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TSC Project Evaluation Series

The Rochester New York Integrated Transit Demonstration

Volume I: Executive Summary

Final Report
March 1979

Service and Methods Demonstration Program

U.S. DEPARTMENT OF TRANSPORTATION
Urban Mass Transportation Administration
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16. Abstract

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 report contains a description of the implementation process and the impacts of individual services and innovations on the 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.

The report consists of three volumes. Volume I contains an Executive Summary of the most significant demonstration findings. Volume II consists of a detailed description and analysis of the Rochester demonstration. Volume III contains the appendices, including a glossary, copies of measurement instruments, and tabulations of survey results.

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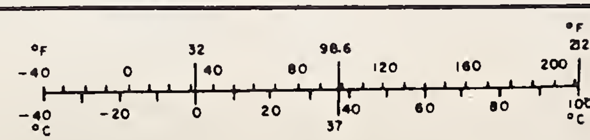
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

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

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inchss	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.6	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	36	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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 I: EXECUTIVE SUMMARY

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. New 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.

1. SUMMARY

1.1 THE PURPOSE OF THE DEMONSTRATION

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 sought affordable means of extending transit coverage into suburban areas by using integrated mixes of fixed-route and paratransit services. Since the issue of extending transit within tight budget constraints is of widespread concern, the Rochester experience is a lesson for many U.S. cities.

The demonstration tests the hypothesis that, in low demand density situations such as those existing in suburban areas and in central cities at night and on weekends, demand-responsive transit services can offer more efficient, higher-quality service than conventional fixed-route services. It was further hypothesized that users who are transit-dependent can be better served by demand-responsive services than by conventional services. The demonstration also tested the use of a fully-computerized system for dispatching demand-responsive vehicles.

Partial funding for the demonstration was provided under the Urban Mass Transportation Administration's Service and Methods Demonstration (SMD) Program (Grant No. NY-06-0048). The SMD Program provided about 71% of the $3,646,600 planning and operating costs (Grant No. NY-06-0048); the Rochester-Genesee Regional Transit Authority (RGRTA) funded the remainder. Another UMTA grant (Grant No. NY-03-0075) paid 80% of the capital costs of $858,000; RGRTA provided 16% and the State of New York contributed 4%.

1.2 THE NATURE OF THE DEMONSTRATION

Four types of innovations were demonstrated: service; system integration; equipment; and fares, marketing and promotion.

1.2.1 Services

Service innovations included augmenting conventional fixed-route service with many-to-many dial-a-bus (DAB) services, route and point deviation services, doorstop and checkpoint subscription services, and special services for the transit-dependent. Each service was designed to support a market that was not well served by the existing fixed-route system.

1.2.2 System Integration

The demonstration included means of coordinating the demonstration services with each other and with the existing fixed-route network. At the operational level, this included coordinating transfers, establishing joint fares, and replacing selected fixed-route services with demand-responsive services. Fixed-route replacement by DAB service, known as "route rationalization," was used to save bus hours, lower costs or provide a higher-quality service.

System integration also included the institutional coordination required to manage the multi-modal transit system. The existing fixed-route transit operating agency was responsible for operating the vehicles used in the new demand-responsive services, but did not wish to assume total management responsibility for the services. As a result, close coordination was needed between the management of the new demand-responsive services and the existing transit operating organization.

1.2.3 Equipment

Several types of small buses were used for PERT service in order to evaluate which were more suitable for subsequent expansion. Video communications equipment was installed for communication between the control center and the drivers. In addition, computerized dispatching and scheduling were implemented to improve the level of service provided to users. Determining the costs of computerization was not an objective of the demonstration; the computer arrangement was designed for ease of experimentation rather than cost-efficiency.

1.2.4 Fares, Marketing and Promotion

Several marketing and promotional techniques were implemented to increase ridership on the new services. These included temporary fare reductions to encourage initial use and long-term fare changes to increase overall revenue recovery and to encourage or discourage certain types of trips.

1.3 THE DEMONSTRATION SETTING AND HISTORY

Demonstration services were implemented in two suburban areas of Rochester, New York. With about 300,000 residents, Rochester is the center of the nation's fortieth largest urbanized area, with a population of 700,000 persons. The demonstration services were implemented in the suburban areas of Greece and Irondequoit, as illustrated in Exhibit 1.1.

The history of demand-responsive services in Rochester began in 1970, when several Rochester transportation officials became interested in implementing DAB and other demand-responsive transit services in the Rochester area. After successfully implementing a small DAB system in the town of Batavia, 35 miles from Rochester, the Rochester-Genesee Regional Transportation Authority (RGRTA) decided to test the concept in a Rochester suburb. At that time, DAB was perceived as a cost-effective means of reversing the steady decline in transit ridership by serving the growing suburban population that was unserved by conventional fixed-route systems.

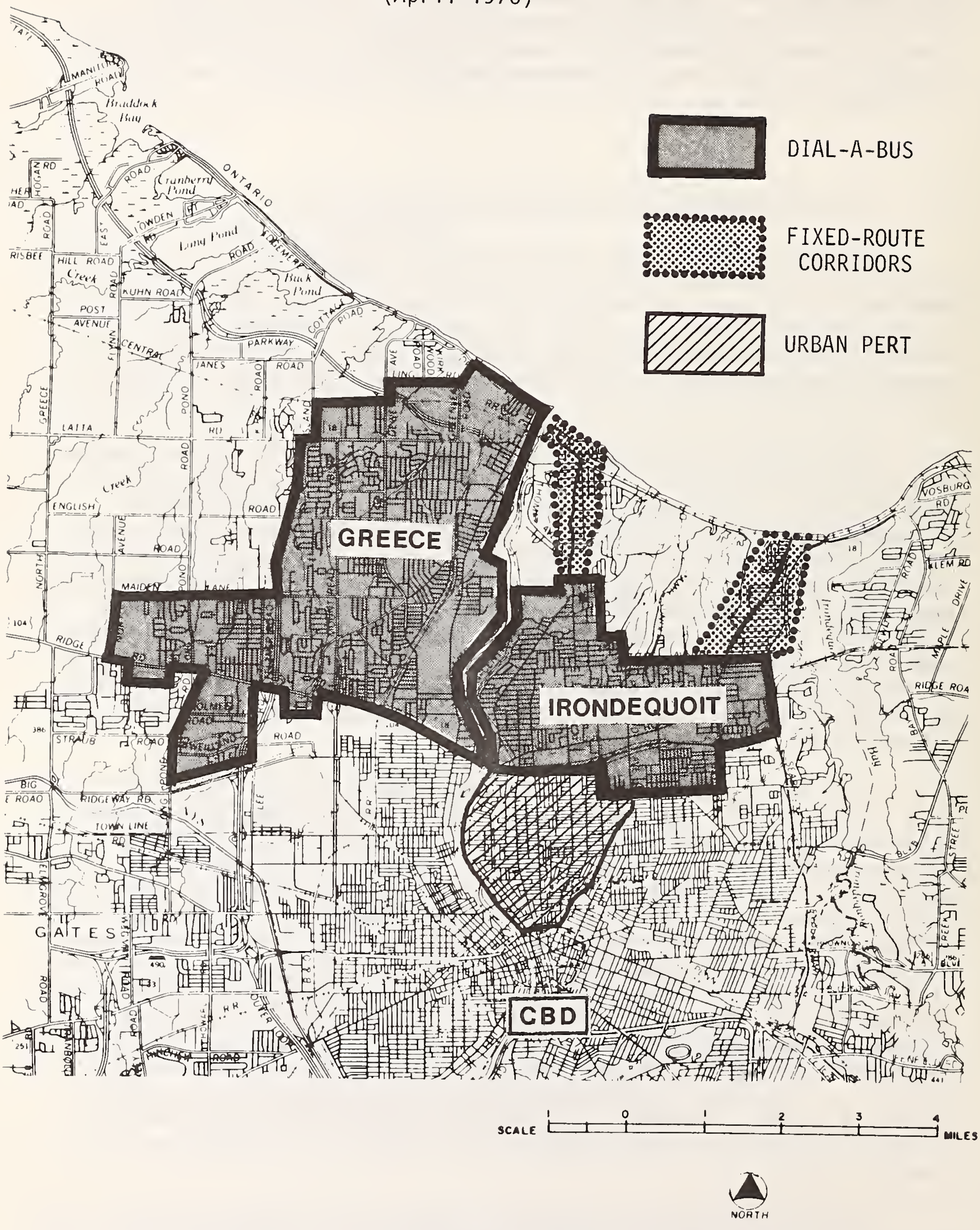
In August 1973, the Regional Transit Service (RTS, an operating subsidiary of RGRTA) implemented DAB and subscription services in a 9.6 square mile area of Northwest Rochester and Greece; this area had a population of about 52,000 persons. Contractual assistance was provided throughout the demonstration by the Massachusetts Institute of Technology (MIT) Department of Civil Engineering. The new services were called PERT, for PERsonal Transit. RGRTA plans called for the gradual expansion of Greece services and the implementation of PERT services in seven additional suburban areas. To help implement these plans, RGRTA sought and received an UMTA Service and Methods Demonstration (SMD) grant. A two and one-quarter year demonstration program began on April 1, 1975, which included the initiation of PERT services in the neighboring suburb of Irondequoit in April 1976.

During the period between August 1973 and October 1977, PERT services were launched, modified, and deleted (as

EXHIBIT 1.1

PERT SERVICE AREAS

(April 1976)



summarized in Exhibit 1.2) as the RGRTA moved toward more productive demand-responsive services based on the travel patterns and costs observed in Greece. As this report is being prepared, the search is continuing under an extension of the demonstration agreement with UMTA. Under the new demonstration, DAR service has been expanded to two additional suburbs where it is provided by a private operator.

1.3.1 PERT Services in Greece

In Greece, there were four RTS fixed-route bus services before PERT services were introduced in 1973. Three of these fixed-route services were operated all day and one was operated only during peak commuter hours. Between 1973 and 1976, four PERT services were introduced: Dial-A-Bus (DAB); work, feeder and school subscription services; special services; and handicapped service. DAB service carried passengers between any two points in a designated service area which grew from 9.6 square miles to 15.2 square miles between 1973 and September 1976. The DAB service extended transit coverage and replaced several fixed routes during the off-peak hours, when they were only lightly used. (See Exhibit 1.3 for a before/after representation of services.)

The subscription services carried customers from any point within the DAB service area to any of three major employment centers and three local elementary schools. These services could also be used to feed fixed-route buses. The special services took large groups from point to point within the service area; the most common trips were regularly-scheduled services between elderly housing centers and shopping malls. Finally, the handicapped service transported elderly and handicapped service area residents to several locations outside the service area.

