdown of demonstration funds and expenses, see Appendix A.19.

EXHIBIT 2.3

RELATIONSHIP AMONG ORGANIZATIONS INVOLVED IN THE DEMONSTRATION



Capital Equipment

UMTA (Grant #NY-03-0075)	$ 686,400	80%
RGRTA	137,040	16%
State of New York	34,560	4%
Total	$ 858,000	100%

3. THE DEMONSTRATION SETTING

This chapter describes the setting of the Rochester Integrated Transit Demonstration. This material is included in order to familiarize the reader with the conditions existing when the project began. It thus serves to indicate the nature and magnitude of the transit needs which PERT attempted to meet, as well as the constraints on PERT's ability to meet those needs. Furthermore, the picture of the Rochester environment should enable persons from other transit districts to assess the applicability of the findings and conclusions presented in this report to their own areas. For the latter purpose, standarized variables -- such as those appearing in regular U.S. Census publications -- are utilized insofar as possible to facilitate comparisons between Rochester and other urban areas.

This chapter includes three sections. Section 3.1 provides a general description of the demonstration site, based primarily on census statistics. Section 3.2 describes the local transportation system. In both sections, the analysis proceeds from a general description of the Rochester metropolitan area to a detailed description of the Greece and Irondequoit service areas. The third section describes the non-experimental factors which may have affected the project results.

3.1 GENERAL DESCRIPTION OF THE ROCHESTER METROPOLITAN AREA AND THE GREECE AND IRONDEQUOIT SERVICE AREAS

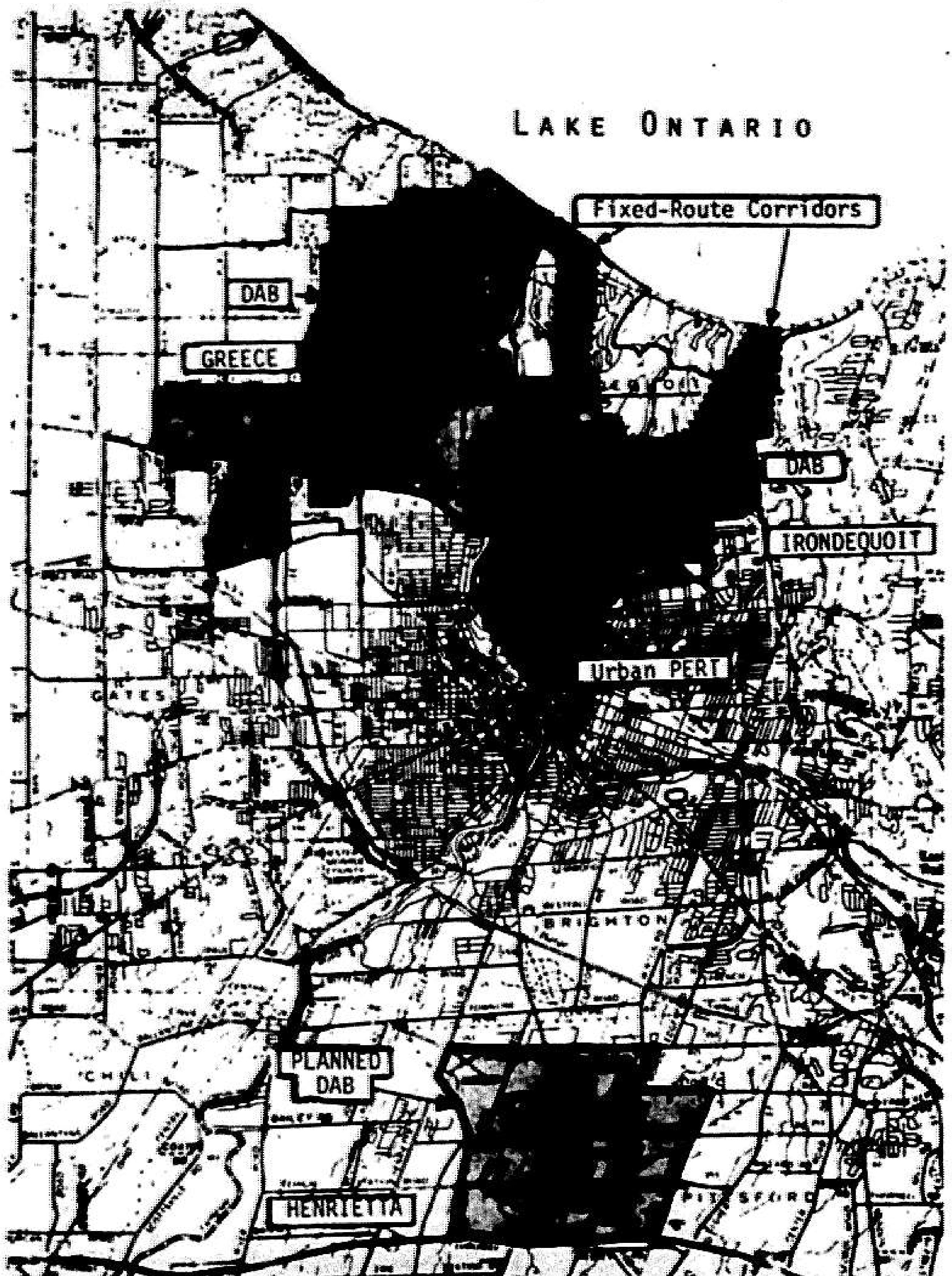
3.1.1 Rochester

Rochester, New York is located approximately midway on the southern shore of Lake Ontario (see Exhibit 3.1). Its central business district is about six miles south of the lake, astride the Genesee River. The Rochester urbanized area, which had a population of 601,361 in 1970, was the third largest in New York State and the fortieth in the nation. With a land area of 145.7 square miles, the Rochester urbanized area density was thus 4,127 persons per square mile. The City of Rochester contains nearly half of the urbanized area population in an area of 36.7 square miles, resulting in a density of 8,072 persons per square mile.

The Rochester standard metropolitan statistical area (SMSA), as defined by the U.S. Census, includes four counties and 951,516 persons. Of these four counties, Monroe is

EXHIBIT 3.1 PERT SERVICE AREAS

(April 1976)



the largest with 711,917 people or 75% of the SMSA population. Eighty-four percent of the Monroe County population resides within the Rochester urbanized area, although only 22% of the County's land area is within the urbanized area. This data is summarized in Exhibit 3.2.

Exhibit 3.3 summarizes relevant demographic data for the City of Rochester, Monroe County, the Greece PERT service area during its greatest expansion (September 1975-September 1976), and the three Irondequoit areas discussed in Section 3.1.3. Monroe County is used rather than the Rochester SMSA as a representation of the metropolitan area, because the other SMSA counties are predominantly rural and are considerably distant from Rochester.

The demographic characteristics of Monroe County closely resemble those of the nation with a few exceptions generally related to income. Median family income exceeds the national average by about 30%, and only a small part of this can be attributed to the generally higher income associated with urban areas. The Rochester SMSA had the 16th highest per capita income in the nation in 1969, although its rank had decreased to 24th in 1973. Consequently, the number of families and persons living below the low-income level is lower than average.

Automobile ownership is slightly above average. Only 9.2% of the workers travel to work by public transportation (bus or rail), compared to 11.8% in all SMSA's having populations over 250,000.

The Rochester metropolitan area is noted for its high concentration of large manufacturing corporations, particularly Kodak and Xerox. Consequently, 40% of Monroe County non-agricultural workers were employed by a manufacturing company in 1970, compared to about 27% nationally. Trade and service industries consequently employ a smaller proportion of the labor force than in other metropolitan areas.

Although about 58% of the Monroe County population lived outside of Rochester in 1970 (a percentage which is estimated to have increased to about 61% in 1974), approximately 66% of the County's jobs were in Rochester. This results in considerable commuting into Rochester from its suburbs; approximately 54% of those living outside of Rochester commute into the City. In addition to the CBD, there is a great concentration of jobs at Kodak Park in Northwest Rochester, where approximately 25,000 persons work. There are several other major employment centers outside of the CBD, although none approach Kodak Park in magnitude.

The City of Rochester is related to Monroe County in the same way that many central cities are related to their

EXHIBIT 3.2

COMPONENTS OF THE ROCHESTER SMSA, 1970

Component	Area (sq. mi.)	% of Total	Population	% of Total	Population Density (pop./sq.mi.)
City of Rochester	37	1.2	296,233	31.1	8,072
Rochester Urbanized Area	146	4.9	601,361	63.2	4,127
Monroe County	675	22.8	711,917	74.8	1,055
Rochester SMSA	2,966	100.0	951,516	100.0	321

EXHIBIT 3.3

ROCHESTER AREA DEMOGRAPHIC CHARACTERISTICS, 1970

Population and Area	U.S. Average (Urban & Rural)	Rochester	Monroe County	Irondequoit Target Area[a]	Irondequoit DAB Service Area[b]	Urban PERT Service Area	Greece PERT Service Area[c]
Population	---	296,233	711,917	56,390	40,295	67,155	68,820
Area (square miles)	---	36.7	675	15.2	8.6	6.5	15.2
Population density (persons/sq.mi.)	---	8,072	1,055	3,710	4,685	10,332	4,528
Social Characteristics							
Persons per household	3.14	2.93	3.23	3.16	3.12	3.04	3.25
% of population under under 18	34.2	30.6	34.3	31.4	30.3	33.0	34.5
% of population 65 and over	9.8	13.7	9.7	10.5	11.3	12.9	7.7
% of population black	11.1	16.7	7.3	0.4	0.5	19.3	0.3
% of population with Spanish as native language	5.1	2.4	1.2	0.4	0.5	5.5	0.9
% of population foreign stock (foreign-born or foreign or mixed parentage)	16.5	28.7	26.3	36.2	40.1	35.0	25.3
% of population over 5 yrs. living in same house	53.0	52.2	54.7	68.3	67.9	55.0	61.6
Economic Characteristics							
% of population over 16 years in labor force							
Male	79.2	74.3	79.7	81.6	81.1	74.5	84.4
Female	42.8	46.8	44.9	44.2	46.3	45.1	45.1
Total	60.3	61.2	59.3	61.7	62.4	58.6	63.7
% of total population in labor force	42.1	42.9	42.4	44.9	46.1	41.3	44.0
Median family income (1969)	9,590	9,996	12,420	N/A	N/A	N/A	N/A
Mean family income(1969)	N/A	10,762	13,642	14,787	13,999	10,806	13,602
% of families below low-income level	10.7	8.9	5.0	2.4	2.5	9.6	2.4
% of persons below low-income level	13.7	12.0	6.9	3.2	3.5	13.0	[illegible]

[a] Area between Genesee River and Irondequoit Bay north of the Keeler Expressway and Norton Street (see Exhibit 3.11).

[b] Including September 1976 expansion.

[c] Including September 1975 expansion.

(Exhibit 3.3, Continued)

Economic Characteristics	U.S. Average (Urban & Rural)	Rochester	Monroe County	Irondequoit Target Area[a]	Irondequoit DAB Service Area[b]	Urban PERT Service Area	Greece PERT Service Area
% of persons age 65 & over below low-income level	24.6	18.1	15.2	10.9	11.7	17.3	9.6
% of housing units in 1-unit structures	69.4	42.6	63.0	82.3	78.6	50.1	76.1
% of occupied housing units owner-occupied	62.9	47.4	64.9	80.7	77.6	54.5	73.4
Transportation Characteristics							
% of households with:							
0 cars	18.6	28.8	15.3	6.3	7.1	29.8	5.5
1 car	51.4	53.6	51.8	54.3	55.3	50.3	60.7
2 cars	24.3	15.1	28.4	33.1	31.5	16.8	30.2
3 or more cars	5.7	2.6	4.6	6.3	6.1	3.1	3.6
mean cars/household[d]	1.18	0.92	1.23	1.41	1.38	0.94	1.33
Means of Transportation to Work (%)							
Automobile driver	66.0	54.3	66.5	69.7	69.2	53.4	71.1
Automobile passenger	11.7	13.5	13.4	15.0	15.3	15.1	14.3
Bus	5.5	13.4	9.5	7.1	7.4	17.4	6.5
Rail	2.3	0.1	0.1	0.0	0.0	0.1	0.0
Walk	7.4	11.1	7.3	4.9	5.0	11.3	5.9
Work at home	3.5	1.4	1.8	1.5	1.3	1.5	1.1
Other	3.6	1.3	1.5	1.8	1.7	1.2	1.1
Location of Workplace							
Rochester CBD	---	12.7	10.3	10.9	11.0	11.2	8.0
Remainder of Rochester City	---	61.2	52.0	53.6	54.1	61.1	60.1
Total Rochester	---	73.9	62.3	64.4	65.1	72.2	68.1
Remainder of Monroe County	---	16.6	30.6	31.4	30.6	19.3	27.7
Total Monroe County	---	90.5	92.9	95.8	95.8	91.6	95.8
Outside Monroe County	---	0.9	1.5	1.2	1.2	0.6	0.8
Not reported	---	8.6	5.6	3.0	3.0	7.9	3.4
% of population within 1/4 mile of a fixed-route bus route (peak)[g]	---	N/A	N/A	73.0	82.8	95.2	49.3
% of population within 1/4 mile of a fixed-route bus route (off-peak)[g]	---	N/A	N/A	65.3[f]	73.5[e]	89.1[f]	49.3[e]

[d] 3.2 average assumed for households with 3 or more cars

[e] Mid-day

[f] Late evening

[g] Before PERT

metropolitan region. Population density is higher, personal income is lower, a greater proportion of the population is black and elderly, there is lower automobile ownership, and there is a greater dependence upon public transportation in the central city. The magnitudes of these differences may be seen in Exhibit 3.3.

A final significant factor in the Rochester environment is its weather, which is colder and damper than most other large cities in the United States. The average daily temperature is below freezing from late November to mid-March, and the average annual snowfall is 82 inches. The average number of annual degree days in Rochester is 6,719, which exceeds that recorded in Boston, Cleveland, and Chicago. Combined with the damp and windy conditions resulting from its proximity to Lake Ontario, the Rochester weather is appropriate for a transit system in which one may wait for a bus in the warmth of one's home. It is hypothesized that this is one of the reasons that DAB has generally been more successful in Canadian cities, although a lower automobile ownership rate also plays a role. Also, the winter weather can affect operation and vehicle performance. These conditions may be absent in other American cities with a less extreme climate.

3.1.2 Greece Service Area

The Greece PERT service area following the September 1975 expansion is shown in Exhibit 3.4. A transit user could request service by PERT DAB between any two points within the service area. Only two PERT services operated outside of the area. One was the work subscription service serving the General Motors Rochester Products plant about one and one-half miles south of the service area; the other was the "special handicapped service" which took passengers to a limited number of specific facilities outside the service area.

The service area was expanded four times since August 1973 when PERT services began operating. As indicated in Exhibit 3.5, these expansions were into areas of lower population density, and have thus lowered the overall density of the service area over time. Although not officially designated as within the service area, PERT service was also provided to a small developed area just west of the service area on Latta Road, where approximately 1,000 persons resided. In addition, DAB would also pick up or drop off passengers along Ridge Road for about one and one-half miles west of the service area during the off-peak period. This compensated for the elimination of a fixed route during this period (Section 4.2.2). In September 1976, the northern

EXHIBIT 3.4

GREECE PERT SERVICE AREA

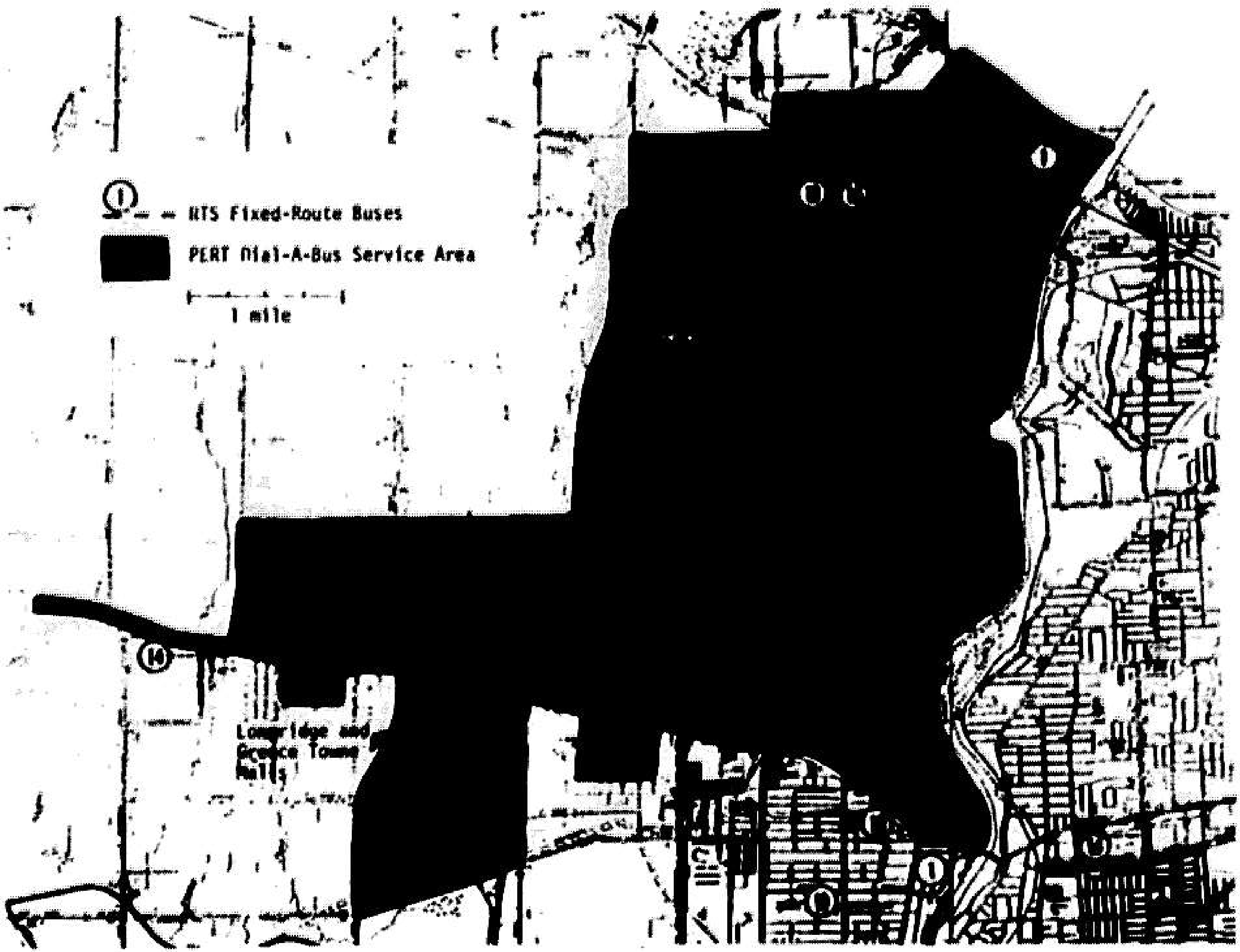
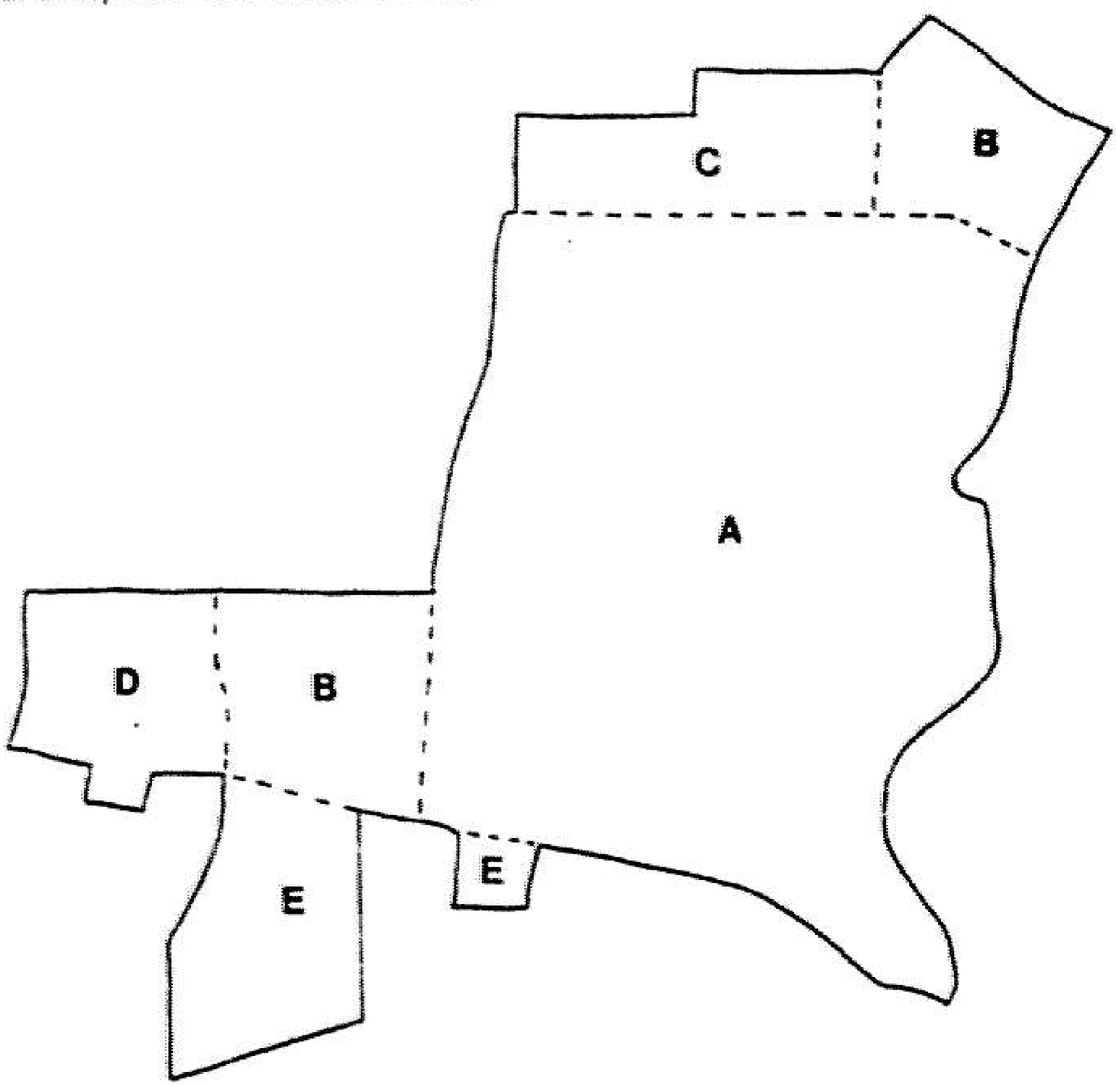


EXHIBIT 3.5

EXPANSION OF THE GREECE PERT SERVICE AREA

Date of Expansion	Map Zone	1970 Population	Percent	Percent Change*	Area (sq. miles)	Percent	Percent Change*
August 1973	A	51,135	74.3%	- %	9.6	63%	-%
June 1974	+B	60,565	88.0	13.7	11.7	77	14
September 1974	+C	62,760	91.2	3.2	12.8	84	7
November 1974	+D	65,784	95.6	4.4	13.7	90	6
September 1975	+E	68,820	100.0	4.4	15.2	100	10

*Based on September 1975 service area size



part of the service area was removed from DAB service when the Dew-Ridge Shuttle operated. However, the latter service offered doorstop service to most residents formerly served by DAB.

Greece was selected for PERT's introduction for several reasons. First, the original service area had a population density of 5,326 persons per square mile, which was relatively high for a suburban area. Yet the area was not well served by transit prior to PERT. In addition, several major activity centers are located along Ridge Road in the southern portion of the service area. This includes the Kodak Park complex where, of the 25,000 persons employed, about one-third resided in the service area. In addition, Longridge and Greece Town shopping malls, located in the southwest portion of the service area, contain 110 stores. Two other shopping centers on Ridge Road, both of which are about one mile from Longridge Mall in opposite directions, contain an additional 45 stores. These characteristics of the service area suggested that sufficiently high demand might be generated to guarantee operational efficiencies in demand-responsive services. The predicted level of demand, however, was considered to be too low for fixed-route transit to operate efficiently in the entire area.

Including the September 1975 expansion, the Greece service area included parts of seventeen census tracts. Four of these census tracts were part of the City of Rochester, and accounted for about one-fifth of the service area's population and size. The remainder of the service area was in the town of Greece. The PERT service area included about two-thirds of the Greece population, although it covered only a small part of its land area.

Exhibit 3.3 includes a listing of the relevant characteristics of the Greece service area. The data reported was constructed from U.S. Census tract and block population data. Tract averages were weighted by their respective populations within the service area in order to derive many of the aggregate area measures. One shortcoming of this technique is that only the mean family income of the area could be estimated, although the median family income is generally a more common socioeconomic measure. Greece census tract differences between mean and median incomes were not large, however, suggesting that the service area median family income in 1969 was approximately $13,500.

On the average, the Greece service area population is considerably more affluent than that reported for the United States, the City of Rochester, and Monroe County. Since Rochester accounts for about 40% of the Monroe County population, Greece closely resembles that portion of Monroe County outside the City of Rochester. Thus, the Greece service area is a fairly typical Rochester suburb, characterized by above-average income and high automobile ownership. Its concentration of elderly residents is somewhat above other Rochester suburbs, although it is still below national and regional averages. Likewise, public transit usage in commuting to work is below the national average (and considerably below the national urban average), but is somewhat higher than other Rochester suburbs.

Many of the Greece demographic characteristics vary within the service area. Generally, the areas further to the north and west (which were developed most recently) tend to be of a lower density and more affluent. Exhibits 3.6 through 3.8 show how three variables (household automobile ownership, median family income and elderly population) vary by census tract in the area. These maps may be somewhat misleading when part of a census tract is outside the service area, since the maps imply a uniform distribution of the characteristics within each census tract. Nevertheless, they tend to explain why the eastern and southern portions of the service area generated higher transit demand than other parts of the service area. The four fixed-route buses in the area all operated in these eastern and southern portions of the service area.

3.1.3 Irondequoit Service Area

Unlike in neighboring Greece, where PERT services were generally restricted to a clearly-defined service area, a variety of PERT services were operated in different areas of Irondequoit. This prevents the demarcation of a single PERT service area. Consequently, three PERT areas are defined and discussed within this section: an Irondequoit target area, a DAB service area, and an Urban PERT service area.

The Irondequoit target area is assumed to represent the general impact area for PERT services in Irondequoit. It includes all of the area between the Genesee River and Irondequoit Bay north of the Keeler Expressway on the west side of Carter Street and north of Norton Street on the east side of Carter Street (Exhibits 3.9 and 3.10).
Most of the town of Irondequoit is included, as well as the part of the City of Rochester that was included in the Irondequoit DAB service area.

The DAB service area is a component of the Irondequoit target area, and represents the area that received DAB service (Exhibit 3.11). When not specified, the DAB service area is assumed to include two expansion areas that were added in September 1976.

EXHIBIT 3.6

HOUSEHOLDS WITHOUT AN AUTOMOBILE, 1970

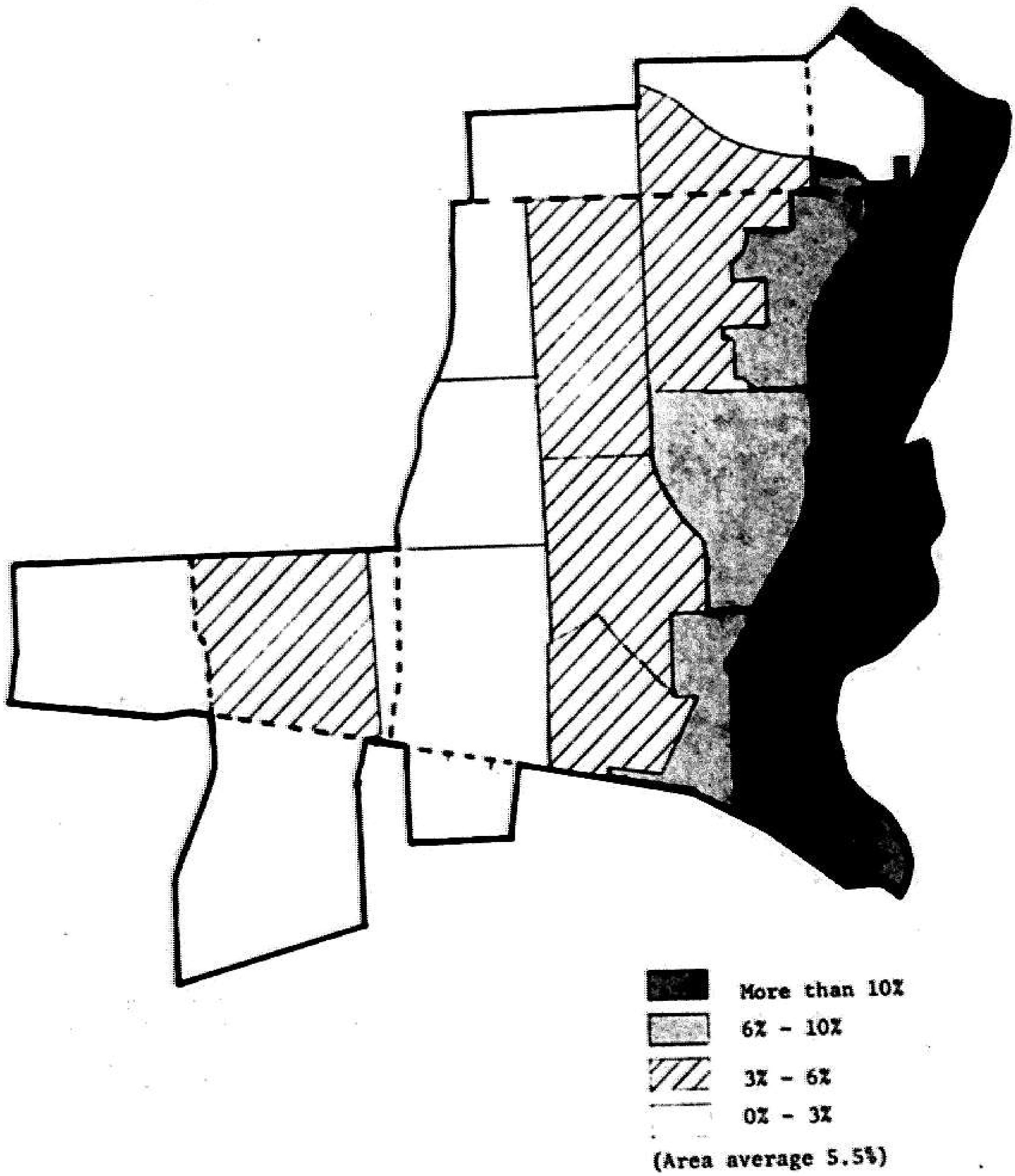
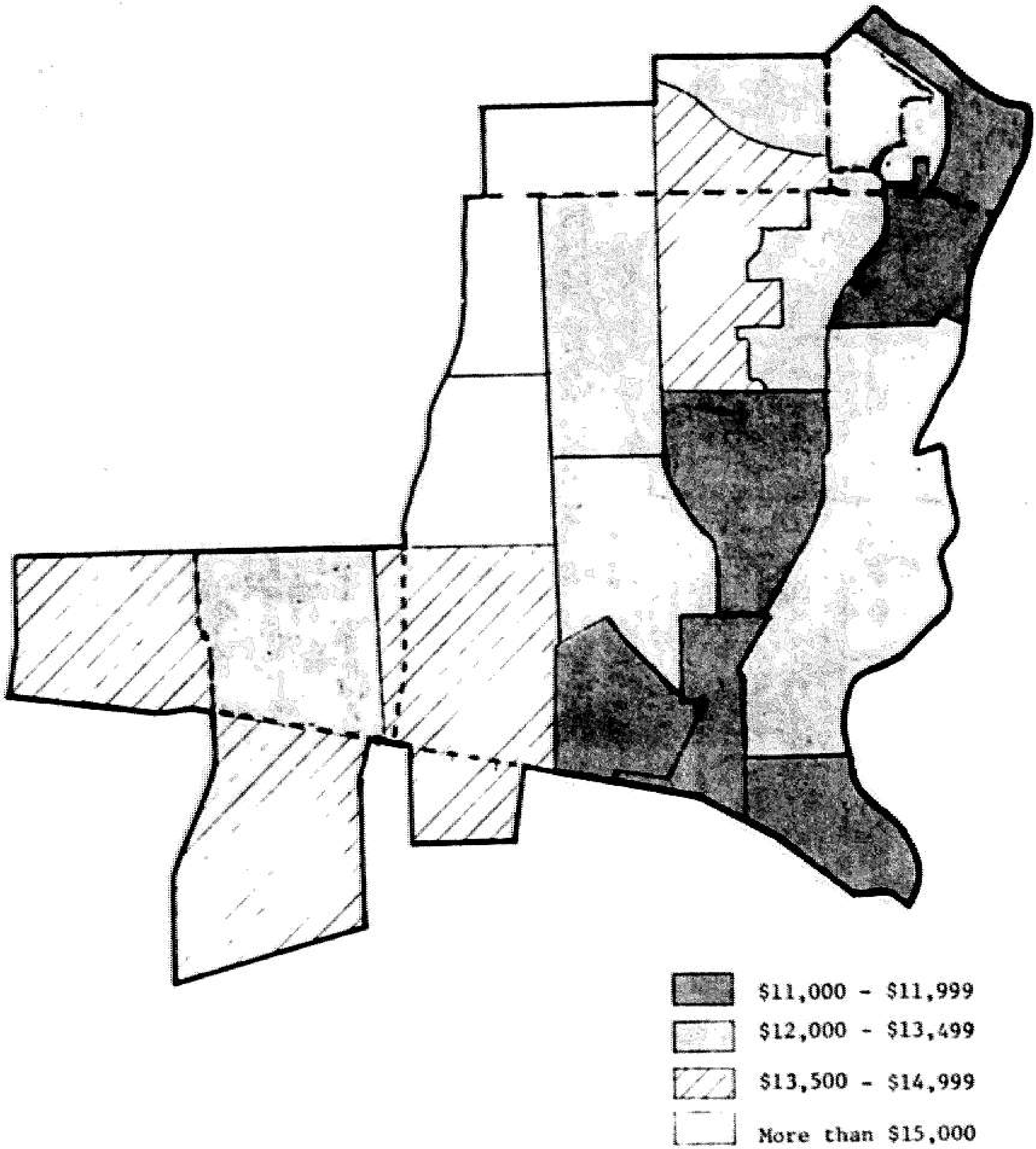


EXHIBIT 3.7

MEDIAN FAMILY INCOME, 1969



Area Average(Mean Income) = $13,602

EXHIBIT 3.8

PROPORTION OF THE POPULATION AGE 65 & OVER, 1970

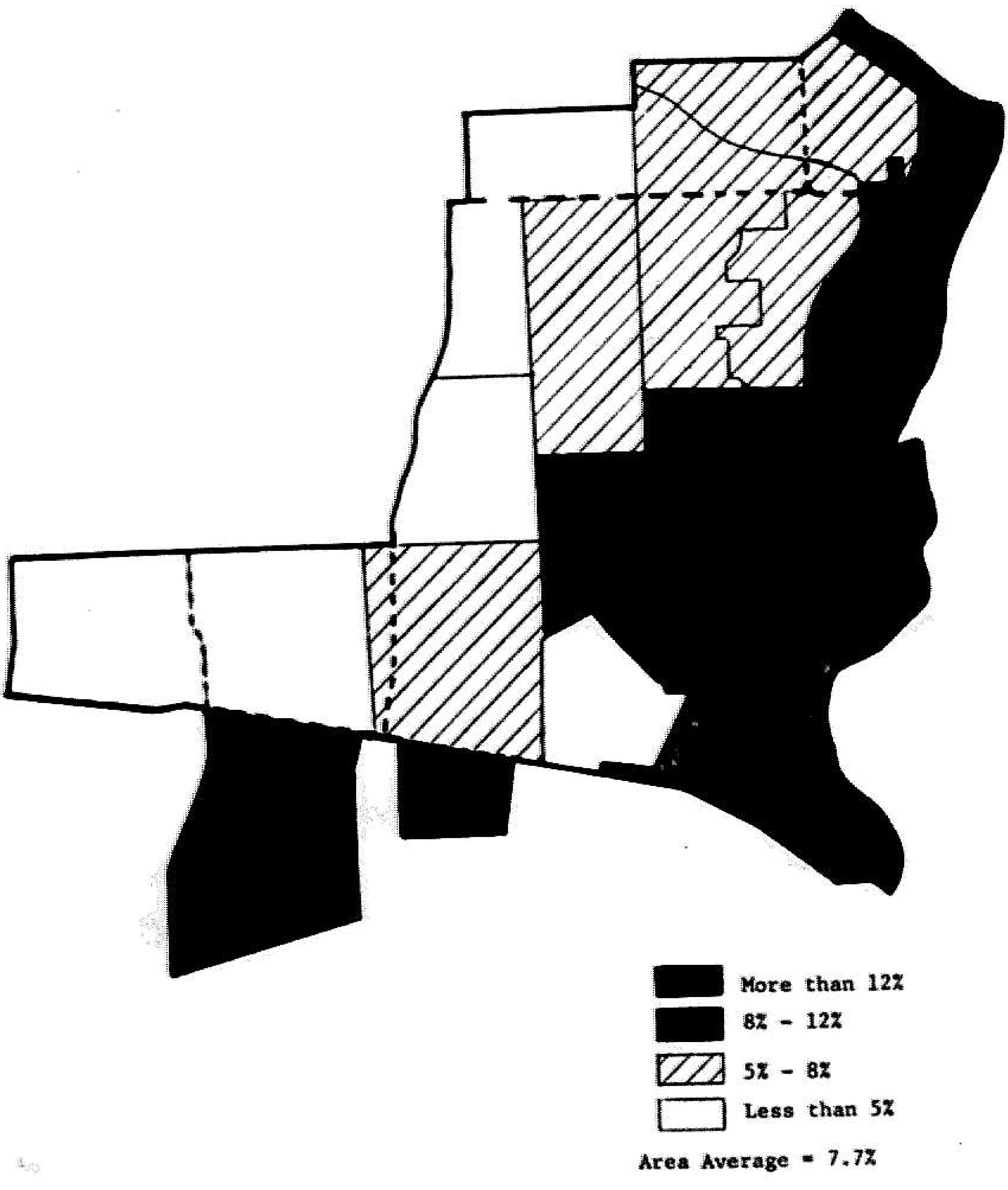


EXHIBIT 3.9

MAJOR THOROUGHFARES IN IRONDEQUOIT AREA

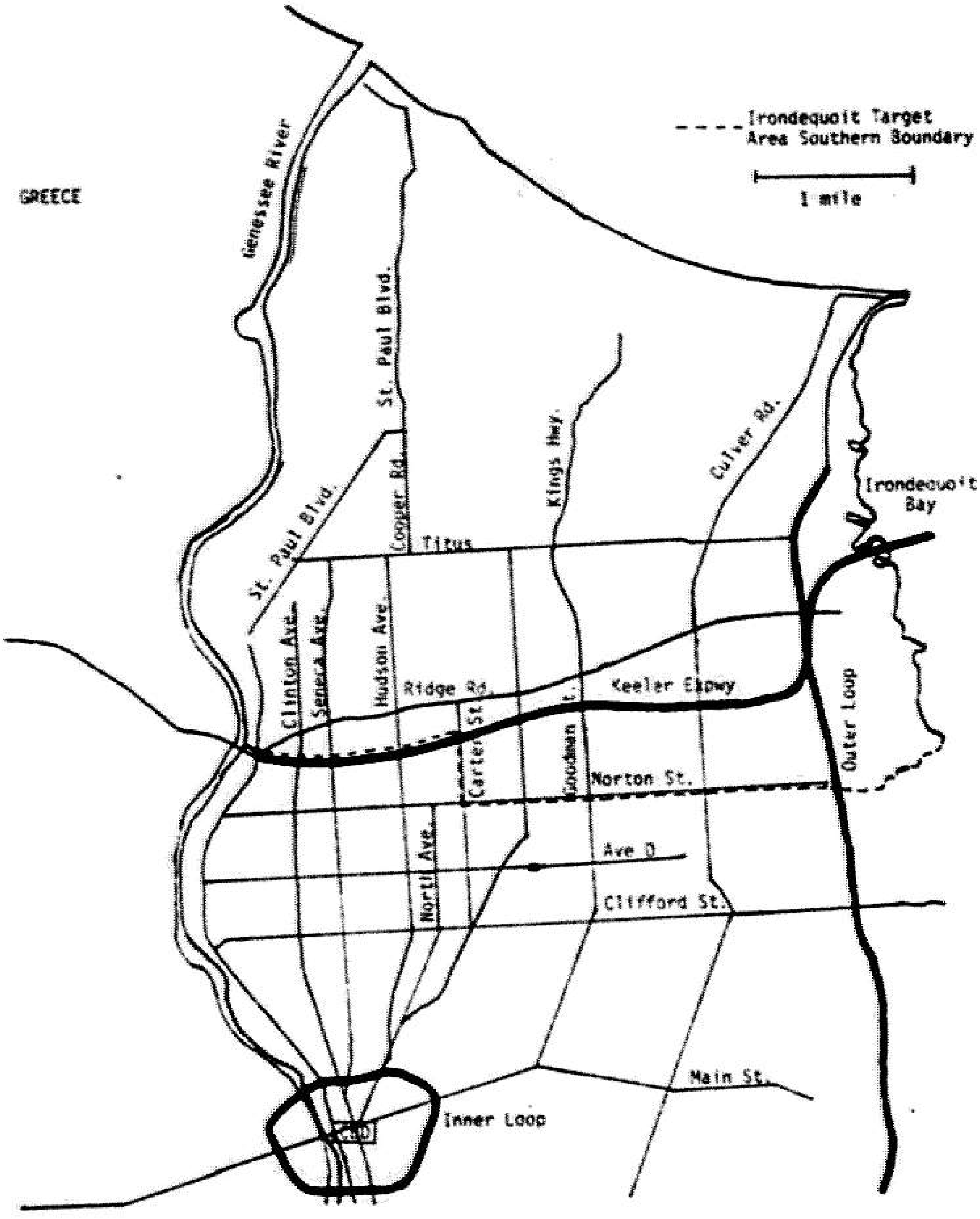


EXHIBIT 3.10 IRONDEQUOIT TARGET AREA

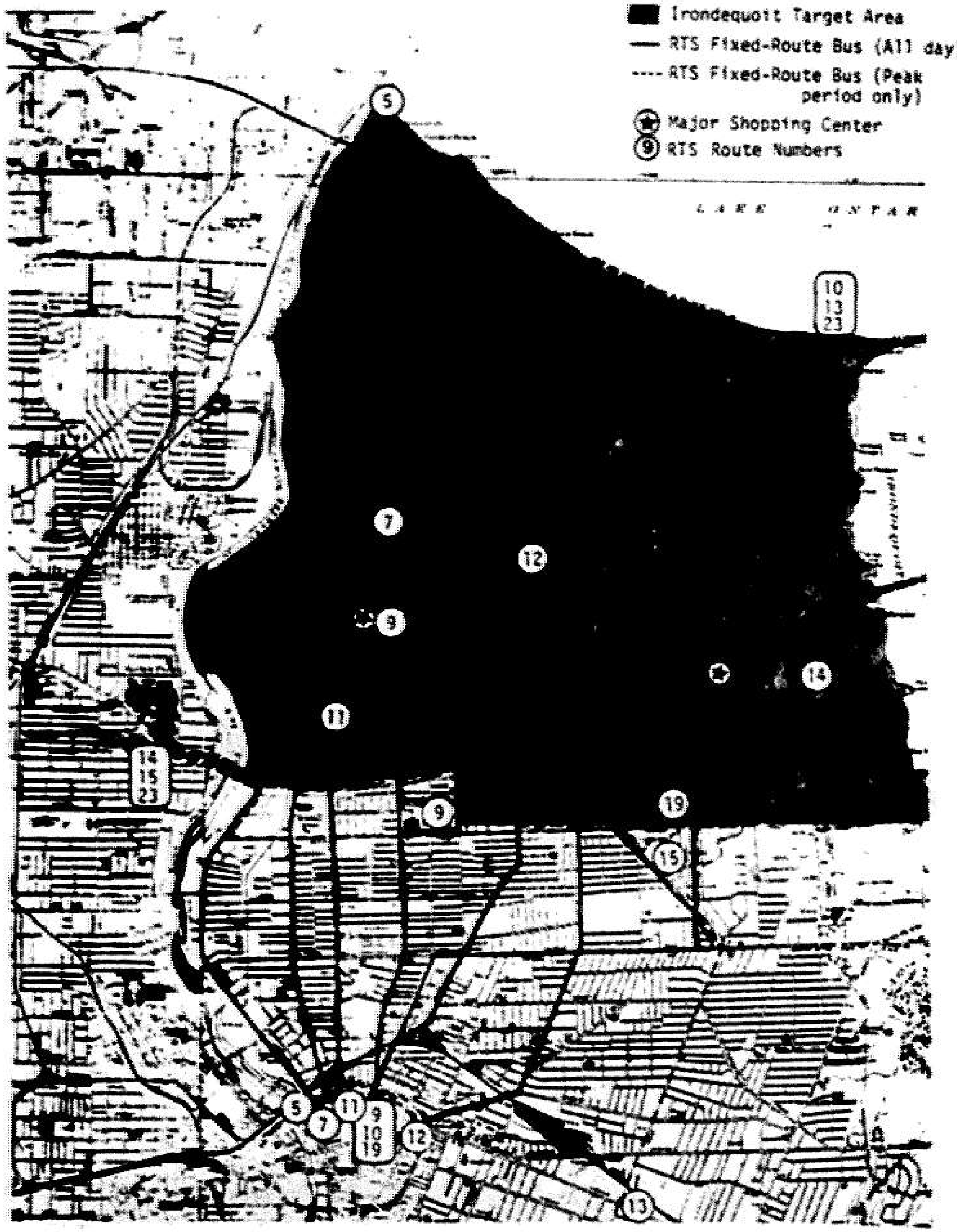
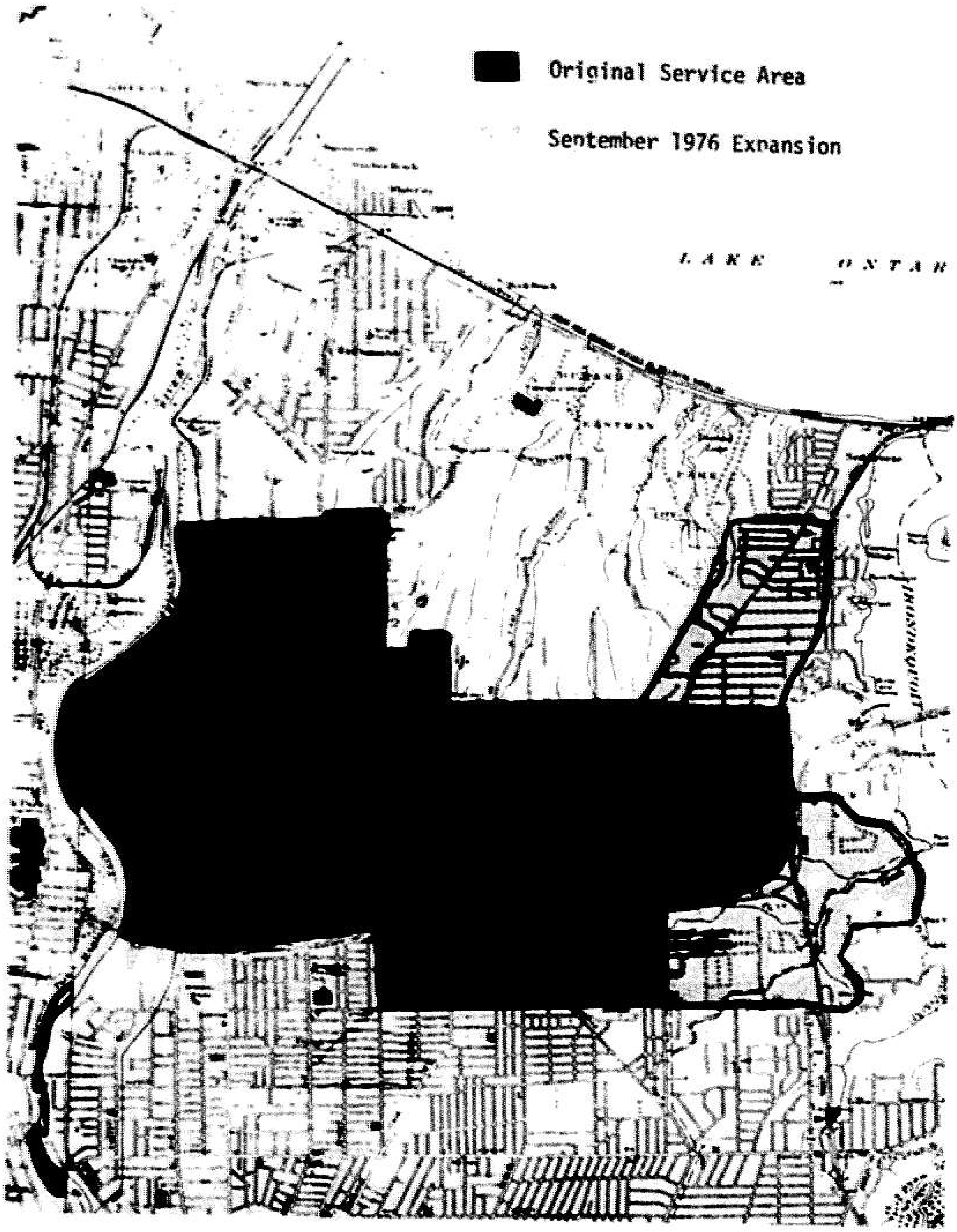


EXHIBIT 3.11

DIAL-A-BUS SERVICE AREA



The Urban PERT service area represents the area that was provided with Urban PERT route deviation service (Exhibit 3.12). Unlike the other two areas, the majority of the population residing within this area are residents of the City of Rochester.

Demographic characteristics for the three Irondequoit PERT service areas described above are contained in Exhibit 3.3. The DAB service area differs little from the larger Irondequoit target area, and can be treated together. The greater population density of the DAB service area is deceptive because of the inclusion of significant parkland within the target area.

Overall, these two areas are quite affluent: 1969 target area mean family income was $14,787 (approximately $22,800 in 1976 dollars), and less than 7% of all households did not own at least one automobile. The area predominantly consists of single-family homes, and two-thirds of the residents lived in the same house five years earlier, suggesting considerable neighborhood stability. Also noteworthy is that elderly residents make up over 10% of the population (as high as 11.3% in the DAB service area), above the metropolitan and national averages of around 9.8%.

Considerable variation of the above parameters exists within the Irondequoit target area. Generally, the characteristics of the southwest portion of the target area suggest a greater dependence upon transit than in other areas. This is graphically illustrated in Exhibits 3.13 through 3.15, where elderly population, household auto ownership, and median family income are mapped by census tract. The northeastern corner of the target area is also relatively transit-dependent, while the central, northwestern and southeastern of the area are more affluent. Since the 1970 Census was taken, three elderly housing complexes have been built in the southwestern portion of the Irondequoit target area, which has further increased the concentration of elderly residents in this area.

Irondequoit's major activity centers are located in the central and southern portions of the target area. The two major shopping centers, Irondequoit Plaza and Ridge-Culver Plaza, are located at Hudson and Titus Avenues and Ridge and Culver Roads, respectively (denoted by stars in Exhibit 3.10). Six smaller shopping centers are located along or near Ridge Road. There are no major industrial employers in the area; however, Kodak Park is located immediately across the Genesee River in the Greece service area and employs several thousand workers.

Unlike the Irondequoit target area and the DAB service

EXHIBIT 3.12 URBAN PERT SERVICE AREA

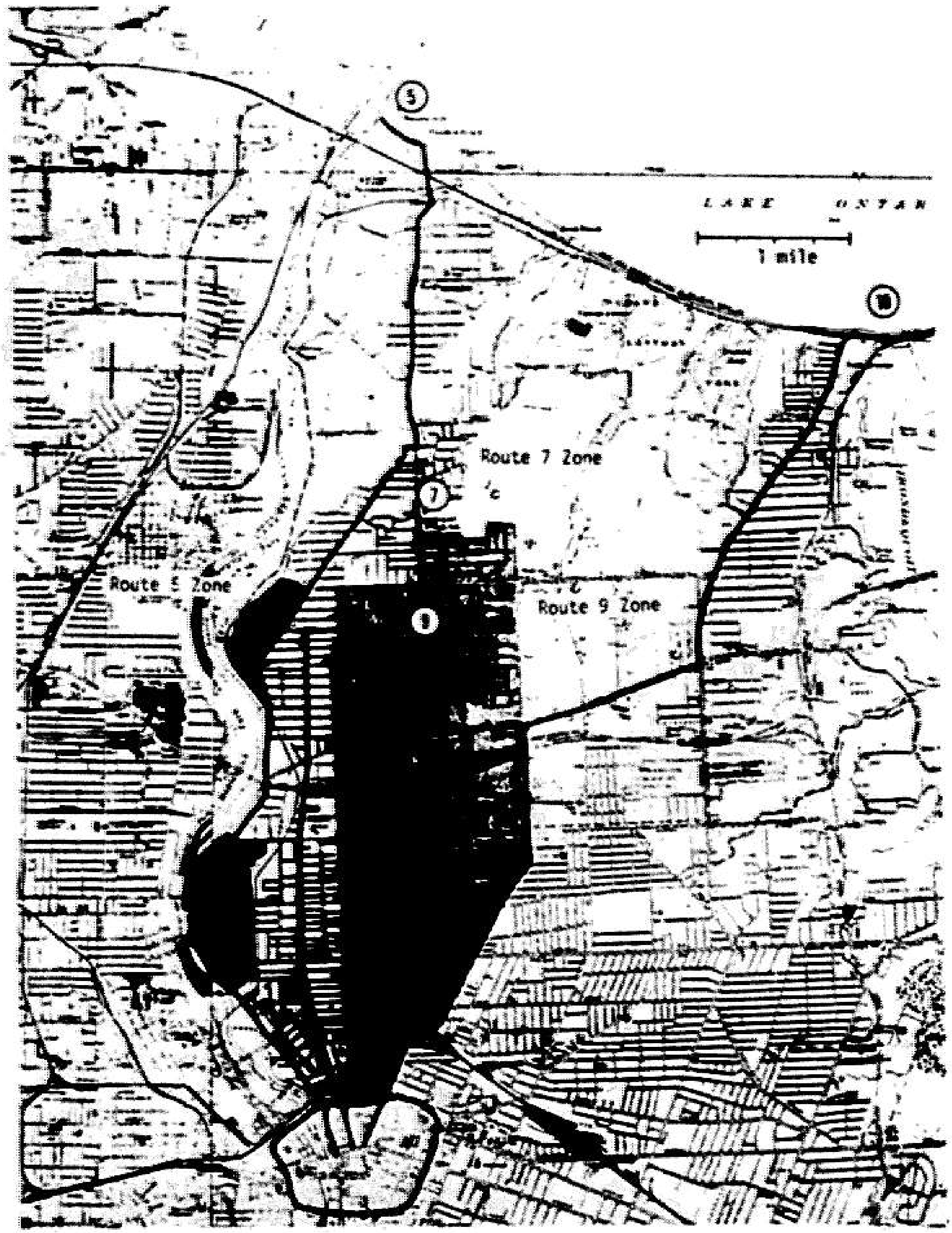


EXHIBIT 3.13

PERCENT OF POPULATION AGE 65 & OVER BY CENSUS TRACT, 1970

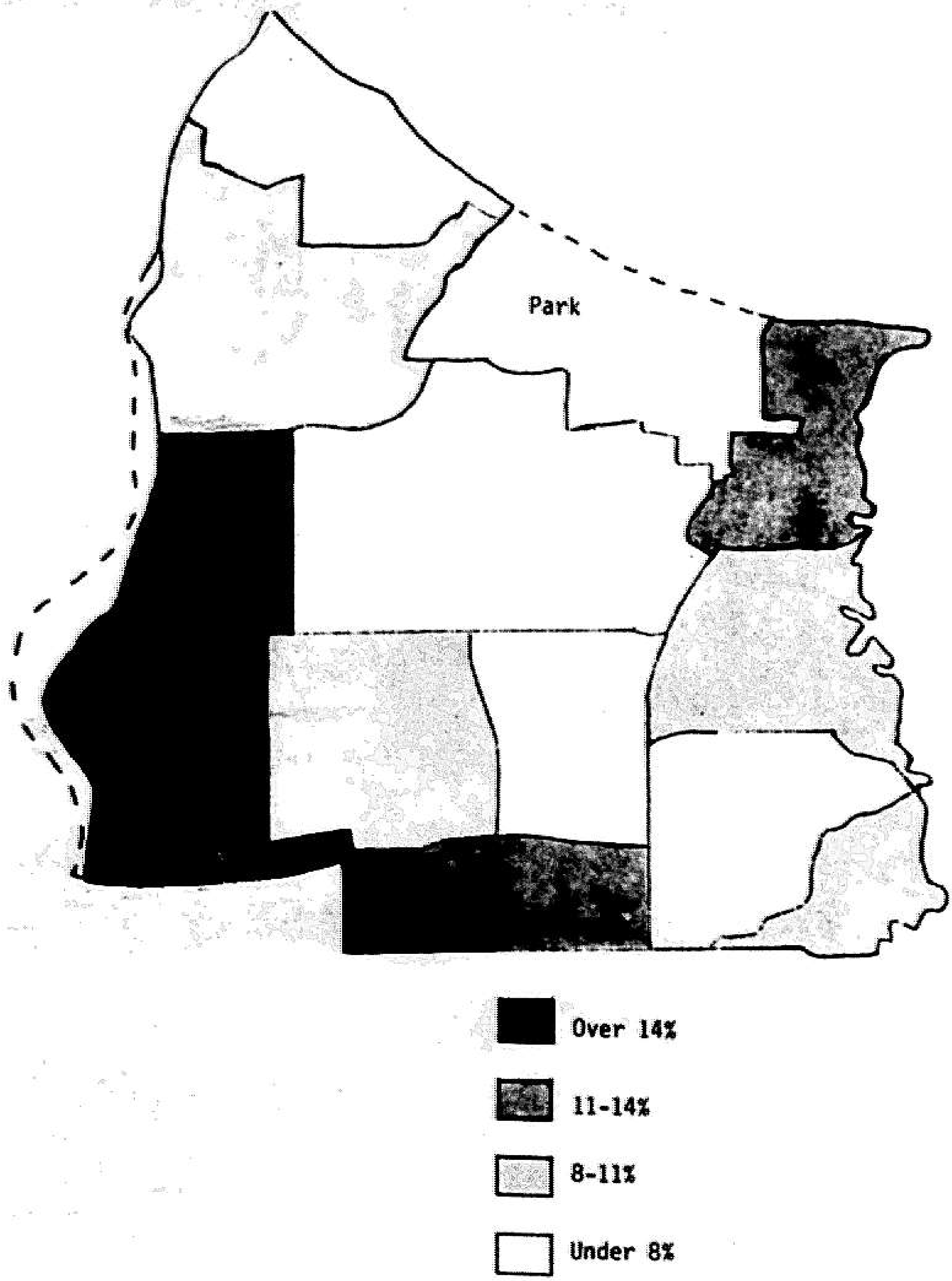


EXHIBIT 3.14

PERCENT OF HOUSEHOLDS NOT OWNING AN AUTO BY CENSUS TRACT, 1970

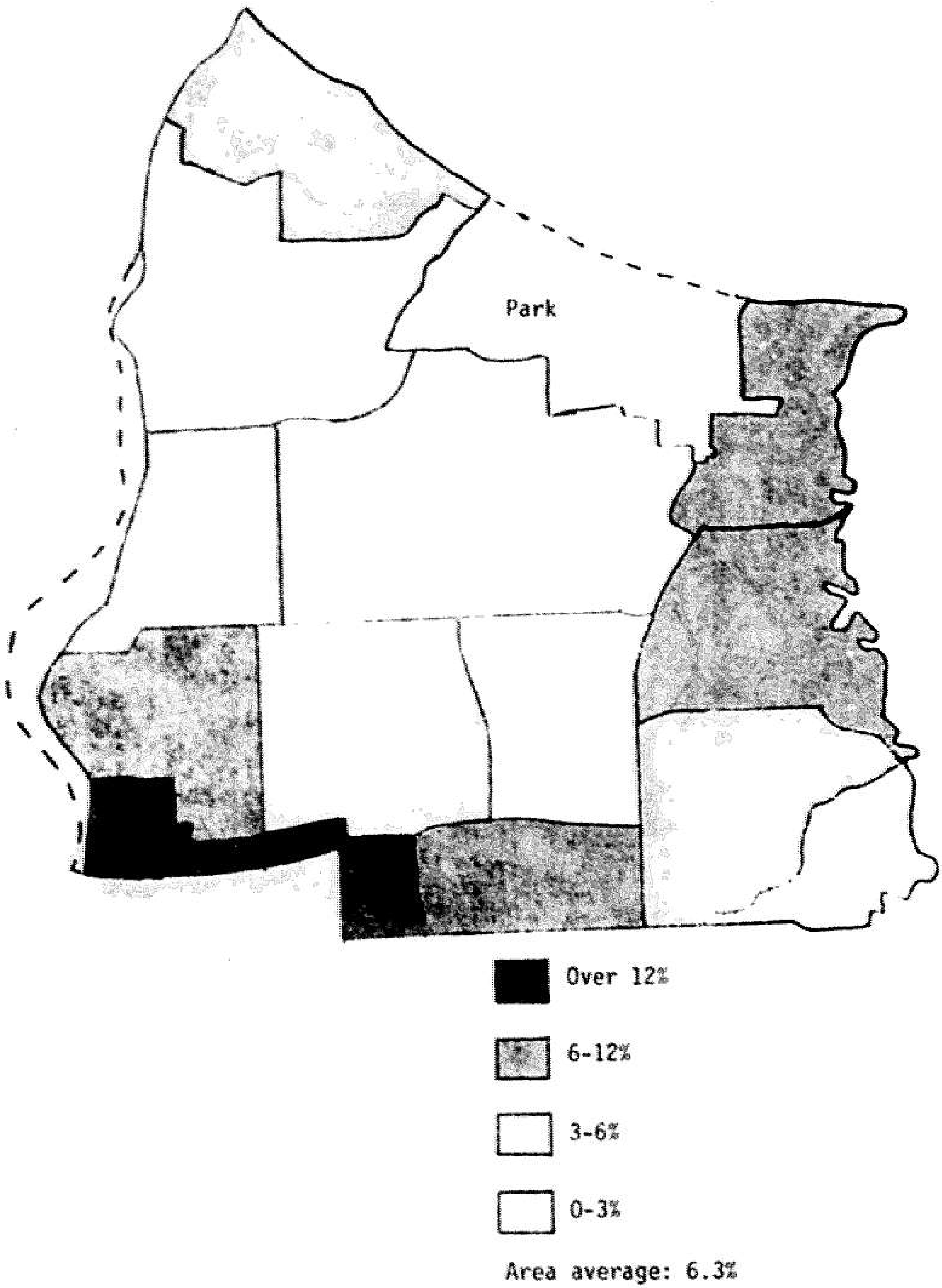
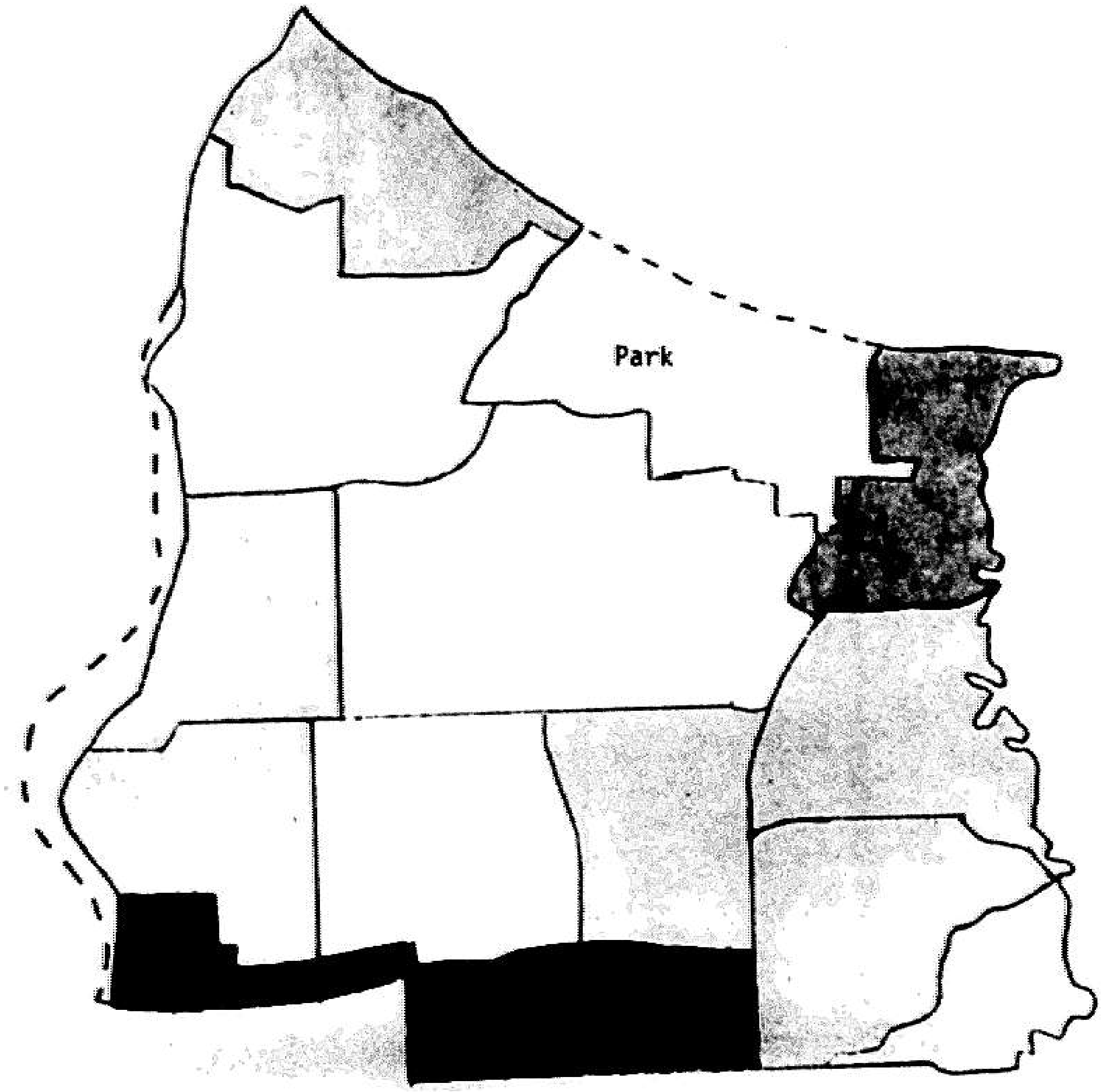


EXHIBIT 3.15

1969 MEDIAN FAMILY INCOME BY CENSUS TRACT



$10,000-$11,500

$11,500-$13,000

$13,000-$14,500

Over $14,500

Area average (mean): $14,787

Estimated area median: $13,300

area, the Urban PERT service area is largely within the City of Rochester, and Rochester residents comprise 77% of the area's population. Demographically, the Urban PERT service area is very similar to the City of Rochester as a whole. The area contains substantial black and poor populations, and roughly 30% of the households are autoless. In the southern portion of the Urban PERT service area near the CBD (the area south of Clifford Street containing 16,700 persons), 56% of the households are autoless (see Exhibit 3.14). Thus, the Urban PERT service area is representative of the City of Rochester, whereas the Irondequoit target area typifies the older Rochester suburbs.

3.2 THE URBAN TRANSPORTATION SYSTEM

3.2.1 Street and Highway Network

General

The development of the Rochester transportation system is typical of that of many older Eastern cities. A dense central city was served first by horse-drawn trolleys, followed by electric streetcars and, later, buses. A system of main arteries radiating from the CBD eventually evolved. Following World War II and the rapid rise in automobile ownership and usage, several limited-access freeways were built.

The New York State Thruway (the State's principal toll highway) bypasses Rochester seven miles south of the CBD. Interstate 490 is a spur from this throughway, approaching the Rochester CBD from both the east and west. Its two sections are called the Eastern and Western Expressways, and are the only freeways leading to the CBD. They both join the "Inner Loop," a circumferential highway completely encircling and serving to define the CBD. Much of an "Outer Loop" roadway (State Highway 47) has also been built, although it is not yet finished. When completed, it will form a "horseshoe" figure opening up toward Lake Ontario. The acquired right-of-way defines much of the service area's western boundary. A third limited-access road, the Keeler Expressway, runs from Webster through Irondequoit and Northern Rochester, meeting Ridge Road near the Genesee River. This expressway provides a convenient route for those traveling westward to Kodak Park. Finally, the Lake Ontario State Parkway passes through Northern Greece before meeting Lake Avenue. Persons traveling from distant northwest suburbs toward the Rochester CBD might use this road for part of their trip.

Partially because there is no north-south freeway passing through the CBD and Kodak Park, the greatest congestion occurs in the Lake Avenue corridor. This corridor, which passes through the service area, is the metropolitan area's busiest non-expressway thoroughfare. Recent plans to develop a rail transit system in Rochester have focused upon this corridor.

Greece

Within the Greece PERT service area, major arteries are spaced between 3/4 mile and one mile apart, forming the framework for a well-patterned grid system. The major north-south routes are Lake Avenue, Dewey Avenue, Mount Read Boulevard, and Long Pond Road. Those in the east-west direction are Ridge Road, Maiden Lane, English Road and Latta Road. Stone Road, the only major diagonal route, runs from Ridge Road northeast to Lake Avenue. This road is significant because it provides a "short cut" for northern Greece residents traveling to the major shopping malls on Ridge Road West.

This system of arterials seems to provide for the efficient movement of traffic. Speed runs made during May 1976 consistently indicated an average automobile travel speed of approximately 20 miles per hour during both the peak and off-peak periods. Only in the immediate vicinity of Kodak Park during the peak period was average travel speed somewhat less than this average. For trips in the northwestern portion of the service area, where there are few traffic signals, average speed was slightly higher than 20 miles per hour. Thus, traffic congestion has not been perceived as a major problem in Greece, other than in the Kodak Park vicinity during peak periods.

Parking in Greece is also generally adequate. The major shopping areas are located in malls with ample parking facilities, and Kodak provides adequate parking space for its employees at a nominal fee. However, in some cases, workers must walk for several minutes between their cars and their workplaces.

Irondequoit

Irondequoit has also developed a basic grid-patterned street system which is supplemented by two major freeways, the Keeler Expressway and the Outer Loop Road. The major north-south local streets are St. Paul Boulevard, Cooper Road and Hudson Avenue, Kings Highway and Culver Road. Well-traveled east-west routes include Ridge Road, Titus Road, Norton Street and Clifford Street (see Exhibit 3.9). Little congestion and parking shortages have been noted.

3.2.2 The Regional Transit Service (RTS)

Public transportation in the Rochester metropolitan area is provided by the Regional Transit Service, Inc. (RTS), the operating subsidiary of the Rochester-Genesee Regional Transportation Authority (RGRTA). RTS was created in 1968, when the City of Rochester purchased the failing Rochester Transit Corporation. In 1970, the four-county regional transportation authority was created by the New York State Legislature, and the authority purchased RTS from the City of Rochester.

As is typical of most public transit systems, ridership steadily declined during the three decades following World War II, but began to stabilize in the mid-1970's. During the fiscal year ending in March 1976, there were 16.5 million revenue passengers, a decrease of only about 1/2% from the previous year. However, because of a May 1976 fare increase (described below), ridership dropped 10% in the 1977 fiscal year.

Operating costs have also increased over time, especially during recent years. Total costs per vehicle-hour, for instance, have increased from $13.00 in fiscal year 1973 to $20.96 in fiscal year 1977, a 61% increase in four years. Major RTS operating characteristics for the fiscal year ending in March 1977 are shown in Exhibit 3.16. (PERT operations are excluded.)

In addition to the establishment of PERT services, the RGRTA has implemented several transit innovations since its formation. In 1971, the Batavia B-Line DAB system was instituted in the small town of Batavia, approximately forty miles southwest of Rochester. The service area included 18,000 persons in a 5.5 square mile area. More recently, RTS instituted a major fare restructuring. Prior to June 16, 1975, the basic RTS fare was 40 cents, with additional zone charges assessed for trips into the suburbs. At that time, zone charges were eliminated completely, the off-peak fare was reduced to 25 cents, and transit trips totally within the Inner Loop (i.e., within the CBD) were made free. Since that time, operating deficits have increased substantially, although this has been caused more by increases in operating costs than lost revenues.

Budgetary constraints in the State of New York as well as Monroe County resulted in less operating assistance than required to maintain existing fare levels, and fares were consequently increased beginning May 8, 1976. Peak period and weekend fares rose to 50 cents, increases of 10 cents and 25 cents respectively; off-peak weekday fares rose to 30 cents (a 5-cent increase).

EXHIBIT 3.16

OPERATING CHARACTERISTICS OF THE REGIONAL TRANSIT SERVICE, INC.

(Fiscal Year Ending March 31, 1977)

Service	Passengers	Revenues	Fare Revenue/Passenger
Regular service	11,695,607	$4,656,581	39.8¢
Commuter service	1,034,282	742,142	71.8¢
Student	1,853,930	654,651	35.3¢
Children	268,993	53,798	20.0¢
Transfer charges	(3,686,262)	184,313	5.0¢
	14,852,812	$6,291,485	42.5¢

Other Revenues	Amount
Charter	232,176
Route Guarantees	24,476
Advertising	75,000
Total Revenues	$6,623,137

Expenses	Amount	Percent of Total Costs
Drivers' wages	$4,942,522	40.9%
Fuel and oil	694,130	5.7
Other transportation expenses	679,143	5.6
Maintenance and garaging	2,303,912	19.1
General & administrative;rent	580,939	4.8
Pensions & employee welfare (benefits)	979,316	8.1
Advertising	130,116	1.1
Insurance & safety	511,280	4.2
Taxes	480,203	4.0
Depreciation	772,775	6.4
Total Expenses	$12,074,336	100.0%

Total cost per vehicle-hour: $20.96 (FY 1976: $19.44)
Total cost per vehicle-mile: $ 1.77 (FY 1976: $ 1.64)
Total cost per revenue passenger: 81.3¢ (FY 1976: 69.6¢)
Total revenue per passenger: 44.6¢ (FY 1976: 37.6¢)
Operating ratio (revenues/costs): 0.55 (FY 1976: 0.54)
Vehicle productivity (revenue passengers/vehicle-hour): 25.8 (FY 1976: 27.9)
Vehicle productivity (revenue passengers/vehicle-mile): 2.18 (FY 1976: 2.35)
Vehicle-hours operated: 576,187 (FY 1976: 589,912)

Operating Assistance

Federal	$2,702,582
State of New York	931,950
Monroe County	912,000
Wayne County	10,450
Livingston County	9,500
	$4,566,482

The impacts of these fare changes, both of which occurred during the demonstration period, have not been fully ascertained. Less than one year transpired between the first fare change and the 1976 increase. A significant increase in ridership within the CBD occurred; it is assumed that most of that increase was due to diverted walking trips. The number of revenue passengers after the fare reduction was slightly under that which occurred before the fare change. Although RTS ridership had been steadily decreasing for many years up to that point, these decreases were becoming steadily smaller over time. It was quite possible that Rochester ridership was stabilizing regardless of the fare change. Thus, a reasonable conclusion is that the June 1975 fare decrease had a positive impact on overall transit ridership, but the impact was not significant except for trips within the CBD.

The May 1976 fare increase, on the other hand, resulted in a 10% to 15% decrease in ridership. Since the average fare increase was about 22%, ridership was expected to drop by only 7% based on experience with conventional fare elasticity. Thus, the fare hike increased total revenue only slightly.

3.2.3 Public Transportation in Greece

Prior to the demonstration, four RTS buses operated within the Greece service area. Exhibit 3.17 displays the area served by these fixed routes, assuming a one-quarter mile accessibility corridor on each side of the bus route. Exhibit 3.18 describes the average headways on each route at the time PERT services were implemented. Altogether, about 49.3% of the Greece service area population had access to at least one of the fixed-route buses (within 1/4 mile), and 65.3% lived within 3/8 mile of a route. Services have remained essentially unchanged for Routes 1 and 15, but have changed on Routes 10 and 14, as noted below.

Route 1 (Lake)

Route 1 operates from Island Cottage, at the northernmost point of Rochester, down Lake Avenue past Kodak Park to the CBD. Only during the peak period, however, do Route 1 buses operate along Beach Avenue to and from Island Cottage. At other times, buses terminate at the intersection of Lake and Beach Avenues (the Charlotte terminal), and some run only as far north in Kodak Park during both peak and off-peak periods. Approximately 9,900 persons in the PERT service area (or 14% of the population) are within 1/4 mile of Route 1. Route 1 is the most heavily used of all the

EXHIBIT 3.17

FIXED-ROUTE BUS SERVICE AREAS

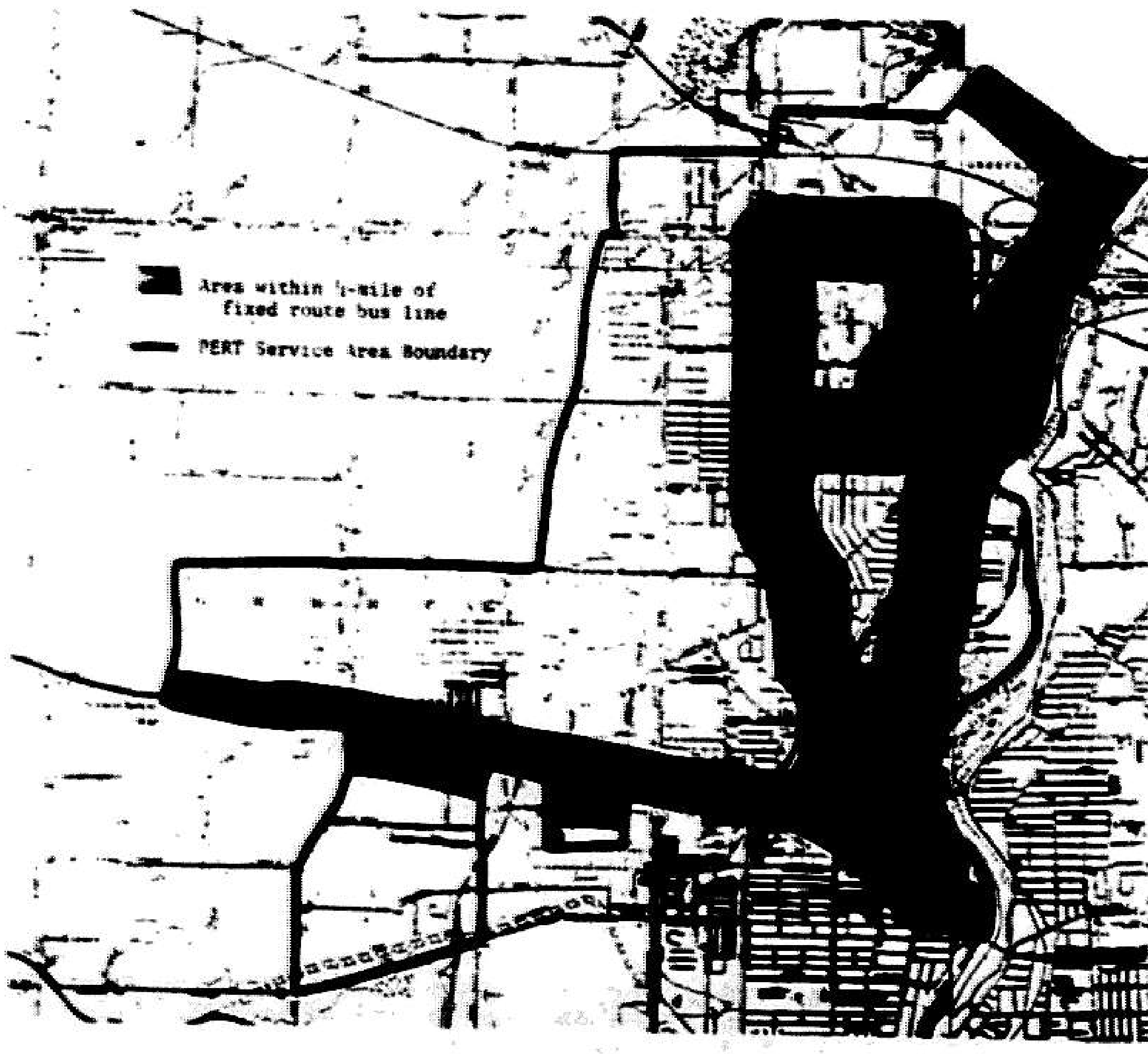


EXHIBIT 3.18

GREECE RTS FIXED-ROUTE COVERAGE BEFORE PERT

Location	% of Service Area Population Within		Average Headways in minutes before PERT				
	1/4 mi.	3/8 mi.	Peak (6-8:30 AM, 3:30-6 PM)	Midday	Evening & Night	Saturday	Sunday
1-Lake	14.4	18.3	8 (20[a])	24	34	25	47
10-Dewey (to downtown)	26.1	36.7	29[b]	45	45	40	41
14-Ridge	11.1	16.1	20	40	40[c]	59	--
15-Dewey (to Kodak Park)	26.2	36.9	14	--	--	--	--

[a] Above Charlotte

[b] Buses follow Route 15 to Kodak Park and then follow Lake to the C.B.D.

[c] Evening only

Note: Many Route 1 and Route 10 buses terminate at Ridge Road, the southern boundary of the service area. The average headways stated above only include buses continuing or starting north of Ridge Road. During the midday period, for instance, only about every other Route 1 bus continues north of Ridge Road (Kodak Park) and only every third Route 10 bus crosses Ridge Road. The midday Routes 1 and 10 headways at or below Ridge Road would thus be about 12 and 15 minutes respectively.

fixed-route buses passing through the Greece service area, and has the highest overall vehicle productivities. Peak-period demand north of Ridge Road was approximately 260 demands per hour. Route 1 runs only within the City of Rochester, hence there were no zone charges on this route prior to June 1975. Route 1 has the shortest headways of any of the fixed-route buses in Greece. No significant changes were made in its operation after PERT services began.

Route 10 (Dewey)

Route 10 buses serve the Dewey Avenue corridor from Latta Road to the CBD. Route 10 has the greatest penetration into the Greece service area, with about 18,000 persons or 26% of the service area population living within one-quarter mile of the route. However, the combination of long headways, a circuitous path within Greece, and passage through areas of high automobile ownership resulted in a much lower utilization of Route 10 than that of Route 1 above Ridge Road. Peak-period demand north of Ridge Road was about sixty trips per hour. Consequently, it was chosen as one of the routes to be "rationalized" shortly after PERT was introduced. After January 1975, there was no midday, evening or Saturday Route 10 service north of Ridge Road. Prior to the RTS fare restructuring in June 1975, a trip on Route 10 that crossed Eastman Avenue (the Greece-Rochester border) cost 50 cents. Thus, for most PERT service area residents wishing to use Route 10, a 50-cent fare was required.

Route 14 (Ridge)

Route 14 is a crosstown route primarily serving Kodak Park at Lake Avenue and Ridge Road. This route runs along Ridge Road as far west as Manitou Road in West Greece. Headways are relatively lengthy. Seventy-six thousand service area residents (11% of the population) reside within one-quarter mile of the fixed route. Peak-period demand was about sixty trips per hour. In June 1974, all service except for the peak period was eliminated. As with Route 10, a 50-cent fare was charged prior to June 1975 for trips between the Town of Greece and Rochester (the standard 40-cent fare applying otherwise).

Route 15 (Dewey)

Route 15 is a peak-period-only route primarily transporting commuters to and from Kodak Park. Its route coincides with Route 10 above Ridge Road, but then turns and follows Ridge Road to Kodak Park. Peak-period demand was about eighty trips per hour.

3.2.4 Public Transportation in Irondequoit

In contrast to the situation in Greece, the Irondequoit PERT areas were relatively well served by RTS fixed-route services prior to PERT's introduction in April 1976 (see Exhibit 3.10). Eight bus routes traversed the Irondequoit target area, of which three operated only during the peak period.

The all-day routes (Routes 5, 7, 9, 10 and 12) all served the CBD. The three peak-period-only lines (Routes 13, 14 and 23) were cross-town routes. Three additional routes (11, 15 and 19) operated along the edge of the target area. Together, these routes managed to provide transit coverage to a major portion of the target area, as shown in Exhibit 3.19. Assuming that persons residing within one-quarter mile of a bus route have access to that route, 73.0% of the target area population had access to transit during the peak period, and 65.3% were covered during the off-peak period.[1] Within the DAB service area, which had a higher route density, 82.8% and 73.5% of the population lived within one-quarter mile of transit during the peak and off-peak periods, respectively. Because it was nearest the CBD, the Urban PERT service had the greatest transit coverage. During the late evening hours when Urban PERT operated, 89.1% of the population lived within one-quarter mile of an operating bus route.

Target area residents without one-quarter mile access of a fixed-route bus during the peak period lived in three general areas. The largest group (about 7,600 persons) resided in the northwestern area of Irondequoit. An additional 4,700 persons were located in the southeastern portion of the target area. The remaining 2,900 residents were scattered among four small areas in Central Irondequoit (see Exhibit 3.19).

Thus, most potential users of PERT service already had the option of using a fixed-route bus and not having to walk more than one-quarter mile to access it. Headways on these buses varied, as shown in Exhibit 3.20, but were generally around 15 minutes during the peak period and 30 minutes during the off-peak period. However, except for the peak-period-only routes, all of the routes were aligned toward the CBD. Consequently, transit only carried a small portion of the total travel market. A 1974 household survey conducted by the New York Department of Transportation

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[1]The off-peak period refers to the weekday midday period. Route 12 did not operate north of Norton Street during the evening or on weekends.

EXHIBIT 3.19 FIXED-ROUTE BUS SERVICE AREAS (¼-MILE ACCESS)

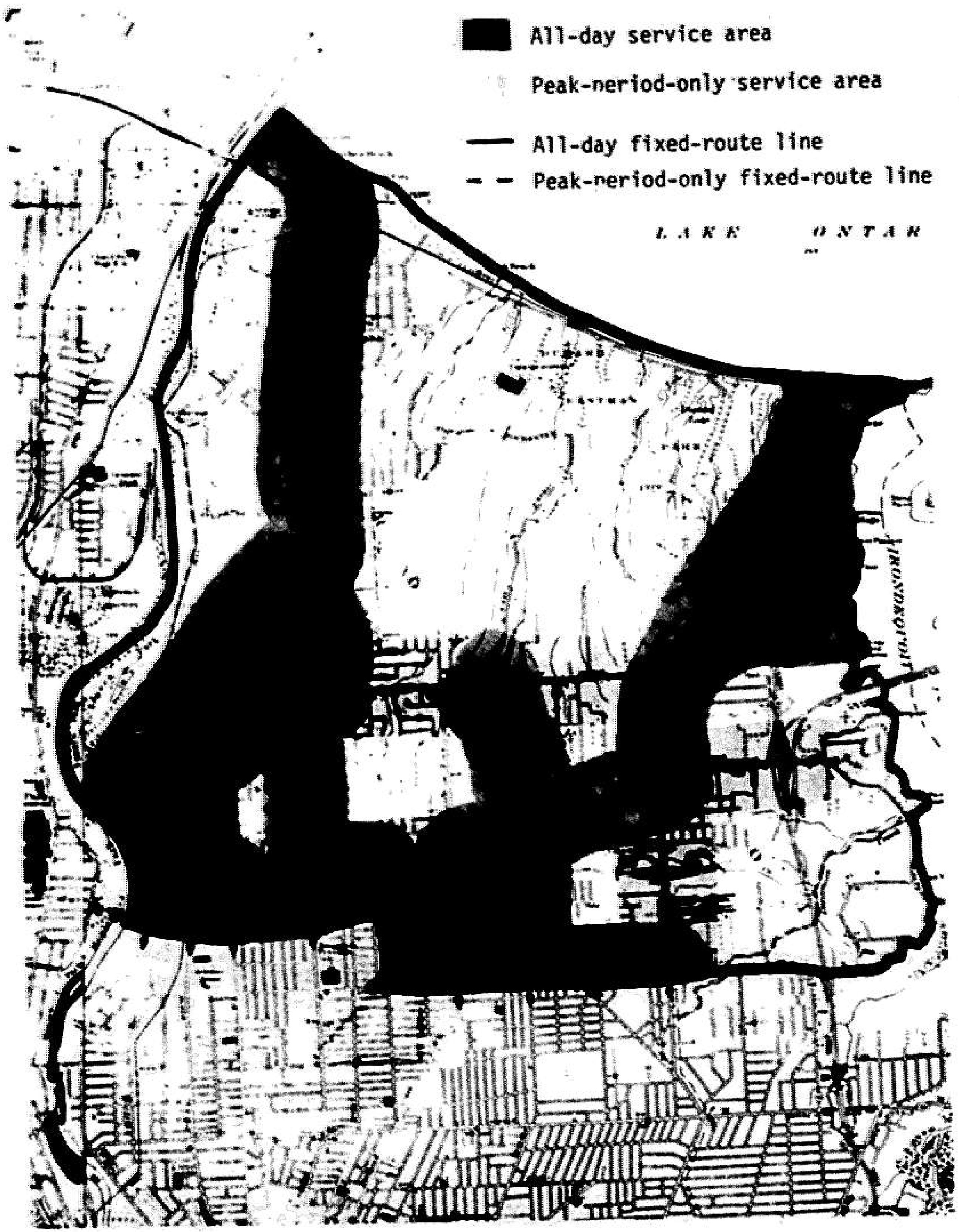

EXHIBIT 3.20

IRONDEQUOIT TARGET AREA BUS ROUTES

Route	Average Headways, January 1976 (minutes) Peak (6-8:30 AM; 3:30-6 PM)	Midday (9:30 AM-2:30 PM)	Average Irondequoit Target Area Ridership Per Round-Trip Run Peak[a]	Midday[b]	Peak Period Ridership (# of runs during peak X riders/run)
5 St-Paul	15	45	13.0	21.0[c]	286
7 Clinton	17	32	15.6	13.8[c]	306
9 Hudson (Irondequoit Plaza Spur)	19	35	16.8 (combined)	16.8[d]	476 (combined)
9 Hudson (Carter St. Spur)	35	35		4.6[d]	
10 Portland	15	30	32.4	21.0[e]	713
11 Joseph	13	22	N/A	N/A	N/A
12 Goodman	13	20	12.9	6.4[d]	323
19 Clifford	12	15	N/A	N/A	N/A
13 Culver X-Town	30	--	1.2	--	12
14 Ridge	34	--	13.6	--	122
15 Norton	27	--	9.1	--	127
23 Titus X-Town	40	--	11.5	--	58

[a] Peak period ridership is calculated from counts made at or near edge of target area and thus underestimates ridership by excluding passengers both boarding and disembarking within Irondequoit, estimated to be between 5% and 10% of ridership.

[b] Midday ridership includes all passengers boarding or disembarking north of points noted (footnotes c-e)

[c] North of Ridge Road.

[d] North of Norton Street

[e] North of Rochester General Hospital

Source of Ridership Data: Center for Transportation Studies, Massachusetts Institute of Technology. Rochester Integrated Adaptable Transit Service Program First Year Report (June 1976), page A-80 (sample sizes not reported), and RTS ridership records.

(NYDOT) disclosed that only about 2.2% of all trips originating or ending in the Irondequoit area[2] were made by transit. In addition, although local intra-Irondequoit trips made up 52% of all trips in the NYDOT survey, RTS ridership counts suggest that only about 5% to 10% of Irondequoit transit riders were using the bus to make local trips.

Work trips and trips to the CBD are more likely to be made by transit than local trips. In 1970, 7.1% of target-area workers used the bus for commuting. Although much lower than the transit mode share within the City of Rochester, this was greater than that reported in any other Rochester suburb. The spatial variation of work trip transit mode share is shown in Exhibit 3.21.

3.2.5 Irondequoit Transit User Characteristics

Prior to the start-up of Irondequoit PERT services, off-peak on-board surveys were conducted on several fixed-route buses. The surveys were taken on Thursday, March 25 and Saturday, March 27, 1976. During the Thursday midday period (9:00 A.M. to 3:00 P.M.), riders on Routes 5, 7, 9, 10 and 12 boarding or exiting north of Norton Street were surveyed. Route 5 and 7 passengers were also surveyed between 6:00 P.M. and 9:00 P.M., since the PERT Summerville Shuttle would also impact these riders. Route 5, 7, 9 and 10 passengers were also surveyed on Saturday between 8:00 A.M. and 6:00 P.M. (Route 12 did not operate north of Norton Street on Saturdays.) Collectively, these passengers represent the "day" group. Passengers on Routes 5, 7, 9, 10 and 11 boarding or exiting north of the downtown terminal after 9:00 P.M. were also surveyed on both days. The latter "night" passengers represent the Urban PERT impact group. Altogether, about 1,900 survey forms were distributed, and 962 were returned either on-board or by mail. The results are contained in Appendix A.10 and are stratified by day and night passengers. Generally, responses did not vary significantly by route or day of week.