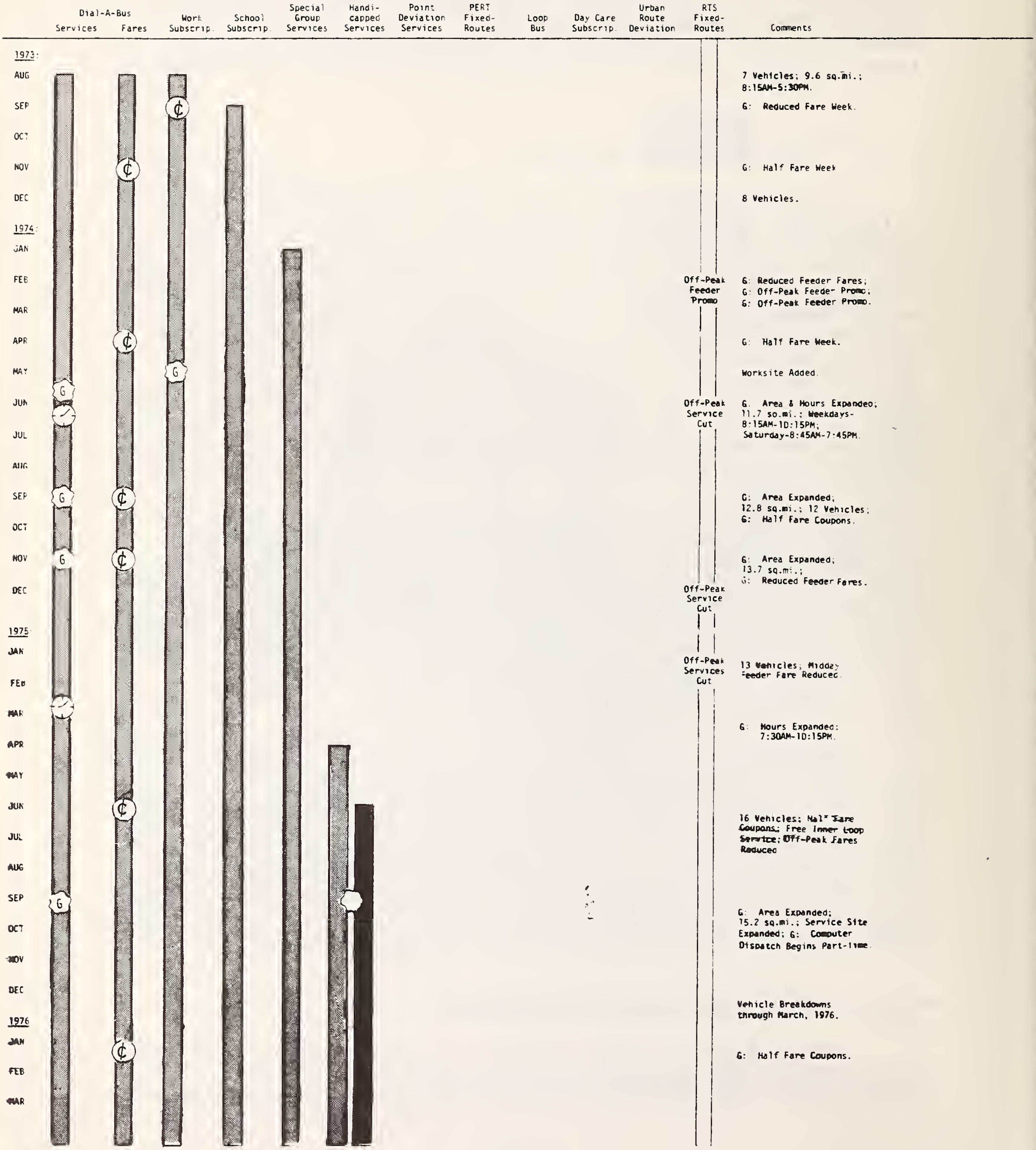
DAB was the most important of the PERT services; it carried over two-thirds of the total PERT passengers during the first three years, and accounted for about three-quarters of the PERT vehicle-hours. The subscription services accounted for most of the remaining passengers and vehicle-hours. During PERT's fourth year of operation, DAB service was curtailed and supplemented by a point deviation service called the Dew-Ridge Shuttle.

1.3.2 PERT Services in Irondequoit

Unlike Greece, where DAB was the predominant PERT service in terms of passengers carried and vehicles used, the Irondequoit PERT service package included a greater variety

EXHIBIT 1.2

CHRONOLOGY OF EVENTS



(Exhibit 1.2, Continued)

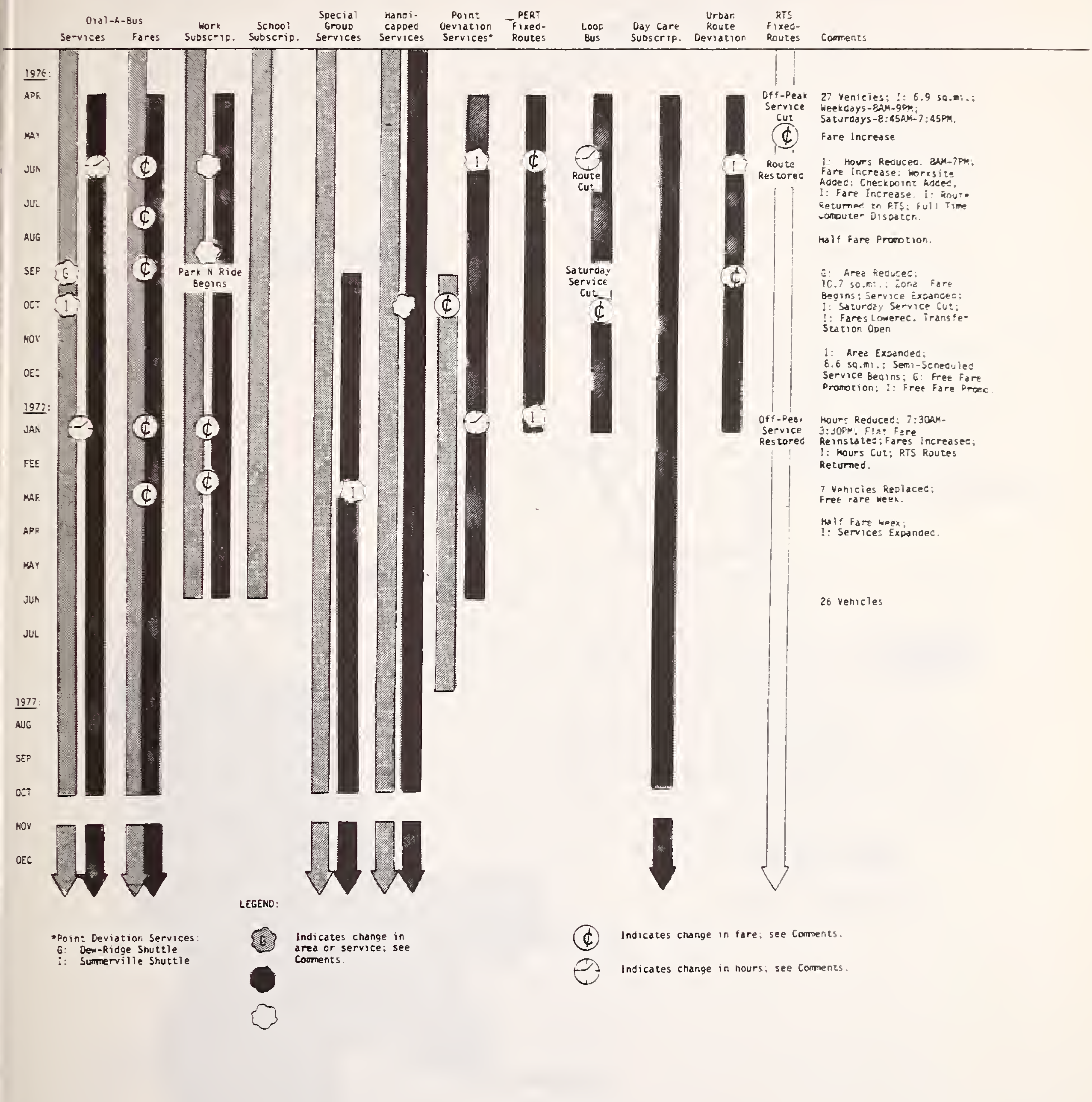
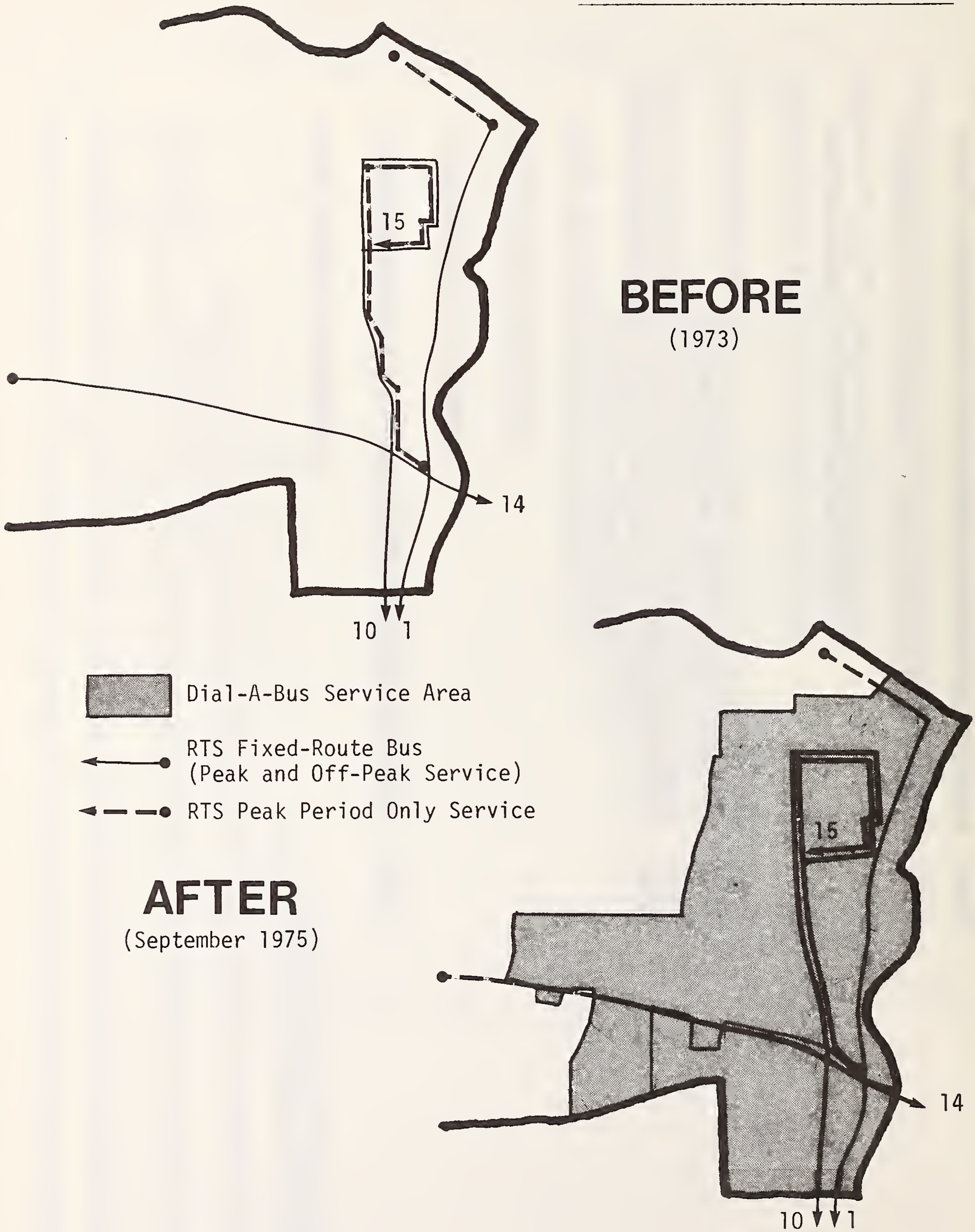