Section 9.9 discusses the survey results in detail, and compares those results to similar surveys taken on PERT services. However, at this point it is instructive to summarize the response to the three attitudinal questions in the survey. Passengers generally agreed that safety,

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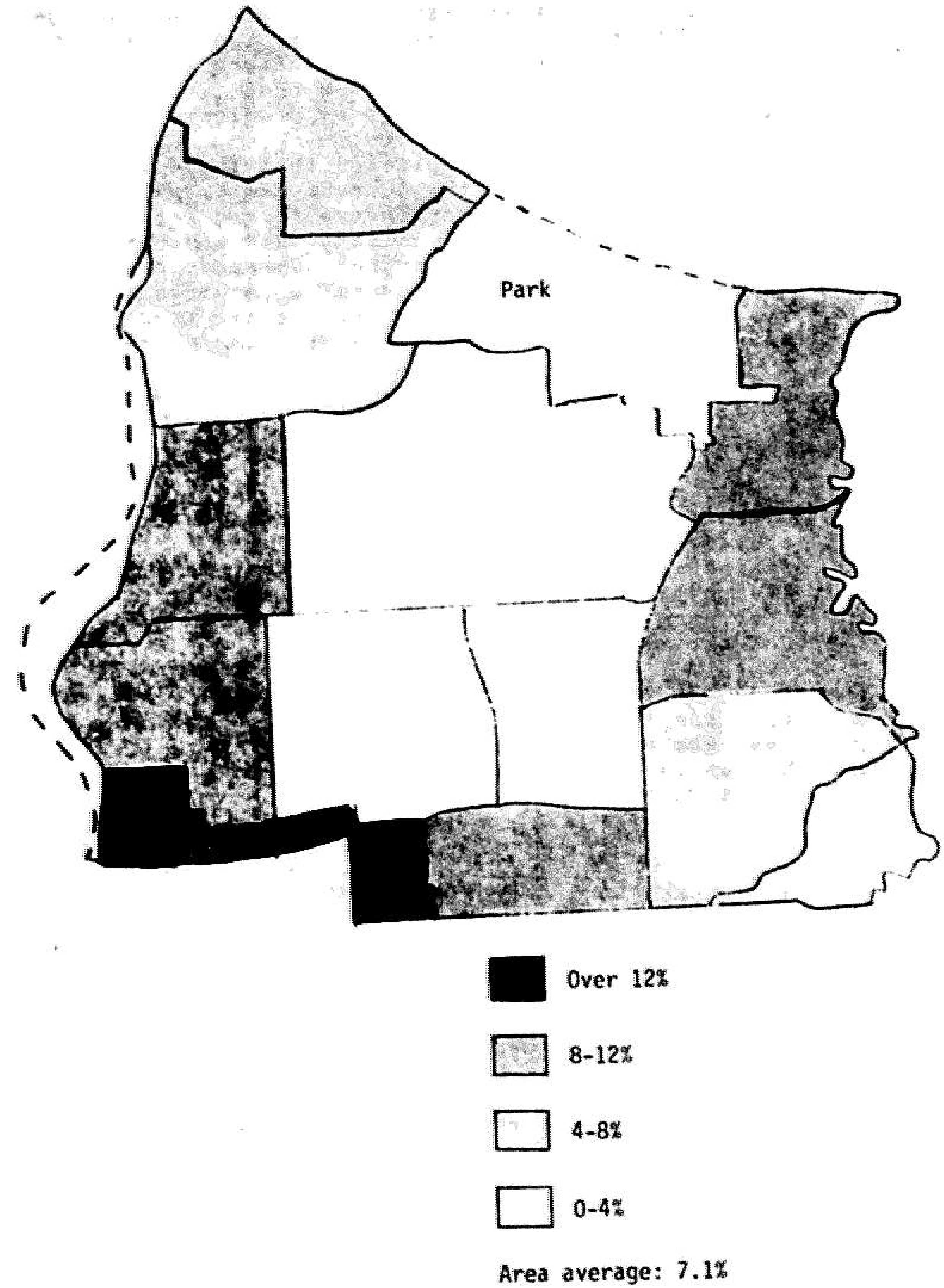
[2]The entire town of Irondequoit plus northern Rochester north of Norton Street was analyzed (an area slightly larger than the Irondequoit target area).

EXHIBIT 3.21

PERCENTAGE OF WORK-TRIPS MADE BY TRANSIT BY CENSUS TRACT, 1970



convenience and punctuality were the most important travel mode characteristics for making travel mode decisions. The cost of travel was slightly less important, while speed, comfort and simplicity were judged to be considerably less important. In rating RTS bus travel, however, users judged it very favorably regarding safety and convenience, but much less so regarding punctuality. Responses to a third question indicated that waiting for buses and bus scheduling were the most serious perceived problems.

These responses indicated that the most needed improvement, in the view of the current users, was in the area of punctuality. Demand-responsive services primarily emphasize convenience, safety and comfort, and sometimes sacrifice punctuality since they may not adhere to a schedule. The success of PERT demand-responsive services thus appeared to rest upon their ability to attract new transit users rather than substantially improve service for current RTS users.

3.2.6 Other Transportation Services

In addition to buses, taxi service is provided in the City of Rochester by 260 taxis, the number of licenses approved by the Rochester City Council in 1968. One local newspaper report in 1975 stated that there was a waiting list of 90 persons for taxi-plate registrations, and that they were being sold privately for as much as $3,000 each.[3] The official fee is $35.

The Town of Greece presently has two cabs, both owned by a single operator. A second company consisting of three taxicabs went out of business in 1975; whether or not PERT had an impact on this is unknown. No taxi companies are based in Irondequoit.

3.3 EXOGENOUS FACTORS

PERT service innovations in Greece and Irondequoit were introduced into stable communities with well-developed travel patterns and some fixed-route transit. Many factors exogenous to the demonstration, both within and outside the community, had a pronounced impact upon the demonstration. These factors must be included in the evaluation of PERT service, and should be considered by other jurisdictions when relating the results in these two communities to their

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[3]Rochester Times-Union, March 2, 1975.

own areas. The setting described earlier in this chapter identifies some of these factors; additional ones are described below.

3.3.1 Gasoline Shortages

The first winter of Greece's PERT operation, 1973-74, was the period of gasoline shortages and price increases. The resulting nationwide shift to transit also occurred in Greece. The shortage crisis was resolved during the period covered in this analysis, but the higher gasoline prices persist. This fact and the fear of future shortages may have affected behavior in Greece, and possibly to a lesser extent in Irondequoit, during the demonstration.

3.3.2 New York City and State Fiscal Problems

In 1975, the financial viability of New York City became a national concern when it appeared that the City could not service its debt. The situation had repercussions on the finances of the entire State, as it became clear that State funds for transit subsidies would be scarce. This crisis occurred at a time when the entire nation was experiencing an inflation level exceeding historical levels in an economy that was not growing or was growing much more slowly than during previous periods.

The impact on RTS was profound. Although operating costs were rising, reduced tax revenues resulting from the economic slowdown prevented subsidies from increasing correspondingly. A budget crisis occurred and, by mid-1976, there was serious question as to whether RTS and transit operations in Rochester could survive through 1977. This was in sharp contrast to the situation existing in 1973, when services began and RTS was expanding. This pessimism caused many local decisionmakers to consider the non-handicapped and non-elderly PERT services a luxury they could not afford. Since these feelings were expressed in the media, the general public may have begun to perceive PERT as a set of services which could not be relied upon for their future transport needs.

3.3.3 Cessation of Back-Up Computer Dispatching Services

In April 1976, a major fire at a contractor's facility destroyed several computers and associated hardware that served as back-up for computerized scheduling and dispatching. Without the necessary back-up capabilities, computerized scheduling and dispatching were subject to interruptions due to hardware failures. Computer usage was impossible for about two weeks, and transit service levels declined for several weeks afterward.

3.3.4 Severe Winter Weather

As discussed in Section 3.1.1, Rochester winters are colder and snowier than in most other U.S. cities. However, the 1975-76 and 1976-77 winters were both unusually severe and seriously impacted PERT vehicle performance and service reliability. During December 1975 and January 1976, a total of 58.2 inches of snow fell in Rochester, about 65% above normal for these two months. January temperatures were over four degrees below normal, averaging 19.8 degrees. It was during these months that serious vehicle breakdown problems began (see Section 5.2.2), and the weather may have been a contributing factor.

The following winter was also exceptionally cold and snowy. December 1976 and January 1977 snowfall totaled 54.7 inches, and temperatures were 6.6 degrees below normal. In January 1977, the average daily temperature was 15.5 degrees, and the temperature passed the freezing point on only two days during the entire month. Again, vehicle performance, operations, and ridership were affected by these unusual conditions.

3.3.5 Media Coverage of the Demonstration

During the first two and one-half years of PERT service, until early 1976, media coverage of PERT was generally favorable and mainly reflected the content of RGRTA press releases. Press coverage was primarily factual, outlining the service offerings and expansions, the growth of ridership, etc. In early 1976, however, PERT began to receive negative publicity because of several concurrent events including the deterioration of service levels during the 1975-76 winter, public arguments about the Irondequoit PERT service package and, most important, the growing RTS financial crisis.

Beginning in late 1975, PERT vehicle breakdowns became an extremely serious problem and caused a significant deterioration in the level of service offered to users (see Section 5.2). During the early stages of computerized dispatching, services levels were also often very poor.

These phenomena caused a number of users to write angry letters to local newspapers, and many of these letters specifically cited the "computer" as the culprit because drivers tended to blame service delays on the computer when confronted with an angry rider.

At about the same time, Irondequoit service planning was being conducted with many public hearings and considerable media attention. These events were generally reported favorably; however, one faction -- led by Eugene Mazzola, a County legislator from Irondequoit -- was very vocal in expressing displeasure regarding the proposed service plan and the lack of planned DAB service in East Irondequoit.

The budget crisis that faced RTS had the most pronounced effect on the demonstration's media coverage. As RTS was struggling to secure additional funding and had to raise fares, the $3.6 million demonstration which served relatively few people compared to RTS became an easy target for critics. As early as March 18, 1976, the project was portrayed in a worrisome manner:

> Dial-A-Bus is not defunct; neither is it completely "well," although reasonably "alive" according to reports from the PERT system.[4]

By September, the future of DAB service was being called into question by the press. Thomas Frey, the chairman of the State Assembly transportation committee, was quoted as calling the demonstration an "absolute disaster" and a "pie in the sky.[5] " The local press also published pessimistic statements made by acting RGRTA executive director Howard Gates:

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[4]"Dial-A-Bus Promises Increased Capacity, Service, New Buses," Rochester Democrat and Chronicle, March 18, 1976.

[5]"Gloom Grows Over Bus System Future," The Irondequoit Press, October 14, 1976.

> Unless additional funding can be obtained, "it is going to be extremely difficult to continue Dial-A-Bus service as it is now" after June 1977..."I have to say that the outlook for Dial-A-Bus is a little bleak. I hope something can be worked out," Gates states, "even if we have to pare down the service.* "

The PERT service cutbacks that took effect in January 1977 were promoted by RGRTA as the culmination of a "continuing experiment to find a viable economic alternative to fixed-route public transit." The press releases and advertisements also noted that "the results of the experiment so far indicate that a combination of limited Dial-A-Bus and fixed-route services is the most likely answer to our public transit needs and problems." With the improved PERT level of service in 1977 and a relative lull in RTS financing concerns, media coverage of PERT returned to a less sensational level.

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*"Drastic Cuts Coming for Bus Service? Decision is Near," _The Irondequoit Press_, September 19, 1976.

4. PERT OPERATIONS AND MANAGEMENT

This chapter contains descriptions of PERT services and the non-service innovations for implementing and integrating PERT services. The implementation process is described, as well as the changes that occurred in the supply of these services over time.

4.1 INTRODUCTION

Although Rochester was not designated as a demonstration area until nearly two years after PERT services began in Greece, this report treats the entire period in which PERT operated. This is necessary because the period prior to the demonstration included the implementation of most of PERT's service, system and fare innovations. When the demonstration began on April 1, 1975, the Greece PERT service area had been expanded three times, several promotional activities had been completed, and changes in the fixed-route bus system had been made. Consequently, the major growth in DAB ridership occurred prior to the demonstration, and ridership had stabilized by the time the demonstration began. For these reasons, little differentiation is made in the analysis between the demonstration and pre-demonstration periods. Unfortunately, extensive data collection activities did not occur until the demonstration period, a fact which limits the scope of the analysis of the early phases of the project.

Exhibit 4.1 contains a chronology of the major events in the evolution of Rochester PERT service. Events occurring from August 6, 1973 through April 12, 1976 pertain only to Greece; thereafter, services were expanded to include Irondequoit. In October 1974, when the application for demonstration funding was submitted to UMTA, RGRTA had adopted a plan calling for the expansion of PERT DAB and subscription services into five additional suburban areas, including Irondequoit. The demonstration was proposed as a means of implementing PERT services in two of these areas: Irondequoit and Henrietta. Although demonstration services were implemented only in Irondequoit, the new demonstration initiated in November 1977 will focus on demand-responsive services in the towns of Brighton and Henrietta.

Six distinct PERT services were provided in Greece, including many-to-many DAB, work and school subscription services, special group trip services, a handicapped passenger service, and the Dew-Ridge Shuttle, a hybrid fixed-route and point deviation service. DAB was the most predominant of these services, accounting for about three-quarters of

EXHIBIT 4.1

DEMONSTRATION CHRONOLOGY

August 6, 1973	PERT service begins in Greece, including Dial-A-Bus (DAB) and work subscription service to Kodak Park; service area = 9.6 square miles; population served = 52,000; fleet size = 7 vehicles; DAB operating hours = 8:15 A.M. to 5:30 P.M.
September 10, 1973	School subscription service begins in Greece.
September 24-28, 1973	Work subscription service reduced-fare promotion.
November 12-16, 1973	First DAB half-fare week.
December 10, 1973	Eighth PERT vehicle acquired.
January 24, 1974	First shoppers' special is operated in Greece.
February 11-12, 1974	Off-peak and subscription feeder reduced-fare promotions.
April 22-26, 1974	Second DAB half-fare week.
May 28, 1974	Work subscription service to Rochester Products begins.
June 24, 1974	Service area significantly expanded and DAB operating hours extended; Saturday service begins; Route 14 service cut during off-peak period.
September 3, 1974	Ninth-twelfth PERT vehicles acquired, including one vehicle subsequently equipped with a wheelchair lift.
September 9, 1974	Route 10 service cutback to Ridge Road at night and on Saturdays and to Northgate Plaza during midday; Greece service area expanded.
September 30 to October 4, 1974	Half fare DAB coupons appear in newspaper advertisements.
November 4, 1974	Service area expanded.
November 11-14, 1974	Subscription feeder reduced-fare promotion.
January 6, 1975	Route 10 service cut to Ridge Road during midday; $0.50 midday feeder fare incorporated; thirteenth PERT vehicle (the Electrobus) acquired jointly with Rochester Gas and Electric.
April 1, 1975	Demonstration officially begins (delayed from January 1975).
April 7, 1975	Handicapped service begins in Greece.

(Exhibit 4.1, Continued)

June 16, 1975	RTS off-peak fares reduced to $0.25; special handicapped service begins in Greece and Irondequoit; transit fares in Rochester inner loop are eliminated; fourteenth - sixteenth PERT vehicles put into service.
June 1975	Promotional newsletter with half-fare coupons mailed.
September 8, 1975	Service area expanded; nine new locations added as special handicapped service destinations.
September 1975	Computerized dispatching begins to be implemented.
December, 1975	Severe vehicle breakdowns begin to be encountered. Twelve new GM vehicles acquired. Electrobus retired from service.
January-February 1976	Promotion with half-fare coupons mailed.
April 12, 1976	Irondequoit PERT services begin:

Dial-A-Bus: Operates in a 6.9 square mile area between 8:00 A.M. and 9:00 P.M. on weekdays and 8:45 A.M. to 7:45 P.M. on Saturdays. Service also provided to three checkpoints in eastern Irondequoit.

Irondequoit Loop Bus: Operates from 9:00 A.M. to 3:00 P.M. on weekdays and 9:00 A.M. to 6:00 P.M. on Saturdays in counter-clockwise direction only at 45-minute headways.

Summerville Shuttle: Operates from 9:30 A.M. to 2:30 P.M. and 7:00 P.M. to 10:00 P.M. on weekdays, and from 7:00 A.M. to 10:00 P.M. on Saturdays, at 45-minute headways. Two deviation checkpoints provided.

Work Subscription Service: Checkpoint service provided to Building #205, Kodak Park West.

ARC Subscription Service: Checkpoint service provided to ARC, 999 East Ridge Road.

Routes 14 and 23: PERT operates Routes 14 and 23; no route changes.

Urban PERT: Route deviation service provided by Routes 5, 7 and 9. PERT buses also used on Route 10.

Transit-Dependent Service: PERT special handicapped service (in conjunction with Greece PERT service) continued.

RTS Routes 5, 7 and 11 terminate at Clinton and Ridge during periods when Summerville Shuttle operates.

(Exhibit 4.1, Continued)

April 12, 1976	RTS Route 9 terminates at Hudson-Ridge Towers on Keeler Street between 9:30 A.M. and 2:00 P.M. on weekdays and 9:30 A.M. and 6:00 P.M. on Saturdays.
	RTS Route 12 terminates at Northside Hospital between 9:30 A.M. and 2:00 P.M. on weekdays.
May 10, 1976	RTS fares raised to $0.50 during peak period and weekends, $0.30 during off-peak periods.
June 21, 1976	PERT fixed-route fares and DAB additional passenger fares increased from $0.25 to $0.30.
	Subscription service to Xerox facilities in Webster begins.
	Full-time computerized dispatching begins in Greece.
	Irondequoit:
	Dial-A-Bus service cut back to 7:00 P.M.
	Third deviation checkpoint added to Summerville Shuttle.
	Irondequoit Loop operating hours changed to 10:00 A.M. to 4:00 P.M. on weekdays; Brookview and Coronado Street route eliminated. Service in both directions offered on Saturdays.
	Route 10 operations under Urban PERT returned to RTS.
	RTS Route 9 midday service north of Ridge-Hudson Towers restored.
July 26 to August 7, 1976	Dial-A-Bus half-fare promotion using newspaper coupons.
September, 1976	Greece: Transfer station opens at Dewey and Ridge Road.
	Irondequoit: Transfer station opens at Clinton and Ridge.
September 13, 1976	Zonal DAB fare system introduced.
	Greece: A midday "Dew-Ridge" fixed-route/point deviation shuttle begins service on Dewey Avenue and Ridge Road. Greece DAB service area contracted.
	Irondequoit:
	Dial-A-Bus service area expanded to 8.6 square miles.
	Park-and-Ride service provided by work subscription buses returned from Xerox in Webster. Work subscription service expanded.
	Experimental clockwise-direction Saturday Loop Bus service terminated.

(Exhibit 4.1, Continued)

September 13, 1976	Irondequoit: Weekly special service to Jewish Home and Infirmary begins. Route deviation fares on Urban PERT lowered.
October 4-9, 1976	Irondequoit: Loop Bus promotion; free service offered.
October 11-15, 1976	Greece: Dew-Ridge Shuttle Free-Fare Week.
October 18, 1976	Revised PERT Handicapped Service implemented, featuring semi-scheduled service.
January 3, 1977	Evening and Saturday DAB service eliminated; Zonal DAB fares eliminated; replaced by flat $1.25 fare, $0.50 for additional passengers. Irondequoit: Loop Bus eliminated. Urban PERT service eliminated; RTS service on Routes 5, 7 and 9 restored. Route 14 and 23 operations returned to RTS. Evening Summerville Shuttle service eliminated. RTS restores evening service on Routes 5 and 7 and midday service on Route 12, but half of the latter buses continue to terminate at Northside Hospital.
January 17, 1977	Work subscription fares increased.
January - February 1977	Seven new vehicles (vans and maxi-vans) acquired. Seven older vehicles retired from fleet.
February 1977	Irondequoit: Computerized dispatching of Dial-A-Bus begins.
February 28 to March 4, 1977	Work subscription service free all week.
March 1977	Irondequoit: Two new special services for elderly begin.
March 7-11, 1977	Irondequoit: Dial-A-Bus promotion; half-fare all week.
March 14-18, 1977	Greece: Dial-A-Bus promotion; half fare all week.
June 20, 1977	Work subscription service eliminated. One vehicle retired from service. Greece: School subscription service terminated. Irondequoit: Summerville Shuttle service eliminated; RTS service on Routes 5 and 7 restored.
October 28, 1977	Demonstration ends (original termination date June 30, 1977). Operations cease for one week and then start up again while awaiting decision on proposed follow-on demonstration.
December 7, 1977	New demonstration grant awarded, enabling continued operation of existing Greece and Irondequoit PERT services, and expansion into Brighton and Henrietta through June 1979.

the PERT vehicle-hours supplied and two-thirds of the passengers carried through September 1976. At that time, the Dew-Ridge Shuttle was implemented within the DAB service area and attracted about one-third of the DAB demand.

Between August 1973 and September 1975, the DAB service area was expanded from 9.6 to 15.2 square miles. Evening and Saturday service hours were also added, and service was eliminated on two of the three former off-peak fixed routes in the area. When the Dew-Ridge Shuttle was implemented, the DAB service area was contracted and, in January 1977, service was again cut back to weekdays.

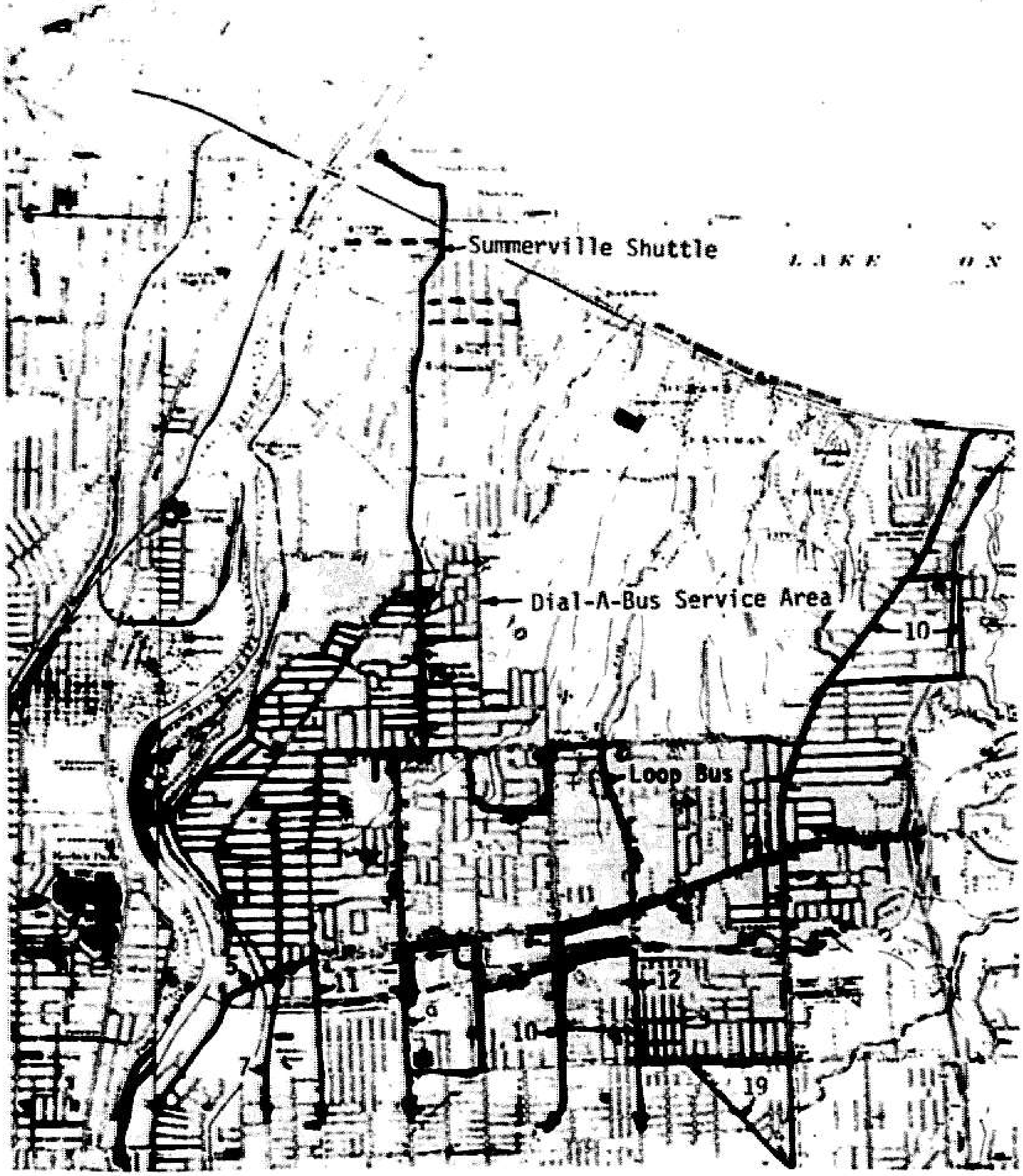
The PERT services implemented in Irondequoit differed from the original PERT expansion plan, which emphasized DAB and subscription service. These changes reflected both the results of nearly three years of PERT operating experience in Greece and the unique characteristics of Irondequoit.

DAB service in Irondequoit was designed to play a smaller overall role in the PERT service package than in Greece. A relatively extensive fixed-route network already existed in Irondequoit, and the problems in Greece associated with the replacement of fixed-route services by DAB needed to be avoided. However, the existing fixed-route system inadequately served local travel patterns within Irondequoit. The Irondequoit PERT service package consequently focused upon improving PERT reliability and economics, as well as achieving PERT's objective of increasing transit coverage by adjusting and supplementing the fixed-route system rather than replacing it with a new set of services.

As in Greece, Irondequoit PERT services mainly operated during the off-peak period. During the weekday midday period and all day Saturday, three new services operated: RTS Routes 5 and 7 north of Ridge Road were replaced by the Summerville Shuttle which offered route deviation service in northwestern Irondequoit; the Irondequoit Loop Bus ran counter-clockwise in central Irondequoit, connecting most of the town's activity centers; and DAB service was provided in a 6.9 square mile area in southern Irondequoit. During this midday period, RTS service on portions of Routes 9 and 12 was eliminated. An overview of the transit services (PERT and RTS) available in the Irondequoit target area during the midday period is shown in Exhibit 4.2.

During the peak period, PERT operated work subscription services to Kodak Park and later to Xerox facilities in Webster, east of Irondequoit. A subscription service to the Association for Retarded Children (ARC) Center for handicapped children was also provided. PERT also assumed operation of peak-period-only Routes 14 and 23, making minor scheduling alterations.

EXHIBIT 4.2 IRONDEQUOIT OFF-PEAK (MIDDAY) TRANSIT SERVICES (PERT & RTS)



A final component of the Irondequoit service package was the route deviation Urban PERT service, which operated within a wedge-shaped area between the Rochester CBD and central Irondequoit (see Exhibit 3.12). After 9:00 P.M., PERT operated RTS Routes 5, 7, and 9, offering doorstop pick-ups and drop-offs within this area for a surcharge.

The above PERT services underwent a number of modifications following their introduction in April 1976; these changes are outlined in Exhibit 4.1.

4.2 INNOVATIONS

4.2.1 Services

Greece services included DAB, the Dew-Ridge point deviation service, work and school subscription services, a handicapped service, and specially-arranged group trip services for the transit-dependent. Although DAB required the greatest vehicle allocation, the other services are important because they catered to specific transportation needs that could be more effectively met by special services. Similarly, the PERT service package in Irondequoit included DAB, route deviation services (Summerville Shuttle, Urban PERT), subscription services (work and ARC subscription), and special services for the transit-dependent. Fixed-route services (Loop Bus, Routes 14 and 23) were also operated by PERT in Irondequoit. Each of these services is described in this section, with the specific innovation applied to either the Greece or Irondequoit service area.

Dial-A-Bus (DAB)

DAB is a demand-responsive, door-to-door transit service in which passengers are transported from any origin to any destination within the service area. The service is similar to taxi service, except that additional passengers may be picked up or dropped off while a particular customer is being transported. It offers the door-to-door convenience of a taxi, while the shared riding raises vehicle productivity and lowers the cost per passenger. Small buses or converted vans are usually used to provide DAB service, since passenger loads do not require full-sized buses (unless there is a highly concentrated demand to or from one location). While vans and even automobiles can usually provide adequate DAB service, the use of minibuses provides the flexibility to offer, with the same equipment, supplementary services that attract greater passenger volumes. In both Greece and Irondequoit, where the same buses provided a variety of services, the vehicle fleet initially consisted almost entirely of minibuses.

In addition to the "many-to-many" mode, which carried passengers from any point to any other point within the service area, DAB was designed to serve as a feeder mode for the fixed bus routes in the area. In Greece, as many as one-third of all DAB riders transferred between DAB and Route 10 at Dewey Avenue and Ridge Road. DAB/fixed-route transfers were less common in Irondequoit, but efforts were made to coordinate transfers between DAB and Routes 5, 7 and 11 at Clinton Avenue and Ridge Road. Some transfers between the Greece and Irondequoit DAB services were also made at Dewey and Ridge.

Customers used DAB by telephoning the PERT control room and giving the PERT order processor the following trip information: customer's name and phone number (if available), origin and destination, and desired time of departure. Requests were classified as "immediate" if the customer wanted to travel as soon as possible, and "advance" if the customer booked a trip for later in the day or week. A customer often made both an immediate and an advance request, with the advance request being for his or her desired return trip. For immediate requests, customers were given an estimated time of pick-up. Toward the end of the demonstration, customers were given a ten-minute range around the estimated pick-up time.

DAB service was initiated in Greece on August 6, 1973 in a 9.6 square mile service area between 8:15 A.M. and 5:30 P.M. on weekdays. Following service initiation, many of these service parameters underwent changes. The Greece service area was expanded four times, so that by September 1975, a 15.2 square mile area was served. Concurrent with the first service area expansion in June 1974, the operating hours were extended to the period from 8:15 A.M. to 10:15 P.M. on weekdays and 8:45 A.M. to 7:45 P.M. on Saturdays. Service between 7:30 A.M. and 8:15 A.M. was added on March 3, 1975.

The regular DAB fare was $1.00 plus $0.25 per additional passenger making the same trip; transfers to a fixed-route bus were $0.05. The regular DAB fare for the elderly was reduced to $0.50 during the off-peak period in November 1974. In addition, a $0.50 fare to and from the Dewey and Ridge transfer point was instituted between 9:30 A.M. and 3:30 P.M., coinciding with the cutback of Route 10 fixed-route service to Dewey and Ridge during the off-peak period in January 1975.

Irondequoit DAB service was initiated on April 12, 1976 in a 6.9 square mile area. Three checkpoints outside of the service area where riders could be picked up or dropped off were also established. Service was offered between 8:00 A.M. and 9:00 P.M. on weekdays and 8:45 A.M. to 7:45 P.M. on

Saturdays. However, because of very low evening demand, service was cut back to 7:00 P.M. on June 21, 1976. The Irondequoit service area was expanded to 8.6 square miles on September 13, 1976. The Greece DAB service area was contracted at this time, and only a 10.7 square mile area was served during the midday period. The remaining area was served by the new Dew-Ridge Shuttle (see next subsection).

In September 1976, a zonal fare system was jointly established in the Greece and Irondequoit service areas. The Irondequoit service area was divided into two zones, and the adjacent Greece service area was divided into four additional zones. Zones overlapped at a few major activity centers including the Rochester General (Northside) Hospital-St. Ann's Nursing Home area in Irondequoit (see Exhibit 4.3). The basic fare for a trip within one zone was $0.75. The fare increased by $0.50 each time a zone boundary was crossed up to a maximum of $2.75 (a trip from eastern Irondequoit to western Greece). Half-fares for the elderly during the off-peak period continued to apply; additional passengers were charged 30 cents, regardless of trip length.

The zonal fare system was constructed so that fares more closely corresponded to the costs of various types of trips. In addition, the zonal fare system was intended to encourage longer trips on RTS and PERT fixed-route buses, thus increasing the number of shorter trips carried by DAB and consequently its vehicle productivity.

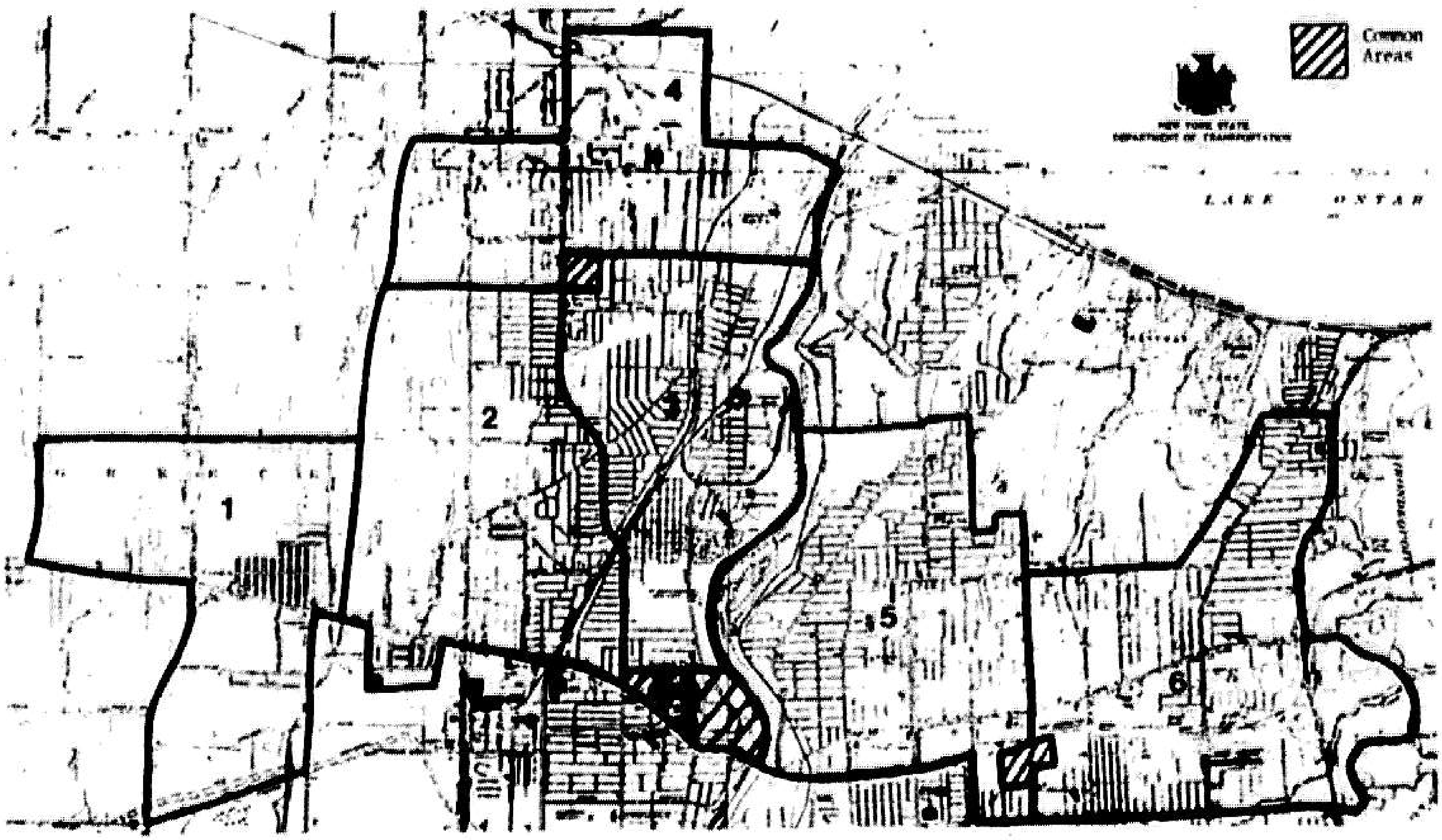
During the four months under the zonal fare system, drivers, control room personnel and customers all experienced considerable difficulty in calculating fares, especially in Greece where there were four zones. In addition to the zone charges, there were reduced fares for the elderly, transfer charges, and charges for additional passengers, resulting in a multitude of possible fares. For example, on the day of the Greece DAB on-board survey, the 156 passengers surveyed reported paying 24 different fares. The system proved to be too cumbersome to justify the small equity improvements that it promoted.

In January 1977, the zonal fare system was abandoned for a flat $1.25 fare ($0.50 for the elderly and handicapped and additional passengers). DAB service hours were also cut to 7:30 A.M. to 3:30 P.M. on weekdays only as part of a general reduction in the supply of PERT services. At that time, the future of PERT services after the demonstration's scheduled termination in June 1977 was uncertain because of PERT's relatively high costs and RTS' unstable financial condition. Consequently, the service and fare changes implemented in January 1977 were designed to reduce the scope of PERT services, increase their revenue recovery rates, and reduce the PERT peak vehicle requirements during

EXHIBIT 4.3

DIAL-A-BUS FARE ZONES

(SEPT. 1976-JAN. 1977)



the late afternoon when subscription services operated. The reduction of vehicles was an objective because of the continued shortages being experienced since late 1975. The change in DAB hours restricted PERT operations, other than subscription services, to the morning and midday hours.

DAB's role in Greece was to demonstrate its potential for efficiently providing a high level of transit service within an area which, because of its low transit demand density, could not support an extensive network of fixed-route buses. Correspondingly, existing fixed-route services operating at low vehicle productivity levels were reduced (see Section 4.2.2).

The major role of DAB service in Irondequoit was to provide a transit alternative for intra-Irondequoit trips. Although the DAB service area was relatively well-served by fixed-route services prior to DAB's implementation, these routes were primarily used to access downtown Rochester. The radial configuration of these routes required that most Irondequoit residents travel to downtown Rochester and transfer in order to access local Irondequoit activity centers. As discussed in Section 3.2.4, few local trips were consequently made by transit. DAB was designed to increase the frequency of such trips, and by connecting with the Greece DAB service, additional opportunities for circumferential travel by transit were created.

Another role of DAB was based on the hypothesis that if DAB ridership increased, fixed-route services could be introduced or expanded to substitute for DAB, because at higher demand levels they operate more cost-effectively. Under this premise, the role of DAB was one of providing transit service more efficiently and with a higher service level than fixed-route buses and of promoting ridership so that, if higher demand levels did result, fixed-route services could be implemented at more efficient operating levels.

DAB had two additional significant attributes: First, DAB was especially valued by the elderly and handicapped because of its door-to-door service. Since these two groups are more dependent upon public transportation than the general population, DAB made a significant contribution to the mobility of the transit-dependent. Second, computerized dispatching and scheduling of DAB was implemented in Greece and Irondequoit with the intention of improving service quality and productivity (see Section 4.2.3). DAB thus provided a means of testing this concept.

<u>Point and Route Deviation</u>

Point deviation is a demand-responsive transit service which makes regularly-scheduled stops at designated points but is free to provide door-to-door service between checkpoints. Route deviation refers to a demand-responsive transit service pattern in which a fixed-route bus leaves the route upon request to serve patrons not on the fixed route. These services are generally considered to be a relatively low-cost means of extending fixed-route transit coverage. Excessive layover times or slack in fixed-route schedules may be replaced with point or route deviation options without requiring additional operating time.

Greece: The Dew-Ridge Shuttle

The Dew-Ridge Shuttle was a combination fixed-route/point deviation service implemented in September 1976. The Shuttle operated with three small buses at half-hour headways between 9:00 A.M. and 3:00P.M. along Ridge Road and Dewey Avenue between Longridge Mall and Northgate Plaza. Above Northgate Plaza, the Shuttle served users at three checkpoint locations or offered doorstop service in the slightly contracted portion of the DAB service area north of English and Denise Roads.

The Dew-Ridge Shuttle operated only on weekdays, but service was also provided on three Saturdays in December 1976 in order to serve Christmas shoppers. The regular fare was 30 cents (20 cents for elderly and handicapped) along Ridge Road, Dewey Avenue, or to one of the three checkpoints in the DAB service area (reduced to one checkpoint in January 1977). A deviation request cost an extra 45 cents (15 cents for the elderly and handicapped).

An important feature of the Dew-Ridge Shuttle was that it restored fixed-route service along most of the routes where it had been removed by route rationalization in 1974 and 1975 (see Section 4.2.2). Whereas the former fixed-route configuration expedited travel to and from the CBD, the Dew-Ridge Shuttle served local trips. Trips to and from the CBD still required a transfer; however, since both services followed fixed schedules that were coordinated at the transfer point, it was hoped that passenger transfers would be more reliable and require less waiting time than when DAB was used for one leg of the trip.

Irondequoit: The Summerville Shuttle

The Summerville Shuttle replaced RTS Route 5 and 7 service north of Ridge Road during the weekday midday and early evening periods and on Saturdays. This change was prompted by the low ridership level on Route 5 along St. Paul Boulevard between Ridge Road and Cooper Road. The Summerville Shuttle followed the Route 7 route between Ridge Road and its terminal on Cooper Road. It then continued north until it rejoined the Route 5 route on St. Paul Boulevard, and followed St. Paul Boulevard to Summerville (Exhibit 4.2). An additional feature of the Summerville Shuttle was that it offered route deviation upon request to two locations in northwest Irondequoit. A third deviation checkpoint was added in June 1976. The Summerville Shuttle retained the basic 25-cent off-peak RTS fare (30 cents after June 1976) and charged an additional 10 cents for deviation requests (no charge for elderly passengers). In January 1977, the deviation surcharge was raised to 45 cents, but remained free for senior citizens.

The Summerville Shuttle had several objectives. First, a net cost savings resulted as one PERT bus replaced two RTS buses on Routes 5 and 7. However, service along lower St. Paul Boulevard was eliminated to make this substitution possible, and headways along the former Route 7 segment of the Shuttle's route lengthened from 32 to 45 minutes. The second function of the Summerville Shuttle was to extend transit coverage in northwestern Irondequoit through the point deviation option. Third, the Summerville Shuttle enabled northwest Irondequoit residents to directly access Irondequoit Plaza by transit, rather than bypassing this activity center as Route 5 did. Riders could also transfer to the Loop Bus at this point in order to reach other Irondequoit activity centers. Finally, the provision of fast and convenient transfers for passengers who previously did not have to transfer was a major objective. The Summerville Shuttle was timed to meet every third Route 5 bus, which was realigned to terminate at Clinton and Ridge. In addition, RTS Route 11 was realigned to terminate at Clinton Avenue and Ridge Road along with Routes 5 and 7. This permitted the Summerville Shuttle passenger to transfer to three different RTS routes at that point, thus increasing the likelihood of a fast transfer and expanding the rider's choice of destinations. Transfers between RTS buses and the Summerville Shuttle were free, so that former Route 5 and 7 passengers paid the same fare as before.

Summerville Shuttle operations were terminated in June 1977 because little deviation demand was attracted and many fixed-route passengers were lost. RTS restored service on Routes 5 and 7 at this time.

<u>Irondequoit: Urban PERT</u>

After 9:00 P.M., RTS bus headways generally increase to about 60 minutes. Furthermore, buses from the various routes converge downtown at Main and Clinton and then leave at 9:17 P.M., 10:22 P.M., 11:30 P.M. and 12:30 A.M. This pattern facilitates transferring, and also enhances passenger safety while waiting, since there is usually a large crowd of people waiting for the many different buses. On

weeknights and Saturday nights. PERT vehicles provided service on Routes 5, 7, 9 and 10 north of downtown (5, 7 and 9 only after June 1976) because PERT vehicles had insufficient passenger capacity for Route 10's nighttime demand generated by Seabreeze Amusement Park.

For an additional $0.75 fare, the buses on Routes 5, 7 and 9 would deviate from the regular route to pick-up or drop-off passengers within a designated area (see Exhibit 3.13). This option could be provided without additional operating time, because of existing slack in the schedules resulting from the downtown convergence scheme described above. It also allowed the final low-demand, outbound midnight runs to be combined, as 5 and 7 became one line while 9 and 10 became a second line.

The Urban PERT service area was primarily in the City of Rochester, which has a relatively high transit route density. Only 11% of its population lived more than one-quarter mile from a bus route that operated during the late night period. However, the late-night setting presumably introduced an additional safety consideration that altered conventional definitions of acceptable walking distances and outdoor waiting times.

Little use was made of the route deviation option, and the surcharge was lowered to $0.20 in September 1976. However, partly due to poor marketing of the available service option and fare reduction, usage did not significantly increase and the service was terminated in January 1977.

Subscription Services

Subscription services are those in which users are transported each day, or at some other regularly-recurring period, at a regular time to and from their destinations. These services are appropriate for passengers who regularly travel to the same location or to several locations in the same vicinity. For this situation, subscription service is intended to provide faster and more reliable service at higher productivity levels than many-to-many DAB, while maintaining the convenience of DAB's door-to-door service. The most suitable trips for subscription service are the daily home-to-work and home-to-school trips. Both of these, along with feeder trips, were served in Greece, while home-to-work and a special handicapped day-care service were provided in Irondequoit.

Greece: Work Subscription Service

Home-to-work subscription service to Kodak Park near Lake and Ridge began along with DAB on August 6, 1973. Work shifts beginning between 7:00 and 8:00 A.M. and ending between 4:00 and 5:00 P.M. were served. In May 1974, the service was extended to include the 7:00 A.M. to 3:00 P.M. shift at the General Motors Rochester Products plant, located about two miles south of the service area at Mount Read Boulevard and Lexington Avenue. On these routes, passenges were picked up at their homes. Checkpoint subscription service, in which passengers were picked up at only a few previously-designated locations, began in June 1976 when subscription service to the Xerox plant in Webster was initiated. (These tours also served Irondequoit residents, and were considered to be a part of the Irondequoit service package rather than a Greece service.) The service area in which subscription pick-ups were made generally corresponded to the DAB service area, although certain area expansions occurred for subscription service prior to DAB expansion. A weekly ticket to Kodak Park cost $7.00 and a single one-way trip cost $0.80. The weekly ticket cost increased by 29% to $9.00 in January 1977. Similarly, Greece and Irondequoit's checkpoint deviation service to Webster increased from $8.00 to $11.00 per week. Reservations were required by 2:00 P.M. on the day preceding the trip for those not subscribing on a weekly basis.

Because Kodak Park had a high concentration of workers in a non-CBD location, service there provided an opportunity to test the work subscription concept. It is estimated that approximately 7,000 persons from the PERT service area work at or near Kodak Park. Since many of these persons do not have access to fixed-route buses, subscription service was primarily an alternative to the automobile. At the same time, the large potential demand offered the possibility of high productivity levels and thus lower costs per passenger.

<u>Greece: Feed-A-Bus Subscription Service</u>

Feed-A-Bus subscription service was a special feature of the work subscription service. This service, which also began in August 1973, took a peak-period passenger to and from a transfer point for an RTS fixed-route bus. These transfer points were Dewey and Ridge (Route 10) and Lake and Ridge (Route 1). Since both locations are in the vicinity of Kodak Park, Feed-A-Bus service was combined with work subscription service to that facility. The weekly fare was $7.50 (ten trips including transfers; a single trip fare was $0.85). Reservations were required by 2:00 P.M. on the day preceding the trip.

<u>Greece: School Subscription Service</u>

School subscription service to four schools in Greece began with the start of the school term on September 10, 1973. A weekly ticket booklet cost $5.00, a four-week booklet cost $16.00, and a single trip fare was $0.65. As with the other subscription services, reservations were required by 2:00 P.M. on the day preceding the trip.

Work and school subscription services were terminated in June 1977, because these services were unable to recover a high enough percentage of their operating costs through passenger fares.

Irondequoit: Work Subscription Service

Work subscription service in Irondequoit began on April 12, 1976 with one tour to Kodak Park West on Mount Read Boulevard near the Greece service area. Unlike Greece subscription service, where passengers were picked up at home, passengers were picked up and dropped off at selected checkpoints, much like a schoolbus service. These checkpoints were usually street corners near a person's home, unless the bus could be conveniently routed past that home. The fare was $5.00 per week, or 65 cents per ride. In June 1976, checkpoint subscription service to Xerox Corporation in Webster began with a fare of $8.00 per week ($1.00 per ride). The Xerox tours also picked up passengers in the Greece service area.

These services were expanded in September 1976 and, in addition, the two buses serving Xerox began carrying Park-and-Ride patrons to Kodak Park on their return trips. These passengers were charged the regular RTS fare of 50 cents and many used prepaid monthly RTS passes. An additional doorstop route to Kodak Park was added in January 1977 with a weekly fare of $7.00, as in Greece.

Work subscription fares were raised between 29% and 40% on January 17, 1977 in an effort to increase the service's revenue recovery. Kodak checkpoint tour fares rose from $5.00 to $7.00 per week; Kodak doorstop tours rose from $7.00 to $9.00 per week, and Xerox tours rose from $8.00 to $11.00 per week.

As in Greece, the Irondequoit work subscription services were terminated on June 20, 1977, primarily because of their low revenue recovery relative to RTS peak-period services.

Irondequoit: ARC Subscription Service

PERT also provided a daily checkpoint subscription service to the Association for Retarded Children (ARC) Center at Ridge Road near Carter Street. Handicapped persons were carried to the day-care facility for $5.00 per week or $0.65 per trip, the same price as checkpoint work subscription service.

Handicapped Services

Persons confined to wheelchairs were able to use the regular DAB service in Greece after April 1975, shortly after a bus equipped with a wheelchair lift was put into service. During the off-peak period, the elderly reduced-fare structure also applied to the handicapped. On June 16,1975, "special handicapped service" began, which permitted disabled and elderly passengers from the Greece service area, the entire town of Irondequoit, and northern Rochester north of Norton Street to travel to three locations outside of these service areas for $2.00 ($0.25 for each additional passenger). Nine additional destinations were added in September 1975. These locations were predominantly health and social service facilities near the Rochester CBD. The special handicapped service hours of operation were 9:00 A.M. to 6:00 P.M. on weekdays and 10:00 A.M. to 5:00 P.M. on Saturdays. Passengers were requested to make reservations by 12:00 noon on the day preceding the trip.

On October 18, 1976, the PERT handicapped service was revised so that the first passenger collections were at 9:00 A.M. in the northern, outlying Greece/Irondequoit areas and the last passenger collections were at 10:00 A.M. or earlier in the service areas' southern region adjacent to the CBD. Return trips began at 10:00 and were completed by 11:00. This two-hour round trip cycle occurred three times during the day, with a fourth cycle -- having the last drop-offs at 5:00 P.M. -- added in the spring of 1977 due to the high demand. Although all trip requests had to conform to this general schedule, passengers could receive door-to-door service with the new 24-hour advance-reservation system. The fare was also reduced to $0.50, with no discounts for additional passengers.

Initially, the revised PERT handicapped service was not actively promoted because the four PERT vehicles with wheelchair lifts were among the least reliable in the fleet, and reliable service could consequently not be guaranteed. In January 1977, however, three new vehicles with wheelchair lifts were acquired (see Section 4.2.3), and the service was more actively promoted. In addition, customers residing in the wedge-shaped area between Irondequoit and downtown Rochester were included in the service area, since the buses had to pass through this area during their tours. By March 1977, demand had increased so much that two vehicles were needed to provide this service during most of the day.

Although small compared to the magnitude of other PERT services, the handicapped services were significant, as they served a population with severely limited mobility. Unless someone was available to drive these handicapped persons, they were dependent upon special wheelchair taxis which charged $6.00 or more per trip. These taxi services usually transported the passenger between a building and the vehicle, however, whereas PERT only provided curb-to-curb service.

Shoppers' Specials and Other Special Services

PERT special services consisted of specially-arranged group bus trips, usually to a common destination. One of the special services allowed groups of five or more riders to request a PERT vehicle for trips within the service area. This was similar to a regular DAB request, except that the group size justified the dispatching of a special bus. Groups were charged $0.40 per person for such trips, the fare being computed on the basis of the DAB fare for five people traveling together ([$1.00 + 4(.25]/5 = $0.40).

In addition, special trips were formed for elderly and handicapped groups, typically from an elderly housing development to an activity center such as a shopping mall. Special services were significant components of the Rochester demonstration for several reasons. First, they were formed and disbanded according to demand, and were consequently adaptable to changing travel needs. Second, PERT transit services were usually directed toward the transit-dependent, especially the elderly population, and thus played a major role in meeting the needs of this group. Third, special services tended to transport groups of persons, and therefore had the potential for generating high vehicle productivity levels and for increasing the overall productivity of the entire PERT system. Finally, PERT management cooperated with non-transportation groups in establishing special services, some of which were financed by outside organizations -- such as local merchants -- rather than by the passengers directly. Sectors of the community that are not traditionally included in the marketing and financing of transit were thus involved.

Greece: The first Shoppers' Special service, initiated in January 1974, was a once-per-week shopping service to Northgate Plaza for residents of the Lakeview Towers housing development for the elderly, and was paid for by the Wegman's Supermarket chain. After February 1975, the destination changed to the Wegman's at Mount Read Boulevard and Maiden Lane. Three round-trips were provided from Lakeview towers and Riverview Manor each Wednesday. Wegman's was billed $45 for each day of operation. A second service, consisting of two round-trips, operated each Tuesday from Lakeview Towers and Riverside Manor to Longridge Mall for a fare of $0.25. A third service began in Greece in March 1975, transporting the elderly of Lakeview Towers to Northgate Plaza every other Thursday. The Northgate Merchants Association was billed $37.50 for the two round-trips made on each day of operation.

Irondequoit: Several specially-arranged services also operated regularly in Irondequoit. The first of these regularly-scheduled services began in September 1976 and operated every Friday from Seneca Towers, an elderly housing facility on Seth Green Drive near St. Paul Boulevard and Keeler Street to the Jewish Home and Infirmary, approximately one mile south on St. Paul Street. Day-care service at the Jewish Home was provided on Fridays; buses left at 9:15 A.M. and 3:00 P.M. A 30-cent fare was charged.

In March 1977, two additional special services for Seneca Towers residents began. On Tuesdays, a bus left for Longridge Mall at 11:00 A.M. and returned at 2:00 P.m. A 50-cent fare was charged. Also, on the second Thursday of each month, two buses took residents to the McDonald's on Ridge Road near Dewey Avenue for 25 cents each way. McDonald's bought a free lunch for persons having birthdays in that month.

A fourth service began in June 1976 and operated every other Monday from the Jewish Home and Infirmary to an ice cream vendor at Lake Avenue and Beach Avenue at the very northern tip of Rochester along Lake Ontario. Eight persons were taken each time, including two wheelchair passengers. The Jewish Home was charged $10.00 for this service each time it operated.

Fixed-Route Services

Irondequoit: The Loop Bus

The Irondequoit Loop Bus was a fixed-route service that operated in a counter-clockwise direction, connecting most of the Irondequoit activity centers including Irondequoit Plaza, Irondequoit's largest shopping center with 34 stores; Ridge-Hudson shopping plaza (14 stores); Two Guys Plaza (one department store); Ridge-Hudson Towers, housing 345 elderly residents; Atlantic shopping center with 13 stores; the Rochester General (Northside) Hospital; the Wilson Health Center; the St. Ann's and Nortonian nursing homes; Hunter Plaza (eight stores); and Irondequoit Town Hall. The service operated during the weekday midday period and on Saturdays for a 25-cent fare, which increased to 30 cents in June 1976.

Along with the fare hike, an experimental second bus was added on Saturdays, running in the opposite direction (clockwise) at 45-minute headways. Instead of increasing ridership, the reverse bus service caused ridership to split between the two directions, and it was therefore eliminated in September 1976.

Like DAB, the Loop Bus focused upon serving local trips, although it could also have been used to transfer to and from a fixed-route bus. For those residing near its route, the Loop Bus provided a lower-cost alternative to DAB. In addition, the Loop Bus was offered as a means of circulating people between several activity centers in close proximity. In this role, the Loop Bus has broad implications since many urban and suburban communities are confronted by similar situations of clustered activity centers that are either beyond convenient walking distance from each other or, alternatively, are not widely separated but discourage walking trips because of an emphasis on facilitating automotive traffic movement. In such cases, there is a large, multi-directional pattern of traffic that is usually not well served by transit.

The Loop Bus failed to generate its expected ridership and was terminated in January 1977.

Irondequoit: Routes 14 and 23

Routes 14 and 23 were the RTS routes that PERT operated in Irondequoit between April 1976 and January 1977. Originally, route deviation experimentation was proposed for these routes; however, a January 1976 ridership survey indicated that there was little demand for such an option. Consequently, the only changes implemented, other than the use of small buses, were small scheduling alterations in order to better coordinate service with Kodak Park workshift times. However, these changes were insufficiently publicized, leaving potential new users unaware of the possible benefits of the modified service. Thus, little ridership change was observed, and RTS resumed operation of these routes in January 1977 according to the original timetable.

4.2.2 System Integration Innovations

PERT services were designed primarily to extend the coverage of transit to new geographic areas, in new time periods, and to new users by providing convenient service comparable to alternative modes in both service quality and price. By creating a single integrated system in which PERT service and fixed-route service components complement each other, transit coverage could be extended and a major demonstration objective achieved. Integration was accomplished by transfer timing, the provision of attractive and convenient transfer locations, coordinated fares, and special services. This facilitated the use of more than one service for certain trips, such as a Summerville Shuttle passenger transferring to the Loop Bus or DAB in order to travel to an Irondequoit activity center, or the subscription feeder to fixed-route service in Greece.

PERT/RTS integration was also demonstrated by PERT's operation of regular RTS during the demonstration, particularly on Urban PERT where PERT drivers and vehicles provided service on Routes 5, 7 and 9, supplementing the regular service with route deviation options. To achieve operational integration between RTS and PERT, coordination was required at the institutional as well as the operational level. Institutional issues of the Rochester demonstration are discussed in Section 4.3.

In addition to integration with the existing fixed-route system, DAB was used to substitute for fixed routes which were not economically viable, a strategy called "route rationalization." Route rationalization and transfer coordination are treated as separate innovations in this section.

<u>Route Rationalization</u>

Route rationalization refers to the strategy of using a combination of fixed-route and demand-responsive services to efficiently match service to particular demand characteristics, usually demand densities. The goal of route rationalization is to achieve greater coverage and higher productivities than can be achieved by fixed-route service alone. This is accomplished by utilizing demand-responsive services to provide coverage in low demand density areas and fixed-route services where demand is or may be aggregated.

<u>Greece:</u> In Greece, route rationalization consisted of substituting DAB service for the ends of two routes with historically low productivities. Route 14 West (see Exhibit 3.4) was an all-day route running east and west along Ridge Road, joining route 14 East, a "peak period only" route in Irondequoit. On June 24, 1974, Route 14 West also became a peak period only route. At the same time, the Greece DAB service area was extended to include all of the Route 14 West path. Previous users of Route 14 whose trips were not entirely served by Route 14 would have had to transfer to another fixed route. After route rationalization, they could make their entire trip by DAB if their destination was within the Greece DAB service area. These riders could also use DAB to transfer to another fixed-route bus for destinations outside the service area.

Prior to rationalization, Route 10 was an all-day, north-south route from a loop in northern Greece to downtown Rochester. In September 1974, the first route cutback was made by eliminating off-peak service on the Dewey Avenue-Latta Road loop above Northgate Plaza at English Road on weekdays, and terminating all service above Ridge Road during the evening and on Saturday. When DAB was in operation, Northgate Plaza became the terminal for Route 10 during the midday period, and Ridge Road on Saturday and in the evening. On January 6, 1975, midday Route 10 service above Ridge Road was also eliminated. The integrated service concept was for former Route 10 users to use DAB for local trips, and to transfer to fixed-route buses at Dewey and Ridge for destinations outside the service area. Beginning January 6, 1975, the fixed-route fare of $0.50 was retained for the combined service, including transfer, during the midday period.

In September 1976, the Dew-Ridge Shuttle began providing fixed-route service along most of the route mileage eliminated under the route rationalization program. The $0.50 feeder fare was eliminated at that time.

Irondequoit: In Irondequoit, the Summerville Shuttle replaced two RTS services, Routes 5 and 1 north of Ridge Road during the off-peak period. Also, off-peak service on RTS Routes 9 and 12 north of Ridge Road was discontinued during the midday period. However, the Irondequoit Loop Bus operated along the eliminated portions of Routes 9 and 12, and Route 9 was restored after two months, following citizen protests.

Transfer Coordination

The transfer coordination concept was closely related to that of route rationalization. Since the overwhelming majority of the former fixed-route bus riders traveled to destinations outside the service area (usually the CBD), after rationalization these riders had to use PERT and transfer to a fixed-route bus to complete their trips. Consequently, the convenience and comfort of these transfers was an important element affecting route rationalization. Transfer coordination specifically involved the provision of uniformly short transfer wait times in a pleasant environment.

Greece: Efforts to coordinate transfers were focused upon the Dewey and Ridge transfer point, where Route 10 terminated during the off-peak period beginning in January 1975. Dewey and Ridge was also the designated point for transfers between Greece and Irondequoit DAB services. The first effort to coordinate transfers was the establishment in January 1975 of a policy for DAB vehicles to meet every other Route 10 bus arriving at Dewey and Ridge during the off-peak period. This policy was supplemented in June 1976, when every other DAB leaving the PERT garage near Dewey and Ridge began its run by picking up passengers waiting for DAB service at the transfer point. Between 9:00 A.M. and 3:00 P.M., approximately three buses left the garage each hour, although their departures were not uniformly spaced in time. The final transfer coordination effort was the construction of a small waiting facility at the Dewey and Ridge transfer point, so that waiting passengers would not have to stand outdoors. This station opened in September 1976. At that time, the Dew-Ridge Shuttle started operations, and its schedule was coordinated with RTS Route 10 to encourage transfers.

Irondequoit: Irondequoit transfer coordination focused on the Clinton Avenue and Ridge Road transfer point, where passengers transferred between the Summerville Shuttle and RTS Routes 5, 7 and 11. Schedules were coordinated for quick transferring, and a transfer station also opened at Clinton and Ridge in September 1976. DAB passengers could also transfer at Clinton and Ridge to RTS buses, but there was little demand for this option.

In addition, the Loop Bus schedule was devised so that quick transfers could be accomplished between it and the Summerville Shuttle and RTS Routes 9, 10 and 12. This expedited trips from northern Irondequoit to central Irondequoit's activity centers (Summerville Shuttle or Route 10 to the Loop Bus) and from central Irondequoit to downtown Rochester (Loop Bus to Routes 9 or 12).

4.2.3 Equipment Innovations

Vehicles

PERT service in Greece began with seven Twin Coach minibuses in August 1973. A Ford Courier modified van was purchased from the nearby Batavia DAB system in December 1973, and put into service the following month. Four additional buses, two Grummans and two Rek-Vee's, were then acquired for the September 1974 service changes, and one Grumman vehicle was fitted with a wheelchair lift. The Electrobus, acquired in conjunction with the Rochester Gas and Electric Company, began revenue service in January 1975. Three additional vehicles with wheelchair lifts manufactured by FMC Corporation were introduced into service in June 1975. Finally, twelve GMC-built small buses were acquired in December 1975 and January 1976 in anticipation of the start of Irondequoit service. The Electrobus was removed from service in February 1976.

Of these 28 vehicles (including the Electrobus), 27 were small buses seating between 12 and 20 passengers; the Ford Courier van had a seating capacity of only 10 persons. These were the only small buses regularly operated by RTS and, for that reason, represented an innovative form of transit in the area.

This mixed fleet was the result of a conscious management decision to obtain a variety of bus makes and models. The objective was to evaluate a variety of small transit buses in order to choose the most appropriate bus for future fleet purchases. None of the vehicles used actually proved to be highly reliable and, in January 1977, the PERT fleet acquired seven new vehicles, including three Dodge Fortibuses seating between 17 and 20 passengers each, three Dodge Fortivans equipped with wheelchair lifts that could carry ten seated passengers or six seated passengers and two wheelchair passengers, and one Dodge Fortivan with a 14-passenger seating capacity. At about the same time, seven PERT vehicles were retired from service, including the three FMC vehicles, the two Grumman vehicles, one of the two Rek-Vee vehicles and the Ford Econoline van. Thus, the fleet size remained at 27 vehicles, but several of the most unreliable were replaced.

Six of the seven new PERT vehicles were leased from a local Dodge dealer and maintained under contract. The seventh, a Fortivan, had been previously acquired by RTS to use as a shuttle bus over a bridge whose sidewalks were being repaired. Routine maintenance on this vehicle was performed by RTS, but major work was done at the local Dodge dealer. This substantially reduced the PERT maintenance workload at the RTS garage. Whereas RTS mechanics previously serviced five different types of PERT vehicles, their efforts could now be concentrated on the remaining 12 GM vehicles, the seven Twin Coach buses, and a single Rek-Vee bus. This last Rek-Vee bus was retired from service in June 1977.

Communications Equipment

Since DAB operations depended heavily upon communication between drivers and the PERT control room, the effectiveness of the communication modes used was crucial to operating success. Based on their operational success in the Batavia DAB system, the first 16 PERT vehicles had digital printers installed. Tour listings were transmitted to individual drivers through digital radio transmissions, and drivers could also communicate to each other and to the control room by voice radio transmissions. The digital printers reduced the likelihood of communication errors, and also reduced communication time compared to voice communication alone.

During the spring of 1976, the digital printers were replaced with cathode-ray terminal (CRT) video equipment. Video communication equipment had never before been used on transit vehicles, although they are widely used in police work. Under computerized dispatching of DAB, vehicle communications were anticipated to become much more frequent because instructions to make individual stops rather than entire tours would be transmitted to drivers. Consequently, a means of communication faster than the printers was necessary in order to avoid transmission backups. The new equipment also automated the communication process. Instead of signaling the dispatcher when drivers were ready for tour instructions, they began to directly access the computer for tour instructions beginning in January 1977.

Computerized Scheduling and Dispatching

On September 23, 1975, the computer-based automated dispatching system to control Greece DAB operations was implemented. Before this and during subsequent periods, the system was controlled manually. Following its initial testing in September 1975, the software was continually refined and, beginning in early June 1976, Greece DAB dispatching and scheduling was controlled by computer; manual control was only necessary when the computer system failed.

In April 1976, Irondequoit PERT services were initiated under manual control. Computer control of Irondequoit DAB operations began in February 1977 and was fully operational by March 1977. Since most of the implementation problems were solved during the Greece phase-in process, the implementation of computerized procedures proceeded rapidly in Irondequoit.

When vehicle dispatching was being controlled manually, order processors recorded customer and trip information on computer cards. These cards were then passed on to the dispatcher, who assigned the request to a vehicle after considering such factors as current vehicle locations, outstanding requests, and driver schedules. The information was then relayed to the driver of the vehicle to which the customer was assigned, usually along with several other requests in order to form a tour. Manually dispatching DAB buses thus relied upon the ability of a single dispatcher to integrate all the relevant information and make assignment decisions which ensured operating efficiency. This task was demanding, and left little time for quantitative tour planning. Instead, the manual dispatching process depended upon quick, astute decisions.

Under computerized dispatching, each order processor operated a cathode-ray terminal, through which he or she interacted with the computer system. When recording a request, the operator typed the relevant trip information (origin, destination, etc.) into the terminal. If the request was for immediate service, the order processor estimated the user's pick-up and delivery time and conveyed this information to the requestor. After the computer had experimented with all possible vehicle tour configurations given the existing state of the system, individual pick-up and delivery times were estimated. To select optimal tour configurations, the computer system stored both static information (such as the street network and vehicle speed) and dynamic information (such as vehicle locations and outstanding trip requests).

Computer-based dispatching systematically assigned customers to buses using predetermined service quality criteria, so the entire vehicle tour could be planned. In theory, the systematic vehicle assignments made possible by computerization were to improve overall service quality as well as increase vehicle productivity (passengers per vehicle-hour). Computerized dispatching is hypothesized to be most advantageous in larger systems with eight or more vehicles. The capabilities of a single dispatcher are exceeded in such systems, and coordination is difficult with more than one dispatcher. In addition, the larger the system, the greater the potential for cost reductions as manual dispatching is replaced by computerization. Thus, the potential improvements resulting from computerized dispatching concerned productivity and cost as well as service quality.

Other possible benefits of computerized dispatching include improvements in the processing of service requests. For a recordkeeping operation with a large number of transactions, a computerized system reduces paperwork dramatically and generates a superior records system. Valuable DAB service quality data were automatically recorded under computerized dispatching, while cumbersome manual recording was required otherwise. Computerized DAB dispatching also gave the order processors much quicker access to vehicle tour information, for use in responding to inquiries about late buses. Order processors could easily recall stored information in order to learn the latest pick-up time estimates. The computer system could also generate the names of passengers who were, for some reason, scheduled to be picked up much earlier or later than originally promised when the service request was made. Control room personnel could then notify those passengers of the change.

Against these benefits, the costs of implementing and operating the computerized system should be weighed. The budgeted costs of implementing and operating the computerized dispatching system was $492,000, including $302,430 for equipment leasing, $109,630 for system design and testing, and $79,940 for network coding. Computer operating time was leased at a fixed monthly rate from First Data Corporation; this rate was significantly less than the actual market value of the computer time. The actual computer usage cost per passenger request was estimated at between $0.50 and $0.75 for the supply and demand conditions generally existing in Rochester.[1] This cost is not indicative of what is possible using a less costly dedicated minicomputer, which is planned for the follow-on demonstration in Rochester. Consequently, a cost-benefit analysis was not attempted based on the demonstration results.

In addition to the financial costs incurred, certain implementation problems had to be dealt with, including resistance on the part of users and employees in adopting the system, efforts to modify software after a mistake was recognized in practice, and the "dehumanizing" aspects of computerization, such as the possible reduction in drivers' discretion in rearranging tours to which they have been assigned. The reactions of drivers and dispatchers to the computerized system were important, since a successful computerized system required that the staff have confidence in the dispatching plans generated by the algorithm.

Computerized dispatching of DAB was initially implemented during the last few months of the Haddonfield, New Jersey demonstration project, which took place between February 1972 and March 1975. Using a small dedicated computer, the Haddonfield system successfully demonstrated that automated scheduling and dispatching was feasible. An automated control system was also used in the short-lived Santa Clara County, California DAB system during late 1974 and early 1975. Finally, the Ann Arbor, Michigan demand-responsive transit system utilizes a computer for processing but not for scheduling service requests; dispatching is done manually using the output from the computer.

The software used in the Rochester demonstration is an outgrowth of the system developed for the Haddonfield demonstration. It was developed by First Data Corporation with the assistance of MIT beginning in 1974. Whereas the Haddonfield software had been written in a programming language that was specifically for the computer hardware used in Haddonfield, the Rochester software was written so that it could be used with numerous hardware facilities. In addition, the scheduling algorithm used in Rochester was much more sophisticated that that used in Haddonfield. The software has also been continually refined since 1974, reflecting efforts to increase its capabilities as demonstrated in day-to-day operations.

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[1] Paul Connolly, "Time and Cost Associated with Rochester DAR System," TSC Memorandum, March 15, 1976.

4.2.4 Fares, Marketing and Promotion

The marketing of PERT services was intended to perform a number of functions. First, PERT was an innovative form of transportation for the area and, like any new product, required a marketing program to promote citizen awareness and acceptance. Second, PERT was introduced during a period when transit ridership, both in Rochester and nationally, had been declining. Consequently, PERT required a strong and imaginative marketing effort to combat this trend. In addition, PERT offered a variety of services operating at various times of day and with various fare structures. The complexity of these alternatives required that a marketing effort be conducted to make the available transit choices clear to the prospective user. Finally, PERT operated in service areas that did not correspond to any city's political boundaries, and the Greece service area underwent several changes since the start of service in 1973. Consequently, publicity was necessary to make the public aware of the geographic coverage of PERT service.

Marketing PERT was accomplished in a number of ways: several direct mailings to all households in the area; newspaper advertisements; and slide show presentations to public officials, large employers, community groups, merchants' associations, and the news media. PERT literature was distributed in many stores and public buildings in the area.

Fare Changes

Several reduced-fare promotions, usually for one week at a time, were conducted. These sometimes involved half-fare coupons that were either mailed to all households or appeared in local newspapers. Reduced-fare periods served several purposes: They were promotional devices and also served as tests of the capacity of the system if ridership increased significantly.

Long-term fare changes also occurred during the project, especially in Irondequoit. These changes consisted of fare increases to raise revenue recovery and decreases to encourage specific types of trips (such as trips by the elderly, transfer trips, and off-peak versus peak trips). Long-term fare changes are outlined in Exhibit 4.1 (Demonstration Chronology) and Irondequoit fare changes are consolidated in Exhibit 8.2. Fare promotions are listed below.

Greece: DAB Reduced-Fare Promotions

The Greece DAB reduced-fare periods are listed below in chronological order.

1. Longridge Mall Half-Fare Coupons (I). During the week of August 23-31, 1973, corresponding to the major Greece shopping mall's "Back to School" promotion, half-fare coupons were available at all stores in the Longridge Mall and were valid only for the return trip from the mall. The Merchants' Association paid the difference, and there was consequently no loss in revenues.

2. First Half-Fare Week. During the week of November 12, 1973, the DAB fare was $0.50 rather than $1.00 between 9:00 A.M. and 3:00 P.M. A direct mailing to 17,000 households was used to publicize the discounts.

3. Off-Peak Feeder Reduced-Fare Promotion. For two weeks in mid-February 1974, the off-peak feeder fare (including transfer) was set at $0.40, and the reverse PERT trip was free (riders still had to pay the $0.40 RTS fare). A PERT and RTS bus trip generally cost $1.05: $1.00 for PERT plus $0.05 for the transfer.

4. Longridge Mall Half-Fare Coupons (II). During the week of April 1, 1974, half-fare coupons were again distributed at the Longridge Mall for trips from the mall.

5. Second Half-Fare Week. The second DAB half-fare week occurred during the week of April 22-26, 1974. Unfortunately, the first day coincided with the last day of a five-day RTS drivers' strike.

6. Senior Citizens Week. On May 15-16, 1974, several hundred half-fare coupons for senior citizens were distributed at Longridge Mall.

7. Half-Fare Newspaper Coupons. During the week of September 30, 1974, half-fare coupons for DAB were placed in local newspapers.

8. Half-Fare Coupon Mailing (I). During three weeks in June 1975, promotional PERT newsletters were mailed to 22,000 households in the service area; the newsletters included half-fare coupons for specific services and weeks. Unfortunately, the use of third-class postage resulted in all households receiving the newsletters at about the same time and generally late. Customers were consequently allowed to use the coupons for one week after their expiration date.

9. Half-Fare Coupon Mailing (II). A second half-fare coupon mailing was conducted between late January and early March 1976. The service area was divided into five subareas, with roughly the same number of households in each, and a "Winter Wonderline" half-fare coupon was mailed to all 22,894 households over a six-week period. The coupons mailed within each subarea were valid during overlapping two-week periods. Senior citizens could split the coupon and use it for two half-fare coupons during the midday reduced-fare period for the elderly.

10. Third Half-Fare Week. A third DAB half-fare week occurred during the week of March 14, 1977. Unfortunately, the newspaper advertisements announcing the change appeared late.

Greece: Subscription Service Reduced-Fare Promotions

The following subscription service reduced-fare promotions were conducted in Greece:

1. Work Subscription Service Promotion. During the week of September 24, 1973, a reduced-fare promotion was instituted for work subscription service, with the weekly fare reduced from $7.00 to $5.00.

2. Subscription Feeder Promotion (I). Coinciding with the off-peak DAB feeder promotion in February 1974 was a three-week subscription feeder promotion in which the weekly subscription rate was reduced from $7.50 to $5.00.

3. Subscription Feeder Promotion (II). During the week of November 11, 1974, a second promotion of subscription feeder service was conducted similar to the promotion conducted earlier in the year. The weekly fare was reduced from $7.50 to $5.00.

4. Work Subscription Service Free-Fare Week. During the week of February 24, 1977, no fare was charged for work subscription service. However, this was not actively promoted, but was described by PERT management as an expression of appreciation to the riders who had continued using the service through the severe winter weather, vehicle shortages and a fare increase.

Dew-Ridge Shuttle Reduced-Fare Promotion

During the week of October 11, 1976, no fare was charged for Dew-Ridge Shuttle service.

Irondequoit: Reduced-Fare Promotions

Four reduced-fare promotions were held in Irondequoit as a means of increasing ridership:

1. DAB Half-Fare Coupons. For two weeks between July 26 and August 7, 1976, DAB passengers could use half-fare coupons that appeared in the weekly Irondequoit Press.

2. Loop Bus Free-Fare Week. During the week of October 4, 1976, there was no fare on the Irondequoit Loop Bus.

3. Work Subscription Service Free-Fare Week. This promotion coincided with the Greece work subscription free-fare week of February 28, 1977 (see above).

4. DAB Half-Fare Week. During the week of March 7, 1977, the regular DAB fare was reduced from $1.25 to $0.60. Special DAB fares (elderly and handicapped, additional passengers) were halved.

Initial Marketing and Promotion (Greece, Pre-Demonstration)

The PERT marketing and promotion program began in April 1973 -- three months before the start of service in Greece -- when preparation of printed information materials and the visual slide show was initiated.[2] Altogether, the initial "start-up" marketing effort continued through the first six weeks of service; the listing in Exhibit 4.4 summarizes the activities of that period. The dollar figures are the initially-budgeted amounts, and serve as an indication of the level and allocation of the budget.

The total first-year marketing budget for PERT was approximately $42,000, which represented 13.8% of the first-year operating budget. Many of the funds left over from the start-up campaign were spent in the late spring and early summer of 1974, prior to changes in the Greece service area and operating hours made in June 1974. The marketing techniques used were similar to those of the start-up program; direct mailings continued to be used most heavily.

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[2] For a more detailed description of PERT marketing activities prior to and during the early stages of PERT service in Greece, see Marketing PERT Dial-A-Bus in Rochester, New York, presented at the Fifth Annual International Conference on Demand-Responsive Systems on November 13, 1975 in Oakland, California by Howard W. Gates, Director of Public Information, Rochester-Genesee Regional Transportation Authority.

EXHIBIT 4.4

INITIAL MARKETING EXPENSES

Preparation and initial marketing of visual presentation	$ 500
Preparation and printing of information folders	3,000
Direct mailing of 20,000 general information brochures and special interest brochures; preparation costs	7,250
Outdoor advertising; 12 boards for 3 months each; production costs	5,800
Newspaper advertisements: six 4-by-10 ads in local papers, two ads in major metropolitan papers; production costs	3,450
Production and distribution of counter displays	1,000
In-plant industrial promotion	2,000
Press releases, news conference-luncheon, etc.	750
First-day-of-service activities	2,250
Contingencies	2,000
TOTAL	$28,000

Demonstration Marketing Program

Over the scheduled two and one-quarter years of the Greece and Irondequoit demonstration beginning April 1, 1975, $114,472 was budgeted for marketing and promotion, or $4,240 per month. This represented 3.5% of the total demonstration project operating grant of 3.6 million dollars. (The total demonstration budget is estimated at about $4.8 million.) The marketing budget included $35,500 for direct mailings, $40,022 for newspaper advertisements, and $18,325 for brochures. In addition to the above, $23,062 was set aside for the marketing and promotion of fare, service, and marketing experimentation.

Irondequoit PERT services were planned and implemented with considerable community input. In July 1975, nine months prior to the start of service, an Irondequoit Citizens' Ad Hoc Committee on Transportation was formed. This group met every two or three weeks with either PERT, RGRTA or MIT officials. The committee reviewed and commented on the service plan prior to its implementation, and forwarded other residents' reactions following its implementation. Four public meetings were also held prior to service initiation: two in September 1975 in order to solicit citizen views on transit needs, and two in February 1976 in order to present the Irondequoit service plan. For the latter meetings, an audio-visual slide presentation was made. Presentations were also made to various community organizations, local elected officials, large employers, merchants' associations, and the news media. Prior to the start-up of Irondequoit services, information brochures were mailed to approximately 22,000 households in and adjacent to the Irondequoit target area. Radio and newspaper advertisements also appeared during the three weeks prior to service initiation and continued for several weeks afterward. Specially-directed promotions were also conducted. In May 1976, for example, a free DAB pass was mailed to households in the lower St. Paul Boulevard area. These households represented the market formerly served by Route 5 which had to use DAB during the midday and early evening periods when Route 5 was discontinued. However, it should be noted that little promotion was done in the Urban PERT service area.

In addition to fare incentive promotions and the initiation of PERT service, there was an extensive marketing program associated with the expansion of service for the handicapped. Handicapped service to points outside the Greece service area began in June 1975, and was expanded in September 1975 to include handicapped Irondequoit residents. This required considerable direct contact with social service agencies, nursing homes, etc.

Public Relations

Aside from the specific marketing and fare promotion efforts described, PERT maintained an on-going public relations program. A permanent customer relations professional was employed during the demonstration to maintain close contact with the community, and one MIT staff member also worked directly with community groups. Continual interaction occurred with large employers such as Kodak, merchants' groups, senior citizen and other community social groups, various church and civic groups, social service agencies and nursing homes.

In addition to working through recognized organizations, PERT attempted to remain responsive to its individual customers. Several direct mailings in the service area were made, as described earlier. New residents were contacted through the "Welcome Wagon/Hospitality Hostess" and given a complimentary pass for one free fare. In this way, all residents of the service area were indirectly contacted by PERT at some time.

Beginning in January 1975, postage-free cards were placed on all PERT buses in Greece for riders to submit comments on PERT service. All cards and letters were answered, although the specific issues raised were often not directly addressed. A complimentary pass for one free fare was included in this response letter. However, the majority of the interaction with customers occurred by telephone, mostly in the form of complaints about a specific service delay. Beginning in November 1975, a "weekly complaint log" was kept by PERT management, providing a daily record of the number of complaints received.

4.3 PERT SERVICES IMPLEMENTATION

4.3.1 Implementation Process

Development of the PERT System

In 1969, a research team from MIT began an investigation of possible sites for a federal dial-a-bus demonstration. The PERT idea was conceptualized when this team visited Rochester in October 1969 and met with several local transportation officials, including James Reading, Resident Manager of the National City Lines Management Company, which was operating the City-owned transit system at the time. Mr. Reading was particularly enthusiastic about implementing dial-a-ride in Rochester, and suggested that it might be used to replace unprofitable fixed-route bus lines, in addition to serving suburban areas not then covered by transit.

In the summer of 1970, UMTA selected Haddonfield, New Jersey rather than Rochester as the location for an UMTA-sponsored demonstration project. (The Haddonfield demonstration was initiated in February 1973 and ended in March 1975; the system ceased operations at that time.) Although Rochester was not chosen as the location of the UMTA demonstration project, interest in a dial-a-bus service remained high. In July 1970, Robert Aex, Executive Director of the recently-formed Rochester-Genesee Regional Transportation Authority, attended a one-day seminar devoted to dial-a-ride at MIT. Mr. Aex subsequently expressed a willingness to implement an experimental dial-a-bus and subscription service program in Rochester, and MIT staff members soon became involved in the planning of the system. MIT was also requested to develop a computerized dispatching system that was foreseen as an integral part of the planned transit system.

In October 1971, RGRTA implemented a small dial-a-bus and subscription service system in the town of Batavia, a small, self-contained community whose private fixed-route bus system had just been acquired by RGRTA. The results of this system were favorable, and MIT was asked to investigate several suburban areas of Rochester and then select the most appropriate site for a suburban test project. The suburban area of Greece and northwestern Rochester was chosen because it had a relatively high population density, was poorly served by conventional transit, and contained a number of large employers within a concentrated area. The Kodak Park complex, with an employment of 25,000 persons, was a particularly attractive site for implementing work subscription services.

MIT tested a number of potential service areas using a dial-a-bus simulation model and, as a result, a 9.6 square mile service area was chosen. MIT estimated that the dial-a-bus system would have a mode share of about 1.5 to 2 percent, or about 8.7 to 11.8 demands per square mile per hour after about one year of service. Sample simulation runs were made assuming a 1.5 percent mode share, 1.2 passengers per trip demand, and 10 vehicles with an average vehicle speed of 15 miles per hour. These runs generated a vehicle productivity level of 9.6 passengers per vehicle-hour and an average wait time of 14 minutes.[3] In actuality, demand density did not reach the estimated levels and vehicle speeds averaged about 11 miles per hour, resulting in productivity and service levels which were lower than those forecast by the simulation.

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[3] Massachusetts Institute of Technology, "Development of the First Personal Transit System for the Rochester Metropolitan Area," November 1973, page 21.

As preparations for PERT service in Greece were being made, plans were also underway to expand PERT services into other suburban areas. In January 1974, only five months after PERT service in Greece had been implemented, plans were made to implement dial-a-bus systems in five other suburban areas by February 1976, including Irondequoit, Henrietta, Gates-North Chili, Brighton, and Pittsford-Penfield-Perinton. In addition, the Greece service area was scheduled to be expanded in three stages. By February 1977, a total PERT vehicle fleet of 70 vehicles was envisioned. Computerized dispatching of the dial-a-bus system was to begin in early 1975.[1]

The planned expansion of the PERT system was confirmed in the Comprehensive Development Program for Public Transportation prepared for the RGRTA in October 1974 by ECI Systems, Inc. (now Multisystems, Inc.). In this report, a system of seven rather than six PERT areas was envisioned. In addition, a proposal was made to substitute dial-a-bus for inner-city, fixed-route service during evening hours and on Sunday.

Demonstration Plans

The PERT expansion plans culminated in an application to UMTA in October 1974 to establish a two and one-half year demonstration project in which demand-responsive services would be expanded and integrated with the established fixed-route system. The application called for the implementation of computerized dispatching in Greece in early 1975, the expansion of the Greece system and the initiation of the Irondequoit system in September 1975, and the establishment of a PERT system in Henrietta in July 1976. A total of 20 small buses would be acquired, bringing the PERT fleet to 32 vehicles.

The demonstration officially began on April 1, 1975, three months later than planned. Consequently, the timetable of events was set back by three months. However, the original June 30, 1977 demonstration termination date was retained.

Computerized Dispatching Problems and Delays

Implementation of computerized dispatching, scheduled to be phased in at the start of the demonstration, did not begin until September 1975. The phase-in proved to take longer than anticipated due to the gradual discovery and

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[1]Massachusetts Institute of Technology, "Expansion Strategy for the PERT Dial-A-Bus System," January 1974.

correction of errors in the coded street network, unacceptably slow computer response times, a delay in the delivery of the new communication equipment required for efficient computerized operations, and an April 1976 fire at First Data Corporation time-sharing computer facilities which further reduced computer capacity and increased response time.

After the September 1975 initiation, an increasingly large number of evening service hours were operated under computer control, generally beginning around 4:00 P.M. (demand usually dropped sharply after 3:00 P.M.). The first attempt to operate by computer for an entire day was made on Saturday, October 4, 1975. By December 1975, most evening and Saturday service was being operated under computer control. Weekday computerized dispatching was attempted first on January 12, 1976, but several months passed before it was operating satisfactorily. The first week of June 1976, 15 months after the demonstration began, marked the beginning of full-time computerized dispatching; reversion to manual control was necessary only when a major system failure occurred. This section describes the major problems that resulted in this delay.

Street File Errors: Early problems in the implementation of computerized dispatching were caused by errors in the street file. In order for the system to function properly, all possible addresses within the service area and their geographical coordinates had to be entered in the computer's memory bank. Through a gradual trial and error and rechecking process, omissions were discovered and errors rectified.

Computer System Response Time: The Rochester computerized dispatching system was operated through the time-sharing computer facilities of First Data Corporation in Waltham, Massachusetts. Although direct phone lines were established between Rochester and the First Data Corporation facilities, system response times were often excessive because of queuing at the First Data facilities. Delays of 30 seconds to one minute were common during the first few months. Since access to the computer was required with each incoming request and each time a vehicle made a pick-up or drop-off, intolerable delays in the control room and on the road occurred.

The response time problem was corrected during the winter of 1976 through the assignment of greater computer priority to the Rochester DAB scheduling requests. However, in early April 1976, a fire destroyed much of the First Data Corporation computer facilities and system response problems continued for the next two months. Around mid-June, First Data Corporation modified its system so that up to 35% of its resources could be allocated to the DAB system if required. This change essentially solved the system response problems.

<u>Communications Equipment:</u> The implementation of full-time computerized dispatching was delayed for several months by a delay in the installation of the on-board video communication equipment. As discussed in Section 4.2.3, the frequent transmission of tour information to drivers under computerized dispatching necessitated a more efficient communication system than could be provided by either the radio or digital systems previously used. However, the cathode-ray terminals were not installed on all of the PERT vehicles until May 1976. Operations prior to that time relied principally on vehicles with digital equipment and radios. The General Motors buses, which were used as substitutes between December 1975 and April 1976, had no communication equipment during most of this time. Under such conditions, the resulting communication delays seriously limited the effectiveness of computerized dispatching. Consequently, reliable testing of the system was delayed.

<u>Other Software Changes:</u> During the entire demonstration period, the computerized dispatching software was continually evaluated and modified. These changes were usually made to correct perceived problems in the operation. For example, the number of pick-ups or drop-offs transmitted to drivers during each communication was increased from one to two and later to three in response to drivers' complaints about their inability to answer passengers' questions about when they would be dropped off. Another change occurred in May 1976, when passengers transferring to DAB were assigned greater priority because of the poor service they were receiving.

A major software change occurred in January 1977, when direct driver communication with the computerized dispatching system was implemented. Formerly, drivers would signal the dispatcher that they had made a stop and the dispatcher would direct the system to update that driver's tour. After the change, drivers received a revised tour directly from the computer upon completing a stop. This lowered the dwell times at each stop and relieved the dispatcher of this work.

Other software adjustments were made to the operation. In April 1976, a number of changes were made so that new tours were generated in response to certain conditions, such as a vehicle running significantly ahead or behind schedule. The method of scheduling driver relief times was reprogrammed in October 1976 because of inefficient tours resulting from the existing procedures.

Finally, the relative weights of the objective function parameters were constantly readjusted over time in order to derive the most desirable form for the given demand levels. The objective function formed the heart of the dispatching algorithm by representing a set of parameters that were to be minimized in making passenger assignments to buses. (These parameters included system response time, ride time, pick-up deviations and tour lengths.) Adjusting the weights of these parameters consequently affected the way that passenger assignments were made. For example, drivers complained that there was too much emphasis on reducing wait times, and tours consequently zigzagged excessively. In response, greater priority was given to shorter ride times and a penalty factor for reversing directions was inserted into the algorithm in March 1977.

• <u>Hardware Facilities:</u> Computer operations were often subject to interruption by hardware system failures. As shown in Exhibit 4.5, there was an average of 17 system failures per month once full-time computerization began in June 1976. Each failure lasted an average of about two hours, resulting in about 9% of all operating time being under manual control. Although no statistical data are available, hardware failures were apparently much more frequent during April and May 1976, following the fire at First Data Corporation.

The reversion to manual operations following a system failure was aided by a back-up log of all computer transactions that was continually updated and printed on a terminal in the PERT control room. When a system failure occurred, this log would inform the dispatchers of all requests that were awaiting pick-up as well as what passengers were presently on tours.

Even with the aid of the back-up log, the control room staff needed several minutes to orient themselves toward the state of the system and assign waiting passengers to vehicles. Consequently, when the system was down, no further service request calls were accepted while inquiries were made regarding the nature of the failure. If a short interruption was foreseen, operations were temporarily halted as the control room waited for the computer system to be repaired. If a longer failure was anticipated, the control room reverted to manual operations. In either case, a delay occurred and the level of service provided to customers suffered.

<u>Other Schedule Delays and Changes</u>

<u>Irondequoit Start-Up Delay.</u> Originally scheduled to begin under computerized dispatching on January 1, 1976, Irondequoit PERT service did not begin until April 12, 1976. This was primarily caused by a delay in the delivery of the

EXHIBIT 4.5

COMPUTER DISPATCHING SYSTEM RELIABILITY

(June 1976-June 1977)

Month	Number of Breakdowns[a]	Down Time (Hours)	Down Time as Percent of Total Operating Hours
June 1976	9	38	7.8%
July 1976	14	21	4.7%
August 1976	27	17	3.7%
September 1976	11	4	0.9%
October 1976	17	80	15.7%
November 1976	39	38	8.3%
December 1976	14	61	12.2%
January 1977	17	30	10.3%
February 1977	27	31	10.7%
March 1977	19	59	16.5%
April 1977	10	70	20.4%
May 1977	4	5	1.8%
June 1977	8	11	4.0%
Average	16.9	36.0	9.1%

[a]Includes computer hardware and communications equipment breakdowns as when service was stopped because of software problems.

Source: Nigel H.M. Wilson and Neil J. Colvin, Computer Control of the Rochester Dial-A-Ride System, Massachusetts Institute of Technology, July 1977.

new buses and communication equipment required for Irondequoit service. In addition, the collection of PERT services in Irondequoit were more extensive and diverse than in Greece and required a greater planning and market effort prior to implementation. Because of the delays in implementing computerized dispatching in Greece, Irondequoit computerized dispatching did not begin to be tested until February 1977.

Henrietta Service Cancellation. In the summer of 1976, the decision not to implement PERT service in Henrietta was made for two reasons. First, severe vehicle breakdown problems were experienced during the 1975-76 winter, and there were frequent vehicle shortages. Establishment of a third area distantly removed from the other two would have compounded the problems. Second, since demand and revenues in Greece were falling short of those estimated in the demonstration budget, it appeared that there might not be sufficient funding available to support service in Henrietta.

Transfer Station Delays. To help integrate PERT and RTS bus services, two transfer station facilities were constructed for the convenience of transferring passengers. In Greece, a station was built at Dewey and Ridge, adjacent to the PERT garage. In Irondequoit, a station was built at the Clinton Loop where the Summerville Shuttle and RTS Routes 5, 7 and 11 terminated during the off-peak period. These stations were opened to the public in September 1976 after a series of delays. These facilities were initially planned to be completed for the 1975-76 winter.

Planning work actually began in July 1975 when RGRTA contracted with a local architectural firm for design work. The firm worked for several months, but its designs proved to be too expensive to implement within the allocated budget. (The contract, which specified a fixed-percentage-of-construction fee, may have encouraged elaborate designs.) In December 1975, RGRTA stopped working with the local architect and, instead, a local engineering firm was engaged to do site drawings of the two respective areas and to prepare specifications for bids. Bids were advertised on March 4, 1976 and opened on April 2. Contracts were awarded and site preparation work was completed in June. There was a delay in construction of the transfer stations as a result of additional design and analysis required by the City of Rochester before building permits could be granted. Following that, there was a short delay in the delivery of the stations' fiberglass panels. Even as the stations were being completed, the fixtures for the direct telephones were being delayed by a UPS strike. The PERT manager finally had to construct plywood fixtures for temporary use when the stations opened.

After the stations opened, the heating was found to be inadequate as the weather turned colder. A contractor was engaged to make necessary modifications, but the contractor was a one-person operation and he had a heart attack in November 1976 followed by a relapse in January 1977. Consequently, the winter passed with no improvements in the heating system; the situation was still unresolved in mid-1977.

Organizational Issues

Differences in priorities existed between the various institutional organizations involved with the provision of PERT services. In the early stages of the system's development, there was disagreement over PERT between RGRTA staff and RTS upper management. RGRTA was concerned that RTS bus ridership had been steadily declining for over 25 years, operating costs were beginning to rise rapidly, and the prospect of increasingly large deficits seemed imminent. Robert Aex, the first executive director of RGRTA, felt that radical innovations were necessary to counter these transit trends. Perceiving an untapped suburban market, innovative services such as Park-and-Ride routes, Dial-A-Bus and other paratransit services were conceived for reversing Rochester's transit trends. Dial-a-Bus was viewed as a means of expanding transit coverage into previously unserved areas and therefore boosting ridership, and of substituting for unprofitable off-peak fixed-route services, thereby improving RTS operations.

Jack Garrity, who replaced Reading as manager of RTS, viewed the situation differently. He observed that the fixed-route system was basically sound, but in desperate need of new capital equipment and facilities and additional funding for operating expenses. He felt that the development of a reliable fixed-route system should be the foremost objective, and viewed DAB as an effective but expensive mechanism for expanding transit coverage into low-density suburbs. He felt that DAB subsidies would be far greater than those on the fixed-route system, and that it was unrealistic to expect DAB to improve the system's financial standing as Aex predicted.

Garrity essentially refused to commit RTS to the DAB concept because he thought the DAB objectives were unrealistic. Although RTS officially operated PERT services, and many of its staff members came from RTS, Garrity viewed PERT as an autonomous organization to which RTS provided drivers and vehicles and billed accordingly. Consequently, RGRTA and MIT had to play a major role in planning and managing PERT services, a role for which neither was well prepared. RGRTA lacked the manpower to closely oversee the project, and MIT was hindered by distance and, as an academic organization, was perhaps not prepared for the role of managing a transit system. Thus, the PERT system was somewhat isolated from RTS. Many persons, both inside and outside the PERT organization, viewed PERT as the orphan in the family of Rochester transit services.

Since RTS would not play the leadership role in PERT planning and management, the demonstration was structured so that MIT would be responsible for PERT operations and management.[5] In addition to MIT staff members having a proven expertise in the new paratransit field, MIT was seen as uniquely qualified to implement the computerized dispatching system planned for the demonstration. This arrangement was acceptable to RTS, since it did not require RTS to take responsibility for PERT. At the time of the demonstration application, the route rationalization actions of 1974 had apparently strengthened the opposition to PERT among RTS officials. Although a logical expediency given the unwillingness of RTS to manage PERT, the lack of management integration of PERT and RTS created the operational problems described subsequently, which were not resolved until the demonstration's second year.

The organizational problems were compounded by the division of authority between the RGRTA commissioners, the RGRTA staff and RTS management. The designated chain of command is from the RGRTA commissioners to RTS management, with RGRTA staff serving in a staff role to the commissioners. In actuality, however, the RGRTA commissioners did not assert themselves as the primary policymakers until about the middle of the demonstration. Until that time, RGRTA commissioners and other staff members could not recall an occasion in which the commissioners did not follow RGRTA staff recommendations. In fact, Robert Aex abruptly resigned as executive director of RGRTA in January 1976, after receiving a majority vote of confidence that was not unanimous:

> Aex's resignation came as a shock, authority commissioners said later. Moments before he resigned, Aex was given a 5 to 1 vote of confidence by the commissioners. Two commissioners abstained from voting. Another commissioner was absent. Aex, 63, gave no

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[5]The demonstration application states, "The Authority will contract with a consultant (MIT) who will have responsibility for overall demonstration project administration, operations administration (including a resident operations manager), administrative overhead (including travel expense, secretarial support staff, materials and supplies, etc.), and liaison with project participants (UMTA, RTS, NYSDOT, and any independent contractor selected by UMTA)."

reason for his resignation then and has since remained silent on the question. While the vote for Aex appeared favorable, the tally could have been construed as insufficient support by a man who demanded almost total backing by commissioners, sources said.[6]

Following Aex's resignation and until the appointment of Joseph Silien as executive director in October 1976, RGRTA did not play a strong role in PERT management. Howard Gates, the RGRTA director of public relations, was acting director during this period, but did play an active leadership role, possibly because of the temporary status of his new position.

Although the overall demonstration program suffered from some management difficulties, the computerized dispatching component of the demonstration was managed quite effectively. This was significant because the previous UMTA demonstration of computerized dial-a-bus dispatching in Haddonfield, New Jersey suffered from several management problems. For that demonstration, one contractor developed the hardware and software for the project, while three other contractors were ultimately responsible for implementing and operating the system. There was a frequent lack of coordination between these four firms. In Rochester, the assignment of full responsibility to MIT for both developing and operating the computerized system proved to be a much more effective management structure.

4.3.2 Daily Operations

Personnel Requirements

Administrative and Control Room Staff. Prior to the demonstration, PERT was managed by a full-time resident manager with a full-time secretary. They were joined after June 1974 by an administrative assistant who also dispatched part-time. Initially, there was a full-time dispatcher and two full-time order processors, one of which dispatched part-time. As DAB service in Greece expanded, additional persons were added to the control room. By early 1975, there were generally one dispatcher and two order processors working during morning and afternoon hours, and one dispatcher and one order processor working during evening hours. After the demonstration began, a director of special

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[6]Pritchard, Keith, "Frustration Takes its Toll at RTS," Rochester Democrat and Chronicle, February 1, 1976, page 1B.

markets was hired to take responsibility for marketing and public relations. A computer programmer/operator was also hired in the control room when computerized operations began.

In early 1976, the PERT administrative structure was significantly revised by the new resident manager in conjunction with the initiation of Irondequoit service. Since the demonstration requirements had greatly increased the data tabulation and recordkeeping tasks, this function was occupying most of the administrative assistant's time. A full-time bookkeeper was hired and the administrative assistant became responsible for driver supervision and general administration. The former senior dispatcher became responsible for all control room operations, which were expanding with the addition of Irondequoit service. This allowed the resident manager to concentrate his efforts on general troubleshooting and vehicle availability, which had become the system's major problem.

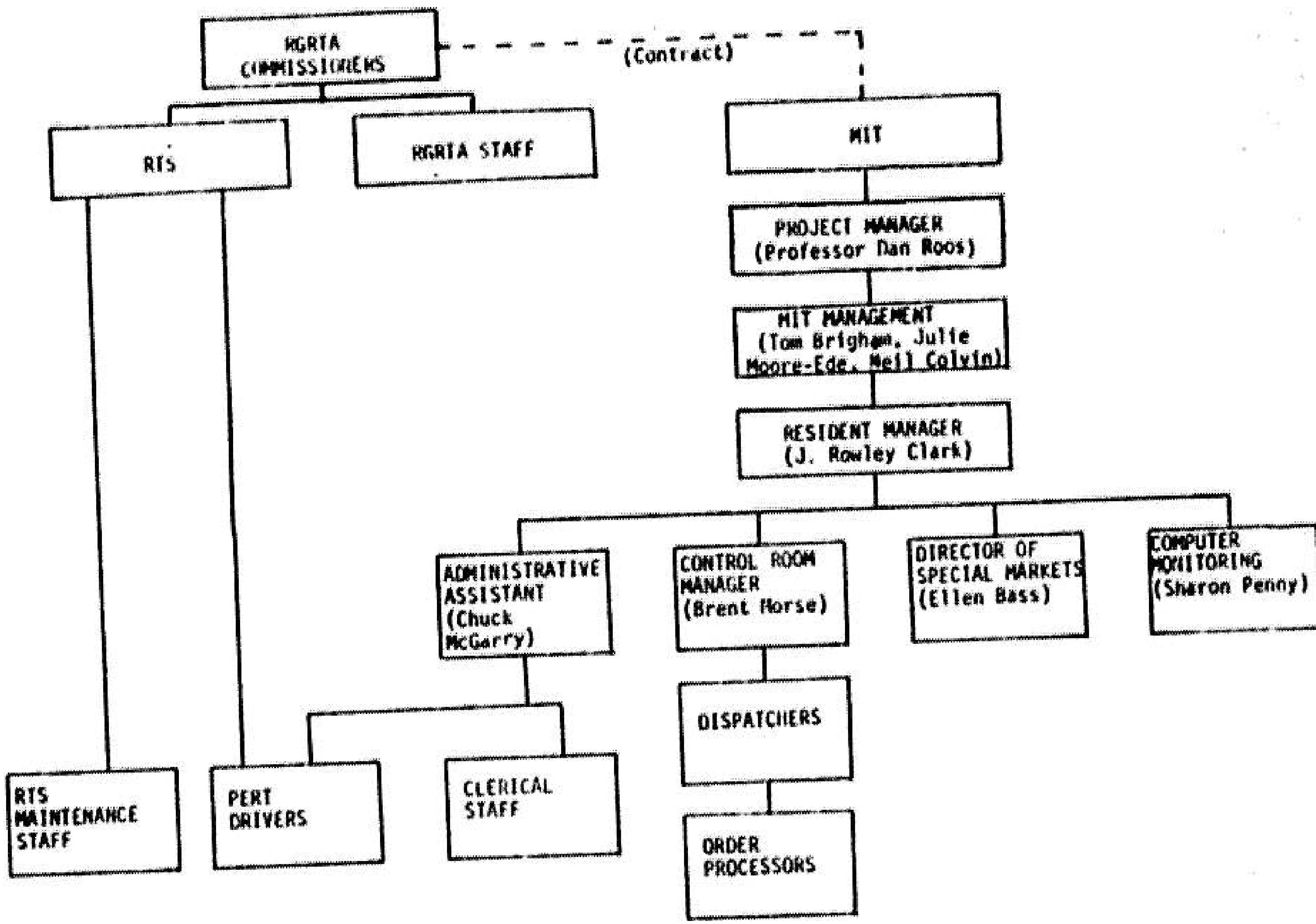
With the cutback of PERT services in January 1977, the control room staff was also trimmed slightly. By that time, the PERT system had evolved into the organizational structure shown in Exhibit 4.6. The resident manager position was eliminated as many operational problems were solved.

When computerized dispatching was introduced, it was anticipated that one dispatcher would be able to handle both Greece and Irondequoit DAB operations. Initially, each service area continued to have a separate dispatcher, primarily because of the need for a manual back-up capability. Beginning in June 1977, however, one dispatcher handled both service areas with the control manager or computer supervisor becoming a second dispatcher when manual dispatching was required. The number of order processors was also reduced in both January 1977 and again in June 1977, when one order processor was required to handle both service areas. However, these changes reflected the DAB and work subscription service cutbacks at those times rather than computerized dispatching.

Drivers and Maintenance Staff. PERT drivers were unionized employees of RTS working under the same union agreement as other RTS drivers. This required paying union pay scales and prohibiting part-time drivers, thus escalating PERT's operating costs relative to other DAB systems (see Appendix Section A.20).

Drivers chose PERT work rather than regular RTS work on the basis of seniority. The only difference was that drivers chose PERT on an annual basis each January rather than being scheduled three times per year as other RTS drivers were. This change was made in order to limit the amount of

EXHIBIT 4.6 PERT ORGANIZATION STRUCTURE (SPRING 1977)



training of new drivers. In addition, PERT demand did not slacken significantly in the summer as RTS demand does and, consequently, driver vacations had to be staggered over the year.

PERT drivers formed a unique group in the RTS union because of the different nature of their work and their physical separation from other drivers. Unlike other RTS employees who reported to work at the RTS garage on East Main Street, PERT drivers reported to the PERT garage in the Greece service area. PERT also maintained its own extra board -- those drivers who do not have scheduled runs but substitute for regular drivers who are absent, or who provide additional services such as charters.

The mechanics who serviced PERT vehicles, on the other hand, were generally regular RTS mechanics who worked at East Main Street and serviced both RTS and PERT vehicles. (One full-time mechanic was located at the PERT garage and provided very minor maintenance services, and a bus washer cleaned the buses at the PERT garage each night.) After early 1975, four RTS mechanics devoted most of their effort to the 28 PERT vehicles. In January 1977, during the most critical vehicle shortage, two additional mechanics were assigned to PERT vehicles. At the same time, seven PERT vehicles were taken out of service and replaced by vans and buses maintained under contract by private sector organizations. This left only the twelve GM vehicles, the seven Twin Coaches and one Rek-Vee vehicle to be maintained by RTS. The remaining Rek-Vee vehicle was retired from service in June 1977.

<u>Personnel Training</u>

When PERT services began, personnel training took place over a five-week period prior to the start of service. During the first week, an RTS dispatcher was chosen to be the PERT dispatcher and was oriented toward the nature of PERT services. During the remaining four weeks, the PERT dispatcher, the project manager and an MIT representative established control room procedures and trained the remaining staff of ten drivers and two order processors. They were introduced to PERT concepts, familiarized with the Greece service area, and trained to use the new equipment.

Training of personnel hired later was less extensive, since they had the benefit of observing an ongoing operation. Drivers and order processors were generally familiarized with the service areas and then observed other workers for two days before starting on their own. Discussions with a number of drivers and order processors in March 1977 revealed that these employees generally felt that their training was satisfactory.

Dispatchers, on the other hand, had varying amounts of training and some problems were reported. Most of these persons were former order processors. Their training consisted primarily of watching the dispatcher process orders; on some days, they were allowed to dispatch under the guidance of the dispatcher. During this period, trainees were familiarized with union work rules. Some of these dispatchers said that dispatching was very difficult at first, particularly when they were learning union work rules and had to handle the special situations that arose with day-to-day operation.

When computerized dispatching and the new communication equipment were introduced, all employees received special training for about two days by MIT and First Data Corporation staff. Drivers and control room employees felt this training was adequate. In addition, a full-time computer programmer/operator worked continuously in the control room to handle any computer problems.

Coordination and Effectiveness

Management. Virtually everyone in Rochester connected with the demonstration, from the PERT order processors to the RGRTA commissioners, expressed concern about the fact that major demonstration decisions were made by a non-resident group. The situation was viewed as unsatisfactory during the demonstration's first year and the 19 months of operation prior to the demonstration. Beginning in the summer of 1976, Tom Brigham of MIT began to play a full-time, in-residence management role, and control room personnel unanimously agreed that this considerably improved the situation.

Members of the control room staff had a number of specific complaints about the management system prior to the summer of 1976. Almost everyone told of situations in which a memo would be received mandating an immediate change in operations, but no one who knew the motivation for the change was present to answer questions or help implement the change. At other times, the PERT managers would be asked to comment on a proposed change, and while they analyzed the change and prepared comments, the directive for implementation would already be received. There were also communication problems at the upper levels of management as a result of the division of management responsibilities between RGRTA, RTS and MIT. The RGRTA director of marketing, who was responsible for preparing PERT promotional materials, told of first learning about a planned promotion scheduled for three weeks later at a regular RGRTA commissioners' meeting, along with everyone else present, including the press. Other promotions were planned and implemented with little input from PERT or MIT staff members, and a number of tactical and typographical errors resulted.

__Service Planning.__ Persons involved in the project also felt that too many service changes were implemented during the project's life. Major service and fare changes were implemented with virtually every drivers' pick (three times per year) between June 1974 and January 1977. As a result, drivers and control room staff were sometimes confused, which led them to believe that customers were even more confounded. The zonal fare system, implemented between September 1976 and January 1977, represented an example of this confusion. With special rates for elderly users, transfers and groups, computation of fares became a cumbersome task that evoked confusion and occasional confrontations between customers, drivers and control room workers.

Many of the major service changes also occurred during the period between late 1975 and early 1977 when there were constant vehicle shortages. A number of PERT and MIT workers felt that it was futile to experiment with service and fare innovations when the system did not have sufficiently reliable equipment to guarantee a satisfactory level of service. The pressures of change were also manifested in many of the changes themselves: Two major marketing promotions were ineffective because advertisements and promotional materials did not reach the public until after the promotion period.

__Control Room Operations.__ Although several problems were reported by workers, the PERT control room staff maintained a high morale, even during periods when vehicle shortages and computer problems caused service levels to seriously deteriorate. The staff was a useful one, and almost everyone was enthusiastic about trying to make PERT successful. Working conditions were improved in March 1976, when the PERT control room was moved from very cramped quarters in the old RTS garage to the new RTS administration building. Most of the problems cited reflected the control room staff's frustrations in attempting to make the PERT system successful.

Turnover during the nearly four years of the PERT project was extremely low. However, three order processors and two part-time dispatchers were dismissed in January 1977 because of the service cutbacks occurring at that time. PERT managers acknowledged that some of those let go were "problem cases." The entire PERT managerial staff expressed full satisfaction with the performance of the remaining control room workers (three dispatchers, two order processors, one bookkeeper/order processor and one secretary).

The one common problem that surfaced in interviews with control room staff (including PERT management) was that workers did not perceive a clearly defined line of authority. Several described the situation as being one of "too many chiefs and not enough Indians." After January 1977, when the interviews with workers were conducted, there were five managerial workers at PERT plus the MIT management staff and only seven dispatchers, order processors or clerical workers. Consequently, a number of order processors and dispatchers reported that work orders and requests came from a number of different people and that they were sometimes in conflict with each other. It was occasionally difficult to resolve a question that arose, since the different managers sometimes had different interpretations of the problem. For example, rules regarding subscription signups and cancellations were often relaxed for the convenience of the customer, but there were differing opinions over the extent to which a rule might be eased.

A second problem that surfaced concerned the requirements placed on the dispatchers. The principal dispatcher until the initiation of Irondequoit service was Brent Morse, a former RTS dispatcher. At that time, he was moved into a managerial position, and additional dispatchers were trained for both Greece and Irondequoit. These new dispatchers were almost all former order processors without the deep familiarity with transit operations that Brent Morse had obtained as an RTS and PERT dispatcher. The new dispatchers also worked at a significantly lower pay scale than the RTS dispatchers. These policies were adopted because the computer was expected to assume most of the difficult aspects of dispatching, and lower-level personnel would then be able to serve as dispatchers.

As it turned out, the implementation of computerized dispatching was delayed. Furthermore, reverting to manual operations when the computer system failed proved to be a complex and cumbersome task, one that was not comfortably mastered by the control room staff for many months. The dispatchers also had to cope with any problems occurring on the road and to assign extra board drivers when required. Several dispatchers were young women, and there were initially some doubts about their effectiveness in directing older male drivers who were accustomed to the brusque methods of RTS dispatchers. Most of the new dispatchers described an initial period of uncertainty before they became more confident.

Of the drivers interviewed in March 1977, only a small minority actually expressed dissatisfaction with the performance of the dispatchers. Most thought that they were very cooperative and did an effective job. Several drivers also expressed appreciation of the dispatchers' efforts to foster enjoyable working conditions. For example, the dispatchers might display messages on a driver's screen like "have a nice weekend" prior to finishing a run.

Coordination with RTS Operations. Initially, passengers transferring from an RTS bus to DAB were required to call for service prior to boarding the RTS bus or when arriving at the transfer point. Calling prior to boarding the RTS bus could have been inconvenient, or it might have been difficult to know when one would arrive at the transfer point. Alternatively, calling upon arrival at the transfer point would have resulted in the normal delay between calling for immediate service and being picked up (an average of 25 minutes). Consequently, beginning in February 1974, passengers were asked to inform the RTS driver of their DAB request. The RTS driver was instructed to radio the request to the RTS dispatcher, who then telephoned the PERT control room to relay the information.

This procedure, which had two intermediaries between the customer and the PERT control room, proved to be unsatisfactory. There was no formal tabulation of the number of transfer requests made to the RTS driver that did not reach the PERT control room, but PERT dispatchers believed that such cases were quite frequent. Both RTS drivers and dispatchers may have been negligent on occasion. Even when the request arrived at the PERT control room, the message had sometimes been misinterpreted along the way.

The procedure was altered in January 1977 so that the RTS dispatcher was bypassed. Only one of the two RTS radio channels was used during the off-peak period, and the second RTS radio channel was reserved for DAB transfer requests during this time. In addition to bypassing the RTS dispatcher, this allowed the PERT control room to indirectly communicate with the customer through the RTS driver. This was helpful when there were problems involved with the request, such as a request for service to a point outside the service area.

Drivers. PERT drivers generally expressed a preference for PERT work over RTS runs, an expected response since PERT drivers could have chosen RTS work if they desired. The initial ten PERT drivers in 1973 were all very high on the seniority list, having an average of 29 years experience. As the PERT system expanded, drivers with less seniority were able to choose PERT work. (After the Irondequoit start-up, there were 30 scheduled PERT runs compared to about 240 for RTS.) Drivers stated that the work was more enjoyable than RTS runs because there was less vehicular traffic to deal with, fewer problems with noisy teenagers, a friendly rapport with the customers (unlike dealing with the anonymous passengers on regular RTS runs), and less monotony.

Several drivers also noted the more pleasant PERT working environment, as opposed to the RTS East Main Street garage. Drivers described PERT managers and dispatchers as being more understanding than RTS managers; in the regimented RTS working environment, communication between workers and managers was uncommon, and neither management nor the workers trusted each other. The small PERT operation encouraged a more comfortable relationship between drivers and management.

Though satisfied with the performance of most drivers, PERT management acknowledged a few problems with some drivers, especially before January 1977. Because they do not adhere to a fixed schedule, demand-responsive services allow a driver much more freedom than a fixed-route run would permit. It was alleged several times that drivers took unauthorized and extended breaks after dropping off their last passenger. To be aware of actual driver behavior, supervisors had to follow buses around; this was viewed as harrassment by many drivers. Adding to these difficulties was the extreme distance of the control room from the garage (four miles).

PERT managers were sometimes distressed over the lack of commitment of the drivers to the project. Part of this problem was attributed to union rules; drivers could not do any work other than drive, not even to tighten a bolt so a mirror wouldn't fall off. Management also complained that some drivers wouldn't take a bus out if they could find the most trivial thing wrong with it, either so they would not have to go out on the road or could go out in a newer bus. Drivers responded to this charge by saying these precautions were for security and safety reasons; they could be held responsible for any accidents in which they were involved, and did not want to take any unnecessary risks. During the year and one-half of vehicle shortages, drivers felt that buses were returned to service before they were ready and were sometimes even dangerous. They felt that they were already "bending" the work rules for PERT (such as backing up buses without an observer, despite RTS regulations prohibiting this), and that their commitment to PERT was acceptable.

There are undoubtedly elements of truth to both sides. A PERT manager summed the situation up by saying that it was essentially no different from RTS itself or any other large organization; the majority were good workers, but problem cases occasionally arose.

<u>Vehicle Maintenance.</u> PERT vehicles were maintained by the RTS maintenance staff. Because of the severe vehicle breakdown problems, PERT workers and management grew suspicious of both the competence and effort of the RTS maintenance department. Dispatchers complained that it sometimes took hours before the RTS tow truck reached a crippled vehi-

cle. The PERT resident manager spent much of his time as an on-the-road troubleshooter, keeping a gasoline container and a spare farebox in the trunk of his car.

Although not stated as formal policy, RTS management may have considered PERT to have a lower priority than fixed-route maintenance service. To compound this situation, RTS management was also restricted by some of the demonstration policies and operating procedures, making it difficult to resolve some of the vehicle problems. For example, a spare parts inventory was not established until February 1977 because the regulations specified that parts could not be charged to the demonstration until they were actually used. Because of the diversity of vehicles, a comprehensive spare parts inventory would have required a large cash outlay far in advance of compensation. On the other hand, it may be hypothesized that if RTS management had been totally responsible for PERT, they would have sought to change these constraints.

Nevertheless, the major problems with PERT vehicle maintenance were in the vehicles themselves and the entire RTS maintenance operation. The use of several different bus models hampered maintenance efforts in several ways. First, it became prohibitively expensive to stock a spare parts inventory. Second, mechanics were forced to become familiar with a variety of new buses. The RTS maintenance staff was accustomed to maintaining only the large General Motors diesel buses, and now had to work on a variety of gasoline-powered vehicles. Finally, several vehicle types proved to be of a very low quality and are no longer manufactured, while others were prototype vehicles that were expected to have "bugs."

The RTS maintenance department was seriously disrupted during the demonstration by the construction of the new RTS garage, which was still not complete in June 1977. In addition, until the 1974 union contract, union regulations specified that present employees be given priority for all promotions. Consequently, RTS mechanics rose from the ranks of the bus washers and no trained mechanics were hired directly for mechanic's work. In the 1974 union contract, the mechanical department was separated from the bus-washing operation; however, bus washers hired before November 1974 still receive priority for transferring into the mechanical department. The last of these bus washers will probably have moved up by 1979, allowing RTS to begin hiring trained mechanics. Despite these problems and much outside criticism, the RTS director of maintenance expressed confidence in his workers and operation, although he acknowledged a great need for a second tow truck.

<u>Communications Equipment.</u> During early 1976, the digi-

tal printers used on the buses were replaced by cathode-ray terminals to facilitate transmitting tour information from the dispatchers to the drivers. In January 1977, direct driver communication with the computerized dispatching system was introduced.

During busy periods under manual dispatching in 1975, the PERT dispatcher was often delayed in transmitting tour information to vehicles because of the high level of communication demand on the system. Vehicles consequently had to idle while waiting for instructions, thereby lowering productivity. It was foreseen that under computerized dispatching, the printer speed would be inadequate, as only one pick-up or drop-off instruction was to be transmitted at one time rather than an entire tour. Consequently, cathode-ray terminals with a much faster communication speed were purchased and installed.

Generally, drivers spoke favorably of the new communication equipment, mainly because of the larger readout compared to the small printing on the digital printers. Complaints focused on aspects of computerized dispatching which the new terminals were designed to accompany. For example, when picking up a large group of passengers at a shopping mall, some drivers found it convenient to obtain a single hard-copy listing of all passengers which they could check off as drop-offs were made. With the cathode-ray terminals, only two or three drop-offs were listed at a time.

Both the digital printers and cathode-ray terminals were favored over radio communication, which was slower and more subject to error. Between February 1976 and June 1976, when full-time computerized dispatching began, radio communication was used during periods of manual dispatching, which decreased system productivity. After June 1976, voice was used only when the computer system was down.

4.3.3 Employee Reactions to Computerized Dispatching

PERT employees in Greece and Irondequoit, including management personnel, control room workers and drivers, were interviewed by the Rochester evaluation team during the first week of March 1977. Computerized dispatching was one of the topics discussed. At the time these interviews were conducted, computerized dispatching had been operating full-time in Greece for nine months, and for about two weeks in Irondequoit. It had been 17 months since testing of computerized dispatching began in Greece. Only a few of the control room workers and drivers had directly experienced

PERT's full evolutionary process from a smaller manual DAB system in 1973 to a well-developed manually-controlled system in 1975 to the smaller computer-controlled system of 1977.

PERT Management (Excluding MIT)

PERT managerial personnel expressed a variety of views about computerized dispatching. One person felt that computerization of transit operations was inevitable, just as other government and business organizations have had to computerize their operations to remain efficient and competitive. Under this view, the breakdowns and inconveniences that have accompanied the computer's implementation were overshadowed by its eventual benefits. Other persons, however, questioned the role of computerization in an operation such as PERT.

The latter group cited several operational problems of computerized dispatching, many of which were also mentioned by control room staff and drivers. One problems frequently cited was that under computerized dispatching, and especially under conditions of high demand when a large backlog of requests developed, vehicle tours were constantly rearranged. This made the drivers' job frustrating, since they were constantly shifting directions. Furthermore, inefficient tours often resulted because the success of such tour rearranging depended upon the vehicles actually being where the computer thought they were at the moment. Since drivers would sometimes go faster or slower than the speed that was input into the computer, the rearranged tour was sometimes based on false locational information. Furthermore, if drivers made a pick-up or drop-off that was out of order without notifying the dispatcher (which they were not supposed to do), further problems resulted.

The PERT management staff agreed that computerized dispatching had not been sufficiently tested under high demand conditions such as those in 1975. However, under the low demand density conditions that prevailed after September 1976, computerized dispatching was viewed as working effectively. The greatest difficulty occurred when the system failed and a reversion to manual control was required. The dispatchers needed time to orient themselves to the buses' locations and the demand backlog before they could dispatch effectively.

Because of the personnel required when a computer breakdown occurred, the PERT managers generally felt that two dispatchers were still required for Greece and Irondequoit. Thus, they did not foresee a reduction in control room personnel costs through computerizaion unless system reliability greatly improved. Some of those interviewed also felt that even under computerized dispatching, the remaining dispatchers' work required that two dispatchers be present. This additional work included making sure runs began on time, handling the extra board, communicating with the drivers, and handling vehicle breakdowns. Although one dispatching position was eliminated in June 1977, the PERT operation was sufficiently scaled down at this point so that the control room manager handled many of the functions that a dispatcher normally would.

Control Room Workers

The dispatchers and order processors echoed many of management's thoughts regarding computerized dispatching. One dispatcher said that handling unusual events such as bus breakdowns was more difficult under computerized dispatching but, overall, the work was generally much easier than under manual control. In addition to eliminating the construction of tours, the dispatchers no longer had to respond to the order processors' requests for information about projected pick-up times. However, because of the need for backup capability when the computer failed and the additional work required, the dispatchers agreed with management that two dispatchers were still necessary.

Order processors cited the early frustrations caused by errors in the street address file when asked about computerized dispatching. Before errors were identified and corrected, which took several weeks, they described frequent occurrences when they had to experiment with various names before the computer would accept an address. In general, though, order processors viewed the system as inherently more efficient than under manual control, citing the reduced paperwork tabulations, the additional information available when interacting with customers, and the elimination of the need to disturb the dispatcher when pick-up information was needed.

Drivers

PERT drivers were the most vocal group when computerized dispatching was discussed. The drivers could generally be divided into two groups: those who had joined PERT with the Irondequoit expansion in April 1976 or later, and those who had worked with PERT during 1975 prior to computerized dispatching. The latter group felt that DAB service had deteriorated, and attributed this partially to computerized dispatching. They were much more critical of the concept than the former group.

Almost every driver, regardless of when they joined PERT, felt that the tours constructed by computer gave undue weight to pickups. This resulted in a constant zigzagging across the service area and excessively long ride times. Several drivers pointed out that this practice reduced productivity at a time when PERT management and RGRTA were emphasizing higher productivity. Most annoying to the drivers were the times they were told to turn around and return to an area they just left in order to make a new pickup. This problem was subsequently addressed by inserting a penalty factor in the dispatching algorithm for such turnarounds. However, such turnarounds could still occur if the computer misjudged the vehicle's location. The more general complaint about excessive zigzagging was subsequently corrected by increasing the importance of ride time relative to pick-up deviation and wait time in the dispatching algorithm.

A second major driver complaint was that only three pick-up or dropoff messages were transmitted to the drivers at one time. Several drivers had tales of passing very close to a passenger's destination without dropping him or her off because they were unaware of the destination. Drivers also felt that it was sometimes embarrassing to not know what route they would be taking when customers inquired about it. They consequently couldn't tell a customer when he would be dropped off, unless it was among the three messages on his screen. Furthermore, since tours changed constantly under computerized dispatching, there was uncertainty even when a destination did appear on the screen. Drivers resented this loss of control over their work. One driver even felt management's demand for higher productivity was insulting, since at the same time they were limiting the drivers' control over the matter. The example of traveling faster than the computer assumed and consequently being called to an out-of-the-way pick-up was cited as an example of this contradiction.

Some drivers also mentioned the more subjective aspects of the work that the computer could not consider. For example, sometimes a passenger had to make an appointment and a driver would occasionally rearrange an assigned tour in order to drop that customer off first if others were not greatly inconvenienced. Others mentioned minor things that a driver knew when driving, but which the computer did not. For example, left turns off main roads were difficult to make at certain times of day, and a tour could be completed faster using a slightly indirect path. While such factors could theoretically be incorporated into a dispatching algorithm, it would be very difficult to do in practice. In effect, these drivers felt that DAB work was somewhat of an art, and that the computer could not successfully control all aspects of this work; they felt some driver initiative should be retained.

Several older drivers from 1975 spoke of the period before computerized dispatching in an almost nostalgic fashion, describing very busy days when the PERT dispatcher, Brent Morse -- whom the drivers greatly respected -- would announce at the end of the day that a new ridership record had been set. These drivers much preferred the manually-dispatched procedure in which they received a complete tour each time they communicated with the control room. They felt that such a procedure generated much higher driver commitment and morale.

5. GREECE: LEVEL OF SERVICE

The attractivenes of transit services, including demand-responsive services such as PERT, is largely determined by such factors as coverage, accessibility, fares, speed, and the reliability of the service. These factors -- especially the last two -- have come to be known as "service quality" or "level of service.[1] " Headways, travel speed, and on-time arrival records are the primary parameters by which the service quality of a fixed-route bus system is measured. Total travel time consists of an access time to the bus stop from one's origin, a wait time for the bus to arrive, a ride time on the bus, a time to execute a transfer if required, and an egress time to one's destination. There are no headways in a DAB system, but the speed of response to a request is important, as well as the accuracy with which that response can be predicted. These and other G-eece service quality measures are discussed in this chapter, along with results from the period prior to June 1977.

5.1 COVERAGE

Coverage refers to the availability of transit to the total population. A summary of several key measures of coverage is shown in Exhibit 5.1. The impact of PERT services on coverage is described in this section.

5.1.1 Population and Area Coverage

The fully-expanded Greece service area had a 1970 U.S. Census population of 68,820 persons within 15.2 square miles. Census block data showed that approximately 33,910 of these persons, or 49.3% of the total population, lived within one-quarter mile of at least one of the four fixed routes, three of which operated only during the peak period after route rationalization. Approximately 1,500 persons, most residing in the southeast corner of the service area, lived within one-quarter mile of two or more routes. (In this case, routes which share the same alignment, such as Routes 10 and 15, are considered as one route.) Over half

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[1]Level of service is sometimes used to denote the ratio of travel time by transit to travel time by automobile. To avoid confusion, this will be referred to as the level-of-service ratio, and "level of service" by itself will be used more generally.

EXHIBIT 5.1

COVERAGE BY MODE (GREECE)

	1970 Population Served (Percent of Service Area as of 9/75)			Population Using (Average Daily Ridership)					
	Total	Elderly (65+)	Handicapped	Total	Elderly	Handicapped	Fares	Route Miles	Daily Transfers
Previous Fixed Routes	33,910[a] (49.3%)	3,146 (59.4%) (see Exhibit 3.8)	N/A	2,600 (peak est.) 1,200 (off-peak est.)	N/A	N/A	40¢-50¢ 5¢ transfer	19.0 peak 18.0 off-peak	N/A
Auto	65,076 (94.5%)	N/A	N/A	153,000	N/A	N/A	-	-	-
Taxi	68,820 (100%)	5,301 (100%)	N/A	163 (pre-PERT) 65 (1976)	N/A	N/A	60¢first 1/6mi. +10¢addl.1/6 mi.		
New fixed route: peak	33,910[a] (49.3%)	3,146 (59.4%)	N/A	2,600 est.	N/A	N/A	40¢-50¢ 5¢ transfer	19.0	N/A
Off-peak Route 1	9,936 (14.4%)	1,196 (22.6%)	N/A	875	N/A	N/A	25¢-50¢ 5¢ transfer	4.6	N/A
DAB	68,820 (100%)	5,301 (100%)	2,200 (100%)	475	57 (12% of total)	1	$1.00 50¢ (elderly; midday feeder)	-	150
Subscription (work)	7,000 est. (100%)	-	-	150	-	-	70¢-80¢	-	-
Subscription (school)	16,000 est.	-	-	80	-	-	40¢-65¢	-	-
Shoppers Special	-	560 (62 & over) (9%)	-	70 (days of operation only)	70	0	0-25¢	-	-
Special Handicapped Services	-	5,301	2,200	-	Incl. in handi-capped	2 including DAB	$2.00 25¢ additional passenger	-	-

a = Within 1/4 mile of fixed route
N/A = Not available

(Exhibit 5.1, Continued)

Notes

Population Served:

Population served by fixed-route buses is population within 1/4 mile of route.

Data on elderly population served is interpolated from census tract averages.

Handicapped population based on 3.3% of population being non-elderly and handicapped and not able to use transit or able to use it only with difficulty. Figure used is reported in HEW National Center for Health Statistics, 1970 Census of Population.

Population served by automobile is based on the proportion of households with one or more automobiles.

Percentage figure based on proportion of population in service area.

Population Using:

Fixed-route ridership estimates are based on averages of load and ride counts between 1973 and 1975. Peak ridership is one-way ridership only (inbound A.M., outbound P.M.); off-peak ridership includes inbound and outbound passengers boarding or exiting in service area.

PERT ridership is generally the highest level that has been experienced for an extended period of time.

Automobile ridership based on 1969-1970 FHWA Nationwide Personal Transportation Study: Number of auto passengers = total number of households X 3.8 auto trips/household X 1.9 passengers/trip.

Taxi ridership based on 1973 national average per taxicab, reported in "An Analysis of Taxicab Operating Characteristics," International Taxicab Association (August 1975).

of those within one-quarter mile of fixed-route buses, 26.1% of the total population, lived in the Dewey/Latta corridor served by Routes 10 and 15. However, these buses ran on relatively long headways and a substantial portion of their routes were along a one-way loop, causing more indirect routing and longer travel times. Route 1, with the most frequent service, served 14.4% of the service area population.

A one-quarter mile width is generally assumed to be the coverage measure of a fixed-route bus. While the one-quarter mile definition indicates the geographical extent from which most regular riders are drawn to the service, three-eighths of a mile is assumed to be the extent of the route's coverage in terms of providing service if its use were a necessity. Applying the three-eighths mile definition meant that 65.3% of the population within the Greece service area had access to a fixed-route bus. Therefore, nearly two-thirds of the Greece population had access to fixed-route bus transit during peak hours, but slightly less than half lived close enough to become regular riders.

By definition, Greece PERT services could be accessed by all persons living within the service area. Thus, prior to the DAB service area contraction when the Dew-Ridge Shuttle was introduced, 35,000 persons without convenient (one-quarter mile) access to transit were provided PERT transit service. Furthermore, PERT services in Greece offered door-stop service, which is more egalitarian in nature than fixed-route service. With fixed-route buses, those residents living next to a bus stop are clearly in a more advantageous position than those living further away. Using the simple definition of fixed-route transit coverage, however, both users are defined as being equally covered. With DAB and other doorstop demand-responsive systems, almost all residents have geographically equal access to transit. The only exceptions are those persons without access to a telephone and those living on narrow cul-de-sacs which are not wide enough for a minibus to turn around. In the latter case, users usually wait for the bus at the nearest corner.

5.1.2 Time and Service Area Changes

Periodically, when management thought improvements could be made, PERT hours of operation and service area size were increased. By definition, these innovations increased geographic and temporal coverage. The key question concerns the degree to which these changes induced behavioral changes by attracting more riders during the extended time periods and from pre-expansion areas. A second question concerns the extent of coverage that may be achieved by a given fleet, which is a productivity issue. Finally, a related question concerns the coverage that can be achieved without a reduction in service quality.

The PERT service area was expanded four times. DAB operating hours were increased twice, followed by a service area and operating hour cutback. After the September 1975 expansion, the PERT service area was approximately 60% larger than the original service area of August 1973. Approximately 17,000 additional residents were served, representing an approximate 35% increase. Most of these new residents were not served by fixed-route buses.

The details of these changes were outlined in Sections 3.1.2 and 4.2.1 and the spatial changes are summarized in Exhibit 5.2. Generally, the areas added to the service area had a lower residential density, and between 60% and 80% of their populations were further than one-quarter mile from a fixed-route bus. Thus, as the PERT service area was expanded, it reached further into areas not served by fixed-route transit. However, these expansion areas had lower residential densities, higher incomes per capita and more automobiles per capita; all these factors have traditionally made them difficult to serve efficiently with transit. The September 1976 service area contraction, prompted by the introduction of the Dew-Ridge Shuttle, is shown in Exhibit 5.3.

5.1.3 Fares

RTS and PERT fare structures were discussed in Sections 3.2.2 and 4.2.1. A comparison of user costs for these alternative modes is shown in Exhibit 5.4. These comparisons are described in the following paragraphs.

There were such a variety of PERT fares, which varied by type of trip, time of day, and the period of the project, that any simple comparison of PERT and RTS fares is impossible. Furthermore, since the fixed-route and DAB services served different demands, a weighted average fare would be equally misleading. Nevertheless, some generalizations are possible.

DAB travel was generally more expensive than RTS bus travel, but this varied according to the type of trip. For example, a group of five people traveling from Longridge Mall to the Upper Lake corridor during the peak period between May and September 1976 paid only 40 cents per person on DAB, compared to 55 cents per person by fixed-route bus (Route 14 and transfer to Route 1). However, for a single person traveling locally in a fixed-route corridor during

EXHIBIT 5.2

PERT DAB COVERAGE GROWTH (GREECE)

Date	Map Zone	1970* Population	Percent	Percent Change**	Area* (sq. miles)	Percent	Percent Change**
August 1973	A	51,135	74.3%	- %	9.6	63%	-%
June 1974	+B	60,563	88.0	13.7	11.7	77	14
September 1974	+C	62,760	91.2	3.2	12.8	84	7
November 1974	+D	65,784	95.6	4.4	13.7	90	6
September 1975	+E	68,820	100.0	4.4	15.2	100	10

*While those living within 1/4 mile of the service area might be considered to have access to DAB, neither the population nor the service area includes this 1/4 mile.

**Based on September 1975 service area size.

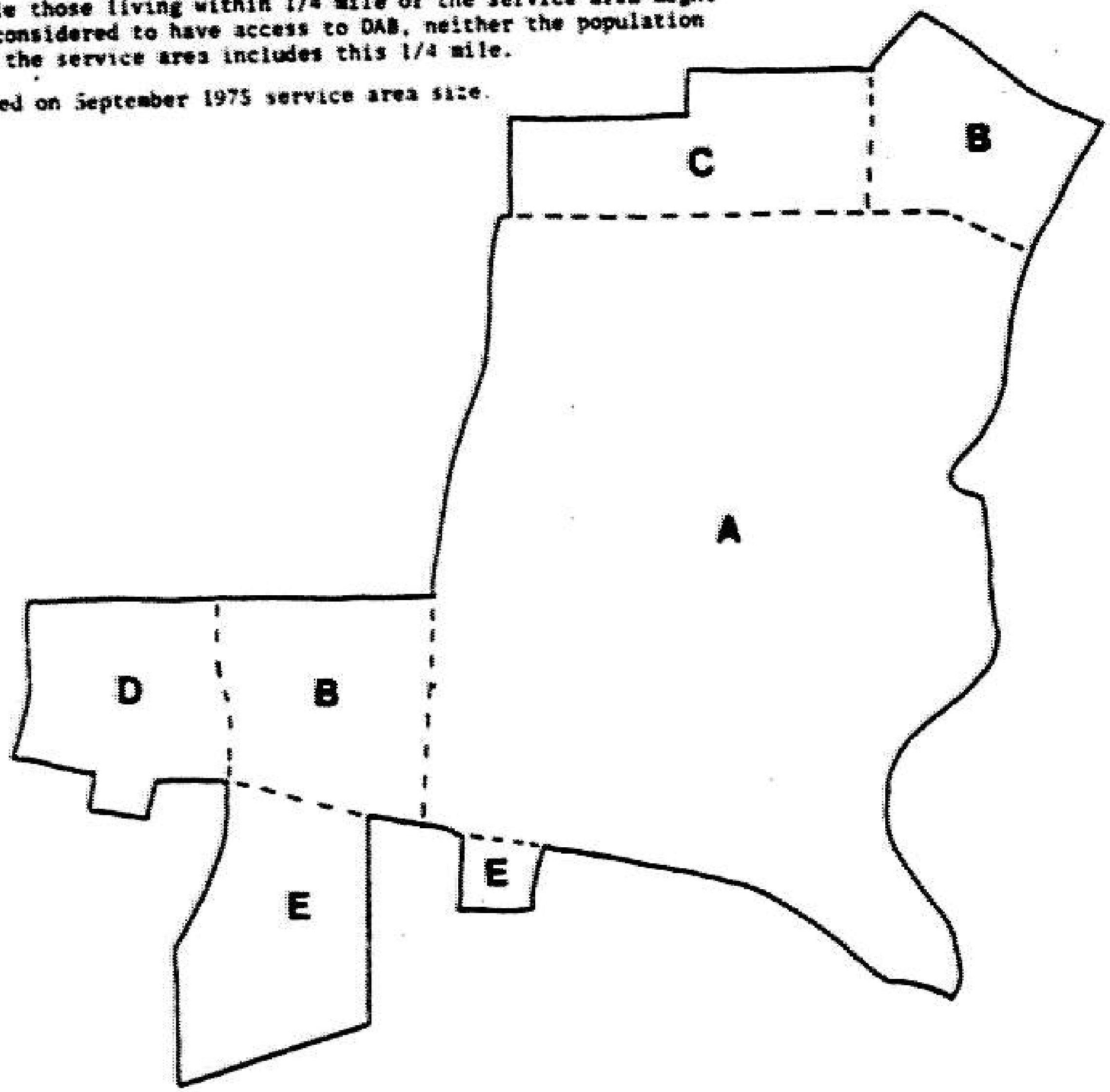

EXHIBIT 5.3

DEW-RIDGE SHUTTLE SERVICE

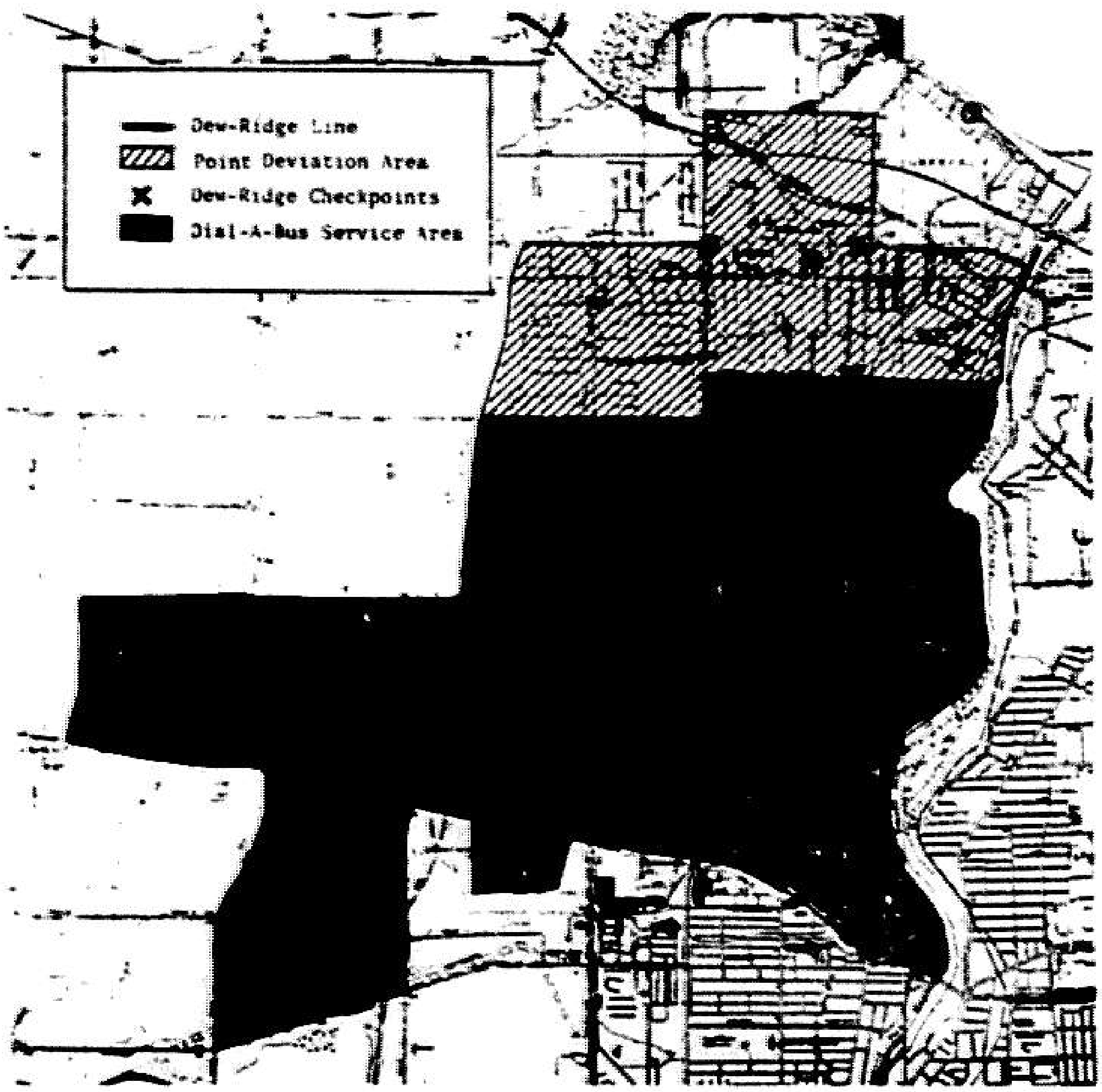

EXHIBIT 5.4

USER COST COMPARISONS (SUMMER 1976)

TRIP TYPE	MODES						
	RTS	PERT			AUTO	CARPOOL	TAXI
		DAB	SPECIAL SERVICES	SUBSCRIPTION			
GENERAL-PEAK							
Single Passenger	$.50	$1.00	-	-	$.45	-	$2.20
Average Passenger	N/A	.82	-	-	.35	$.25	1.70
Trip	N/A	1.07	-	-	.45	.50	2.20
GENERAL-OFFPEAK							
Single Passenger	.30	1.00	-	-	.45	-	2.20
Average Passenger	N/A	.82	-	-	.35	.25	1.70
Trip	N/A	1.07		-	.45	.50	2.20
GENERAL-OFFPEAK WITH TRANSFER (FEEDER FARE)							
Single Passenger	.35	.50	-	-	-	-	-
Average Passenger	N/A	.44	-	-	-	-	-
Trip	N/A	.58	-	-	-	-	-
ELDERLY/HANDICAPPED-OFFPEAK							
Single Passenger	.20	.50	0-25¢	-	-	-	-
Average Passenger	N/A	.44	0-25¢	-	-	-	-
Trip	N/A	.58	0-$4.50	-	-	-	-
GROUP (Five or More Persons)	30¢-50¢	-	.40	-		.09	.44
SPECIAL HANDICAPPED							
Single Passenger	-	-	$2.00	-	$2.72	-	$6.00+
Average Passenger	-	-	.38	-	1.81	-	2.20+
Trip	-	-	2.40	-	2.72	-	6.00+
WORK (Kodak & Rochester Products)							
Single Passenger	.50	-	-	70¢-80¢	.58	-	2.60
Average Passenger	N/A	-	-	.77	.56	.32	2.50
SCHOOL							
Single Passenger	20¢ (<age 6) 35¢ (>age 6)	-	-	40¢-65¢	.35	-	1.20
Average Passenger	N/A	-	-	.45	.22	-	.75
Trip	N/A	-	-	.73	.35	-	1.20

NOTE: Averages are calculated where appropriate based on the following assumptions:
- Summer 1976 fares are used; auto charged at 16¢/mile.
- Average trip distance equals 2.8 miles generally and 3.4 miles for work trips. Carpool distances 10% longer.
- Average costs and trip costs based on following passenger/trip ratios:
  - DAB: 1.3
  - Work Subscription: 1.05
  - School Subscription: 1.6
  - Special Services: 18.0
  - Special Handicapped: 2.7
  - Auto: 1.3 (1.05 for work trips)
  - Carpool: 2.0
  - Taxi: 1.3 (1.05 for work trips)
- Parking charges included for work trips only.
- Taxi costs include gratuity.
- NA = Not available.

the off-peak period between June 1975 and May 1976, DAB was as much as four times more costly than a fixed-route ride. Relatively few fixed-route users actually transferred (about one in eight), and most DAB passengers traveled during the off-peak in groups of one or two. Thus, DAB was more expensive than fixed-route buses for most users. Likewise, work subscription fares were higher than fixed-route peak-period fares, and school subscription fares were also higher than RTS student fares for trips to and from school, which were 35 cents (above grade 6) and 20 cents (grade 6 and under).

Special service fares varied, ranging from no fare when a merchants' group paid the costs to 40 cents per passenger for group trips. Special services were thus generally less expensive than other PERT services. The special handicapped service fare of $2.00 (plus 25 cents for each additional passenger) was the highest of the PERT service fares, but trip lengths for these services were also the longest. Furthermore, regular buses were generally not an alternative for these users, and special taxi services for the handicapped cost $6.00 per trip or more.

5.2 VEHICLE SUPPLY AND RELIABILITY

The supply of vehicles available to a transit system determines both its capacity to serve passengers, and hence its coverage, and the level of service supplied by the system. This section is therefore divided into an initial discussion of the fleet size of each PERT service, followed by an analysis of the operating and maintenance problems encountered, and overall performance of these vehicles, concluding with these effects on service quality. This discussion applies to both Greece and Irondequoit services, except where specific Greece services are noted. For similar Irondequoit vehicle results, refer to Section 8.2.

5.2.1 Vehicle Allocation to Services

As discussed in Section 4.2.3, the number of PERT vehicles grew from seven vehicles in August 1973 to 28 vehicles in early 1976, after which the least reliable vehicle was removed from service. This growth in the PERT fleet was necessitated by the steady expansion of PERT services and vehicle requirements, as shown in Exhibit 5.5.

RTS driver schedules (known as run guides) are generall, rearranged three times per year in January, June and September. Consequently, most of the changes in PERT operations and vehicle allocation coincided with these periodic

EXHIBIT 5.5

PERT VEHICLE SUPPLY

Date	Fleet Size	Peak Vehicle Requirement[a]	Fleet Size/ Peak Vehicle Requirement
August 1973	7	6	1.17
June 1974	8	7	1.14
September 1974	11	11	1.00
January 1975	13	12	1.08
June 1975	16	11	1.45
September 1975	16	13	1.23
January 1976	16	13	1.23
April 1976	27	21[b]	1.29
June 1976	27	21[b]	1.29
September 1976	27	21[b]	1.29
January 1977	27	16[b]	1.69

[a]Represents the maximum number of vehicles regularly scheduled for service at a single time.

[b]Includes PERT services in Irondequoit.

schedule changes. At these times, PERT management anticipated a new set of vehicle requirements that reflected the new service changes and the predicted demand response. At times when no service changes were made, the run guide might be rearranged to better match existing demand.

Exhibit 5.6 demonstrates how the average number of daily vehicle-hours for each PERT service in Greece changed over time. Although the subscription services vehicle supply underwent only minor fluctuation, DAB vehicle supply increased substantially during the project until June 1976. By 1975, an average of eight vehicles during the day and four vehicles at night provided DAB service. By early 1977, however, only five DAB vehicles were operating during the day, with the Dew-Ridge Shuttle operating three buses during the midday period. Throughout the project, work subscription service required between four and seven vehicles over four peak hours of the day, while school subscription service utilized two or three vehicles.

5.2.2 Vehicle Performance

The performance of the PERT vehicle fleet has been measured by three variables: the vehicle out-of-service time as a percentage of operating time, the average time between vehicle failures, and the average time to repair each breakdown. These measures are displayed in Exhibits 5.7 and 5.8 for each vehicle type used in Greece and Irondequoit.

Vehicle performance varied considerably between the various vehicle types and according to the period of the project. During the first two years of the project, prior to the start-up of Irondequoit service, PERT vehicles were out of service for maintenance 13% of the time, which is typical for a bus fleet. However, beginning in the 1975-76 winter, serious vehicle reliability problems were encountered and, between November 3, 1975 and February 12, 1977, PERT vehicles were out of service an average of 34.5% of the time. The slight improvement that occurred after February 1977 was a result of the replacement of several less reliable vehicles by new vehicles which were maintained under contract with private garages. The performance of the older vehicles did not improve. During the period after November 3, 1975, PERT vehicles were taken out of service after an average of 3.1 days in service, and returned after 1.5 days in the shop. Comparable data from before November 1975 is unavailable. It is debatable whether the improved reliability of the newer vehicles was because they were new, were better-built vehicles, or received better maintenance attention than at RTS.

EXHIBIT 5.6

AVERAGE DAILY VEHICLE-HOURS BY SERVICE

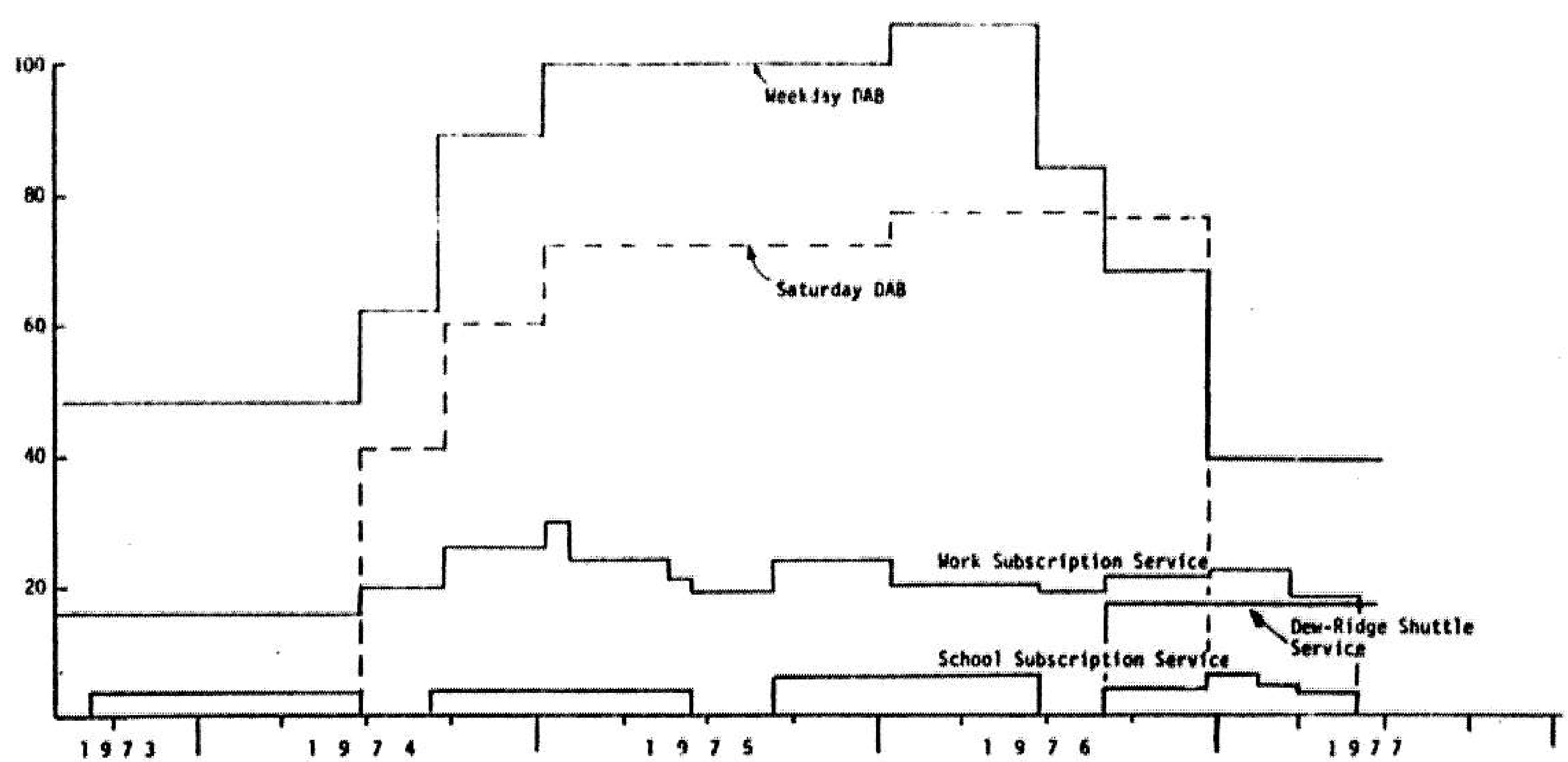

EXHIBIT 5.7

PERCENTAGE OF TIME OUT OF SERVICE PER VEHICLE TYPE

MAKE	VEHICLE NUMBERS	8/6/73-10/18/75	11/3/75-2/12/77	2/14/77-5/27/77
Twin Coach	1-7	7.2	40.5	38.2
Ford Econoline	8	21.9*	30.0*	--
Grumman	9-10	23.2*	52.6*	--
Rek-Vee	11-12	17.8*	31.6	31.9**
ElectroBus	13	55.7*	--	--
F.M.C.	14-16	21.3*	55.6*	--
G.M.C.	17-28	--	21.0*	29.3
Dodge Vans	29-32	--	17.7*	17.8
Dodge Minibuses	33-35	--	--	7.9
ALL:		13.0	34.5	28.0

* In service for part of period only.

** Only one bus in service.

Calculations based on a 16-hour operating day (6:00 A.M.-10:00 P.M.)

EXHIBIT 5.8

AVERAGE TIME BETWEEN BREAKDOWNS AND TIME TO REPAIR BY VEHICLE TYPE

(11/3/75 to 5/27/77)

Make	Vehicle Numbers	Average Time Between Failure (Days)	Average Time to Repair (Days)
Twin Coach	1-7	2.58	1.74
Ford Econoline	8	2.72	1.17
Grumman	9-10	1.86	2.06
Rek-Vee	11-12	3.28	1.52
F.M.C.	14-16	2.23	2.79
G.M.C.	17-28	3.61	1.06
Dodge Vans	29-32	8.42	1.72
Dodge Minibuses	33-35	7.01	0.60
ALL:		3.07	1.54

Calculations based on a 16-hour day (6:00 A.M.-10:00 P.M.)

None of the PERT vehicle types performed well between the 1976 and 1977 winters when Irondequoit service began. The 21.0% GMC figure is misleading because, until the initiation of Irondequoit service in April 1976, these vehicles were used only as substitutes. The Grumman and FMC vehicles were the least reliable; the Ford Econoline, Rek-Vee and GMC vehicles performed better, although they still were out of service about 30% of the time. The Twin Coach vehicles, while out of service about 40% of the time, were considerably older than the other vehicles, excluding the Ford Econoline. The Twin Coaches' performance during their first two years of service far exceeded that of the other vehicles. The Dodge vans and minibuses, however, also performed well following their introduction in 1977. These vehicles replaced the Grummans, the FMC's, the Ford Econoline and one Rek-Vee vehicle which were taken out of service at that time.

The causes of the PERT vehicle fleet breakdowns are shown in Exhibit 5.9, expressed as a percentage of total out-of-service time attributed to each problem area. This data were reported by the PERT control room, and represents the initial appraisal of the vehicle's problem; it is not fully accurate and there is considerable unreported data. While some variation between vehicles is reported, most problems were in the basic engine and transmission components of the vehicles.

5.2.3 Impact on the Level of Service

As displayed in Exhibit 5.5, the PERT vehicle fleet size generally exceeded peak vehicle requirements; during the period of severe vehicle breakdowns after November 1975, the fleet size was between 20% and 30% greater than the peak vehicle requirement. However, as discussed in the previous section, PERT vehicles were out of service an average of 34.5% of the time during the 15 months following November 3, 1975. This resulted in a frequent vehicle shortage, causing drivers to start their runs late as they waited for a bus to return from service. During the 16-week period from December 22, 1975 through April 10, 1976, an average of 1.61 daily runs started late (out of 15.8) as a result of insufficient vehicle availability. After the start of Irondequoit service, the situation grew worse because of the additional service requirements. From April 12, 1976 through September 11, 1976, an average of 3.63 runs (out of 14.9 Greece runs) started late each day. Between September 13, 1976 and December 31, 1976, an average of 1.91 PERT driver runs (out of 14.2) started late each day because of vehicle shortages. This was an improvement over previous months, but vehicle reliability continued to be a problem that negatively impacted the level of service offered.

EXHIBIT 5.9

PERCENT OF OUT-OF-SERVICE TIME ATTRIBUTED TO VARIOUS PROBLEM AREAS

(11/3/75 to 5/27/77)

Make	Engine/ Fuel System/ Exhaust	Trans-mission/ Drive Train	Brakes	Body	Access-ories	Electrical	Air Pressure System	Steering	Tires & Wheels	Suspen-sion	Other/ Unidenti-fied
Twin Coach	11.4	22.9	9.0	11.5	6.0	4.1	4.9	4.6	2.0	0.6	22.9
Ford Econoline	60.1	10.1	5.4	2.3	8.1	0.0	0.0	2.8	0.2	0.0	11.0
Grumman	4.6	7.3	7.1	0.6	6.1	8.7	0.6	1.1	2.4	1.5	59.4
Rek-Vee	9.2	11.7	14.4	1.5	19.0	20.0	1.8	4.9	1.8	0.0	15.6
F.M.C.	25.8	24.0	6.3	4.6	4.8	1.8	1.0	1.0	2.0	0.0	28.7
G.M.C.	27.1	6.3	11.8	10.5	7.6	4.6	4.9	2.9	6.2	2.5	15.7
Dodge Vans	9.4	3.3	0.0	2.3	10.9	0.0	39.9	3.9	0.0	0.0	30.4
Dodge Minibuses	39.9	5.1	0.0	4.0	13.3	24.4	0.0	0.0	6.4	0.0	6.9
ALL:	18.5	15.5	9.2	7.9	7.3	5.5	3.9	3.1	3.1	1.0	24.9

In January 1977, PERT services were substantially curtailed. Consequently, the peak vehicle requirement was reduced from 21 to 16 vehicles. In addition, seven of the least reliable vehicles were replaced (Section 4.2.3). The beneficial effects of these changes were initially offset by extremely harsh weather conditions during January 1977: During the first five weeks of the new year, an average of 2.44 daily runs (out of 11) started late, and service levels continued to suffer.

By February 1977, however, the new PERT vehicles were all in use and services began to improve. An average of only 0.43 runs (out of 11) started late between February 7, 1977 and May 6, 1977, and on over 75% of all days no runs started late. During this period, the seven new vehicles performed fairly reliably, but the 20 older PERT vehicles continued to have an excessive number of breakdowns (see Section 5.2.2). The improved level of service was primarily due to the higher reliability of the new vehicles and the reduced vehicle requirements, rather than to an improvement in performance of the older PERT vehicles. (Actual service quality results for this period are included in the discussion of computerized dispatching impacts in Section 5.3.2).

Since drivers are paid regardless of vehicle availability, late runs reduce the supply of service with no corresponding cost reductions. The actual durations of these late starts were not recorded, but were generally between 15 minutes and two hours. The longer delays occurred when an unusually large number of vehicles were out of service simultaneously. Although strong statistical correlations between the number of late runs and service quality variables were not found in the available data, the reduction in vehicle supply has an a priori negative effect on service levels. On-the-road breakdowns also have an obvious detrimental effect, as passengers on-board and assigned to the crippled bus must be reassigned to other vehicles.

Demand-responsive services are more sensitive to vehicle reliability problems than fixed-route services. If a fixed-route run is missed because of a vehicle shortage, headways will lengthen slightly. During peak periods, headways are usually short and the major adverse effect of a missed run is that the remaining buses are overcrowded. With PERT, however, vehicle shortages had a more critical impact. If a subscription tour was missed, passengers were stranded until another bus finished a tour, which could have been a half-hour or more. Consequently, subscription tours received first priority and DAB operated with a reduced fleet during periods of vehicle shortage, causing a significant deterioration of DAB service levels. The situation was not immediately rectified when the scheduled buses returned to service; a long backlog of trip requests had usually developed, and several hours passed before the system had "caught up" with demand.

Reducing the supply of vehicles, and thus lowering overall service quality, can also adversely affect DAB no-show[2] and cancellation rates. The immediate impact, reflected in a survey of no-show passengers and from no-show and cancellation records, indicates a positive correlation between service quality and these two variables. From the end of 1975 through early 1977, customer cancellations and no-shows remained high, peaking in late 1976, which was the same period that PERT experienced its most severe reliability problems and greatest shortage of vehicles.

Although the vehicle breakdown problems were corrected and DAB service levels improved by February 1977, those patrons who requested a DAB vehicle during the periods of deteriorated service may still not have felt that they could rely on this service. The long-term implications of these earlier service problems may have thus been reflected in continued high rates of cancellations and no-shows. (For more detailed cancellation and no-show results, see Section 6.1.)

5.3 DIAL-A-BUS SERVICE

This section introduces Dial-A-Bus (DAB) service by defining the basic level-of-service terms, followed by a discussion of these parameters according to the type of transit access used. PERT's service quality is then analyzed during different periods of manual and computerized dispatching, allowing travel time comparisons to be made with the other modes of transport available in the Greece service area. A subsequent section on transit system integration discusses transfer coordination and route rationalization. The results from on-board and control room time studies are also evaluated.

5.3.1 Service Level Definitions

In order to accurately describe DAB service levels and facilitate a comparative analysis with fixed-route services, level-of-service parameters for DAB and fixed-route services are defined as follows:

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[2]No-shows are persons who request service but then do not appear when a bus arrives to pick them up.

Fixed-Route

Access Time: The duration between the time a passenger leaves his origin and the time he arrives at the point where he will board the bus.

Wait Time: The length of time between passenger arrival at the bus boarding point and the actual boarding of the bus.

Ride Time: The period of time spent by the passenger on-board the bus.

Transfer Time: When two or more bus rides are required to complete one trip, the length of time between exiting from one bus and boarding another.[3]

Egress Time: The duration between exiting from the last bus and arrival at the traveler's destination.

Total Travel Time: Access Time + Wait Time + Ride Time (+ Transfer Time + Ride Time) + Egress Time

Dial-A-Bus

Call-In Time for a Customer Booking: The period of time between acknowledgment of a service request by the control room and the introduction of that request into the system.

Immediate Request: A request for service as soon as possible.

Advance Request: A request for service at some future time.

Actual Pick-Up Time: The time the customer boards the bus.

Promised Pick-Up Time: The pick-up time promised at the time of a customer booking. For an immediate request, pick-up time is estimated based on current and expected future system states. For advance requests, pick-up time is specified by the requestor when the service request is made.

Promised Wait Time: Time duration from customer booking to promised pick-up (immediate request only).

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[3]When the bus must delay its departure in order to adhere to the schedule, the length of time the passenger spends waiting for the bus to leave is also included in transfer time.

System Response Time: The length of time between the booking of a service request and customer pick-up (immediate request only).

Pick-Up Deviation: The difference between promised pick-up time and actual pick-up time. If positive, the bus arrives late for pick-up; if negative, the bus arrives early for pick-up.

Pick-Up Deviation Distribution: The actual distribution of pick-up deviations for a sample of customer trips.

Ride Time: The length of time between boarding the bus and being dropped off at one's destination.

The total travel time for fixed-route bus customers is simply the sum of all the components described above. The computation of travel time for DAB service is not as straightforward. Whereas each component of DAB travel time and its variability (as measured by the standard deviation) is a measure of some aspect of system performance, total travel time is not the direct sum of the components. Specifically, the computation of DAB travel time requires assumptions concerning user behavior. For this purpose, two types of transit user behavior are assumed: planned and random access arrivals.

The division of users into planned and random access users is an attempt to facilitate the comparison of DAB and fixed-route travel times. Within each group, there are numerous subgroups and the number of users of each mode that could be classified into each group depends on numerous factors, including type of trip, trip origin, headways on the fixed route, perceived reliability of the system, etc. Ideally, the behavior of individual users should be observed in order to derive true average values of travel time for different modes. Since this is not a practical measurement alternative, travel times for two general types of trips (planned and random access) are calculated from the aggregate values of travel time components. This allows for a meaningful but simplified basis of comparing modes.

Planned access DAB users are those who make advance requests, or those who make immediate requests but constructively utilize the time prior to the bus arrival. This time can most certainly be used at home, and perhaps also at other locations. For example, at a shopping center, a user may -- if the promised pick-up time is sufficiently long -- be able to run an additional errand. If system response times are consistently long, users may learn to call for immediate service before they are actually ready to travel. In such cases, it would be inaccurate to include all of the system response time as a component of travel time, because not all of that time is spent waiting for service. If the customer must wait at all, it is because the bus is late (the wait is equal to the pick-up deviation), or because experience has shown the customer that the bus is sometimes early and he must be ready to travel early. For the purpose of travel time calculations, it is assumed that these customers are ready prior to the actual pick-up time by an amount equal to one standard deviation of the pick-up deviation distribution. This assessed wait time is considered to be travel time. (Assuming a normal distribution for pick-up deviation, this means there is an 84% chance that the customer will be ready to travel when the bus arrives.) This is shown graphically in Exhibit 5.10 for DAB planned access users.

Random access DAB users are those who call for immediate service when they are ready to travel. It is assumed that they cannot utilize the system response time for other purposes. Their assessed wait time is the system response time (see Exhibit 5.10).

For fixed-route systems, planned access users are those who know the bus schedule and plan their arrival to provide a margin of safety prior to the scheduled arrival of the bus. For purposes of travel time calculation, this margin is assumed to be five minutes. Random access users are those who do not plan their arrival at a bus stop with knowledge of the scheduled bus arrival. Their arrivals will be uniformly distributed in time and their wait time will, on the average, be one-half the headway time. When headways are less than ten minutes, all fixed-route users are assumed to be random arrivals. Both fixed-route cases are shown in Exhibit 5.10.*

In addition to their contribution to total travel time, the DAB time components defined above are used as measures of other attributes of DAB systems. System response time represents the ability of the system to respond to service requests. The variability of system response time, as meas-

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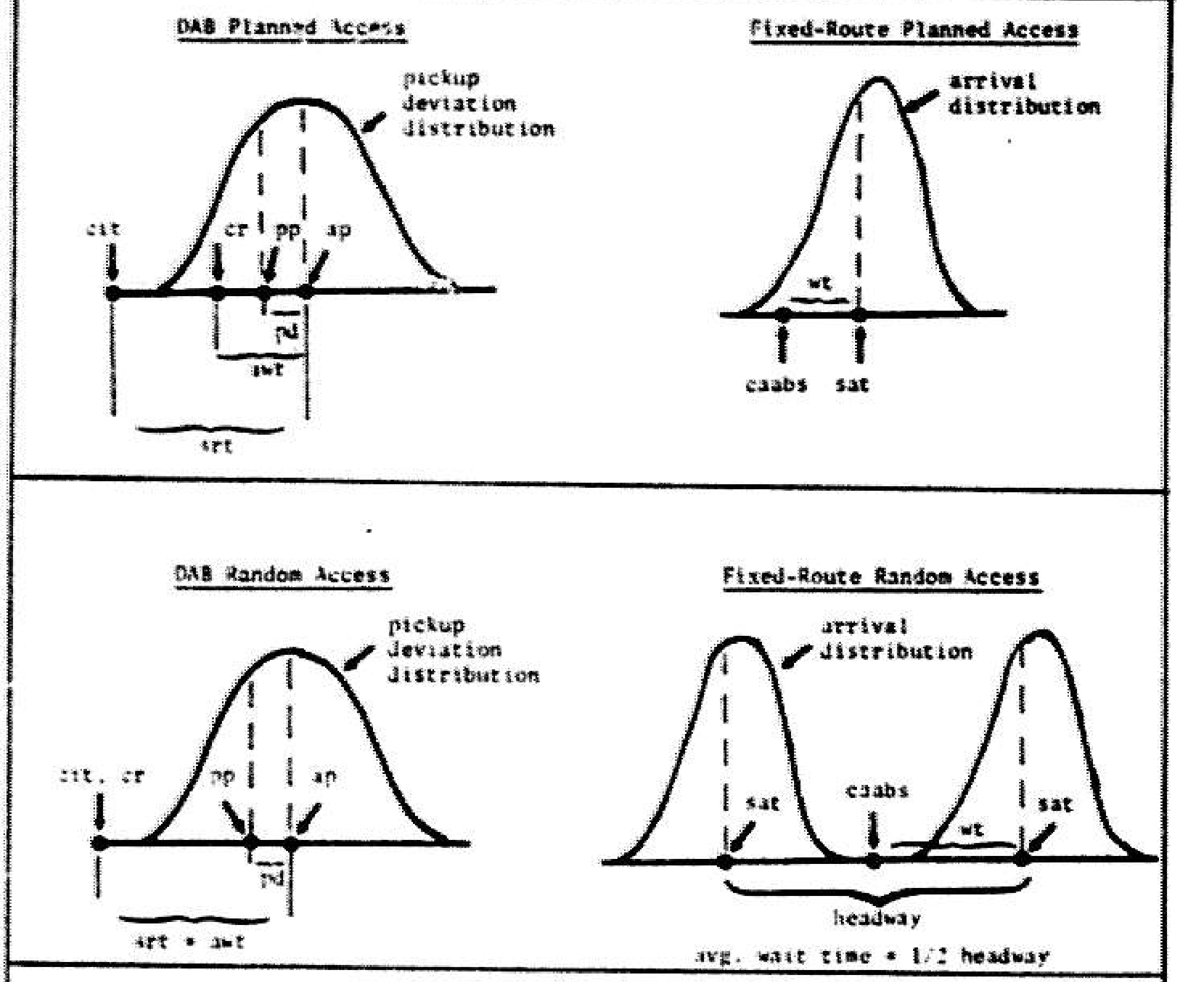
*Passenger wait times measured in England suggest that, when headways exceed 10 to 12 minutes, the random arrival assumption is a poor one and an increasing number of passengers time their arrival at the bus stop (planned access). When headways are 30 minutes, for example, average wait time (both planned and random arrivals) is around 10 minutes rather 15 minutes if all passengers arrived randomly. See J.K. Jolliffe and T.P. Hutchinson, "A Behavioral Explanation of the Association Between Bus and Passenger Arrivals at a Bus Stop" (University College, London, May 1975).

EXHIBIT 5.10

DAB AND FIXED-ROUTE WAIT TIMES



Abbreviations:
- ap = actual pick-up
- awt = assessed wait time (for travel time calculations)
- caabs = customer arrives at bus stop (to insure arrival before bus about 95% of time)
- cit = call-in time
- cr = customer ready (approximately one standard deviation of the pick-up deviation distribution)
- pd = pick-up deviation
- pp = promised pick-up
- sat = scheduled bus arrival time
- srt = system response time
- wt = wait time

ured by the standard deviation of system response time or by pick-up deviations, indicates the level of accuracy the system affords its customers in planning their trips.

The pick-up deviation represents the convenience which the system provides in terms of the bus arriving when the customer is prepared to leave (preparation being based on the time they had been told they would be able to leave when they telephoned for service). The variability of pick-up deviations tells the frequent customer whether or not to take the promised pick-up time seriously. If bus pick-ups are consistently late (large average pick-up deviation but low variability), users quickly learn they can reliably plan on the bus being a few minutes late and plan accordingly. If, on the other hand, pick-up variability is also high (the bus could be early, late or on time), it is impossible to predict when the bus will arrive and customers must be ready to travel at what they perceive to be the earliest time the bus may arrive.

Finally, ride time represents the component of travel time in the vehicle, and is therefore related to the in-vehicle traveling speed and tour makeup. The variability of ride time along with the variability in pick-up time can provide some indication of the reliability of on-time arrivals. However, even if ride time variability is zero, if the pick-up deviation is high, the arrival times will still vary widely. These factors will also be greatly influenced by the variation in passenger trip lengths, time of day, vehicle speed, and the number of other passengers picked up or dropped off on a tour.

5.3.2 Manual Dispatching Results

Prior to the implementation of computerized dispatching, which began to be used in Greece on an irregular basis in the fall of 1975, 24 "service quality checks" were conducted. An additional service quality check under manual dispatching was conducted in Greece on February 5, 1976. On these days, the times that customers requested service were recorded, as well as the times they were promised service and their actual pick-up and drop-off times.

The results of these 24 service quality checks under manual dispatching are indicated in Exhibit 5.11. At the bottom of the exhibit, the results of the 15 service quality checks taken between February and October 1975 are averaged. These 15 checks represent Greece service quality levels during a relatively stable period which followed the growth and expansion of the first one and one-half years, and during which DAB demand and vehicle supply were fairly uniform.

EXHIBIT 5.11 DAB SERVICE QUALITY CHECKS UNDER MANUAL DISPATCHING

(Steady State Period is Shaded)

		[illegible]						ADVANCE REQUESTS			
		System Response Time		Pickup Deviation		Ride Time		Pickup Deviation		Ride Time	
Date	Sample Size(%)	Avg.	S.D.	Avg.	S.D.	Avg.	S.D.	Avg.	S.D.	Avg.	S.D.
✓ 10-17-73		22.4	16.72			13.5	8.65[a]	3.96	(11.26)		
11-29-73		24.6	12.65			13.10	8.25[a]	8.71	10.00		
1-08-74		26.4	19.15			19.4	11.06[a]	6.65	13.00		
✓ 2-21-74		17.1	5.22			13.4	8.3[a]	1.95[b]	5.43		
4-16-74		17.7				13.3		3.0[b]			
5-21-74		15.5				13.9		6.9[b]			
7-31-74		28.8				17.0		11.4[b]			
1-21-75		41.74	20.83	25		16.32	8.48	21	22.52	19	9.47
2-06-75	64.0	21.45	11.21	3.59	9.62	14.52	8.13	6.0	12.94	15.33	9.15
[illegible]-01-75	12.0	23.00	[illegible]	[illegible]	7.29	14.79	8.76	7.05	[illegible]	[illegible]	[illegible]
[illegible]-11-75	35.6	27.56	[illegible]	[illegible]	12.42	[illegible]	10.6	9.97	[illegible]	[illegible]	[illegible]
[illegible]-25-75	[illegible]	[illegible]	[illegible]	5.25	[illegible]	15.41	9.95	7.73	[illegible]	[illegible]	[illegible]
[illegible]-09-75	[illegible]	[illegible]	[illegible]	6.62	6.9	14.55	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]-23-75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12.35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]-75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10.66	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]-75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10.47	15.27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15.67	16.46	10.64	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]-75	[illegible]	20.07	[illegible]	8.41	16.70	17.26	10.15	[illegible]	[illegible]	[illegible]	11.30
[illegible]-75	[illegible]	25.41	[illegible]	[illegible]	11.07	18.70	11.49	6.62	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	7.40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2-05-76	100.0	28.43	18.80	8.51	18.04	17.40	11.01	7.28	12.24	17.22	10.11
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[a] Not differentiated into immediate and advance.

[b] Figures developed by assuming any advance request picked up ahead of the schedule time has 0 delay. Other figures do not assume 0 delay.

[c] Night dispatching (7-10) done under computer assistance.

✓ On board surveys

Assuming these averages represent the Greece system's performance during this period, the average passenger requesting immediate service was picked up 25.2 minutes after calling, which was 5.0 minutes longer than was estimated by the control room, and the average in-vehicle travel time was 15.6 minutes. The average advance request passenger was picked up 7.1 minutes after the scheduled pick-up time, and rode for 16.1 minutes.

There was a considerable spread among these average values. The system response time standard deviation was 14.8 minutes. The substantial response time variations caused customers desiring to leave at a specific time to be unsure of when to call for service. The standard deviation of the pick-up deviation of 11.9 minutes indicates that customers were very uncertain about their pick-up times, even after a specific pick-up time was promised. (Under a normal distribution, 50% of the pick-ups were within a 16-minute range around the average pick-up deviation, 75% were within a 27-minute range, and 90% were within a 39-minute range.) These results suggest that much of the 25-minute average DAB system response time should be considered as wait time, since the arrival time of the bus is difficult for the customer to predict. Using one standard deviation of pick-up deviation as the margin of preparedness required (as described above), about half of the system response time between calling and pick-up should be assessed as wait time and, therefore, as part of total travel time. This would result in a calculated travel time of 27.5 minutes when ride time is added to the pick-up deviation standard deviation.

For advance requests in which a customer requests service for later in the day or for another day (planned access), the pick-up deviation parameters were similar to those of immediate requests. Using the standard deviation of the pick-up deviation to measure the wait time component of travel time, a total average travel time of 27.3 minutes results; this is almost identical to that of immediate requests. Thus, for those passengers who could use their waiting time constructively, there was little advantage in making an advance request.

5.3.3 Day-to-Day Service Quality Variations Under Manual Dispatching

The variations of system response time, pick-up deviation, and ride time among trips within a given day have been used as a service quality measure in the previous section because they indicate system reliability. In addition to the within-day variations, the day-to-day variations of these times could also be used as a service quality measure. In addition, both daily and day-to-day variations can be used to analyze the effects on service quality of several parameters which change in time, such as the number of vehicles in service, the number of trips, and the service area size. This analysis is described in this section using hourly data in order to provide a sufficiently large sample.

Hourly service quality data were available from the last 11 service quality checks in 1975 and one day in 1976 under manual dispatching. In the analysis undertaken, data after 6:00 P.M. were eliminated because of the limited ridership during the evening hours. Also, data from before 9:00 A.M. were not used because of the difficulty in estimating the number of vehicles in DAB service at the time.[5] Finally, the 9:00-10:00 A.M. period was eliminated in order to allow the use of a lag variable. Thus, a sample size of 88 was generated (11 days of 8 hours) for analysis.

Many linear and non-linear regression equations have been fit to the data: the ten service quality parameters were regressed against combinations of such system parameters as demand, vehicle supply, and service area size (which varied only once over the period considered) and the previous hourly service levels. Regression equations using daily averages of the variables were also made. None of the regressions, either for the daily averages or the hourly data, provided statistically valid explanations of the results. Signs of the coefficients were often opposite to those hypothesized.[6] More complex supply models were also

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[5]Data on the number of vehicles in revenue service for each Greece PERT service by time of day were unavailable. Consequently, this figure had to be estimated from PERT driver run guides, adjusting for vehicle breakdowns or other unexpected events. Between 8:00 and 9:00 A.M., several buses switched from providing subscription service to providing DAB service, making an estimation of the number of DAB vehicles uncertain. In the evening, this was less of a problem in that subscription service was usually provided by vehicles entering service at that time.

[6]It is assumed that increasing demand and service area size affects service quality negatively, and increasing vehicle supply improves service quality. Increasing vehicle productivity should thus lower service levels, but this was not found to be the case in the data examined.

utilized to help define a discernible pattern in the data, including a model developed by Flusberg and Wilson of MIT.[7] Neither this model nor others were effective in explaining the variations in service quality experienced in Rochester. In conclusion, the variation in the level of service provided in Greece during the 1975 steady-state period cannot be explained using other quantifiable system variables. It has been suggested that the service quality data base may have been inaccurate; pick-up and drop-off times were generally recorded by the driver, and it is conceivable that drivers did not record this data accurately. This cannot be confirmed, however.

5.3.4 Computerized Dispatching Results

Beginning in June 1976, Greece DAB dispatching and scheduling were regularly conducted under computer control, and service quality data were continuously generated.

The level of service provided by DAB under computerized dispatching is summarized in Exhibit 5.12, which reports service quality data for ten different time periods. The first column summarizes the results of 15 days of manually-dispatched operation in 1975 (shaded portion of Exhibit 5.11). This served as a reference point for analyzing the computerized dispatching results. Columns 2 through 6 summarize weekday results for five distinct periods:

* June 1976 (Column 2) represents the initial regular use of computerized dispatching on weekdays. This period was characterized by excessive computer response time and repeated hardware failures. Ridership and vehicle productivity were low. During all of 1976, vehicle shortages occurred frequently and negatively affected service quality.

* From June to September 1976 (Column 3), ridership and productivity were somewhat higher, but were still lower than in 1975 under manual dispatching.

* From September to December 1976 (Column 4), DAB ridership and productivity dropped as a result of the substantial demand captured by the Dew-Ridge Shuttle. The service area was also considerably smaller.

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[7] Flusberg and Wilson, "A Descriptive Supply Model for Demand-Responsive Transportation System Planning," prepared for the Transportation Research Forum, March 22, 1976, page 4.

EXHIBIT 5.12 SERVICE QUALITY PARAMETERS UNDER COMPUTERIZED DISPATCHING

(Average Values in Minutes)

	WEEKDAYS						SATURDAYS			WEEKDAY EVENINGS ONLY
	Manual	Computer (see footnotes)					Computer			Computer
	1 1975 Manual (n=15)	2 6/1/76- 6/19/76[a] (n=11)	3 6/21/76- 9/11/76[a] (n=46)	4 9/13/76- 12/31/76[a] (n=62)	5 1/3/77- 2/4/77[b] (n=20)	6 2/7/77- 5/6/77[b] (n=37)	7 1/31/76- 6/19/76[c] (n=11)	8 6/21/76- 9/11/76[c] (n=11)	9 9/13/76- 12/31/76[c] (n=11)	10 1/26/76- 5/31/76[d] (n=52)
Immediate Requests										
System Response Time (Mean)	25.2	34.2	26.4	23.4	27.9	17.2	28.2	18.1	22.4	31.4
System Response Time (Standard Deviation)	14.8	30.5	19.6	16.0	21.1	10.8	18.2	12.7	14.9	19.8
Pickup Deviation (Mean)	5.0	12.5	7.7	7.8	9.5	5.0	9.3	5.7	9.2	7.8
Pickup Deviation (Standard Deviation)	11.9	24.0	15.2	11.2	16.3	8.5	14.3	12.3	12.7	11.7
Ride Time (Mean)	15.6	19.0	19.5	16.1	15.7	11.6	19.2	16.3	17.3	16.9
Ride Time (Standard Deviation)	9.6	15.4	14.0	12.9	14.5	8.6	17.3	10.9	12.6	12.6
Advance Requests										
Pickup Deviation (Mean)	7.1	13.7	10.1	8.7	14.2	5.6	11.5	5.6	9.5	10.2
Pickup Deviation (Standard Deviation)	11.2	16.5	14.4	13.7	15.6	9.4	15.3	11.0	15.4	12.0
Ride Time (Mean)	16.1	19.3	19.7	16.2	17.5	12.4	20.3	16.3	17.4	15.1
Ride Time (Standard Deviation)	9.7	17.0	14.5	13.2	13.9	9.1	15.0	8.9	12.3	12.4
Service Area Size (Sq. Miles)	13.9-15.2	15.2	15.2	10.7/Day 15.8/Eve	10.7	10.7	15.2	15.2	13.8	15.2
Daily Operating Hours	16.5	16.5	16.5	16.5	8.0	8.0	11.0	11.0	11.0	--
Average Daily Ridership	515	292	403	245	109	149	321	308	278	--
Average Daily Noshows	21	41	51	25	12	9	32	26	38	--
Average Number of Daily PERT Runs - Out Late/ Number of Scheduled Runs	·	5.1/ 17	5.1/ 15	1.7/ 15	2.3/ 11	0.6/ 11	1.2/ 10	0.9/ 10	2.4/ 10	--
Average Vehicle Productivity For Period (Passengers/Vehicle Hrs)	5.2[e]	3.4	4.6	3.8	3.6	3.9	4.2[e]	4.1[e]	4.1[e]	--

a - All days of more than 700 minutes computer operation.
b - All days of more than 400 minutes computer operation.
c - All days of more than 500 minutes computer operation.
d - All days of more than 200 minutes computer operation.
e - Actual for days included in sample.

* During January 1977 (Column 5), severe winter weather sharply restricted the supply and, as a result, the demand for DAB service.

* Finally, from February to May 1977 (Column 6), a stable condition was achieved, characterized by a smaller service area, curtailed operating hours, and lower demand compared to 1975 and 1976. Vehicle breakdowns did not appreciably affect the supply of service.

The remaining four columns summarize Saturday results and the phase-in results of several earlier months, when computerized dispatching operated only during the evening on an experimental basis.

As Columns 2 through 6 indicate, weekday service quality under computerized dispatching was initially lower than that under manual dispatching, but steadily improved over time except for a temporary decline during January 1977 caused by severe winter weather conditions. Saturday service quality also improved, except during the fall of 1976 when vehicle shortages were more frequent. During the February-May 1977 period, DAB service quality was higher than it had ever been, including the 1975 period under manual dispatching. For example, average travel time in 1977 for planned and random access users (see Section 5.3.1 for definitions) was 20.9 and 28.8 minutes respectively, compared to 27.4 and 40.8 minutes in 1975 under manual dispatching. A survey of transfer wait times on March 31 and April 1, 1977, although based on a small sample, also indicated a service quality improvement. Outbound (RTS to DAB) transfer wait times averaged 7.7 minutes (n=15) compared to four previous studies in 1975 and 1976 which generated means of 8.2 to 16.4 minutes.

The improved service quality results during 1977 must be interpreted in consideration of the smaller service area, lower demand density, and lower vehicle productivity compared to earlier periods, especially in 1975 under manual dispatching. In order to perform a comparative analysis, service quality results from each period were regressed against several demand and supply variables, including ridership, the number of no-shows, and the number of runs starting late. A calendar variable was also included to reflect improvements in computerized dispatching over time. (A similar analysis of the 15 service quality measurements under manual dispatching disclosed few significant relationships; see Section 5.3.3.)

Although the computerized dispatching data were based on larger sample sizes than were the manual dispatching results, few significant trends were found. The level of no-shows was the only variable that was significantly related to the service quality variables; however, no-shows were both a cause and effect of service quality deterioration. The DAB demand level had a significant effect on the service quality parameters in only a few of the regressions tried. During 1977, for example, an increase in ridership was found to significantly affect only the advance request pick-up deviation parameters, tending to make them slightly larger. Other service quality parameters were not sensitive to ridership levels. This suggests that service quality under computerized dispatching would not change appreciably if demand density in 1977 had increased to those levels existing under manual dispatching. However, this conclusion is based on an extrapolation of the results within a relatively narrow range of demand, and it is not clear if large increases in demand would have had the same minor effect on service quality.

In an attempt to determine the effect of greater demand, it was artificially increased by about 35% on September 3, 1976 by having a group of students repeatedly request service during the day. Service quality on that day suffered somewhat and the experiment was called off at around 2:30 P.M. due to vehicle shortages and a steadily deteriorating level of service. The impact of higher demand was still unclear.

In summary, other than a steady improvement over time of service quality under computerized dispatching, the variations in service quality seem to have been unrelated to other factors. Consequently, the performance of computerized dispatching under the conditions that existed under manual dispatching in 1975 cannot be predicted from the existing data. Although service quality under computerized dispatching finally reached a point where it was better than that measured under manual dispatching, computerized dispatching has yet to provide a comparable level of service while maintaining equivalent productivity levels, nor has it been successfully tested under comparable demand densities.