EXHIBIT 1.3

INTRODUCTION OF GREECE PERT SERVICES

AND EXPANSION OF SERVICE AREAS



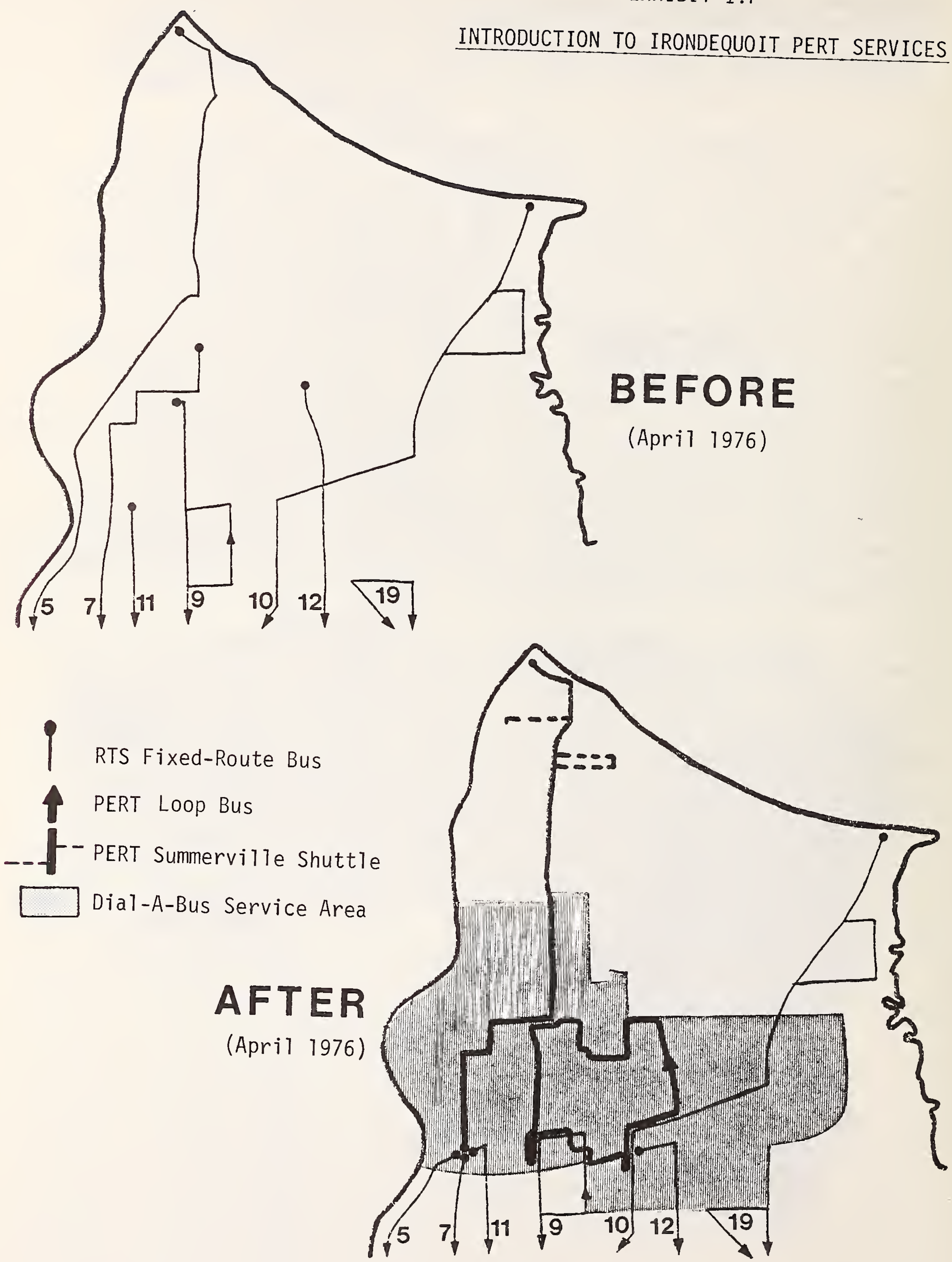
of transit services. The original plan to extend DAB service was modified as a result of experience in Greece, where demand was lower than expected, operating costs per passenger were higher, and there was an adverse user reaction to the replacing of fixed-route services with DAB.

In Irondequoit, an extensive network of fixed-route buses already existed. Consequently, PERT services were designed primarily to supplement these services rather than to replace them. The PERT services implemented included (1) DAB, which was operated in only a portion of Irondequoit; (2) a Loop Bus, a fixed-route shuttle that connected Irondequoit's major activity centers; (3) the Summerville Shuttle, a route deviation service that replaced portions of two fixed-route services; (4) work subscription service to two employers; (5) a day-care subscription service for handicapped children; (6) special group trip services for transit-dependents; and (7) Urban PERT, a route deviation service that operated in both central Rochester and Irondequoit during the late evening hours. The demand-responsive elderly and handicapped service implemented under Greece's PERT operations also served Irondequoit residents. Some RTS off-peak fixed-route mileage was eliminated by the PERT innovations; in most cases, PERT provided equivalent services along these routes (as well as additional options such as route deviation; see Exhibit 1.4).

Irondequoit PERT services were thus designed to serve a market that the existing fixed-route services were not serving or were not serving well. In particular, DAB, the Loop Bus and the Summerville Shuttle were designed to serve local intra-Irondequoit trips rather than the CBD-bound travelers who were carried by the fixed-route buses. Work subscription service also served a new market. To a lesser extent, PERT extended transit coverage with DAB service, the deviation options of Urban PERT, and the Summerville Shuttle to new geographic areas that were not served by the fixed-route system. The major objective of the remaining services was to improve service for the elderly and handicapped.

EXHIBIT 1.4

INTRODUCTION TO IRONDEQUOIT PERT SERVICES



1.4 RESULTS AND IMPLICATIONS

The demonstration tested nine different paratransit services, two changing service areas, innovations in computerized dispatching, and a mixed vehicle fleet. The services were affected by fire, freezing, fiscal crisis, vehicle breakdowns, and international petroleum politics. The demonstration findings should be interpreted in the light of the multiplicity of changes in service and their effects on user behavior, the exogeneous events which occurred during the demonstration (described in Section 1.5 and 3.3), and the unique characteristics of the Greece and Irondequoit service areas (discussed in Sections 3.1 and 3.2).

The findings are numbered sequentially to facilitate referencing. Although the statements of findings are brief, they are supplemented by detailed analyses in the sections of the main report referenced with each finding; the information in those sections should also be considered to prevent an oversimplication or misinterpretation of the results.

This section summarizes the demonstration findings in terms of the following categories:

Level of Service (Supply);
Demand;
Operating Efficiency;
Service for Transit-Dependent;
Institutional Issues; and
Environmental Impacts.

The findings on transit-dependent services have been separated from those of the other services, in order to highlight them.

The findings are identified as applying to Greece, Irondequoit, or both. When they can be generalized, the implications of the different findings are presented.

For Greece, the four-year period from August 1973 through June 1977 is considered, but emphasis is placed on the period before September 1976, when major service changes took place. The Irondequoit results are based on the period between April 1976, when Irondequoit PERT service began, and July 1977.

Demonstrations do not succeed or fail because of the success or failure of the services and innovations which comprise them. Rather, they succeed if they generate information and experience that is useful to the host city and to other transit jurisdictions. In that sense, the demonstration was successful, although many of the innovations did not meet the expectations which motivated them.

The search for the appropriate combination of components for an integrated transit system in Rochester is still underway, with assistance from a new demonstration grant.

1.4.1 Level (Quality) of Service

Levels of service are those characteristics of the transit service that are perceived by the user, such as availability, travel time, reliability, and fares. The impacts of the demonstration services on levels of service were mixed. The new services did extend the availability of transit to users not previously served, and they provided door-to-door convenience to both new and old transit users. Travel time impacts depended on the fixed routes that served the users before PERT services were inaugurated and the time of day selected for travel. In different situations, travel time increased, decreased, or remained about the same. Travel time increases must be traded off against door-to-door convenience and with the ability of additional persons to use transit (particularly persons who may have had to make several transfers to use fixed-route service). Reliability, or punctuality, as measured by the passenger's ability to predict arrival times, was generally lower than fixed-route reliability.

PERT fares were higher than those of 95% of the other demand-responsive systems (Appendix A-20). Findings relative to the impact of fares are discussed in the sections on Demand and on Marketing and Promotion.

1.4.1.1 Transit Coverage.

Transit coverage is a measure of the availability of transit, from both geographic and time-of-day viewpoints. Only geographical coverage is treated in this report. Geographical coverage is expressed as the percentage of service area residents who live within walking distance of a bus route (maximum walking distance is usually considered to be one-quarter mile).

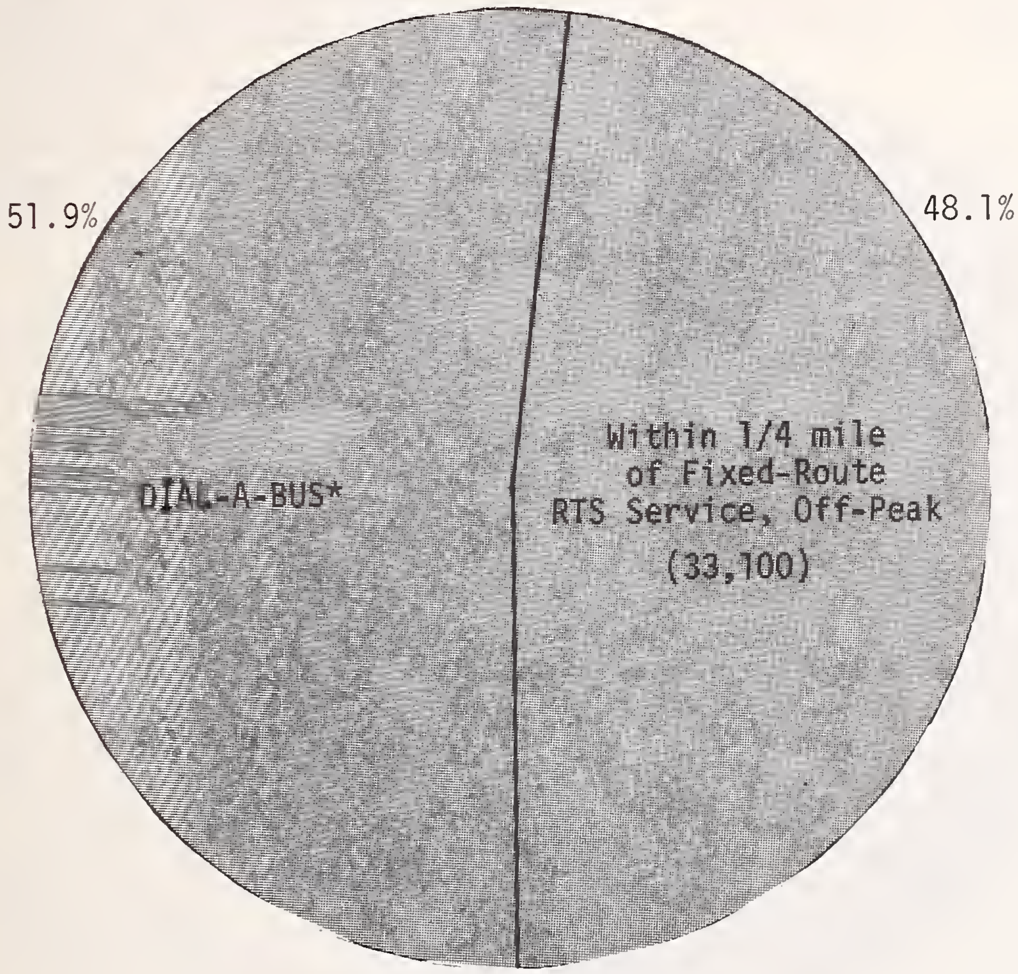
Greece Findings

1. PERT services greatly increased spatial transit coverage in Greece by providing many-to-many service to service area residents who did not have access to fixed-route buses (Exhibit 1.5). About one-third of the DAB users reported that they could not have made their trip if DAB had not been available (Sections 5.1, 6.2.4 and Finding 15).