5.3.5 Comparison to Other Modes

In Greece, the total average DAB travel times were compared to the longest and shortest fixed-route trips and equivalent automobile trips in order to provide an idea of relative travel times. These comparisons, broken down according to the "steady-state" manual or computerized dispatching period as shown in Exhibit 5.13, are only illustrative and not precise. A comparison of real average trip times would also be imperfect, since riders are more likely to select the most expedient mode for their trips, and

EXHIBIT 5.13

INTERMODAL TRAVEL TIME COMPARISON UNDER MANUAL (1975) AND

COMPUTERIZED (1977) DISPATCHING (GREECE)

Travel Time Components	Dial - A - Bus								Previous Fixed Route				Auto	
	Random Access (immediate request)		Planned Access (average of immediate and advance requests)		Other Definitions (average of immediate and advance requests)				Random Access		Planned Access			
	Assessed Wait Time = System Response Time		Assessed Wait Time = S.D. of Pickup Deviation		Assessed Wait Time = Pickup Deviation		Assessed Wait Time = 0		Min[1]	Max[2]	Min[1]	Max[2]		
	1975	1977	1975	1977	1975	1977	1975	1977	'75(77)	'75(77)	'75(77)	'75(77)	1975	1977
Access	-	-	-	-	-	-	-	-	2.5	2.5	2.5	2.5	-	-
Wait	25.2	17.2	11.6	8.9	6.0	5.3	0	0	4[3]	20.0[3]	4[3]	5[3]	-	-
Ride	15.6	11.6	15.8	12.0	15.8	12.0	15.8	12.0	10(9)	11(10)	10(9)	11(10)	8.4	7.4
Transfer	-	-	-	-	-	-	-	-	-	22.5	-	22.5	-	-
Egress	-	-	-	-	-	-	-	-	2.5	2.5	2.5	2.5	-	-
TOTAL	40.8	28.8	27.4	20.9	21.8	17.3	15.8	12.0	19(18)	58.5 (57.5)	19(18)	43.5 (42.5)	8.4	7.4

[1]Route 1 only during peak period

[2]Route 14 to Route 10 with transfer during midday

[3]Wait times may be more onerous for fixed-route users.

Note: Data based on average DAB trip lengths of:
2.8 miles in 1975,
2.4 miles in 1977.

different trip types would be compared. In addition, many DAB trips could not be made by fixed-route bus because there was no fixed-route bus service in much of the Greece DAB service area.

The average DAB planned access travel time of 27.4 minutes is used, based on Greece's 1975 manual operations (average of calculated immediate and advance request travel time). Using the average DAB trip length of 2.8 miles during this period (see Section 6.1.5) and the average Greece automobile speed of 20 miles per hour (see Section 3.2.1), an automobile trip time of 8.4 minutes is obtained. This results in a 1975 Greece level-of-service ratio for DAB of 3.3 (27.4/8.4).

By February 1977, the average DAB planned access travel time dropped to about 21 minutes. Since the average DAB trip length at this time was about 2.45 miles (see Section 6.1.5) due to the contraction of the DAB service area, and assuming an average Greece automobile speed of 20 miles per hour, an automobile trip would take 7.35 minutes. The corresponding 1977 Greece level-of-service ratio is 2.8 (20.9/7.35), disclosing a 15% DAB service improvement relative to the 1975 DAB/automobile trip time ratio.

DAB travel time can be computed in other ways, such as figuring only ride time, ride time plus system response time for immediate requests (random access), or ride time plus average pick-up deviation. These methods give average 1975 DAB trip times of 15.8 minutes (average of immediate and advance request ride times), 40.8 minutes, and 21.8 minutes respectively. The appropriate level-of-service ratios are consequently 1.9, 4.9 and 2.6.

With computerized dispatching, alternative average DAB travel times of 12.0 minutes (average of immediate and advance request ride times), 28.8 minutes (ride time plus system response time for immediate requests, assuming random access) and 17.3 minutes (ride time plus average pick-up deviation) are calculated. The respective level-of-service ratios are then 1.6, 3.9 and 2.4, revealing about an 8% to 20% relative improvement in DAB service quality, depending upon the assumptions used to compute total travel time.

The attractiveness of DAB compared to the automobile with regard to travel speed clearly depends upon how users view or use wait time; that is, which definition of travel time one adopts. Interestingly, the derived planned access definition which uses the standard deviation of the pick-up deviation added to the ride time results in a total travel time that is very close to the average of the other three methods (27.4 minutes compared to 26.1 minutes under manual dispatching and 20.9 minutes compared to 19.4 minutes for computerized operations).

Comparisons to fixed-route bus travel are more difficult because of different headways on the various routes at different times of day and the variation resulting from transfers. Moreover, the in-vehicle travel time on RTS buses in Greece was not uniform because the Route 10 loop routing substantially lengthened some trips. The quickest trip on the fixed-route system would be a trip on Route 1 (Lake) during the peak period. In 1975, the in-vehicle travel time for a 2.8-mile trip would be about 10 minutes (at a speed of 17 miles per hour). With headways of 8 minutes, wait time would average 4 minutes. Assuming access and egress times of 2-1/2 minutes each (1/8 mile at 3 miles per hour walking speed), the total travel time would be 19 minutes, which is faster than the 1975 average DAB travel time. In the 1977 calculations, the average DAB trip length decreased to 2.5 miles as a result of the smaller service area, and this reduced the corresponding RTS in-vehicle ride time by about 1-1/2 minutes.

On the other hand, an off-peak period trip from Longridge Mall to a point north of Ridge on Dewey Avenue would require the use of Routes 10 and 14, which had midday headways of 45 and 40 minutes respectively. Using the 1975 random access assumption, wait time is equal to half the headway and average transit travel time is 2-1/2 minutes (access time) + 20 minutes (Route 14 wait time) + 8 minutes (Route 14 ride time) + 22-1/2 minutes (Route 10 transfer wait time) + 3 minutes (Route 10 ride time) + 22-1/2 minutes (egress time) = 58.5 minutes. Again, the 1977 fixed-route travel time would be about 1-1/2 minutes less. These results are considerably more than the random access DAB trip times and, because of their excessive length, probably do not represent a significant number of trips. Other types of trips which could be made by fixed-route transit would generally lie somewhere between these two extremes.

The above fixed-route travel time calculations are based upon wait times equaling half the headways (random access). For routes with short headways (such as Route 1 during the peak period), this assumption is probably valid. For those with longer headways but for which schedules are readily available, as in Rochester, passengers are likely to time their arrival at the bus stop so as to minimize their wait times under the constraint of not wanting to miss the bus if it is early (planned access). The situation is analogous to the DAB planned access case in which a customer uses his wait time for other purposes (see Exhibit 5.11). The average fixed-route wait time in such cases is estimated to be five minutes. This would result in a 20-minute total fixed-route travel time for a 2.8-mile non-transfer trip with 1/8-mile access and egress, which is seven minutes or 25% faster than Greece DAB planned access trips (operated manually).

Based on 1975 data, one may conclude that a fixed-route bus is quicker than DAB for trips within a single corridor. When a transfer is required, however, the added transfer wait time will usually make the fixed-route trip longer, unless the schedules are coordinated. Moreover, transit users usually perceive wait time more negatively than ride time; thus, even if equal total trip times were possible, most riders would prefer the single-vehicle trip. In Greece, there was no such coordination between the east-west Route 14 and the north-south Routes 1 and 10. Consequently, a fixed-route trip in Greece that required a transfer would generally be longer than with DAB because of the added transfer time. (The exception would be a transfer from Route 14 to Route 1 during the peak period, when the transfer wait time would be only four minutes.) In 1977, however, DAB level of service had improved substantially, so that the fastest fixed-route trip was less than 3 minutes faster than a similar DAB planned access trip. A service area contraction, the implementation of computerized dispatching, followed by a decrease in demand during 1977 had enabled DAB to achieve travel times comparable to single-corridor fixed-route trips.

5.3.6 System Integration

The previous section compared PERT demand-responsive service levels to the RTS fixed-route services in Greece. One of the principal objectives of the Rochester demonstration was to integrate these two service types. Route rationalization and transfer coordination were the two major innovations designed to achieve this goal. Route rationalization refers to the elimination of Route 14 (Ridge Road) service and the cutback of Route 10 during the off-peak period when DAB operated. Rationalization took place between June 1974 and January 1975. Transfer coordination consisted of several techniques for providing pleasant and efficient transfers between PERT and RTS services, in addition to the primary objective of minimizing wait times. These techniques included the designation of scheduled meetings of fixed-route and DAB buses at Dewey and Ridge, the placing of direct DAB telephone lines at Dewey and Ridge, the construction of a small transfer station at Dewey and Ridge, and the establishment of a reduced midday feeder fare of 50 cents including transfer.

Transfer Coordination

The results of six transfer time studies are reported in Exhibit 5.14. The first two days of data (August 8 and October 14, 1975) may slightly understate transfer time, because only the period between arriving on one vehicle and

EXHIBIT 5.14 TRANSFER WAIT TIMES

(May 6-8, 1976)

	OUTBOUND			INBOUND			Greece Irondequoit
	Thurs. - Friday	Saturday	3 Days	Thurs. - Friday	Saturday	3 Days	3 Days
Time of Survey	9:00-15:00 18:30-21:00	9:00-11:00		9:00-15:00 18:00-21:00	9:00-11:00		
Sample Size	93	85	148	73	40	113	17
Mean	16.5	16.2	16.4	7.3	11.5	8.8	16.7
Standard Deviation	12.7	13.0	12.8	5.0	5.2	5.4	10.7
Coefficient of Variation	.77	.80	.78	.69	.45	.61	.64

OTHER TRANSFER STUDIES (all weekdays)

	OUTBOUND					INBOUND				
	8/8/75	10/14/75	10/24/75	3/31/77	4/1/77	8/8/75	10/14/75	10/24/75	3/31/77	4/1/77
Time of Survey	11:00-14:00	9:00-14:15	9:00-15:15	All Day	All Day	11:00-14:00	9:00 14:15	9:00-15:15	All Day	All Day
Sample Size	38	41	46	9	6	17	42	49	11	14
Mean	8.2	13.1	14.2	10.0	4.2	3.3	6.7	6.8	8.3	5.3
Standard Deviation	6.1	14.1	11.6	11.1	5.9	2.3	4.9	5.7	7.4	4.7
Coefficient of Variation	.74	1.08	.82	1.19	1.4	.70	.73	.84	.89	.89

boarding another was recorded. PERT and RTS buses (especially the latter since they adhered to a schedule) sometimes remained at the Dewey and Ridge transfer point for several minutes before departure. In the October 24, 1975, May 1976, and March/April 1977 surveys, the period between bus arrival and departure was recorded as transfer time.

The results suggest that convenient transfers between PERT and RTS were not realized initially. For inbound passengers transferring from DAB to Route 10, the average weekday transfer wait time in October 1975 and May 1976 was slightly less than half the average midday Route 10 headway of 15 minutes; this is close to what can be assumed to occur when passengers do not attempt to coordinate their arrival at the bus stop with the bus schedule. In addition, four evening passengers were included in the May 1976 sample; evening headways averaged 30 minutes rather than the 15-minute afternoon headway. However, this increases the average random arrival wait time for May 1976 passengers by only 0.4 minutes, and thus does not significantly affect the interpretation of the results.

For outbound passengers, average transfer wait times of about 15 minutes were recorded (except for August 8, 1975 and March/April 1977, when average transfer wait times were considerably shorter). While this was less than the average DAB system response time for immediate requests (see Section 5.3.2), most outbound transferring passengers told the Route 10 bus driver to notify PERT by radio that they wished to transfer. Therefore, the PERT control room should have received the transfer request 10 to 20 minutes before the passengers arrived at Dewey and Ridge. (The bus trip from Main Street in downtown Rochester to Dewey and Ridge took 23 minutes.) Thus, the total trip time between notifying the PERT control room and boarding DAB should have been between 25 and 35 minutes, which is longer than the average immediate request DAB system response time. As discussed in Section 4.3, however, most transfer requests did not reach the PERT control room.

One of the transfer coordination efforts was to assign every other Route 10 bus as a "meet" bus, indicating that PERT Dial-A-Buses would meet these buses for convenient transferring.* Although outbound transfers from these buses were substantially quicker on October 24, 1975 (7.9 minutes compared to 20.6 minutes), there was little difference on the other days surveyed. In fact, on October 14, 1975 and

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*In the Route 10 bus schedule, these buses were marked with the notation, "Direct connections available to or from Dial-A-Bus at Dewey and Ridge."

May 6 and 7, 1976, average transfer times from these "meet" buses were slightly longer than from the non-designated buses. Consequently, passengers probably disregarded these designations and rode Route 10 buses indiscriminantly.

The most recent transfer time study was made on two days during the spring of 1977. Because of the reduced demand, only 40 transfer times were recorded: twenty-five inbound trips had an average transfer time of 6.6 minutes, and 15 outbound trips had an average transfer time of 7.7 minutes. The outbound results are much better than in 1975 and 1976.

However, it is possible that the method in which transfer times were surveyed influenced the results of the outbound wait times. The transfer time studies were done by either PERT, MIT, or SYSTAN personnel, all of whom were familiar with the system's operation. Before February 1977, requests radioed by the RTS driver had to be relayed by the RTS dispatcher to the PERT control room; some transfer requests were lost in this process and never received by the PERT control room. Consequently, passengers were advised to call the control room from the free telephone available at the Dewey and Ridge transfer point to confirm their request. The surveyors had the effect of prompting such calls immediately, rather than after the passenger became frustrated from waiting. While this was not in keeping with the goal of objective data collection, the transfer time studies provided rare opportunities for attitudinal interaction with PERT passengers. Under such conditions, it would have been poor public relations for the surveyors not to assist waiting passengers in confirming their requests. In an ordinary situation, some of these passengers whose requests were not received by the PERT control room might have waited longer before they were prompted to call in their request. Nevertheless, a 1977 survey of transferring passengers showed that user attitudes toward transferring had improved significantly over the earlier periods. The mean perceived wait time for transferring from RTS to DAB dropped by 15 minutes (from 36 minutes in the spring of 1976 survey to 21 minutes in the spring 1977 results), reflecting the generally improved service quality in 1977, the completion of the transfer station at Dewey and Ridge in September 1976, and the improved communication link between RTS buses and the PERT control room.

Route Rationalization

The previous section reported the results of the transfer time studies. The results of these surveys and other information already discussed are the basis of Exhibit 5.15, which compares travel times to destinations outside the PERT service area before and after route rationalization. Several assumptions underlie the analysis:

EXHIBIT 5.15

ROUTE RATIONALIZATION TRAVEL TIME ANALYSIS -

TIME TO OR FROM ROUTE 10 BUS AT DEWEY & RIDGE

(All Calculations in Minutes)

		PLANNED ACCESS				RANDOM ACCESS			
		INBOUND		OUTBOUND		INBOUND		OUTBOUND	
PRE-RATIONALIZATION		Weekday	Sat.	Weekday	Sat.	Weekday	Sat.	Weekday	Sat.
Route 10 Only	Walk Time	2-1/2	2-1/2	2-1/2	2-1/2	2-1/2	2-1/2	2-1/2	2-1/2
	Wait Time	5	5	-	-	22	20	-	-
	Ride Time	13	13	13	13	13	13	13	13
	TOTAL	20-1/2	20-1/2	15-1/2	15-1/2	37-1/2	35-1/2	15-1/2	15-1/2
Route 14 & Transfer to Route 10	Walk Time	2-1/2	2-1/2	2-1/2	2-1/2	2-1/2	2-1/2	2-1/2	2-1/2
	Wait Time	5	5	-	-	19	30	-	-
	Ride Time	10	10	10	10	10	10	10	10
	Transfer Time	9	10	19	30	9	10	19	30
	TOTAL	26-1/2	27-1/2	31-1/2	42-1/2	40-1/2	52-1/2	31-1/2	42-1/2
AFTER RATIONALIZATION									
PERT and Transfer to Route 10	Wait Time	12	12	-	-	25	25	-	-
	Ride Time	15	15	15	15	15	15	15	15
	Transfer Time	6	6	12	12	6	6	12	12
	TOTAL	33	33	27	27	46	46	27	27

* Average fixed-route walk times are assumed to be 2-1/2 minutes, which is approximately 1/8-mile at a walking speed of three miles per hour. This is based on the definition of a 1/4-mile access corridor for fixed-route service.

* Fixed-route wait times are assumed to be half the average headway during the period before the route was eliminated for random access users. It is assumed that planned access users try to meet the buses when headways are long, and an average wait time of five minutes is assumed, although not all Route 10 buses entered the PERT service area and an unknowing rider boarding the wrong bus might have had to wait at Dewey and Ridge for the next Route 10 bus north.

* Transfer times to and from DAB are based upon three Greece transfer point studies during 1975 which indicated averages of six minutes for PERT to RTS and twelve minutes for RTS to PERT transfers. The three-day transfer time study in May 1976 reported wait times of eight and sixteen minutes, while the March/April 1977 survey documented wait times of approximately seven or eight minutes, respectively.

* Transfer times between Routes 10 and 14 are based on the scheduled arrival and departure times of these routes at Dewey and Ridge. No transfer coordination was scheduled.

* Fixed-route ride times are based on an average trip length of 2.8 miles, equivlent to the average Greece DAB trip length in 1975 (walking distance is ignored). Route 10, however, travels around a 3.8-mile one-way loop at its northernmost end. All passengers boarding on the loop must travel around the loop (half of 3.8). In addition, there is a 2.7-mile portion between the loop and Dewey and Ridge. It is estimated that half of the Route 10 passengers board on the loop, since it begins about 2.7 miles from the Dewey-Ridge transfer point. This results in an average trip distance of around 3.3 miles for Route 10 passengers, longer than for Route 14.

* DAB wait and ride times are based on the average of 15 weekday service quality checks in Greece during 1975. The figure for planned access users' wait time is the standard deviation of the pick-up deviation for immediate requests (see Section 5.3.2). For random access users, the mean system response time is used as the measure of wait time. Saturday

DAB travel times are assumed to be equivalent to the weekday figures. Later data under computerized dispatching suggests that Saturday service quality was better than on weekdays, but this may not apply to 1975 because of the differences in vehicle availability and demand levels.

The conclusions drawn are dependent on the type of trip made. Former Route 14 users saved time by using PERT for outbound trips, whereas inbound trips took longer than the previous fixed-route trips. PERT trips by former Route 10 users were generally longer than their fixed-route trip, partially because of the addition of the transfer. It is impossible to draw conclusions regarding reliability, as there were no on-time performance records for Routes 10 and 14.

5.3.7 On-Board Time Studies

Three times during the PERT project, observers were placed on-board PERT buses to chronologically record each vehicle's operation in DAB service. These observers recorded to the second the time the bus stopped to make a pick-up, the time the customer boarded the bus, and the time the bus began moving again. When a passenger was being dropped off, the time the bus stopped, the time the passenger exited from the bus, and the time the bus moved again were recorded. The results of these studies are shown in Exhibit 5.16.

The mean periods of time that a DAB vehicle was not moving were influenced by a few unusually long periods of ten minutes or more (600 seconds); these occurred when a bus had no requests to serve following a drop-off, or when a bus waited at a transfer point or shopping center for additional passengers to arrive. In the last two studies, when demand was much lower than in February 1976, this phenomenon was especially likely to occur. Consequently, the medians are more typical measures of pick-up and drop-off situations.

The study results indicate that the average passenger pick-up took between 50 and 70 seconds, and that an average drop-off was accomplished in 15 to 25 seconds. There was little difference in results between manual and computerized dispatching. Researchers attempting to use these results, however, should be aware of the extreme variations in vehicle stops.

EXHIBIT 5.16

DIAL-A-BUS ON-BOARD TIME STUDIES

Period	Sample Size	All Time Durations in Seconds		
		Mean	Standard Deviation	Median
February 5, 1976 (Manual Operations)				
Pick-Up Stops				
Passenger Access Time	258	52.7	87.2	24.7
Passenger Boarding Time and Time Until Bus Leaves	258	27.5	36.8	11.8
Total Time at Stop	319	83.1	106.3	49.3
Drop-Off Stops (no pick-ups)				
Passenger Exiting Time	277	10.5	18.0	5.2
Time Until Bus Leaves After Passenger Exit	273	36.1	129.1	5.4
Total Time at Stop	320	45.8	122.8	13.3
September 8, 1976 (Computer Operations)				
Pick-Up Stops				
Passenger Access Time	240	88.1	154.4	35.8
Passenger Boarding Time and Time Until Bus Leaves	238	53.4	92.2	23.2
Total Time at Stop	239	141.2	191.9	69.8
Drop-Off Stops (no pick-ups)				
Passenger Exiting Time	243	15.5	19.9	9.5
Time Until Bus Leaves After Passenger Exit	242	60.3	160.2	10.1
Total Time at Stop	242	75.8	162.6	23.3
April 20, 1977 (Computer Operations)				
Pick-Up Stops				
Passenger Access Time	118	94.7	158.7	30.5
Passenger Boarding Time and Time Until Bus Leaves	118	39.3	117.5	11.5
Total Time at Stop	118	133.7	227.7	53.5
Drop-Off Stops				
Passenger Exiting Time	119	18.0	39.6	6.1
Time Until Bus Leaves After Passenger Exit	120	77.2	266.6	10.3
Total Time at Stop	122	93.5	276.2	23.5

NOTE: All variable distributions were very positively skewed, resulting in mean values that greatly exceeded the median. The median is consequently a more "typical" measure of these variables.

5.3.8 PERT Telephone Interface With Users

The telephone interaction between PERT users and the PERT control room was an important feature of DAB service. Excessive telephone waiting time is known to irritate customers. Moreover, the period spent on the telephone should be considered part of total travel time, though it usually is not. Therefore, the user/supplier telephone interface is a significant indicator of DAB system convenience. One of the objectives of computerized dispatching was to streamline the communication process between user and supplier by making information on pick-up times more accessible by the order processors. In addition, if higher-quality service is provided, the number of calls by persons inquiring about their bus arrival time will presumably decrease, allowing the order processors more time to devote to service requests.

Five studies of the user/supplier telephone interface were conducted during the demonstration, according to the following parameters:

<u>Bus Arrival Inquiry Call:</u> A call from a customer who has already made a service request and is seeking more information on the bus arrival time.

<u>Cancellation Call:</u> A call from a customer who has already made a service request and is cancelling that request.

<u>General Information Call:</u> A call from a person seeking PERT information which is unrelated to a specific service request.

<u>(Telephone) Hold Time:</u> The period between the time the phone begins to ring and the time an order processor begins to serve that caller's request. (This includes any time that the call is on hold while the order processor completes another call.)

<u>Service Request Call:</u> A call from a person requesting PERT service for himself or someone else.

<u>(Telephone) Service Time:</u> The length of time between the time the order processor begins to serve a caller's request and the time the conversation is terminated. (This includes any time during the conversation that the order processor must interrupt in order to place another call on hold.)

Four of these studies were made between February 1975 and February 1976; they describe the status of the user/supplier interface before computerized dispatching was introduced in

Greece. In March 1977, another time study was completed which assessed the impact of computerized dispatching on control room operations. This study included requests for Irondequoit services. The results of these studies are shown in Exhibit 5.17.

Call Purposes

Approximately 59% of the calls to the PERT request numbers in the three full-day samples were service requests. Bus arrival inquiries constituted 17% of the calls in August 1975 and 20% in February 1976. (This increase probably reflected the declining service levels of the 1975-76 winter.)

The March 1977 survey disclosed that bus arrival inquiries accounted for only 5.2% of all the calls received. To some extent, this reflects the tremendous improvement in vehicle availability and reliability. However, information requests on the same day numbered 47, or over one-fifth of all calls received. In the other two full-day samples, general information requests made up about 10% of the calls. Therefore, in all three full-day samples, bus arrival and information inquiries represented about 25% to 30% of all the calls received. It is possible that the March 1977 observer classified some bus inquiry calls as general information calls.

Between 11% and 15% of the calls received were for other reasons, including cancellations, request changes, personal calls, crank calls, and wrong numbers.

The results suggest that order processors play a larger role in providing DAB service than merely recording requests. Based on the 1975 and 1976 surveys, one of every three customers called back to ask about when their bus would arrive, indicating that the order processor must remain constantly aware of present bus tours if they are to placate waiting customers. In addition, the order processors played a major role in providing information about the PERT system. PERT users expressed some dissatisfaction with PERT order processors through the suggestion cards on buses and the on-board surveys. Clearly, the order processors were in a vulnerable position from the point of view of customer complaints, since they were the only link between users and PERT during a frustrating wait for a late bus to arrive. The importance of the order processor as a representative of the demand-responsive transit system is obvious.

Telephone Hold Times

Telephone hold times were measured on three occasions.

EXHIBIT 5.17

PERT TELEPHONE TIME STUDIES

CALL PURPOSES	8/6/75-Full Day		9/3/75-2 Hours		2/5/76-Full Day		3/30/77-Full Day	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Service Request	341	57.8	41	64.1	294	58.3	142	61.7
Bus Arrival Inquiry	101	17.1	10	15.6	103	20.4	12	5.2
Information Request	58	9.8	3	4.7	51	10.1	47	20.4
Cancellations	-	-	-	-	20	4.0	-	-
Other	90	15.3	10	15.6	36	7.1	29	12.6
TOTAL:	590	100.0	64	100.0	504	100.0	230	100.0

HOLD TIMES

	2/14/75	2/5/76	3/30/77
Time of Survey	8-10:45 A.M.	Full Day	Full Day
Number of Calls	139	504	230
Mean (Seconds)	35.0	11.9	10.7
Standard Deviation	42.2	26.0	24.7
Percent of Calls by Second Intervals:			
0- 9 seconds	48.9	74.0	77.0
10-19 seconds	8.6	6.9	6.1
20-29 seconds	3.6	5.4	3.0
30-39 seconds	7.2	3.8	6.5
40-49 seconds	3.6	2.0	0.9
50-59 seconds	2.2	1.8	0.9
60 seconds and over	25.9	6.2	5.7

SERVICE TIMES

Call Purpose	Sample Size	Mean (Seconds)	Standard Deviation	Smpl. Size	Mean	Std. Dev.	Smpl. Size	Mean	Std. Dev.
	9/3/75 - 2 Hours			2/5/76- Full Day			3/30/77 - Full Day		
Service Request	41	60.5	25.3	294	56.4	31.3	131	69.4	70.0
Bus Arrival Inquiry	10	40	N/A	103	46.7	33.6	4	34.3	26.1
Information Request	3	90	N/A	51	76.3	82.5	53	57.6	65.9

The average telephone hold time decreased dramatically between 1975 and 1976, from 35.0 seconds to 11.9 seconds, and by 1977 was averaging 10.7 seconds. Variability, as measured by the standard deviation, also decreased. The time periods of the studies were different, but a comparison of equivalent time periods gives the same results as those shown in Exhibit 5.17.

Unfortunately, telephone service times were not recorded in 1975, but the hold time data suggests that the order processors were much more efficient in handling calls in 1976 and 1977 than in 1975. As a result, by February 1976, about two of every three calls were answered immediately (within five seconds), and only about 5%-6% were held for over one minute. This was a marked improvement from 1975, when 26% of the calls were not serviced for over one minute.

Although there was no strong relationship between the number of calls received in a given time period and the average hold time, the data can be used as a basis for determining the number of order processors needed in a manual system. In 1975 and 1976, order processors in Rochester handled between 20 and 30 calls per hour. The number of calls appears to be about 1.2 times the actual ridership, based on the two full-day samples. These relationships provide rules of thumb for calculating the number of order processors required (order processors required = 1.2 (hourly ridership)/25).

Telephone Service Times

Telephone service times can be expected to vary by call purpose, as summarized in Exhibit 5.17. Many calls classified under "other" have extremely short service times (such as wrong numbers and crank calls). Their inclusion in any aggregated analysis would distort the results considerably. Thus, an accurate discussion of service times requires that the results be presented separately for various call purposes.

Although there was considerable variation, the average time required to handle a service request call was about one minute, increasing slightly by 1977. Bus arrival inquiries were somewhat shorter and general information calls were somewhat longer, averaging 75 seconds. As expected, information call lengths varied considerably, since some callers asked about only one specific item of information while others asked very general questions and required full descriptions of PERT service. The decreased information call service time in 1977 substantiates the hypothesis that some bus arrival inquiry calls were mistakenly classified as information calls (see "Call Purposes").

Because of the reduced DAB demand levels after January 1977, each order processor answered considerably fewer calls than in the previous studies. Consequently, order processors reported that they felt less rushed and had less reason to handle calls quickly; this may be why service times for service request calls increased compared to 1975 and 1976. As discussed in Chapter 4, order processors generally agreed that computerized dispatching made their job easier and more efficient. Despite the results of the time study, computerized dispatching appears to have increased the order processors' effectiveness.

5.4 WORK SUBSCRIPTION SERVICE

To evaluate the level of service provided to work subscription riders in Greece, travel times and trip distances have been calculated from data recorded in the on-board time study of February 5, 1976. Data from 19 (out of 20) bus tours was recorded; there were 145 passengers and two no-shows on these tours.

Travel time is defined as the time between a passenger boarding and getting off the bus. Thus, waiting time and lateness are not included, as they are for DAB. Data on lateness is not available, but an April 1975 survey of subscription passengers suggested that lateness was not a perceived problem (see Section 6.4.7).[9]

Precise travel times were recorded in the survey for only 25 passengers. In other cases, individual passengers boarding or exiting at specific locations were not clearly identified; hence, only an average passenger travel time could be computed for all passengers on that tour. In computing the average travel time, each tour average was weighted by the number of passengers on the appropriate tour.

Several assumptions were made in the process of estimating trip distances:

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[9]In fact, the recorded workplace arrival time data suggests the opposite. Buses arrived an average of 19 minutes before workers began their shifts, based on the nine morning tours analyzed. A ten-minute early arrival would probably have allowed enough time for riders to access their offices, and provided sufficient slack for late pick-ups. The extra ten minutes recorded that morning, if typical, may have been a factor contributing to the low worker response to subscription service.

* The work ends of all Kodak Park trips were measured from the center of the Kodak Park development near Dewey and Lake. Trips to and from Rochester Products (GM) were measured at the center of the site northeast of the Lexington Avenue and Mount Read Boulevard intersection.

* Distances were measured along a north-south path until Ridge Road, and then along Ridge Road in a northwest-southeast direction to Kodak Park. (Trips to Rochester Products continued north-south at Mount Read Boulevard.)

* Five home trip ends could not be located precisely, so it was assumed they were located at a point between the location of the preceding and succeeding stops, consistent with the lengths of travel time spent between the three points.

* One morning and one afternoon passenger rode an entire tour and returned to their origins. These were excluded from trip time and distance calculations.

5.4.1 Results

Exhibit 5.18 summarizes the time, distance, and speed information on each bus tour for which data were available, as well as averages for all riders and rides to each work location. Individual trip distances ranged from 0.6 to 5.3 miles, and averaged 3.41 miles. Rochester Products passengers traveled slightly further than Kodak passengers -- 4.33 compared to 3.33 miles. The average passenger rode for 23.2 minutes, which is considerably longer than the average DAB ride time of about 16 minutes. This difference is due to the higher vehicle load factors and productivities resulting in more pick-up and drop-off deviations, and slightly longer trip lengths. Due to lower productivities, Rochester Products trips were slightly faster than Kodak Park trips despite the longer distances. The average subscription trip speed was 8.81 miles per hour. Little difference was noted between morning and evening tours; A.M. travel speeds averaged only 0.28 miles per hour faster than in the P.M. The speed of trips to Rochester Products was considerably higher than those to Kodak, averaging 12.35 miles hour. For comparison, the average DAB passenger travel speed (in-vehicle time only) was 10.6 miles per hour.

In general, a passenger was considerably better off being picked up near the end of the tour in the morning rather than at the beginning. On the nine A.M tours, the

EXHIBIT 5.18 GREECE WORK SUBSCRIPTION TRAVEL TIMES

BUS LOAD	AM or PM	NUMBER OF PASSENGERS & NO-SHOWS	NUMBER OF WORK STOPS	AVERAGE PASSENGER TRIP DISTANCE	AVERAGE TIME PER PASSENGER (min.)	AVERAGE PASSENGER TRAVEL SPEED (m.p.h.)	LEVEL OF SERVICE RATIO*	LENGTH OF TOUR (1st pick-up to last drop-off (minutes)
1	AM	8	3	3.55	24.7	8.63	2.31	43.2
2	AM	9	3	4.19	24.4	10.32	1.94	38.2
3	AM	11	6	3.56	24.8	8.62	2.32	49.3
4	AM	7	4	2.78	20.9	8.00	2.52	34.9
5	AM	8	2	4.09	21.4	11.48	1.74	35.0
6	AM	14	6	2.32	25.2	5.52	3.60	49.8
7	PM	9	4	3.90	27.2	8.62	2.32	52.4
8	PM	2	2	3.40	16.1	12.69	1.58	21.9
9	AM	11	6	3.12	25.7	7.29	2.73	43.6
10	PM	7	4	3.15	20.1	9.41	2.12	37.1
11	PM	6	3	3.04	16.1	11.30	1.77	26.8
12	PM	8	3	3.96	32.5	7.30	2.73	49.0
13	PM	5	2	3.39	20.3	10.03	1.99	24.3
14	PM	7	2	3.23	21.7	8.96	2.24	29.8
15	PM	11	4	3.45	27.1	7.62	2.61	47.0
16	PM	9	3	2.65	17.3	9.18	2.16	36.3
17	AM	3	3	3.26	10.9	17.16	1.11	24.5
KODAK		7.94	3.53	3.33	23.5	8.52	2.35	37.8
18	AM	6	2	4.33	24.4	10.66	1.88	37.1
19	PM	6	2	4.33	17.7	14.68	1.36	29.5
GM		6.0	2.0	4.33	21.1	12.35	1.62	33.3
TOTAL		7.74	3.26	3.41	23.2	8.81	2.27	37.4

* Assuming average auto speed of 20 m.p.h.

first passenger picked up averaged 7.62 miles per hour as the bus detoured to pick up additional passengers. The last passenger boarding in the morning had an average trip speed of 13.35 miles per hour, 75% faster than the first passenger's. The last passenger picked up often had to stop at one or more drop-off points before exiting; otherwise, his travel speed would have been even faster.

In the evening, there was little overall difference in travel speeds according to when a passenger was dropped off. In fact, the last rider dropped off had a travel speed that was an average of 0.22 miles per hour faster than the first rider, contrary to expectations. This occurred because there were usually relatively long spans of time between pick-ups at the workplace (averging a total of nine minutes), and those passengers dropped off first tended to be the ones that were picked up earliest. Consequently, their travel times were lengthened and there was little correlation between P.M. travel speeds and passenger drop-off order.

In order to calculate automobile travel times, a speed of 20 miles per hour was assumed. For the average 3.41 mile trip distance, the passenger traveling by private automobile could be expected to spend 10.21 minutes traveling to work. Thus, the overall level-of-service ratio for subscription service -- obtained by dividing the average passenger time by the comparative automobile time -- is 2.27. The Rochester Products passengers had a level-of-service ratio of 1.62, while the Kodak passengers had a 2.35 level-of-service ratio. However, the Rochester Products passenger trip data is based on only two tours (one in the morning and one in the evening) compared to 17 Kodak tours. Time for parking and local traffic congestion at the workplace have not been included in the calculation of automobile travel time. Such time varies considerably, but could conceivably add as much as five minutes to the individual times involved in automobile travel. The latter assumption generates an average subscription service level-of-service ratio of 1.55 rather than 2.27. On the other hand, subscription service wait time has not been considered but may occasionally be significant. This would serve to lengthen the effective travel time of subscription service.

Subscription service travel time may also be compared to travel time on regular transit for those Kodak passengers with access to fixed-route buses (about 31% of all Kodak subscription passengers). The data in Exhibit 5.19 is derived from RTS schedules, and assumes a walk to the bus stop of 2-1/2 minutes (1/8 mile) a trip of 3.3 miles on the fixed-route bus, and a wait time equal to half the average headway between 6:00-8:00 A.M. inbound and 3:30-5:30 P.M. outbound.

EXHIBIT 5.19

TRAVEL TIME TO KODAK PARK BY FIXED-ROUTE TRANSIT

(Minutes)

	Route 1 (Lake)	Route 14 (Ridge)	Route 15 (Dewey)
Walk Time	2-1/2	2-1/2	2-1/2
Wait Time	4	10	7
Ride Time	11	12	11
Total	17-1/2	24-1/2	20-1/2

Comparative subscription time: 23.5 minutes
Comparative automobile time: 10.0 minutes

Travel to Kodak Park by fixed-route bus is slightly faster than by subscription service in two out of three cases. Route 14 travel time is slightly longer because of a longer wait time due to lengthier headways. If it is assumed that commuters are likely to time their arrival at the bus stop to meet the bus (planned access rather than random access), Route 14 travel time would be comparable to that of Routes 1 and 15.

Thus, travel to Kodak Park by fixed-route bus (for those within walking distance) is slightly faster than by subscription bus (a level-of-service ratio of around 2.0 compared to 2.3). Apparently, subscription users within walking distance of a fixed-route bus opted for PERT's service because of the convenience of being picked up at one's home rather than because of any travel advantage. In the April 1975 survey of subscription users, 57% of those responding stated that this was PERT's most attractive feature, confirming this hypothesis.

5.4.2 Variation in Subscription Travel Speeds

To aid planners of subscription services, the reasons for variations in subscription travel speeds are analyzed in this section.

The difference between the Rochester Products and Kodak data, as well as the variation between Kodak tours, may be partially explained by two variables: the number of passengers on the bus tour (including two no-shows on one tour) and the average distance of the trips on the tour. A strong negative relationship (see Exhibit 5.20) exists between the average passenger trip speed and the number of passengers on the tour ($r=-.77$).[10] In addition, a weak positive relationship ($r=+.35$) exists between the average passenger trip speed and the average passenger trip distance.

When average trip speed is regressed against both the number of passengers and the distance, a multiple R^2[11] value of .63 is obtained, but nearly all of this predictability (.60 of .63) is obtained from the "number of passengers" variable. Reversing the order that the variables are brought into the equation results in an R^2 of only .12 after trip distance is introduced. The regression equation is:

Passenger Trip Speed (m.p.h.) =

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[10] r is the correlation coefficient.

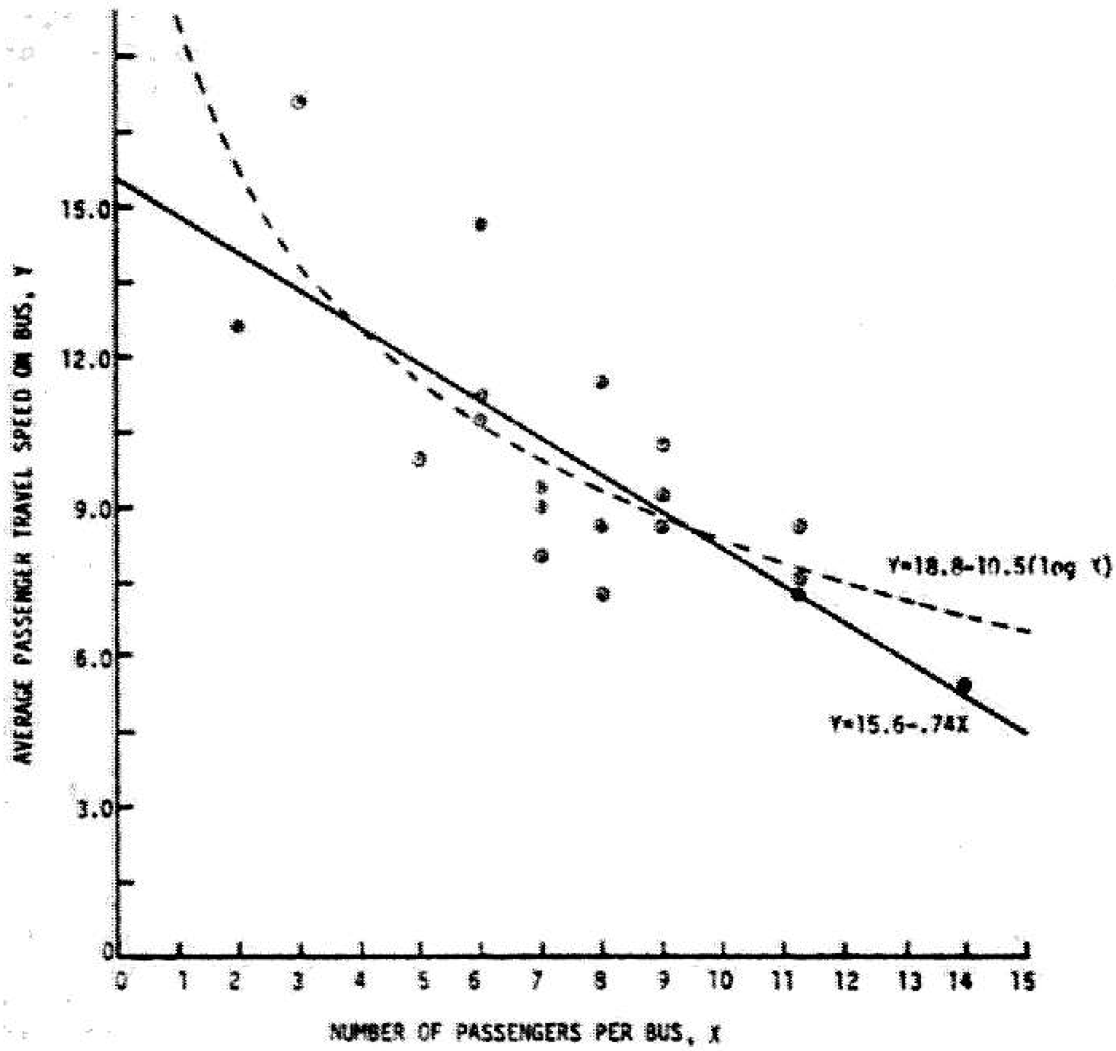
[11] R^2 is the percent of variation explained by the regression equation.

EXHIBIT 5.20

WORK SUBSCRIPTION SERVICE (GREECE)

AVERAGE PASSENGER SPEED vs. NUMBER OF PASSENGERS ON TOUR

(n=19)



12.3 - .70 (# passengers) + .86 (average trip distance in miles)

Thus, an additional passenger slows the average trip speed by .70 miles per hour (about 1.9 minutes for the typical Greece subscription trip), while increasing travel distance increases overall speed slightly. The number of drop-off points at the work location was also included in a trial regression, but a strong correlation (r=.75) with the number of passengers results in this variable having a very weak effect on total predictability (increases R^2 by only .008). Thus, it was excluded from the above regression equation.

The above regression implies that a tour of only one person traveling the average 3.4-mile distance (comparable to an automobile or taxi) would have an average speed of only 14.5 miles per hour. This is lower than the assumed average automobile speed of 20 miles per hour. However, the model is not well calibrated for this low passenger range, for only two tours had less than five passengers, and one of these -- with three passengers -- had an average speed of 17.2 miles per hour. Thus, the fact that average speed rises quickly at low passenger levels is not reflected in the above regression equation. When a regression using the log of the number of passengers rather than the actual number of passengers is made, the following equation is obtained:

Passenger Trip Speed (m.p.h.) =

14.1 - 10.04 (log # of passengers)
+ 1.25 (average trip distance in miles)

While the predictability remains about the same (a multiple R^2 of .64 compared to .63), a bus tour of one passenger traveling 3.41 miles would now have an average speed of 18.4 miles per hour. This is probably more realistic than that obtained from the previous regression, but additional data is required to determine which regression form more accurately reflects the actual conditions.

5.4.3 School Subscription Service

The on-board time study of February 5, 1976 was also used to evaluate the level of service provided by school subscription service. On that day, 81 passengers were carried on six tours to and from three schools. The results are summarized in Exhibit 5.21. The average passenger trip distance was calculated by taking the average straight-line distance and multiplying by a street adjustment factor of 1.2 (see Section 6.1.5). In comparison to work subscription

EXHIBIT 5.21

SCHOOL SUBSCRIPTION TRAVEL TIMES

Tour	Trip	Passengers	Avg. Passenger Trip Distance (Miles)	Passenger Travel Time		Average Passenger Travel Speed (m.p.h.)
				Avg.	S.D.	
School #38 AM	14	28	1.0	22.2	12.0	2.7
School #38 PM	13	23	1.0	18.5	7.7	3.2
School #42 AM	9	9	1.5	18.3	8.5	4.9
School #42 PM	9	9	1.5	14.9	4.9	6.0
St. Charles School AM	3	6	0.9	9.6	4.0	5.6
St. Charles School PM	3	6	0.9	7.5	4.3	7.2
TOTAL	9.0	13.5	1.1	17.9	9.9	3.7

service, trip distances and travel speeds are considerably lower. The average passenger trip was only 1.1 miles long (driving distance) but took nearly 18 minutes, resulting in an average travel speed of 3.7 miles per hour. Unlike work subscription service, in which time of day had little impact, afternoon travel time was about 20% faster than in the morning for all three schools served.

As with work subscription service, the number of passengers on the tour affects school subscription trip speed. School #38 service, with the most passengers, had the slowest average trip speed, while the St. Charles School tour, which made only three pick-ups or drop-offs, had the fastest travel speeds. The equations developed for work subscription service, however, would uniformly overpredict travel speed if applied to the school subscription service tours. The work subscription equations are not calibrated for the short trip distances involved in school subscription service. In school subscription service, a short but very circuitous path is followed, unlike in work subscription service where more direct routing is utilized. In addition, all customers of work subscription service lived on the same side of the workplace, since Kodak Park and Rochester Products are both located on or outside the edges of the service area. This was not true for school subscription service. The small school subscription data base that is available (six tours) prevents the establishment of a meaningful set of relationships for this service.

6. GREECE: DEMAND

This chapter assesses PERT demand, including ridership trends, user and trip characteristics, and user attitudes. The information reported was gathered from PERT operational records and user surveys. Because the recordkeeping format was changed several times during the project, some variables were recorded only during portions of the project.

6.1 DIAL-A-BUS AND DEW-RIDGE SHUTTLE DEMAND

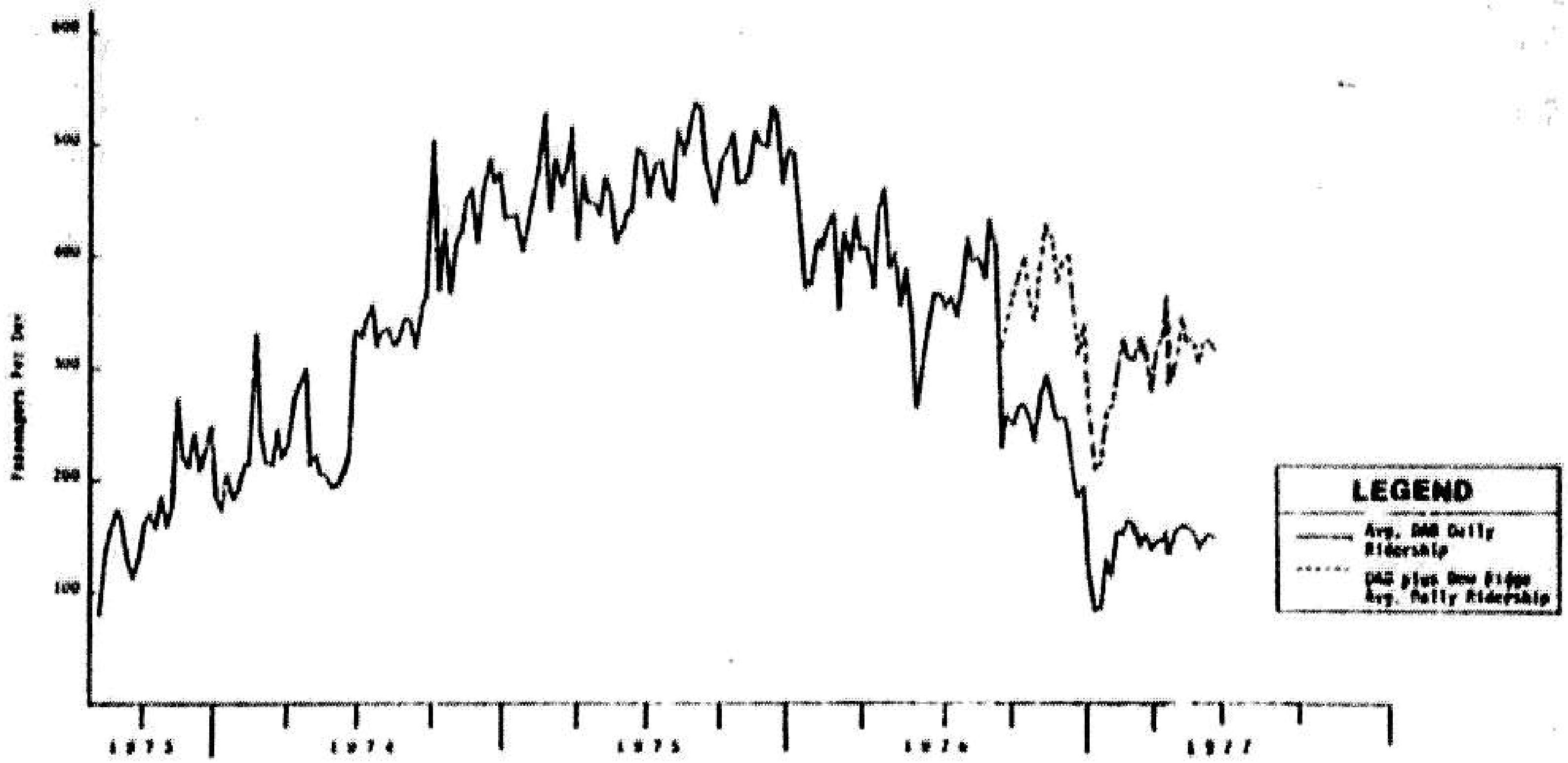
6.1.1 Ridership Levels

Exhibit 6.1 displays the average Greece Dial-A-Bus (DAB) daily ridership by week from the start of PERT service on August 6, 1973 until June 17, 1977. (Ridership for DAB as well as other services is presented as a daily average calculated over the course of the week, unless otherwise stated. This is done to eliminate some of the day-to-day variations and to compensate for short weeks with holidays.) DAB ridership in Greece grew quickly, from under 100 riders per day during the first week to over 500 passengers per day on several occasions in 1975; it began decreasing in early 1976. DAB ridership dropped further in September 1976 and again in January 1977 following the introduction of the Dew-Ridge Shuttle, the September 1976 contraction of the service area, and the cutback of operating hours in January 1977.

The ridership represented in Exhibit 6.1 and discussed in the subsequent analysis is expressed in terms of the number of passengers. When analyzing DAB demand, it is also useful to consider the number of "trips" or "demands" (where these terms indicate one or more persons traveling between the same points at the same time). Thus, although they are counted as two passengers, two people traveling together constitute one trip. The relationship between the number of passengers and trips was fairly constant throughout the project. During the first 152 weeks of DAB service (through July 3, 1976), there were 1.46 passengers per trip during periods when school was not in session (summer and other vacations), and 1.28 passengers per trip during the greater part of the year when school was in session. Relatively small standard deviations of .14 and .10 passengers per trip, respectively, indicate that the differences between the means are highly significant. It is assumed that during school vacations, students were more likely to travel in groups, either with other students or with a parent. There were approximately 1.34 passengers per trip on an annual basis, since school is in session for about two-thirds of the year.

EXHIBIT 6.1

AVERAGE DAILY DIAL-A-BUS RIDERSHIP, BY WEEK

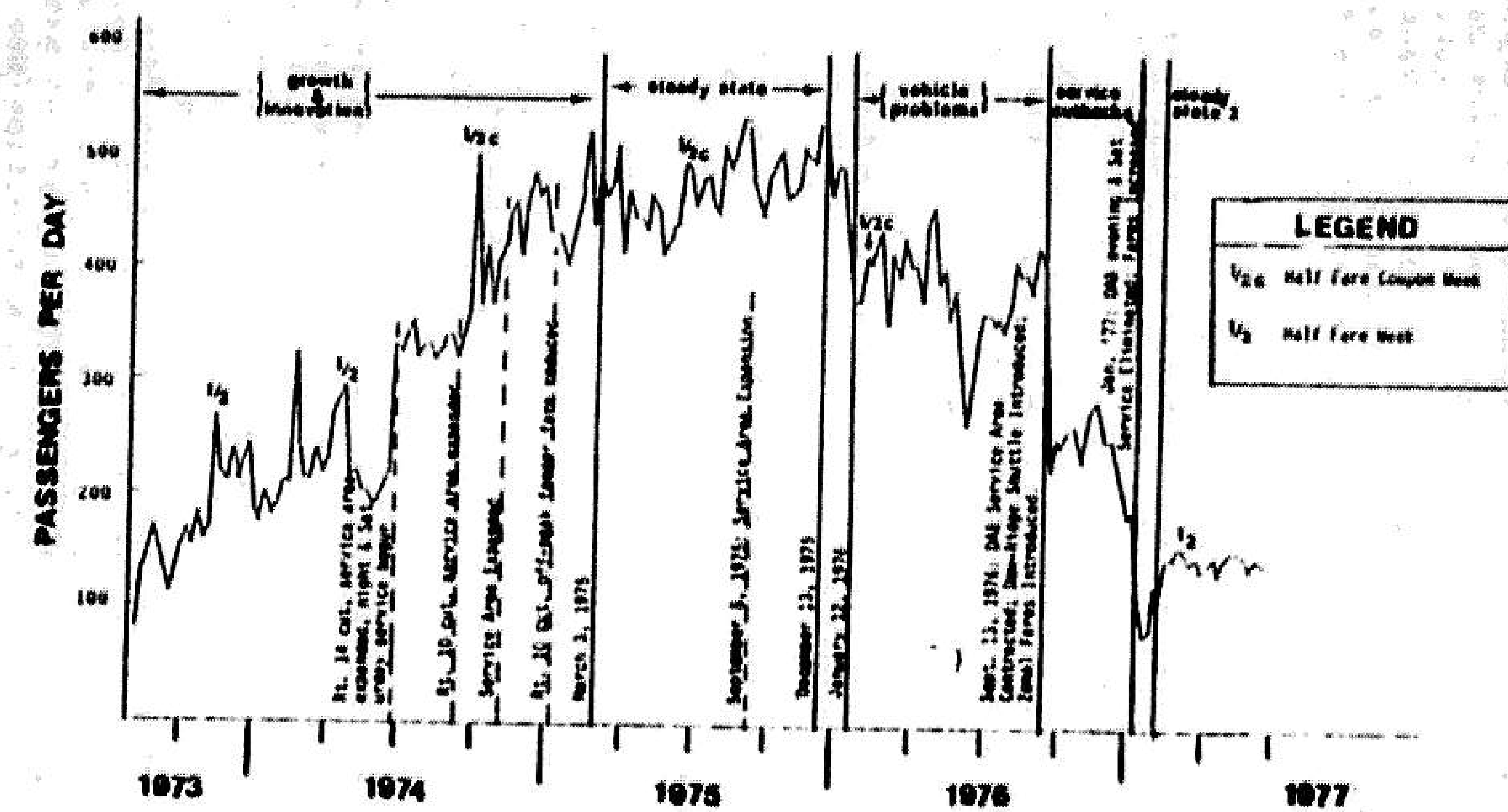


The saw-toothed nature of the Exhibit 6.1 graph indicates that weekly ridership fluctuated considerably. Nevertheless, trends can still be detected; Exhibit 6.2 separates ridership into five distinct periods. The first period covers the first year and one-half of the project, when many ridership-boosting service changes were implemented and there was considerable marketing activity. During this period, two DAB half-fare weeks were conducted, and an extensive newspaper half-fare coupon promotion was undertaken. Two of these promotions had an unmistakably positive effect on ridership (see Section 6.8.3). In addition, between June 1974 and January 1975, the service area was expanded three times, evening service began, RTS Routes 10 and 14 in Greece were eliminated during the off-peak period, and the midday feeder fare was reduced. All these changes seem to have positively affected ridership, although their time proximity makes it difficult to discern their individual impacts. Together, however, they define a "growth-and-innovation" phase, which ended approximately two months after the last major service change. During this period, average daily ridership increased by about 200% over the levels of the first three months. The period is also marked by several abrupt rises (such as on June 24, 1974 when Route 14 service was eliminated and evening service began), but ridership grew steadily overall.

Following the cutback of Route 10 service in January 1975, a fairly stable period of DAB operations began, and the supply of DAB service (measured by such factors as vehicle-hours and service area) stabilized. Similarly, demand was fairly level from March to December 1975, a period which has been called "steady-state." Seasonal variation did exist during the steady-state period, consisting mainly of ridership losses in the spring. March 1975 (the end of winter) daily ridership averaged 488 persons, summer daily ridership averaged 486 (June 23-August 31 corresponding to school vacation), and fall ridership (September 2-December 13) averaged 492 passengers per day. During the spring (March 31-June 21), however, there were only 446 passengers per day, or about 9% less than the remainder of the year. This spring decline accounts for about one-quarter of the statistical variation over the entire steady-state period. Similar trends seem to have occurred in 1974 and 1976, but they are obscured by other events. During the entire steady-state period, DAB ridership averaged 476.5 passengers per day, with a standard deviation of the weekly average of 32.5 (a coefficient of variation of .07). A service area expansion was made in September 1975, but this was relatively insignificant in terms of the number of passengers served. A June 1975 half-fare coupon promotion was confounded by a delay in mail delivery; many of the coupons were delivered after their validation period (see Section 6.8.3). As a result, the ill-fated promotional effort only slightly affected ridership levels.

EXHIBIT 6.2

AVERAGE DAILY DIAL-A-BUS RIDERSHIP, BY WEEK



During the steady-state period, the average daily ridership corresponded to an average hourly ridership of 34 passengers and 25 trips. Depending on whether the September 1975 service area expansion is included, an average demand density of between 1.6 and 1.8 demands per square mile per hour can be calculated.

Serious vehicle breakdowns began in December 1975, and DAB ridership began to decrease. On-the-road breakdowns became more frequent, scheduled vehicle-hours were lost due to the lack of available buses, and service quality generally suffered. By mid-January, ridership leveled off again at less than 400 passengers per day. From January 12 through September 11, 1976, daily ridership averaged 386.3 passengers, or 21% less than the 1975 steady-state level. This corresponds to the third "vehicle problems" phase, which continued until major service changes were implemented in September 1976. During this phase, ridership fluctuated considerably more than in 1975; a standard deviation of 44.4 passengers results in a coefficient of variation of approximately 0.115. Almost one-third of this variation resulted from the number of no-shows and cancellations, both of which underwent great variation during this period due to declining service levels. Thus, the number of persons wishing to use the system had about the same variation during both 1975 and 1976. (See Section 6.1.8 for a more detailed analysis of this phenomenon.)

During the 11 weeks after the Dew-Ridge Shuttle and the zonal fare system were introduced on September 13, 1976, DAB ridership dropped 36% to 261 passengers per day; this period is the fourth of the distinct ridership periods. Weekday ridership fell by about 40% to 256 daily passengers, while Saturday ridership dropped by about 10% to 285 passengers. As expected, DAB transfer ridership decreased more than non-transfer ridership, since the Dew-Ridge bus connected with RTS Route 10 at Dewey and Ridge. Overall DAB transfer ridership dropped by 47%, compared to about 30% for DAB non-transfer ridership. In December 1976, ridership again decreased, as cold weather caused vehicle shortages and lowered service quality.

The Dew-Ridge Shuttle did not operate on Saturdays, so the 10% DAB ridership decrease is assumed to be the result of the zonal system fare changes introduced at that time. Consequently, 30% of the former weekday DAB riders (the 40% ridership decrease minus the 10% drop attributed to the fare changes), or 127 daily passengers, were presumably diverted to the Dew-Ridge Shuttle. The average daily Dew-Ridge ridership of 146 passengers during this period (excluding the first two weeks) seems to include this group plus a small number of other passengers who did not previously use DAB. Approximately 16% of the Dew-Ridge Shuttle passengers took advantage of the route deviation option, primarily on inbound trips (passengers requested doorstop pick-up rather than doorstop dropoff).

During the Dew-Ridge Shuttle's fifth week of operation (October 11-15, 1976), no fare was charged. Ridership that week rose by about 11% from the previous two weeks, but returned to slightly less than its previous level during the following three weeks. Thus, this promotion was unsuccessful in boosting Dew-Ridge Shuttle ridership (see Exhibit 6.3).

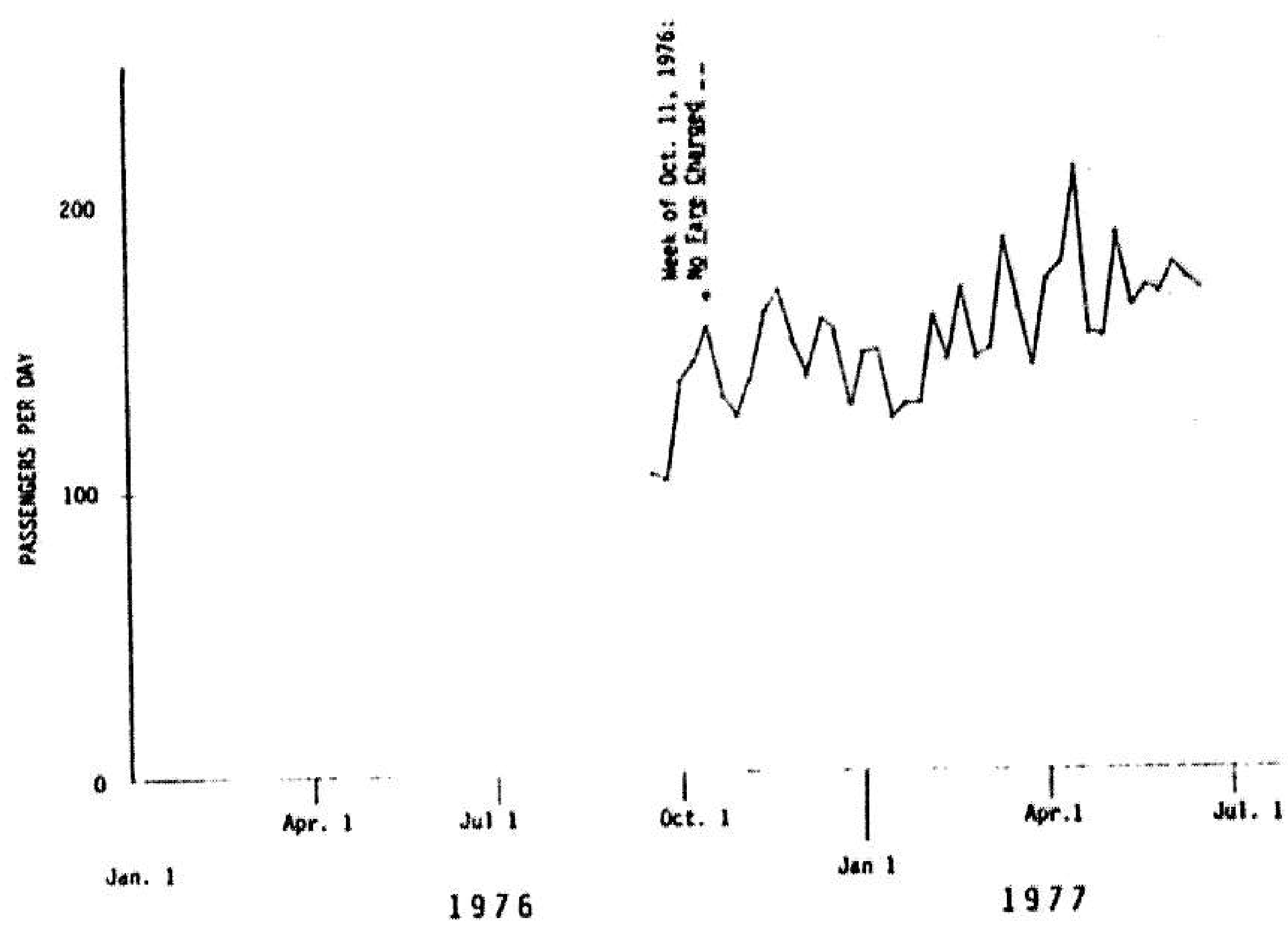
When the January service changes were implemented, Rochester was undergoing one of the coldest and snowiest winters on record. DAB ridership did not stabilize until early February, at an average of 150 daily passengers; this was about a 42% decrease from the weekday DAB ridership prior to the change. This new steady-state comprises the fifth period. The decrease probably resulted from the elimination of service after 3:00 P.M.; the lost ridership represents the approximate proportion of DAB passengers previously riding after 3:00 P.M. Any ridership loss resulting from the fare increase cannot be detected, and may have been counteracted by the ridership increase resulting from service level improvements. Also resulting from the higher-quality service being offered, DAB no-shows stabilized at around 6% of completed trips after February 1977. This was a substantial decrease from the 15-20% level experienced in the fall and winter of 1976, and only slightly more than that experienced during the 1975 'steady-state' period.

Dew-Ridge Shuttle riders increased by about 20% to 165 per day, and exceeded DAB ridership after January 1977. The number of deviation requests also increased slightly, to 18% of the total ridership; this increase reflected the elimination of the two checkpoints in the Northgate area.

In 1975, the DAB service attracted more riders than most other U.S. dial-a-ride systems have been able to do (see Appendix A.20). After accounting for the Greece service area population and the number of daily operating hours (which also exceeded most other systems), however, the difference was insignificant. The lower 1977 ridership, though reflecting fewer riders per capita than are typical, was slightly above average after considering the short service hours.

EXHIBIT 6.3

AVERAGE DAILY DEW-RIDGE SHUTTLE RIDERSHIP, BY WEEK



6.1.2 Temporal Variation in Dial-A-Bus Ridership

In addition to eliminating some of the erratic variations between days, using weekly averages to measure ridership trends obscures the regular variation which occurs over the days of the week. These trends are recorded in Exhibit 6.4, which examines ridership by day of the week for the entire 1975 steady-state period (excluding four weeks in which there was a holiday and the week of March 31 in which a snowstorm essentially eliminated service for two days). Monday through Thursday ridership was fairly evenly distributed; the major difference was between Mondays and Thursdays, but it was not significant. However, Friday ridership was 12% above the Monday through Thursday average, and the difference was significant at well below the .01 level. On the other hand, Saturday ridership was considerably lower than that of the other days. Altogether, Saturday ridership averaged 78.5% of the weekday average (including Friday). Average Saturday demand density, however, was actually slightly higher than weekday demand density due to the shorter DAB operating hours on Saturday.

Ridership also varied over the course of the day. Exhibit 6.5 displays the proportion of weekday DAB passengers picked up during each hour of the day; the figures were derived from a 17-day sample of days in which service quality checks were conducted. The curve in Exhibit 6.5 resembles a positively skewed curve (except that it is bimodal), with one peak between 9:00 A.M. and 10:00 A.M. and another between 12:00 noon and 2:00 P.M. The distribution curve reported for Saturday is based on only one day's ridership, but suggests a more normally distributed curve with most trips occurring in midday (Exhibit 6.6).

The results suggest that demand density varied considerably over the time of day and the day of week. During the 1975 steady-state period (after the 1975 area expansion), average demand density during the busiest weekday and Saturday hours (9:00-10:00 A.M. and 12:00-2:00 P.M. on weekdays; 12:00-2:00 P.M. on Saturdays) was about 2.6 demands per square mile per hour; demand dropped sharply during other hours of the day. The overall demand density of 1.6 demands per square mile per hour quoted in the previous section represents the average of these figures.

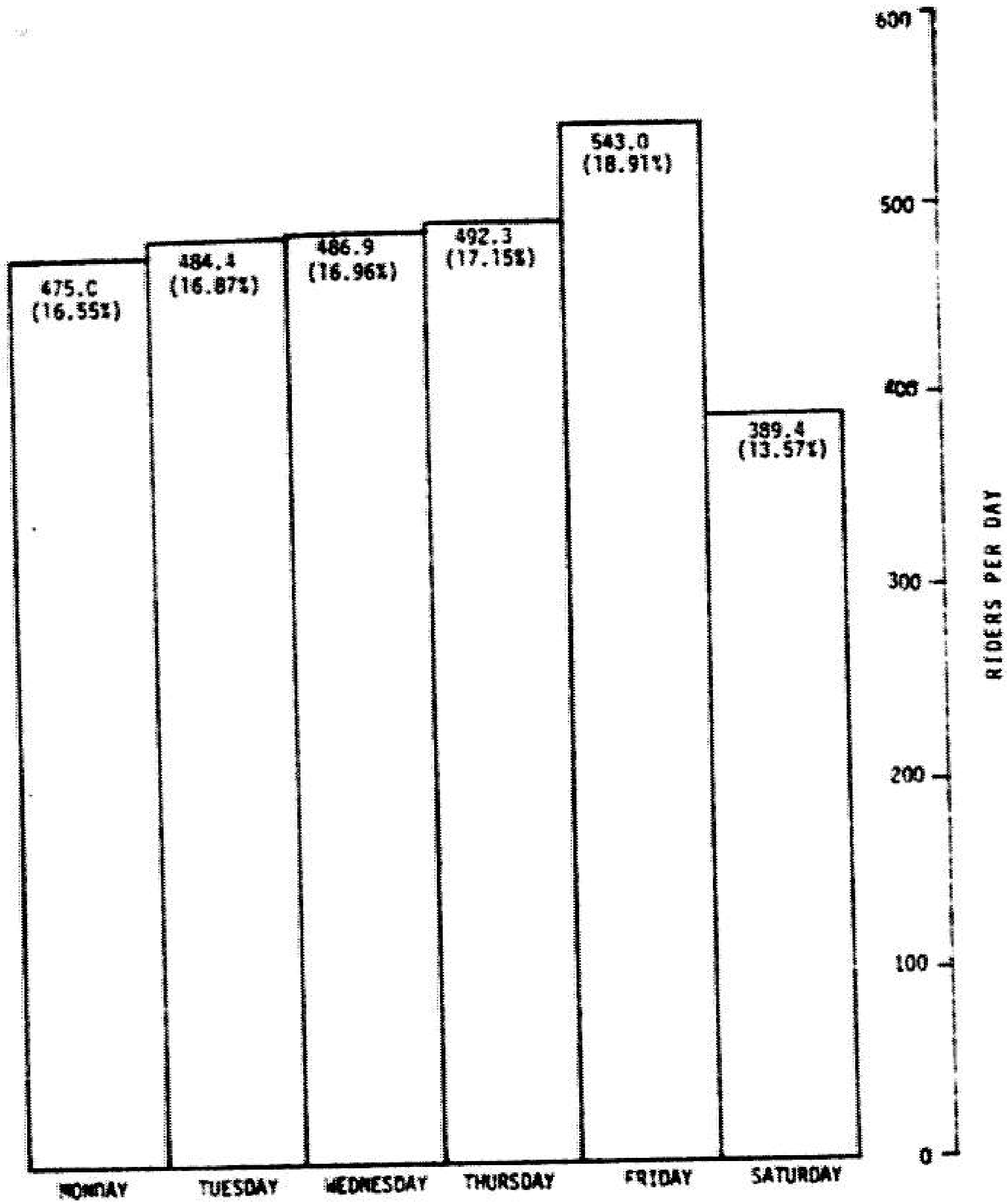
6.1.3 Spatial Demand Patterns

The results of four weekday origin/destination studies are summarized in Exhibit 6.7. A system of five zones is used in order to simplify presentation of the results. The map of the five zones used is displayed in Exhibit 6.8. The

EXHIBIT 6.4

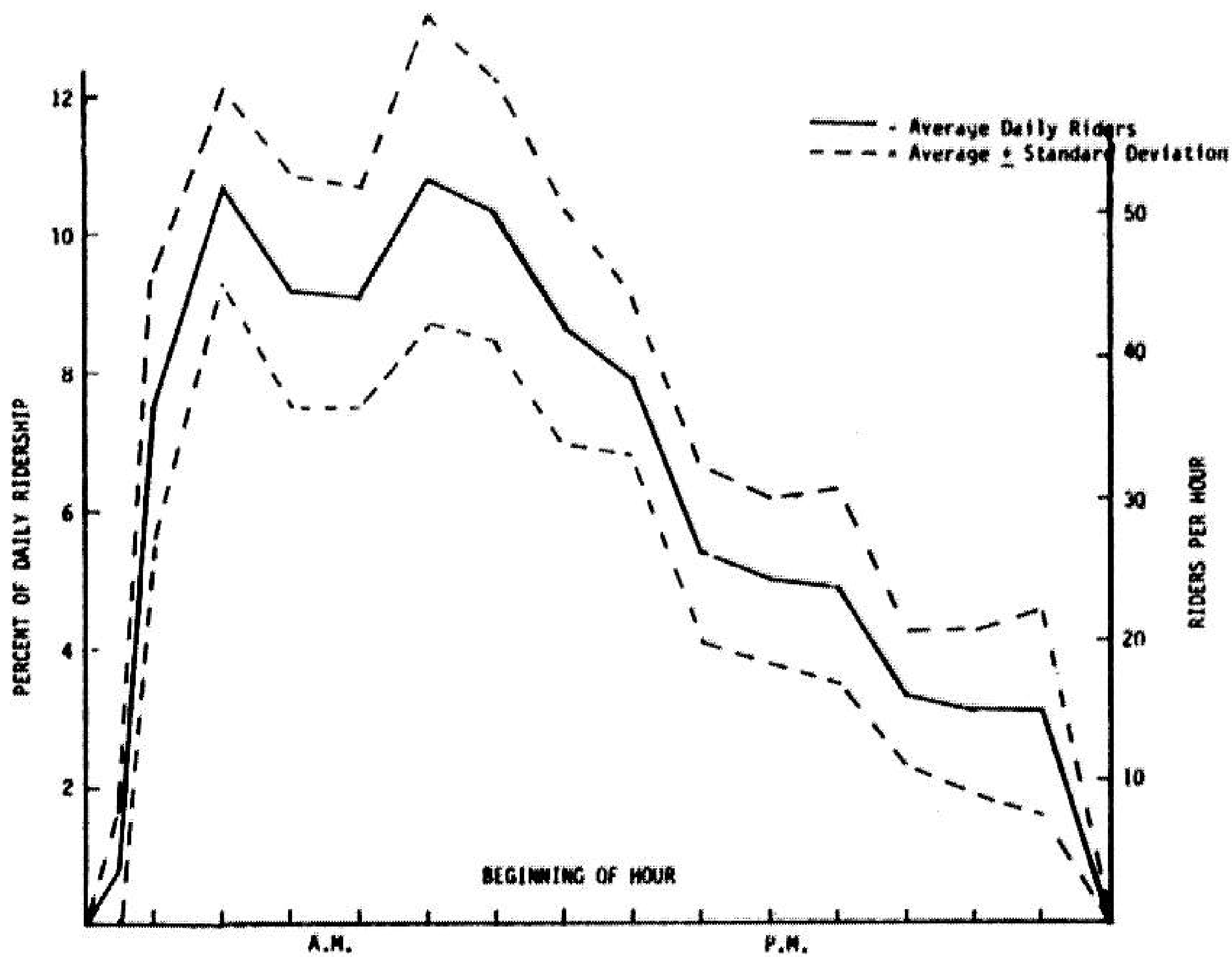
DIAL-A-BUS RIDERSHIP, BY DAY OF WEEK

(March 3, 1975 - December 12, 1975)



Based on 36 weeks' data between 3/3/75 and 12/13/75. (Holiday weeks and one snowstorm week excluded.) Total passengers in sample equals 103,353.

EXHIBIT 6.5 <u>WEEKDAY DIAL-A-BUS RIDERSHIP, BY TIME OF DAY</u>



(17-Day Sample Between July 1974 and February 1976; Average Daily Riders = 484.9)

EXHIBIT 6.6 <u>SATURDAY DIAL-A-BUS RIDERSHIP, BY TIME OF DAY</u>

(October 4, 1974; Daily Ridership = 398)

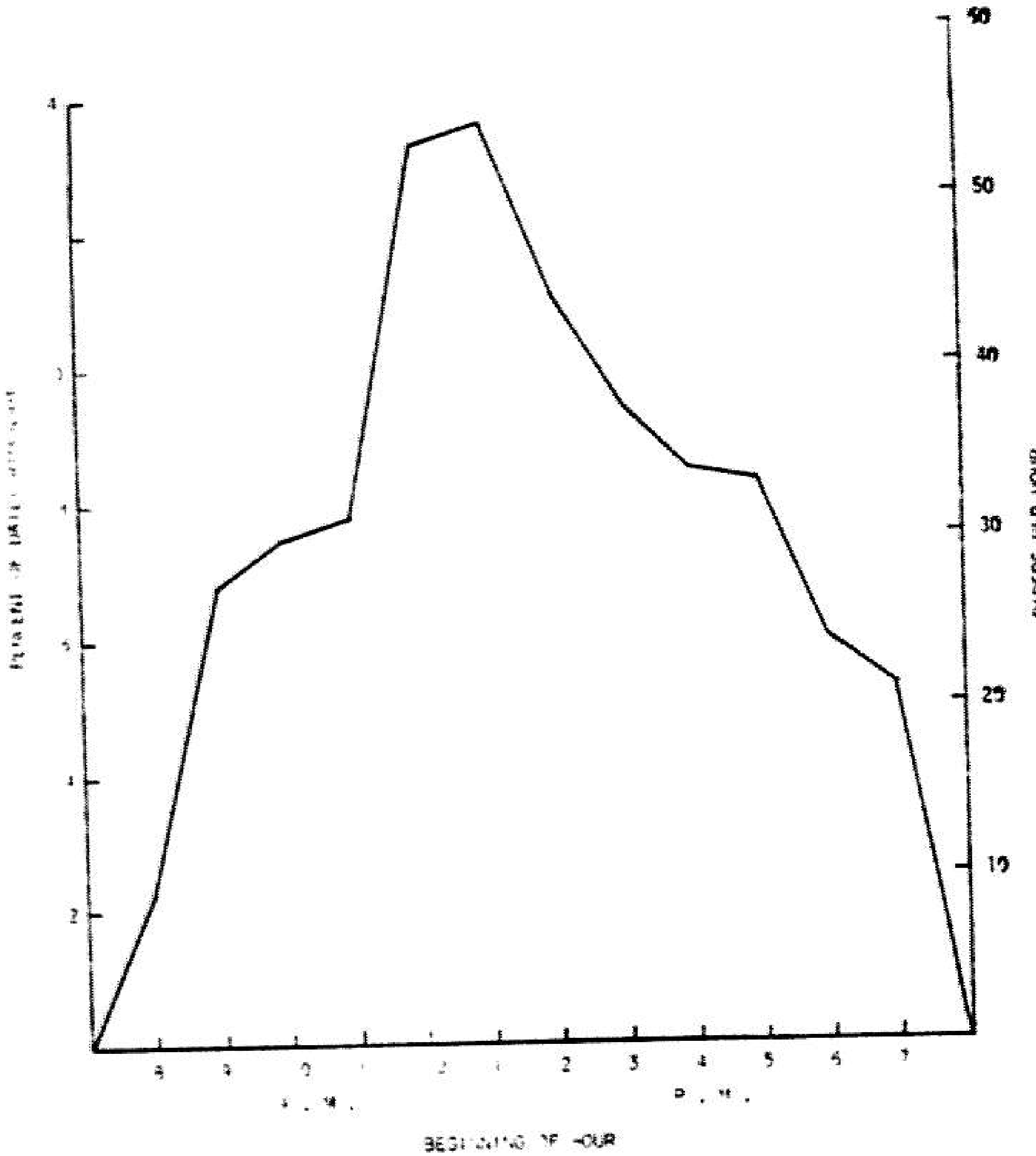


EXHIBIT 6.7

DIAL-A-BUS ORIGIN/DESTINATION STUDIES

(Number of Trips)

January 8, 1974:

		DESTINATIONS						
		SW	SE	NE	NC	NW	TOTAL	%
ORIGINS	SW	3	7	4	6	6	26	15
	SE	26	7	3	9	3	48	28
	NE	9	3	3	4	1	20	11
	NC	11	10	4	12	2	39	22
	NW	26	8	0	4	2	41	24
TOTAL		75	35	14	35	15	174	100
%		43	20	8	20	9	100	-

Percent of trips to or from:

SW Malls	43%
Dewey and Ridge	9%
Northgate Plaza	14%
SW and SE (Ridge Rd. Corridor):	81%

Percent of trips totally within SW and SE: 24%

May 1974 (Two Days):

		DESTINATIONS						
		SW	SE	NE	NC	NW	TOTAL	%
ORIGINS	SW	4	9	4	10	14	41	22
	SE	16	16	2	5	6	45	24
	NE	12	7	2	7	1	29	15
	NC	16	6	4	8	6	40	21
	NW	17	7	3	1	6	34	18
TOTAL		65	115	15	31	33	189	100
%		34	24	8	16	17	100	-

Percent of trips to or from:

SW Malls	48%
Dewey and Ridge	9%
Northgate Plaza	13%
SW and SE (Ridge Rd. Corridor):	80%

Percent of trips totally within SW and SE: 24%

January 20, 1975:

		DESTINATIONS						
		SW	SE	NE	NC	NW	TOTAL	%
ORIGINS	SW	8	15	3	15	7	48	18
	SE	23	15	5	30	7	80	30
	NE	7	11	3	7	2	30	11
	NC	19	34	4	11	5	73	27
	NW	16	9	1	6	3	35	13
TOTAL		73	84	16	69	24	266	100
%		27	32	6	26	9	100	-

Percent of trips to or from:

SW Malls	28%
Dewey and Ridge	23%
Northgate Plaza	6%
SW and SE (Ridge Rd. Corridor):	84%

Percent of trips totally within SW and SE: 23%

February 1976 (Three Days):

		DESTINATIONS						
		SW	SE	NE	NC	NW	TOTAL	%
ORIGINS	SW	61	97	36	21	30	245	28
	SE	102	72	17	30	26	247	28
	NE	35	21	12	22	19	109	12
	NC	36	51	17	14	22	160	18
	NW	25	44	24	18	15	126	14
TOTAL		279	285	106	105	112	887	100
%		31	32	12	12	13	100	-

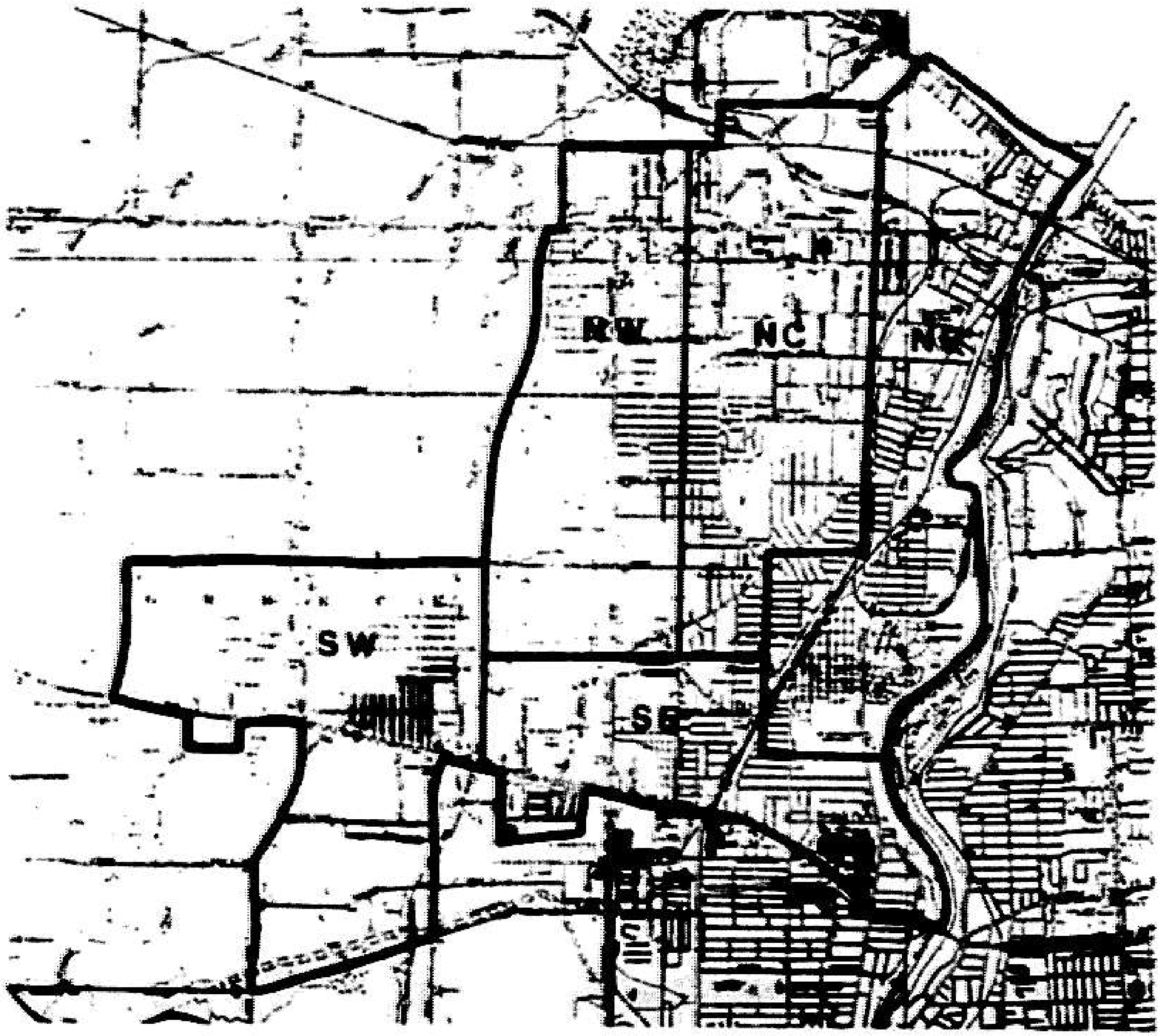
Percent of trips to or from:

SW Malls	34%
Dewey and Ridge	24%
Northgate Plaza:	7%
SW and SE (Ridge Rd. Corridor):	82%

Percent of trips totally within SW and SE: 37%

EXHIBIT 6.8

DIAL-A-BUS ORIGIN/DESTINATION ZONES



first two studies were made prior to any service area expansions or route rationalization changes. At that time, the "SW Malls" on West Ridge Road (Longridge Mall, Greece Town Mall, and Ridgemont Plaza) were essentially the only locations in the official service area located in the SW zone. At that time, however, passengers were allowed to travel to and from other locations in that general area. The January 1975 study was made after Routes 10 and 14 were rationalized, and after most of the service area expansions had been completed. Finally, the February 1976 study was made during computerized dispatching operations, when vehicle breakdowns had already caused ridership losses. The latter study also reflected the fully-expanded service area. Together, the four studies cover the most important evaluation stages of DAB service, before the Dew-Ridge Shuttle was introduced in Greece.

The notations to the right of the matrices in Exhibit 6.7 summarize the most important features of DAB trip patterns. These trip proportions indicate that the origin/destination patterns changed over the course of the project. Prior to June 1974, nearly half of all trips were to or from the malls on West Ridge Road. After the service area expansions, they accounted for only between one-quarter and one-third of all trips, although this represented an absolute increase in daily trips of around 50% due to a general ridership increase. Conversely, prior to the route rationalization of Routes 10 and 14, there were relatively few trips to the Dewey and Ridge or Lake and Ridge transfer points. By 1975, trips to and from Dewey and Ridge alone represented about one-quarter of all DAB trips. Finally, the Northgate Shopping Plaza in northern Greece diminished as an important trip attractor as the service area expanded and DAB became an important feeder mode. Roughly the same number of trips to Northgate Plaza were made over time, but as total ridership increased they became a smaller proportion of the total.

The results suggest that DAB was effective in moving most of the demand in a north-south direction (which generally comprised over half of the DAB demand). There was no single dominant corridor, but rather a general movement from the northern areas to two separate areas in the southern portion of the service area. Along the southern boundary, however, a fixed-route or route deviation service along Ridge Road may have been more effective in handling this demand, since the demand pattern is somewhat more concentrated. One can also perceive a demand concentration along the Dewey corridor (northeast to southeast), especially in the January 1975 study after Route 10 was cut back during the off-peak period. The Dew-Ridge Shuttle was established in September 1976, partly in response to these trip patterns.

In all four case studies, 80% or more of all DAB trips began or ended within a relatively narrow southern portion of the service area along Ridge Road. In the first three studies, about one-quarter of all trips were completely within this corridor; this percentage rose to over one-third in the February 1976 study. Consequently, most DAB demand could be summarized by the three general trip patterns displayed in Exhibit 6.9. One of these consists of those trips within the two southern zones, which comprised between one-quarter and one-third of all trips. The second and third groups are trips from the three larger northern areas to each of the southern zones. Most of these trips connected to the malls in the southwest zone, and to the Ridge Road transfer point (at Dewey and Lake Avenues) and Kodak Park in the southeast zone. Less than 20% of all DAB trips -- those totally within the northern zones -- are excluded from this three-pattern model.

6.1.4 Impact of Service Area Expansions

The service area expansions of 1974 and 1975 offered DAB service to more affluent areas with higher automobile ownership, suggesting that DAB trips by residents would be lower in the expansion areas. On the other hand, the newer service areas were poorly served by fixed-route transit and DAB provided the only transit service, which suggested more trips per capita. The question of whether trips per capita in the expansion areas were more or less than those in the original service area was answered by comparing the percentage of trips which began or ended in both areas with their respective populations. It should be noted that trips per capita in this case refer to those trips made by residents of the area; this definition differs from demand density, which counts all trips originating in a particular area. For areas containing many trip attractors, such as shopping malls, employment centers and transfer points, the trip-density measure would be much higher than the trips-per-capita measure. The subsequent analysis calculates both trip densities and trips per capita. For the latter, trip ends which could be identified as being at major trip attractors were eliminated.

The results of the origin/destination data examined are shown in Exhibit 6.10, separated by origin, destination, and both types of trip ends. The two percentage columns within each group indicate the proportion of all trip ends and for those trip ends exclusive of the major trip attractors described above. The results show that less than 20% of the total trip ends were located outside of the original August 1973 service area, although these additions accounted for 25.7% of the population. This unadjusted trip data shows

EXHIBIT 6.9

DIAL-A-BUS DEMAND PATTERNS

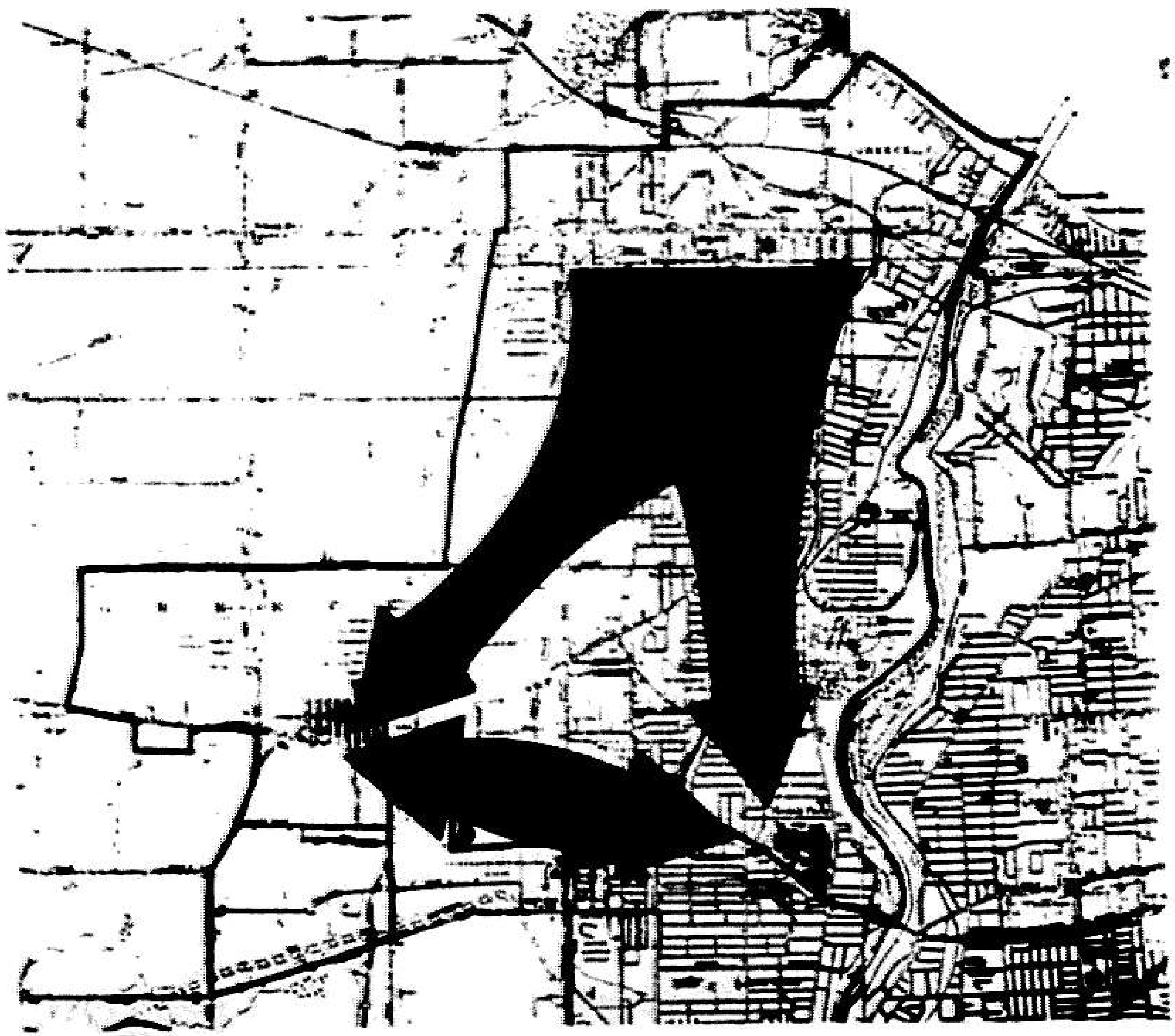


EXHIBIT 6.10 LOCATIONS OF ORIGINS/DESTINATIONS BY SERVICE AREA EXPANSION COMPONENTS[1]

	Population Percent[2]	Area Percent[2]	ORIGINS			DESTINATIONS			ORIGINS & DESTINATIONS		
			Number	% of Total Incl. Trp. Attractor	% of Total Excl. Trp. Attractor	Number	% of Total Incl. Trp. Attractor	% of Total Excl. Trp. Attractor	Number	% of Total Incl. Trip Attractor	% of Total Excl. Trip Attractor
Original Service Area	74.3	63	4,114	80.3	-	4,239	82.7	-	8,353	81.5	-
Original Service Area but Excluding Malls, Kodak Park, Transfer Points	-	-	(2,498)	-	71.3	(1,834)	-	67.4	(4,332)	-	69.6
June 1974 Addition	13.7	14	536	10.5	15.3	151	8.8	16.6	987	9.6	15.9
September 1974 Addition	3.2	-	147	2.9	4.2	114	2.2	4.2	261	2.5	4.2
November 1974 Addition	4.4	6	212	4.1	6.0	177	3.5	6.5	389	3.8	6.2
September 1975 Addition	4.4	10	112	2.2	3.2	146	2.8	5.4	258	2.5	4.1
TOTAL Including Malls, Kodak Park, Transfer Points	100.0	100	5,121	100.0	-	5,127	100.0	-	10,248[a]	100.0	-
TOTAL Excluding Malls, Kodak Park, Transfer Points	100.0	100	3,505	(68.4)	100.0	2,722	(53.1)	100.0	6,227[b]	(60.8)	100.0

95% Confidence Ranges

Percentage	[a] n = 10,248	[b] n = 6,227
50%	±1.0%	±1.2%
40 or 60%	±0.9%	±1.2%
30 or 70%	±0.9%	±1.1%
20 or 80%	±0.8%	±1.0%
10 or 90%	±0.6%	±0.7%
5 or 95%	±0.4%	±0.5%

[1] Based on 16 days in 1976 including 3 days in February, 3 in June, and 13 in July.