EXHIBIT 1.5

TRANSIT COVERAGE PERIOD IN GREECE

(September 1975)



*Does not include overlap with fixed-route; DAB served 68,820, total Greece target population.

About half of the Greece service area population of 70,000 persons resided more than 1/4 mile from an RTS fixed—route bus line; about one-third of the residents lived over 3/8 of a mile from a bus route. Therefore, PERT provided service to between one-third and one-half of service area residents who previously did not have convenient access to transit. Furthermore, using DAB made it possible to make transit trips that were previously difficult or impossible due to the route structure or excessive transferring between fixed-route buses. Between one-third and one-half of all DAB trips served the large shopping malls on West Ridge Road, which were inconveniently served by fixed-route transit.

School subscription service accommodated students who did not live the required one and one-half miles from their school and therefore did not qualify for schoolbus service. Originally, five schools were served, but this number decreased over time.

Irondequoit Findings

2. PERT services only slightly increased the overall spatial transit coverage in Irondequoit. PERT did, however, offer a more expeditious means of making local trips (Section 8.1 and Exhibit 1.6).

Because Irondequoit had a relatively extensive fixed-route bus network prior to the demonstration, PERT's role in providing transit coverage for new geographic areas was less substantial than in Greece(Exhibit 1.6). All PERT services together provided transit service to 24% of the service area population that did not previously have access to fixed routes during the off-peak period. In the DAB service area, only 17% of the service area population lived over one-quarter mile from a peak period bus route, and only 27% of the service area population lived more than one-quarter mile from an off-peak bus route.

The primary contribution of PERT transit coverage was to provide a convenient means for making local circumferentially-directed trips. Using fixed-route services, these trips required the traveler to go considerably out of his way to move radially to and from the CBD, where a transfer between two radial bus routes was needed. Both DAB and the Loop Bus provided convenient circumferential service.

Implications

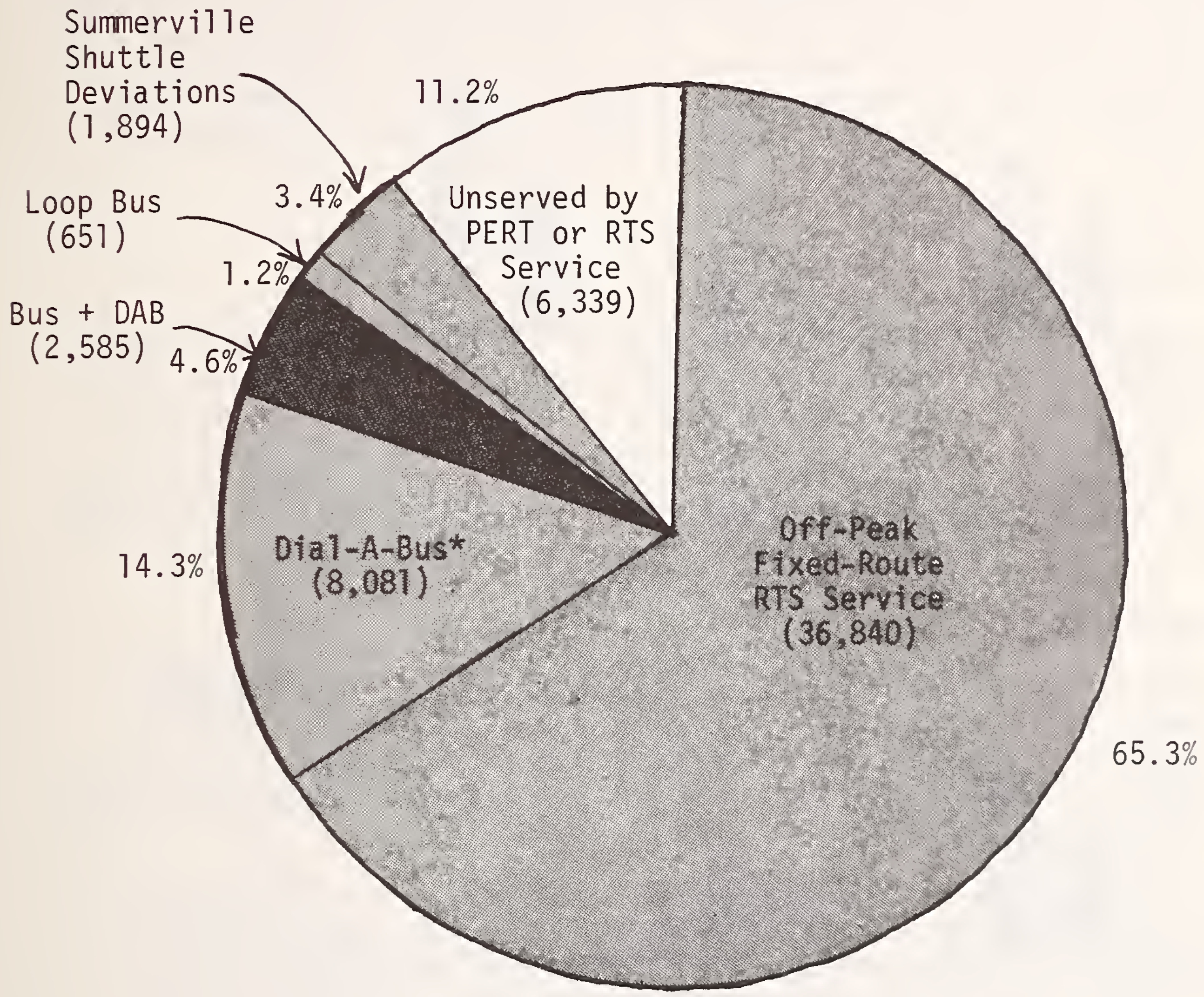
PERT-like services, especially door-to-door DAB, can provide greater transit equity to a suburban population than fixed-route service because PERT offers transit service to virtually 100% of the population within a service area.

EXHIBIT 1.6

TRANSIT COVERAGE IN IRONDEQUOIT

(Incremental Areas Served by PERT Compared to Original Fixed-Route Service)

(April 1976)



56,390 = Total Irondequoit Target Area Population

*Does not include overlap with fixed-route; DAB served 40,000 persons.

Nonetheless, this politically attractive feature of demand-responsive services should not be allowed to dominate system selection. Instead, transit providers should determine if their objectives can be accomplished at a lower cost by the creative integration of door-to-door services with other paratransit services.

Because DAB services are theoretically less expensive per passenger at low demand levels, time coverage may be extended more cost-effectively by demand-responsive services than by fixed-route services. Off-peak substitutions of DAB for fixed-route services should be undertaken with care, however, as this strategy was not effective in Greece (see the section on Route Rationalization later in this summary).

1.4.1.2 Transit Reliability.

Transit reliability is measured by the dependability or predictability of the service--that is, the confidence with which users plan their activities around transit performance. Elements of reliability include: the earliness or lateness of the pick-up (pick-up deviation); the variability of ride times; and the elapsed time between a call for immediate service and bus arrival (response time).

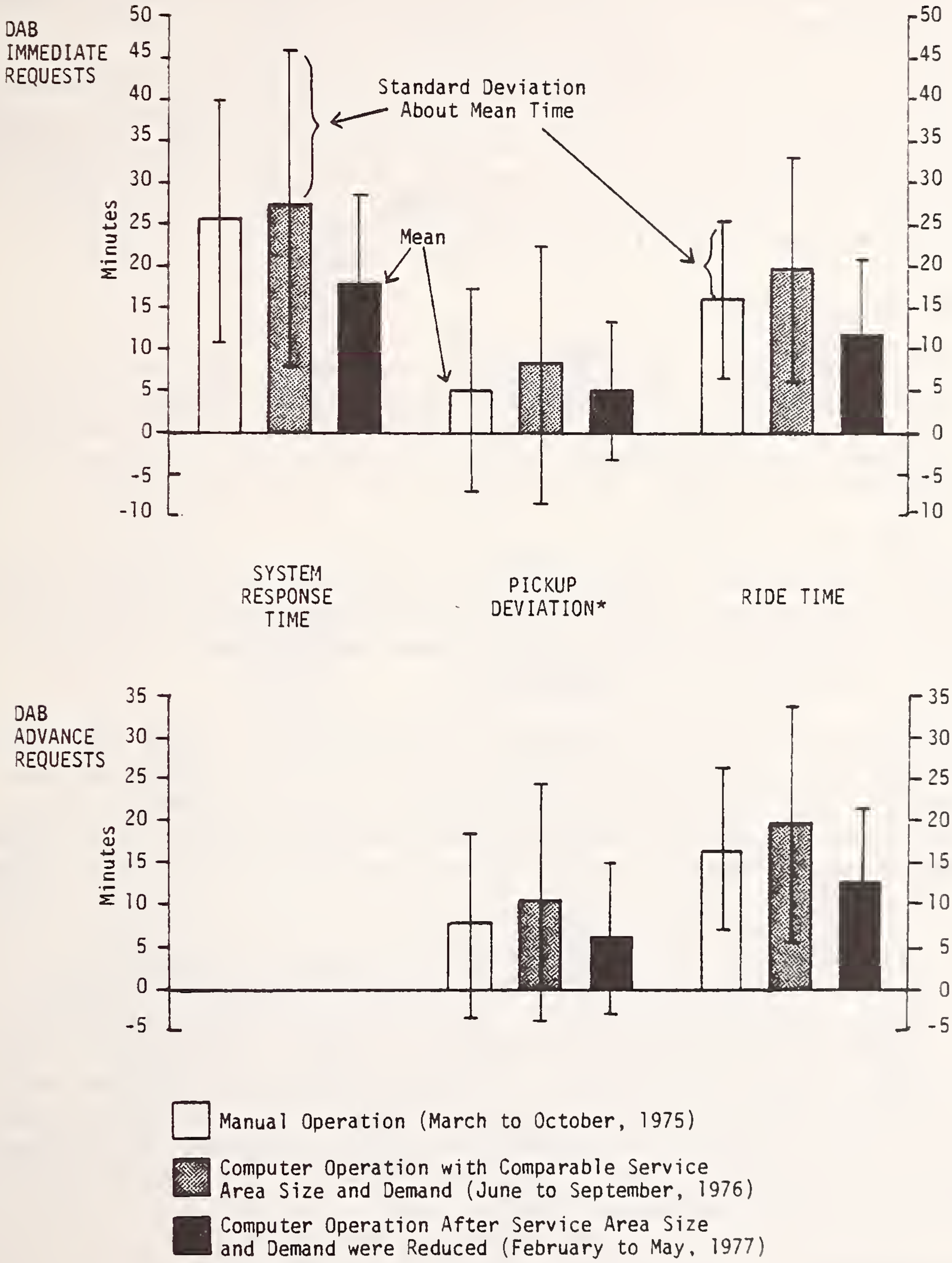
<u>Greece Findings</u>

3. DAB service was less reliable than fixed-route service when reliability is defined as the ability of users to predict the starting times of their trips (Section 5.3 and Exhibit 1.7). Response times and trip durations were usually acceptable.

DAB service unreliability was the principal complaint voiced by DAB users in the on-board surveys and through correspondence (see Finding 10). During 1975, the actual pick-ups of immediate request DAB passengers occurred an average of five minutes after they were promised, and the advance request pick-up was made seven minutes late on the average. Furthermore, the actual pick-up times varied widely around the promised pick-up times, making it difficult for users to plan their travel schedules. Assuming a normal distribution of pick-up times around the mean, approximately 70% of all pick-ups occurred outside the band from five minutes early to five minutes late, and 15% were 20 or more minutes early or late. During 1976, when there was a constant shortage of vehicles and difficulties with implementing computerized dispatching, service quality declined. The service area was reduced in 1977, with an accompanying improvement in service and service reliability. Although the average pick-up was still a few minutes late,

EXHIBIT 1.7

DAB RELIABILITY (GREECE)



* Bar below the line represents early DAB arrivals.

vehicle arrivals were less variable. A bus was more than 20 minutes early or late only about 6% of the time.

Average response times for the entire demonstration were about 25 minutes. Average ride times varied between 13 and 19 minutes; their variability was typically about 60% of total ride time.

Data on the reliability of the other PERT services and the fixed-route services are not available. When surveyed in April 1975, however, work subscription service users considered the service to be quite reliable. Less than 20% of the survey respondents arrived late to work more than once a month because of PERT delays.

Irondequoit Findings

4. In general, PERT fixed-route and route deviation buses provided reliable service to Irondequoit (Section 8.2). Although conditions improved in 1977, DAB was plagued by reliability problems similar to those experienced in Greece (Section 8.3 and Exhibit 1.8).

The PERT fixed-route and route deviation buses were generally reliable, except during December 1976 and January 1977 when there were excessive vehicle breakdowns. A few Summerville Shuttle users complained about poor transfer coordination with RTS buses.

Because it did not adhere to a schedule, DAB was more likely to be perceived as unreliable. The situation was especially serious during the fall of 1976, when vehicle shortages were acute. For example, about 20% of all immediate-request passengers were picked up more than 20 minutes early or late.

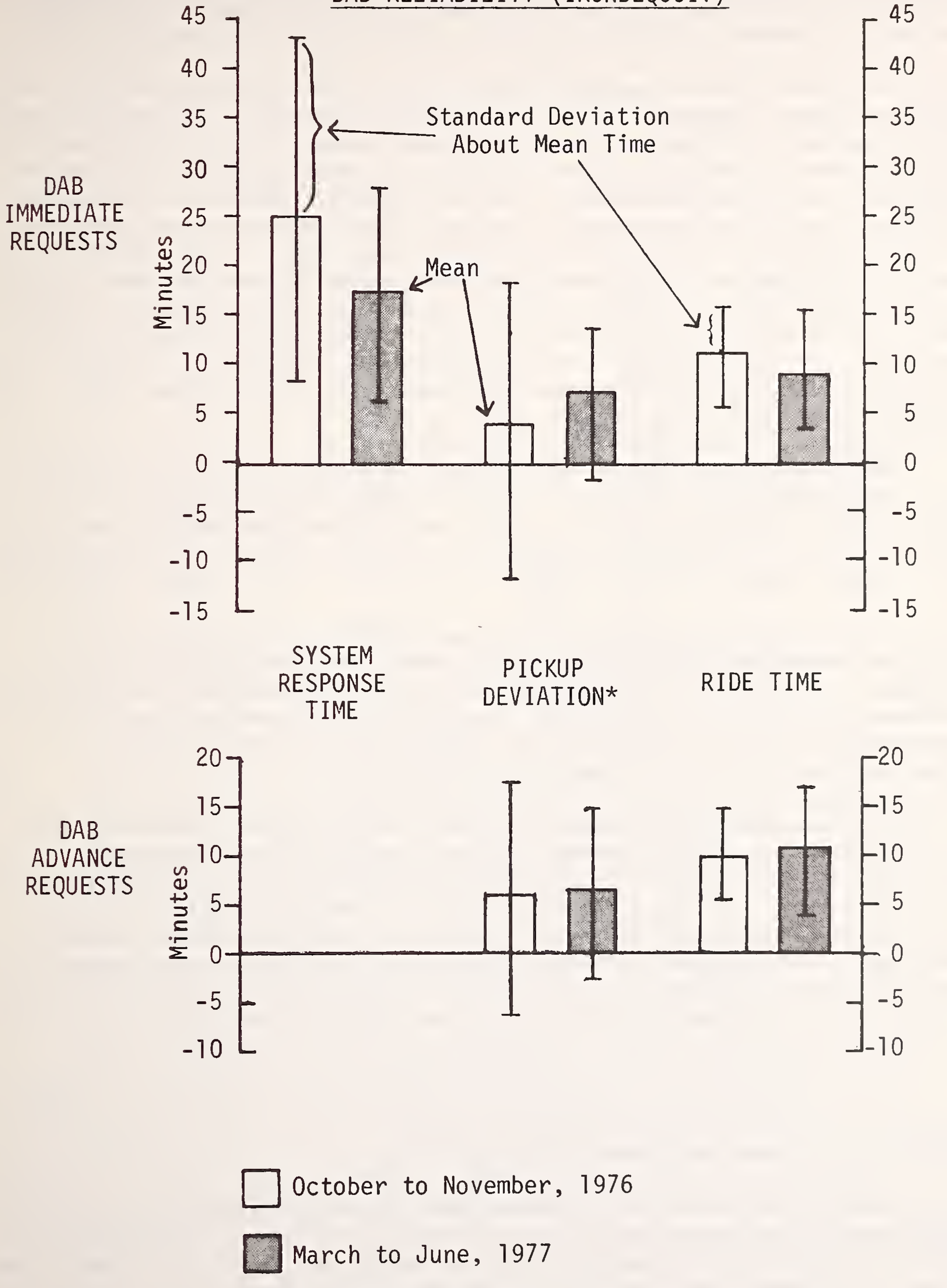
In two on-board surveys, users rated predictability as DAB's least attractive attribute when compared to other travel modes (Exhibit 1.12). In December 1976, 44% of the survey respondents said that DAB was less predictable than their usual mode of travel. By comparison, only 34% said that DAB cost was too high, even though DAB was more expensive than most users' alternative modes (taking RTS buses, being driven or driving). Perceptions of DAB reliability improved in the spring of 1977.

Implications

Demand-responsive service flexibility in responding to calls for immediate service is accompanied by decreased reliability. The many-to-many DAB service was the most flexible, while the scheduled subscription and route deviation services more closely resembled fixed-route services.

EXHIBIT 1.8

DAB RELIABILITY (IRONDEQUOIT)



* Bar below the line represents early DAB arrivals.

A trade-off exists between the doorstop convenience and areawide coverage of DAB service and the schedule reliability of a fixed-route bus; different users place different values on each.

Perceived DAB reliability depends largely on user expectations, based either on promised pick-up times or past experience. If the vehicle arrives when it was promised, the system is perceived as reliable, whether the user waited 10 minutes or 30 minutes. If the usual immediate request requires a 30-minute wait, the service is perceived as being less responsive than one that requires only a 10-minute wait. If the bus arrives when promised, the user can depend on the response. This suggests that operators should give particular attention to accurately predicting arrival times, and that arrival time intervals should be quoted rather than specific times. Pick-up should be made within the predicted interval almost all of the time.

Many users are not as concerned with pick-up reliability as with predictable arrivals at their destinations. This suggests that systems that accept and schedule according to arrival times, as some airport limousine services do, are convenient for many users.

Subscription services are sensitive to vehicle reliability, especially during peak commuting hours when the number of vehicles available for back-up support is limited. Because only one bus serves each tour, passengers waiting for a disabled vehicle are stranded until the bus is repaired or another is made available.

Since demand-responsive and subscription services are sensitive to vehicle availability, special maintenance procedures that enhance vehicle availability and reliability are required. A larger-than-usual fleet of spare vehicles systems may also be necessary, and preventive maintenance should be stressed. The additional cost of a comprehensive maintenance program is probably an intrinsic characteristic of successful demand-responsive services (Section 5.2.3 and 8.2.2).

1.4.1.3 Transit Travel Times.

Travel time is defined as the total elapsed time required to make a trip, including: (1) the time taken to get to the pick-up point; (2) any waiting time; (3) the time spent on-board the vehicle; (4) any time spent waiting for a transfer; and (5) the time spent moving from the bus debarkation point to the final destination. Calculations of transit travel times, especially those of DAB, depend on how wait time (the time between calling for service and bus arrival) is measured. To deal with variations in waiting time, transit trips are divided into "planned access" and "random access" categories. When a rider attempts to coordinate their trip with the bus schedule, that trip is planned. Fixed-route users try to meet the bus at its scheduled arrival time, allowing some margin of safety in case the bus is early. DAB patrons can often make constructive use of the period spent waiting for the bus to arrive, though they must take care not to miss a possible early arrival. Random access trips are assumed to start randomly in time, without consideration of the bus schedule. Travel time for such trips begins when a persons sets out for the bus stop or telephones for DAB service. It is assumed that waiting time is not used productively.

Travel time comparisons between fixed-route and PERT services are based on trips that can realistically be made by transit. The comparisons do not adequately reflect DAB's ability to improve travel times for trips that are poorly served by fixed-route lines, such as those which require a time-consuming transfer.

Greece Findings

5. In general, DAB travel times were longer than those of the fixed routes for those users who previously could complete their trips without a transfer. Some subscription users' travel times were shorter than fixed-route travel times; others were longer, depending on the fixed route used previously. DAB travel times decreased significantly after the 1977 service changes were made, until they were roughly equivalent to non-transfer fixed-route travel times (Sections 5.3.4, 5.3.5, 5.4.1 and Exhibits 1.9 and 1.10).

6. In most cases, route rationalization increased travel times to points outside the DAB service area (Section 5.3.6 and Findings 9, 22 and 23).

The average DAB random access trip during the 1975 steady-state period took 41 minutes, while planned-access trips on DAB averaged about 27 minutes (see Section 5.3.1 for assumptions). In-vehicle ride time was about 16 minutes in each case. An equivalent trip by automobile would take about 8.4 minutes or 20% to 30% of the DAB times (see Exhibit 1.9). During 1976, however, frequent vehicle breakdowns resulted in constant vehicle shortages and caused DAB waiting times and in-vehicle ride times to increase.