[2] Based on September 1975 service area size.

that area expansion resulted in a decrease in demand density, as indicated by the lower trip end percentages of the area additions compared to the total area percentages. The last area expansion in September 1975 had the lowest demand density.

When the major trip attractors are excluded, the trip end percentages suggest that DAB ridership per capita was slightly higher in the areas added after service initiation compared to that of the original service area, implying that despite the higher economic status of the new service areas, a relatively high demand for public transit services existed. This result was obtained by comparing the distribution of trip ends other than those located at the major trip attractors. Although the differences were statistically significant (see the 95% confidence range for the trip end distribution), the imprecise manner of defining residential trip density by eliminating trip ends at major trip attractors weakens the conclusion. While the available data suggests that DAB per-capita use was slightly higher in the expansion areas, the empirical evidence supporting this conclusion is weak.

6.1.5 Trip Lengths

To determine the average DAB trip length, two methods of analysis were used. In the first method, origins and destinations were manually plotted and the straight-line distances between them were recorded. This was done for the 391 DAB trips on March 3, 1975, and an average straight-line distance of 2.30 miles was obtained with a standard deviation of 1.17 miles. The coefficient of variation[1] was .51, closely corresponding to the ride time coefficients of variation recorded during the service quality checks. These coefficients of variation were generally between .55 and .65, suggesting that much of the variation in ride time was a function of trip length (see Section 5.3.2 and 5.3.3).

The second method was used for data collected under computerized dispatching. In this case, origins and destinations were assigned to a fairly elaborate zonal system and trip lengths between the centers of each zonal combination were measured. A zone-to-zone matrix for three weekdays in February 1976 (875 trips) was then applied to this distance matrix. The average straight-line trip length by this

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[1]The coefficient of variation, calculated by dividing the standard deviation by the mean, controls for the magnitude of the variable being measured.

method was computed to be 2.35 miles, a difference of only 2% from the previous result; 2.3 miles was thus assumed to be the average straight-line trip length for DAB service after the January 1975 service changes were made.

To derive an average passenger-trip distance which corresponded to actual driving distance, the average straight-line trip length was multiplied by a street adjustment factor of 1.2 for Greece.[2] This resulted in an average DAB passenger-trip distance of 2.8 miles (although the actual number of miles traveled generally exceeded this because of deviations made to pick up and drop off other passengers).

Based on the results of these two methods of analysis, the average trip length was calculated to be equal to 0.75 times the square root of the service area (three-quarters of a side of a square service area).[3] Using this equation results in an average DAB passenger-trip distance of 2.45 miles following the DAB service area contraction in 1976 ($0.75\sqrt{10.7} = 2.45$). These figures (2.45 and 2.8) are used in subsequent analyses dealing with DAB passenger miles.

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[2] For a theoretical area with a perfect grid street system and trips equally likely to be generated in all directions, a street adjustment factor of 1.273 was obtained:

$$\int_0^{\pi/2} \frac{\sin x + \cos x}{\pi/2} = 1.273$$

For Greece, which is essentially a grid system with a few key diagonal routes (Stone and Ridge Roads, Lake Avenue), this figure drops to around 1.2.

[3] An average trip length of about 2.8 miles was found for samples taken when the service area was 13.7 square miles and 15.2 square miles; $0.75\sqrt{13.7} = 2.78$; $0.75\sqrt{15.2} = 2.92$. A many-to-many DAB system with demand distributed homogenously within a square service area and with a perfect grid system would have an average trip length equal to .67 times the square root of the service area. A many-to-few system in which all destinations are equally distributed along one edge of the service area would have an average trip length of .83 times the square root of the service area. A many-to-one system with the activity center in the center of one edge would have an average trip length equal to .75 times the square root of the service area. The Greece DAB system operated between the many-to-few and many-to-many situations.

6.1.6 No-Shows

No-shows are persons who request service but then do not appear when the bus arrives to pick them up. The problems associated with no-shows are obvious; the bus spends unnecessary time traveling to the pick-up location and waiting for a passenger to appear, service quality for the remaining passengers suffers, and productivity declines.

In any system, there are bound to be some prank calls which result in no-shows. Others may result from a change in plans and the failure of the requestor to notify PERT. Beyond these causes, however, it is believed that service quality affects the number of no-shows. In these cases, the bus arrives late and the requestor has already taken an alternative mode. If service quality has been poor, requestors may be more impatient. In other cases, the bus arrives early and leaves before the customer is ready; this situation is also recorded as a no-show.

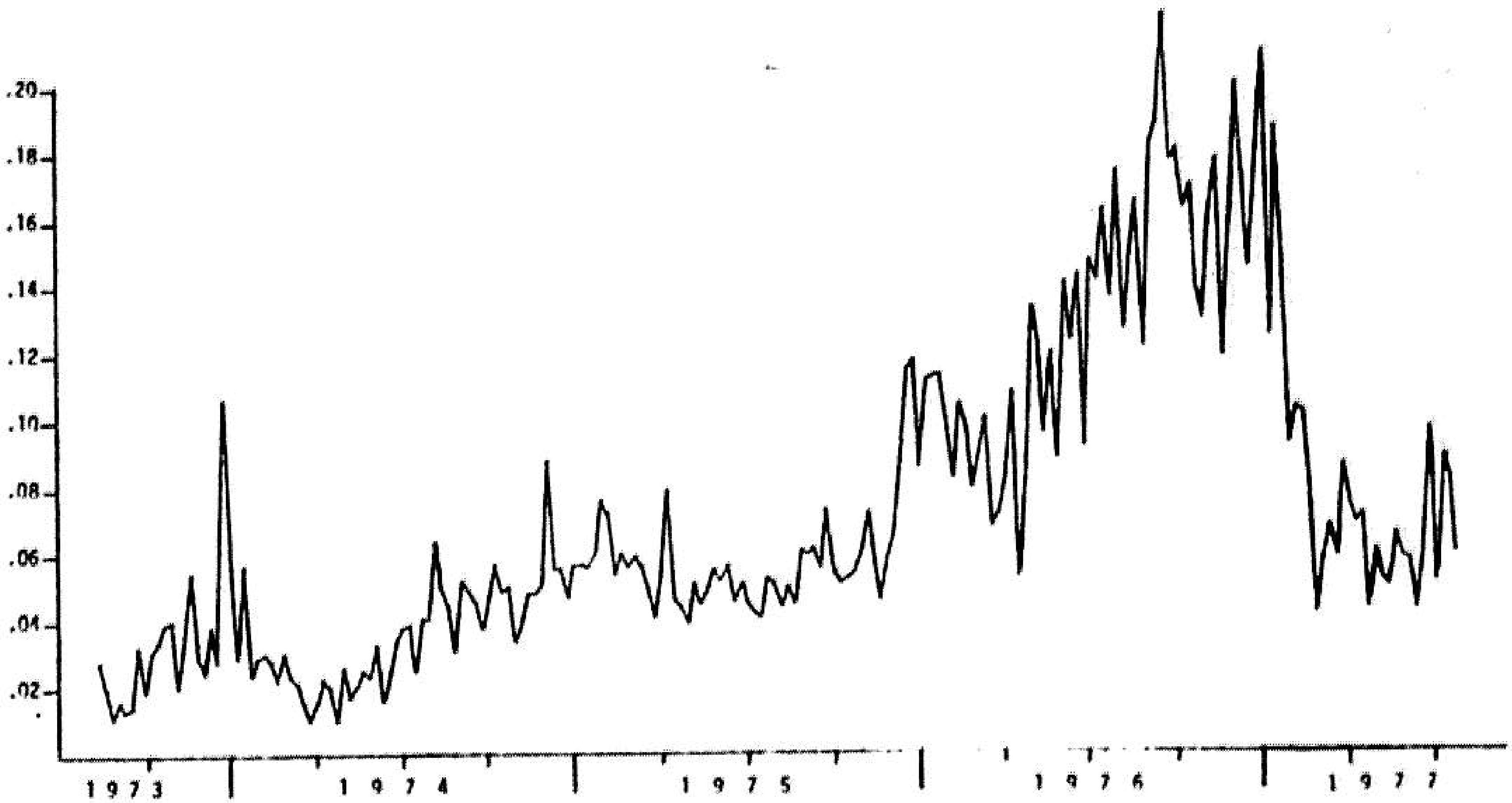
Exhibit 6.11 charts weekly DAB no-shows as a proportion of total trips. From relatively low levels of between 2% and 4% of all DAB trips, the number of no-shows increased during most of 1974 until it leveled off at around 5% during most of 1975 (5.3% during the steady-state period with a standard deviation of 0.9%). This consistent rate further supports the characterization of March-December 1975 as a steady-state period. No-shows increased dramatically in December, when vehicle breakdown problems began, to as high as 11.9%. By July 1976, no-shows were averaging approximately 15% of total trips, meaning that about one of every eight DAB requests resulted in a no-show. This high level fluctuated between 12% and 20% until February 1977, when improved service levels resulted in a decrease to around 6% of all DAB trips; this is comparable to 1975 levels.

While the trends in the number of no-shows are clear from Exhibit 6.11, the number of no-shows fluctuated considerably, especially after December 1975 when no-show levels were unusually high. For example, from January 12, 1975 to July 3, 1975, no-shows as a percentage of weekly trips averaged 10.3%, with a standard deviation of 2.4% (a coefficient of variation of 0.23). The variation was even greater on a daily basis.

The number of DAB no-shows is largely a result of low-quality service, and this explains much of the variation in no-show frequency. After June 1976, most daily operation was under computerized dispatching; the service quality data generated at that time allowed an investigation of the relationship between no-shows and service quality within a fixed time period. From May 29, 1976 to July 31, 1976, there were 37 days in which all or almost all of the day's dispatching

EXHIBIT 6.11

DIAL-A-BUS NO SHOWS/DIAL-A-BUS TRIPS, BY WEEK



was done by computer. On these 37 days, no-shows as a proportion of completed trips averaged 14.6%, with a high standard deviation of 7.1%.

The number of no-shows as a proportion of DAB trips, however, was strongly correlated with all six service quality variables affecting pick-up times (the averages and standard deviations of immediate request wait time and pick-up deviation of both immediate and advance requests; see Exhibit 6.12A). The correlations ranged from +.34 to +.72, and were all significant at the .01 level. When DAB no-shows were regressed against the six service quality variables, a multiple-R^2 of .62 was obtained, suggesting that variation in service quality accounted for 62% of the wide variation in no-show levels (see Exhibit 6.12A). Thus, if service quality had been consistently higher during this period, there would have been fewer no-shows as well as less fluctuation.

The same analysis was conducted for the fifteen service quality checks made during the 1975 steady-state period. The no-show percentage was only about one-third of what it was in the 1976 sample (5.0% average compared to 14.6%). Furthermore, there was relatively little variation between the days compared to 1976. (The standard deviation was 1.7% compared to 7.1% in the 1976 sample.) Service quality was also more uniform during this period. Consequently, the variation in no-shows in 1975 was probably more random than in 1976, when substantial service quality variations are presumed to have been more influential. This hypothesis can be confirmed by the results displayed in Exhibit 6.12B. The correlation coefficients between the no-show percentage and the six service quality variables are all lower than those appearing in the 1976 correlation table.

Thus, no-shows seem to become more sensitive to service quality when the latter is low. At satisfactory service levels, the number of no-shows is low and fairly consistent. When service quality is poor, however, no-shows not only increase but become more sensitive to variations in service quality.

In August 1975, a survey of no-shows was conducted by MIT to further examine the nature of no-shows. Of the 150 DAB no-shows analyzed, only 22 (15%) were at residential addresses The remainder were almost all from either the Dewey and Ridge transfer point or Longridge Mall, and could not be contacted. Of those requestors from residential addresses, only 12 could be contacted. Of these, eight cited a late bus as ther reason for not showing. All but one was able to get a ride from a neighbor or relative. Seven of the eight also had appointments which they would have missed by waiting for the bus; the eighth just became

EXHIBIT 6.12-A

DIAL-A-BUS NO-SHOWS AND SERVICE QUALITY

(37 days between 5/29/76 and 7/31/76, including 10 Saturdays)

	37-Day Statistics	CORRELATION COEFFICIENTS					
		Immediate Requests				Advance Requests	
		Avg. Wait	Wait SD	Avg. Pickup Dev.	Pickup Dev. SD	Avg. Pickup Dev.	Pickup Dev. SD
Immediate Requests							
Average Wait Time	25.5 mins.	1.00					
Wait Time SD	19.5 mins.	.81	1.00				
Average Pickup Deviation	7.3 mins.	.92	.81	1.00			
Pickup Deviation SD	15.9 mins.	.67	.96	.70	1.00		
Advance Requests							
Average Pickup Deviation	10.4 mins.	.84	.62	.75	.53	1.00	
Pickup Deviation SD	14.5 mins.	.73	.50	.69	.40	.83	1.00
No-shows/Dial-A-Bus Trips (X 100)	14.6%	.67	.45	.66	.34	.57	.72

EXHIBIT 6.12-B

DIAL-A-BUS NO-SHOWS AND SERVICE QUALITY

(15 days between 2/5/75 and 10/30/75)

	15-Day Statistics	CORRELATION COEFFICIENTS					
		Immediate Requests				Advance Requests	
		Avg. Wait	Wait SD	Avg. Pickup Dev.	Pickup Dev. SD	Avg. Pickup Dev.	Pickup Dev. SD
Immediate Requests							
Average Wait Time	25.2 mins.	1.00					
Wait Time SD	14.8 mins.	.32	1.00				
Average Pickup Deviation	5.0 mins.	.92	.42	1.00			
Pickup Deviation SD	11.9 mins.	.14	.94	.29	1.00		
Advance Requests							
Average Pickup Deviation	7.1 mins.	.77	.17	.68	.03	1.00	
Pickup Deviation SD	11.2 mins.	.53	.47	.60	.41	.50	1.00
No-shows/Dial-A-Bus Trips (X 100)	5.0%	-.11	.32	-.08	.22	.10	.17

frustrated waiting. Of the other four persons contacted, two got rides from friends and neglected to cancel their requests. One person claimed that she used the service and did not know why she was classified as a no-show. (She may have been a no-show for a bus which arrived early and then called again to be rescheduled to another bus.) Finally, one person requested service for 6:00 A.M. and was told it was unavailable; she also didn't know why she was classified as a no-show.

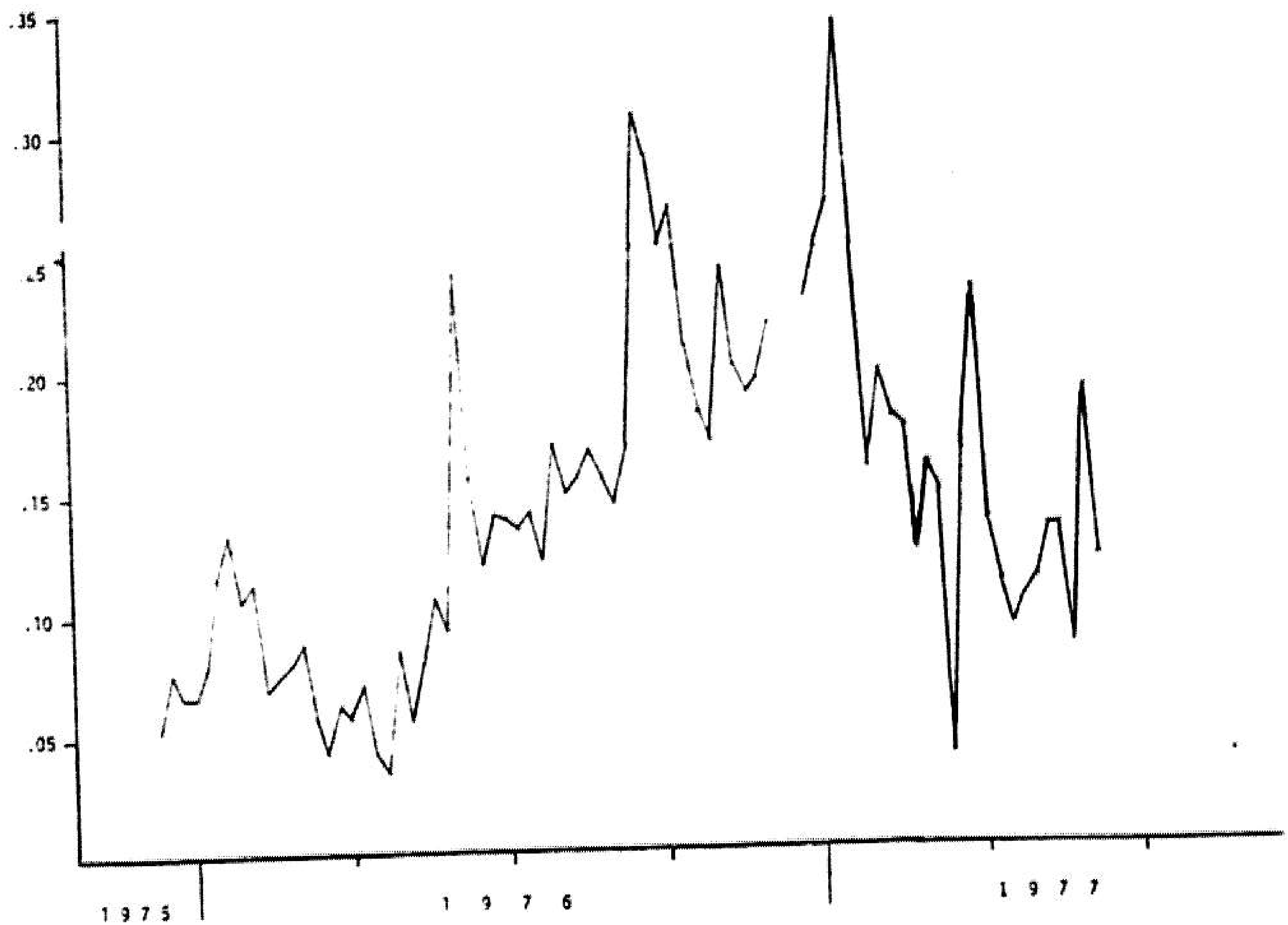
Even with the small sample, the survey indicates that many no-shows from residential addresses were a result of late buses. For the more numerous no-shows at Longridge Mall and the Dewey and Ridge transfer point, other explanations are possible. Peak period patrons may have taken fixed-route buses. In addition, patrons at Longridge Mall may have met a friend or neighbor who drove them home. It is also possible that passengers boarded a bus other than the one to which they were assigned (which happened if the driver felt that he could drop them off without disrupting his schedule). Unless the driver notified the control room, the passengers were classified as no-shows when the assigned bus arrived.

6.1.7 Customer Cancellations

Beginning in November 1975, the PERT order processors recorded the number of passengers cancelling their requests. This information -- averaged by the week -- is shown in Exhibit 6.13. The level of cancellations closely correlates with that of no-shows for the same period, with a sharp increase in January 1975 (somewhat later than the increase in no-shows which began in December). Cancellations then declined, followed by an increase in spring and summer analogous to the no-show trend. By the summer of 1976, cancellations were running at around 14% of ridership (19% of all trips, assuming the annual average of 1.3 passengers per trip). Thus, cancellations and no-shows together resulted in about one of every four original service requests (service requests = trips + cancellations + no-shows) being voided.

Cancellations rose sharply in September 1976 to over 20% of total ridership, and then rose again in January 1977, probably in response to the lower service levels which immediately followed the DAB service and fare changes. By February 1977, the cancellation rate began to steadily decline, although the wide fluctuations continued (see Exhibit 6.13). By May 1977, cancellations averaged 10% of ridership.

EXHIBIT 6.13 <u>CUSTOMER CANCELLATIONS/DIAL-A-BUS RIDERSHIP, BY WEEK</u>



6.1.8 Ridership Changes Due to Service Deterioration

Because cancellations and no-shows represent riders who were willing to use the service but were discouraged, the increases in cancellations and no-shows during 1976 accounted for part of the ridership decrease during that year when compared to 1975. During the 1975 steady-state period, there was an average of 379.8 daily DAB trips. From January 12 through August 7, 1976, an average of 306.3 daily trips were made, a decrease of 19.4%. However, the relative decrease changes if the number of passengers trying to use the system is examined (see Exhibit 6.14). In the 1975 steady-state period, no-shows averaged about 5% of completed trips, and a few weeks' data in November 1975 suggests that cancellations would also run about 5% of total trips under normal conditions. Thus, it is estimated that the total number of service requests in 1975 (trips plus no-shows plus cancellations) averaged 419.5 per day, assuming cancellations equalled 5% of trip demand. In 1976, however, trips plus no-shows plus cancellations averaged 377.4 per day, a decrease of 10.0% from 1975 levels. Thus, while the number of trips dropped 19.4%, the number of service requests dropped only 10.0%. This suggests that there was only about a 10% loss in the number of customers desiring service during December and January when ridership declined. The remainder of the decrease in ridership was the result of an unusually large number of customers cancelling or not showing because of the poor service being offered.

The above analysis also explains the wide trip demand fluctuations which took place in 1976. From a weekly coefficient of variation for daily trips of 0.066 in 1975, a 50% increase occurred during the winter to a level of 0.100 in the 1976 period. The coefficient of variation of the total number of service requests, however, remained uniform at about 0.069 during the 1975 steady-state period and in 1976, as shown in Exhibit 6.13. Thus, the number of persons requesting DAB service in 1976 did not vary over time any more than in 1975; however, the increased variability in the number of no-shows and cancellations resulted in substantial ridership fluctuations compared to 1975.

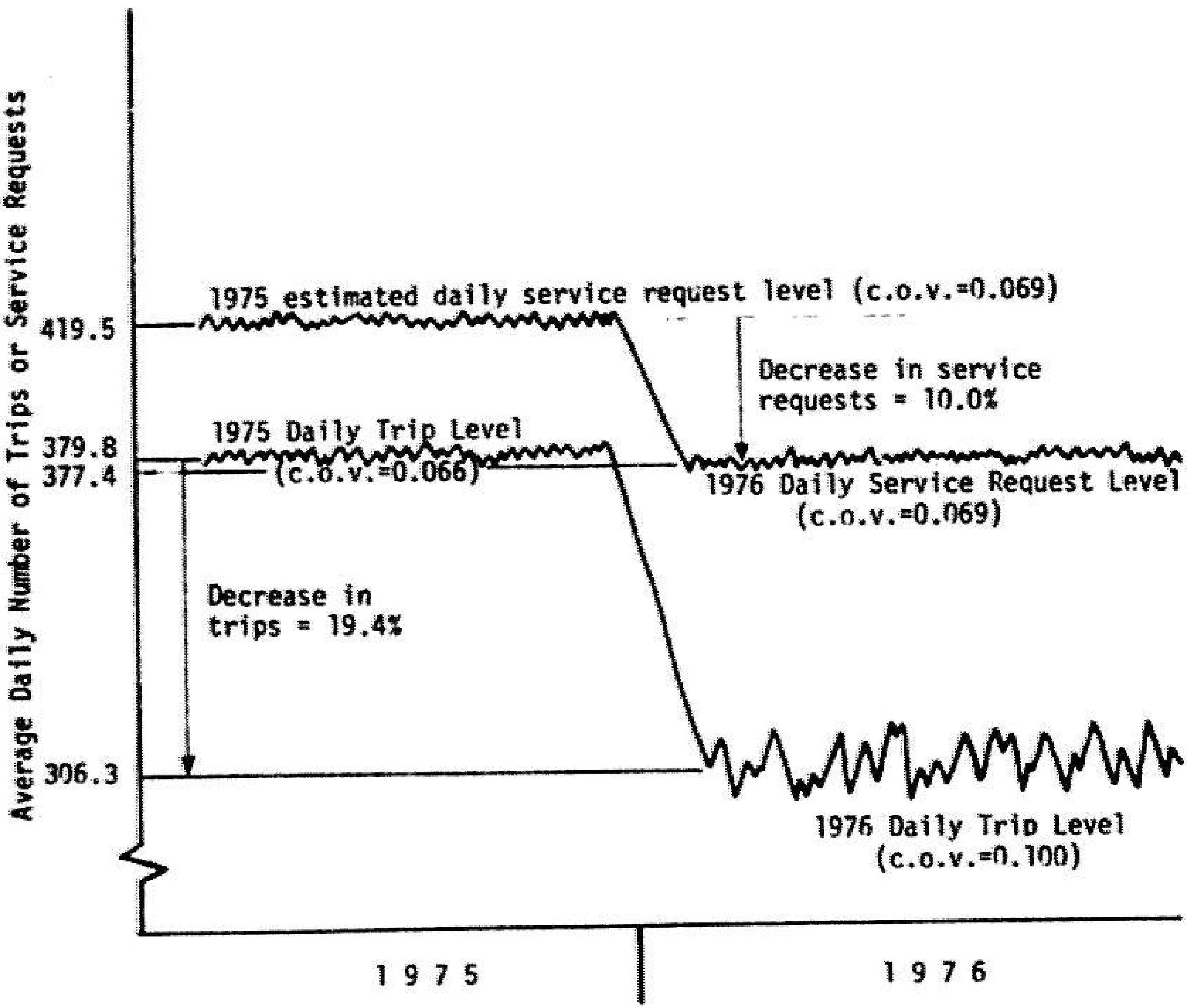
6.1.9 Late Bus Complaints

A second item recorded by the order processors after November 1975 was the number of persons calling to inquire about late buses; this is illustrated in Exhibit 6.15. The number of complaints rose quickly in December 1975 and January 1976, to as high as 38% of the ridership (paralleling the increases in no-shows and cancellations), and then

EXHIBIT 6.14

CHANGES IN DIAL-A-BUS DEMAND LEVELS

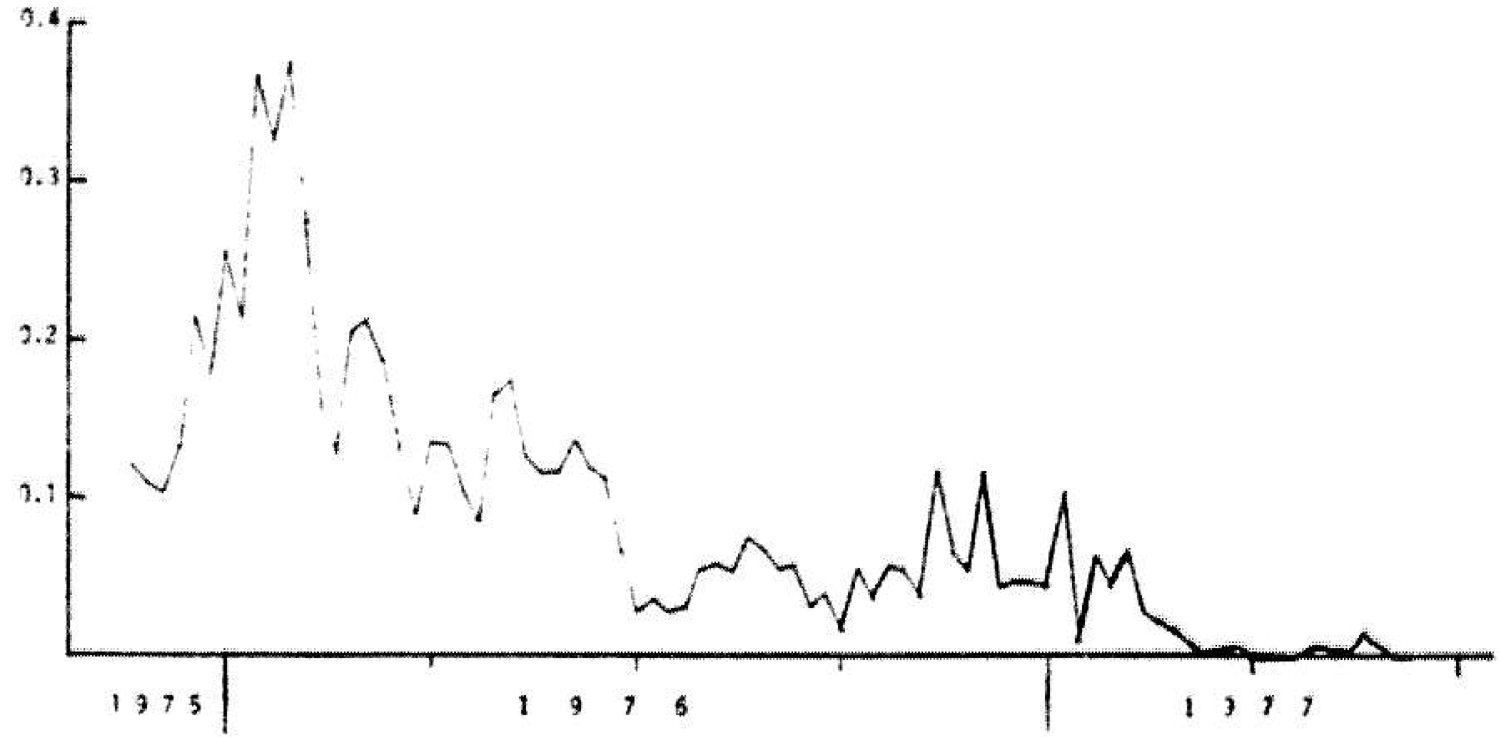
BETWEEN 1975 AND 1976



c.o.v. = coefficient of variation
= weekly standard deviation/mean

EXHIBIT 6.15

LATE BUS COMPLAINTS/DIAL-A-BUS RIDERSHIP BY WEEK



declined to what appears to have been their original level of around 10%-15% of ridership. Surprisingly, a second decline occurred in June 1976; complaints were less than 6% of ridership during the first six weeks of the summer, and fluctuated between 5% and 10% through the fall and winter. At the same time, however, no-shows and cancellations continued to increase. The number of complaints dropped in 1977, and represented less than 2% of ridership during the spring of 1977.

Three phases of customer reaction to DAB can be identified for the period after December 1975, when serious vehicle breakdown problems began. During the first phase (December and January), ridership dropped dramatically as no-shows, cancellations and complaints rose sharply. From January through April, many riders who would have complained about service either cancelled or did not show and began to drop out as users; no-shows, cancellations and complaints thus declined while ridership remained fairly steady. During the spring and summer, however, no-shows and cancellations began to increase again; ridership during this period declined, although less dramatically. This time, however, complaints decreased while the other two parameters rose. This suggests that users had learned that a complaint would not bring them a bus any faster, so they simply cancelled or did not show without calling in a complaint. If this is true, customer complaints over the long run may not be a useful indicator of service levels.

6.2 DIAL-A-BUS SURVEY RESULTS AND USER ATTITUDES

6.2.1 On-Board Surveys

Five DAB on-board surveys were conducted during the Greece project. The first occurred on Wednesday, October 17, 1973, only two months after the service began. The sample size for this survey was relatively small (86 responses), but this included about 84% of the day's individual passengers (about half the passengers made a round-trip). The second on-board survey was conducted on Thursday, February 21, 1974, approximately four months later, before any major service changes were made. The sample size of 131 represented a response rate of about 46%; the lower rate was probably because school was not in session and young people traveling in groups did not fill out surveys.

The third and fourth on-board surveys were made during the demonstration period; each included two days, one of which was a Saturday. The third survey was conducted on Friday and Saturday, June 6 and 7, 1975. Three-hundred thirteen Friday responses represented a response rate of about 83%, and 146 Saturday responses represented a response rate of about 81%. The fourth survey was taken one year later on Saturday and Monday, June 12 and 14, 1976; 292 Monday responses represented a response rate of about 92%, and a response rate of 87% was represented by the 283 Saturday responses. Unlike previous surveys, passengers making a round-trip were surveyed twice; this increased the relative sample size and may have introduced a duplication bias. Finally, on Thursday, December 16, 1976, Greece DAB users were surveyed for the fifth time. One hundred and sixty-two responses were received, for a response rate of about 75%. These response rates were high enough to minimize non-response biases.

The first two on-board surveys gauged the characteristics of DAB users and trips prior to the various service changes such as route rationalization; the third on-board survey measured conditions during the 1975 steady-state period. The fourth survey was taken during the period when vehicle breakdowns caused the quality of service to deteriorate, and the fifth on-board survey measured user trips, characteristics and attitudes when service quality was still poor and the Dew-Ridge Shuttle had been introduced. The results of the third and fourth surveys are summarized in Appendices A.2 and A.3, and are the source of most of the information discussed in this section and the following section on trip characteristics. When the results of either the first two surveys or the final survey differ from the on-board surveys discussed, they are included. The results of the December 1976 survey are outlined in Appendix A.8, and the results of all of the DAB survey questions are summarized in Appendix A.4.

6.2.2 User Characteristics

Demographic Characteristics

DAB riders were predominantly female, accounting for about 75% of the ridership in the summer of 1975 and 1976 surveys, which was slightly lower than the other surveys reported. Transit ridership usually consists of more females than males, but the proportions represented on DAB were somewhat more extreme. About one-third of the riders were under age 20, and another third were between 20 and 44. The proportion of riders age 65 and over fluctuated between 7.6% and 14.0% on the various surveys, generally more than the area population average of 7.7%. Riders represented a wide range of ages, with the average age increasing over time. The last two surveys indicated that just over one-third of the riders was employed, slightly under one-third were students, with the remainder divided evenly between retired persons and homemakers. Again, a wide cross-section was represented.

Automobile Access

The last three surveys revealed that between 60% and 65% of total DAB ridership did not have a driver's license, although the number was slightly lower (54.1%) in one previous survey. Saturday riders were less likely to be drivers. About one-fifth of the riders also came from households in which no automobile was owned, increasing to about 27% in December 1976. This is considerably above the area average of 5.5%. In the two earlier surveys, only between 15% and 18% came from such households. However, 30% or more of the riders responding to the first four surveys came from households with two or more automobiles (the 1970 area average is 33.8%), confirming the heterogeneous nature of the ridership.

Dial-A-Bus Usage

The June 1976 survey disclosed that about one-fifth of the ridership used DAB and one-fifth used RTS buses for most of their local travel. By December, 30% of the respondents reported using PERT, with RTS ridership declining slightly. Thus, about 40% were truly "transit dependent." Of the remainder, most relied on being driven (28%). Only 17% of the survey respondents usually drove, and 14% usually walked or bicycled.

About 65% of the 1976 survey respondents said they used DAB at least once each week, down from 74% in 1975. In the earlier surveys, about 60% said they used DAB once per week or more, but there were more first-time users at that time (20% to 30% of the ridership). Nevertheless, as late as

June 1976, 9.3% of the riders on the day of the survey were first-time riders. Since this was a period of declining ridership, this suggests that either very few of these new riders became regular users or that many regular users were rejecting DAB and using a different travel mode. Weekday users were found to be more frequent users; this explains some of the difference between 1975 and 1976, since Saturday riders accounted for a larger proportion of the riders surveyed in 1976.

About 40% of the riders surveyed in June 1976 said they used RTS buses at least once each week. However, approximately 28% said they never used RTS buses, suggesting that a considerable portion of the DAB riders either could not or chose not to use regular bus service.

Summary

The picture of DAB users emerging from the on-board surveys is essentially one of heterogeneity. In a fairly affluent and automobile-dependent area, DAB was, not surprisingly, more successful at attracting those with less access to an automobile. However, initially many other residents also used DAB service, resulting in a mixed group of users. It seems that this user diversity resulted in a variety of user preferences regarding what modes of service were desirable (see Section 6.2.6). However, the later surveys showed that riders were slightly more transit-dependent than before. These results suggest that as DAB lost some passengers with travel alternatives, transit-dependent users began to constitute a larger share of the DAB market.

6.2.3 Trip Characteristics

Type of Request

Although immediate requests made up 61% of all requests in the last three surveys, there were considerably more advance requests on weekdays. Advance requests made up 46.8% of the June 1976 weekday response and 44.0% in 1975. Advance requests made up only between one-quarter and one-third of Saturday requests. The use of advance requests on weekdays in 1975 and June 1976 had dropped slightly from the earlier surveys, when 50.4% and 51.8% of the requests were for advance service. (This difference was only statistically significant at the .19 level.) By December 1976, however, advance request service had declined to 38.2%.

Trip Purpose

Trip purposes were significantly different between weekdays and Saturdays. On weekdays, work trips comprised the largest category of trips, making up over one-third of all trips (as high as 44% on the first survey). Shopping trips comprised about one-quarter of all trips, and other categories (school, medical, recreation, personal visits) each made up between 5% and 10% of the total. On Saturdays, shopping trips were by far the most frequent, making up just over half of all trips. Work and recreation trips each comprised about one-sixth of the total, and other categories were a very small portion of the total.

6.2.4 Alternative Modes

The proportion of passengers using DAB for a round-trip was slightly over 50% in all five surveys. The majority of the one-way users were driven in the other direction of their trip; use of RTS buses was the next most frequent mode. In the first three surveys, between 10% and 20% drove the other leg of the trip; by 1976, only 5.1% drove. When asked if there was an automobile available for their trip (either to drive or be driven), about 78% of those responding to the last three surveys said no. Three-quarters of those with an automobile available indicated that its use would have inconvenienced someone. Thus, only about 6% of the DAB users had access to an automobile without inconveniencing someone.

In the 1975 and 1976 surveys, 38.1%, 29.2%, and 30.6% respectively of those responding said they would not have made their trip if DAB were not available. This is considerably more than reported on the 1973 and 1974 surveys, where 12% and 14% indicated this situation. There was also considerable variation between weekdays and Saturdays, with Saturday riders being more dependent on DAB service. In June 1976, 22% of all weekday riders could not have made their trip without DAB, while on Saturday the figure was 37%. In the 1975 survey, the results were 32% and 50% for Friday and Saturday, respectively. Of those who could have made their trip by other means, 1976 users were most likely to have been driven; 1975 users were equally likely to have taken an RTS bus or be driven. Weekday users were more likely to use an RTS bus, but this does not account for all of the difference between 1975 and 1976. There was also a significant drop in the number of persons who would have driven between the first three surveys (13-19% of all weekday riders and the last two in 1976 (4.5-5.3% of all riders), even though the proportion of riders with driver's licenses remained fairly constant between June 1975 and June 1976.

6.2.5 User Attitudes

In the 1975 and 1976 surveys, DAB users were asked to rate DAB service according to various attributes. While the formats of the questions differed in the three surveys, making comparisons difficult, the relative responses to each attribute were similar. DAB service was generally rated very well for comfort and safety, while speed, cost and predictability/promptness received relatively less favorable ratings (although generally not unfavorable). By December 1976, however, users rated DAB cost relatively unfavorably when compared to other modes, reflecting the fare changes instituted in September 1976. In all the surveys, DAB convenience was rated between these two groups.

The on-board surveys were also used to gauge user perceptions of service quality variables. Immediate request customers were generally found to perceive wait time and pick-up deviation as shorter than actually occurred.

6.2.6 Dew-Ridge Survey Results

During November 1976, an on-board survey of Dew-Ridge Shuttle passengers was conducted. (See Appendix A.7 for sample questionnaire and survey results.) In general, Dew-Ridge Shuttle riders were found to be more transit-dependent than DAB users: 46% were 65 years of age or over, and 76% had no driver's license. Although most Dew-Ridge Shuttle users formerly used DAB, 66% reported that they no longer used it. Over 80% of the riders never used RTS Routes 14 or 15, although about half had taken Route 10. Thus, the majority of riders reported that they walked to one of the Dew-Ridge Shuttle stops, with another one-fourth requesting route deviation service, and 17% transferring from fixed-route service. Not surprisingly, almost half of the Dew-Ridge Shuttle trips were for shopping, reflecting the shopping mall service orientation; the majority of these users reported boarding the bus between 12:00 and 2:00 P.M.

6.3 DAB TRANSFER DEMAND

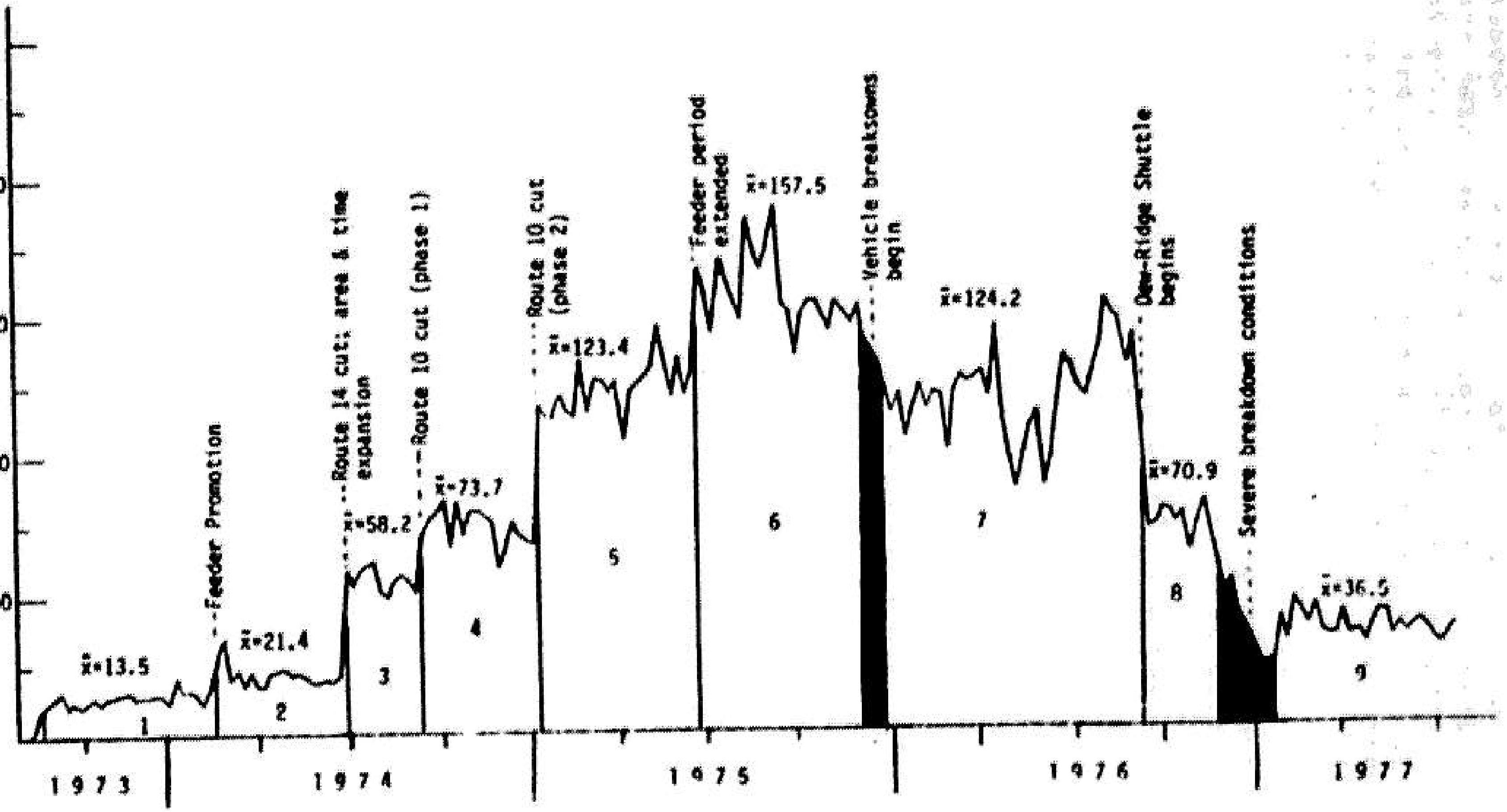
6.3.1 Ridership Levels

As a result of the emphasis on integrating DAB and RTS fixed-route buses, the number of DAB passengers transferring to or from a fixed-route bus was monitored throughout the project. The average number of daily transferring passengers over time, displayed in Exhibit 6.16, resembles a step function which can be divided into distinct periods. Transfer ridership increased during the first six periods, and the proportion of all DAB passengers who transferred also steadily increased. By late 1975, transfer trips comprised a third of all DAB trips.

The first period average was 13.5 passengers, but following a two-week reduced feeder fare promotion, the average increased to 21.4 during the second period. A significant change occurred on June 24, 1974, when Route 14 off-peak service was eliminated and the service area and operating hours were expanded. Daily transfers during this third period averaged 58.2 until September 9, 1974, when the

EXHIBIT 6.16

AVERAGE NUMBER OF DAILY DIAL-A-BUS TRANSFERS TO AND FROM FIXED-ROUTE BUSES, BY WEEK



first Route 10 cutback was instituted. Transfers increased to 73.7 per day during the fourth period until January 6, 1975, when the Route 10 cutback was completed and a reduced midday feeder fare period was extended one hour. Daily transfers averaged 157.5 until the 1975-76 winter, when vehicle breakdowns caused a drop in patronage. From December 23, 1975 to September 13, 1976 (when the Dew-Ridge Shuttle was introduced), there were 124.2 transfers per day.

Transfer ridership initially decreased significantly more than DAB non-transfer patronage during the seventh period because of the long outdoor wait times for transferring passengers. Moreover, when DAB computer control was implemented, the policy of having a DAB meet every other Route 10 bus was abandoned. Instead, transfer requests were treated like any other service request. Whereas transfer wait times had previously been less than regular DAB wait times, the new policy caused transfer wait times to increase disproportionately compared to regular DAB wait times. PERT buses were not scheduled to meet specific RTS buses until May 1976. The subsequent seventh period data suggests that this change may have helped to restore transfer ridership to a higher level.

After September 13, 1976, the Dew-Ridge Shuttle attracted a large proportion of transferring riders; daily transfer ridership through November 27, 1976 averaged 70.9 passengers, a decrease of 43% compared to a decrease of about 32% in non-transfer DAB trips. This differential occurred because the Dew-Ridge Shuttle could better serve many former DAB transfer trips.

Transfer ridership declined further after the January 1977 service cutback and fare increase; it averaged 36.5 passengers per day through June 1977, a decrease of almost 50% from the eighth period. Again, the drop in transferring passengers exceeded that of non-transfer ridership, which was about 42%. This probably occurred because the fare increase from the zonal fare structure affected transferring passengers more than non-transfer passengers. By 1977, transfer ridership had dropped to about one-quarter of all DAB demand.

The ridership differences between each of the above nine periods and its preceding and following periods were significant in all cases at the .001 level.

6.3.2 Temporal Variation in Ridership

The variation in transfer ridership by the day of week is shown in Exhibit 6.17 for the steady-state period used in the Section 6.1 analysis of general DAB ridership. The pattern differs, however, in that the Friday transfer peak was much less pronounced. While Saturday transfer levels were only 59% of the weekday transferring passenger average, Saturday non-transfer ridership was 83% of the weekday non-transfer average. According to the last two on-board surveys, transfer trips included more work trips and fewer shopping trips than other DAB trips. Since Saturdays are heavy shopping days, a greater number of non-transfer trips were made compared to transfer times. In addition, the reduced midday feeder fare -- which accounted for about 60% of weekday transfer trips -- did not apply on Saturday, further depressing Saturday transfer ridership levels.

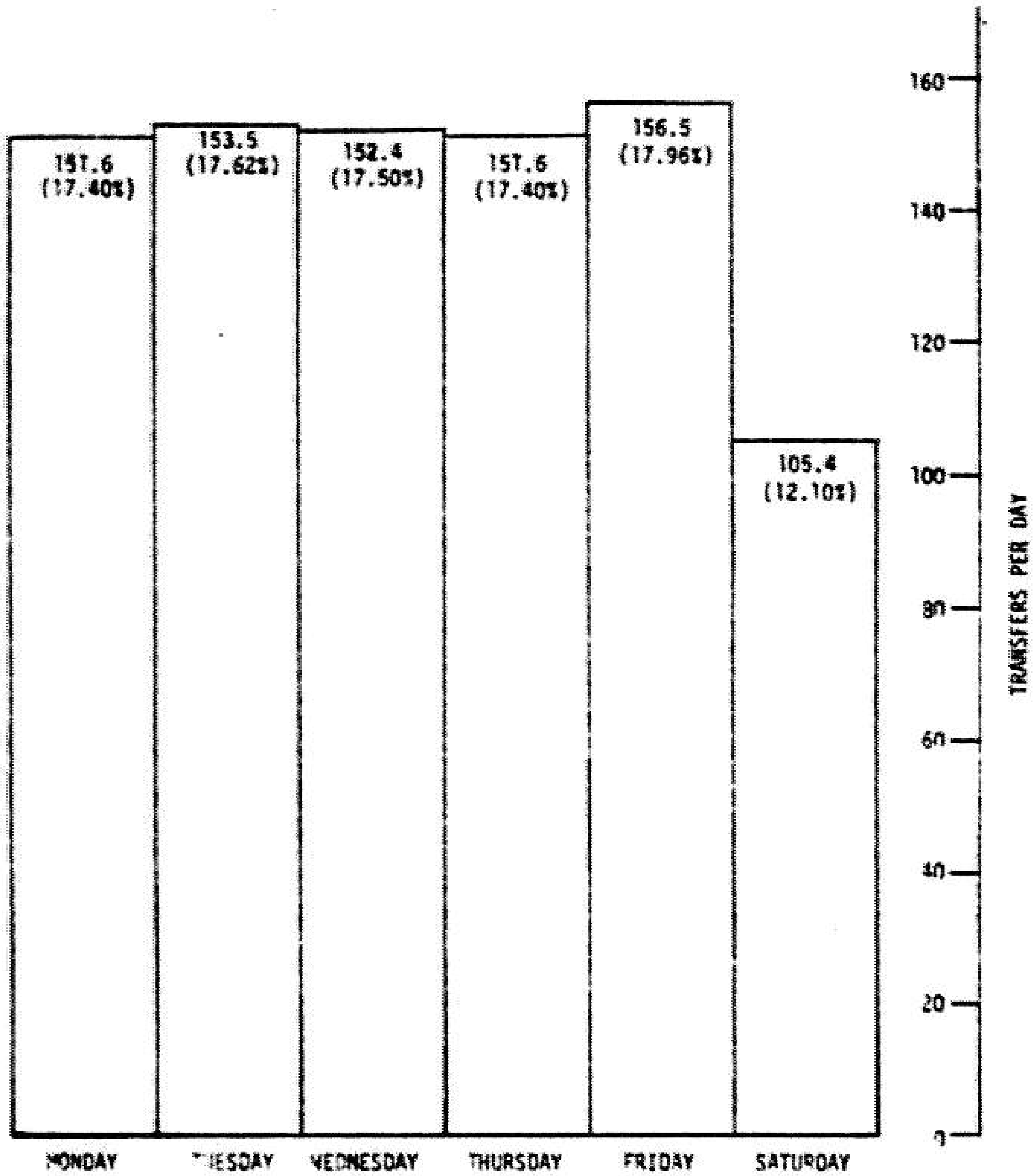
6.3.3 Spatial Demand Patterns

The spatial distribution of transfer trips is significant because of its impact on the route rationalization concept. As the previous discussion of transfer ridership indicates, most of the transfer ridership appears to have been generated following the cutback of Routes 10 and 14. (See Section 6.3.5 for a more detailed analysis of the ridership diverted to DAB.) Consequently, an important question regarding system integration is whether DAB carried people who might have used the old fixed-route buses if they operated, or whether DAB predominantly attracted people without access to these routes.

A survey of transferring passengers completed in May 1976 disclosed that approximately 40% of the transferring passengers came from or were going to a point within one-quarter mile of Route 10; another 29% had a trip end in the Route 14 corridor (defined by a one-quarter mile band on each side of the route). Although a small sample was included in this survey (n=62), a more extensive analysis of transferring passengers made on several days in early 1975 (n=522) supports these results. The larger sample disclosed that 35.6% of transferring passengers were traveling to or from the Route 10 corridor in Greece, slightly less than the result of the previous survey. Therefore, on the basis of usage, it seems that about two-thirds of DAB transferring passengers previously had access to the old fixed-routes.

EXHIBIT 6.17

DIAL-A-BUS TRANSFER RIDERSHIP, BY DAY OF WEEK



Based on 36 weeks' data between 3/3/75 and 12/13/75 (Holiday weeks and one snowstorm week excluded). Total transfer passengers = 31361.

6.3.4 Transfer Passenger Attitudes

The following information on the attitudes of transferring passengers is based primarily on a May 1976 three-day survey of passengers boarding and exiting RTS Route 10 at Dewey and Ridge during the off-peak period. These results are supplemented by similar surveys taken in January of 1975 and March and April of 1977 at the Dewey and Ridge transfer point. The total sample sizes were 99, 29 and 43 persons, respectively, but some surveyed passengers did not transfer to or from DAB. Thus, the 1975 and 1977 survey results are considered to be less reliable due to their relatively small sample sizes. In addition, perceptions of transfer wait times were gauged in the latter two transfer surveys as well as in the DAB on-board surveys.

The May 1976 survey was designed primarily to measure users' reactions to the route rationalization innovations. The results summarized in Appendix A.5 indicate a high degree of dissatisfaction with the existing system requiring transfers between DAB and RTS buses when traveling outside the service area: 72% of those responding preferred Route 10 or Route 10 with a transfer to Route 14 on Ridge Road compared to riding DAB and transferring. Among persons who actually did transfer (rather than walk to Dewey and Ridge, for instance), the preference for these fixed-routes was a comparable 64% (Appendix A.5; crosstab #1). Since about 69% of the trips made by these transferring passengers began or ended within the Dewey or Ridge corridors, defined as within one-quarter mile of a bus route (Appendix A.5; crosstab #2), this result was not surprising.

The mode preference for access to Route 10 at Dewey and Ridge was significantly related to the location of the trip end (Appendix A.5, crosstab #3). For those trips starting or ending in the Route 10 corridor (outside of the Dewey and Ridge vicinity), 85% preferred using only Route 10. For those in the Route 14 corridor, 55% preferred Route 10 with a transfer to Route 14. Finally, of those in other areas of the Greece service area (who made up only about 22% of the passengers surveyed), 53% preferred DAB. Thus, persons with access to a fixed-route bus generally preferred only the fixed-route system, while persons outside of the fixed-route corridor preferred DAB. Because the vast majority of the transferring passengers (69%) were within the fixed-route corridors, there was a strong preference for a return of the fixed-route system by transferring DAB passengers. Since only 37% of the service area population resided within the Dewey or Ridge fixed-route corridors, the results of the transfer point survey indicate that the proportion of transferring passengers with access to fixed-route buses significantly exceeded the general population proportion.

Fixed-route buses seem to have been preferred in the 1976 summer because they were perceived to be faster and more reliable. About half of the respondents preferring fixed routes checked these attributes as their reasons. In addition, 55% of those preferring Route 10 checked "more convenient" and 38% checked "simpler to use." This is twice the proportions of those preferring Route 14 who checked these reasons, reflecting the value attached to not having to transfer. Trip cost had a more modest influence on the respondents' choices.

Questions about perceived wait time further indicate the high degree of the 1976 transfer user's dissatisfaction with PERT service; 63% rated the length of wait for a PERT bus to arrive at Dewey and Ridge as poor or very poor, compared to 6% with regard to an RTS bus. The average perceived wait time for PERT was 36 minutes, although this reflects many people who may have given exaggerated responses such as "two hours" (responses over 99 minutes were coded as 99 minutes). The median response, however, was 30 minutes -- about twice the average actual wait time. This discrepancy between perceived and actual wait times probably reflected people's frustration with waiting. Perceived RTS wait times more accurately reflected actual wait times.

The March and April 1977 transfer point survey, summarized in Appendix A.9, disclosed that user attitudes toward transferring from RTS to DAB had significantly improved. The mean perceived wait time for transfers to DAB dropped from 36 to 21 minutes (the median dropped from 30 to 20 minutes). In the 1975 on-board survey, however, transferring passengers also estimated their usual transfer wait times; in this case, a mean of 14.4 minutes was obtained, which was very close to the average actual wait time.

Finally, some dissatisfaction with the 1976 transfer environment was noted: 43% rated it poor or very poor. During the afternoon, passengers transferred in front of a small bar in an industrial area about 100 yards south of Ridge Road on Dewey Avenue. In the evening, passengers waited for DAB in a fast-food restaurant at the corner of Dewey and Ridge. A small transfer facility on Dewey north of Ridge, adjacent to the PERT garage, opened in the fall of 1976. The 1977 survey results disclosed that perceptions of the transfer environment had improved, reflecting the comfort and convenience of the transfer station. Finally, the March-April 1977 survey showed many DAB passengers switching to the Dew-Ridge Shuttle, since its schedule was coordinated with the Route 10 bus. The respondents perceived transferring between RTS and Dew-Ridge Shuttle buses considerably more favorably than using DAB to transfer.

6.3.5 Route Rationalization and Transfer Coordination

The number of passengers transferring between DAB and RTS buses can also be used to determine the impact of route rationalization on ridership. According to the December 1974 Route 10 survey and Route 14 load counts, almost all the former fixed-route passengers were traveling to destinations outside of the Greece service area; following route rationalization, they would have had to use DAB plus a transfer in order to make the same trip by transit. Alternatively, they could have traveled during the peak period and continued to use the fixed-route buses; they could have used some other means of transportation (including a fixed-route if it were accessed by a means other than DAB), or they could simply have stopped making the trip. Unfortunately, no surveys identifying specific customers were taken prior to the rationalization, as this event preceded the designation of Rochester as a demonstration area. Therefore, it was not possible to cost-effectively contact former users to determine how they made their trips after route rationalization. Information must therefore be deduced from indirect measures, such as ridership and transfer statistics. The situation is further complicated by several other innovations that occurred simultaneously with route rationalization (such as service area and operating hour expansions) and the lack of a reliable fixed-route data base for the period before route rationalization.

The success of the rationalization concept depended upon persons taking DAB and transferring to a fixed-route for trips that were previously possible by fixed-route alone. Therefore, transferring passengers are the key to evaluating the route rationalization concept. As reported in Section 6.3.1, transferring ridership grew in six distinct steps: the graph of the number of transfers is found in Exhibit 6.16. Three of these periods (#3, #4 and #5) followed route rationalization events and provide the basis for the analysis. The fifth period also followed a fare change for midday transferring passengers.

The total effect of route rationalization, including the feeder fare and fixed-route cutbacks, is estimated as a loss of approximately 67% of the former fixed-route riders. This was calculated as follows: The Route 14 cutback resulted in a ridership capture of 32% (30.4 of 95 passengers), and the Route 10 (Phase 1) cutback resulted in a capture of 15% (15.5 of 101 passengers). Although not measured directly, the midday feeder fare is assumed to have increased these figures by 38%. (See discussion under Route 10 Cutback, Phase 2.) The Phase 2 cutback of Route 10 resulted in a ridership capture of 34% (21 of 62 passengers), which already includes the effect of fares. An average effect is calculated as follows:

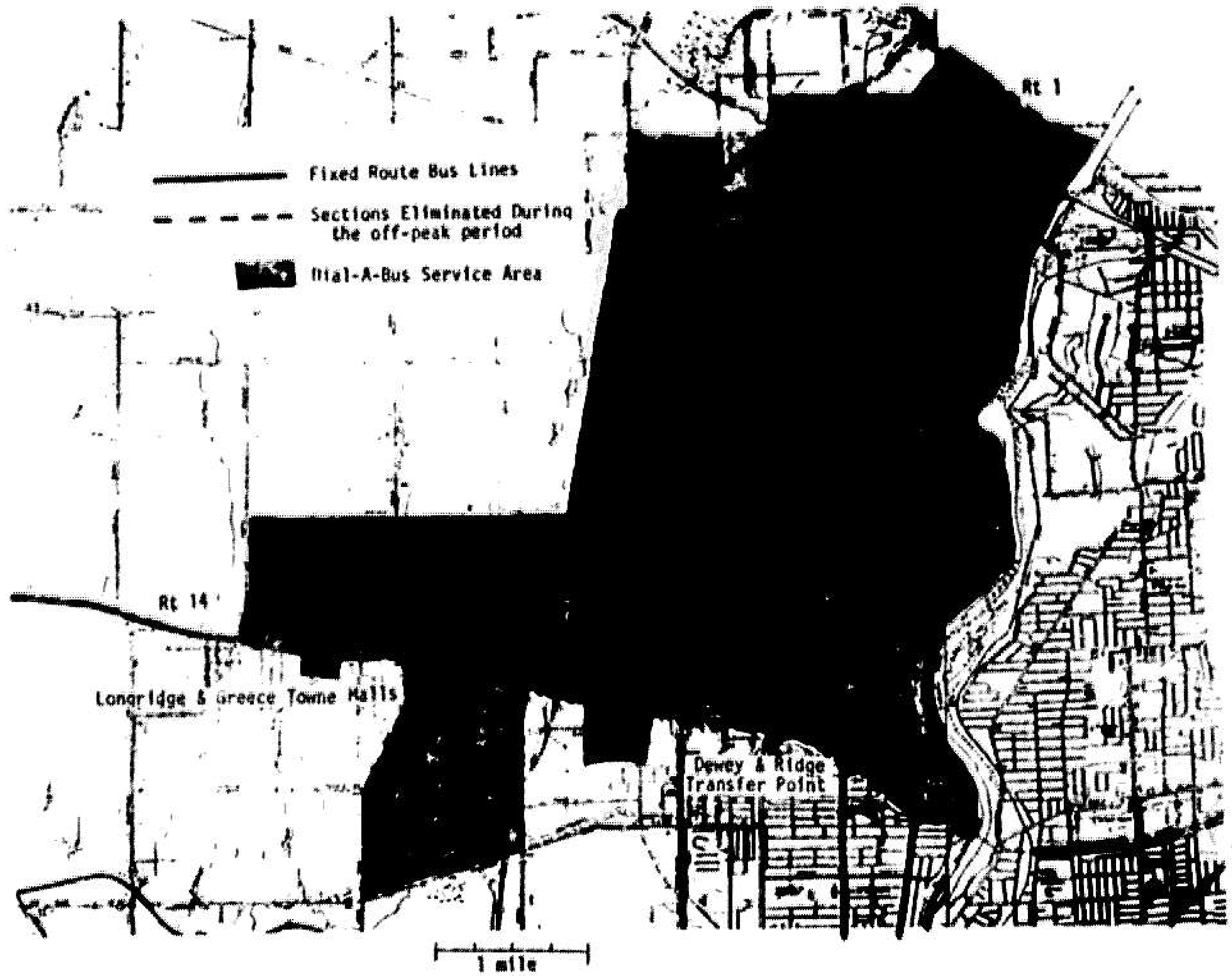
	Passengers Transferring	Former Fixed-Route Riders
Route 14	30.4 X 1.38	95
Route 10 (Phase 1)	15.5 X 1.38	101
Route 10 (Phase 2)	21	62
Total	84.3	258

The total ridership capture was 33% (84.3/258) and, hence, the lost or time-shifted ridership was 67%. The following sections detail the methodology used to derive these results.

Route 14 Cutback (Exhibit 6.18). On June 24, 1974, Route 14 service on Ridge Road was cut during the off-peak period (weekday midday and early evening, and most of Saturday). Former Route 14 passengers now had to use DAB, and faced a fare increase of 91% ($1.05 compared to $0.55). In addition, evening and Saturday DAB service began, and about 9,400 people were added to the PERT service area. Daily transferring passengers increased from an average of 21.4 before this cutback (in the second period) to 58.2 (in the third period), an increase of 172%. Some of these additional transferring passengers may have been new riders attracted by the increase in service hours and the expansion of the service area. Others can be assumed to be those who previously used Route 14. No data exists to distinguish the number of new riders from the number of former fixed-route riders. Non-transferring DAB ridership increased by 30% as a result of the service area expansion, the extension of operating hours, and a few former Route 14 passengers who did not transfer because they could make their entire trip on DAB. If area and time expansions resulted in a general 30% ridership increase, then 142% of the 172% transfer ridership increase (172%-30%), or 30.4 passengers per day, were due to Route 14's service cutback.

Based on 69 load counts and 12 ride counts in 1972 and 1973, ridership on Route 14 during the weekday off-peak period averaged 124 passengers per day with a 95% confidence

EXHIBIT 6.18 EXISTING AND FORMER RTS FIXED ROUTES



range of ± 15%.[4] About 85%, or 105 passengers, got off at Dewey and Ridge or Lake and Ridge and about 90% of these, or 95 passengers, transferred to Route 1 or 10 to travel toward downtown.[5] Assuming that the all-day Saturday Route 14 ridership characteristics resembled the weekday off-peak results (the total number of hours was comparable), the increase of 30.4 transferring passengers due to Route 14's cutback represents about 32% of those who previously used Route 14 and transferred. Therefore, approximately 68% did not take advantage of the new service, and either no longer made the trip, made the trip during the peak period, or used another mode.

Route 10 Cutback - Phase 1 (Exhibit 6.18). On September 9, 1974, Route 10 off-peak service was partially cut back. Midday service above Northgate Plaza was eliminated, as well as evening and Saturday service above Ridge Road during the hours of DAB operation. A small area was added to the service area, increasing the service area population by 3.6%, but this was a relatively insignificant increase.

As shown in Exhibit 6.16, the percentage increase in transferring passengers during Period 4 (September 9, 1974 to January 4, 1975) was almost identical to the percentage increase in non-transferring passengers: 27% compared to 26%. Although this seems to suggest that the Poute 10 service cutback did not result in any additional transferring passengers, a closer inspection of the data reveals otherwise. During the week of September 29, half-fare coupons were placed in local newspaper advertisements; the increase in non-transferring passengers occurred after this time in Period 4. The approach of Christmas also probably boosted the number of non-transferring passengers. The number of non-transferring passengers, however, remained fairly steady at the increased level throughout the period, though tending to decrease slightly over time. Consequently, the 27% increase in transferring passengers, or 15.5 passengers, is assumed to be independent from the non-transferring passenger increase (the non-transferring passenger increase being attributable to the fixed-fare promotion, and the transferring passenger increase being attributable to the fixed-route service cutbacks).

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[4]The use of load counts tends to underestimate ridership, since only passengers on board at one point are counted. On the other hand, the load counts made were disproportionately made between 9 and 10 A.M. and 2 and 3 P.M., when ridership may have been higher than the overall midday average. These factors are assumed to balance each other.
[5]Massachusetts Institute of Technology Memorandum, The Rationalization of the RTS Fixed-Route Bus System, March 15, 1974, pages 3-4.

The increase of 15.5 transferring passengers represents those who shifted from Route 10 to DAB plus a transfer. In order to estimate what percentage of the former Route 10 passengers this represents, it is necessary to examine former Route 10 ridership for the midday, nights and Saturdays, as these periods were affected differently by the cutback.

Scant data exists on Route 10 ridership before the service cutback.* It is estimated that there were 155 midday RTS riders per day (about 30 per hour) above Ridge Road. A December 1974 RTS on-board survey (after the cutback) recorded 98 passengers during the midday period, suggesting that approximately 57 persons were no longer served by Route 10. (The latter on-board survey also disclosed that 10% of the riders began or ended their trips at locations more than 3/8 of a mile north or east of Northgate Plaza, and would probably have preferred to board Route 10 at points where it was eliminated.)

Night-time users of Route 10 who boarded above Ridge Road were estimated at 50 passengers per night. About 10% of these were assumed to be able to walk to the Ridge Road transfer terminal following the Route 10 cutback, leaving 45 persons who had to use DAB and transfer to Route 10.

The estimated former Saturday ridership on Route 10 above Ridge Road was 230 passengers. Again, assuming that 10% could walk to the Ridge Road terminal, 205 are assumed to have been candidates for DAB with a transfer.

The total weekly number of former passengers no longer served by Route 10 is calculated as follows:

Weekday afternoon	57 X 5 = 285
Weekday night	45 X 5 = 225
Saturday	205
Total	715 ÷ 6 = 119

The December 1974 survey of Route 10 riders indicated that 15% were traveling within the PERT service area, 65% were traveling to the CBD, and 20% were traveling to other Rochester locations (all to the south of Greece). Thus, about 85% traveled outside of the service area, suggesting that approximately 101 passengers per day (.85 X 119) would now have to transfer from DAB to Route 10 in order to continue making their trips by transit. The increase of 15.5 daily transferring passengers resulting from the cutback suggests that only about 15% of these passengers actually began using PERT.

This proportion is only about half of that assumed to

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*All Route 10 ridership data in this section is found in an analysis of route rationalization by Dave Brandt, RTS dispatcher; that data consists of estimates developed by MIT and RTS. Like the Route 14 rationalization, the Route 10 changes were made before the demonstration began.

have used PERT as a substitute for Route 14. It has been suggested that former Route 10 passengers had to transfer, whereas Route 14 passengers always had to transfer, and this accounts for the difference (see Section 5.3.4 for travel time comparisons). However, the questionable reliability of the Route 10 ridership data makes the results less certain than those of Route 14, and meaningful comparisons are difficult to make with confidence. The available evidence suggests that both route rationalization steps failed to attract a majority of the previous fixed-route riders to DAB.

<u>Route 10 Cutback - Phase 2 (Exhibit 6.18).</u> On January 6, 1975, at the start of Period 5 (as shown in Exhibit 6.15), all Route 10 service above Ridge Road was eliminated except during the peak period. In addition, a midday feeder fare of 50 cents was established (a 52% reduction). Transfer ridership increased 67% (compared to Period 4), yet non-transfer ridership during the same period dropped by 6%. The small drop in non-transfer ridership resulted from the seasonal decline associated with spring; however, transfer ridership increased slightly during the spring (the fifth period). The difference in the behavior of transferring and non-transferring passengers once again suggests a difference between these two types of riders. In addition, the planned improvements in transfer service were implemented in January 1975 by scheduling PERT vehicles to meet every other Route 10 bus at Dewey and Ridge. Previously, only one of every three Route 10 buses continued north beyond Dewey and Ridge, and there was little or no coordination between PERT and RTS buses. As discussed in Section 5.3.5, this new policy was not effective and is therefore assumed to have had no effect on transfer ridership.

To isolate the effect of the Phase 2 cutback, the impacts of the new reduced fare must be identified and separated from the cutback effect. The impact of the midday feeder fare may be found by looking at the increase in transfer trips by passengers living outside the Route 10 corridor (one-quarter mile on each side of the route), as these passengers represent a control which is assumed to have not been affected by the cutback but only by the fare reduction. A sample of 106 transfer trips in July 1974 (prior to the first phase of Route 10 rationalization) disclosed that only one trip came from or went to a point within the Route 10 corridor. It is thus assumed that about 99% of the pre-September 1974 transfer ridership was from outside the corridor, or 58.2 riders daily (the average ridership during Period 3 times .99). In March 1975 (two months after the completion of the second phase of Route 10 rationalization), however, it was found that only 64.4% of the transfer ridership (from a sample of 522 with a 95% confidence range of +4.1%) was from outside the Route 10 corridor. For the January-June 1975 period (Period 5), this results in a daily transfer ridership of 79.4 to or from outside the Route 10 corridor, or an increase of 37.9%. This increase in transfer ridership was assumed to be due to the fare reduction.

Thus, the fare reduction alone accounted for a 38% increase in the number of transfers, or over half of the 67% increase which occurred after the Route 10 service cutback. The Route 10 cutback was therefore assumed to result in a 29% (67%-38%) increase in transferring passengers (about 21 passengers per day).

Based on the December 1974 Route 10 survey ridership count, roughly 83 (85% of 98 passengers surveyed) former Route 10 weekday midday passengers traveled to points outside the service area. If 10% could walk to the Ridge Road terminal following the Phase 2 cutback, approximately 75 persons had to use PERT and transfer, resulting in a daily average of 62 passengers when averaged over the six-day week (75 X 5/6). The increase of 21 transferring passengers per day thus accounted for about 34% of the former Route 10 ridership. This is more than the figure obtained for the first phase of Route 10 rationalization, but it was influenced by the lower available fare. It is almost identical to that obtained in the analysis of the Route 14 rationalization.

The resulting transfer ridership increase implied a fare elasticity of at least 0.72 (ϵ = .379/(.55/1.05)). Elasticity cannot be determined precisely because the reduced fare only applied for a few hours of the day. An analysis of a six-month sample (June-December 1975) disclosed that 52.7% of all transfer ridership qualified for the midday feeder fare. If total transfer ridership increased by 37.9% as a result of the fare decrease, the new revenue was almost exactly equal to that received prior to the fare change:

Transfer passenger revenues before fare change =

Transfer passenger revenues after fare change

($1.05)(Pre-fare change ridership) =

[$1.05(47.3%)+$0.50(52.7%)](Pre-fare change ridership X 1.379)

$1.05 = $1.05

6.4 WORK AND FEEDER SUBSCRIPTION DEMAND

6.4.1 Ridership Levels

Demand for home-to-work subscription service underwent strong seasonal variation, rising during the fall and winter and declining during the spring and summer (Exhibit 6.19). The highest demand levels were reached during the 1973-74 winter, when the perceived gasoline shortage induced temporary transit ridership increases nationwide. Daily ridership exceeded 200 passengers per day during the week of February 25, 1974. Ridership declined rapidly during March and April, and by early May averaged under 100 passengers per day or less than half of the winter's peak ridership. During the two subsequent winters, ridership was generally between 150 and 175 passengers per day or around 2.6-2.8 demands/square mile/hour averaged over four hours. (The number of demands was essentially equal to the number of passengers, since there were 1.03 passengers per demand over the life of the project.) Spring and summer ridership fluctuated between 100 and 125 passengers per day. In 1975, a 25% decrease occurred over seven weeks beginning in February; in 1976, a 20% ridership drop occurred during four weeks starting in early March. These three years of experience suggested that the seasonal cycles were gradually diminishing in magnitude.

During the week of January 17, 1977, following the work subscription fare increase, ridership dropped 23% from the average of the previous eleven weeks (excluding three holiday weeks). Ridership fell another 9% the following week, and finally stabilized. Though these decreases were significant, the effect of the fare increase is confounded by the seasonal trends.

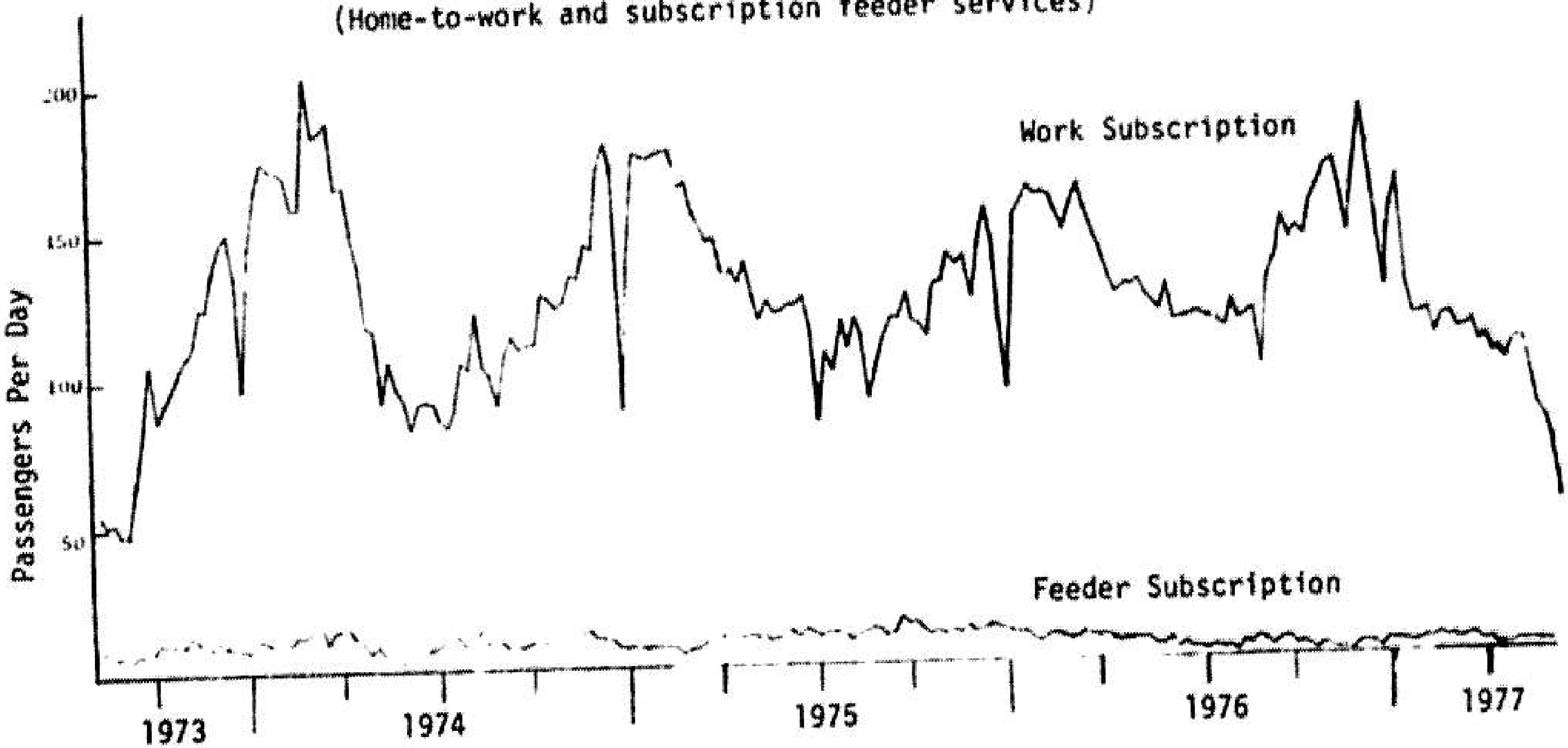
Interestingly, a much smaller ridership decrease was reported in early spring of 1977, suggesting that many of the persons who stopped using the service following the fare increase would have done so in late winter anyway. The total ridership drop from before the fare increase to late April was approximately 40%. Based on the experience of the two previous years, a normal seasonal decline of between 20% and 25% could have been expected, indicating that the ridership loss due to the fare increase was approximately 15% to 20%. Since fares increased by 29%, this suggests a work subscription fare elasticity of between 0.5 and 0.7, about the mean value of the fare.

After May 1974, when the GM Rochester Products plant began to be served, these tours accounted for about 10% of work subscription ridership, while 90% traveled to Kodak Park. Subscription feeder (Feed-A-Bus) service fluctuated between 5 and 15 passengers per day during the entire

EXHIBIT 6.19

AVERAGE DAILY SUBSCRIPTION RIDERSHIP, BY WEEK

(Home-to-work and subscription feeder services)



project, and thus represented a small proportion of total subscription ridership. Through July 3, 1976, there was an average of 8.6 feeder subscription passengers per day, with a weekly standard deviation of 2.5 passengers per day. Unlike work subscription ridership, no seasonal trends can be detected, but this may be because the small ridership hides any underlying trends.

6.4.2 Temporal Variation in Ridership

Exhibit 6.20 indicates that there was a slight drop in ridership (about 5%) on Mondays and Fridays when compared to Tuesdays through Thursdays. This drop probably coincides with normal absenteeism at Kodak Park and Rochester Products.

6.4.3 No-Shows

Exhibit 6.21 displays the number of no-shows as a proportion of trips for the work (including feeder) subscription service. Work subscription no-shows exhibited an irregular but steady decline, from around 5% of total trips when the service began to around 1% in mid-1976 -- a dramatic improvement.

Work subscription no-shows were also surveyed in the August 1975 no-show survey. The ten persons contacted had a variety of reasons for not meeting their bus, although none were related to the bus being late. Three persons overslept and took back-up buses, one became sick while waiting for the bus, one was on vacation, one worked overtime, and one decided to ride with her husband in the morning. Thus, work subscription no-shows did not seem to be related to service quality, and the 1976 decline in no-shows probably reflected an increase in people cancelling their requests before the bus arrived to pick them up. However, in the winter of 1976 and 1977, vehicle reliability became a problem, and the no-show rate surged to over 6% during the first week of January. Work subscription no-shows subsequently dropped to around 3% of total trips until the service was terminated in June 1977.

6.4.4 Subscription User Survey

Most of the information on subscription user and trip characteristics was derived from the results of an April 1975 telephone survey of all identifiable persons who had

EXHIBIT 6.20

HOME-TO-WORK SUBSCRIPTION RIDERSHIP, BY DAY OF WEEK

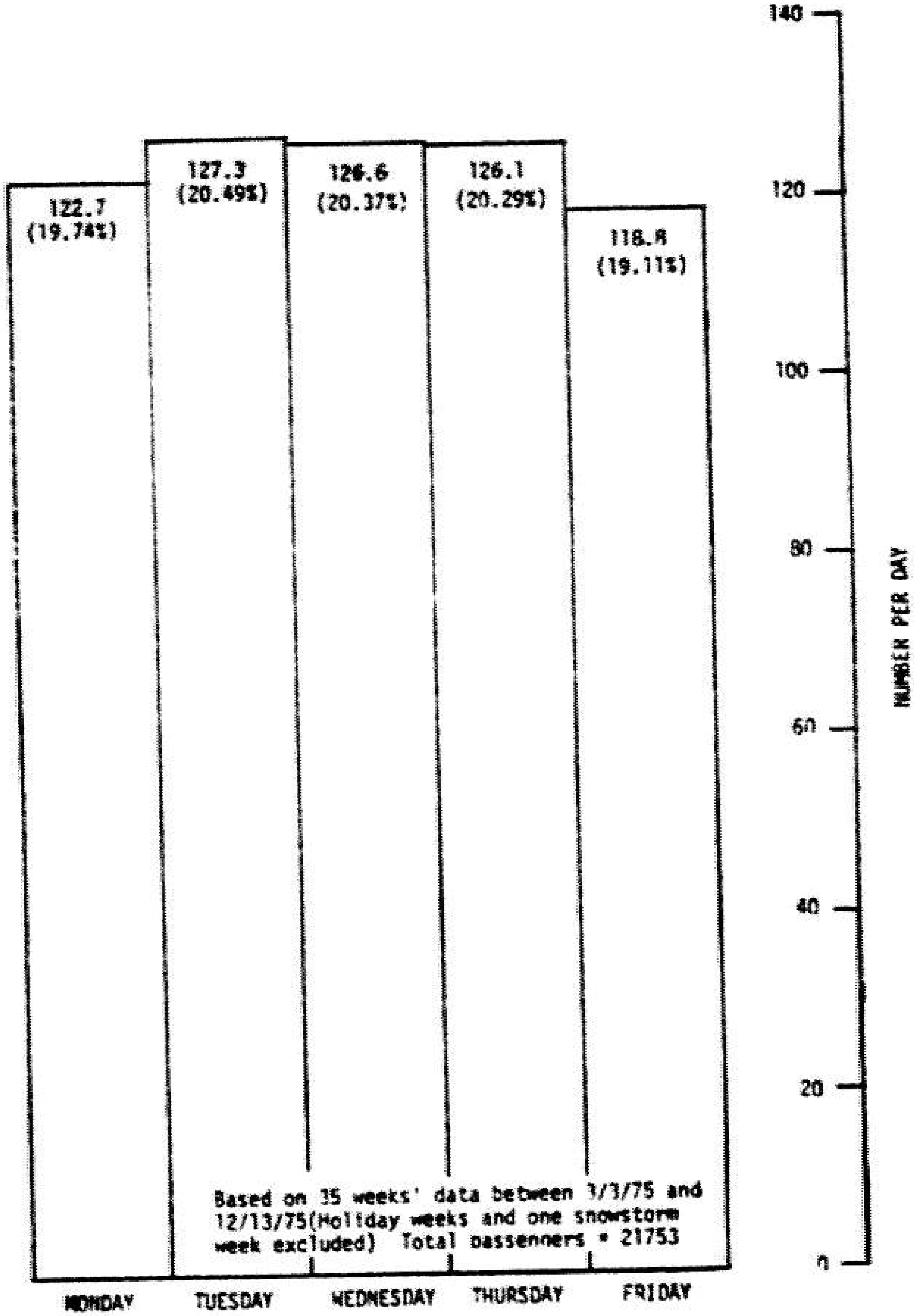
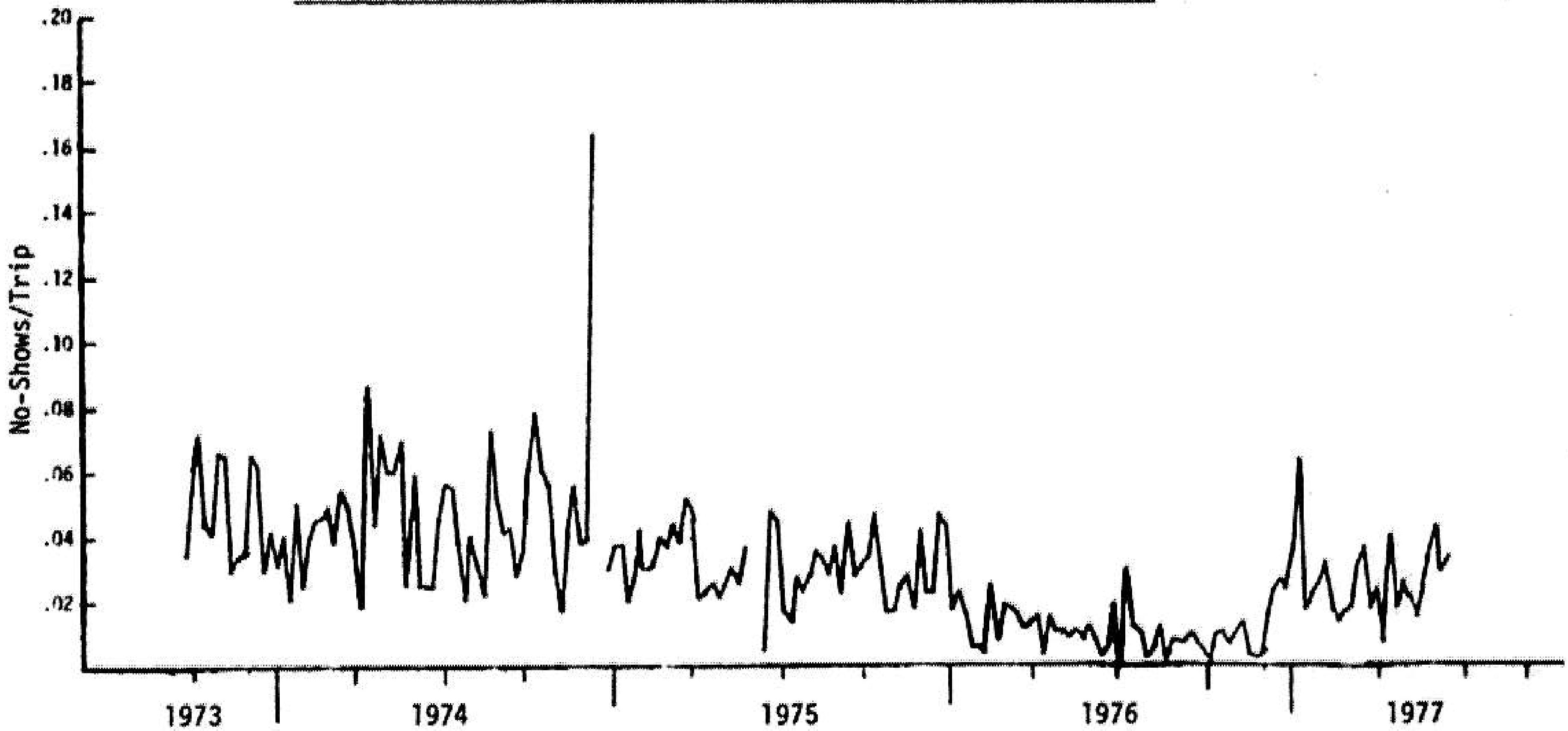


EXHIBIT 6.21

WORK SUBSCRIPTION NO-SHOWS/WORK SUBSCRIPTION TRIPS, BY WEEK



Discontinuities due to missing data.

ever used work or feeder subscription service. The total user population at the time of the survey was 210 persons. (Before December 1973, names of persons who stopped using the service were discarded, and the PERT dispatcher estimated that an additional 20 persons used the service prior to that time.) Of the 210 persons, 124 were contacted; 46 had unlisted telephone numbers and 40 could not be reached despite at least three call-back attempts over two evenings.

Of the 124 persons surveyed, 70 were current users (representing almost the entire current ridership) and 54 were former users. One hundred persons traveled to Kodak Park, 9 traveled to Rochester Products, and 15 were feeder subscription passengers. Generally, the responses of the former users were not significantly different from those of the current users. Due to the relatively few users traveling to locations other than Kodak Park, little significant variation can be detected between these groups. Therefore, only total results will be discussed unless there are significant variations of interest. A sample survey form and a tabulation of the survey results are contained in Appendix A.6.

6.4.5 User Characteristics

Work subscription users were apparently more affluent and better educated than area residents generally, and were much more affluent than other transit mode riders. Fifty-six percent of work subscription users were male, which differentiates this service from DAB and transit in general, both of which have higher female utilization. Just under half (48%) of the users were between the ages of 45 and 64 years of age; 40% were age 25 to 44 and 12% were under 24; 30% reported that they were college graduates, and only 9% did not finish high school. Half of those responding said that their annual household incomes exceeded $20,000, and 75% said that it was $15,000 or more.

Users relied upon the automobile for most of their travel. Eighty-four percent of subscription riders reported that they had driver's licenses, and only 4% came from households without automobiles; 35% came from households with two or more automobiles. Their use of other transit modes was consequently low; 72% reported that they never used RTS buses or other PERT services. In fact, one-quarter of those surveyed did not know how far they lived from a fixed-route. Of the remainder, one-half said they lived within three blocks of a fixed-route and about one-third said they lived more than five blocks away from a fixed-route. Their use of PERT subscription service seems to have been because there was more workers than cars in their families. In fact, there were more workers than cars in the households of 89% of the current users and 78% of the former users. Sixty-six percent of all users were from households where there were two or more workers per available automobile. Thus, it appears that subscription riders viewed their other trip needs relative to public transit service quite differently than their home-to-work trips.

6.4.6 Trip Characteristics

Of those surveyed in April 1975, about three-quarters (74%) said they used both morning and evening subscription service; 17% said they rode only in the morning, and 9% only used the service in the evening to return home. More than half (53%) said they had driven to work before using PERT; 21% drove with someone or carpooled, 17% took an RTS bus, and 9% had been using PERT since working at Kodak or Rochester Products. If PERT discontinued operation, most current users said they would revert to their previous modes -- 55% would drive, 22% would carpool or be driven, 20% would take an RTS bus, and 3% would walk. However, a larger proportion of former users (36%) were actually carpooling or being driven; 49% were driving, 8% were using an RTS bus, and 8% were walking. It may be deduced that most subscription riders did not perceive regular RTS service as a viable alternative, for over half said they lived within three blocks of an RTS bus route (which would serve the work destination of 93% of those surveyed; no Greece bus connects with the Rochester Products plant). In addition, an analysis of all work subscription trips on February 5, 1976 disclosed that 28% of the residential trip ends (n=143) were within one-quarter mile of a fixed-route bus and 48% were within three-eights of a mile. Thus, many subscription users could have used an RTS bus at a lower fare, but relatively few said they would use RTS even if PERT were not available. As stated above, almost all subscription users came from households with more workers than cars. Apparently, by saying that they would drive if PERT did not operate, subscription users would rather have forced household confrontations on the use of the family cars than take an RTS bus.

Based on the study of February 5, 1976 subscription trips, it was concluded that the average one-way subscription trip length was 3.4 miles, although trips to GM Rochester Products averaged 4.3 miles and Kodak Park trips averaged 3.3 miles. (This finding is described in more detail in Section 5.4.)

6.4.7 User Attitudes

During the April 1975 telephone survey of work subscription passengers, an extensive effort was made to assess users' perceptions of the service. Significant differences between the perceptions of current and former users were found. Since there were no significant differences between the user characteristics and trip characteristics of these groups, the attitudinal differences serve to differentiate the two groups. For instance, when asked about the service's least attractive feature, 41% of the current users reported "nothing," compared to only 22% of the former users. Excessive trip length was the most frequently cited problem area. On the other hand, over half of both groups said that having a home pick-up was the most attractive feature of the service. Not having to drive and the low cost of service -- which are traditional transit advantages -- were less frequently cited as attractive features.

Of those who stopped using the service, about half did so for reasons outside of PERT's control, such as a job change or having used the service only temporarily as a fallback when a car was not available. Of the remainder, excessive travel time and trip length were cited most often as reasons for discontinuing use. PERT drivers were judged to be courteous and the trip-scheduling and ticket-purchasing system was generally felt to be convenient. Current users tended to say that PERT was cheaper than driving (57% to 43%), while former users felt driving was cheaper (65% to 35%), a significant difference at the .03 level. (In Section 5.1.3, driving was estimated to be slightly less expensive than subscribing to PERT on the average.)

Work subscription users seemed to perceive travel times accurately. Although the results were categorized by ten-minute intervals (by using six minutes for 0-10 minute responses, 16 minutes for 11-20 minute responses, etc.), a mean perceived travel time of 22.1 minutes was computed. This is very close to the 23.2 minute average revealed by the February 1976 on-board time study (Section 5.4.1). The distribution of perceived travel times was slightly higher than were actually recorded, but the one day of observations may not be a truly representative sample. In addition to ride time, users reported a mean after-work wait time of about eight minutes (almost half reported a wait time of less than five minutes). Finally, and perhaps most significant, users were asked how many late work arrivals occurred each month due to PERT; 72% of the current users and 53% of the former users reported none, and 88% and 73% of the current and former users, respectively, reported one or less per month. These results, combined with the low subscription no-show levels, confirm that subscription service was perceived by its users as very reliable.