Before Greece's route cutbacks, fixed-route travel times varied according to the route, the time of day, and whether or not a transfer was necessary. In 1975, DAB

EXHIBIT 1.9

COMPARATIVE TRAVEL TIMES (GREECE)

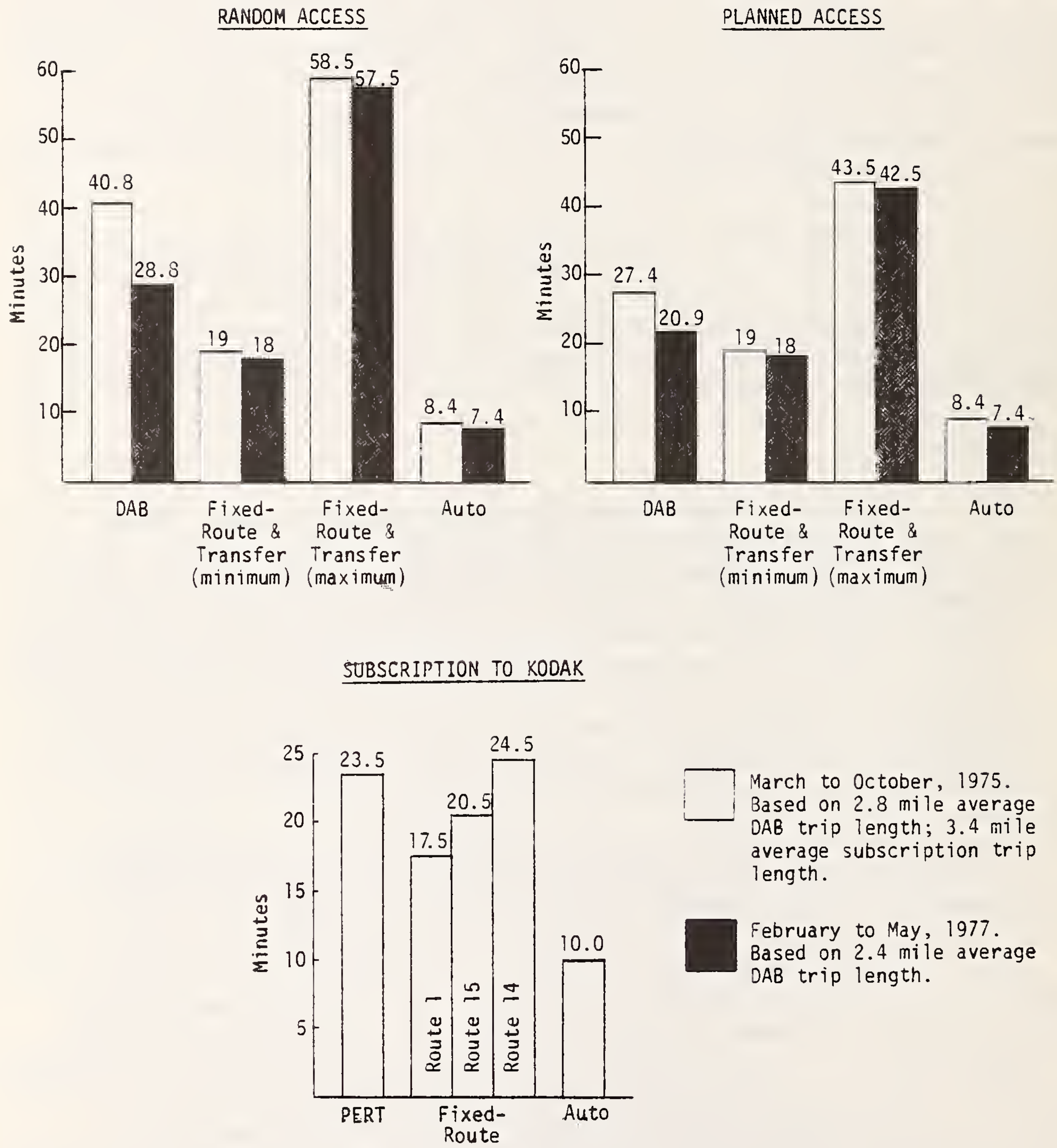
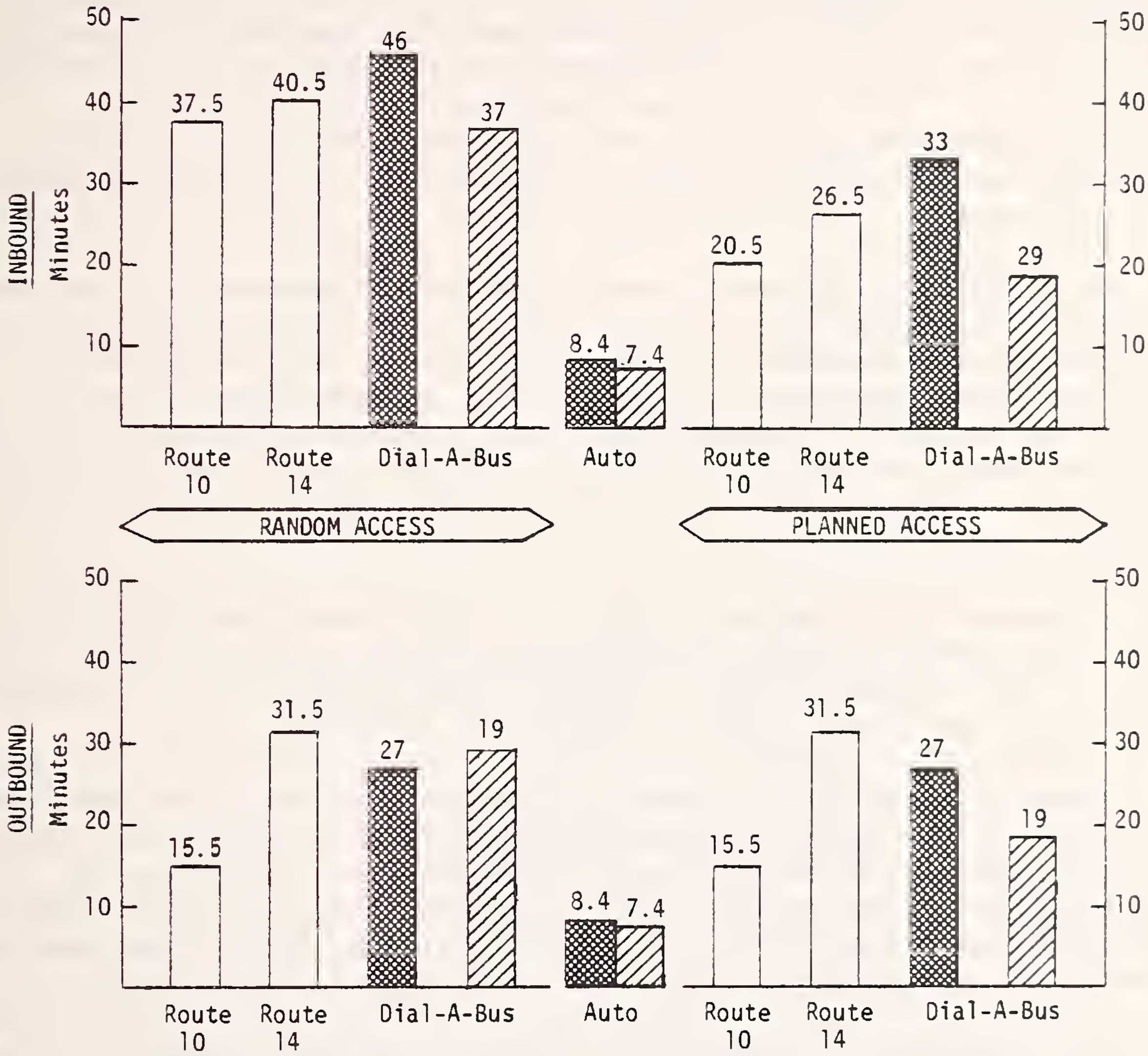


EXHIBIT 1.10

DAB TRAVEL TIMES TO AND FROM TRANSFER POINT (GREECE)

(For Downtown Service, Before and After Rationalization on Weekdays)



1974 Data — Before Rationalization: Fixed-route travel times based on published schedules.

1975 Data
1977 Data — After Rationalization: DAB travel times based on service quality checks and transfer point time studies. Auto travel times based on average DAB trip length.

(See Section 5.3.5 and Exhibits 5.13 and 5.15 for additional assumptions.)

travel times were longer for trips within a corridor served by fixed-route transit, but slightly shorter if the fixed-route trip required a transfer (Exhibit 1.9). Thus, in most cases, route rationalization increased travel times (see Exhibit 1.10). DAB travel within the Route 10 (Dewey Avenue) corridor was found to be especially inferior to fixed-route service when the rider wished to travel outside the DAB service area. Trips outside the service area required a transfer between DAB and RTS Route 10, where a direct fixed-route trip was previously possible. The average DAB-to-RTS transfer time was approximately seven minutes, about half the Route 10 headway. For the RTS-to-DAB transfer, transfer times of between 12 and 16 minutes were recorded.

In 1977, DAB travel times decreased because trips were shorter in the smaller service area. A low vehicle productivity (3.9 passengers per vehicle-hour) may also have contributed to shorter travel times and better service. During early 1977, the average DAB random access trip took about 29 minutes while a planned access trip averaged about 21 minutes, considerably less than the 1975 results (Section 5.3.4).

Average work subscription travel time (excluding wait time) was about 23 minutes, compared to about 10 minutes for driving and 18 to 25 minutes for fixed-route bus for patrons living in the fixed-route corridors (Exhibit 1.9).

Travel time for school subscription services averaged 18 minutes, but the average trip length was only 1.1 miles; the average travel speed was 3.7 miles per hour, only slightly faster than the walking speed of an adult. This poor performance was caused by circuitous tours needed to serve the area adjacent to the school (Section 5.5).

Telephone interaction with users appears to have been satisfactory during the latter part of the demonstration. Full-day control room studies in February 1976 (Greece) and March 1977 (Greece and Irondequoit) disclosed that about two-thirds of all calls were answered immediately (within five seconds); only 6% were held for over one minute before being answered. A less detailed Greece study in February 1975 had disclosed a much longer wait time. Throughout the project, booking a service request took about one minute once the call had been answered (Section 5.3.8).

Irondequoit Findings

7. In general, PERT services in Irondequoit did not significantly affect transit travel times. The route deviation option of the nominally fixed-route PERT service attracted few riders and thus travel times on

these routes were not particularly affected (Sections 8.3.1, 8.3.2 and 9.1.3).

8. Although DAB and the Loop Bus did lower circumferentially-directed transit travel time, these services were not widely used, and as a result had little influence on aggregate travel times. Nevertheless, once the vehicle breakdowns had abated, DAB was able to provide travel times approximately equal to fixed-route travel times (Section 8.3.5 and Exhibit 1.11).

By 1977, the average DAB random access trip time was reduced from 35 to 26 minutes. In general, persons requesting immediate DAB service could expect the bus to arrive in about 17 minutes, reaching their destination approximately 9 minutes later; this was slightly less than the average midday travel time for a person arriving randomly at a bus stop and traveling by fixed-route bus. Planned access DAB and fixed-route passengers had average travel times of around 18 minutes (Exhibit 1.11). Although Irondequoit Loop Bus riders faced longer average travel times--because of a longer headway, an indirect route, and one-way-only operation--their trips were substantially faster than the alternative fixed-route bus service, which required travel to and from the CBD (Section 4.2.1). In all cases, equivalent automobile trip time was 25% to 30% of DAB trip times (excluding the time taken to park the automobile).

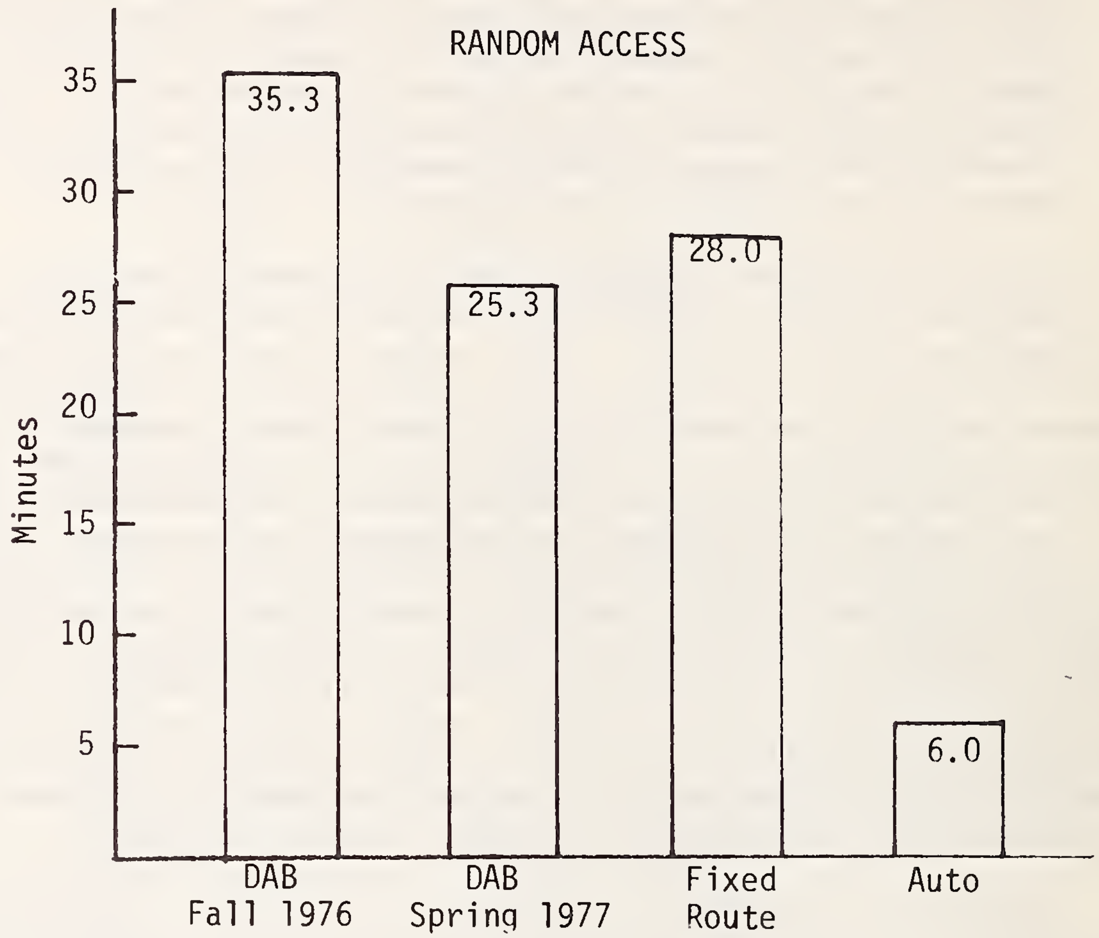
Due to the infrequent usage of the route deviation option and loop service in Irondequoit, it is impossible to determine the impacts that more usage would have had on overall travel times. Therefore, these results may have little transferability because of the low demand density and low vehicle productivity that existed (see Findings 18 and 21 and Section 10). Only about 2.8 passengers per vehicle-hour were carried by DAB in Irondequoit and, as a result, DAB service approximated single-passenger taxi service.

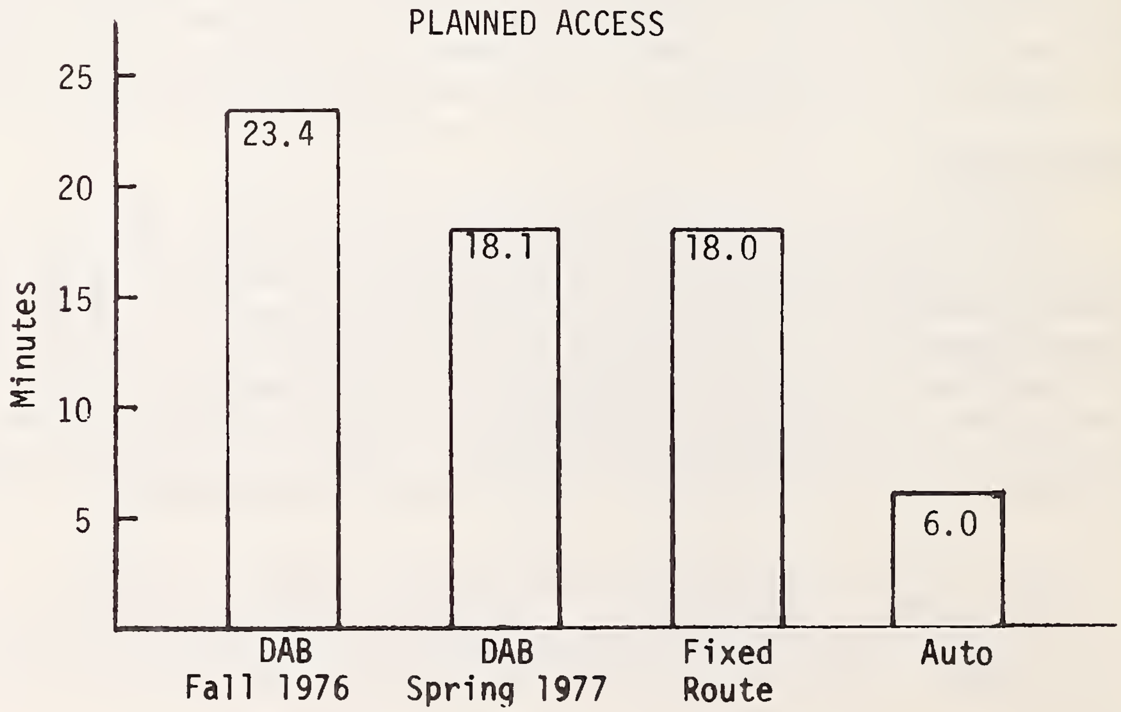
Implications

As a general rule, operators initiating demand-responsive services in uncongested suburban areas should not expect those services to yield average travel times that are substantially less than those experienced by fixed-route alternatives, even when fixed-route headways are as long as 45 minutes or an hour. Demand-responsive travel times may be shorter than fixed-route travel times in cases where transfers are required for the fixed-route trip.

EXHIBIT 1.11 COMPARATIVE TRAVEL TIMES (IRONDEQUOIT)

(Two-Mile Average Trip; See Section 5.3.1 and 9.1.1 for Other Assumptions)





1.4.1.4 Transfer Coordination.

Transfer coordination refers to strategies that reduce the waiting time of travelers transferring between two modes or two routes. Several transfer coordination strategies were tested in Greece. Passengers aboard RTS fixed-route buses could ask the driver to radio their DAB request to the control room. Some RTS routes were designated to be met by DAB buses. Transfers from DAB to RTS depended on the scheduler's ability to predict passengers' drop-off times at the transfer points.

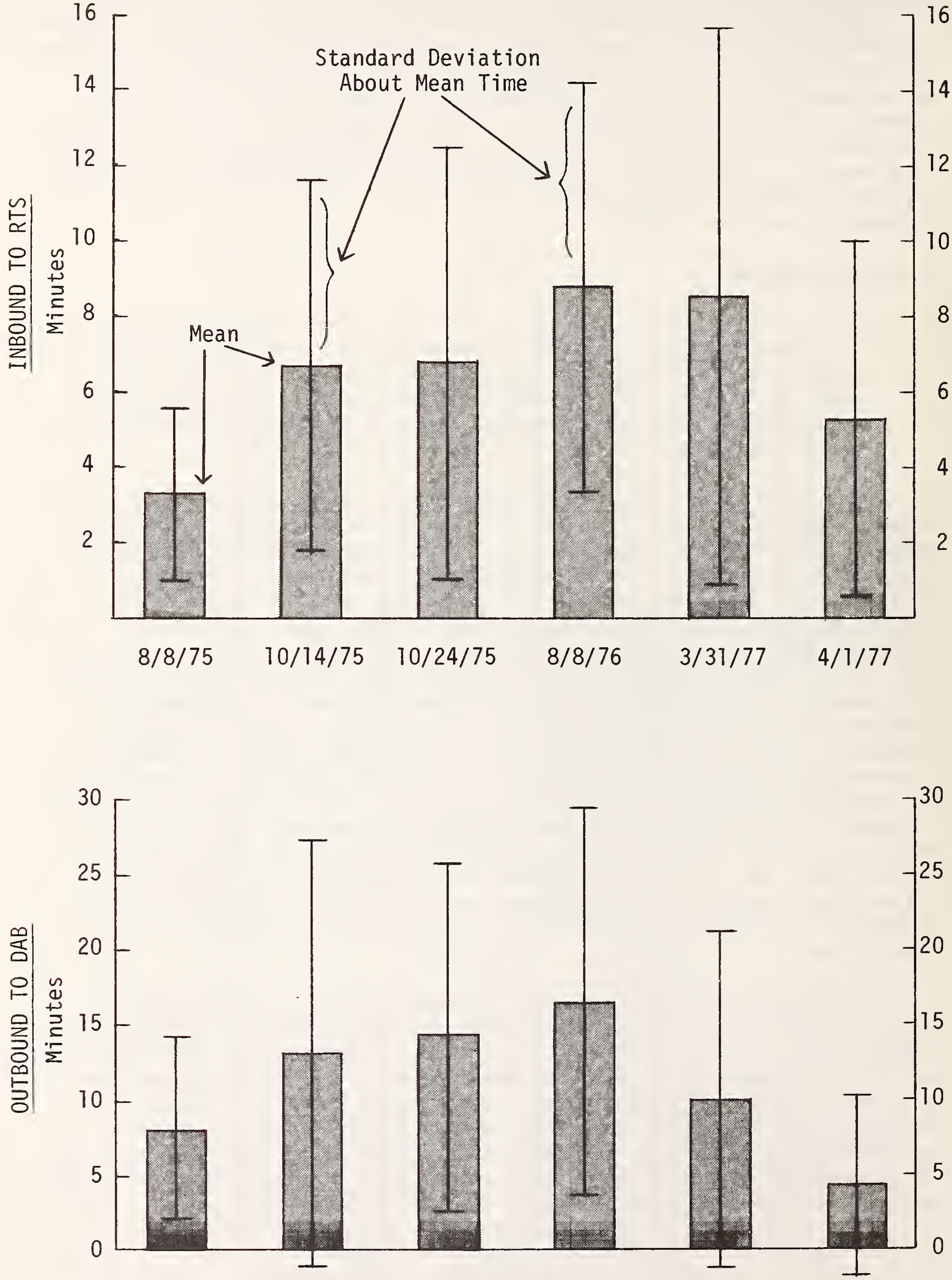
<u>Greece Finding</u>

> 9: During 1975 and 1976, efforts to improve transfers between DAB and fixed-route services did not appreciably reduce transfer times (Sections 5.3.6 and 6.3.4 and Exhibit 1.12). When the Dew-Ridge Shuttle was introduced and coordinated with RTS, many DAB passengers switched to the Shuttle (Section 6.1.1).

In 1975 and 1976, transfer times from DAB to Route 10 buses were slightly longer than half the average headway, resulting in about the same transfer time than a passenger arriving at random could expect. In contrast, average transfer times from fixed-route buses to DAB (15 minutes) were shorter than the average wait time for immediate request DAB users (25 minutes; see Exhibit 1.11). However, the total DAB notification time for an RTS transfer passenger was slightly longer than the wait time experienced by the average immediate request user. The radio transfer request from the RTS drivers to the PERT control room was normally made between 10 and 20 minutes before the arrival of the RTS bus at the transfer point. As a result, the request was received 25 to 35 minutes before the actual DAB arrival. Not all requests were communicated from RTS to PERT, and, as a result, there were some longer-than-expected transfer times. The strategy of designating fixed-route buses to be met by DAB vehicles had little impact on transfer times.