Another survey question asked users if they would use a "stop and shop" option: this service would take them to a shopping mall after work and a DAB vehicle could be used for the trip home at no extra cost. About half said they would not use the option; 7% were unsure; and most of the rest predicted relatively infrequent use (twice per month or less). If the customers behaved as they indicated they would in the survey, there would have been an average of only four requests per day for the stop and shop option, or about one person on every other bus tour; the option was consequently never implemented.

6.5 SCHOOL SUBSCRIPTION SERVICE DEMAND

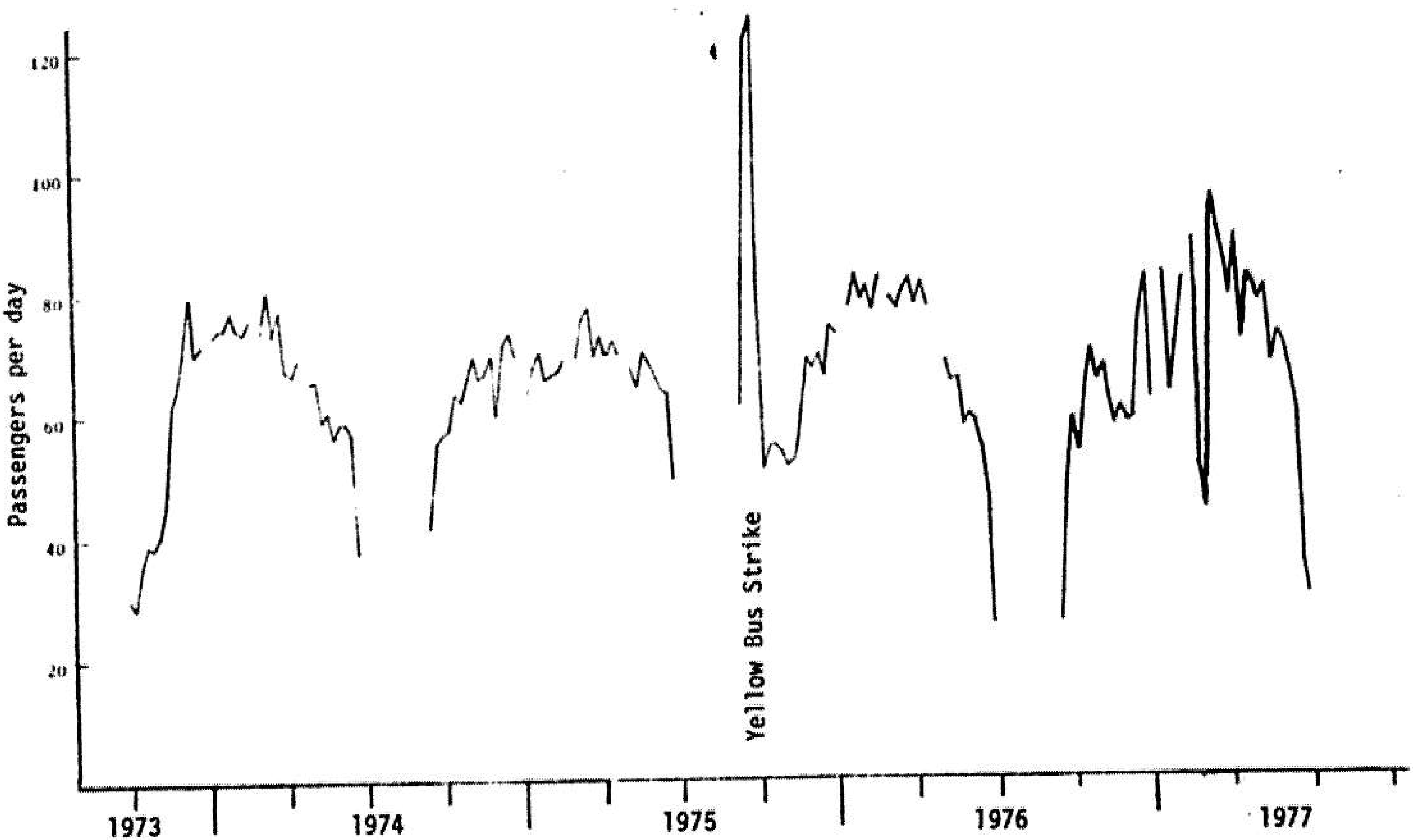
Daily home-to-school ridership was reasonably constant at between 60 and 80 passengers during the first three years, increasing to between 65 and 95 by the 1976-77 school year (Exhibit 6.22). (There were usually less riders in the fall and winter.) The only major deviations from this trend occurred in September 1975, when a yellow school bus strike of two and one-half weeks temporarily doubled ridership, and two weeks in February 1977, when severe winter weather and fuel shortages threatened to close the schools. (Exhibit 6.21 excludes data on the first week of February 1977, when snow and fuel problems made it difficult to record.) The average number of passengers per trip was 1.52 over the first three years of service, rising to 2.13 during 1976 and 1977 (an increase of 29%).

Ridership increased slightly toward the end of the week, but differences by day of week were insignificant; the maximum deviation from the average was on Tuesday, when ridership was only 3.7% less than the weekly average (Exhibit 6.23). During the 1975-76 school year, when three schools were served, the average trip distance was calculated as 1.1 miles, based on a 0.9-mile average straight-line distance. This was considerably shorter than average DAB or work subscription trips. No survey was taken of school subscription passengers or their families, so little is known about user or trip characteristics. However, most of the students who used this service did not qualify for regular school bus service.

Home-to-school no-show levels are displayed in Exhibit 6.24. No-shows generally represented less than 10% of all trips, although their numbers were erratic.

EXHIBIT 6.22

AVERAGE DAILY HOME-TO-SCHOOL RIDERSHIP, BY WEEK



Discontinuities reflect school vacations.

EXHIBIT 6.23

HOME-TO-SCHOOL SUBSCRIPTION RIDERSHIP, BY DAY OF WEEK

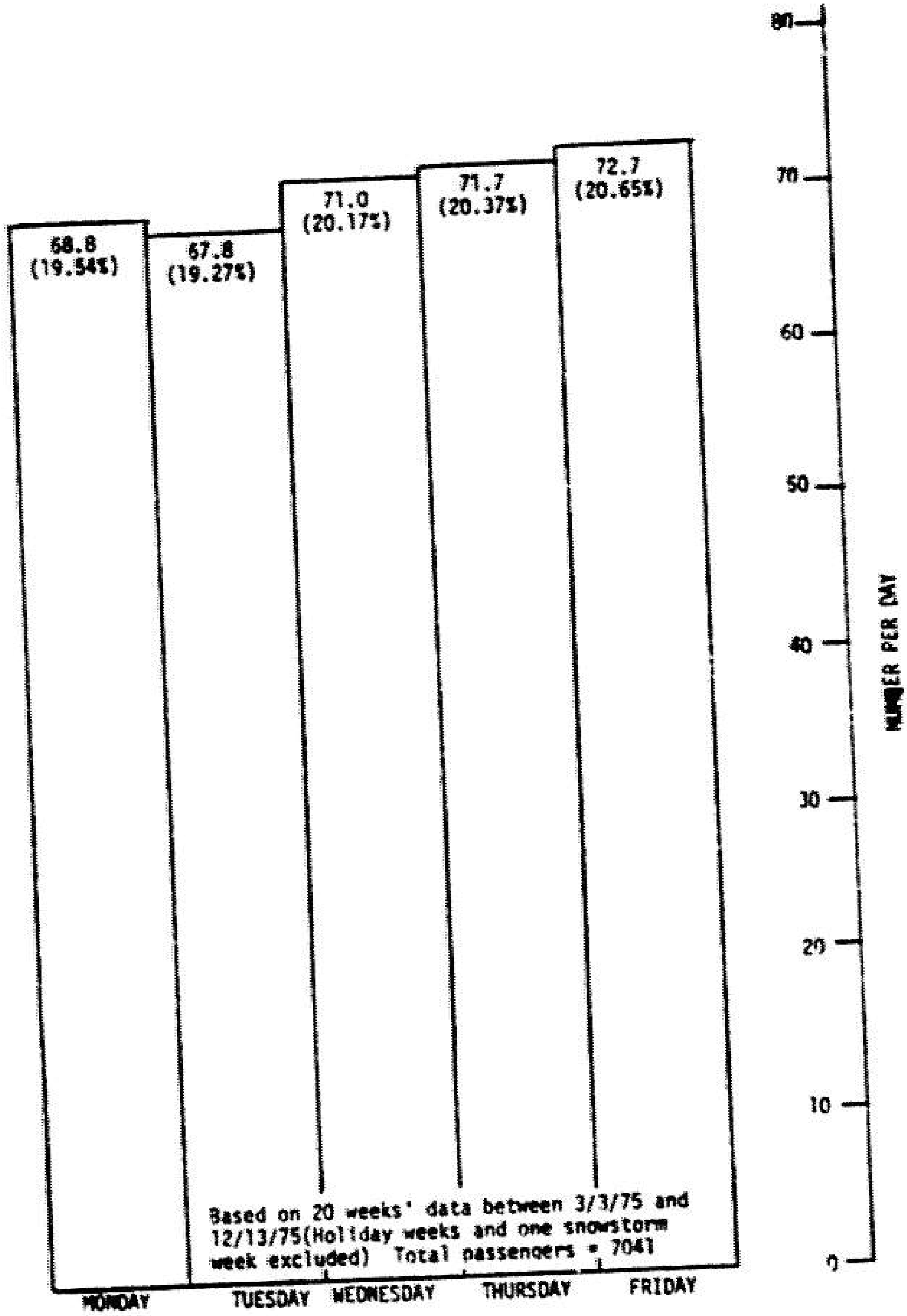
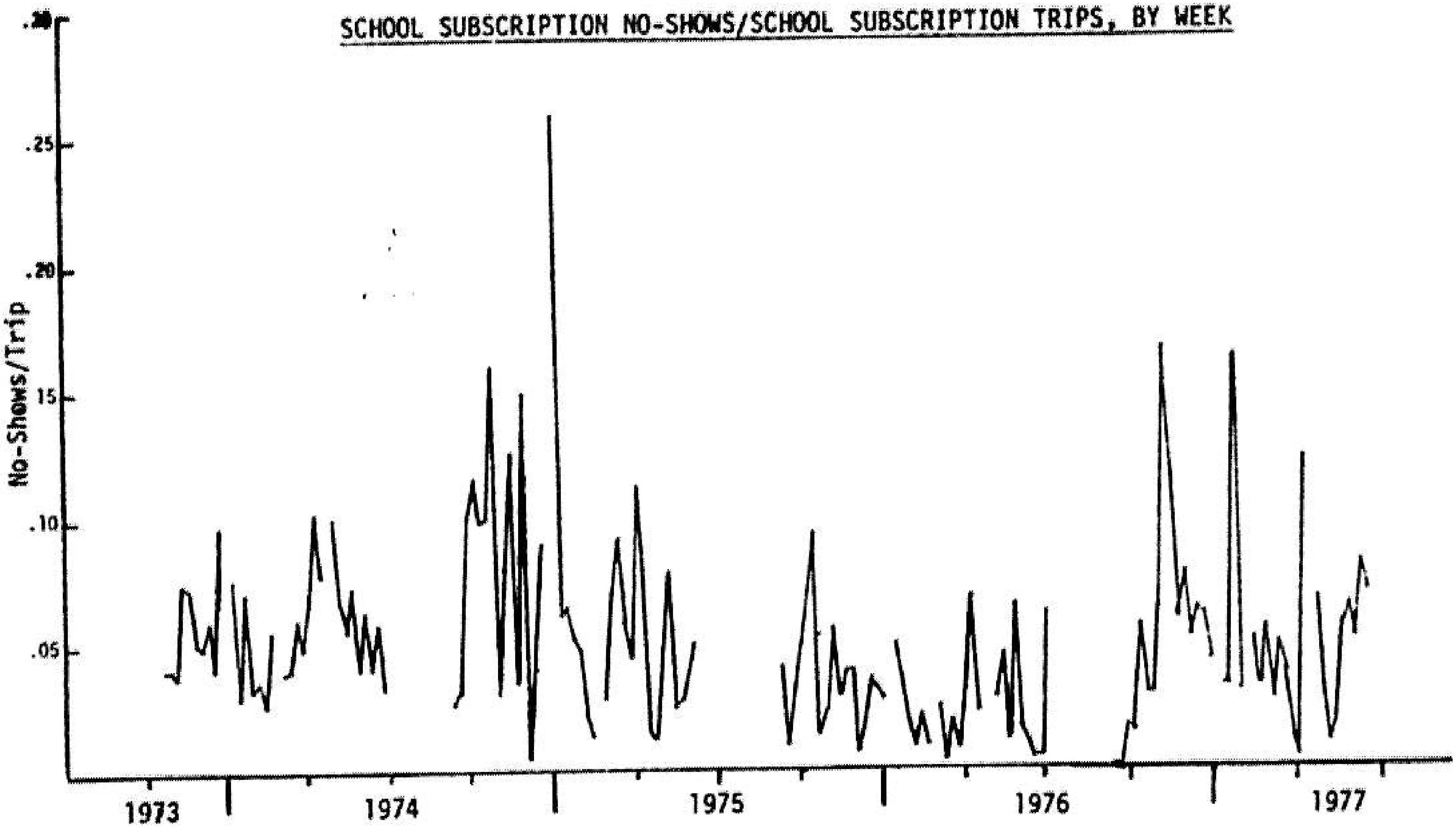


EXHIBIT 6.24

SCHOOL SUBSCRIPTION NO-SHOWS/SCHOOL SUBSCRIPTION TRIPS, BY WEEK



6.6 SPECIAL SERVICE DEMAND (EXCLUDING SPECIAL HANDICAPPED SERVICE)

The number of PERT special service riders varied considerably over time because of several service changes (Exhibit 6.25). Although two weekly senior specials operated continuously since early 1974, other services have appeared and disappeared. Minor services to YMCA's and night schools were operated during parts of 1974 and 1975, and special service was occasionally provided to other groups. On the weekly specials from two elderly housing units (Lakeview Towers and Riverview Manor) to Longridge Mall and Wegman's Grocery Store, many of the riders were elderly. Beginning in April 1975, a third special bus operated every other week from Lakeview Towers to Northgate Plaza. After early 1974, between 150 and 200 passengers took advantage of this service.

Ridership data for the individual special services have been available only since the beginning of 1975. During the 66 weeks between January 9, 1975 and April 10, 1976, an average of 40.8 passengers used the weekly Longridge Mall special (with a 25-cent fare), while 137.8 passengers rode the free weekly Wegman's special to Northgate Plaza. From April 12, 1976 to June 17, 1977, the biweekly special to Northgate Plaza (also free) carried 71.3 passengers (or 35.6 per week). The Wegman's special, which then served the Wegman's on Mount Read Boulevard rather than Northgate Plaza, showed an average ridership decrease, as only 94.7 persons took advantage of the service. About 25% of these passengers are presumed to have switched to the biweekly Northgate Plaza special when it began operating. Longridge Mall special passengers increased by only 6% to 43.4, a statistically insignificant change. Since total weekly ridership on the three senior specials after April 1976 was almost identical to that of the previous senior specials, the addition of the third senior special may have diverted rather than generated demand (see Exhibit 6.26).

No surveys of special service passengers were taken.

EXHIBIT 6.25

WEEKLY SPECIAL TRIPS RIDERSHIP

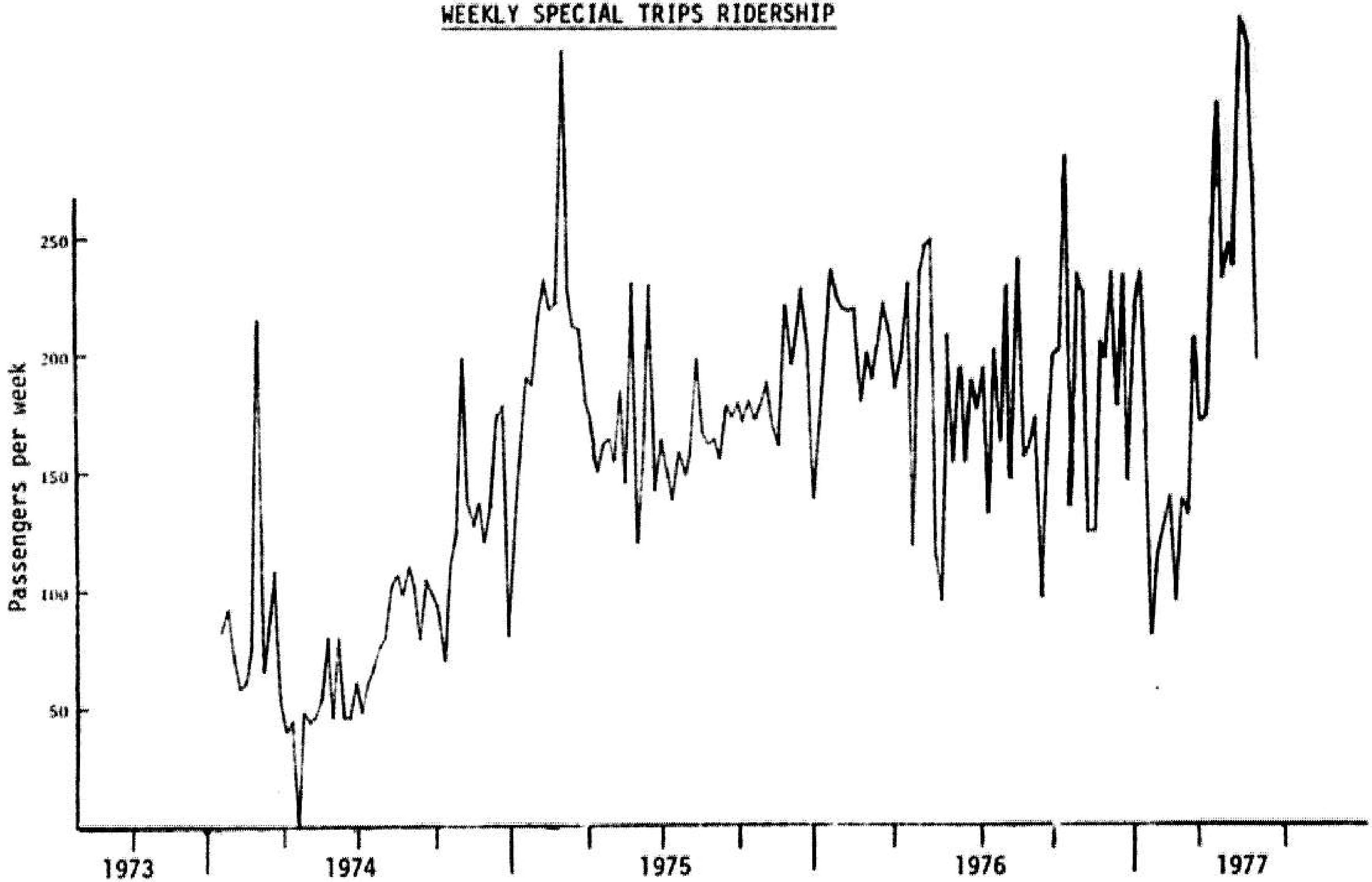


EXHIBIT 6.26

RIDERSHIP ON PRINCIPAL SHOPPERS' SPECIALS

Period	Number of Weeks	Average Weekly Ridership			Total
		Longridge Mall Special	Wegman's Special	Northgate Plaza Special	
1/9/75-4/10/76	66	40.8 (22.8%)	137.8 (77.2%)	--	178.6 (100%)
4/12/76- 6/17/77	62	43.4 (25.1%)	94.1 (54.4%)	35.6 (20.6%)	173.1 (100%)

6.7 HANDICAPPED SERVICE DEMAND

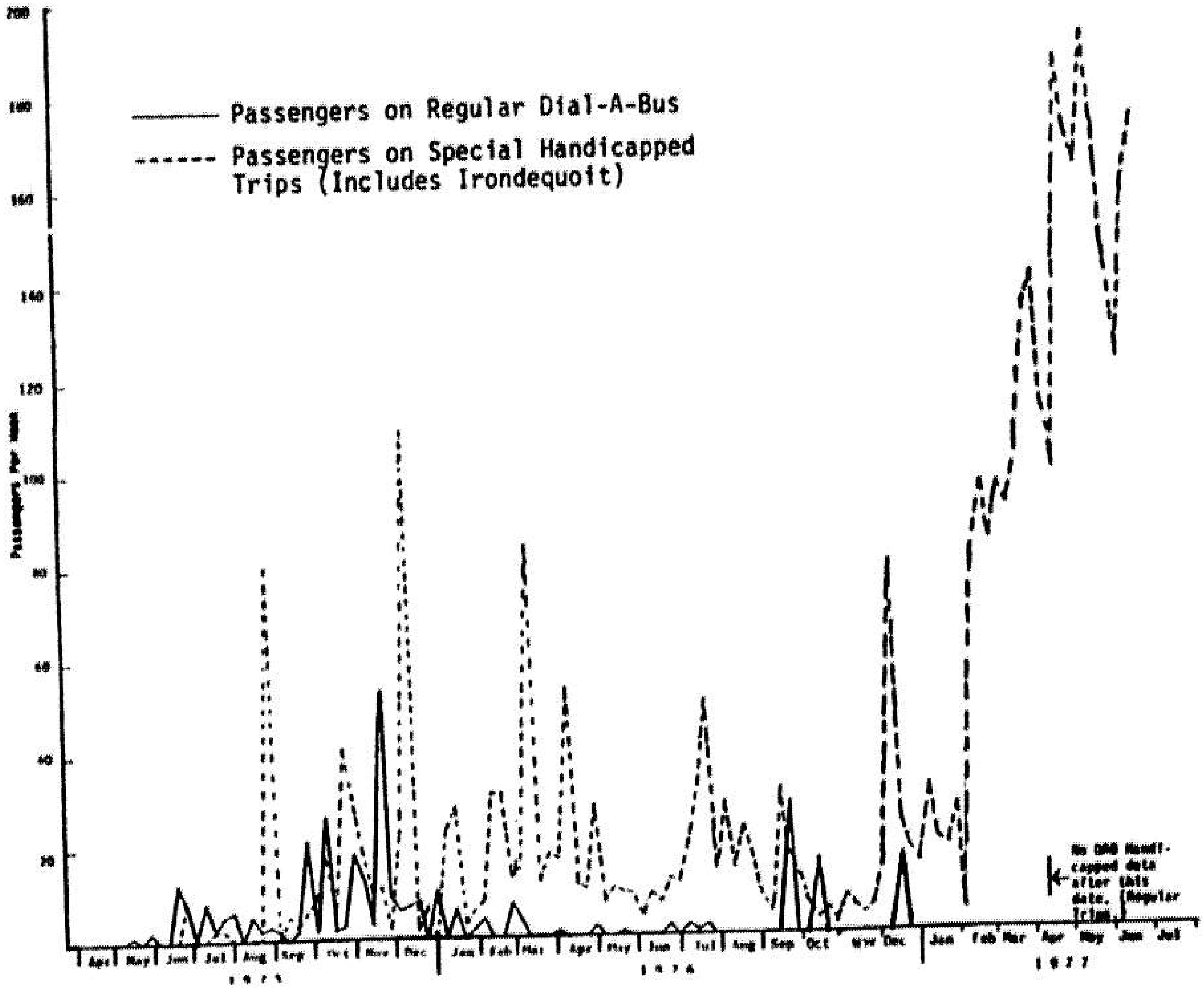
Exhibit 6.27 shows the weekly number of handicapped PERT users since service for the disabled began. Service use by the handicapped varied considerably over time. In the 68 weeks following the first handicapped DAB passenger on May 14, 1975, there were 275 handicapped passengers or 4.0 per week; this was about 0.2% of total DAB ridership. There were also 1,005 special handicapped passengers (including those in Irondequoit) from June 16, 1975, when the service began, through September 11, 1976; a weekly average of 16.2 passengers can be calculated.

This service was available for both elderly and handicapped passengers, but the count of handicapped passengers using regular DAB service included only persons specifically requesting a wheelchair-lift vehicle. The sharp ridership peaks in 1975 and 1976 represent weeks when a large group was served. The average number of handicapped service passengers per trip was was 2.46 during this period.

The PERT handicapped service was revised in October 1976, resulting in an increased demand and higher vehicle productivity. Prior to this time, and aside from a few group trips, most of the PERT handicapped ridership was accounted for by a few individuals. For example, during the eight-week period from May 24 to July 17, 1976, three persons accounted for 114 of the 140 special handicapped passenger trips. Two of these persons, who made 99 trips between them, did not require a wheelchair vehicle. Of the 12 special handicapped service destinations, only six had been served by any requests as of August 1976 -- Strong Memorial Hospital, Rochester General Hospital, and the Rochester Psychiatric Center. The first two destinations generated the most demands because the two steady users traveled there several times per week.

Aware that the existing service was not meeting the travel needs of handicapped persons identified by local social service agencies and elderly organizations, the PERT Director of Special Markets introduced a new PERT handicapped service on October 18, 1976. The new service focused on the identified demand patterns, and had specified schedules for key collection and distribution points. Unfortunately, acute vehicle shortages even prevented this 24-hour advance reservation service from being operated regularly until February 1977. At that time, the Director began to promote this and other PERT services within the elderly and handicapped community. Ridership then began to increase steadily, reaching 190 passengers during the week of May 9, 1977. However, ridership was constrained by a very low vehicle density within a large service area and relatively long trip lengths. Approximately 25% of the users were wheelchair-

EXHIBIT 6.27 <u>HANDICAPPED TRIPS PER WEEK (INCLUDES IRONDEQUOIT)</u>



confined, which is considerably higher than that reported by other special services for the elderly and handicapped.[7]

As is the case with any transit service which accepts customers on an advance-reservation basis, cancellations and no-shows can significantly impact ridership and productivity. On mild-weather days, cancellations averaged between 5% and 15% of the previously booked handicapped passengers. During the winter, the number of cancellations to requests received seemed to increase in the proportion to the severity of the weather, particularly on snowy days.

6.8 EFFECTS OF PROMOTIONAL ACTIVITIES

6.8.1 Analysis Methods and Threats to Validity

Three on-board user surveys were taken which were used to analyze the relative effectiveness of alternative uses of the media in promoting DAB service. Users were asked "How did you first learn about PERT Dial-a-Bus?" in the first and third on-board surveys. In the fourth and fifth surveys, users were asked "Where did you get most of your information on PERT?" This question had a different scope and determined which sources of information were most helpful to the user. Another question on the fourth survey asked users how they happened to ride DAB for the first time.

The behavioral response to advertising cannot be easily determined. Surveying is a rather imprecise means of determining which use of the media is most effective. Proper analysis considers the entire set of media presentations, as well as other promotional activities, in a framework which measures behavioral responses to alternative marketing strategies. This approach was not taken within the demonstration, since the evaluation of marketing was only a minor objective.

An analysis of the response to fifteen reduced-fare promotion methods was performed by measuring three types of ridership changes:

- Changes from a period prior to the promotion to the period during the reduced fare;

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[7] The nearby Syracuse Call-A-Bus system for the elderly and disabled, for example, reported that wheelchair-confined users constituted less than 3% of all ridership.

* Changes from the before period to a period after the fare promotion; and

* Comparable changes during a similar period of a different year when there was no promotion in order to account for seasonal variations.

The choice of before and after periods was made by selecting the longest possible period which does not include any other promotional activity or major service change. These periods are sometimes very short. Seasonal ridership changes, such as those occurring during the Christmas season, also limit the lengths of the before and after periods. In fact, this is a crude method of analysis made necessary by the large number of events and lack of knowledge of what ridership would have been in the absence of these events. The method may be improved by attempting to more explicitly account for several exogenous effects: growth trends not due to service changes or promotions, seasonal fluctuations, the effects of levels of service, and transport supply. Trends and seasonal variations are difficult to extract from the Greece demonstration site because, throughout the three years for which ridership data were analyzed, a number of events probably influenced ridership. In addition, the severe vehicle reliability problems during the 1975-76 winter had an impact on ridership. Consideration was given to utilizing Batavia or other demand-responsive systems as a control group to discern seasonal patterns and perhaps start-up trends. Any other system, however, is bound to have some unique characteristics which limit its potential for use as a control system for Rochester. For these reasons, the approach used seems the most reasonable, albeit crude; the conclusions must be tempered by the lack of rigorous analysis.

The promotions varied in their effectiveness. Two of the DAB promotions were highly successful, while little impact was discerned from others. Subscription service promotions were the least effective. Fare promotions conducted during the fall were generally more successful, probably benefiting from the increased shopping travel market and the approaching colder weather.

6.8.2 Survey Results

The results from two questions from different DAB surveys about PERT information are shown in Exhibit 6.28. The first two DAB surveys pertained to initial sources of PERT information, whereas the 1976 survey discloses the sources contacted for additional information. The results suggest that between the direct mailings and the RTS flyers, about half the riders at the beginning of the project found

EXHIBIT 6.28

SOURCE OF INFORMATION ABOUT PERT

(DAB Passengers)

Survey Date	Sample Size	Max.Conf. Range at a = .05	Dial-A-Bus Riders' Information Sources					
			Direct Mail	Newspaper Ads	TV/Radio/ Newspaper	RTS Info Flyers	Word of Mouth	Other
10/17/73	86	±10.8%	19.8%	20.9%	8.1%	10.5%	9.3%	31.4%[1]
6/6-7/75	442	± 4.7%	14.9%	36.4%	12.9%	4.7%	20.1%	11.0%[2]
6/12-14/76	355	± 5.2%	18.6%	13.5%	5.1%	25.7%[3]	34.9%	2.3%
12/15/76	117	± 9.1%	35.9%	14.5%	3.4%	22.2%[3]	20.4%	2.6%

[1]The October 1973 survey listed the above five categories and respondents checked one. The 31.4% under "other" checked more than one category.

[2]The June 1975 survey asked respondents to fill in a blank and the results were categorized by MIT personnel; 11.0% of the responses listed a source other than the categories above.

[3]The 1976 surveys listed seven categories; RTS Info/Flyers includes: "Calling PERT," "PERT Bus Drivers," and "RTS."

(Work Subscription Passengers)

Direct Mailing	34.7%
Advertisement	23.4%
Kodakery (Kodak Newspaper)	9.7%
Other Workers	7.3%
At Home	12.1%
Other	12.9%

(Maximum 95% confidence range is ±8.5%)

out about PERT directly from RTS information. By the time the project was two years old, most of the riders had heard about PERT through more general sources, including the news media and "word-of-mouth." This might be partly because persons who had known about PERT for several months or more were likely to check "word-of-mouth" or "newspapers" if they could not remember where they first heard about PERT. About half of the "other" responses to the 1975 survey were people saying they saw the buses on the road.

On the 1976 DAB surveys, rather than being asked about their first source of information about PERT, users were asked from what source they received most of their information on PERT. About one-third in June 1976 answered friends or family (essentially "word-of-mouth"), and about one-sixth each cited the household mailings and by telephoning PERT. Newspapers were cited fourth, followed by the PERT bus drivers and radio or television.

The results seem to indicate that marketing PERT information may require a multi-phased strategy. Although most users first became acquainted with PERT services through the more traditional and planned media efforts, over half of the subsequent information was obtained from other PERT users and employees (order processors and drivers). The public relations role of these employees can thus be a significant one.

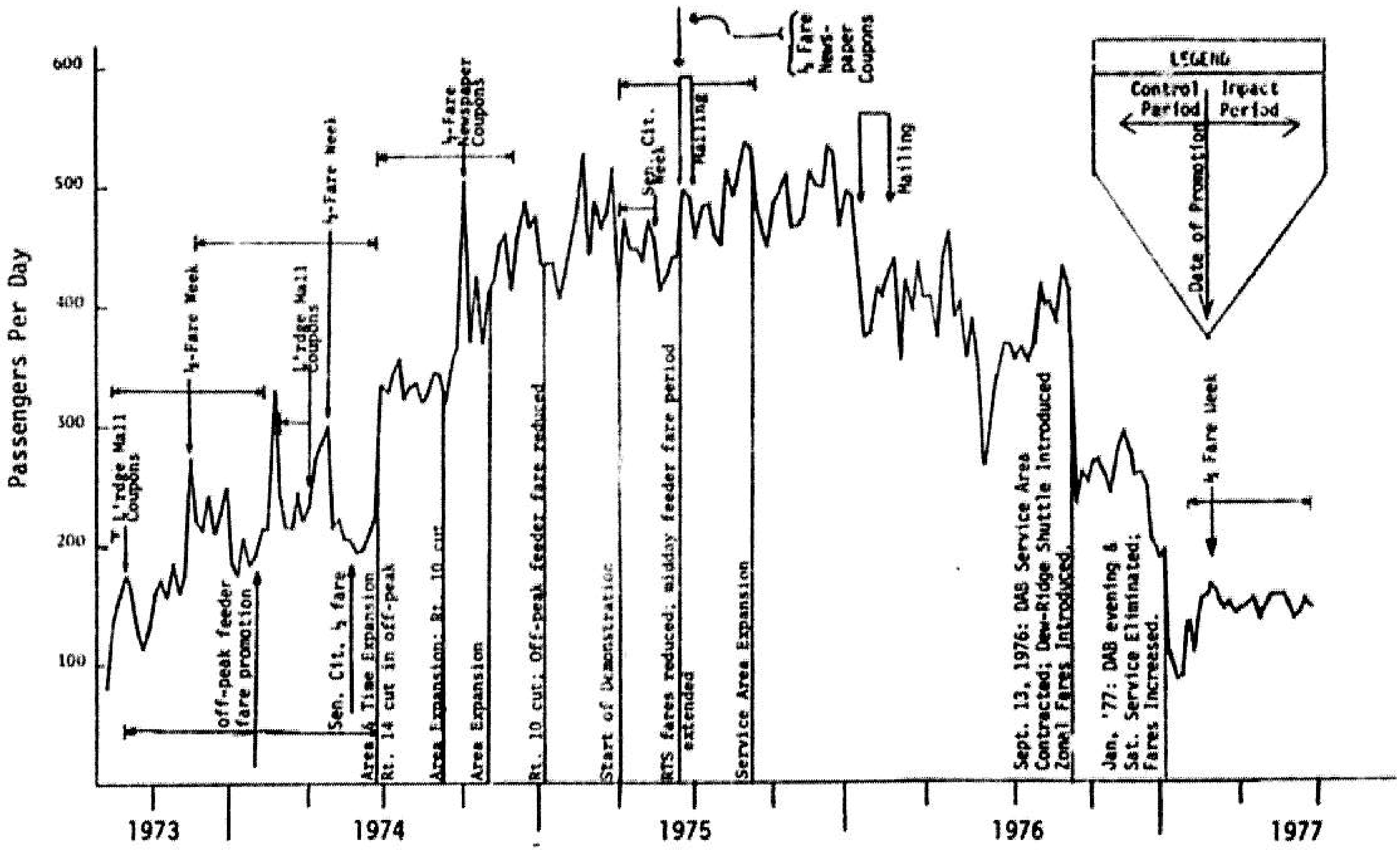
In addition to the two DAB on-board surveys discussed above, a similar initial source of information question was asked in the April 1975 telephone survey of home-to-work subscription service users. Altogether, there were 124 responses divided among the sources of information listed in Exhibit 6.28. Although the categories differ somewhat, the results were similar to those of the first DAB on-board survey.

6.8.3 Reduced-Fare Promotions (Dial-A-Bus and Dew-Ridge Shuttle)

In addition to the continued dissemination of information during the PERT project, considerable incentive marketing was conducted, primarily through the lowering of fares for short periods. These DAB reduced-fare periods and their impacts are discussed in this section. The ridership data used for this analysis is presented in Exhibit 6.29, which shows the various promotions as well as the before and after periods used in the analysis. This exhibit also indicates the significant events which occurred during the demonstration.

EXHIBIT 6.29

AVERAGE DAILY DIAL-A-BUS RIDERSHIP, BY WEEK



In general, the earlier promotions had the greatest impact on ridership. For example, the first half-fare week, implemented three months after the start of service, was extremely successful in attracting riders to DAB. In April 1974, when the second half-fare week occurred, ridership increased only slightly and, by the third half-fare promotion in 1977, no impacts could be discerned. These results indicate that later promotions might become progressively less effective, since each has a smaller pool of potential new users it can hope to attract.

First Half-Fare Week. During the week of November 12, 1973, the DAB fare was 50 cents rather than $1.00 between 9:00 A.M. and 3:00 P.M. A direct mailing to all 17,000 households within the service area was used to publicize the discounts. Ridership during that week averaged 273 passengers daily, up 73% from the average of twelve weeks preceding the promotional week. The ridership increase thus exceeded the fare reduction, 73% compared to 50%. The daily revenue average was $172, compared to about $120 during the previous twelve weeks. Ridership might have been even higher, but low-quality service caused by increased demand led to an unusual increase in no-shows and cancellations. An even more significant result of this promotion was that during the following twelve weeks (until the new promotion on February 11, 1974) DAB averaged 210.3 passengers per day, 33% more than the pre-promotion level (see Exhibit 6.30).

Some of this increase can be traced to the normal pre-Christmas increase starting in mid-November; that is, the first six weeks after the half-fare week (through December 28) averaged 227.6 passengers per day, while the six-week period from December 30 through February 8 averaged 192.9. Thus, ridership dropped markedly after Christmas, but was still 22% above the average before the half-fare week. Much of the increase can be attributed to the nationwide gasoline shortage for several months after the half-fare week. National transit ridership during this period tended to be relatively high. Rochester RTS ridership between December 1973 and March 1974 ranged between 5% and 10% above figures for the previous and following years. Thus, the gasoline shortage and Christmas season probably accounted for some portion of the overall ridership increase which followed the half-fare experiment.

Off-Peak Feeder Reduced-Fare Promotion. For two weeks in mid-February, 1974, the off-peak feeder fare (including transfer) was set at 40 cents, and the reverse PERT trip was free (riders still had to pay the 40-cent RTS fare). A PERT and RTS bus trip would usually cost $1.05 -- $1.00 for PERT plus 5 cents for the transfer. For 25 weeks before the promotion (after an initial two-week growth period when service began), the average number of DAB transfers per day

EXHIBIT 6.30

DAB HALF-FARE PROMOTION IMPACTS

Promotion		First Half-Fare Week	Half-Fare Off-Peak Feeder	Second Half-Fare Week	Third Half-Fare Week
Promotion Dates		Nov. 12-16, 1973	Feb. 11-22, 1974	April 22-26, 1974	March 14-18, 1977
Pre-Promotion Control Period	Dates	8/20/73-11/9/73	8/20/73-2/8/74	11/19/73-4/19/74	2/7/77-3/11/77
	Start of Control Period	After initial two-week ridership growth	Two weeks after start of service.	One week after 1st half-fare week (include Washington's Birthday)	A month after service and fare changes
Post-Promotion Period	Dates	11/19/73-2/8/74	2/25/74-6/21/74	4/29/74-6/21/74	3/21/77-6/17/77
	End of Impact Period	Start of feeder fare promotion	Route 14 cut-back; service area & time expansion	Route 14 cut-back; service area & time expansion	End of Demonstration
Changes in ridership from control period (significance level)	During Promotion	+73%[a] (.01)	+127%[b] (.01)	+32%[a] (.06)	-3% (.34)
	After Promotion	+33%[a] (.01)	+50%[b] (.01)	-8%[a] (.16)	-4% (.14)
Other Influential Factors		Normal X-mas season increases perceived gasoline shortage		Easing of gasoline shortage; Spring seasonal decline; RTS strike during promotion	Poorly timed advertising; Recent service quality and vehicle problems
Comments				Before period includes off-peak half-fare feeder promotion, which had a minor effect; and Longridge Mall coupon which had little effect	

[a]Dial-A-Bus

[b]Dial-A-Bus Transfers

remained fairly steady at 13.5. From February 11 to June 21, 1974, the number of transfers per day averaged 21.4 fairly consistently (see Exhibit 6.16). In addition to the promotion, however, the practice of RTS drivers booking DAB requests for riders also began on February 11, 1974. These effects may be isolated by examining Exhibit 6.31, which compares the respective increase in transfers to and from RTS buses. The assumption underlying this analysis is that this new policy only affected transfers to PERT.

As shown in Exhibit 6.31, transfers to fixed-route buses actually increased more than transfers from RTS buses to DAB, or 60% compared to 53%. This suggests that the new policy of drivers being able to request PERT service did not affect the number of transferring passengers, since transfers to RTS buses actually increased by a greater proportion.

The increase in transferring passengers which began on February 11, 1974 may also have been due to total DAB ridership growth as well as to the two-week promotion. Therefore, it is necessary to compare transfer ridership to DAB non-transfer ridership. For this analysis, the non-transferring riders serve as a control group; that is, if DAB usage generally increased overall, one would expect comparable increases in the number of transferring and non-transferring passengers. During this period, there was a 25% overall increase in DAB ridership and a 23% increase in non-transferring passengers, compared to a 58% increase in transferring passengers (see Exhibits 6.29 and 6.16).

This can be explained by the fact that total DAB ridership during the pre-promotion period grew in two distinct phases. Until November 12, non-transferring ridership averaged 144 per day. Stimulated by the general DAB half-fare promotional week, non-transferring ridership after November 12 until the feeder promotion averaged 201 per day, an increase of 29%. However, this figure only rose to 213 following the off-peak feeder promotion. Thus, when comparing the latter portion of the off-peak feeder pre-promotion period to the post-promotion period, the increase in non-transferring passengers is only 6% (201 to 213), and the 52% increase (58%-6%) in transferring passengers may be attributed to the two-week promotion. It seems, then, that the two-week promotion of feeder service in February 1974 stimulated most of the 58% increase occurring over the next 19 weeks when compared to the preceding 25 weeks.

<u>Second Half-Fare Week.</u> The second DAB half-fare week took place during the week of April 22-26, 1974. Unfortunately, the first day coincided with an RTS drivers' strike. Average daily ridership for the week, however, was 300.5, about 32% higher than the average of 227.8 for the 22 weeks

EXHIBIT 6.31

INCREASE IN TRANSFERS BY DIRECTION OF TRANSFER

Mean Number of Daily Transfers	PERIOD		Percent Change	2/11/74-2/22/74 Only (Promotion Period)
	1 (8/20/73-2/8/74)	2 (2/11/74-6/21/74)		
DAB to RTS	10.68	17.08	+60%	23.70 (+122%)
RTS to DAB	2.8	4.28	+53%	6.90 (+146%)
All Transfers	13.48	21.36	+58%	30.60 (+127%)

following the first half-fare week. This was somewhat less than the 73% increase recorded during the first half-fare week. Less revenue was also collected; a daily average of $159.31 in revenues were collected during the half-fare week, compared to $173.99 during the previous 22 weeks. In addition, unlike the first half-fare week, ridership during the eight weeks following the half-fare promotion dropped to 209 passengers per day, or 8% less than the 22-week pre-promotion average. Major service innovations were implemented after eight weeks, making further comparison impossible. Thus, the impact of this half-fare week on ridership was smaller than that of the first half-fare week.

The ridership decrease which followed the second half-fare week is puzzling, but may be explained in two ways. First, May and June appear to be "slow" months, perhaps influenced by warmer weather. Trend data also reveal an approximate 9% drop in DAB ridership during these months in 1975, and a similar decline in 1976. Another important factor is that the panic caused by the perceived gasoline shortage began to abate at this time. RTS ridership during May and June 1974 ranged from 5% to 10% below the winter levels of that year. These two factors may account for the 8% decrease in ridership following the half-fare promotion. In fact, their combined effects probably exceed 8%, suggesting that a slight ridership increase resulted from the promotion.

<u>Third Half-Fare Week.</u> The third DAB half-fare week occurred from March 14-18, 1977. During that week, DAB ridership averaged 150 passengers per day, about a 3% increase compared to the previous four-week period. The absence of any ridership increase was probably because the newspaper advertisements announcing the promotion appeared late (see Exhibit 6.30).

Ridership remained fairly stable following this half-fare week, decreasing by only 4% through June 1977, when the analysis period ended.

<u>Half-Fare Newspaper Coupons.</u> During the week of September 30, 1974, half-fare DAB coupons were placed in local newspapers. Ridership during that week averaged 504.8 passengers per day. The appropriate control period was the period since June 24, 1974, when many service changes were made. DAB ridership averaged 338.3 during that period. Thus, there was a 49% increase in ridership during the week of September 30. After September 30, until the major Route 10 cutback on January 6, 1975, DAB ridership averaged 421.4. This is 25% more than the preceding control period, making the results similar to those of the first half-fare experiment (see Exhibit 6.30 and 6.32). As in the first experiment, the approaching Christmas season helped to boost

EXHIBIT 6.32

DAB HALF-FARE COUPON AND DEW-RIDGE FREE FARE IMPACTS

Promotion		Half-Fare Newspaper Coupons	Half-Fare Coupon Mailings (I)	Dew-Ridge Shuttle Free Fare Week
Promotion Dates		Sept. 30- Oct 5, 1974	June 16-28, 1975	October 11-15, 1976
Pre-Promotion Control Period	Dates	6/24/74-9/28/74	4/8/75-6/14/75	9/27/76-10/9/76
	Start of Control Period	One week after Route 14 cutback; service area & time expansion	After winter weather	Two weeks after service began
Post-Promotion Period	Dates	10/7/74-12/7/74	6/30/74-9/6/74	10/18/76-12/4/76
	End of Impact Period	X-mas season increase	Service area expansion	X-mas season increase
Changes in DAB ridership from control period (significance level)	During Promotion	49% (.01)	11% (.01)	10% (.16)
	After Promotion	25% (.01)	11% (.01)	3% (.72)
Other Influential Factors		Approaching X-mas season	Summer ridership increase, mail timing problems	Approaching X-mas season; new service
Comments				

ridership during the post-promotion period, for ridership after the promotion steadily increased until Christmas.

Half-Fare Coupon Mailing (I). During three weeks in June 1975, promotional PERT newsletters were mailed to 22,000 households in the service area; these newsletters included half-fare coupons for specific services and weeks. Unfortunately, the use of third-class postage resulted in all households receiving the newsletters at about the same time and generally late. Customers were consequently allowed to use the coupons for one week after their expiration date. Since the general confusion resulting from the mailing error may have invalidated the experiment, an extensive analysis was never undertaken. Although the ridership data indicates that the 11% ridership increase was statistically significant (at the .01 level), the increase could easily reflect depressed spring ridership levels rather than impacts of the promotion (see Exhibit 6.32).

Half-Fare Coupon Mailing (II). A second half-fare coupon mailing was conducted between late January and early March 1976. The service area was divided into five sub-areas, with roughly the same number of households in each, and a "Winter Wonderline" half-fare coupon was mailed to all 22,894 households over a six-week period. The coupons mailed within each sub-area were valid during overlapping two-week periods. Senior citizens could split the coupon and use it for two half-fare rides during the midday reduced-fare period for the elderly.

A total of 703 coupons was used during the promotion, or 3.07% of the total number mailed; 307 coupons were used by passengers who would normally pay the regular fare, and 396 were used by the elderly and handicapped. Thus, if each elderly or handicapped user used the coupon for two rides, the promotion would have impacted 505 persons (307 + 396/2).

The impact of this promotion was seriously affected by several operational problems experienced during the promotion period. Most significant, a high level of vehicle breakdowns beginning in December 1975 had a detrimental effect on service levels, and caused DAB ridership to drop dramatically during the month of January. Daily DAB ridership after January 1976 was less than 400 persons, representing an approximate 20% decrease in ridership from late-1975 levels. Thus, the effect of the "Winter Wonderline" promotion on total DAB ridership was overshadowed by the ridership decrease resulting from the deteriorating level of service. Consequently, a "before and after" analysis was not done.

Dew-Ridge Shuttle Free-Fare Week. During the week of October 11-15, 1976, the Dew-Ridge Shuttle's fifth week of operation, no fare was charged. Average ridership that week was 157 passengers per day, an increase of about 10% when compared to the previous two-week level of 141. However, Dew-Ridge ridership had been growing since the Shuttle was introduced four weeks earlier. After the week of October 11, until the approaching Christmas holidays boosted demand during mid- and late-December, Dew-Ridge ridership averaged 145 passengers per day, up only slightly from the preceding control period. This change was only significant at the .72 level, and therefore should not be considered a significant variation in Dew-Ridge Shuttle ridership. These results indicate that the fare promotion had little or no effect on ridership (see Exhibit 6.32).

Longridge Mall Half-Fare Coupons (I). The first fare incentive program was held during the week of August 23-31, 1973, corresponding to the major Greece shopping mall's "Back to School" promotion. Half-fare coupons were available at all stores in the Longridge Mall, and were valid only for the return trip from the mall. Since the Merchants' Association paid the other half of the fare, there was no loss in DAB revenue.

Trips from Longridge Mall during the promotion represented about 15% of total DAB ridership, and overall DAB ridership did not seem to have been affected. DAB ridership during the week of August 27, 1973 averaged 173.4 per day, and was the highest compared to several weeks thereafter. However, the last week in August is typically a high ridership period, as reflected by data for later years. In 1974, the 346.3 average daily DAB ridership during the last week in August was the second highest of the demonstration. The 538 passengers/day average during the week of August 25, 1975 was a system high not exceeded until just before Christmas. Finally, ridership during the week of August 30, 1976 was the highest since April of that year. Thus, the minor increase in ridership occurring during the half-fare program does not seem to be significant, considering the trend that surfaced in the latter years (see Exhibit 6.33).

Longridge Mall Half-Fare Coupons (II). During the week of April 1, 1974, half-fare coupons were again distributed at Longridge Mall for trips from the mall. Average DAB ridership during that week was up 7% from the preceding control period. The change was only significant at the .66 level when compared to the control period and, thus, it was judged to be an insignificant variation in average daily DAB ridership. Any increase in overall ridership resulting from this promotion cannot be detected from the available data (see Exhibit 6.33).

Senior Citizens Week. On May 15 and 16, 1974, several hundred half-fare coupons for senior citizens were distrib-

EXHIBIT 6.33

LONGRIDGE MALL COUPON IMPACTS

Promotion		Longridge Mall Half-Fare Coupons (I)	Longridge Mall Half-Fare Coupons (II)	Senior Citizens Week
Promotion Dates		Aug. 23-31, 1973	April 1-5, 1974	Coupons distributed May 15-16, 1975
Pre-Promotion Control Period	Dates	8/20/73-8/24/73	11/19/73-3/29/74	4/8/75-5/10/75
	Start of Control Period	After initial 2-week ridership growth	After first half-fare week	After winter weather
Post-Promotion Period	Dates			
	End of Impact Period			
Changes in DAB ridership from control period (significance level)	During Promotion	+9% (-)*	+7% (.66)	-5% (.26)(May 13-24)
	Post-Promotion			
Other Influential Factors		Normal high ridership during week before Labor Day		
Comments		Trips from Longridge Mall represent about 15% of total DAB ridership	Trips from Longridge Mall represent about 15% of total DAB ridership	

*Control period only 1 week long

uted at Longridge Mall. No significant change in DAB ridership could be detected during that week or the next; in fact, a small decrease in ridership actually occurred (see Exhibit 6.33).

6.8.4 Subscription Service Reduced-Fare Promotions

Subscription ridership over the course of the demonstration is shown in Exhibit 6.34, which also identifies the important events affecting ridership. The ridership data in this exhibit is the basis of the following analyses.

Work Subscription Service Promotion. During the week of September 24, 1973, a reduced-fare promotion was instituted for work subscription service, with the weekly fare reduced from $7 to $5; the results of this promotion are summarized in Exhibit 6.35. Home-to-work subscription ridership during that week rose 31% over the previous week. The fare reduction was 28%, and a very small decrease in revenue resulted from the promotion.* It should be noted that this promotion took place only seven weeks after the start of subscription service, and ridership was growing rapidly. For example, during the two weeks preceding the promotion, consecutive ridership gains of 41% and 26% respectively were recorded. Ridership during the week after the promotion was slightly higher than the week before the promotion, but there were also weekly ridership increases as high as 13% over nine of the next ten weeks (Thanksgiving Week was the exception). Then, after three weeks of lower ridership during the Christmas season, new ridership records were set for another two weeks in a row. Thus, it is impossible to assess exactly how great a long-term impact the promotion had in view of the constant ridership increases occurring before and after it.

Subscription Feeder Promotion (I). Coinciding with the off-peak DAB feeder promotion in mid-February 1974 was a three-week subscription feeder promotion in which the weekly

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*In order to increase total revenues, the percentage increase in ridership (Pr) must exceed the percentage decrease in fares (Pf) according to the formula:

$$Pr > \frac{100(Pf)}{100-Pf}$$

EXHIBIT 6.34

AVERAGE DAILY SUBSCRIPTION RIDERSHIP, BY WEEK

(Home-to-Work and Subscription Feeder Services)

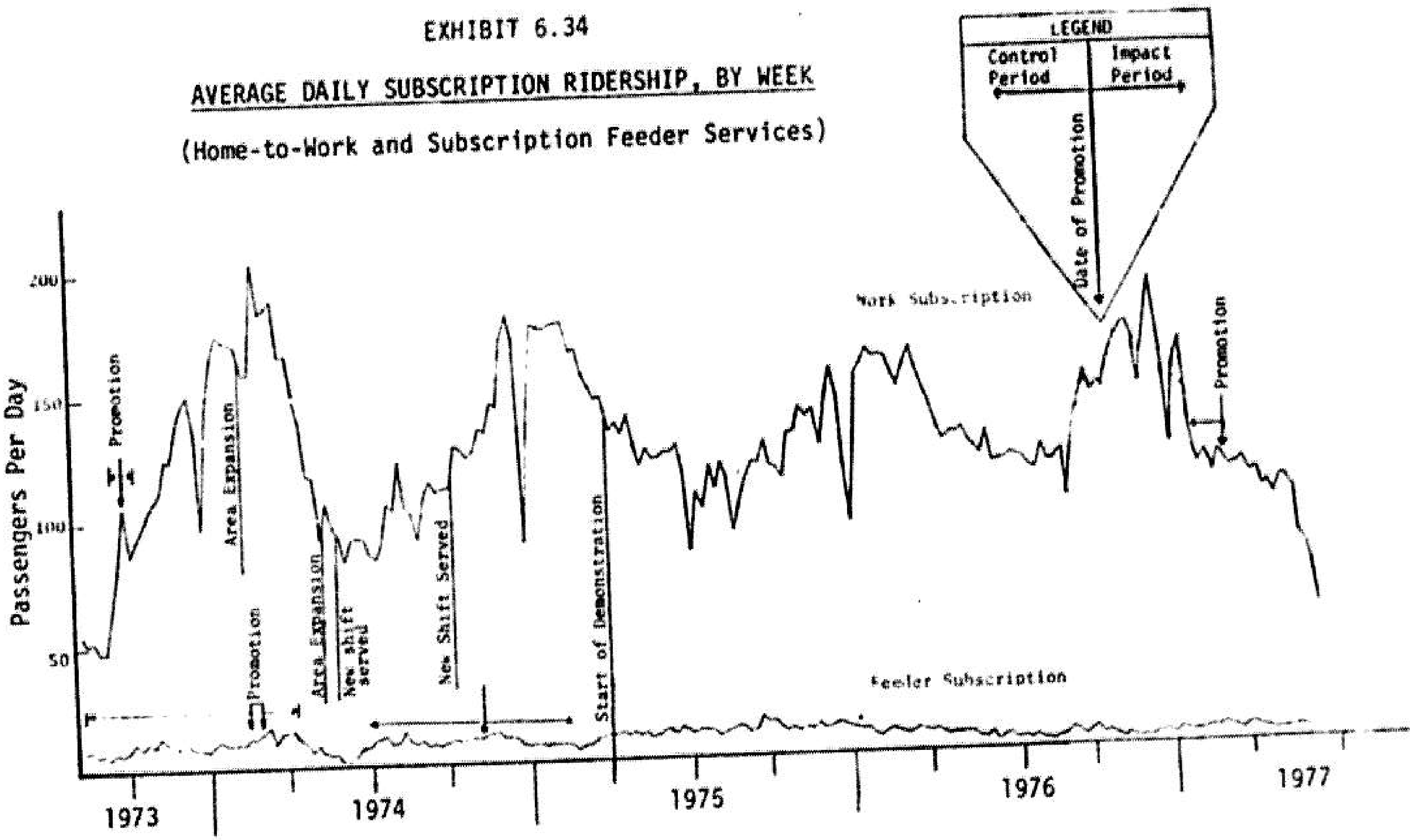


EXHIBIT 6.35

SUBSCRIPTION PROMOTION FARE IMPACTS

Promotion		Work Subscription	Subscription Feeder (I)	Subscription Feeder (II)
Promotion Dates		9/24/73-9/28/73	2/11/74-3/1/74	11/11/74-11/16/74
Pre-Promotion Control Period	Dates	9/17/73-9/21/73	8/6/73-2/8/74	6/24/74-11/8/74
	Start of Control Period	1 week before; ridership in growth trend	Start of PERT project	June, 1974 service changes
Post-Promotion Period	Dates	10/1/73-10/5/73	3/4/74-4/5/74	11/18/74-2/8/75
	End of Impact Period	1 week after; ridership in growth trend	Spring decline in subscription ridership	12-week cutoff point
Changes in ridership from control period	During Promotion	+31%[1] (-)*	+38%[2] (.01)	+24%[2] (.13)
	Post-Promotion	+8%[1] (-)*	+42%[2] (.01)	-9%[2] (.23)
Other Influential Factors		Ridership rising for several weeks before and after promotion		
Comments			Small ridership (around 10 passengers/day) makes changes suspect	Small ridership (around 10 passengers/day) makes changes suspect

*Control period only one week long.

[1]Work subscription ridership.

[2]Subscription feeder ridership.

subscription rate was reduced from $7.50 to $5.00. During this promotion, daily ridership averaged 12.3 passengers, a 38% increase over the pre-promotion level of 8.9 riders per day. Since fares were decreased by 33%, a slight revenue loss resulted. The five weeks following the promotion brought a relatively high daily ridership of 12.7 passengers, although a decline began after that time corresponding to the sharp decline in home-to-work subscription riders. The warmer spring weather and the abatement of the gasoline shortage seem to be the major reasons for this change.

While the ridership levels during and after the promotion were significantly different than pre-promotion levels (at the .01 level), the actual difference was less than four passengers per day (or two users per day, since most subscription riders made a round-trip on the bus). (See Exhibit 6.35.)

Subscription Feeder Promotion (II). During the week of November 11, 1974, a second promotion of subscription feeder service was conducted. This promotion was similar to that conducted earlier in the year, when the weekly fare was reduced from $7.50 to $5.00. Ridership during the promotion week averaged 10.8 passengers per day, 24% above the average of 8.73 riders for the previous four and one-half months. Ridership remained high (more than nine passengers per day) for the next four weeks, but over the twelve-week period following the promotion, subscription feeder service averaged 7.91 trips per day, or 9% less than the pre-promotion period. This twelve-week period, however, was one in which subscription home-to-work ridership was particularly high, suggesting that some other factors were influencing these peak-period subscription ridership levels. Not surprisingly, the reported significance levels were weak (.18 and .23), indicating that this promotion did not have a strong impact on subscription ridership levels.

Work Subscription Service Free-Fare Week. During the week of February 28, 1977, no fares were charged for work subscription service. PERT management did not actively promote this event, viewing it more as a token of appreciation to the riders who continued using subscription service through a fare increase and a prolonged period of service unreliability, rather than as a marketing strategy. On January 17, 1977, work subscription fares had been increased between 29% and 40%, and severe winter weather and vehicle shortages occurred during much of December 1976 and January 1977. These events resulted in ridership dropping by about 28% during the six-week period (1/17/77-2/28/77) before the free-fare week, as compared to the preceding seven-week period (11/29/76-1/17/77) before the hike in fares. Ridership during the promotion week was only 1% higher than the preceding six weeks since the fare increase (α =.95), indicating that no noticeable change occurred. Following the free-fare week, ridership began its spring seasonal decline.

7. GREECE: PRODUCTIVITY AND ECONOMICS

The performance measures which indicate the relative operating efficiency of transportation services are generally referred to as the level of productivity. This chapter contains the calculations of productivities, costs and revenues for each Greece PERT service. Total and average costs and revenues are reported for the various Greece services from December 1973 to March 1976, and the results of the estimation of marginal cost functions are presented. In April 1976, PERT began operating in Irondequoit, and all costs for Greece were combined with Irondequoit services, making it impossible to isolate Greece costs after this time (see Chapter 10). This chapter will therefore only cover the productivity and revenue issues in Greece before March 1976, noting any differences that occurred. The environmental effects of PERT are also considered. Finally, PERT productivities and economics are compared to a hypothetical, areawide fixed-route transit alternative.

Since DAB, work and school subscription services accounted for an average of over 98% of all vehicle-hours and 97% of all passengers in Greece during the periods examined, the analysis focuses on these services. Vehicle mileage was not recorded for each service. Consequently, the best available index by which to allocate the costs of inputs (e.g., driver wages) to each service is vehicle-hours. Therefore, individual service costs were defined by their vehicle-hour share of total PERT costs with one important exception. Control room personnel costs were allocated exclusively to DAB service. This assumption had the effect of slightly raising the vehicle-hour cost of providing DAB service, and lowering (by about 9%) the unit costs of the other PERT services compared to the overall syctem average.

7.1 DEFINITION OF THE THREE FLEET PERIODS

The time period over which Greece costs are analyzed contains the 121 weeks between December 7, 1973 and March 27, 1976. Although service actually began in August, the four-month start-up period is excluded. The end of the cost analysis period chosen was the expansion of service to Irondequoit, since the Irondequoit operating costs were included in the same accounts with Greece. Separation of joint costs would be somewhat arbitrary, so the period of Greece-only service has been analyzed. Refer to Chapter 10 for an assessment of the costs for Greece and Irondequoit's PERT services from March 1976 through June 1977.

To examine cost trends, the full 121-week Greece analysis period was divided into three subperiods, each characterized by a substantially different vehicle fleet size. This was done in recognition that the bus (and driver) is PERT's principal input in any production function. Of course, factors other than fleet size helped determine the number of vehicle-hours; for instance, in the short run, changes in the vehicle run guides, and in the long run, changes in passenger demand for PERT services. (Run guides normally changed three times per year in January, June and September.) However, vehicle fleet size is the fundamental determinant of capacity and, for that reason, three separate periods were demarcated by the substantial changes in this variable. The three subperiods and their associated fleet sizes were: period one, from December 3, 1973 to September 7, 1974, a period of 40 weeks with a fleet of seven to eight buses (the eighth bus was added during the week of January 18, 1974); period two, from September 9, 1974 to June 21, 1975, a period of 41 weeks with a fleet of 11 to 13 buses (the twelfth and thirteenth buses were added during the weeks of December 2, 1974 and January 6, 1975, respectively); and period three, from June 23, 1975 to March 27, 1976, a period of 40 weeks with a fleet size of 16 buses, excluding the use of the 12 new General Motors buses as substitutes beginning in December 1975. The above division creates three almost equally-sized periods for analysis.

Some variation in fleet size occurred within each of the three subperiods, but this variation was more gradual and smaller than that occurring between adjacent periods. Between periods one and two, there was a substantial increase in total PERT vehicle-hours; between periods two and three, little change occurred.

In order to derive the results which follow, a number of adjustments to the PERT accounting records were necessary. These are described in Appendix A.19 along with samples of those records.

7.2 AVERAGE PRODUCTIVITIES, COSTS AND REVENUES

Exhibit 7.1 summarizes the economic and productivity results for PERT and each of its services for each of the three periods defined above. Weekly averages of supply and demand variables are listed, as well as the computer vehicle productivity, costs and revenues. For all cost figures, the zero percent designation means that no interest charge was included in the calculation, while the 10% designation indicates that an inclusion of an annual 10% interest charge on the outstanding capital stock was made. PERT's accounts do not actually include interest charges since Rochester

EXHIBIT 7.1

PERT ECONOMICS AND PRODUCTIVITY SUMMARY

(Weekly Averages)

	Period 1 12/7/73-9/7/74 40 Weeks	Period 2 9/9/74-6/21/75 41 Weeks	Period 3 6/23/75-3/27/76 40 Weeks	Three-Period Average 12/7/73-3/27/76 121 Weeks
Supply				
PERT Vehicle Miles	4,846	N/A	7,386	N/A
PERT Vehicle Hours	361.1	679.2	706.6	582.8
Dial-A-Bus Vehicle Hours	268.2	530.7	572.2	456.6
Work Sub. Vehicle Hours	81.80	120.8	102.1	101.7
School Sub. Vehicle Hours[1]	19.39	18.97	25.18	20.97
Special Service Vehicle Hours	1.500	9.122	8.450	6.380
Special Handicapped Vehicle Hrs.[2]	-	-	6.250	6.250
Demand				
PERT Passengers	2,248	3,772	3,827	3,287
Dial-A-Bus Passengers	1,325	2,616	2,712	2,221
Dial-A-Bus Trips	922.4	2,051	2,154	1,712
Work Sub. Passengers	655.3	715.3	674.9	682.1
Work Sub. Trips	637.8	694.6	646.1	659.8
School Sub. Passengers[1]	317.8	306.3	340.1	319.8
School Sub. Trips[1]	225.8	184.8	195.3	199.3
Special Service Passengers	61.20	157.6	185.5	135.3
Special Service Trips	2.875	15.71	10.37	9.780
Special Handicapped Passengers[2]	-	-	16.38	16.38
Special Handicapped Trips[2]	-	-	6.075	6.075
Vehicle Productivity (Per Vehicle Hour)				
PERT Passengers	6.23	5.56	5.42	5.64
Dial-A-Bus Passengers	5.30	4.93	4.74	4.96
Dial-A-Bus Trips	3.48	3.87	3.76	3.75
Work Sub. Passengers	8.01	5.92	6.61	6.71
Work Sub. Trips	7.80	5.75	6.33	6.49
School Sub. Passengers[1]	16.40	16.15	13.51	15.25
School Sub. Trips[1]	11.65	9.74	7.74	9.51
Special Service Passengers	40.80	17.28	21.95	21.16
Special Service Trips	1.92	1.72	1.23	1.53
Special Handicapped Passengers[2]	-	-	2.65	2.65
Special Handicapped Trips[2]	-	-	0.97	0.97

ANNUAL CAPITAL COST INTEREST RATES

	Period 1 0%	Period 1 10%	Period 2 0%	Period 2 10%	Period 3 0%	Period 3 10%	Average 0%	Average 10%
Total Costs ($)								
Total PERT Costs	6,398	6,910	11,286	12,120	14,213	15,366	10,638	11,446
Dial-A-Bus Costs	4,849	5,225	9,310	9,663	11,742	13,169	8,522	9,330
Work Subscription Costs	1,521	1,637	1,864	2,012	1,877	[illegible]	1,705	1,884
School Subscription Costs[1]	313	341	295	316	463	525	352	389
Special Services Costs	26	28	141	152	155	176	107	118
Special Handicapped Costs[2]	-	-	-	-	115	130	115	130
Unit Costs ($)								
Total PERT Cost Per Vehicle-Hour	17.72	19.14	16.64	17.87	20.11	22.39	18.25	20.32
Total PERT Cost Per Vehicle-Mile	1.32	1.43	-	-	1.87	2.10	-	-
Cost/PERT Passenger	2.85	3.07	2.99	3.21	3.71	4.17	3.24	3.55
DAB Cost Per Vehicle-Hour	18.25	19.70	16.96	18.21	20.52	23.00	18.67	20.43
Cost/DAB Passenger	3.66	3.94	3.46	3.69	4.33	4.85	3.84	4.20
Cost/DAB Trip	5.26	5.67	4.39	4.71	5.45	6.11	4.98	5.45
Other Services Cost/Vehicle-Hour	16.15	17.57	15.43	16.66	18.38	20.86	16.76	18.53
Cost/Work Sub. Passenger	2.32	2.19	2.61	2.81	2.78	3.16	2.50	2.76
Cost/Work Sub. Trip	2.07	2.25	2.68	2.90	2.91	3.30	2.58	2.86
Cost/School Sub. Passenger[1]	0.98	1.07	0.96	1.03	1.36	1.55	1.10	1.22
Cost/School Sub. Trip[1]	1.39	1.51	1.38	1.71	2.37	2.69	1.76	1.95
Cost/Special Service Passenger	0.40	0.43	0.89	0.96	0.84	0.95	0.79	0.88
Cost/Special Service Trip	8.45	9.17	8.96	9.67	14.98	17.00	10.93	12.08
Cost/Special Handicapped Pass.[2]	-	-	-	-	6.93	7.86	6.93	7.86
Cost/Special Handicapped Trip[2]	-	-	-	-	18.91	21.46	18.91	21.46

(Exhibit 7.1, Continued)

Total Revenues ($)	Period 1	Period 2	Period 3	Total
Total	1,398.90	2,611.88	2,506.04	2,341.03
Total PERT Revenue	[illegible]2.44	1,877.04	1,826.76	1,556.07
DAB Revenue	514.62	540.55	509.45	521.70
Work Sub. Revenue	153.91	140.36	142.08	144.72
School Sub. Revenue[1]	18.90	64.16	55.81	86.41
Special Services Revenue	-	-	14.57	14.57
Special Handicapped Revenue[2]				

Unit Revenues ($)	Period 1	Period 2	Period 3	Total
Revenue/PERT Passenger	0.71	0.69	0.66	0.68
Revenue/DAB Passenger	0.73	0.72	0.67	0.70
Revenue/DAB Trip	1.06	0.92	0.85	0.91
Revenue/Work Sub. Passenger	0.79	0.76	0.76	0.77
Revenue/Work Sub. Trip	0.81	0.78	0.79	0.79
Revenue/School Sub. Passenger[1]	0.48	0.46	0.62	0.45
Revenue/School Sub. Trip[1]	0.68	0.76	0.73	0.73
Revenue/Special Service Pass	0.34	0.41	0.30	0.34
Revenue/Special Service Trip	6.34	4.09	5.18	4.75
Revenue/Special Handicapped Pass[2]	-	-	0.88	0.98
Revenue/Special Handicapped Trip[2]	-	-	2.40	2.40

Operating Ratios (Revenues/Costs)	Period 1 0%	Period 1 10%	Period 2 0%	Period 2 10%	Period 3 0%	Period 3 10%	Total 0%	Total 10%
PERT	0.25	0.23	0.23	0.22	0.18	0.16	0.21	0.19
DAB	0.20	0.18	0.21	0.19	0.16	0.14	0.18	0.17
Work Subscription	0.39	0.36	0.29	0.27	0.27	0.24	0.31	0.28
School Subscription[1]	0.49	0.45	0.48	0.44	0.31	0.27	0.41	0.37
Special Services	0.78	0.71	0.46	0.42	0.36	0.32	0.43	0.39
Special Handicapped[2]	-	-	-	-	0.13	0.11	0.13	0.11

[1] Data for "School Subscription Service" based on weeks when school in session:
26 weeks in Period 1
38 weeks in Period 2
28 weeks in Period 3
92 weeks in Total

[2] All data for "Special Handicapped Service" based on Period 3 only.

received substantial subsidies from local and federal sources; however, the 10% adjusted figures indicate what other communities might expect costs to be when borrowing to make capital purchases (see Appendix A-19).

Using the assumptions stated in the appendix, the total PERT cost per vehicle-hour ranged from $16.64 during Period 2 with no capital interest rate assessed to $22.59 in Period 3 with a 10% interest rate on capital assessed. A 10% interest rate on outstanding capital items tended to increase total costs by just under 10%, although it had a more serious effect when several hundred thousand dollars worth of equipment was purchased. In the following discussion, the results of the analysis with no interest rate will be used, since the federal capital funding grant program largely eliminates this cost for local communities.

The average cost per vehicle-hour over the 121 weeks examined in Greece was $18.25. Average vehicle productivity declined during this time from 6.23 to 5.42, averaging 5.64 passengers per vehicle-hour for the entire 121-week period. Consequently, the cost per PERT passenger rose from $2.85 during the first period to $3.71 during the last period. Over the 121 weeks considered, the average cost per passenger was $3.24. With an average revenue per passenger of $0.68, an operating ratio of 0.21 was realized.

Exhibit 7.2 displays the breakdown of total PERT costs by item. The 10% interest charge on the outstanding capital stock is indicated, but is excluded from the totals. The most significant changes over time were increases in depreciation charges and control room salaries during the last period. Depreciation charges increased sharply primarily due to the acquisition of three very expensive buses in June 1975 and the twelve GM buses in December 1975. In the control room, an additional administrative position was created during this period.

Total PERT costs per vehicle-hour were comparable to total RTS costs per vehicle-hour, which were $19.44 in the fiscal year ending March 31, 1976 and $17.49 in the previous fiscal year. Drivers' wages and benefits for PERT were slightly higher than for RTS because PERT drivers tended to have greater seniority and therefore higher average salaries. Hourly wages for drivers with more than two years experience were $4.70 when the project began in 1973, but had increased to $6.46 by February 1976. Although PERT had greater vehicle breakdown problems than RTS, PERT maintenance costs were less than those of the RTS system. The lower expenditures may have contributed to the PERT vehicle reliability problems. Other per-hour costs were comparable (see Exhibit 3.17). A much higher RTS vehicle productivity (27.9 in fiscal year 1976), however, resulted in a much lower cost per passenger as compared to PERT.

EXHIBIT 7.2

COMPONENTS OF TOTAL PERT COSTS

Cost Elements (Per Vehicle-Hour)	PERIOD							
	1		2		3		TOTAL	
	Hourly Cost	%	Hourly Cost	%	Hourly Cost	%	Hourly Cost	%
Operators' Salaries (With Benefits)	8.93	50.4	9.01	54.2	9.35	46.5	9.13	50.0
Control Room Salaries (With Benefits)	2.15	12.1	1.91	11.5	2.59	12.9	2.23	12.2
Fuel, Oil, Etc.	0.87	4.9	0.80	4.8	0.88	4.4	0.84	4.6
Maintenance	1.85	10.4	1.90	11.4	2.18	10.9	2.00	11.0
Administration	1.56	8.8	1.21	7.3	1.73	8.6	1.49	8.2
Rent	0.74	4.2	0.49	2.9	0.88	4.4	0.70	3.8
Depreciation & Amortization	1.60	9.0	1.33	8.0	2.51	12.5	1.86	10.2
10% Interest On Capital	(1.42)	-	(1.23)	-	(2.48)	-	(1.77)	-
TOTAL	17.72	100.0	16.64	100.0	20.11	100.0	18.25	100.0

7.2.1 Dial-A-Bus

Total PERT productivity was influenced most heavily by DAB productivity, since DAB accounted for almost three-quarters of all PERT passengers and two-thirds of all PERT vehicle-hours. DAB productivity also dropped over time, from 5.00 to 4.74 passengers per vehicle-hour. In terms of trips per vehicle-hour, however, an increase occurred between Periods 1 and 2, since the number of passengers per trip dropped sharply.

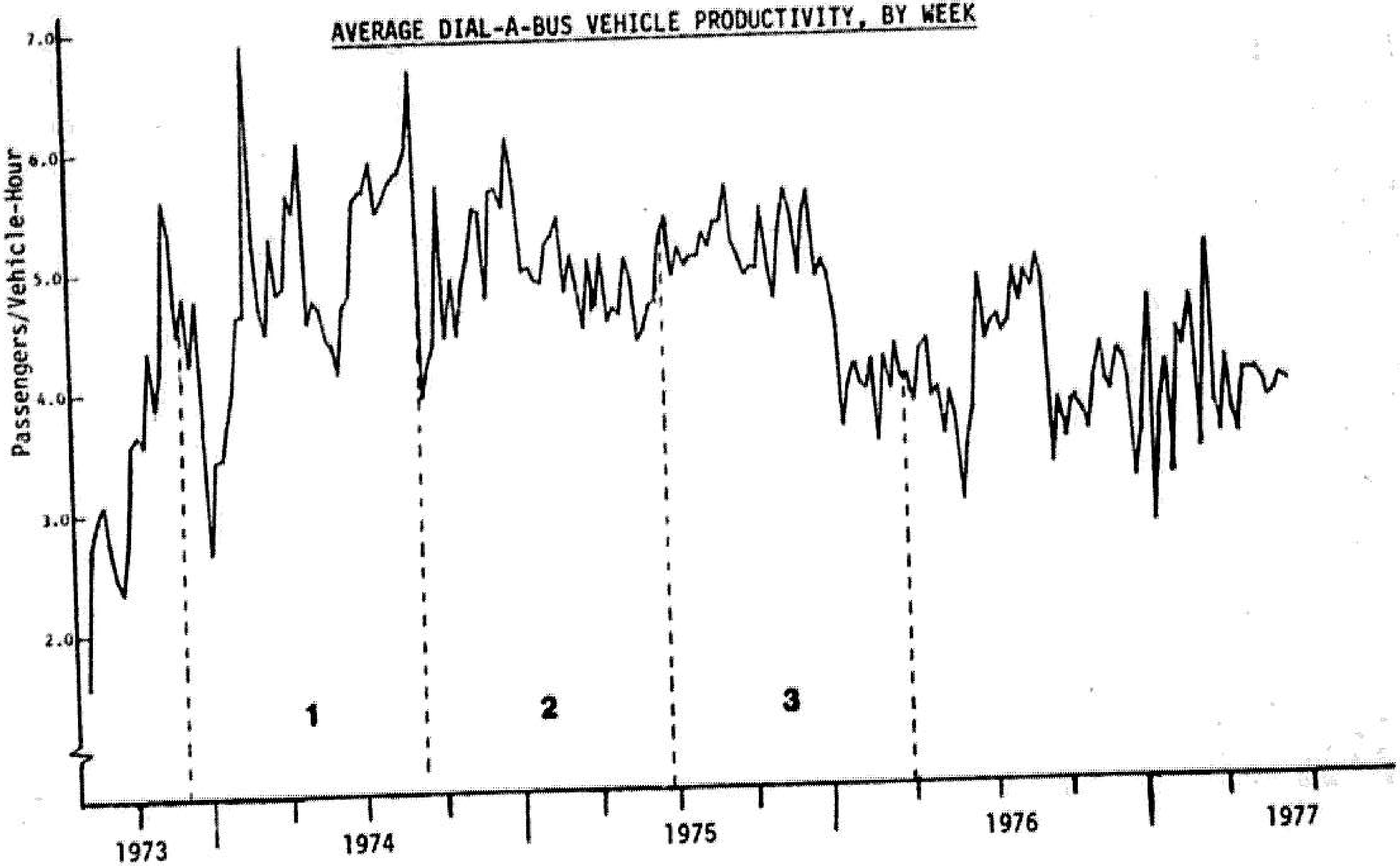
DAB passengers per vehicle-hour are plotted on a weekly basis in Exhibit 7.3, in which the three periods of analysis are shown. The highest weekly vehicle productivity of 6.88 passengers per vehicle-hour was reached during the week of February 18, 1974. Group ridership was high during that week, partly due to a school vacation. However, the highest weekly trip productivity (trips per vehicle-hour) was 4.55, which occurred during the April 1974 half-fare week and the week of September 2, 1974.

The plot of DAB vehicle productivity over time closely resembles that of DAB ridership over time (Exhibit 6.1), compounded by the abrupt changes in vehicle supply which occur three times per year with the new run guides. Vehicle productivity steadily increased with the general ridership increase between the start of service and January 1975; however, an abrupt drop in productivity occurred with the implementation of the September 1974 run guide, when vehicle-hours were added corresponding to the start of the second period. Productivity also dropped in January 1975 with the new run guide, but increased in June 1976 when DAB vehicle allocation was cut. The drop in demand during the 1975-76 winter is also evident from the productivity graph. Overall increases in vehicle-hours tended to cancel out the effects of increasing demand on vehicle productivity. Consequently, DAB vehicle productivity remained at five passengers per vehicle-hour or less. This level seemed to represent an upper bound for the manual system in Greece, above which service levels are likely to deteriorate significantly.

It is instructive to calculate productivity based on passenger-miles. This measure is more appropriate for comparison with other DAB systems with different-sized service areas. In Section 6.1, it was reported that during this time the average DAB passenger trip was 2.8 miles (direct driving distance). Multiplying by the average DAB vehicle productivity of 4.86 results in 13.6 direct-distance passenger-miles per vehicle-hour. Available data from other DAB systems suggest that DAB systems generally operate in the 12 to 15 passenger-miles per vehicle-hour range. In Syracuse, New York and Lincoln, Nebraska, where DAB systems for the

EXHIBIT 7.3

AVERAGE DIAL-A-BUS VEHICLE PRODUCTIVITY, BY WEEK



elderly and handicapped operate in large county areas, vehilce productivities of between 2 and 3.4 passengers per vehicle-hour resulted, but long trip lengths increased the average number of passenger-miles per vehicle-hour to around 14. Likewise, systems with higher passengers per vehicle-hour productivities than Rochester, such as Ann Arbor, Michigan and Haddonfield, New Jersey, experienced shorter trip lengths resulting in direct-distance passenger-miles per vehicle-hour figures in the 12 to 15 range.

The number of DAB direct-distance passenger-miles per vehicle-mile is also estimated. Using the PERT average of around 11 vehicle-miles per vehicle-hour, an average of 1.24 passenger-miles per vehicle-mile results (13.6/11). This translates into an average of 0.97 trip-miles which would have resulted if all DAB passengers could have driven cars to make their trips. However, if all passengers had used taxis, a greater number of vehicle-miles would have been driven due to deadheading.

Because of the full assignment of control room personnel costs to DAB, DAB cost per vehicle-hour was more than that of other services -- $18.67 compared to $16.76 for all three periods. Cost per passenger declined between the first two periods and then increased, averaging $3.84 for 121 weeks. On a passenger-mile basis, the cost was $1.37. The average cost per trip was $4.98, which is substantially higher than the cost of taxi service in the area, assuming that taxi fares cover all operating costs. For the average 2.8-mile DAB trip, a typical taxi fare is $2.20 ($0.60 for the first 1/6 mile; $0.10 per additional 1/6 mile). The cost of an automobile trip or an RTS bus trip was also less than DAB cost.

Average revenues per DAB passenger and trip dropped over time because of the introduction of the reduced fares for the elderly during the off-peak period and the midday feeder fare (see Chapter 4). With an overall average revenue per passenger of $0.70, 18% of DAB costs were recovered from the farebox.

Compared to other dial-a-ride systems, Greece DAB had a slightly lower vehicle productivity and a much higher cost per vehicle-hour and per passenger (see Appendix A.20). The average Greece DAB cost per vehicle-hour of $18.67 was about double the average of other systems for which data were available. All major PERT cost categories (e.g., driver salaries, maintenance, administration, control room) were higher than in these other systems. PERT operating efficiency, as measured by the number of passengers carried per vehicle-hour, was estimated to be about 15% lower than in other systems, which was not statistically significant. This estimate was obtained after controlling for the level of demand density achieved in Greece. As discussed in

Section 7.3, vehicle productivity can be expected to increase with higher demand.

7.2.2 Dial-A-Bus and the Dew-Ridge Shuttle Productivities After 1976

As discussed in Section 4.2, the service and fare changes implemented in September 1976 and January 1977 were primarily designed to improve the efficiency and economics of off-peak PERT operations in Greece by decreasing the total supply of services. The specific objective was to lower the net cost of operations by increasing vehicle productivity and revenues.

The productivity and economic impacts of these changes are summarized in Exhibit 7.4. Average operating parameters are shown for three periods: before September 1976; between September 1976 and January 1977; and after January 1977. The actual data chosen to represent each period was selected in order to represent the period's normal operating characteristics; the December 1976-January 1977 period with unusually severe vehicle problems and depressed ridership was omitted. The percentage change from the previous period is shown in parentheses.

The September service changes had a minor impact on productivity and economics. Total supply (vehicle-hours) remained relatively constant and, although DAB revenue per passenger increased, the Dew-Ridge line charged much lower fares and the combined average revenue per passenger was about identical to that on DAB before the change. A slight decrease in total passengers thus resulted in a small decrease in overall vehicle productivity and revenue recovery.

After January 1977, vehicle supply sharply decreased as late afternoon, evening and Saturday DAB service was eliminated. The weekly (including Saturdays) decrease in DAB vehicle hours supplied was 54%. This decrease exceeded the resulting demand decrease, and combined DAB and Dew-Ridge Shuttle vehicle productivity rose to 5.67 passengers per vehicle-hour, a 24% increase. However, average revenue per passenger dropped as a result of the lower-priced Dew-Ridge line becoming a more important component of the total service package. Consequently, overall revenue per vehicle-hour rose by only 12%, to $3.08. This exceeded DAB revenues during the six-week period prior to the September service changes by 5%, but was still lower than that recorded in the earlier phases of the project, when DAB revenues per vehicle-hour were $3.63, $3.54 and $3.19 respectively (see Section 7.2.1).

EXHIBIT 7.4

PRODUCTIVITY AND ECONOMICS FOR DIAL-A-BUS AND DEW-RIDGE SHUTTLE
(Percent Change from Previous Period)

	Pre-Sept. 1976 (6 Weeks: 8/2-9/11/76)	Sept. 1976 Changes (11 Weeks: 9/13-11/27/76)[1]	Jan. 1977 Changes[2] (16 Weeks: 2/7-5/27/77)
Daily Ridership			
DAB	405.6	260.6 (-36%)	150.3 (-42%)
Dew-Ridge	--	146.1[2]	165.5 (+13%)
DAB & Dew-Ridge	405.6	382.4[3] (-6%)	315.8 (-17%)
Daily Vehicle-Hours			
DAB	82.5	69.7 (-16%)	38.7 (-46%)
Dew-Ridge	--	17.0[2]	17.0 (-)
DAB & Dew-Ridge	82.5	83.7[3] (+1%)	55.7 (-33%)
Vehicle Productivity			
DAB	4.92	3.73 (-24%)	3.88 (+4%)
Dew-Ridge	--	8.59[2]	9.74 (+13%)
DAB & Dew-Ridge	4.92	4.57[3] (-7%)	5.67 (+24%)
Revenue/Passenger			
DAB	59.8¢	77.7¢ (+30%)	88.3¢[4] (+14%)
Dew-Ridge	--	22.0¢[2]	23.4¢ (+6%)
DAB & Dew-Ridge	59.8¢	60.0¢[3] (-)	54.3¢ (-10%)
Revenue/Vehicle-Hour			
DAB	$2.94	$2.91 (-1%)	$3.43[4] (+18%)
Dew-Ridge	--	$1.89[2]	$2.28 (+21%)
DAB & Dew-Ridge	$2.94	$2.74[3] (-7%)	$3.08 (+12%)

[1]Nine weeks for Dew-Ridge; first two weeks not considered because ridership was building.

[2]Actual daily average for days operated (no Saturdays).

[3]Average including Saturdays.

[4]Excludes one DAB half-fare week.

Thus, the September 1976 and January 1977 service and fare changes improved overall PERT vehicle productivity but did not significantly increase revenue recovery rates. Also, dial-a-bus vehicle productivity was to significantly lower than what is typical of other dial-a-ride services in the United States (see Appendix A.20). However, the cutback of services in January 1977 greatly decreased the total cost of providing PERT services and, consequently, the net cost or deficit incurred.

7.2.3 Work Subscription Service

Work subscription service productivity fluctuated considerably, as the graph in Exhibit 7.5 indicates. During the 1973-74 winter, when there was a nationally- perceived gasoline shortage, ridership was high and vehicle productivity remained above ten passengers per vehicle-hour for most of the winter. Following that period, vehicle productivity was between five and seven and averaged 6.71 passengers per vehicle-hour in the 121 weeks considered in this analysis. On a passenger-mile basis, this resulted in 22.8 passenger-miles per vehicle-hour and 2.1 passenger-miles per vehicle-mile. (An average trip length of 3.4 miles and a vehicle speed of 11 miles per hour is assumed.) The passenger mile productivity figures are substantially higher than those obtained for DAB service.

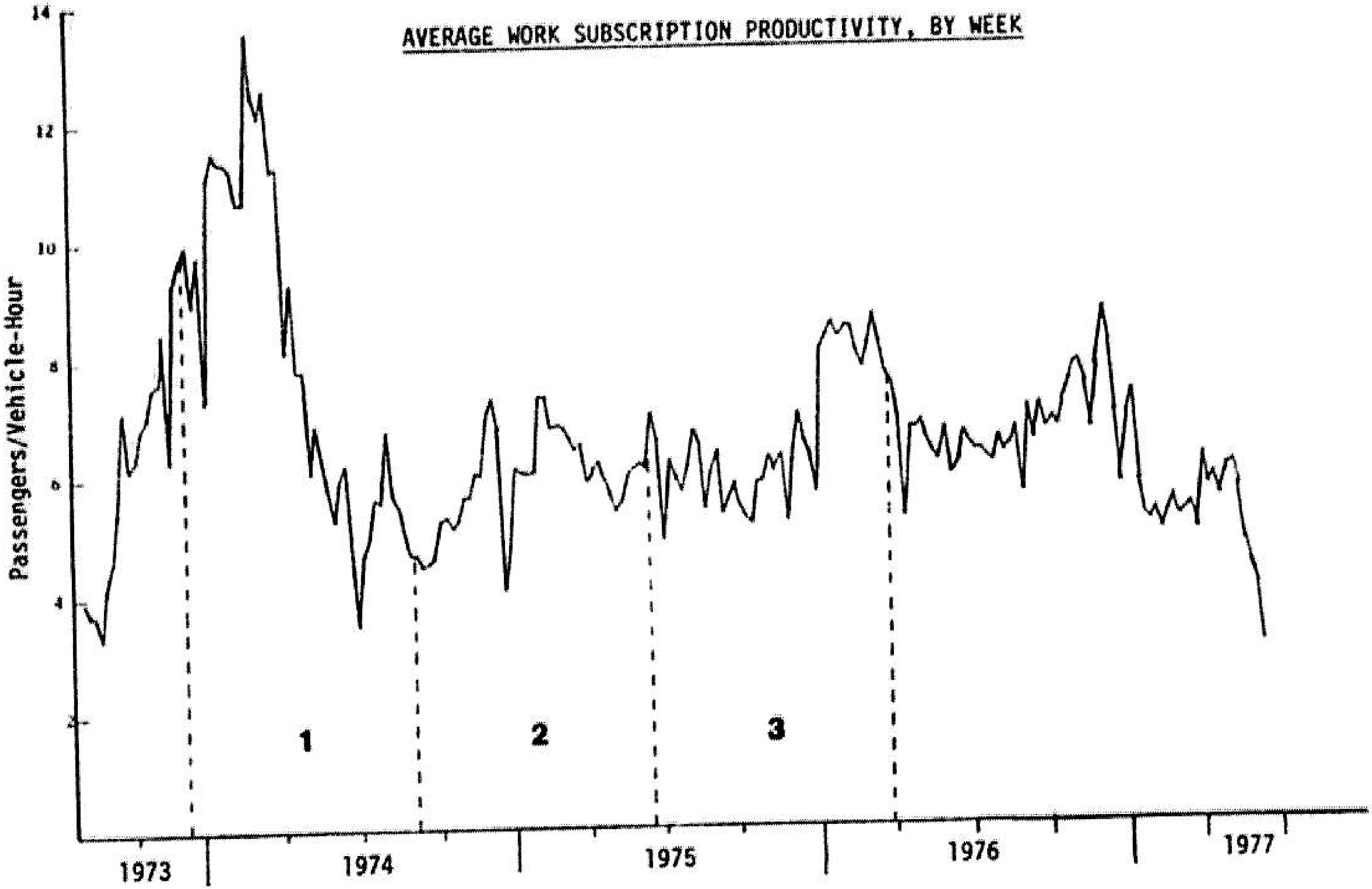
As a result of the lower hourly operating costs and higher productivity, work subscription service costs averaged $2.50 per passenger, about one-third lower than DAB. During the first period when demand was much higher, the cost per passenger was only $2.02. These are comparable to taxi costs, but are still much higher than driving, carpooling or using RTS buses. On a per passenger-mile basis, the cost was $0.74. With an average revenue per passenger of $0.76, a revenue recovery factor of 0.31 was generated, considerably higher than that of DAB.

As discussed in Section 6.4.1, the January 17, 1977 fare increase of 29% resulted in a subscription ridership decrease of 15% to 20% after accounting for seasonal patterns. In addition, tours were reorganized in April 1977, so that 21% fewer vehicle-hours were required to serve the same demand, thus increasing vehicle productivity and revenue recovery.

In actuality, these effects were short-lived because the decision to terminate work subscription service in June 1977 caused ridership to begin dropping in May as users found alternative means of transportation. Also, as discussed in Section 6.4.1, the ridership decrease following

EXHIBIT 7.5

AVERAGE WORK SUBSCRIPTION PRODUCTIVITY, BY WEEK



the fare increase seemed to have prompted riders who would normally stop using the service in the spring to stop immediately. Thus, these passengers' revenues were lost three months earlier than would have been expected otherwise. In summary, then, the subscription fare changes had only a minor overall impact on PERT productivity and economics.

7.2.4 School Subscription Service

School subscription productivity (Exhibit 7.6) was more uniform during the three periods of analysis than that of the other services, and averaged 15.25 passengers per vehicle-hour, dropping slightly in 1975 and 1976. Productivity exceeded that of work subscription service due to more concentrated demand and shorter trip lengths. Since no service changes occurred, the fluctuations in productivity during the 1977 winter are probably due to the severe weather conditions which caused both ridership and vehicle supply to be haphazard.

Due to these relatively high vehicle productivities, school subscription service had a cost per passenger of $1.10 overall. This is higher than the cost of a parent chauffeuring a student to school by car, but the inconvenience and time to the chauffeur is not considered.

7.2.5 Special Services

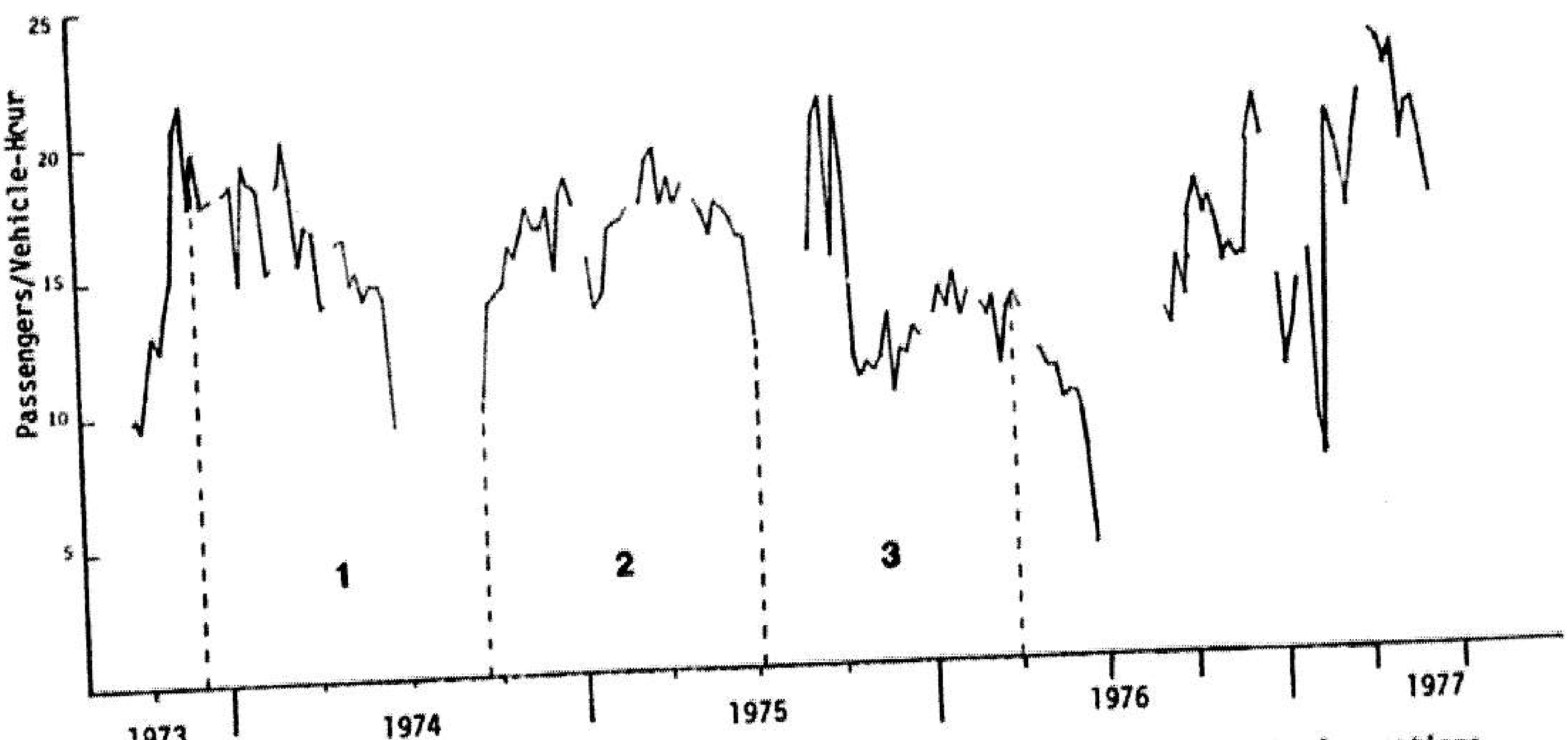
Special services vehicle productivity was the highest of all the PERT services. During the first period, vehicle productivity varied widely, averaging over 40 passengers per vehicle-hour. This dropped to about 20 during the second and third periods with an overall average of 21.16. There were 1.53 trips per vehicle-hour, where a trip indicates a one-way bus trip. (Unlike the other services, two origins and common destination count as only one trip. Thus, the senior special which picked up passengers at two housing units and terminated at Longridge Mall was one trip.)

The average cost per passenger was $0.79, the lowest of any PERT service. This is much lower than taxi fares, and is comparable to the costs of automobile and fixed-route bus travel. Revenue per passenger (including that paid by merchants) averaged $0.34, generating a revenue recovery of 0.43, the highest of any PERT service.

The various shoppers' specials required different degrees of subsidy. Most of the costs of the weekly and biweekly specials to Wegman's and Northgate Plaza were paid by retail stores. Revenue for the Longridge Mall special,

EXHIBIT 7.6

AVERAGE SCHOOL SUBSCRIPTION PRODUCTIVITY, BY WEEK



Discontinuities reflect school vacations.

on the other hand, came only from the $0.25 passenger fares and recovered a much smaller fraction of costs.

7.2.6 Special Handicapped Services

Special handicapped services, which only operated during the last period of analysis, averaged 2.65 passengers per vehicle-hour and 0.97 trips per vehicle-hour. These were the lowest productivity figures of any PERT service. Trip lengths were longer than for other services because destinations were outside the service area. Productivity was low because demand was small and buses usually made the trip to deliver only one special handicapped passengers and then deadheaded back to the service area.

The average cost per passenger of this service was $6.93, the highest of any PERT service. Furthermore, the cost per trip was $18.91, which exceeds the typical cost of private wheelchair taxi service. An average revenue per trip of $2.40 ($0.88 per passenger) resulted in a recovery of only 13% of costs, the lowest of the PERT services.

However, during the first four months following the expansion of PERT handicapped service in February 1977, an average of 2.85 passengers per vehicle-hour were carried. Although this only slightly exceeded the vehicle productivity achieved by the handicapped service during the third analysis period, the earlier service results were distorted by several group excursions. The previous special handicapped service carried an average of one trip per vehicle hour, compared to about 2.4 on the newer service. The PERT handicapped service has operated at capacity since Feburary 1977; its productivity is limited by a very low vehicle density, long trip lengths, and a large wheelchair passenger utilization which slows operations.

The lower fare for the new service resulted in a lower revenue recovery. The new service, with an average fare of $0.50, generated revenues of $1.43 per vehicle-hour, compared to about $2.33 on the older handicapped service.

7.3 THE MARGINAL COST OF PERT SERVICES

This section contains the estimated total cost functions for PERT and its three main services. These functions provide estimates of the marginal cost of PERT services. The total cost functions include the cost of physical inputs discussed in the previous section (i.e., operators' wages, fuel, capital, etc.), but do not explicitly include the costs of passenger time. There has been no control for service quality in the following analysis. As reported in Chapter 5, reliable relationships between service quality, supply and demand could not be generated from the existing data. Therefore, an analysis of cost and service quality trade-offs is not possible.

The basic form of equations used for the marginal cost estimation is linear:

Total cost = a + b (Passengers or Trips).

The coefficient "b" represents the marginal cost of providing service to each additional passenger and "a" represents fixed costs. If, upon estimation, "a" is not significantly different from zero, the estimated fixed costs are zero and the estimated marginal cost will not be significantly different from the average cost. If "a" is significant and positive, "b" (the marginal cost) will be less than the average cost. If "a" is significant but negative, "b" will be greater than the average cost. This might occur in the linear estimation of a cost function having little or no fixed costs and a marginal cost that increases with demand.

Although the basic estimation form was linear, quadratic ($TC = a + b_1$ Passengers $+ b_2{}^2$ Passengers), and cubic ($TC = a + b_1$ Passengers $+ b_2^2$ Passengers $+ b_3^3$ Passengers) functions were also estimated. For non-linear functions, the marginal cost varies depending upon the demand level. Because the precise form of the production function for PERT services (especially DAB) has not been specified, no a priori information existed to define the total cost function. In such cases, an experiment with non-linear estimation is appropriate. The results generated by using non-linear estimation were not significantly different from those resulting from linear estimation, however. For simplicity, only the linear results have been reported here.

The data base for this estimation was a weekly time series taken from PERT's accounting records and adjusted as described in Appendix A.7. However, data from the first three months of 1976 were omitted because the sharp drop in DAB ridership and the increase in operating costs caused by vehicle breakdowns during this period distorted a marginal cost estimation equation. Total costs were also adjusted to account for an 11% annual inflation rate, which reflects the magnitude of driver wage increases during the period analyzed.

In order to determine if the division of monthly and four-weekly costs into weekly periods affected the results, an analysis was also performed on a data set consisting of the 27 four-week periods. The last ten periods corresponded to the demonstration financial reporting periods. Prior to the demonstration, approximately 16 months of reported cost data were divided into 17 comparable four-week periods according to vehicle-hour allocation in each four-week period.

Exhibit 7.7 contains the results of the above regression equation for both the weekly and four-weekly data sets. The marginal cost estimates were about the same in both cases. For DAB service, there was a strong relationship between costs and demand as measured by R values. The marginal cost per passenger was about 75% of the average cost per passenger, indicating that DAB was operating in a region of slightly increasing returns to scale. The marginal cost was sufficiently high, relative to average cost, such that large increases in demand were necessary in order to substantially decrease the cost per passenger. For example, using the first equation of DAB cost [DAB cost = 1908 + 3.14 (DAB Passenger)], it would be necessary to increase the DAB passenger demand to about 5300 passengers per week in order to reduce the average cost per passenger to $3.50 from $3.99. (The highest weekly DAB ridership actually achieved was 3,228 passengers.)

The reason that marginal costs were high relative to average costs is the fact that economies of scale were due only to spreading the capital costs of the control room and maintenance facilities and top management costs over a larger fleet. Lower marginal costs are theoretically possible if vehicle productivities can be made to rise with increasing demand, and several theoretical models as well as MIT simulation results suggest that DAB vehicle productivity should rise with increasing demand density. Alternately, vehicle supply might be increased proportionally to the demand increase, thus keeping vehicle productivity constant and improving the level of service instead. However, productivities in Greece hovered around five passengers per vehicle-hour throughout the period studied despite varying demand rates. Reliable level of service data are unavailable prior to 1975.

During the period analyzed, the service area was also expanded four times. This would tend to bias the marginal costs upward, since periods of greater ridership after the service area expansion had longer average trip lengths (see Chapter 5) and were thus more costly to serve. In order to account for these service area expansions, marginal costs per passenger-mile were also calculated. For this analysis, the average trip length was assumed to be equal to 0.75 times the square root of the service area (3/4 of a side of the square service area) (see Section 1.5). Using these assumptions, the marginal costs would be reduced slightly to about 65% of the average cost. Since DAB fares were lower than the marginal costs, DAB was underpriced from an effi-

EXHIBIT 7.7 PERT MARGINAL COST ESTIMATIONS

11% Annual Inflation Rate Assumed
Data in January 1976 Dollars
No Capital Interest Costs Assumed
Data from December 1973 to January 1976

Equation	R^2	Marginal Cost (MC)	Standard Error of Marginal Cost	Average Cost (AC)	MC/AC	Durbin-Watson Statistic
Data by Weeks (n=108)						
DAB Cost=1908+3.14 (Pass)	.85	$3.14	$0.13	$3.99	79%	.70
DAB Cost=2437+3.78 (Trips)	.88	3.78	0.14	5.22	72%	.69
Work Sub Cost=983+1.15 (Pass)	.33	1.15	0.16	2.62	44%	.53
DAB COST=2700+1.02 (Pass-Mi)	.87	1.02	0.04	1.47	69%	.79
DAB Cost=3153+1.23 (Trip-Mi)	.89	1.23	0.04	1.91	64%	.75
Work Sub Cost=783+0.55 (Pass-Mi)	.53	0.55	0.05	0.99	55%	.58
Data by 4-Week Periods (n=27)						
DAB Cost=6942+3.20 (Pass)	.89	3.20	0.22	3.99	80%	.87
DAB Cost=9384+3.83 (Trips)	.91	3.83	0.24	5.22	73%	.73
Work Sub Cost=5099+0.71(Pass)	.13	0.71	0.35	2.62	27%	.48
DAB Cost=10465+1.03 (Pass-Mi)	.91	1.03	0.06	1.47	70%	.98
DAB Cost=12445+1.24 (Trip-Mi)	.92	1.24	0.07	1.91	65%	.86
Work Sub Cost=3843+0.44 (Pass-Mi)	.39	0.44	0.11	0.99	44%	.54

ciency standpoint. However, the analysis ignores service quality variables as well as the broader social goals of PERT, such as serving the transit-dependent.

Work subscription marginal cost estimations were much less precise than for DAB because of the nature of that service in Greece. Essentially, there were two conflicting trends affecting the marginal cost of work subscription service: additional passengers attracted to an existing subscription tour had a very low marginal cost, but additional passengers attracted to new tours that were established had high marginal costs that could exceed average costs if the new load factors were below average. Consequently, the results of the subscription marginal cost estimations are ambiguous; the results generated represent a balance between these two trends. R^2 values were low, suggesting a weak relationship between costs and demand for this service.[1]

7.4 ROUTE RATIONALIZATION

Although the overall RTS fixed-route system had much higher vehicle productivity than PERT, it has been hypothesized that in low demand density situations, flexible-route services such as DAB can operate more efficiently than fixed-route services. This is because more passengers may be attracted to a single flexible-route bus serving a large area than to a fixed-route bus in its relatively narrow "access" corridor. DAB might also increase vehicle productivities of the remaining fixed-route buses which are fed by the DAB vehicle. This concept underlies the policy of route rationalization in Rochester.

In Greece, where a DAB and fixed-route system coexisted

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[1]Durbin-Watson statistics were calculated for all of the above equations in order to test for possible auto-correlation in the cost data, a frequent occurrence in economic time-series data. Although significant auto-correlation did exist as indicated by Durbin-Watson statistics of less than 1.0, closer inspection of the data indicated that this resulted from a non-linearity of the data which may or may not be part of a long-term trend. While the actual function may be non-linear, the data suggested concave form, whereas theory would suggest a convex form. In any event, there is not sufficient range of data to perceive the shape of the curve. Consequently, adjustments to the data such as those using the Cochrane-Orcutt technique were judged to be inappropriate.

prior to route rationalization, the hypothesis was that the cost of expanding DAB in order to carry the fixed-route passengers was less than that saved from the elimination of the fixed-route service. Whether or not this was actually true is difficult to determine because of the many other changes occurring at the same time.

In order to simplify the analysis, cost and savings are dealt with in terms of vehicle-hours, since transit costs are roughly proportional to vehicle operating hours. A DAB vehicle-hour is generally slightly more costly than an RTS fixed-route vehicle-hour because the added dispatching and control costs tend to exceed the savings associated with the use of the smaller vehicle; however, the differences are relatively minor.

The RTS vehicle-hours saved from route rationalization are summarized in Exhibit 7.8. The savings were due to the elimination of one bus on each route during the off-peak period. On Route 14, only one bus traveled back and forth on Ridge Road during the off-peak period and was thus eliminated. On Route 10, it was possible to cut one bus from the schedule by eliminating the northern portion of the route in Greece.

Prior to the first fixed-route cutback in June 1974, DAB was operating approximately 48 daily vehicle-hours. In June 1974, additional DAB hours were added for the new night and Saturday service (approximately 12 and 14 hours, respectively). By January 1975, following the completion of route rationalization, night and Saturday operating hours had increased to about 19 and 72 hours, respectively, and remained at about these levels until January 1977.

Because night and Saturday PERT operating hours did not exist prior to the Route 14 cutback, it is difficult to determine exactly what proportion of these hours was needed to carry former fixed-route riders and what proportion was needed to transport other DAB passengers attracted by the additional service hours. One method is to allocate the additional vehicle-hours proportionally to the additional passengers attracted by taking the total passengers assumed diverted from the fixed routes (see Section 6.3.5) as a percentage of total new DAB passengers. Under this assumption, less than one-quarter of the Saturday and night DAB vehicle-hours were attributable to the former fixed-route passengers who used DAB and transferred. This is a slightly fewer vehicle-hours than were saved by route rationalization; however, only about one-third of the former fixed-route riders were transported after the cutbacks.

Alternatively, one can use the marginal cost analysis described in the previous section to argue that the marginal

EXHIBIT 7.8

FIXED-ROUTE VEHICLE-HOURS ELIMINATED BY ROUTE RATIONALIZATION

Route	Date Eliminated	Weekday	Saturday	Daily Average
Route 14 (Day)	6/74	5.2	13.4	6.6
Route 14 (night)	6/74	4.2	--	3.5
Route 10 (day)	1/75	4.2	10.1	5.2
Route 10 (night)	9/74	2.7	--	2.3
Total		16.3	23.5	17.6

Source: Memo from David F. Brandt, Dial-A-Bus Replacement Services, August 27, 1976.

DAB cost per passenger is less than the average cost per passenger and, therefore, the cost of carrying additional passengers from the fixed route is less than that of carrying the "regular" passengers. If these assumptions are made, one can attribute only three-quarters as many of the DAB vehicle-hours to former fixed-route passengers as was done in the previous case, and one can claim that nearly twice as many fixed-route vehicle-hours were saved as were added to DAB. Of course, the cost associated with transporting the regular DAB customers increases under this method of analysis.

On weekdays, DAB vehicle-hours increased from 48 prior to June 1974 to approximately 100 hours beginning in January 1975. As stated previously, 19 of the additional vehicle-hours occurred in the added evening and night hours, resulting in a net increase of 33 daytime hours between June 1974 and January 1975. As shown in Exhibit 7.8, only 9.4 midday vehicle-hours were saved by route rationalization. However, in addition to route rationalization, three service area expansions and a major marketing promotion also occurred during this period. Combined with the extension of operating hours, non-transfer DAB ridership increased 54% from before June 1974 to after June 1975. Thus, the addition of 33 daytime weekday vehicle-hours between June 1974 and January 1975 is partly a response to route rationalization and partly to other service changes. In this case, attributing the added vehicle-hours proportionally to ridership is the most appropriate allocation method, since both ridership groups are "marginal." This results in the addition of more DAB vehicle-hours than the number eliminated on the fixed-routes. (The increases in transfer and non-transfer ridership, other than that attributable to the increase in night operating hours, were roughly equal, suggesting an increase of 16-1/2 vehicle-hours for each group of new passengers. This exceeds the 9.4 fixed-route vehicle-hours eliminated during the midday period.)

Altogether, then, it appears that the number of DAB vehicle-hours added due to route rationalization was slightly more than that saved due to the elimination of fixed-route service. A precise determination cannot be made because of the coincident timing of other service changes requiring additional vehicle supply. However, given the relatively small proportion of other former fixed-route riders shifted to RTS peak-period services with excess capacity, it is clear that the additional cost per passenger carried exceeded the former cost per passenger on the eliminated fixed-route buses.

7.5 IMPACT ON VEHICLE-MILES TRAVELED (VMT)

Since PERT services carried a very small proportion of the total trips made in the area, PERT's impact on energy consumption and air quality was relatively minor compared to that generated by other transportation modes. The following analysis examines the impact of the two major PERT services -- DAB and work subscription -- on vehicle-miles traveled (VMT), which is used as a proxy for air pollution and energy consumption.

Dial-A-Bus (DAB). The following calculations are based on the March-December 1975 steady-state period and the results of the June 1975 on-board survey. During this period, there was an average of 476 passengers per day on 95 revenue vehicle-hours. It is assumed that deadheading increased the actual number of vehicle-hours to 100. During the period from June 30, 1975 to August 16, 1976, when vehicle mileage data was available, it was found that the average effective operating speed of all Greece PERT services was 11.12 miles per hour (separate mileage records for each service were not kept). Thus, 100 DAB vehicle-hours resulted in approximately 1,110 DAB vehicle-miles per day.

According to the 1975 on-board survey (weighting Saturday's results by one-fifth), 12.2% of the responding passengers would have driven if DAB were not available, 16.3% would have been driven, and 4.9% would have used other modes, usually a taxi. In the following calculations, the average DAB direct distance trip length of 2.8 miles is used. It is assumed that half of the DAB riders who would be automobile passengers if DAB were not available would require a special automobile trip to be made for them, while half would get a ride with a family member or neighbor who would have made the trip anyway. For these trips, an average extra deviation of 0.7 miles is assumed (one-fourth of the average trip length). In addition a taxi deadheading factor of 2.0 is assumed.[2] The calculation of VMT if DAB did not operate is as follows:

Walk diverted: 476 passengers X (11.7%) X 0 = 0
RTS bus: 476 passengers X (20.1%) X 0 = 0
No trip: 476 passengers X (35.0%) X 0 = 0
Auto diverted: 476 passengers X (12.2% X 2.8 miles) = 163 vehicle-miles
Auto passengers diverted:
476 passengers X (16.3%) X (2.8 miles + 0.7 miles)

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[2] Inferred from information on taxicab vehicle mileage and passenger revenues reported in An Analysis of Taxicab Operating Characteristics, International Taxicab Association, August 1975.

X 0.5 = 136 vehicle-miles
Taxi diverted: 476 passengers X (4.9%) X (2.8 miles) X 2.0 = 131 vehicle-miles

Total = 430 vehicle-miles.

Based on this analysis, DAB generated about two and one-half times as many vehicle-miles than would have occurred if passengers used other modes. Since PERT buses were predominantly gasoline-powered and larger and heavier than automobiles, they got fewer miles per gallon and emitted more pollutants per vehicle-mile than automobiles. The environmental effects were thus worse than the ratio of vehicle-miles indicates.

On the other hand, PERT extended coverage to the 35% of those surveyed who would not have made their trip if DAB were not available, and provided a presumed preferred alternative to those who would use other modes. Moreover, the extra vehicle-miles generated by DAB were less than 0.1% of those generated by area automobiles. (Approximately 28,000 automobiles owned by service area residents travel 27 miles per day (assuming 10,000 miles per automobile per year) resulting in 756,000 VMT per day). It may be concuded that DAB had a negligible but slightly negative environmental impact.

Work Subscription Service. Work subscription service operated between 20 and 24 revenue vehicle-hours per day, or between 21 and 25 vehicle-hours including deadheading. At 11.1 miles per hour, this resulted in a range of 233-278 vehicle-miles per day. Demand fluctuated by season, but will be assumed to have averaged 150 passengers per day. An average trip length of 3.4 miles is also assumed. The results of the April 1975 survey were used to determine alternative mode choices. For respondents who said they would carpool, a load factor of 2.5 persons per carpool is used. For those who said they would be a passenger in a car, an average deviation of 0.8 miles is assumed (one-quarter of the average trip length). The number of vehicle-miles which would have resulted without PERT subscription service is calculated as follows:

Walk diverted: 150 passengers X (2.9%) X 0 = 0
RTS bus diverted: 150 passengers X (20.3%) X 0 = 0
Auto passengers diverted:
150 passengers X (10.1%) X 0.8 miles = 12 vehicle-miles
Carpool diverted: 150 passengers X (11.6%) x 3.4 miles/ 2.5 passengers per car = 24 vehicle-miles
Auto diverted: 150 passengers X (55.1%) X 3.4 miles = 281 vehicle-miles

Total: 317 vehicle-miles.

Thus, PERT subscription services eliminated a small number of vehicle-miles per day, principally because of the high diversion from automobile travel. During the winter, when daily ridership approached 200 passengers per day, the number of daily vehicle-miles saved may have been as high as 160 (approximately 400 vehicle-miles saved minus 240 PERT vehicle-miles). During the spring and summer, however, when riders dropped to under 120 passengers per day, there was an overall increase in VMT. Thus, the results are sensitive to the variation in subscription ridership. In all cases, however, the number of vehicle-miles is very small compared to the total number of vehicle-miles generated by area residents.

In summary, given the approximate nature of the analysis procedure, no clear case can be made that PERT had any effect on VMT. It appears that subscription service reduced VMT slightly and that DAB increased it slightly but, relative to total VMT, any effect was negligible.

7.6 ALTERNATIVES FOR INCREASING TRANSIT COVERAGE IN GREECE

The previous section on route rationalization focused on the replacement of fixed-route services by DAB. As pointed out, DAB operated at lower vehicle productivity levels than the fixed-route buses it replaced, and even the marginal increases in DAB vehicle allocations following route rationalization slightly exceeded the vehicle-hours saved in the fixed-route system. The loss in transit ridership which resulted from route rationalization confirmed that DAB was a more costly alternative than the fixed-route buses eliminated. (The level-of-service aspects of route rationalization were discussed in Section 5.3.5).

While DAB may have been a more costly substitute for the fixed-route buses it replaced, it does not necessarily follow that fixed-route buses would be an effective substitute for DAB. That is, the fixed-route system which existed prior to DAB only covered about half of the service area population in terms of being within one-quarter mile of a potential rider's residence. In order to provide transit service to the entire service area population as DAB did, additional bus routes would have to be established so that all persons would be within one-quarter mile of a route. Whether or not this is an economical alternative to DAB is not entirely clear, since these new routes might have lower productivity than the existing fixed-routes.

To analyze this question, the SYSTAN Macroanalytic

Regional Transportation (SMART) model was used. This model was developed to analyze the operational implication of major modal shifts to transit within integrated regional transportation systems.[3] It is capable of analyzing the operating characteristics of several urban transit modes (including fixed-route, many-to-few DAB, and many-to-one subscription) under a variety of demand and supply conditions. The model consists of feeder modes operating in various-sized service areas, line-haul components, and distribution components. In the application described below, the feeder component of the model was used to analyze the hypothetical application of fixed-route services within the Greece service area by adjusting the model's input parameters to conform to conditions existing in Greece.

Documentation of the fixed-route and dial-a-bus models are contained in Appendix 8. The models assume a square service area with a perfect grid system, homogeneously distributed demand, and all travel being directed to points along one side of the square (a many-to-few system for DAB). These assumptions are reasonable for Greece, since the service area was not exceedingly irregular, and most trips began or terminated along or near Ridge Road, the service area's southern boundary. The following input parameters are required:

Service area size;
Bus capacity;
Route spacing (fixed-route only; parallel routes in one direction only converging at a central terminal);
Maximum headway (fixed-route only) or wait time (DAB);
Demand rate;
Operating and capital cost per vehicle-hour;
Operating cost per vehicle-mile; and
Various vehicle operating speeds and passenger stop time parameters.

To model fixed-route bus applications, 50-passenger buses were assumed to operate at average RTS operating parameters from the 1976 fiscal year (see Exhibit 3.10). Out of an average total cost per vehicle-hour of $19.40, drivers' wages and benefits accounted for approximately $8.75 per vehicle-hour, and depreciation accounted for $1.50 per vehicle-hour. The remaining operating costs were assessed on a per-vehicle-mile basis at $0.77 per vehicle-mile. For flexible-route services, the same driver salary

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[3]Billheimer, Bullemer, Holoszyc, <u>Macroanalysis of the Implications of Major Modal Shifts in Integrated Regional Transportation Networks,</u> SYSTAN, Inc., Los Altos, California, April 1976.

rate of $8.75 per vehicle-hour was assumed. PERT data from fiscal year 1975 was then used, because it was the last year in which its accounting procedures corresponded to those of RTS. Costs were then uniformly increased by 10% to account for inflation (10% was the difference between 1975 and 1976 RTS costs). On this basis, a depreciation figure of $1.23 per vehicle-hour was calculated. Of the remaining costs, DAB service was assumed to require all control room costs, resulting in a $0.75 per vehicle-mile cost for DAB. The result was that the modeled DAB cost per vehicle-hour was very close to that of fixed-route buses. Consequently, vehicle productivity is used as a substitute for costs in measuring efficiency among the various modes.

Using the above assumptions, a number of off-peak transit alternatives for the Greece service area were tested for a range of transit demand conditions. For example, Exhibit 7.9 plots vehicle productivity for the following modeled systems during the off-peak period:

- Dial-A-Bus (many-to-few);
- Fixed-route bus with routes spaced 1/2 mile apart and headways of 30 minutes (approximately 12 buses on eight routes);
- Fixed-route bus with routes spaced 1/2 mile apart and headways of 60 minutes (approximately 6 buses on eight routes);
- Fixed-route bus with routes spaced 3/4 mile apart and headways of 30 minutes (approximately 8 buses on five routes); and
- Fixed-route bus with routes spaced 3/4 mile apart and headways of 60 minutes (approximately 4 buses on five routes).

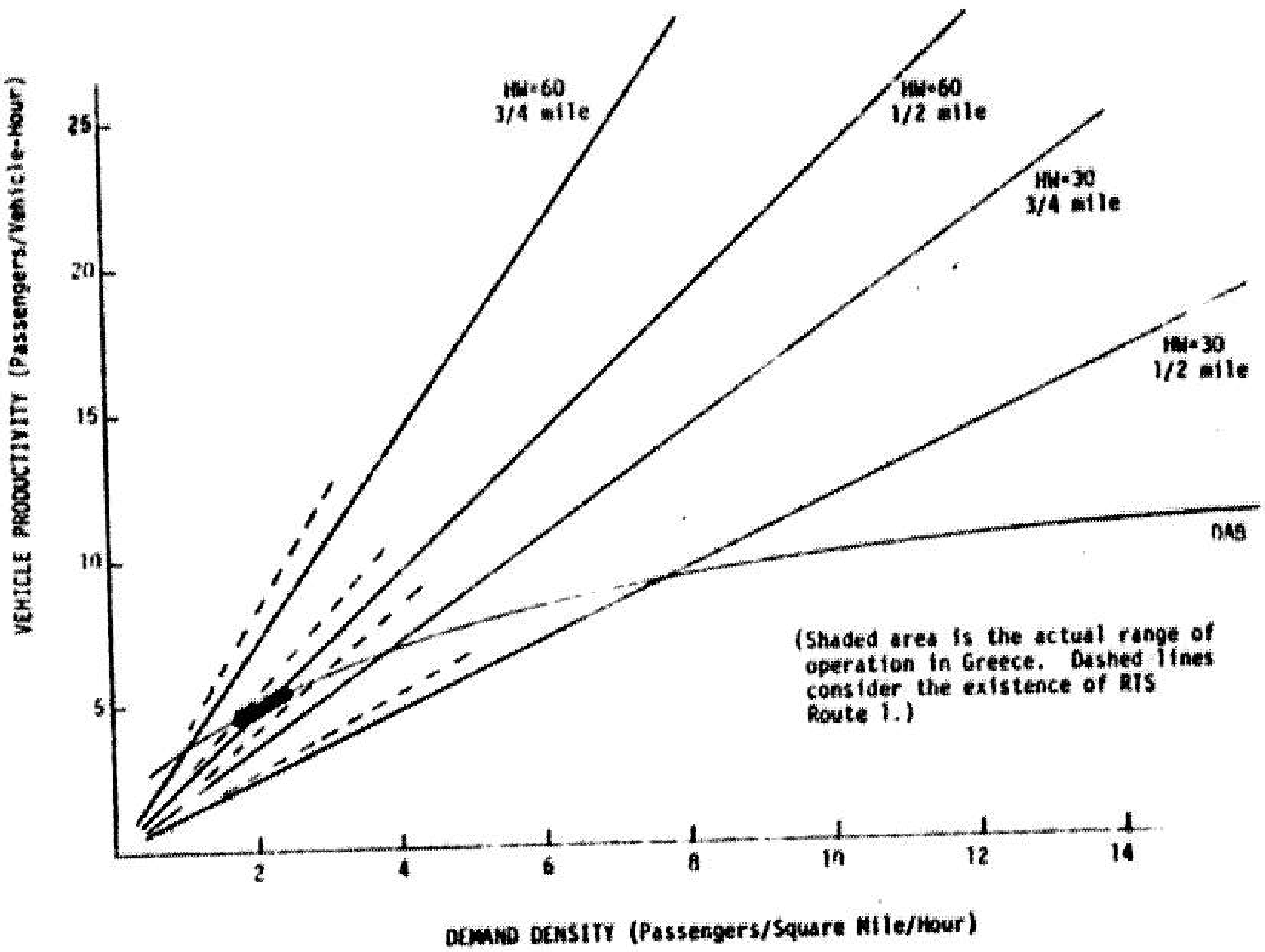
Of the four fixed-route systems considered, the two with 1/2-mile route spacing provided "full coverage" by the classical definition. With 3/4-mile route spacing, some residents would have as long as a 3/8-mile walk to the bus route. All the routes were modeled to converge at a single point midway along one border of the service area.

The shaded area in Exhibit 7.9 indicates the range in which DAB has operated in the 15.2-square mile Greece service area. The model accurately predicted DAB vehicle productivity, and computed an average trip length of 2.92 miles, close to the actual DAB trip length of 2.8 miles. The model also indicated that DAB in Greece operated in a region of increasing returns to scale. In the demand range experienced by PERT, the model computed a marginal cost per passenger of about $1.90, somewhat less than that calculated for Greece.

The relationship between productivity and demand

EXHIBIT 7.9

VEHICLE PRODUCTIVITY FOR ALTERNATIVE MODELED SYSTEMS



density on the fixed-route system is linear. This is because, although each system assumes different parameters, a constant number of buses is used within each alternative; allowing demand to change while vehicle-hours remain constant results in varying productivity levels. This assumes that the demand for which the results are plotted never exceeds the system's capacity. The results suggest that, for the demand conditions experienced by DAB, the fixed-route systems with 30-minute headways would have lower vehicle productivity and, therefore, higher costs per passenger than the DAB system. A system of 1/2-mile route spacing with 60-minute headways requiring six vehicles, however, would be comparable to present DAB operations. (A system with 3/4-mile route spacing and 40-minute headways would have approximately the same unit costs as the 1/2-mile, 60-minute headway system.)

The above analysis does not reflect the existence of Route 1, which currently runs on Lake Avenue and serves the eastern corridor of Greece. This route carries about 875 passengers per day during the off-peak period, which is considerably higher than that carried by DAB. Since Route 1 should be considered to exist in the comparative analysis, some adjustments must be made to the modeled results.

DAB also operated in the Route 1 corridor. Although the demand density for DAB in this corridor was lighter than the average for the rest of the area, for purposes of comparative analysis, the existence of Route 1 requires no change in the modeled DAB results. DAB is merely superimposed on Route 1 operations. Adjustments are required to the fixed-route analysis, however, because Route 1 would become part of the hypothesized fixed-route system. This means that one less new route would have to be provided than was specified in the modeled analysis. The remaining new routes would have a greater productivity, since they are assumed to carry the DAB demand on fewer routes, excluding the Route 1 demand. For example, 1/2-mile route spacing would require eight fixed routes but, with Route 1 operating, only seven new routes would have to be provided. Thus, the demand for DAB can be carried by providing only 7/8 of the original bus allocation, resulting in a net vehicle productivity that is 1/7 larger than originally considered. These new results are plotted as dashed lines in Exhibit 7.9. The fixed-route alternative is thus made somewhat more attractive.

Due to the assumptions made and the fact that differences in demand of various market segments for various services are ignored, the model cannot be taken as a precise representation of the impacts of operating various transit modes in Greece. Nevertheless, it indicates the relative effectiveness of conventional fixed-route and DAB services in Greece. Another portrayal of the situation is shown in Exhibit 7.10, in which average cost per passenger is plotted for the various systems. Again, consideration of Route 1 would lower the fixed-route costs.

Use of minibuses rather than the standard 50-passenger buses on the fixed routes would also lower costs by about 10% in the lower demand regions. However, at high demand densities, minibuses become more expensive because of their smaller capacity. The fixed-route minibus system had a minimum cost per passenger of 63 cents, compared to about 30 cents for the 50-passenger buses.

Travel demand on a fixed-route might rise slightly if the higher demand densities that presently exist in the Route 1 corridor and which existed in the Route 10 and 14 corridors prior to route rationalization are valid predictors of fixed-route demand. Assuming a 10% greater demand than experienced by DAB, the SMART model indicates that a system of eight parallel fixed routes one-half mile apart running at approximately 40-minute headways would have the same unit costs as DAB. (However, the higher demand means that total costs and deficits would also be higher.) Alternatively, a system of fixed routes spaced 3/4-mile apart running at 30-minute headways would achieve approximately the same vehicle productivities as DAB for the same demand. More frequent service, however, would result in higher operating costs unless demand also increased.

The fixed-route system with route spacing of three-quarters of a mile and half-hour headways also provides about the same level of service (as measured by travel time) as DAB service. The travel time calculations shown in Exhibit 7.11 indicate that under the assumption of random access, the travel time for the 3/4-mile, 30-minute headway fixed-route system is 36.25 minutes for an average trip, whereas the modeled DAB time is 36 minutes; the actual DAB average was 41 minutes. For planned access users, the fixed-route travel time is 26.25 minutes, compared to the actual DAB travel time of 28 minutes. (The model does not generate service quality variability parameters and a modeled DAB travel time cannot be computed.)

EXHIBIT 7.10

UNIT COSTS FOR ALTERNATIVE MODELED SYSTEMS

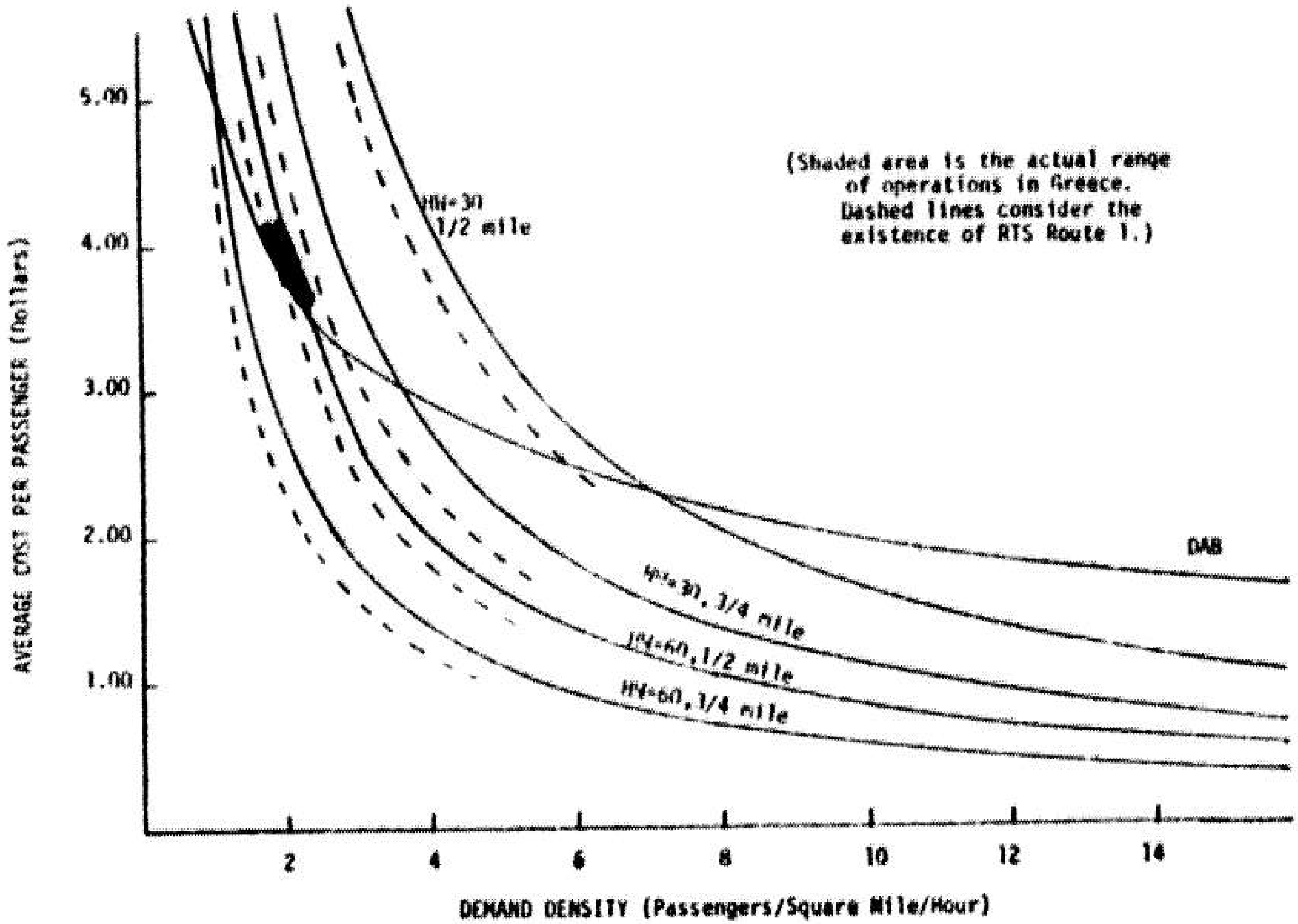


EXHIBIT 7.11

SMART Model Travel Time Results

	RANDOM ACCESS					PLANNED ACCESS				
	Walk	Wait	Ride	Egress	TOTAL	Walk	Wait*	Ride	Egress	TOTAL
Fixed-Routes										
1/2-mile spacing; 30 min. headway	2.5	15	15	2.5	35	2.5	5	15	2.5	25
1/2-mile spacing; 60 min. headway	2.5	30	15	2.5	50	2.5	5	15	2.5	25
3/4-mile spacing; 30 min. headway	3.75	15	15	2.5	36.25	3.75	5	15	2.5	26.25
3/4-mile spacing; 60 min. headway	3.75	30	15	2.5	51.25	3.75	5	15	2.5	26.25
Dial-A-Bus**										
Model:	-	20	16	-	36	-	-	-	-	-
Actual:	-	25	16	-	41	-	12	16	-	28

* Fixed-Route wait times assumed to average 5 minutes

**Dial-A-Bus wait time equals one standard deviation of average pickup deviation; unavailable from model.

This analysis suggests that at similar demand levels, a system of five fixed-routes spaced 3/4-mile apart with average headways of 30 minutes, or eight 1/2-mile spaced routes having headways of 40 minutes, can provide comparable levels of service (travel time) as DAB, at about a 10% higher average cost per passenger. If demand increases by 10%, the fixed-route systems achieved approximately the same cost per passenger as DAB; at demand levels greater than 10%, the fixed-route alternative becomes more cost-effective. However, these results must be tempered by the fact that the services and types of users are not equivalent, since DAB provides the convenience of door-to-door service, whereas fixed-routes offer better schedule reliability.

8. IRONDEQUOIT: LEVEL OF SERVICE

This chapter describes the impacts of PERT services on transit coverage, reliability and travel times in Irondequoit. These variables are used to describe the overall level of transit service that was available to the user. A description of users' level-of-service perceptions and the demand response to this supply of service is contained in Chapter 9.

8.1 COVERAGE

Coverage refers to the accessibility of the transit system to the population. The expansion of transit coverage was a prime objective of PERT services in Irondequoit, and was mainly accomplished by operating in geographical areas that were not previously served by the existing fixed-route system.

8.1.1 Population and Area Coverage

As noted in Section 3.2, the Irondequoit area was relatively well served by fixed-route lines prior to the introduction of PERT. Exhibit 8.1 shows the population groups served by PERT services that were previously unserved by RTS. The data were derived from census block data, and is based on the definition of a person being served by a fixed-route bus if he resides within one-quarter mile from the route. Within census blocks, the population was assumed to be uniformly distributed along the streets defining the block.

PERT services in Irondequoit extended transit coverage to a relatively small number of persons according to the above definitions. In the expanded 8.6 square mile DAB service area, only 10,666 persons (26.5% of the population served) lived more than one-quarter mile from a previously operating, off-peak fixed-route bus. Only 17.2% of the service area population lived more than one-quarter mile from a bus line that operated during the peak period. In the neighboring Greece DAB service area, 49.3% of the population, or 33,910 persons, lived more than one-quarter mile from a fixed-route bus line.

The other PERT services provided first-time transit service to an even smaller number of users. The two point deviation spurs of the Summerville Shuttle provided coverage to only 1,894 new persons; the remainder of the line

EXHIBIT 8.1

POPULATION SERVED BY PERT SERVICES (1970 CENSUS)

Service	Area Served[a]	Population Served	Elderly (65+) Population Served (% of Total)[b]	Pop. Outside 1/4-mile of RTS Fixed Route During Peak Period (% of Total)	Pop. Outside 1/4-Mile of RTS Fixed Route During Off-Peak Period Before PERT (% of Total Pop. Served)[c]
Dial-A-Bus (April 1976)	6.9	33,361	3,894 (11.7%)	4,773 (14.3%)	8,128 (24.4%)
Dial-A-Bus (September 1976)	8.6	40,295	4,552 (11.3%)	6,913 (17.2%)	10,666 (26.5%)
Summerville Shuttle (April 1976)	2.6	N/A	N/A	----	1,894
Loop Bus (April 1976)	2.3	N/A	N/A	----	3,236[d]
Urban PERT	6.5	67,155	8,679 (12.9%)	----	7,322 (10.9%)

[a] Includes designated service area or area within 1/4-mile of a fixed-route or point deviation spur.

[b] Interpolated from census tract data assuming a constant ratio of elderly to non-elderly residents throughout the census tract.

[c] Data refers to midday period, except for Urban PERT which refers to late-night period.

[d] Includes 2,585 persons in Dial-A-Bus service area.

---- Services not provided during peak period.

N/A Information not available.

followed existing fixed-route alignments. The Irondequoit Loop Bus primarily followed existing fixed-route alignments (Routes 9, 10 and 12), and reached only 3,236 new persons, including 2,585 persons who could also use DAB. In September 1976, when the Loop Bus route was changed slightly, the new population served decreased to 2,613 persons. Urban PERT reached about 7,322 new persons, which represents less than 11% of the service area. Because of the greater sensitivity to the threat of crime during the late-night operation of Urban PERT, however, one-quarter mile may not be the most realistic definition of fixed-route coverage for late-night operations.

Although work subscription service increased the level of coverage to Kodak and Xerox workers, it is difficult to determine the exact magnitude of this change; this peak-period service picked up passengers from different checkpoints based on the residential locations of interested riders. However, most target area residents were eligible for the service and no existing RTS services connected Rochester and Xerox, while only two routes (14 and 23) served Kodak Park from Irondequoit. (One Route 5 bus also served Kodak Park each morning.)

Routes 14 and 23 remained unchanged when they were transferred from RTS to PERT operations, providing one-quarter mile fixed-route service coverage to an area of 2.4 and 3.1 square miles, respectively (combined coverage of 3.6 square miles), and thus did not increase the size of the population served.

Finally, the three transit-dependent services served special markets. The PERT handicapped service was available to an estimated 7,000 elderly and handicapped persons in the town of Irondequoit. The ARC subscription service served about 15 persons, and the special group trip service served a variety of groups, but mostly the 700 elderly residents of Seneca Towers benefited from this service.

In the Irondequoit target area during the midday period, PERT services (DAB, Loop Bus and Summerville Shuttle) reached only about 13,200 persons (less than one-quarter of the total population) who did not previously have access to a fixed-route bus. However, PERT's doorstop services (DAB and Urban PERT) provided more egalitarian coverage for all residents within their service boundaries (Section 5.1.1). This feature was especially important to elderly residents, who may not have been able to access the fixed-route services even within one-quarter mile of their homes. Overall, Irondequoit PERT services were available to about 50,000 persons during the midday period.

PERT also offered an alternative set of transit services with a greater orientation toward local travel rather than travel to the CBD. Irondequoit's Loop Bus operated solely within the central service area, Routes 14 and 23 traveled diagonally across the entire target area, the Summerville Shuttle provided north-south local access, and DAB served all directional trips within its service area. Such circumferentially-directed local trips were only possible on the previous fixed-route system by taking a southbound bus to downtown Rochester, and then transferring to another radial northbound bus.

8.1.2 Fares

Irondequoit's PERT and RTS fares underwent several changes during the demonstration, as summarized in Exhibit 8.2. Direct comparisons of user costs among services are complicated by the different trip characteristics of each service and the variety of fare options available. In general, PERT fixed-route fares and checkpoint subscription fares were equivalent to RTS fares, but using DAB or a route deviation option resulted in a higher fare. In June 1976, PERT fixed-route fares were increased to match the May 1976 RTS fare increase. In September 1976, DAB switched to a zonal fare structure; transfer charges were added to the Loop Bus, and Urban PERT lowered its deviation request surcharge to stimulate demand. The subscription service fare was raised in January 1977; DAB's zonal fare system was eliminated, and fares became generally more expensive. The January changes reflect PERT's attempt to increase its revenue recovery.

Except for DAB, automobile travel was generally more costly for the user when assessed at 16 cents per mile. However, DAB -- with its relatively high fare and short trip distances -- was more expensive than automobile travel. For additional fare and user cost comparisons, refer to Section 5.1.3.

EXHIBIT 8.2

IRONDEQUOIT PERT AND RTS SERVICE FARES

	April 12, 1976	June 21, 1976	Sept. 13, 1976	January 3, 1977
Dial-A-Bus				
Regular fare	$1.00	$1.00	$0.75-$2.75 (zones)	$1.25
Elderly and handicapped (off-peak)	$0.50	$0.50	$0.35-$1.35	$0.50
Additional Passengers	$0.25	$0.30	$0.30	$0.50
Transfers	$0.05	$0.05	$0.05	$0.05
Irondequoit Loop Bus				
Regular	$0.25	$0.30	$0.30	--
Elderly & handicapped	$0.20	$0.20	$0.20	--
Transfers	$0.00	$0.00	$0.05	--
Summerville Shuttle				
Regular fare	$0.25	$0.30	$0.30	$0.30
Elderly & handicapped	$0.20	$0.20	$0.20	$0.20
Deviation request surcharge	$0.10	$0.10	$0.10	$0.45
Deviation request (E & H)	free	free	free	free
Transfers to/from DAB, Loop Bus	$0.05	$0.05	$0.05	$0.05
Transfers to/from RTS	free	free	free	free
Work Subscription Service (Per Week)				
Checkpoint to Kodak	$5.00	$5.00	$5.00	$7.00[a]
Checkpoint to Xerox	--	$8.00	$8.00	$11.00[a]
Park-and-Ride (AM return trip)	--	--	$0.50/ride	$0.50/ride
Doorstop to Kodak	--	--	--	$9.00[a]

(Exhibit 8.2, Continued)

	April 12, 1976	June 21, 1976	Sept. 13, 1976	Jan. 3, 1977
ARC Subscription Service (Per Week)	$5.00	$5.00	$5.00	$5.00
Routes 14 and 23	$0.30	$0.50	$0.50	--
Urban PERT				
Regular fare	$0.25	$0.30/weekdays $0.50/Saturdays	$0.30/weekdays $0.50/Saturdays	-- --
Elderly & handicapped	$0.20	$0.20	$0.20	--
Deviation request surcharge	$0.75	$0.70	$0.20	--
Deviation request (E & H)	$0.30	$0.30	$0.20	--
Deviation request (additional passengers)	$0.25	$0.25	free	--
RTS Services				
Peak period	$0.40	$0.50[b]	$0.50	$0.50
Weekday off-peak	$0.25	$0.30[b]	$0.30	$0.30
Weekend	$0.25	$0.50[b]	$0.50	$0.50
Elderly & handicapped (off-peak)	$0.20	$0.20[b]	$0.20	$0.20

[a] Effective January 17, 1977

[b] Effective May 8, 1976

8.2 VEHICLE SUPPLY AND RELIABILITY

General analyses of the PERT fleet size, vehicle operations, maintenance, and overall performance, including their effects on PERT's level of service are contained in Section 5.2. The following section discusses the supply of vehicles for each Irondequoit PERT service, and the specific impacts on Irondequoit's service levels; where additional operational data were available, they were included.

8.2.1 Vehicle Allocation to Services

RTS driver schedules (known as run guides) are generally rearranged three times per year in January, June and September. Consequently, the major changes in PERT operations and vehicle allocation coincided with these periodic schedule changes. Exhibit 8.3 shows the average number of PERT weekly vehicle-hours operated in Irondequoit between April 1976 and July 1977. The data has been divided into five chronological periods, according to the major operational changes. Within each period, the number of vehicle-hours scheduled and supplied (as well as most other supply and demand variables) was relatively stable. The major exception to this rule was in late December 1976 and January 1977, when extremely severe winter weather conditions incapacitated most of the PERT fleet and restricted the supply of PERT services.

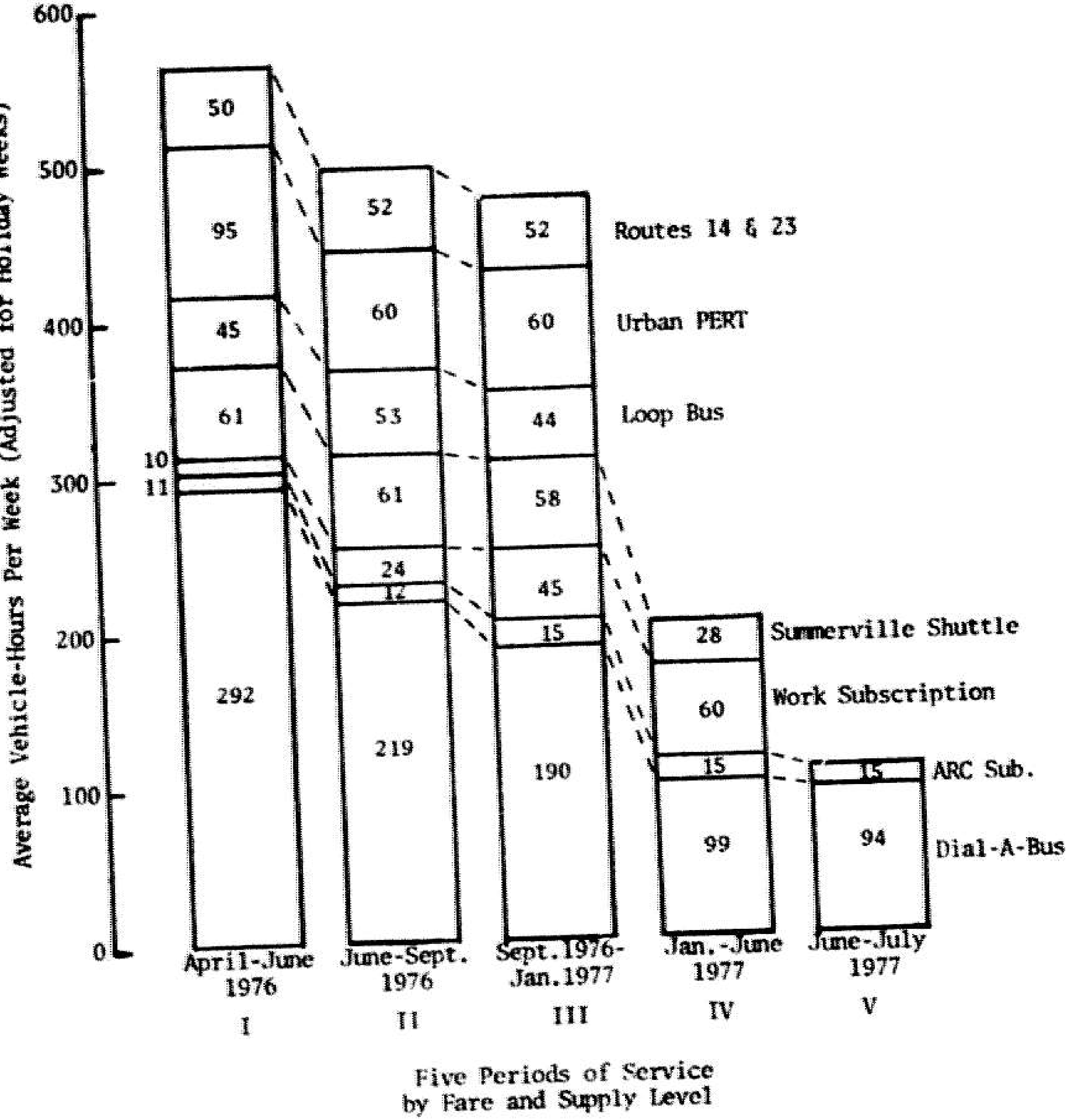
Since operating costs correspond closely to the number of vehicle-hours operated, the latter variable is a good indicator of the relative supply of PERT services. As shown in Exhibit 8.3, the number of PERT vehicle-hours operated in Irondequoit decreased significantly over the course of the project, with major service cutbacks occurring in January and June 1977. A number of PERT services were curtailed at those times, resulting in a 57% drop in weekly vehicle-hours supplied in January 1977 and a further halving of service supply in June 1977. In addition to these changes, DAB service supply decreased during 1976 to accomodate the much smaller than predicted demand, and work subscription service expanded (prior to its termination in June 1977) as additional work locations were served.

8.2.2 Impact on Service Levels

The PERT vehicle fleet size exceeded the peak vehicle requirement by 29% between April 1976 and January 1977. Following January 1977 and the cutback of PERT services in Greece and Irondequoit, the spare ratio (fleet size/peak

EXHIBIT 8.3

IRONDEQUOIT PERT SERVICE VEHICLE-HOURS
(Excluding Special Services)



vehicle requirement) rose to 1.69, as outlined in Exhibit 5.6. While these are relatively high spare ratios for a transit fleet, the unusually long out-of-service times described in Section 5.2.2 resulted in almost constant vehicle shortages, causing drivers to start their runs late as they waited for a bus to return from service. Generally, the PERT fixed-route and subscription services received first priority for available vehicles, and these services were affected less than DAB. However, in December and January 1977, vehicle shortages were so severe that all services suffered extensively.

From the start of Irondequoit service until February 1977, the number of Irondequoit PERT runs starting late steadily increased. Between April and June 1976 (Period 1), an average of 1.5 daily runs (out of 12.5 daily runs including Saturdays) started late; between June and September 1976, 2.2 runs (out of 11.7) started late; and between September 1976 and January 1977, 3.1 runs (out of 11.7) started late. During the first six weeks of 1977, an average of 3.5 out of six runs started late, a deteriorating situation due to the weather and despite the reduced service requirements. After mid-February, however, the situation improved markedly because of the new vehicles delivered and the milder weather. Through June 10, 1977, after which data were no longer recorded, an average of 0.7 runs (out of 5.4) started late.

The reduction of vehicle supply had a negative effect on the level of service provided, and the service quality data reported under computerized dispatching in Irondequoit supported this hypothesis. Between March and June 1977, there were 57 days of full-time computerized dispatching when the number of late-starting runs was recorded. The ten service quality variables measured (see Section 8.3.1) were all positively correlated with the number of late runs (i.e., more late runs lengthened wait time, ride time, etc.), with the actual correlation coefficients ranging from .06 to .59. Seven of the ten correlations were statistically significant at the $\alpha = .05$ level. Immediate request service quality parameters were particularly sensitive to the number of late-starting runs. For example, regression analysis disclosed that one late-starting run (out of the five or six scheduled for the day) increased the average system response time for the day's immediate request customers by 1.7 minutes.[1]

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[1]Immediate request mean system response time = 14.7 minutes + 1.66 (Number of late runs). $R^2 = .34$

8.3 DIAL-A-BUS SERVICE

General level-of-service parameters are defined and analyzed in Section 5.3.1; for travel time comparisons, DAB and fixed-route users were divided according to planned and random access.

The level of service provided during Irondequoit's manual and computerized dispatching periods is discussed in Sections 8.3.1 and 8.3.2, respectively, followed by a comparative analysis of Greece's DAB service quality results. Section 8.3.4 studies the daily variation in service quality, and Section 8.3.5 compares trips on DAB to fixed-route bus and automobile trips of equivalent lengths.

8.3.1 Manual Dispatching Results

Exhibit 8.4 (first column) displays the average DAB service quality parameters for 33 days under manual dispatching in Irondequoit from October through November 1976. Under manual dispatching, system response time was relatively long (25 minutes) compared to other DAB systems and typical taxi systems.[2] However, response time varied considerably, as evidenced by the standard deviation of 18 minutes. Reliability was also low, as measured by the relatively high standard deviations of the pick-up deviations. (For example, the immediate request pick-up deviation mean of 3.4 minutes and standard deviation of 15.2 minutes suggest that about 20% of all passengers were picked up more than 20 minutes early or late.)

Irondequoit's results, similar to Greece's manual dispatching period (Section 5.3.2), suggest that a large portion of the average 25-minute DAB system response time should be considered as wait time due to the uncertainty of actual pick-up times. Ride time consistently averaged 10 minutes, however, suggesting quick on-board travel.

8.3.2 Computerized Dispatching Results

Computerized DAB dispatching began in Irondequoit in February 1977. Exhibit 8.4 (second column) summarizes the service levels provided, based on 71 days in March through June 1977. Eight of the ten service quality parameters changed significantly under computerized dispatching

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[2]Thirty-two surveyed dial-a-bus and shared-ride taxi systems reported an average system response time of 15.2 minutes.

EXHIBIT 8.4 IRONDEQUOIT DIAL-A-BUS SERVICE QUALITY PARAMETERS

(Average Values in Minutes)

	Manual Dispatching Oct.-Nov. 1976 (33 days including 27 weekdays and six Saturdays)	Computerized Dispatching March-June 1977 (71 weekdays)[a]	Significance Level (α) of Change	Percentage of Change Attributed to Changes in Number of Late Runs & Vehicle Productivity (ANOVA)[b]	Significance Level (α) of Change After Controlling for Late Runs & Vehicle Productivity (ANOVA)[b]
IMMEDIATE REQUESTS					
System Response Time (Mean)	25.0	16.5	< 0.001	10%	< 0.001
System Response Time (Stnd. Deviation)	17.9	10.9	< 0.001	44%	0.01
Pick-Up Deviation (Mean)	3.4	6.3	< 0.001	(--)[c]	< 0.001
Pick-Up Deviation (Stnd. Deviation)	15.2	7.5	< 0.001	27%	< 0.001
Ride Time (Mean)	10.3	9.3	0.01	51%	0.25
Ride Time (Standard Deviation)	5.1	6.0	0.02	(--)[c]	0.004
ADVANCE REQUESTS					
Pick-Up Deviation (Mean)	5.8	6.0	0.86	(--)[c]	0.05
Pick-Up Deviation (Stnd. Deviation)	11.5	8.9	0.004	39%	0.05
Ride Time (Mean)	10.0	10.4	0.29	(--)[c]	0.08
Ride Time (Standard Deviation)	4.9	6.5	0.002	(--)[c]	< 0.001
Service Area Size (Square Miles)	8.6	8.6			
Daily Operating Hours	11.5	7.5			
Average Daily Ridership	117.1	58.0			
Average Daily No-Shows	4.3	4.0			
Average Number of Daily Irondequoit PERT Runs Out Late/Number of Scheduled Runs	2.6/11.6	0.7/5.2			
Average Vehicle Productivity (Passengers Per Vehicle-Hour)	3.3	2.9			

[a] All days of more than 400 minutes computer operation.

[b] Based on 33 days of manual dispatching and 57 days of computerized dispatching; late run data not comparable after June 1977 run guide change. ANOVA = Analysis of Variance.

[c] Reflects variables in which service quality decreased under computerized dispatching. The independent variables mitigated this effect rather than accounting for part of it.

compared to manual dispatching and, although some parameters worsened, there was an overall service quality improvement under computerized dispatching. Service levels for immediate request customers especially improved, particularly the reliability of DAB service as measured by system response time and pick-up deviation variability.

Part of the improvement in service quality under computerized dispatching is accounted for by an improvement in vehicle reliability and availability and a decrease in passenger demand resulting in more buses operating per passenger carried (a decrease in vehicle productivity). An analysis of variance (ANOVA) was conducted in which the number of Irondequoit driver runs starting late was used as a measure of vehicle reliability. This analysis (included in Exhibit 8.4) indicated that between 30% and 50% of the improvement in service quality was a result of these factors rather than computerized dispatching. The data also suggests that the service quality parameters which worsened under computerized dispatching would have worsened more under comparable conditions of vehicle reliability and productivity compared to manual dispatching. Although computerized dispatching was still a significant factor in changing service quality, its impact is mitigated when these other factors are considered.

8.3.3 Comparison to Greece DAB

The Irondequoit service quality results are very similar to the results generated under both manual and computerized dispatching in Greece, except that Greece ride times were longer, reflecting the larger service area and the higher load factors. Although the Greece service area generated a higher demand density than Irondequoit, a relatively larger number of vehicles were supplied in Irondequoit (resulting in a lower vehicle productivity). These factors apparently balanced each other so that approximately equivalent service levels were provided in the two areas.

In Section 5.3.4, the Greece DAB system was concluded to be a poor test case of the application of computerized dispatching to large-scale demand-responsive systems because of the relatively low demand density and vehicle productivity compared to that under manual dispatching and other DAB systems. Because of the lower demand density and vehicle productivity in Irondequoit, it is an even less appropriate case than Greece for determining the potential applicability of the computerized dispatching concept in larger systems where it might prove to be more cost-effective than manual dispatching.

8.3.4 Daily Variations in Service Quality

The day-to-day variations in Irondequoit DAB service quality were examined in order to analyze the effects on service quality of several parameters which change in time, including the number of vehicle-hours supplied, the number of passengers carried, the number of driver runs starting late and the number of no-shows.

As discussed in Section 8.3.2, the number of runs starting late had an adverse impact on several service quality parameters. The level of no-shows was also often significantly related to the service quality variables; however, no-shows were both a cause and an effect of service quality deterioration (see Section 6.1.6). DAB demand and vehicle supply, on the other hand, generally had no statistically significant effect on service quality variables in the available data.

Attempts to develop reliable predictive equations of the ten service quality measures based on the above supply and demand variables were unsuccessful. The "explainability" of the equations as measured by the multiple-R^2 factor was generally under 0.4, meaning that less than 40% of a service quality parameter's variation could be explained by quantitative measures of supply and demand.[3]

8.3.5 Comparison to Other Modes

To compare DAB to alternative travel modes, travel times for random and planned access trips were computed (see Section 5.3.1). The average manual and computerized dispatching period results are reported in Exhibit 8.5, along with travel time parameters for a typical fixed-route bus trip of the same 2.0 mile distance. (Refer to Section 9.1.1 for trip length results.) An average headway of 30 minutes is assumed, which is typical of the midday fixed-route headways in Irondequoit; a non-transfer trip is also assumed.

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[3]For example, the predictive equation for system response time which had the highest level of predictability was:

$$\text{System Response Time (Minutes)} = \underset{[3.3]}{10.6} + \underset{[0.3]}{1.6}\,\text{(Late Runs)} + \underset{[0.05]}{0.11}\,\text{(Daily Ridership)} - \underset{[0.154]}{0.039}\,\text{(Daily No-Shows)} - \underset{[0.18]}{0.11}\,\text{(Daily Vehicle-Hours)}$$

Figures in brackets are the standard errors; $R^2 = 0.40$.

EXHIBIT 8.5

INTERMODAL TRAVEL TIME COMPARISON

	DIAL-A-BUS Fall 1976	DIAL-A-BUS Spring 1977	Fixed-Route[e]	Automobile[f]
Random Access				
Access Time	0	0	2.5	0
Wait Time	25.0[a]	16.5[a]	15.0	0
Ride Time	10.3[b]	9.3[b]	8.0	6.0
Egress Time	0	0	2.5	0
Total	35.3	25.8	28.0	6.0
Planned Access				
Access Time	0	0	2.5	0
Wait Time	13.3[c]	8.2[c]	5.0	0
Ride Time	10.1[d]	9.9[d]	8.0	6.0
Egress Time	0	0	2.5	0
Total	23.4	18.1	18.0	6.0

a System response time (mean)

b Immediate requests ride time (mean)

c Average of immediate and advance requests pick-up deviation (standard deviation)

d Average of immediate and advance requests ride time (mean)

e Assumes a 2.0 mile bus trip, 30-minute headways, 1/8-mile access and egress distance, 15 m.p.h. bus speed, 3 m.p.h. walking speed.

f Assumes 2.0 mile trip, 20 m.p.h. speed.

A precise comparison of actual average trip times is not desirable, since when DAB and fixed-route services were available, users were expected to select the most efficient mode based on their individual travel needs. Consequently, each mode attracted very different types of trips. A "before and after" comparison is also inappropriate, since most fixed-route services in Irondequoit remained intact after April 1976 when PERT services were introduced. (This type of analysis was done for Greece in Section 5.3.5.) Thus, the purpose of Exhibit 8.5 is merely to compare trips on DAB with fixed-route bus trips of equivalent length, rather than equivalent trips.

Based on these assumptions, the results indicate that DAB travel under computerized dispatching was comparable to fixed-route bus travel times. However, the fixed-route bus case assumes a non-transfer trip, which was impossible for most of the trips made on Irondequoit DAB. Fixed-route travel times for these trips would have actually greatly exceeded DAB travel times, since a passenger would have had to travel to the CBD to transfer. In all cases, the automobile -- not requiring access, wait or egress time -- resulted in more attractive travel times than the DAB or fixed-route alternatives.

8.4 PERT FIXED-ROUTE SERVICES

To evaluate the level of service provided by PERT's fixed-route services (the Summerville Shuttle, Loop Bus, Urban PERT, and Routes 14 and 23), average vehicle speeds were estimated based on route distances and scheduled travel times. Average headways are also used in this analysis to indicate the relative frequency of the fixed-route services.

Although the Irondequoit PERT service package was primarily intended to supplement, rather than replace, existing fixed-route service, Routes 5 and 7 north of Ridge Road were eliminated when the Summerville Shuttle operated, and the Loop Bus replaced portions of Routes 9 and 12. In these cases, service levels are analyzed before PERT began operating in April 1976, and service quality comparisons on a "before/after" basis are included.

8.4.1 Summerville Shuttle

After the Summerville Shuttle was introduced in April 1976, Routes 5, 7 and 11 were realigned to terminate at the Clinton and Ridge transfer station during the off-peak hours. Exhibit 8.6 compares the scheduled ride times for

EXHIBIT 8.6

IRONDEQUOIT ROUTE RATIONALIZATION TRAVEL TIME ANALYSIS

	Time (minutes)	
Pre-Rationalization (Route 5 Only)	Inbound	Outbound
Summerville - St. Paul/Ridge	16	16
St. Paul/Ridge - C.B.D.	16	16
TOTAL	32	32
After Rationalization (Summerville Shuttle Plus Transfer to Route 5, 7 or 11)	Inbound	Outbound
Summerville - Clinton/Ridge	22	19
Transfer Time	3.5*	16.1*
Clinton/Ridge - C.B.D.	16	—
TOTAL	41.5	35.1

*Assumes first departing RTS bus boarded inbound, best connecting RTS bus boarded outbound.

these services before and after route rationalization. This analysis is based on the scheduled average off-peak weekday service effective between September 13, 1976 and January 3, 1977, and includes the following assumptions:

* Initial passenger wait times and access and egress times for fixed-route services are assumed to have remained constant before and after rationalization. This assumption is justified because RTS headways south of Ridge Road did not change, and the Summerville Shuttle and former Route 5 north of Ridge Road had the same 45-minute headways.

* Since there were so few checkpoint deviations requested on the Summerville Shuttle, they have not been included in the analyses (see Section 9.3).

* Route 5's pre-rationalization service is used to represent pre-rationalization conditions north of Ridge Road. Ride times are based on the average scheduled ride times between the Summerville Loop stop (northern St. Paul Boulevard) and Ridge Road (St. Paul and Ridge before route rationalization; Clinton and Ridge after rationalization), and between Ridge Road and downtown Rochester (Main and St. Paul).

* Transfer times from the Summerville Shuttle to Route 5, 7 or 11 are based on the average scheduled arrival and departure times of these routes at the Clinton and Ridge transfer station between 10:00 A.M. and 2:45 P.M. Inbound passengers are assumed to be traveling to downtown Rochester and to minimize their wait time by boarding the first departing RTS bus. Outbound passengers board the RTS bus that best connects with the Summerville Shuttle. After 7:30 P.M., the average best connecting fixed-route service transfer time increased by 8.5 minutes to 12 minutes.

Before rationalization, the northernmost Irondequoit residents could board an RTS Route 5 bus and arrive in downtown Rochester in about one-half hour, with the Ridge Road stop marking the midpoint of the journey. After rationalization, riders boarding an RTS Route 5, 7 or 11 bus at Clinton and Ridge heading downtown still completed their trip in 16 minutes. However, the Summerville Shuttle added six minutes to the northern leg of the trip, and an average transfer wait time of 3.5 minutes for inbound Irondequoit users increased the total effective ride time to 41.5 minutes. The northern inbound portion of the Summerville trip was scheduled to take 22 minutes, although outbound trips averaged only 19 minutes. The additional inbound ride time was designed so that transfers to and from the Loop Bus at the Irondequoit Plaza would be coordinated (see Section 8.4.2).

According to PERT and RTS schedules, outbound riders could achieve comparable travel times before and after route rationalization. By catching the best connecting RTS bus in downtown Rochester, users would minimize their transfer wait time at Ridge and Clinton and thus reach Summerville in 35 minutes, while a comparable pre-rationalization trip took 32 minutes. However, a one-day 70-passenger transfer count on September 13, 1976 at the Clinton Loop found outbound passengers actually averaging a six-minute wait. This was because many of the surveyed passengers did not coordinate their trips with the bus schedules, rather than due to late buses.

Overall, the Summerville Shùttle was averaging about 13.8 miles per hour, while comparable RTS scheduled runs averaged 17.7 miles per hour. In addition, Route 7 north of Ridge Road before April 1976 averaged 32-minute headways. The Summerville Shuttle, with 45-minute headways, therefore decreased the level of service provided on the eliminated portion of Route 7 north of Ridge Road. Thus, not only were post-rationalization Summerville Shuttle riders receiving less frequent service and slightly longer on-board ride times than previous RTS fixed-route users, but they also had the added inconvenience and time required for transferring. Furthermore, most riders lived near the route, and did not take advantage of the Shuttle's increased level of service through the checkpoint deviation option. Thus, transit service quality in the Rcute 5 and 7 corridor actually declined significantly after PERT introduced the Summerville Shuttle.

8.4.2 Loop Bus

Loop Bus service focused on serving local trips to the major activity centers in Irondequoit, and basically operated one vehicle in a counter-clockwise direction at 45-minute headways. The Loop Bus had a scheduled operating speed of 6.75 miles per hour, considerably slower than local RTS services, which averaged about 17 miles per hour.

Before the Loop Bus was introduced in April 1976, Route 9 directly served the Irondequoit Plaza, the Carter Loop and downtown Rochester every 35 minutes on weekdays and every 40 minutes on Saturdays. Route 12 provided service from Irondequoit Town Hall to Northside Hospital and downtown at 20-minute weekday headways. Sections of Route 9 (Hudson Avenue between Keeler Towers and Irondequoit Plaza) and

Route 12 (Kings Highway between Ridge Road and Irondequoit Town Hall) which the Loop service duplicated were consequently eliminated during most of the Loop service hours.

These cutbacks significantly increased the total travel times for the former RTS users traveling between Irondequoit and Rochester. First, the Loop Bus headway of 45 minutes was substantially greater than the former Route 9 and 12 headways. Second, the only transfers were generally uncoordinated between the Loop Bus and the former RTS routes. Average transfer times between the Loop Bus and the best connecting Route 9 or Route 12 bus were 6.8 minutes (Loop Bus-Route 12), 6.9 minutes (Loop Bus-Route 9), 7.0 minutes (Route 9-Loop Bus) and 11.2 minutes (Route 12-Loop Bus). Finally, passengers transferring from Route 9 to the Loop Bus, or from the Loop Bus to Route 12, had to travel the "long way" around the Loop, thereby greatly lengthening their travel time. Few passengers consequently used the Loop Bus to transfer to or from RTS service.

By June 1976, passenger complaints of "one-way only" service and long headways prompted PERT to increase the level of service by adding a reverse Loop Bus also operating at 45-minute headways on Saturdays. Although passengers were able to travel in both directions, reducing the average ride, wait and total travel time, Loop Bus ridership did not respond to these service level improvements, and this additional Loop service was eliminated in September 1976.

8.4.3 Urban PERT

The personalized doorstop evening service offered by Routes 5, 7 and 9 was intended to increase the level of transit service provided, especially for the more than 7,300 persons not previously served by fixed-route service (see Section 8.1.1). Although Urban PERT replaced RTS service, it did not change any of the line-haul routes. However, relatively infrequent service was provided; headways averaged more than 60 minutes after 9:00 P.M., with buses departing the Main and Clinton downtown station at 9:17 P.M., 10:22 P.M., 11:30 P.M. and 12:30 A.M. Only two routes operated at 12:30 A.M., with Route 5 and 7 passengers traveling on one bus, and Route 9 and 10 riders boarding the second line.

Urban PERT's scheduled vehicle speeds on Routes 5, 7 and 9 between downtown and Titus Avenue averaged 13 miles per hour. Again, this was unchanged from the previous RTS operation of Routes 5, 7 and 9.

8.4.4 <u>Routes 14 and 23</u>

PERT operated peak-period Routes 14 and 23 in Irondequoit from April 1976 to January 1977, and made minor schedule changes from those which existed prior to this under RTS management. Most riders worked at Kodak Park, and PERT attempted to improve the schedule coordination with Kodak Park shift times. Originally, PERT also planned to implement route deviation options for these routes, but an on-board survey disclosed little existing demand for this feature.

The schedule changes made are summarized in Exhibit 8.7. The major Kodak starting times were 7:00, 7:30 and 8:00 A.M. Route 14 schedules were changed so that a bus arrived at Lake and Ridge 11, 18 and 9 minutes prior to these times. Previously, arrival times were 17, 12 and 42 minutes respectively. Route 23 arrival times were also moved 3 and 4 minutes closer to the shift times. In the evening, most workers finished at around 4:12 P.M., 4:45 P.M. and 5:00 P.M. The last shift, which was previously unserved, now could board a 5:14 Route 14 bus. Also, workers finishing work at 4:45 could now board a 4:51 Route 23 bus instead of waiting until 5:15. On the other hand, they previously were served by a 4:59 Route 14 bus and now had to wait until 5:14.

Besides changing scheduling, PERT decreased the total number of inbound A.M. trips from seven to five, and the P.M. trips from six to five. In addition, the few Irondequoit passengers who used to continue on Route 14 past Kodak Park into Greece now had to transfer at Lake and Ridge for the Greece Route 14 bus still operated by RTS.

EXHIBIT 8.7

ROUTES 14 AND 23 ARRIVAL AND DEPARTURE TIMES

FROM LAKE AND RIDGE (KODAK PARK)

	RTS (BEFORE PERT)	PERT
A.M. ARRIVALS		
Route 14:	6:03*	6:49
	6:43*	7:12
	7:00*	7:51
	7:18*	
	8:22	
Route 23:	7:10	7:14
	7:42	7:45
P.M. DEPARTURES		
Route 14:	3:40*	4:28
	4:22*	5:14
	4:37	
	4:59*	
Route 23:	4:25	4:21
	5:15	4:51
		5:15

*Buses continue to or from West Greece.

8.5 PERT SUBSCRIPTION SERVICES

To assess the level of service provided to work and ARC subscription passengers in Irondequoit, travel times and vehicle speeds have been calculated based on the scheduled subscription sign-up files from January 13, 1977, two weeks after the last Irondequoit subscription service was established. Although these files only reflect the scheduled rather than actual ridership, drivers used these sheets as tour guides for timing their morning pick-ups. Since no on-board time studies were taken, precise travel times for individual passengers are not available.

8.5.1 Assumptions

The following assumptions were made in calculating these subscription trip distances:

- The work ends for Kodak Park-east and Xerox 1 and 2 tour trips were measured from the center of the Kodak Park development and Webster Xerox centers respectively. Kodak-West (Building 205) Distribution Center trips were measured from the Mount Read Boulevard entrance. All ARC trips were measured from the Center's Ridge Road entrance near Carter Street.

- All Kodak Park and ARC direct-distance trip lengths were multiplied by a 1.2 street network factor (see footnote, Section 6.1.5). Since approximately 6.5 miles of each Webster-Xerox subscription trip was a direct line-haul on Empire Boulevard Road (Route 404), a street adjustment factor of 1.1 was assumed.

- Each work subscription trip arrival time was assumed to coincide with the passengers' work shift starting times. All ARC trips were assumed to arrive at 8:30 A.M. However, Greece A.M. recorded subscription work arrival time data disclosed that buses were actually arriving about 20 minutes before the workers' shifts began (see Section 5.4). Since no arrival time data were available in Irondequoit, this cannot be invalidated; however, it does suggest that work subscription travel times in Irondequoit were overestimated.

- To partially compensate for this factor, subscription service wait time has not been included in the total travel time calculations. Thus, while the early bus arrivals at work would decrease total travel time, excessive wait times could substantially lengthen individual passengers' effective travel time.

* Comparable automobile travel times were based on the minimum and maximum subscription distances traveled, assuming a speed of 20 miles per hour to Kodak and ARC, and 25 miles per hour to Xerox. Five minutes were added to each calculation to cover parking and driver egress at Kodak and Xerox, and two minutes at ARC where closer parking was available. (These factors were not added to automobile time in the analysis of Greece subscription service, because the Greece subscription times were based upon actual bus arrival time data rather than work shift starting time. Lacking actual bus arrival time data for Irondequoit, this analysis adds a five-minute automobile egress factor to improve the comparison between Irondequoit subscription service and the automobile.)

8.5.2 Results

Exhibit 8.8 summarizes the average trip distance, travel time, and travel speed for the five Irondequoit subscription tours operated after January 1977. The average Xerox passenger traveled almost 11 miles in about 52 minutes. Passenger level-of-service ratios (transit time/auto time) were calculated to be between 1.5 and 2.0. As in Greece, those passengers picked up near the end of the tour had much better service than those picked up at the beginning. For example, the last passenger on the second Xerox tour traveled 8.24 miles in 30 minutes. The same trip by automobile is calculated to take 24.8 minutes (including 5 minutes egress time), resulting in a level-of-service ratio of 1.21. The first passenger, on the other hand, traveled 70 minutes for a 15.32 mile trip, and the level-of-service ratio for that trip was 1.67.

The Kodak Park West subscription tour also had a relatively low level-of-service ratio, but the Kodak Park tour was considerably slower, reflecting its doorstop service and shorter trip length. The ARC subscription tour also had slow travel speeds, but its tour was much more circuitous than the work subscription services, and pick-up dwell times were presumably longer because of the different type of patron. Again, passengers picked up near the end of the tour received better service than those picked up first.

In general, Irondequoit work subscription passengers received a relatively higher level of service than Greece work subscription riders, whose level-of-service ratio aver-

EXHIBIT 8.8

IRONDEQUOIT A.M. WORK SUBSCRIPTION TRAVEL TIMES

Tour	No. of Passen.	Average Passenger Distance (miles)	Average A.M. Travel Time (minutes)	Average Travel Speed (mph)	Auto Travel Time (minutes)	Level of Service Ratio
Xerox 1	9	9.09	53.7	10.2	26.8	2.00
Xerox 2	12	12.14	51.8	14.1	34.1	1.52
Kodak Park West (Mt. Read Blvd.)	12	4.62	34.2	8.1	18.9	1.81
Kodak Park (doorstep)	6	2.67	33.8	4.7	13.0	2.60
ARC	13	3.34	39.3	5.1	12.0	3.27

aged 2.27. This was due to the longer trip lengths and the use of checkpoints for some pick-ups rather than a person's home. The data is inadequate for determining the relative influence of each of these factors.

8.6 TRANSFER COORDINATION

Since most Irondequoit fixed-route services were retained, fixed-route and PERT transfer coordination was not one of the major objectives in the Irondequoit service area, except between the Summerville Shuttle and RTS buses at Clinton and Ridge, where a small transfer station opened in September 1976 to facilitate transferring. Transfers between DAB and RTS buses were also encouraged at Clinton and Ridge, and some transfers between the Greece and Irondequoit DAB services occurred at Dewey and Ridge in Greece. Finally, there was some planned transfer coordination between the Loop Bus and the Summerville Shuttle and RTS Route 10. This was intended to facilitate trips from northern Irondequoit to Irondequoit activity centers by allowing these passengers to conveniently transfer from the Summerville Shuttle or Route 10 to the Loop Bus.

Summerville Shuttle/RTS transfer coordination was discussed in Section 8.4.1. Quick transfers were possible if passengers boarded one of the RTS buses that were scheduled to meet the Summerville Shuttle.

Because the number of DAB transfers was small, no transfer time data were recorded for Irondequoit DAB-RTS transfers, and little data were available on inter-DAB transfers. In May 1976, the average inter-DAB transfer time for 17 recorded trips over three days was 16.7 minutes. In March and April 1977, the average transfer time for 15 trips over two days was 5.6 minutes. The decrease reflects the generally improved DAB service levels in 1977 compared to 1976.

Finally, the Loop Bus schedule was coordinated with the Summerville Shuttle and RTS Route 10 at Irondequoit Plaza and Rochester General Hospital, respectively. Scheduled southbound Summerville Shuttle to Loop Bus transfer times averaged 4.1 minutes, but the reverse transfer averaged 14.1 minutes. Every third southbound Route 10 bus coordinated with the Loop Bus and the scheduled averaged transfer time was 2.1 minutes. No reverse coordination was attempted; the average Loop Bus to Route 10 transfer time of 7.0 minutes was almost half the midday Route 10 headway of 15 minutes.

8.7 TIME STUDIES

No on-board Irondequoit time studies were made during the demonstration. For comparable Greece results under both manual and computerized dispatching periods, see Section 5.3.7.

The telephone interface study conducted in March 1977 applied to both Greece and Irondequoit control room operations, with the analysis and results presented in Section 5.3.8.

9. IRONDEQUOIT: DEMAND

This chapter describes the user response to the Irondequoit transportation system changes discussed in the previous chapters (see Chapters 4 and 8). It describes PERT ridership trends, user and trip characteristics, and user attitudes. The information reported was obtained from PERT operational records and several user surveys.

Irondequoit's ridership trends are discussed in the following sections. For simplification, the data is divided into five periods corresponding to the major service and fare changes implemented in June and September 1976 and January and June 1977. These are shown in various ridership graphs contained in this chapter and a full tabulation of PERT supply, demand, and productivity data for these five periods is contained in Exhibit 10.2 in Chapter 10.

Three Irondequoit PERT services terminated on December 31, 1976 and two ceased operations on June 17, 1977. Only the DAB and ARC subscription services continued operating after this time. Ridership for these services is plotted through August 12, 1977. Except for DAB and the subscription services, for which control room records were kept, all ridership figures are based upon driver-kept records. Ridership is probably slightly underestimated on these services because drivers were suspected of undercounting riders. Data on the special services for the transit-dependent is excluded from the tables and Exhibit 10.2 because this data was combined with the Greece service data for most of the period analyzed (see Chapter 6).

9.1 DIAL-A-BUS

9.1.1 Ridership Levels

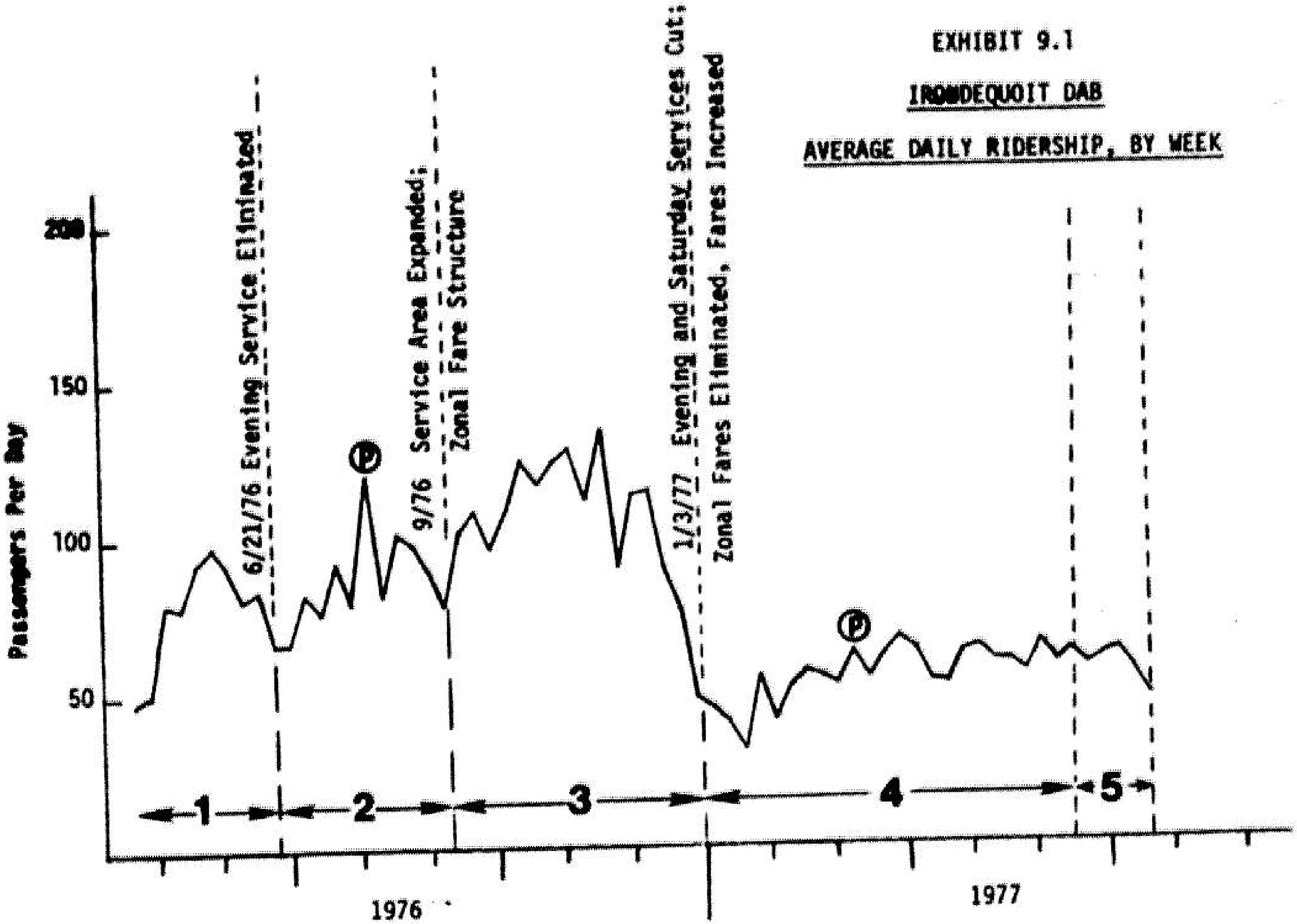
Exhibit 9.1 displays the average daily DAB ridership by week from April 12, 1976, the start of PERT service in Irondequoit, until August 12, 1977.

DAB ridership grew steadily during 1976 and reached a peak of around 130 passengers per day in November 1976. During the first period through June 21, 1976, ridership averaged 74 passengers per day, increasing by 14% in the second twelve-week analysis period. During the September-December 1976 period, an average of 105 daily passengers were carried, including 20 student passengers who were carried on a special tour to and from school on weekdays. Saturday ridership was only about half the weekday average, so that the average weekday ridership during this period was

EXHIBIT 9.1

IRONDEQUOIT DAB

AVERAGE DAILY RIDERSHIP, BY WEEK



Ⓟ Reduced Fare Promotion

about 115 passengers, or 95 passengers excluding the student trips.

Ridership declined during December 1976 as a result of extremely severe winter weather and inadequate vehicle supply. Following the January cutback of service to 3:00 P.M., the school service was discontinued, and the number of daily riders leveled off at around 60. Since about 70% of the 1976 passengers (excluding the school trips) rode before 3:00 P.M. (see Exhibit 9.3), the 1977 ridership represented a slight loss of patronage (about 10%) during the hours operated when compared to 1976. The higher fare and reduced opportunities for return trip-making may have accounted for the difference.

During 1976, there were approximately 1.5 passengers per-service request, resulting in a maximum of 85 daily demands (trips) in November 1976. This corresponds to an average demand density of 0.85 demands per square mile per hour. This was substantially below the maximum of 2.0 demands per square mile per hour achieved in the Greece service area in early 1975. Following the January 1977 service cutback, demand density decreased to 0.75 demands per square mile per hour, and approximately 1.2 passengers were served per trip.

Two DAB reduced-fare promotions were conducted in Irondequoit, but neither had a lasting effect on ridership. A newspaper half-fare coupon promotion from July 25 to August 7, 1976 boosted ridership 37% during its second week, but ridership fell to previous levels the following week. A half-fare week in March 1977 had a similar impact, with ridership rising by 21% that week but declining to its original level the following week.

9.1.2 Transfers

Irondequoit DAB transfer ridership was highest during the summer of 1976 (Period 2) when a daily average of 29.0 transfers were made. This represented 34% of all DAB ridership. Daily transfers declined to 20.0 passengers in the fall of 1976 (19% of ridership) and 10.6 passengers in January-June 1977 (19% of ridership).

Unlike in Greece, Irondequoit DAB passengers transferred to and from a variety of other transit services at several locations. The largest number of transfers occurred at Dewey and Ridge in the Greece service area, where passengers transferred to and from the Greece DAB service. There were 16.4 daily transfers at Dewey and Ridge in the summer of 1976, 11.3 in the fall of 1976, and 7.5 in 1977 (spring data was unavailable). This represented 57% of all transfers in both 1976 periods and 71% in 1977. Most of the remaining DAB transfers occurred at Clinton and Ridge where passengers transferred to RTS fixed-route buses going downtown. However, the actual number of such transfers was small, ranging from an average of 2.9 per day in 1977 to 6.2 in the 1976 summer. A few passengers each day would also usually transfer at several other locations.

9.1.3 Temporal and Spatial Variations

Ridership variations by day of the week for DAB and six other Irondequoit PERT services are shown in Exhibit 9.2. In general, DAB ridership rose slightly during the week, peaking on Fridays at about 117 passengers, with Saturday ridership averaging less than half of the weekday averages.

As shown in Exhibit 9.3, Irondequoit DAB ridership peaked between 2:00 and 4:00 P.M., in contrast to Greece DAB service in which ridership was highest between 9:00 A.M. and 2:00 P.M. One possible reason for the difference is that Greece residents may have used local RTS buses during the late afternoon when they resumed service. However, on-board survey results regarding the use of other modes for the return trip do not support this hypothesis. In both Greece and Irondequoit, approximately half the riders used a mode other than DAB for their return trips and about one-fifth of these riders cited RTS buses as the alternative mode.

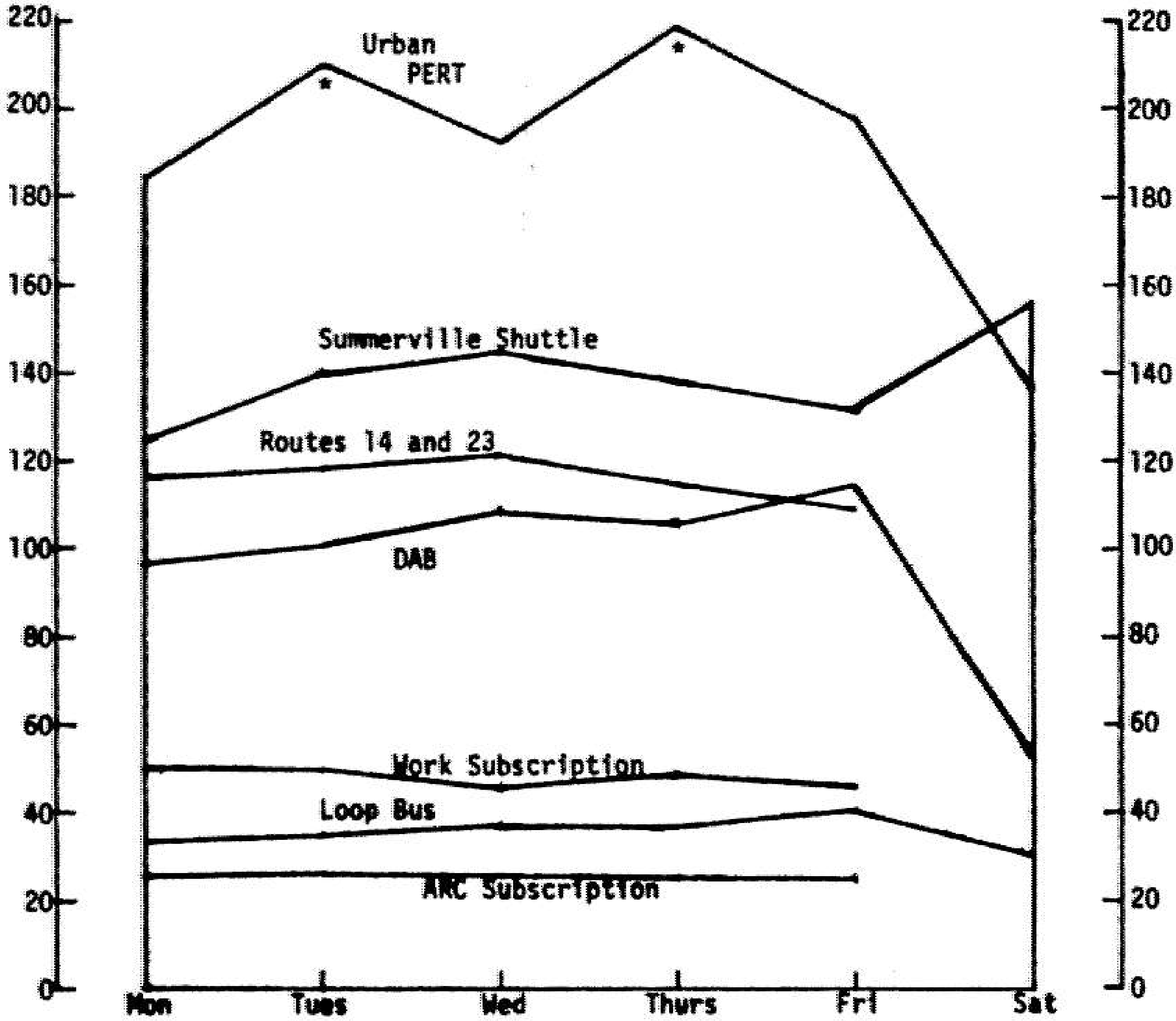
A two-week origin/destination study of DAB demand suggests that the predominant demand patterns were in a north-south direction, and in an east-west direction within the southern portion of the service area. To illustrate this pattern, the service area was divided into five approximately equal-sized zones. An origin/destination matrix was constructed based on two weeks of ridership in July 1977. The results are shown graphically in Exhibit 9.4. Approximately 13% of all trips were totally within the narrow band along the service area's southern border (Zone E), and an additional 49% of all trips were to or from this zone.

The southern portion of the service area contained most of the area's activity centers and elderly housing, such as Rochester General Hospital, the Wilson Health Center, Keeler Towers, St. Ann's Nursing Home, and several shopping centers. Consequently, this area had the greatest demand density. Demand was fairly uniformly distributed in the remainder of the service area, except for the area east of Culver Road (Zone D), where demand density was much lower than in the other areas. The many-to-few nature of Irondequoit DAB demand resembles the demand pattern experienced in Greece, which was also oriented in a north-south pattern.

EXHIBIT 9.2

PERT RIDERSHIP BY DAY OF WEEK

(April 12, 1976-December 31, 1976
Excluding Holiday Weeks)



*Tuesdays and Thursdays are late shopping nights in downtown Rochester.

EXHIBIT 9.3

DIAL-A-BUS RIDERSHIP, BY TIME OF DAY

(33 Days in October-November 1976; Special School Trips Excluded; Average Daily Ridership = 93.8 Passengers)

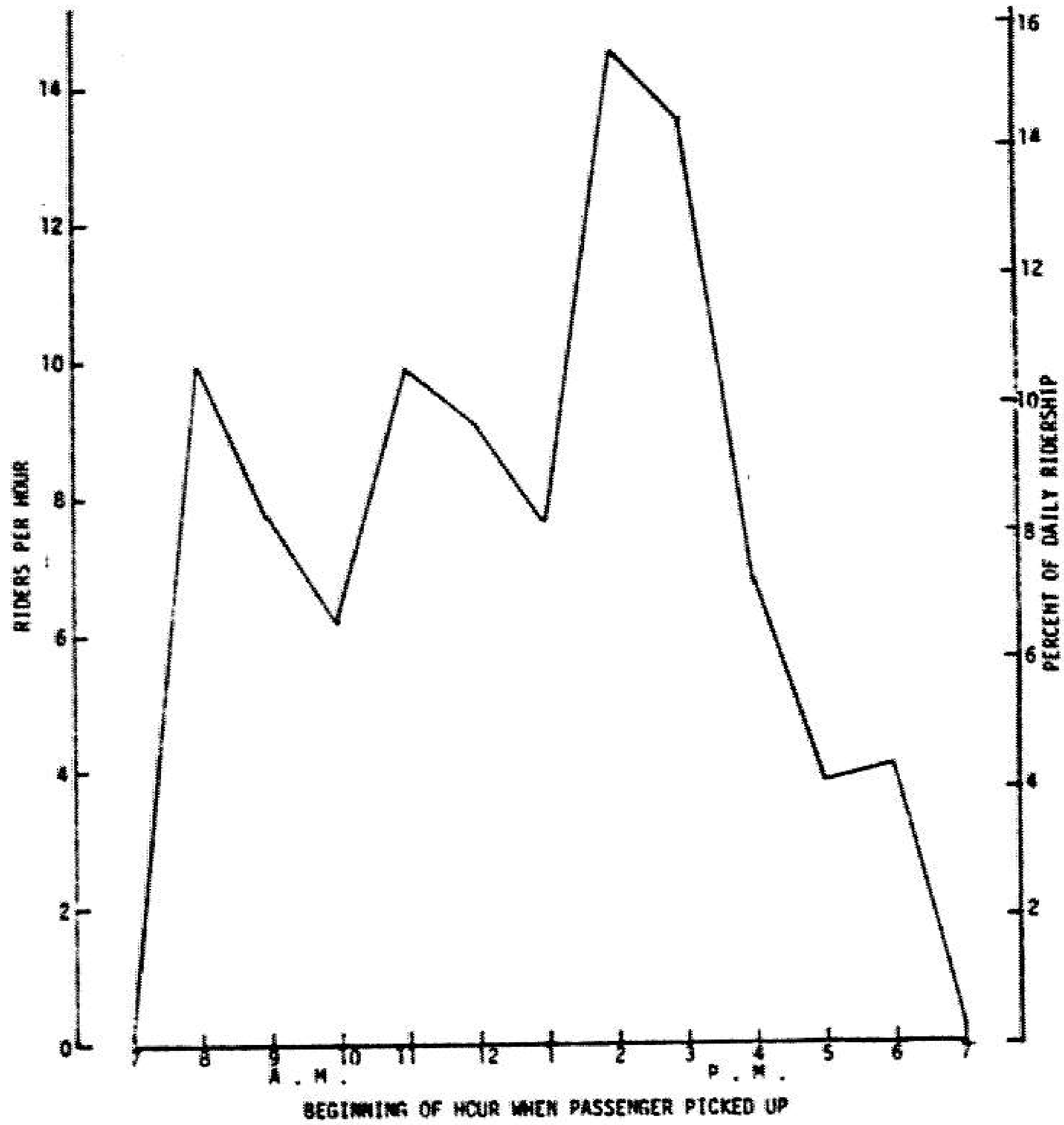


EXHIBIT 9.4 IRONDEQUOIT DAB ORIGIN/DESTINATION STUDY

(Two Weeks; July 18-29, 1977)

Zone	Destinations A	B	C	D	E	F	Total Origins	Total Trip-Ends	Population Residing in Zone	Trip-Ends/ Capita ($X 10^3$)
A	3	4	14	3	30	4	58	96	6,609	14.5
B	2	7	23	12	14	6	64	128	7,067	18.1
C	11	23	5	4	14	15	72	136	8,243	16.5
D	3	2	4	4	43	3	59	99	9,988	9.9
E	17	24	11	14	59	16	141	333	8,388	39.7
F	2	4	7	3	32	1	49	94	--	--
	38	64	64	40	192	45	443	886	40,295	

Compared to Greece, however, Irondequoit DAB demand was more diffused, probably because the fixed-route services in Irondequoit carried much of the concentrated transit demand.

One objective of DAB spatial demand analysis is to identify new concentrated demand patterns and, if demand is high enough, establish a fixed-route service to serve it more efficiently. Exhibit 9.4 indicates that a concentrated demand pattern existed along the service area's southern boundary. However, the total daily demand was so small that a fixed-route bus operating in this corridor (such as along Ridge Road) would be very uneconomical. (RTS presently provides peak-period service only on Ridge Road and Norton Street within this area.)

9.1.4 Trip Lengths

The origin/destination data were also used to estimate the average DAB trip length in Irondequoit. The service area was divided into 36 computer-assigned zones, and trips were assumed to be to and from the centers of each zone. The average straight-line trip distance for 443 trips (ten days) was found to be 1.60 miles (2% of the trips were intrazonal and were assigned trip lengths of 0.4 miles). In order to derive an average passenger trip distance that corresponded to the actual driving distance, the average straight-line trip length was multiplied by a street adjustment factor of 1.25.[1] This resulted in an average DAB passenger trip distance of 2.0 miles.

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[1]For a theoretical area with a perfect grid street system and trips equally likely to be generated in all directions, a street adjustment factor of 1.273 was obtained:

$$\int_0^{\pi/2} \frac{\sin x + \cos x}{\pi/2} = 1.273$$

The Irondequoit service area is essentially a grid system. The only major diagonal route would be Culver Road and Ridge Road when traveling from the northeast area to the southern portion of the service area. Thus, an adjustment factor of 1.25 was used.

9.1.5 No-Shows and Cancellations

Except for the period of extreme vehicle shortages during the 1976-77 winter, there were relatively few no-shows and cancellations. This is illustrated in Exhibits 9.5-A and 9.5-B. During all of 1976, no-shows averaged about 4-1/2% of all completed trips. This rose slightly in 1977, and no-shows averaged about 7% of all completed trips after January 1977. In Greece, however, no-shows ranged between 10% and 20% of all trips during the summer and fall of 1976, although they also averaged around 7% in 1977.

Cancellations averaged about 4% of all trips (less than 3% of the average daily passengers carried) until the fall of 1976, when this rate doubled for the rest of the year. In 1977, the number of cancellations again jumped, averaging about 19% of all trips completed in Irondequoit. However, during this same period in Greece, cancellations were running at about 25% of all completed trips.

The differences between Greece and Irondequoit are probably due to the lower level of service provided in Greece during 1976 and the greater availability of alternative fixed-route services for many DAB trips in Greece. Most DAB no-shows occurred at non-residential locations such as shopping centers and transfer points, where impatient customers would probably take a fixed-route bus if it came first. In Greece, many passengers could take the Dew-Ridge Shuttle or Routes 10 and 14 during the afternoon peak period. There were probably fewer such alternatives available in Irondequoit for DAB users. This may have also been one reason why more Irondequoit DAB riders made round trips by DAB than in Greece. (See Sections 6.1.6 and 6.1.7 for further no-show and cancellation discussion.)

9.1.6 Late Bus Complaints

As summarized in Exhibit 9.5-C, late bus complaints averaged 1.8% of ridership (2.8% of trips) before the 1976-77 winter vehicle problems began. From September 13 through the end of 1976, Irondequoit received an average of six late bus complaints a day, or almost 9% of the number of trips completed. As vehicle reliability and service quality improved, this rate dropped dramatically to an average of 2.1% of daily trips (1.8% of ridership) during the first six months of 1977.

EXHIBIT 9.5-A CUSTOMER CANCELLATIONS/DAB RIDERSHIP, BY WEEK

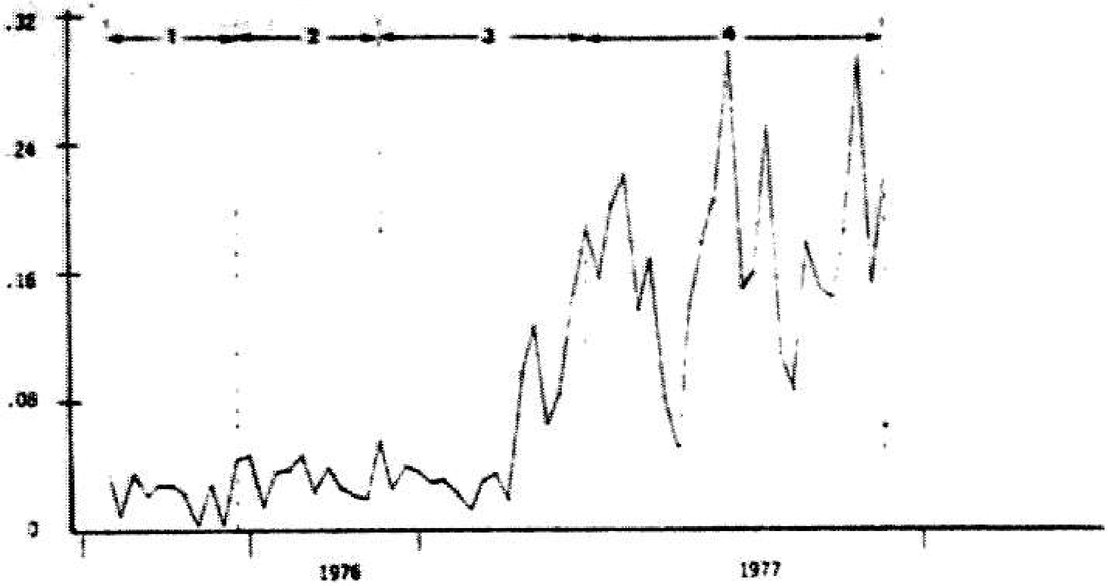


EXHIBIT 9.5-B NO-SHOWS/DAB RIDERSHIP, BY WEEK

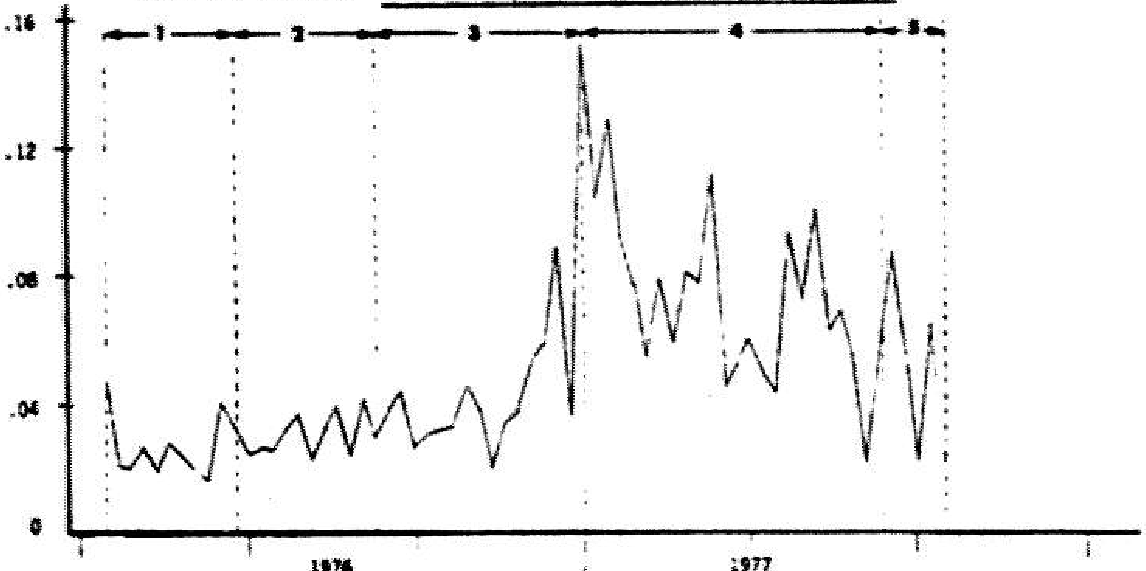
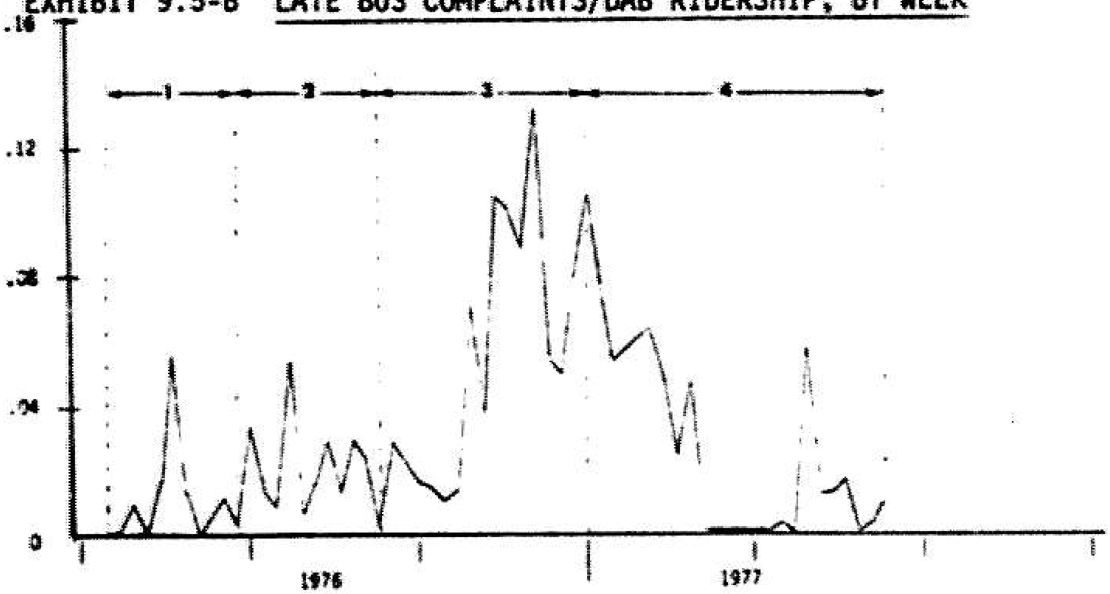


EXHIBIT 9.5-B LATE BUS COMPLAINTS/DAB RIDERSHIP, BY WEEK



9.2 IRONDEQUOIT LOOP BUS

Irondequoit Loop Bus ridership fluctuated between 25 and 45 passengers per day and averaged 37 passengers per day during the duration of its operation, as shown in Exhibit 9.6. Ridership during the initial period averaged over 48 passengers per day, but on June 21, 1976, RTS Route 9 service was restored during the midday and the fare was increased by 5 cents. Consequently, ridership during the summer 1976 period dropped to an average of 34 passengers per day.

In response to "one-way only" service complaints, another Loop Bus running in the opposite direction was added on Saturdays beginning in June 1976. Instead of increasing Saturday ridership, the reverse Loop Bus experiment merely caused ridership to split between the two directions; the service was therefore eliminated on September 13, 1976. Ridership may have remained low because of inadequate information dissemination and marketing efforts.

Riders only exceeded 40 per day during two subsequent weeks, one of which was a promotional week in October 1976 when no fare was charged. However, the promotion had no significant long-term ridership impact. The low demand attracted to the Loop Bus resulted in its termination in January 1977.

9.3 THE SUMMERVILLE SHUTTLE

Exhibit 9.6 shows daily Summerville Shuttle ridership initially averaged about 155 passengers per day, but this decreased to around 130 passengers per day by the fall of 1976. Following the elimination of evening and Saturday operations in January 1977, daily ridership fell to around 92 passengers. Saturday had the most riders because of much longer operating hours (see Exhibit 9.2). Very few passengers used the route deviation option; during 1976, less than two passengers per day requested route deviations. Following a deviation fare increase in January 1977, the number of daily deviation requests dropped to one per week.

Ridership counts on Routes 5 and 7 prior to the start of the Summerville Shuttle indicate that less than half of the ridership formerly served by these routes switched to the Summerville Shuttle. An estimated 298 daily passengers formerly rode on Route 5 and 7 buses north of Ridge Road which the Summerville Shuttle replaced:

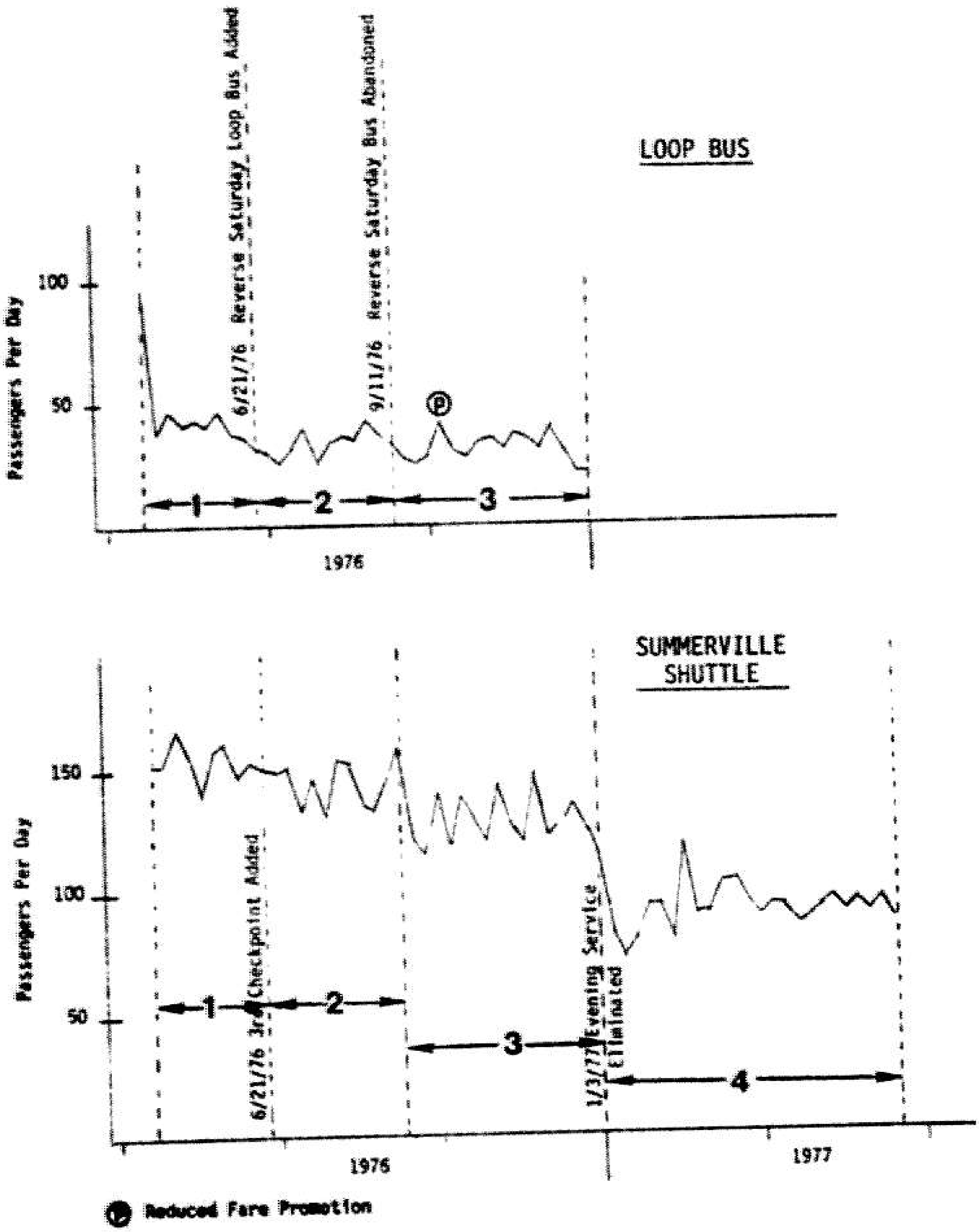
Route 5: weekday afternoon:
21.0 passengers/run X 6-1/2 runs = 136.5
weekday evening:
5.4 passengers/run X 3 runs = 16.2
Saturdays:
12.0 passengers/run X 20 runs = 240.0
Route 7: weekday afternoon:
12.8 passengers/run X 9 runs = 115.2
weekday evening:
2.3 passengers/run X 3 runs = 6.9
Saturdays:
4.5 passengers/run X 38 runs = 171.0

Average daily ridership =
[5 (avg. weekday ridership) + Sat. ridership] / 6 =

[5(136.5+16.2+115.2+6.9)+240.0+171.0]/6 = 297.5.

The Summerville Shuttle, with an average daily ridership of about 136 passengers during 1976 thus represented about 45% of the former ridership. The 1977 ridership of 92 daily passengers represented about 37% of the former weekday afternoon ridership. These figures are corroborated by a December 1976 telephone survey of former Route 5 and 7 passengers who were identified in the March 1976 survey (see Appendix A.11). Approximately 42% of these users reported using the Summerville Shuttle when having to make the same type of trip they were making when originally surveyed. Most of the other users reported using Routes 5 or 7 during the peak period, walking to Ridge Road to access Routes 5 or 7, or using another RTS route. About one-quarter of the respondents cited driving or using DAB.

EXHIBIT 9.6 IRONDEQUOIT PERT AVERAGE DAILY RIDERSHIP, BY WEEK



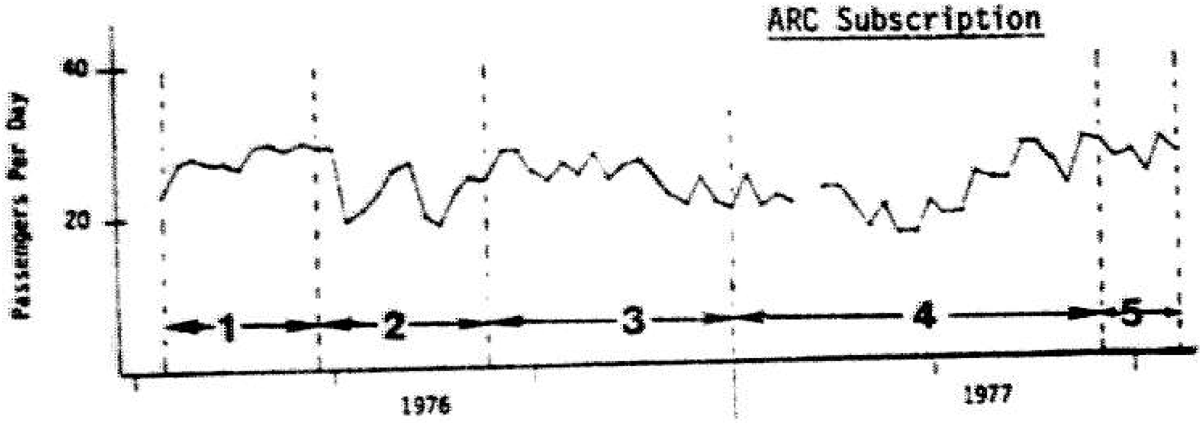
9.4 WORK SUBSCRIPTION SERVICE

Irondequoit work subscription service began in April 1976 with one route to Kodak Park West on Mt. Read Boulevard. During the first analysis period outlined in Exhibit 9.7, an average of 18.8 daily passengers (9.4 each way) were carried. Ridership increased to 30.2 daily passengers between June and September 1976 when a Xerox route was added. In September 1976, a large ridership increase occurred as an additional Xerox route was added, and about 21 daily Park-and-Ride passengers were carried to Kodak Park on the return trip from Xerox. The sudden plummet in work subscription ridership at the end of December 1976 is attributed to the holiday season. Ridership again increased in January 1977 as a Kodak Park East tour was added. On January 17, 1977, work subscription fares were increased, causing a temporary ridership decline, before stabilizing at about 90 daily passengers during February and March. Since the free-fare week of February 28 to March 4, 1977 was not actively promoted, it had no effect on ridership. The recently added Kodak Park East route was subsequently cancelled in April and ridership dropped to its 1976 levels. Shortly thereafter, the decision to terminate work subscription service in June was announced and ridership began to drop off rapidly. Irondequoit work subscription tours averaged about nine passengers, higher than in Greece but still below the capacity of most of the PERT vehicles. No-shows were not a problem in Irondequoit, averaging well below 1% of total ridership.

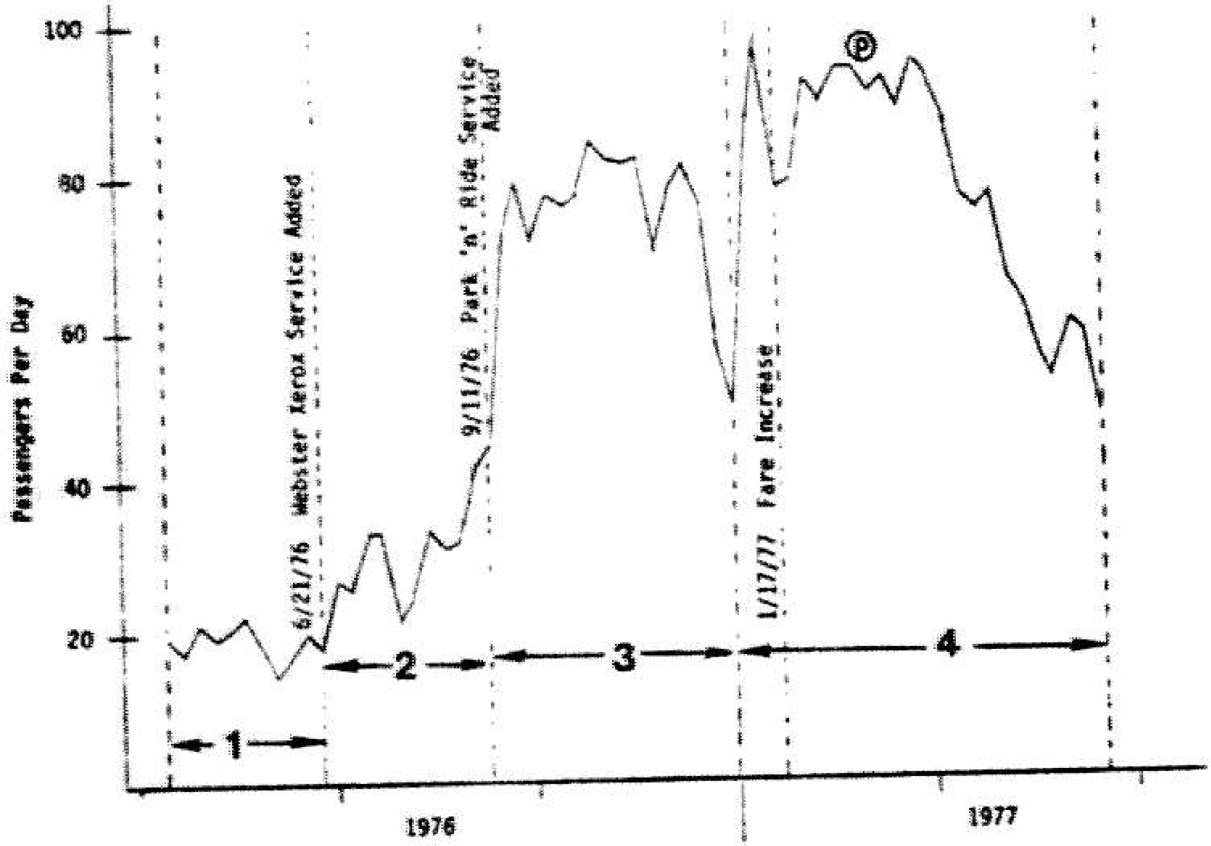
EXHIBIT 9.7

IRONDEQUOIT PERT AVERAGE DAILY RIDERSHIP, BY WEEK

ARC Subscription



Work Subscription



P Reduced Fare Promotion

9.5 ARC SUBSCRIPTION SERVICES

ARC subscription ridership remained fairly constant at around 25 passengers per day during its entire operation, as summarized in Exhibit 9.7. Its load factor (12.5 passengers per tour) thus exceeded that of the work subscription service.

9.6 ROUTES 14 AND 23

Ridership on the two peak-period fixed routes which PERT operated during 1976 averaged 120 daily passengers during the spring and fall and 95 passengers during the summer, as depicted in Exhibit 9.8. Ride counts on Routes 14 and 23 prior to PERT suggest that 168 passengers rode these routes when they were operated by RTS (see Exhibit 3.20). However, data from as early as 1972 was used in these estimates, and Route 14 ridership was apparently significantly overestimated. Data from 1974 through 1976 suggests an average daily ridership of 135.8 passengers prior to PERT operation:

Route 14: 9.4 passengers/run X 9 runs/day
= 84.6 passengers/day

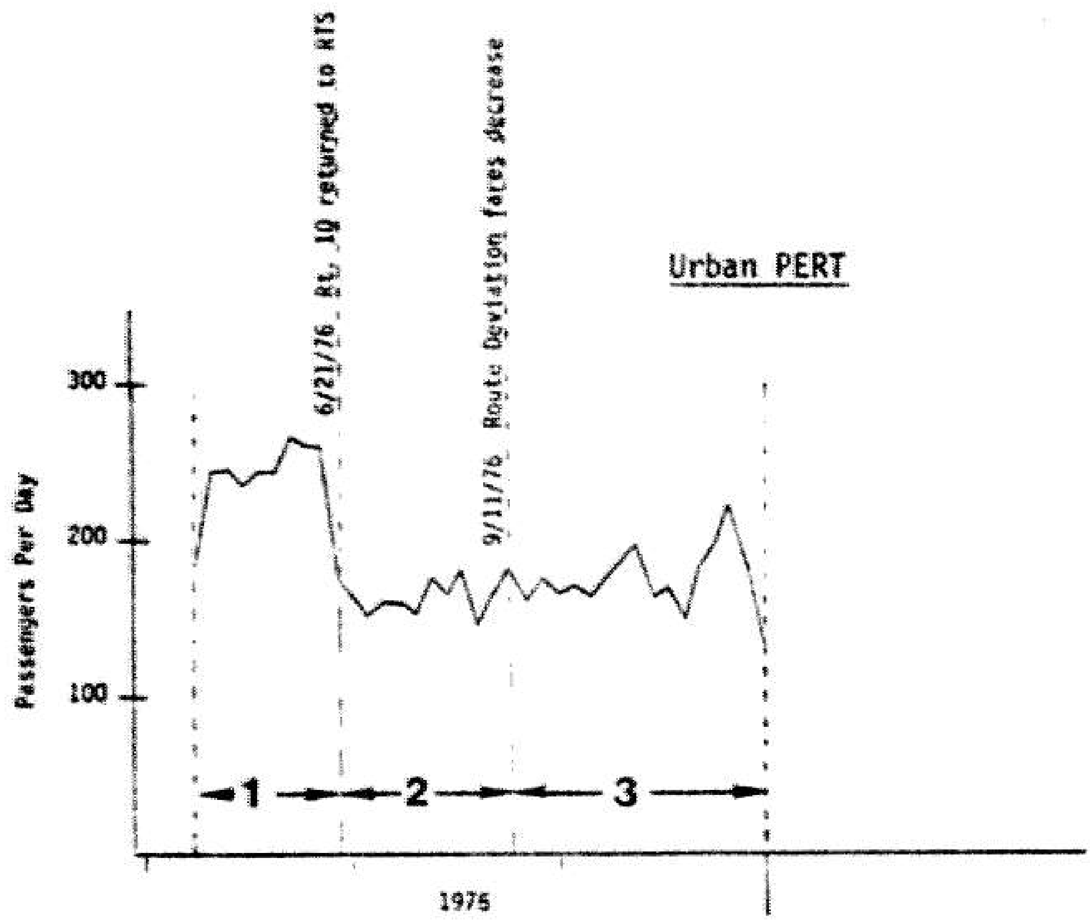
Route 23: 12.8 passengers/run X 4 runs/day
= 51.2 passengers/day

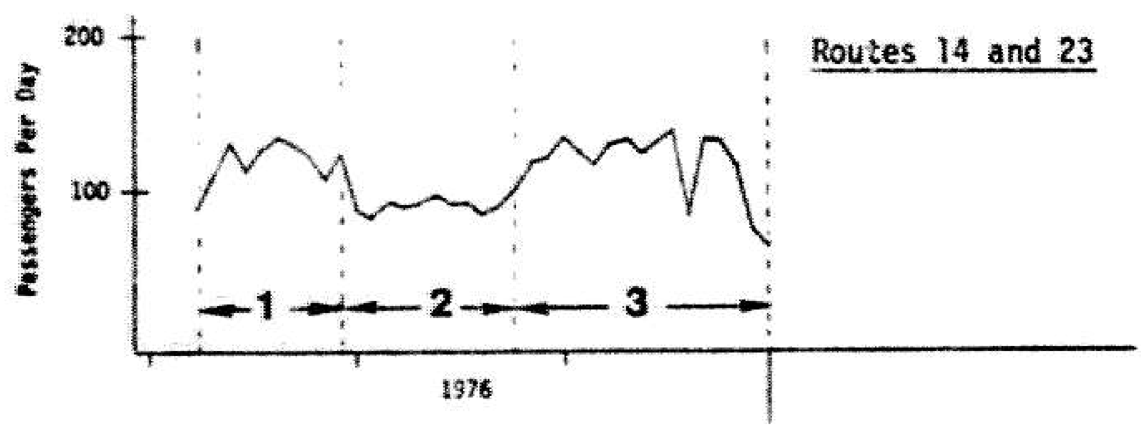
Total 135.8 passengers/day.

Using this data, a small decline (about 12%) is noted between RTS and PERT operation of these routes. Although the difference was not statistically significant, the reduction from 13 to 10 peak direction trips may have caused a drop. Also, the new requirement that Route 14 passengers transfer if traveling beyond Kodak Park in Greece may have caused a small loss of patronage. Previously, most Route 14 buses continued along Ridge Road to West Greece; these services were separated under PERT operation. Finally, inadequate publicizing of the schedule changes may have contributed to the ridership decline.

EXHIBIT 9.8

IRONDEQUOIT PERT AVERAGE DAILY RIDERSHIP, BY WEEK





9.7 URBAN PERT

Urban PERT ridership was 242 passengers between April and June 1976 when four routes were operated, and dropped to around 170 passengers after June (see Exhibit 9.8) when Route 10 operations were returned to RTS. PERT minibuses had insufficient capacity to handle Route 10's summer Seabreeze Amusement Park crowds. Urban PERT ridership generally peaked on Tuesdays and Thursdays, because Rochester's stores were open on these evenings (see Exhibit 9.2).

Only about two deviation requests per week were recorded, representing less than 1/4% of ridership. However, a count made during the night that an on-board survey was conducted suggests that deviation requests were undercounted by PERT management. Outbound requests in which a passenger requested the driver to deviate and thus bypassed the control room apparently often went uncounted. The actual number of deviation requests may have actually been two or three times higher than recorded, although this would still only represent less than 1% of the ridership.

Apparently, existing nighttime users did not feel any need to use the deviation option, since they generally lived near the bus route and were already accustomed to the trip. The deviation option also attracted few new users to the service; one possible reason is that little marketing was done for Urban PERT. Unlike in the DAB service area and northern Irondequoit, no general household promotional mailing was conducted in the Urban PERT service area.

Ride counts taken during the week prior to Urban PERT's operation resulted in an estimated RTS ridership on these routes of about 375 passengers, 100 of which were on Route 10. According to this data, ridership dropped by about 35% following PERT's takeover of these routes. This is very unlikely, since almost nothing about the operation changed. The small buses used were if anything more attractive than the larger RTS buses. The other major change was that passengers going to or returning from the opposite side of the CBD on the same route had to transfer downtown at Main and Clinton. However, the bus schedules did not change and the only difference was that passengers had to wait outside until the PERT bus arrived rather than inside the bus until departure time. Furthermore, most passengers boarded and unboarded at Main and Clinton anyway, so the number of passengers affected by this change was not great. It seems most probable that the RTS ridership data recorded was not representative of the period preceding Urban PERT and that PERT drivers undercounted the number of passengers.

9.8 SPECIAL SERVICES FOR THE TRANSIT-DEPENDENT

The oldest of the Irondequoit special services, the Friday service between Seneca Towers and the Jewish Home and Infirmary, carried an average of 34 passengers (17 each way) with little variation. The Tuesday Seneca Towers-Longridge Mall special carried an average of 32 passengers, and the Seneca Towers-McDonald's special carried an average of 61 passengers each time it operated. Finally, the Jewish Home-sponsored trip to the ice cream vendor on Mondays carried 16 passengers. In addition to these regular services, an occasional group trip was also made through special arrangements.

9.9 USER CHARACTERISTICS AND ATTITUDES

Including the survey of RTS passengers conducted prior to the start-up of Irondequoit PERT services, 10 user surveys were conducted in Irondequoit. Results from the following surveys are tabulated in the following Appendices:

Appendix 10:	March 1976 RTS Fixed-Route On-Board Survey
Appendix 11:	December 1976 Former Fixed-Route Users Telephone Survey
Appendix 12:	August and December 1976 Dial-A-Bus On-Board Surveys
Appendix 13:	April 1977 Dial-A-Bus On-Board Attitudinal Survey
Appendix 14:	November 1976 Loop Bus On-Board Survey
Appendix 15:	August and November 1976 Summerville Shuttle On-Board Surveys
Appendix 16:	December 1976 Urban PERT On-Board Survey
Appendix 17:	March 1977 RTS Routes 9 and 10 Survey.

In addition to identifying ridership characteristics and user attitudes for individual PERT services, these surveys allow before/after comparisons to be made based upon the RTS users' survey conducted in March 1976 (initially reported in Section 3.2.5) prior to the implementation of Irondequoit's demonstration services in April 1976. RTS Route 9 and 10 users, surveyed again in April 1977, are a control group in the analysis, since these routes were not altered by the PERT service package (except for a brief interruption of Route 9 service in April-June 1976 that is assumed to not affect the results of the survey taken several months later).

9.9.1 User Characteristics

Exhibit 9.9 summarizes the demographic characteristics of Irondequoit RTS and PERT off-peak users. Users of the Summerville Shuttle and former RTS daytime routes had similar characteristics, which is logical since the Summerville Shuttle consisted mostly of former RTS passengers. Approximately two-thirds of the riders were female, one-third of the passengers were under 20 years of age, another one-third were between 20 and 44, and approximately 15% were over age 65. The respondents from these two PERT services owned the highest average number of automobiles per household (1.26) compared to other PERT services.

Since Urban PERT replaced the nighttime RTS services surveyed, Urban PERT users generally had the same characteristics as RTS nighttime users. The majority of these riders were male, between the ages of 20 to 44, and employed. There were very few elderly users, which is perhaps one of the reasons that there was little demand for route deviation service. DAB and the Loop Bus, however, had significantly higher proportions of elderly users than on RTS services. Although about the same proportion of persons possessed driver's licenses, a much larger number of DAB and Loop riders came from autoless households compared to RTS users. Approximately half of the DAB passengers reported using transit for most of their local travel; data from other services was not available. Most DAB users also used RTS services occasionally.

9.9.2 Trip Characteristics

Trip characteristics for the various services are summarized in Exhibit 9.10. Although three-quarters of RTS and Summerville Shuttle users made a round-trip by transit, only half of the DAB passengers used DAB for their return trip. Most of the other passengers were driven on the return leg of their trips. This pattern also occurred in the Greece DAB service. In general, trip purposes on PERT and RTS were similar, with over one-third of the trips for work, and approximately 10% for school. Over 60% of the Loop Bus and about 20% of the Summerville Shuttle and DAB trips were for shopping purposes, somewhat more than the 15% carried on the RTS buses. Slightly more than half of the DAB survey respondents used immediate request service. As in Greece, there were considerable more advance requests on weekdays, with advance requests comprising only about one-third of Irondequoit's DAB service requests on Saturdays.

Although automobile availability for trips did not vary much among the various modes, DAB users were more transit-

EXHIBIT 9.9

COMPARISON OF IRONDEQUOIT TRANSIT SERVICES USER CHARACTERISTICS

User Characteristic	Fixed-Routes (Before; Weekdays) Day (n=343)	Night (n=216)	Summer-ville Shuttle[a] (n=94;90)	DAB[a] (Weekday) (n=45;53)	Irondequoit Loop (n=20)	Urban PERT (n=112)	Routes 9 and 10 (Control) (n=129)
Sex							
Male	33.1	61.8	38.4	25.1	25.0	52.7	27.9
Female	66.8	38.2	61.6	74.9	75.0	47.3	72.1
Age							
Under 20	35.9	29.9	36.1	20.4	8.3	25.6	27.3
20 - 44	26.7	52.1	33.1	34.9	8.3	51.1	27.3
45 - 64	23.4	14.7	14.5	22.8	25.0	20.0	32.0
Over 65	13.9	3.3	16.3	21.9	58.3	3.3	13.3
Driver's License							
Licensed	44.7	45.1	46.2	40.1	41.7	41.4	48.8
Not Licensed	55.3	54.9	53.8	59.9	58.3	58.6	51.2
Occupation							
Employed	40.7	59.7	29.5	37.0	8.3	73.6	39.5
Self-Employed	2.1	3.3	4.5	2.3	0.0	3.4	0.8
Student	27.9	24.2	35.9	14.4	8.3	18.4	23.3
Homemaker	10.1	4.3	11.4	20.0	16.7	3.4	14.7
Retired	13.6	2.8	14.2	24.9	66.7	1.1	15.5
Unemployed	--	--	4.5	1.3	--	0.0	
Other	5.6	5.7	--	--	--	--	6.2
Household Auto Ownership							
0	20.1	41.4	30.0	39.7	45.5	N/A	17.5
1	45.0	38.5	32.2	28.3	36.4	N/A	50.0
2	26.5	12.6	25.6	26.0	18.2	N/A	26.3
3 or More	8.4	7.5	12.2	6.0	0.0	N/A	6.1
Mean (assuming 3.2 for 3 or more)	1.25	0.88	1.27	1.00	0.73	N/A	1.22

(Exhibit 9.9, Continued)

User Characteristic	Fixed-Routes (Before; Weekdays) Day (n=343)	Fixed-Routes (Before; Weekdays) Night (n=216)	Summer-ville Shuttle[a] (n=94;90)	DAB[a] (Weekday) (n=45;53)	Ironde-quoit Loop (n=20)	Urban PERT (n=112)	Routes 9 and 10 (Control) (n=129)
Use of RTS Buses							
3-6 days/week	49.2[b]	N/A	46.9[c]	23.3	0.0	N/A	82.6
1-2 days/week	18.9[b]	N/A	24.7[c]	12.7	25.0	N/A	17.5
1-3 days/month	19.7[b]	N/A	18.5[c]	14.8	0.0	N/A	N/A
Less than once/month		N/A		20.2	0.0	N/A	N/A
Never	13.1[b]	N/A	9.9[c]	29.1	75.0	N/A	N/A
Use of Dial-A-Bus							
3-6 days/week	0.8[b]	N/A	2.5[c]	46.4	16.7	N/A	N/A
1-2 days/week	4.1[b]	N/A	7.4[c]	24.1	8.3	N/A	N/A
1-3 days/month	6.5[b]	N/A	9.9[c]	14.3	0.0	N/A	N/A
Less than once/month	3.3[b]	N/A		15.2	0.0	N/A	N/A
Never	85.4[b]	N/A	80.2[c]	--	75.0	N/A	N/A

---

[a] Responses from two surveys averaged.

[b] Based on December 1976 telephone survey of former Route 5, 7 and 12 users; reflects their usage after PERT was introduced.

[c] Based on responses to the following frequency of use categories:

4-7 days/week
1-3 days/week
less than once/week
never

N/A denotes information not available.

EXHIBIT 9.10

COMPARISON OF IRONDEQUOIT TRANSIT SERVICES TRIP CHARACTERISTICS

	Fixed-Routes (Before: Weekdays) Day (n=343)	Night (n=313)	Summer-ville Shuttle[a] (n=94;90)	DAB[a] (Weekday) (n=45;53)	Irondequoit Loop (n=20)	Urban PERT (n=112)	Routes 9 and 10 (Control) (n=129)
Trip Purpose							
Work	36.3	41.7	35.4	39.5	27.3	62.9	37.9
School	17.7	11.4	20.2	2.8	0.0	10.1	15.5
Shopping	10.7	4.0	17.6	22.1	63.6	3.4	9.5
Medical, Dental	3.3	0.0	5.5	11.4	0.0	0.0	4.3
Personal Visit	5.7	9.7	7.7	12.5	0.0	13.5	7.8
Recreation	3.0	10.3	8.3	5.9	9.1	--	4.3
Personal Business	12.0	6.3	2.6	--	0.0	--	12.1
Other	4.0	5.1	2.8	5.7	0.0	10.1	8.6
Multi-Purpose	7.3	11.4	--	--	--	--	--
Alternate Mode for Trip							
No Trip	23.0	14.5	11.4	31.0	18.2	N/A	27.8
Drive	16.8	11.0	11.4	9.6	9.1	N/A	26.1
Driven	26.5	22.0	35.4	16.6	36.4	N/A	27.0
Other RTS Bus	9.6	6.4	13.9	23.2	18.2	N/A	7.8
Walk/Bicycle	7.9	17.9	11.4	10.6	18.2	N/A	9.6
Taxi	4.5	10.4	2.5	7.0	0.0	N/A	0.0
School Bus	--	--	7.6	--	--	N/A	--
Other	4.5	4.6	6.3	2.0	0.0	N/A	1.7
More Than One Alternative	7.2	13.3	--	--	--	N/A	--
Round-Trip by Same Transit Mode							
Yes	81.2	76.6	73.3	53.0	90.9	75.6	69.6
No	18.8	23.4	26.7	47.0	9.1	24.4	30.4
Auto Availability for Trip							
Convenient	N/A	N/A	8.6	15.9	9.1	N/A	19.6
Inconvenient	N/A	N/A	18.7	16.9	0.0	N/A	15.0
Not Available	N/A	N/A	72.7	67.2	90.9	N/A	65.4

[a]Responses from two surveys averaged.

N/A denotes information not available.

dependent than users of the other services. About 31% of the DAB users (41% in August) said they could not have made their trips without DAB. In addition, 23% said they would have used RTS buses as an alternative. The combination of these responses was significantly larger than for other modes.

In summary, Summerville Shuttle and Urban PERT users mainly consisted of former RTS users, and their characteristics were not significantly different than the respective RTS user population surveyed. DAB and the Irondequoit Loop, on the other hand, had more older and transit-dependent users than the RTS services. Irondequoit DAB had a greater proportion of transit-dependent users than in Greece, where fixed-route services were not as readily available.

9.9.3 User Attitudes

The RTS and PERT on-board surveys contained attitudinal questions that asked users to rate transit travel in Rochester on a scale of 1 to 5 (1 being the best) according to eleven travel characteristics (safety, cost, etc.), and to rate how important each of these characteristics were in making their modal travel decisions.

The results are shown in Exhibits 9.11 and 9.12 for six user groups according to service. Irondequoit Loop Bus users constituted too small a sample for deriving reliable results, and are excluded. The dashed lines represent day and night users of Irondequoit fixed-route services before the introduction of PERT. The solid lines represent various PERT user groups, while the dotted line represents users of RTS Routes 9 and 10, which did not change during the demonstration. The latter group is thus a control group for comparative analysis. Differences between RTS routes were minor, and have consequently been ignored in this analysis in order to simplify the presentation.

RTS users rated simplicity, safety, and convenience the highest, but PERT's modernity and comfort was also rated more acceptable than the other transit features. Perceptions of transit generally worsened after PERT was introduced, except for DAB users. However, DAB users included a large proportion of elderly persons, and elderly users generally had the most favorable perceptions of transit. For example, daytime elderly users of RTS services before PERT rated transit an average of 0.5 points better than the total daytime user ratings, but with little difference in the rank ordering of attributes compared to younger users. Thus, the favorable perceptions of DAB were partly skewed by this difference in user ages.

EXHIBIT 9.11

PERCEPTIONS OF TRANSIT BY USER GROUP

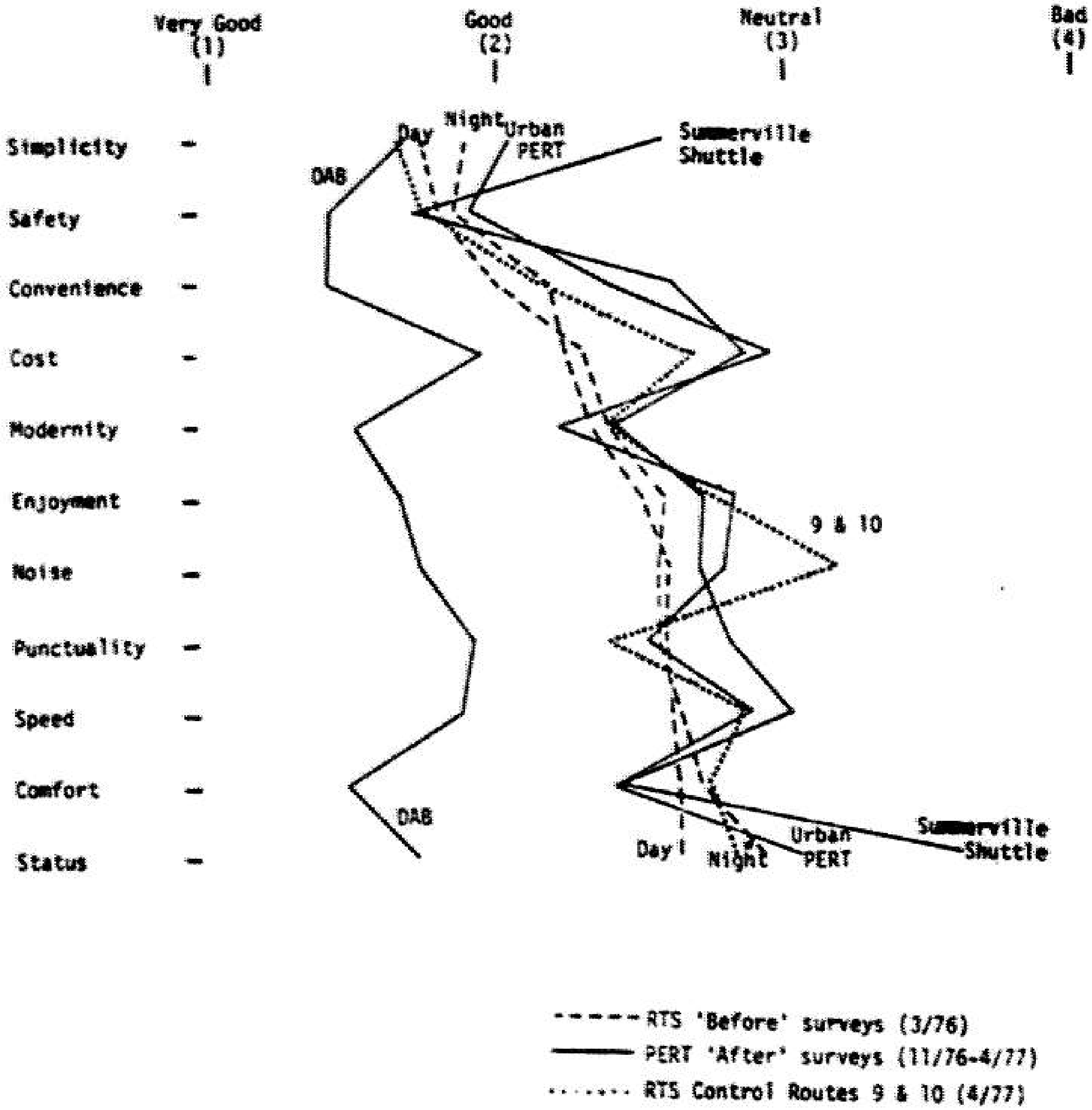
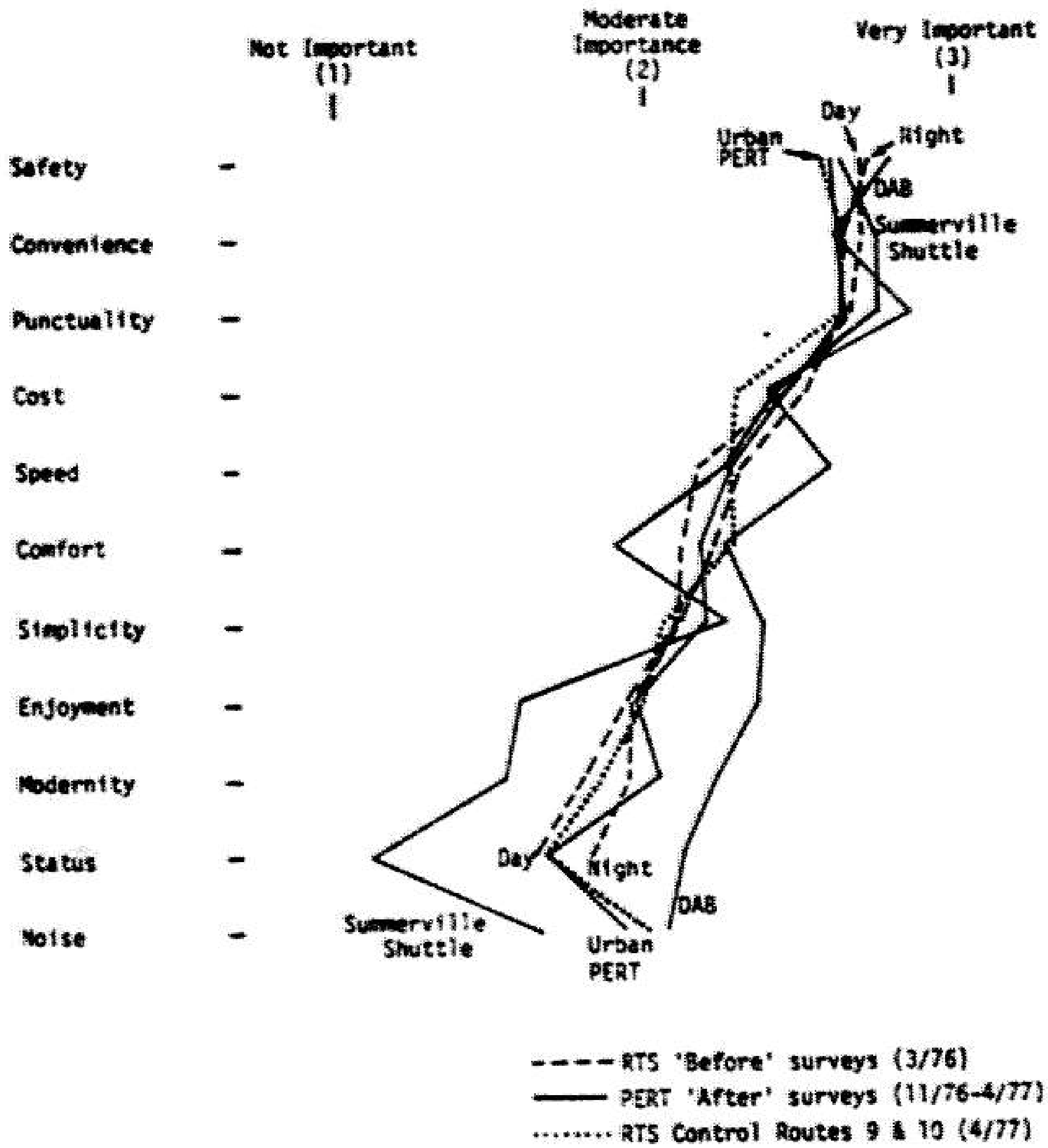


EXHIBIT 9.12

IMPORTANCE OF TRAVEL CHARACTERISTICS BY USER GROUP



Other notable differences between PERT and RTS user perceptions include:

* PERT service users felt transit was more complicated than did RTS users;

* Summerville Shuttle users felt transit was less convenient than did other user groups;

* All users (except DAB) in the "after" surveys had a less favorable perception of the cost of transit service compared to "before";

* PERT users felt that transit was quieter and more comfortable than did RTS users; and

* Summerville Shuttle users felt transit was a lower-status form of travel than did other groups.

In general, the results showed that PERT improved the perceived comfort (including noise levels) of transit, reflecting the use of the smaller buses. However, they also perceived transit to be more complicated to use. Summerville Shuttle users found transit less convenient, reflecting the elimination of a fixed-route and the new transfer requirement for CBD-bound travel. The worsened perception of the cost of transit reflects the May 1976 fare increase rather than any PERT innovations.

Exhibit 9.12 shows how users judged the importance of the various transit characteristics. In this case, no clear trends between before and after PERT service implementation emerged. Rather, users were found to consistently emphasize safety, convenience and punctuality in their travel decisions. Elderly users gave additional weight to the cost of travel, but it still ranked behind safety, convenience and punctuality.

Interestingly, the "before" surveys showed that RTS users judged transit favorably regarding safety and convenience, but less so regarding punctuality. This indicated that the greatest improvements were needed in the area of punctuality. Yet demand-responsive transit primarily emphasizes convenience, safety and comfort and often sacrifices punctuality. DAB users, for example, rated predictability as the worst attribute of DAB service in two 1976 surveys (Appendix D). The April 1977 DAB attitudinal survey, although conducted during a period of greatly improved reliability, disclosed that punctuality was the still second worst attribute of DAB service behind cost (see Appendix E and Exhibit 9.12).

Since Irondequoit's demand-responsive transit did not alleviate the existing transit users' major problem of punctuality, it would only have been a successful innovation if significant numbers of transit-dependent residents, who are less concerned with punctuality, could have been attracted to transit.

9.10 ROUTE RATIONALIZATION

In order to evaluate route rationalization in Irondequoit (the replacement of RTS fixed-route services by PERT services), users of Routes 5, 7 and 12, the RTS services to be altered, were identified in the March 1976 RTS survey for a follow-up survey. In December 1976, a telephone survey was made of these former users (see Appendix 11). Of the 194 persons identified, 123 (63.4%) were successfully contacted. About one-third were not aware of the changes which had been made in the transit system as a result of PERT, but this partially reflected the survey's inclusion of passengers boarding or unboarding between Norton Street and Ridge Road, where no changes were made. Others lived outside the Irondequoit area, and did not regularly travel there.

Altogether, about 76 persons remained who cited having to make the same type of trip as when they were surveyed in March 1976. Among Route 5 and 7 users, most of whom could use the Summerville Shuttle, 42% stated they most frequently used the new PERT service. This supported the conclusion based on ridership counts that only about 45% of the former RTS ridership shifted to the Summerville Shuttle. (See Section 9.3 for analysis of impact on the number of riders, and Section 10.4 for revenue impacts.) Twenty-two percent reported they shifted to RTS during the peak period and about 10% used other RTS routes during the off-peak period. About 8% switched to driving, 10% were driven, and 6% used DAB. Former Route 12 users almost all switched to using RTS during the peak period.

Overall, Route 5 and Route 12 users preferred the old system by a ratio of more than two to one, while Route 7 users were evenly divided in their preference. After PERT was introduced, part of the Route 5 alignment no longer received fixed-route transit service, but along the Route 7 alignment the Summerville Shuttle provided equivalent coverage, although slightly less frequently. While the Loop Bus served the eliminated portion of Route 12, it operated in only one direction. Route 12 passengers also had to detour to Rochester General Hospital in order to transfer.

Those preferring the former system most often cited its reliability and convenience. Those preferring the new system cited a greater variety of reasons, but mainly its speed and reliability. As in Greece, the most severe criticism came from users who were no longer served by a fixed-route bus where there once had been one.

Relatively few people stopped using transit because of the changes, but many switched to RTS during the peak period. The PERT replacement services (the Summerville Shuttle, DAB and the Loop Bus) thus carried fewer persons from these fixed-route corridors than the former RTS off-peak services, attracting relatively few new riders. The ridership response to route rationalization in Irondequoit indicated that PERT services were not successful substitutes for the RTS services. The impact of diverting users to the peak period is undesirable, considering the peaking problems already faced by public transit operators.

10. IRONDEQUOIT: PRODUCTIVITY AND ECONOMICS

This chapter analyzes productivities, costs and revenues for PERT services in Irondequoit, dividing the data into the same five periods of analysis discussed in the preceding chapter (i.e., April 12-June 19, 1976; June 21-September 11, 1976; September 13-December 31, 1976; January 3-June 17, 1977; and June 20-July 22, 1977). Since PERT management aggregated the costs of all PERT services, including those in both Greece and Irondequoit, it was not feasible to accurately pinpoint the cost of operating each PERT service. Instead, the overall cost of operating PERT services was calculated, and each individual service was assumed to have the same operating cost per vehicle-hour. In actuality, the PERT fixed-route and route deviation services (such as the Loop Bus, the Summerville Shuttle, Urban PERT, and Routes 14 and 23) did not require extensive control room efforts, and the vehicle-hour costs of these services are probably slightly overrepresented while the cost of DAB is understated.

All costs reported in the demonstration financial reports (released every four weeks), except for the MIT contract costs, have been included in the calculations of PERT operating costs (see sample financial report in Appendix 19). However, certain line items were amortized. Specifically, the costs allocated under materials, facilities renovation and construction work were amortized over ten years, while start-up costs were amortized over five years. In addition, the capital costs of vehicles and communication equipment were amortized over ten years.

Except for DAB, PERT revenues were estimated by PERT management by multiplying an assumed average passenger fare by total ridership. These multiplier factors were periodically changed when new data samplings suggested that the average fare had changed. DAB fares were recorded by the control room and are more accurate.

10.1 THE COST OF PERT SERVICES

The total cost per vehicle-hour of PERT services (including Greece services) rose from $19.76 in April-June 1976 to about $24.82 during the last three months of 1976, before climbing to $32.66 in January-June 1977. (With inflation running at about 6% during this period, only about $1.00 of the total increase can be attributed to rising wages and material costs.)

The 1977 costs were very high because seven new vehicles were acquired, six of which were leased. The monthly leasing costs were higher than the amortized costs of purchased vehicles. In addition, services were cut back during this period while smaller proportional cuts were made in maintenance, control room and management functions. Over the entire 62-week period analyzed, the total cost of providing PERT services averaged $25.20 per vehicle-hour with depreciation of vehicles and communications equipment accounting for an estimated $3.07, or 12.2% of this total. The costs of computerized dispatching were included in the MIT contract, and are not considered in this analysis, as well as other special demonstration costs such as those allocated for service planning, evaluation and data collection. Exhibit 10.1 summarizes the breakdown of the PERT costs considered in this chapter's analysis.

PERT's unionized driver salaries averaged $10.75 per vehicle-hour, absorbing 42.6% of the total operating costs; although PERT operators in Greece during 1975 averaged $9.17 per vehicle-hour, this accounted for about 50% of total operating costs. The basic driver wage rate per work-hour was $5.80 in January 1975, $6.40 in January 1976, and $6.61 in January 1977 (annual increases of 10.3% and 3.3% respectively). PERT maintenance expenses and depreciation charges per vehicle-hour rose at a much faster rate during 1976 and 1977, which offset the labor wage increases.

By comparison, RTS operating costs per vehicle-hour for the fiscal year ending March 31, 1977 were much lower than for PERT, averaging $20.96, with depreciation accounting for $1.34 or 6.4%. RTS and PERT driver wages, fuel, oil, and maintenance costs per vehicle-hour were comparable (see Exhibit 3.17). However, the PERT vehicle fleet was much larger in relation to the number of vehicle-hours operated, and also used expensive communications equipment compared to RTS buses. In addition, PERT had significantly higher management and control room costs per vehicle-hour.

EXHIBIT 10.1

PERT OPERATING COSTS (GREECE AND IRONDEQUOIT)

164 Weeks; 3/29/76-6/19/77

	Cost/Vehicle-Hour	Percent of Total
Driver Wages and Benefits	$10.75	42.6%
Fuel and Oil	1.38	5.5
Vehicle Maintenance*	3.44	13.6
Control Room Wages & Benefits	2.99	11.9
Administration & Management	1.91	7.6
Vehicle & Communications Equipment Depreciation*	3.07	12.2
Other Equipment, Rent and Other Amortized Expenses (start-up costs, transfer station, etc.)	1.66	6.6
TOTAL	$25.20	100.0%

*The leasing of seven vans beginning in February 1977 included maintenance services, but entire leasing contract costs assigned to vehicle depreciation.

10.2 PRODUCTIVITY, COSTS PER PASSENGER, AND REVENUES

Exhibit 10.2 summarizes the supply and demand levels -- vehicle productivity, costs per passenger, and revenue receipts -- achieved by the various PERT services operating in Irondequoit for each of the five periods. The four-month period between September and December 1976 is used in most of the presentation because, for most services, it resembles a steady-state period occurring five months after their introduction. In addition, several of the services were terminated or cut back after this time, so this period is the most appropriate to use for comparative analysis.

10.2.1 Vehicle Productivity

Vehicle productivity on all of the PERT services was lower than the RTS regionwide system average of 26 passengers per vehicle-hour. The highest PERT productivity was 19.2 on the special group services for the transit-dependent; however, these services carried less than 2% of the entire Irondequoit PERT demand during this period. Those services which essentially replaced existing RTS services -- Urban PERT, the Summerville Shuttle, and Routes 14 and 23 -- had the next-highest productivity levels, ranging between 11 and 14 passengers per vehicle-hour. Both subscription services recorded 8.3 passengers per vehicle-hour between September and December 1976, although higher productivities were achieved initially.

Irondequoit work subscription service had higher vehicle productivity than in Greece because Park-and-Ride passengers were carried on A.M. return trips to the service area and because of higher load factors. During the fall 1976 period analyzed, there was an average of nine work subscription passengers per tour (excluding Park-and-Ride passengers) compared to about eight in Greece. Work subscription trip lengths in Irondequoit were also longer than in Greece because of the longer trips to the Xerox offices in Webster.

Irondequoit's Loop Bus and DAB had the lowest productivities of 4.4 and 3.3 respectively in the fall of 1976. The entire set of Irondequoit PERT services had a vehicle productivity of 7.7 passengers per vehicle-hour, considerably higher than the Greece PERT service average of 5.6 (December 1973-March 1976). However, the Irondequoit service package contained several fixed-route services with relatively high vehicle productivity. The Irondequoit DAB service vehicle productivity was lower than that of Greece, and its average trip length was also shorter than that in Greece. Thus, after all PERT services -- except DAB and the

EXHIBIT 10.2

DEMAND AND SUPPLY DATA FOR FIVE PERIODS OF ANALYSIS

	PERIOD				
	1 10 Weeks (4/12/76-6/19/76)	2 12 Weeks (6/21/76-9/11/76)	3 16 Weeks (9/13/76-12/31/76)	4 24 Weeks (1/3/77-6/17/77)	5 5 Weeks (6/20/77-7/22/77)
All Irondequoit PERT Services (except special services and handicapped services); weekly averages					
Scheduled Driver Runs	75	70[a]	70[b]	25-30[b]	N/A
Late Runs	9.0	13.0	18.3	7.4	N/A
Vehicle-Hours	563.6	496.4	473.6	201.3	98.6
Vehicle-Miles	6438.9	5707.6	5402.6	2280.6	N/A
Miles/Hour	11.42	11.50	11.41	11.33	N/A
Passengers Carried	3966.2	3330.5	3652.9	1231.9	403.7
Vehicle Productivity (Passengers/Vehicle-Hour)	7.04	6.71	7.71	6.12	4.10
Revenue Received	$1275.97	$1098.26	$1114.30	$564.91	$263.87
Revenue/Passenger	$0.32	$0.33	$0.31	$0.46	$0.65
Revenue/Vehicle-Hour	$2.26	$2.21	$2.35	$2.81	$2.68
Estimated Cost/Vehicle-Hour	$19.76	$22.77	$24.82	$32.66	N/A
Estimated Cost/Passenger	$2.81	$3.39	$3.22	$5.34	N/A
Operating Ratio (Revenues/Costs	0.11	0.10	0.09	0.09	N/A

[a] Handicapped service also provided from Irondequoit driver runs; excluded from other data.

[b] Handicapped and special services provided from Irondequoit driver runs; excluded from other data.

(Exhibit 10.2, Continued)

	PERIOD				
	1 10 Weeks (4/12/76-6/19/76)	2 12 Weeks (6/21/76-9/11/76)	3 16 Weeks (9/13/76-12/31/76)	4 24 Weeks (1/3/77-6/17/77)	5 5 Weeks (6/20/77-7/22/77)
Dial-A-Bus					
Daily Passengers	73.6	85.3	105.0	54.4	55.6
Transferring Passengers	19.1	29.0	20.0	10.6	9.9
Non-Transferring Passengers	54.5	56.3	85.0	43.8	45.7
Daily Trips	42.9	56.8	69.8	46.7	45.9
Passengers/Trip	1.72	1.50	1.51	1.16	1.21
Daily No-Shows	1.9	2.6	4.7	3.9	2.8
No-Shows/Trip	0.045	0.046	0.044	0.083	0.060
Daily Cancellations	1.5	2.7	5.5	9.3	7.0
Cancellations/Trip	0.034	0.048	0.080	0.198	0.152
Daily Late Bus Complaints	1.1	1.8	6.0	1.0	N/A
Late Bus Complaints/Trip	0.025	0.031	0.086	0.021	N/A
Daily Vehicle-Hours	48.6	36.5	31.7	19.8	18.7
Vehicle Productivity (Passengers/Vehicle-Hour)	1.51	2.34	3.31	2.75	2.97
Cost Per Passenger	$13.09	$9.73	$7.50	$11.88	N/A
Daily Revenue	$34.34	$49.36	$47.55	$40.59	$40.33
Revenue/Passenger	$0.47	$0.58	$0.45	$0.75	$0.73
Revenue/Vehicle-Hour	$0.71	$1.35	$1.49	$2.05	$2.16
Operating Ratio (Revenues/Costs)	0.04	0.06	0.06	0.06	N/A

(Exhibit 10.2, Continued)

	PERIOD 1 10 Weeks (4/12/76-6/19/76)	2 12 Weeks (6/21/76-9/11/76)	3 16 Weeks (9/13/76-12/31/76)	4 24 Weeks (1/3/77-6/17/77)	5 5 Weeks (6/20/77-7/22/77)
Loop Bus					
Daily Passengers	48.3	34.2	32.1		
Daily Vehicle-Hours	7.51	8.89	7.30		
Vehicle Productivity (Passengers/Vehicle-Hour)	6.43	3.85	4.39		
Cost Per Passenger	$3.07	$5.91	$5.55		
Daily Revenue	$13.31	$9.63	$8.35	Service Discontinued	
Revenue/Passenger	$0.28	$0.28	$0.26		
Revenue/Vehicle-Hour	$1.77	$1.08	$1.14		
Operating Ratio (Revenues/Costs)	0.09	0.05	0.05		

(Exhibit 10.2, Continued)

	PERIOD				
	1 10 Weeks (4/12/76-6/19/76)	2 12 Weeks (6/21/76-9/11/76)	3 16 Weeks (9/13/76-12/31/76)	4 24 Weeks (1/3/77-6/17/77)	5 5 Weeks (6/20/77-7/22/77)
Summerville Shuttle					
Daily Passengers	154.4	145.9	128.2	91.5	Service Discontinued
Daily Deviation Requests	1.26	2.03	1.00	0.18	
Deviation Requests/Passenger	0.008	0.014	0.008	0.002	
Daily Vehicle-Hours	10.2	10.2	9.7	5.7	
Vehicle Productivity (Passengers/Vehicle-Hour)	15.14	14.29	13.23	15.97	
Cost Per Passenger	$1.31	$1.59	$1.88	$2.05	
Daily Revenue	$24.78	$25.51	$19.27	$13.60	
Revenue/Passenger	$0.16	$0.17	$0.15	$0.15	
Revenue/Vehicle-Hour	$2.43	$2.50	$1.99	$2.37	
Operating Ratio (Revenues/Costs)	0.12	0.11	0.08	0.07	

(Exhibit 10.2, Continued)

	PERIOD				
	1 10 Weeks (4/12/76- 6/19/76)	2 12 Weeks (6/21/76- 9/11/76)	3 16 Weeks (9/13/76- 12/31/76)	4 24 Weeks (1/3/77- 6/17/77)	5 5 Weeks (6/20/77- 7/22/77)
<u>Work Subscription Service</u>					
Daily Passengers	18.8	30.2	74.5	78.7	
Work Subscription	18.8	30.2	53.9	55.4	
Park-and-Ride (return trip)	--	--	20.6	23.3	
Daily Trips	18.2	27.4	50.4	52.6	
Passengers/Trip	1.03	1.10	1.07	1.05	
Daily No-Shows	0.03	0.07	0.39	1.29	
No-Shows/Trips	0.001	0.002	0.007	0.023	Service Discontinued
Daily Vehicle-Hours	2.05	4.75	9.00	11.9	
Vehicle Productivity (Passengers/Vehicle-Hour)	9.18	6.38	8.28	6.61	
Cost Per Passenger	$2.15	$3.57	$3.00	$4.94	
Daily Revenue	$9.09	$18.53	$37.33	$47.68	
Revenue/Passenger	$0.48	$0.61	$0.50	$0.61	
Revenue/Vehicle-Hour	$4.44	$3.90	$4.15	$4.01	
Operating Ratio (Revenues/Costs)	0.22	0.17	0.17	0.12	

(Exhibit 10.2, Continued)

	PERIOD				
	1 10 Weeks (4/12/76-6/19/76)	2 12 Weeks (6/21/76-9/11/76)	3 16 Weeks (9/13/76-12/31/76)	4 24 Weeks (1/3/77-6/17/77)	5 5 Weeks (6/20/77-7/22/77)
ARC Subscription					
Daily Passengers	27.7	24.0	24.8	22.8	27.2
Daily Trips	25.6	22.6	24.2	22.8	24.4
Passengers/Trip	1.08	1.06	1.03	1.00	1.12
Daily Vehicle-Hours	2.05	2.38	3.01	2.99	3.00
Vehicle Productivity (Passengers/Vehicle-Hour)	13.52	10.05	8.25	7.63	9.06
Cost Per Passenger	$1.46	$2.27	$3.01	$4.28	N/A
Daily Revenue	$14.94	$12.53	$13.14	$11.64	$14.44
Revenue/Passenger	$0.54	$0.53	$0.53	$0.51	$0.53
Revenue/Vehicle-Hour	$7.29	$5.26	$4.37	$3.89	$4.81
Operating Ratio (Revenues/Costs)	0.37	0.23	0.18	0.12	N/A

(Exhibit 10.2, Continued)

	PERIOD				
	1	2	3	4	5
	10 Weeks (4/12/76-6/19/76)	12 Weeks (6/21/76-9/11/76)	16 Weeks (9/13/76-12/31/76)	24 Weeks (1/3/77-6/17/77)	5 Weeks (6/20/77-7/22/77)
Urban PERT					
Daily Passengers	242.3	165.0	171.9	Service Discontinued	
Daily Deviation Requests	0.40	0.31	0.42		
Deviation Requests/ Passenger	0.0016	0.0019	0.0025		
Daily Vehicle-Hours	15.9	12.5	12.5		
Vehicle Productivity (Passengers/ Vehicle-Hour)	15.25	13.22	13.75		
Cost Per Passenger	$1.30	$1.72	$1.81		
Daily Revenue	$72.84	$38.19	$30.97		
Revenue/Passenger	$0.30	$0.23	$0.18		
Revenue/Vehicle-Hour	$4.58	$3.06	$2.48		
Operating Ratio (Revenues/Costs)	0.23	0.13	0.10		

(Exhibit 10.2, Continued)

	PERIOD				
	1 10 Weeks (4/12/76-6/19/76)	2 12 Weeks (6/21/76-9/11/76)	3 16 Weeks (9/13/76-12/31/76)	4 24 Weeks (1/3/77-6/17/77)	5 5 Weeks (6/20/77-7/22/77)
Routes 14 and 23					
Daily Passengers	119.4	95.4	119.5	Service Discontinued	
Daily Vehicle-Hours	10.0	10.4	10.3		
Vehicle Productivity (Passengers/Vehicle-Hour)	11.94	9.16	11.62		
Cost Per Passenger	$1.65	$2.49	$2.14		
Daily Revenue	$54.73	$41.37	$47.65		
Revenue/Passenger	$0.46	$0.43	$0.40		
Revenue/Vehicle-Hour	$5.47	$3.97	$4.63		
Operating Ratio (Revenues/Costs)	0.28	0.17	0.19		

ARC subscription -- were eliminated in June 1977, Irondequoit's vehicle productivity tumbled to a low of 4.1 passengers per vehicle-hour.

DAB vehicle productivity was also much lower than that experienced in other DAB systems, where -- for the demand density served in Irondequoit -- vehicle productivity between 5.0 and 5.5 passengers per vehicle-hour would be expected. The Irondequoit DAB service, with productivity levels between 2.5 and 3.5, was significantly lower than these other systems, suggesting that operating efficiency was worse than average. However, service levels, demand patterns, and other factors which could affect productivity levels were not considered.

10.2.2 Costs Per Passenger

The average cost per passenger, obtained by dividing the fall 1976 average operating cost per vehicle-hour by vehicle productivity, was $3.22 for all Irondequoit PERT services, but ranged from $1.30 for the special services to $7.50 for DAB (see Exhibit 10.2).

In comparison, RTS reported an average cost of $.81 per revenue passenger carried, the Summerville Shuttle, Urban PERT, and Routes 14 and 23 had unit costs of $1.88, $1.81, and $2.14 respectively. Work and ARC subscription cost $3.00, and the Loop Bus cost was $5.65 per rider.

These results suggest that many DAB and Loop Bus trips could have been carried less expensively by private taxi. For example, the average 2.0 mile DAB trip would have cost about $2.05 by taxi (75 cents for the first one-seventh of a mile and 10 cents per one-seventh thereafter). Since there was an average of 1.5 passengers per DAB trip, the average cost per DAB trip was $11.25. Loop Bus trip length data is unavailable, but it was probably under 2.0 miles, so a comparable taxi trip would also have been much cheaper.

Most of the other PERT services were less expensive per passenger than the same trip carried on a private taxi. Assuming an Urban PERT average trip length of 2.5 miles (half the average route length), a comparable taxi trip would cost $2.55, compared to the average Urban PERT cost per passenger of only $1.81. The work subscription service, however, had an average trip length of approximately 8.6 miles (excluding Park-and-Ride passengers), and its average per-passenger cost of $4.14 (again excluding Park-and-Ride passengers, who are assumed to ride at no additional cost) was considerably less than the comparable taxi cost of $6.75.

10.2.3 Revenues

Because of their low productivity levels, none of the PERT services covered more than about 25% of their costs with revenues. Most services had revenues of between 10% and 25% of total costs, with the recovery ratios generally decreasing over time, as costs continued to spiral. However, the Loop Bus and DAB had revenues totaling only 5% or 6% of costs. Following the fare increase of January 1977, DAB revenue per vehicle-hour rose by 38%, but revenue recovery was essentially unchanged because of increased operating costs.

Although vehicle productivity in Irondequoit was higher than in Greece, revenue recovery was lower because of a much lower average fare per passenger. Consequently, Irondequoit PERT services during the fall of 1976 generated revenues of $2.35 per vehicle-hour, compared to $3.84 in Greece in the December 1973-March 1976 period. (Greece revenues subsequently dropped due to passenger losses and service and fare modifications, but still averaged $3.32 per vehicle-hour during the same September-December 1976 period considered for the Irondequoit service analysis). During this period, all Irondequoit's PERT services covered about 9% of their costs with revenues, less than half the 21% recovery ratio Greece achieved.

10.3 MARGINAL COSTS

All of the Irondequoit PERT services operated well under capacity, in the sense that load factors were low and excess seating capacity existed. In general, a fixed amount of service was provided, and passenger fluctuations were accomodated within this allocation. The marginal costs of these services were consequently near zero.

The exception was DAB, in which vehicle-hours (and therefore costs)[1] varied according to demand levels, and therefore there is some measurable marginal cost per passenger. During 1976, however, the supply of service was actually decreased as demand increased, because demand was initially overestimated and two vehicle supply cutbacks were required before a more efficient supply level was achieved

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[1]Besides being a proxy for actual costs, the use of vehicle-hours as the cost variable is especially helpful in this case because PERT operating costs rose rapidly in late 1976 and 1977, distorting marginal cost analyses based on data from these two years.

in the fall of 1976. A weak negative correlation (r = -.27) thus exists between service supply and demand in 1976. This suggests a negative marginal cost per passenger, but is in fact due to the vehicle supply readjustments which followed the demand overestimation.

More meaningful marginal cost estimation can be derived from examining supply and demand data generated during the fall of 1976 and the first half of 1977. In this case, the marginal cost is found to be about two-thirds of the average cost, as shown in Exhibit 10.3. This is slightly less than the estimated Greece marginal cost per passenger, but about the same as that achieved in Greece when trip length was controlled for. (Since the Irondequoit DAB service area did not change during this period, trip length is assumed to be constant; see Section 7.3 for Greece results.) The results confirm the conclusion drawn in Greece: that increasing returns to scale are possible.

EXHIBIT 10.3

MARGINAL COST ANALYSIS FOR IRONDEQUOIT DAB

Period Analyzed	Number of Weeks	Regression Equation (DAB Cost (Vehicle-Hours) =)	R^2	Marginal Cost/ Passenger	Average Cost/ Passenger	Marginal Cost/ Average Cost
September-December 1976	16	10.6 + 0.201 (Pax)	.50	.20	.30	67%
January-July 1977	29	7.3 + 0.226 (Pax)	.31	.23	.36	63%
September-July 1977	45	7.1 + 0.231 (Pax)	.81	.23	.33	70%

10.4 ROUTE RATIONALIZATION

Route rationalization, or the substitution of demand-responsive services for low-productivity fixed-route services, occurred on a smaller scale in Irondequoit than in Greece. The major changes in the Irondequoit fixed-route system involved modifications to Routes 5, 7 and 12 during the off-peak period. The PERT substitutions for RTS nighttime services (Urban PERT) and Routes 14 and 23 did not substantially change the nature of these services, and the vehicle-hour substitution was essentially one to one. The higher unit cost of providing PERT services relative to RTS services suggested that total costs rose slightly as a result of these substitutions. However, the reported disparity between PERT and RTS costs per vehicle-hour is probably an aberration from the long-run trend in which the costs would be similar. PERT costs were inflated by the poor vehicle performance necessitating an unusually large fleet size, and a greater management effort prompted by the complexity of the demonstration planning and evaluation process, resulting in higher short-run costs.

During the midday and early evening periods, RTS service north of Ridge Road on Routes 5, 7 and 12 was eliminated. The Summerville Shuttle substituted for Routes 5 and 7 in Western Irondequoit. DAB and the Loop Bus provided an alternative where Route 12 formerly operated. DAB also served most of the area in which Routes 5 and 7 operated. Since DAB and the Loop Bus served an area that extended far beyond the former fixed-route corridors, it is inappropriate to consider the cost of providing these services as a fixed-route replacement cost. In addition, less than 7% of the former Route 5, 7 and 12 passengers surveyed reported that they used these services as substitutes (see Section 9.10). Therefore, DAB and the Loop Bus costs are not examined in this analysis, and only the Summerville Shuttle is considered to be a replacement of RTS fixed-route services.

Exhibit 10.4 shows that the replacement of Routes 5 and 7 by the Summerville Shuttle resulted in a net daily decrease of three vehicle-hours. This amounts to an annual savings of about $20,000, assuming a per-vehicle-hour cost of $22.00 (combined average cost for RTS and PERT). Although there was a decrease in ridership associated with the change (see Section 9.3), most of this decrease represented riders diverted to other transit services, some (such as DAB) with higher fares. Thus, there probably was not a major change in net transit revenues caused by route rationalization.

The cost savings cited above came at the expense of both route mileage and service frequency. The Summerville Shuttle operated along all of the Route 7 path north of

EXHIBIT 10.4

REPLACEMENT OF IRONDEQUOIT FIXED-ROUTE SERVICES

	Number of RTS Vehicle-Hours Eliminated*				Number of Daily PERT Vehicle-Hours Added as Substitute		
Route	Weekday Midday	Weekday Evening	Saturday	Daily Average	Route	Daily Average (4/76-12/76)	Difference
5-St. Paul	3.6	1.2	12.8	6.2	Summerville Shuttle	10.0	
7-Clinton	4.0	1.6	12.8	6.8			
12-Goodman	0.0	-	--	0.0		—	
Total				13.0		10.0	-3.0

*Estimates by David F. Brandt, RTS Scheduler in memo to William Evans, RGRTA, Dial-A-Bus Replacement Service-1977 (August 27, 1976).

Ridge Road and then along the Route 5 path north of Cooper Road. Consequently, an approximate 2.6 mile stretch of St. Paul Boulevard between Ridge Road and Cooper Road formerly served by Route 5 no longer had transit service. In addition, Route 7 formerly operated at 34-minute headways during the midday off-peak period; the Summerville Shuttle operated at a 45-minute headway.

RTS was able to eliminate two buses during the off-peak period, while a single bus was used to provide Summerville Shuttle service. However, the net decrease in vehicle-hours supplied was only 23% (3/13) despite the 50% decrease in the number of buses. This discrepancy was caused by the deadheading time required of the RTS buses to travel to and from the RTS garage when they were taken out of service after the morning peak period and returned in the afternoon. The RTS garage was approximately six miles from the Summerville Shuttle route.

Thus, route rationalization in Irondequoit resulted in a relatively small cost savings of about $20,000 annually, and this was accompanied by a small decrease in coverage and service frequency. The entire Irondequoit service package had an annual net cost of around $500,000 during 1976, prior to the service cutbacks of January 1977. This represented about 9% of the RTS 1977 fiscal year annual deficit; however, Irondequoit PERT services only carried slightly more than 1% of the RTS passenger demand. The cost per PERT passenger thus greatly exceeded that of the conventional transit system in Rochester, and this was the primary reason that the work subscription service and the Loop Bus were eliminated. Other services, including Urban PERT, the Summerville Shuttle and Routes 14 and 23, failed to generate higher demand than the RTS services they replaced, and were thus also eliminated. The RGRTA has also investigated more cost-effective techniques for operating DAB and the special services for the transit-dependent, and intends to adopt one of these alternatives in order to maintain these services.

10.5 IMPACT ON VEHICLE-MILES TRAVELED (VMT)

The following analysis uses the number of vehicle-miles traveled to determine the amount of energy consumed and pollutants emitted by DAB relative to other transportation modes in Irondequoit.

Environmental impact analysis for Irondequoit subscription services cannot be done because no user surveys were conducted. The Loop Bus survey had too small a sample to yield significant results, but vehicle productivity levels and user characteristics were similar to those of DAB, so similar results would be expected. Most of the other Irondequoit PERT services were direct substitutes for RTS fixed routes, and no major changes resulted.

The DAB results are based on the 16-week period from September to December 1976 and responses from the December 1976 on-board survey. At that time, ridership averaged 105 passengers and 31.7 revenue hours per day were operated. Deadheading mileage is assumed to increase the total number of vehicle-hours to 35. During this period, the average effective operating speed was 11.41 miles. (This is based on vehicle mileage data collected for all Irondequoit PERT services; separate mileage records for DAB were not available.) Thus, DAB traveling 11.41 miles per hour for 35 hours per day generates approximately 400 vehicle-miles per day.

The two-day on-board survey results from December 1976 (weighting Saturday responses by one-fifth) show that 25.9% of the respondents would not have taken the trip if DAB were not available, 23.8% would have used RTS transit services, 8.3% would have walked, 11.4% would have driven themselves, 22.5% would have been driven by others, and 8.2% would have used another mode, usually a taxi. The average DAB direct-distance trip length of 2.0 miles is used for Irondequoit's calculations. It is also assumed that half of the DAB riders who would have been driven would require a special automobile trip to make their trip, while half would travel with someone who was already making the trip. On these trips, an average extra deviation is assumed to be one-fourth the average trip length (0.5 miles), and a taxi deadheading factor of 2.0 miles is added (see footnote in Section 7.5).

Thus, if DAB did not operate in Irondequoit, the total vehicle-miles traveled is calculated as:

No trip:	105 passengers X (25.9%) X 0 = 0
RTS bus:	105 passengers X (23.8%) X 0 = 0
Walk:	105 passengers X (8.3%) X 0 = 0
Auto diverted:	105 passengers X (11.4% X 2.0 miles) = 24 vehicle-miles
Auto passengers diverted:	105 passengers X (22.5%) X (2.0 miles + 0.5 miles) X 0.5 = 30 vehicle-miles
Taxi diverted:	105 passengers X (8.2%) X (2.0 miles) X 2.0 = 34 vehicle-miles

Total = 88 vehicle-miles.

Irondequoit DAB generated about four and one-half as many vehicle-miles as would have occurred if passengers had used other modes. Environmentally, this impact is magnified by the poorer gasoline efficiency and greater number of pollutants emitted per bus vehicle-mile as compared to the automobile. However, these adverse effects should be considered in light of the benefits received by other users, as well as DAB's impact on the total environment. Survey results documented that 26% of the riders would not have made a trip if DAB were not available, and another 32% seem to have preferred DAB to alternative transportation modes. Relative to the total vehicle-miles generated by area residents (approximately 17,800 automobiles owned by DAB target area residents travel 27 miles per day (assuming 10,000 miles per automobile per year) resulting in 481,000 vehicle-miles traveled per day). Irondequoit DAB added only about .06% extra vehicle-miles per day. In Greece, DAB generated two and one-half as many vehicle-miles as would have otherwise occurred, and less than 1% extra miles relative to total vehicle-miles traveled per day.

Thus, any adverse effects of the Irondequoit DAB service on energy consumption and air quality were relatively minor when compared to those generated by other travel modes. A similar conclusion was also reached in Greece.

END

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