Transfer times from fixed-route buses to DAB were highly variable. In a three-day transfer study conducted in 1976, 14% of the reported outbound transfers to DAB incurred waiting times of 30 minutes or longer. Persons transferring to DAB every day would have been faced with a 30-minute outdoor wait at the transfer point nearly once a week. A survey in the spring of 1977 indicated that the variability in expected waiting time had decreased markedly, coinciding with the general improvement in DAB reliability.

EXHIBIT 1.12 TRANSFER TIMES (GREECE)



The Dew-Ridge Shuttle, which was well coordinated with RTS buses, was established in September 1976. As a result, transfers between DAB and RTS fell sharply (perhaps because users preferred the reliability of two fixed-route services).

The failure of transfer coordination was indicated by users' attitudes, which reflected dissatisfaction with transfer wait times and the inconvenience of transfers. Although transfer conditions improved in 1977, few additional transferring passengers were attracted.

Implications

Transfers are an annoyance to users, even though the unfavorable reaction to transfers is not commensurate with the time required to make them.[1] Therefore, system designers should focus on providing fast, convenient and comfortable transfers when they are required.

1.4.1.5 User Attitudes Toward Transit.

Several surveys were taken aboard each PERT and fixed-route bus to discern users' attitudes toward PERT and RTS services. The survey questions asked users to rate service characteristics on a five-point scale. The key results are reported below.

Greece and Irondequoit Findings

10. DAB services generally received high ratings for comfort and safety, while speed, cost and predictability were rated less favorably, in approximately that order. DAB convenience was rated between these two groups (Exhibit 1.13 and Section 6.2.5).

    Irondequoit RTS users rated safety, convenience and punctuality as important travel attributes, with the elderly including cost as a major consideration. Of these four factors, fixed-route transit users felt that the greatest improvements were needed in punctuality, an area in which PERT made no significant improvements (Sections 9.9.3 and Exhibit 1.14).

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[1] A survey of 786 users rated a "no transfer trip" as the third highest desirable attribute of 32, following only "arriving when planned" and "having a seat." User Preferences for a Demand-Responsive Transportation System: A Case Study Report, R.L. Gustafson, H.N. Curd and T.F. Golob, General Research Laboratories, January 1971.

EXHIBIT 1.13

MEAN ATTITUDINAL RATINGS OF DIAL-A-BUS COMPARED TO USERS' MOST COMMON LOCAL TRAVEL MODE

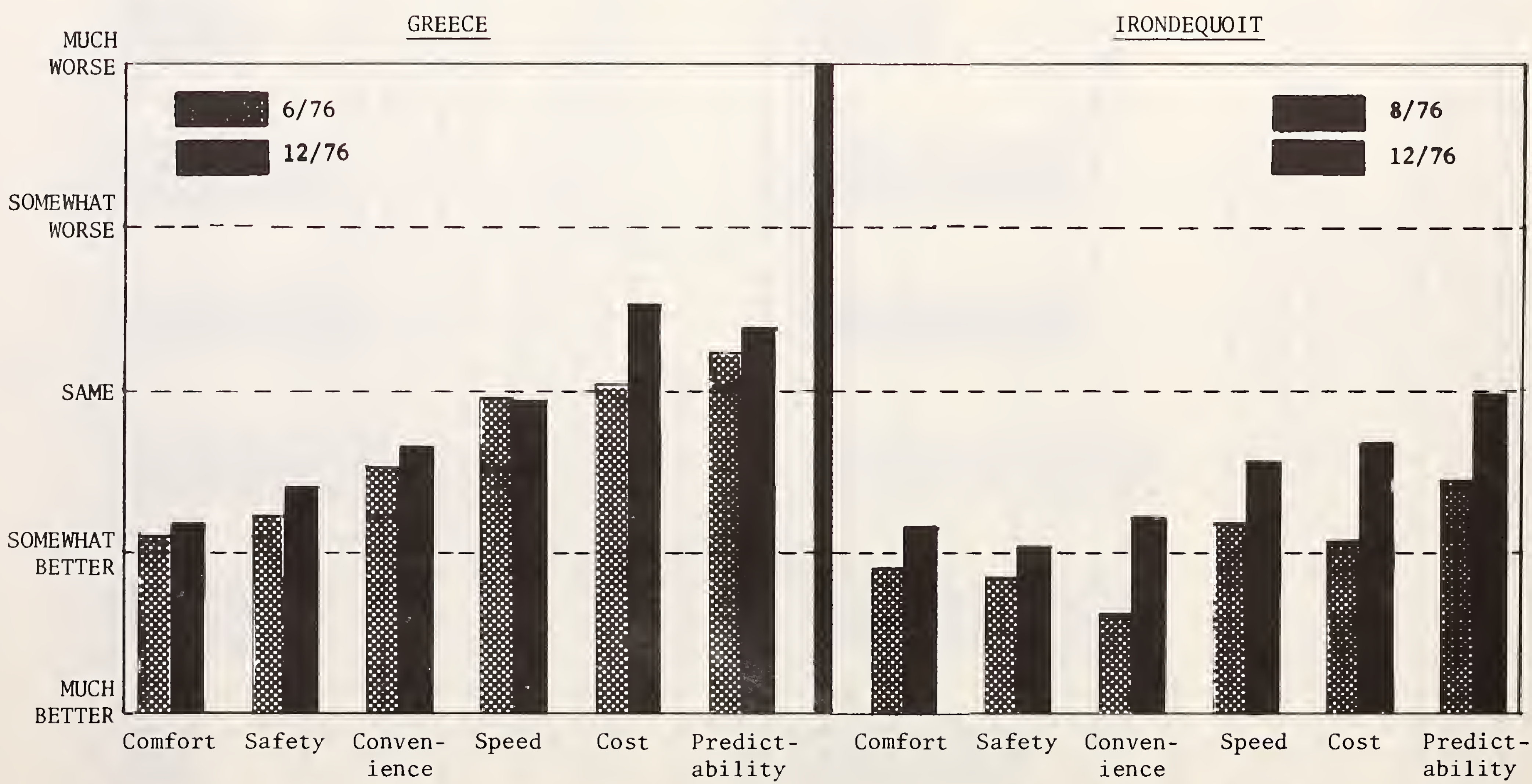
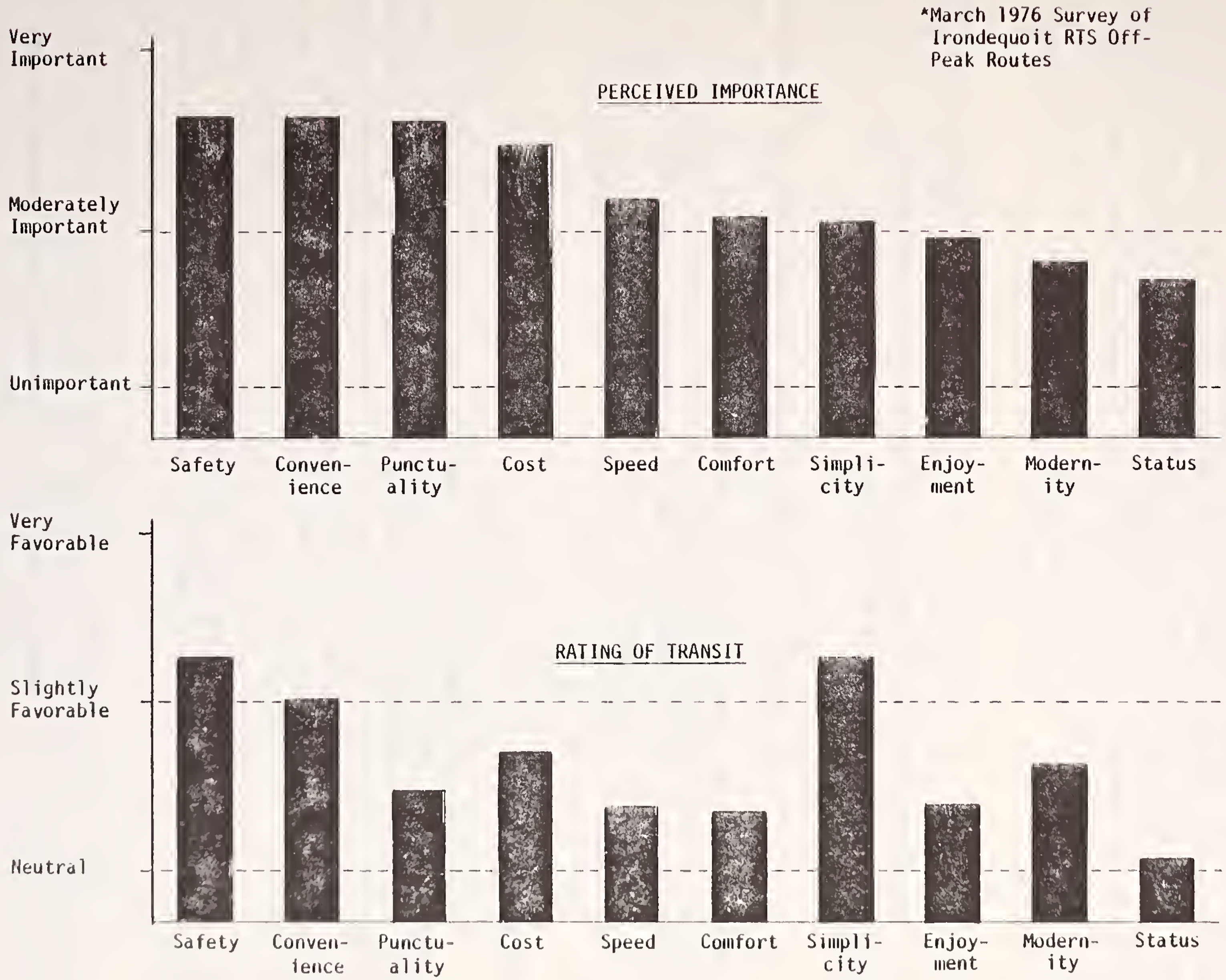


EXHIBIT 1.14 RTS USER ATTITUDES*



*March 1976 Survey of Irondequoit RTS Off-Peak Routes

The demonstration provided the opportunity to survey Irondequoit transit users before and during the demonstration in order to gauge the impact of the new services (Section 9.9.3). Routes unaffected by the demonstration comprised a control group. Prior to the initiation of PERT service, RTS users judged the safety and convenience of transit quite favorably, but were more critical of the transit system's punctuality (Exhibit 1.14). Elderly users, though more favorably disposed to transit overall, ranked the various attributes in the same way. This result suggested that the greatest improvements were needed in the area of punctuality. Demand-responsive services, however, emphasized convenience, safety and comfort and sacrificed punctuality. Demand-responsive services in Irondequoit did not, therefore, correct the most significant of the user-perceived transit shortcomings.

Compared to their usual transit mode, Irondequoit DAB users ranked DAB more highly than did Greece users. This was due to the use of DAB in Greece as a replacement for fixed-route service, whereas in Irondequoit DAB was an additional service.

Surveys of PERT users conducted after PERT's implementation made comparisons possible between PERT and RTS user perceptions of transit. In general, PERT improved the perceived comfort of transit and, to a lesser extent, the modernity and enjoyment of using transit. However, PERT was also judged to have made transit more complicated to use. Perceptions of other transit attributes were not altered by PERT (Section 9.9.3).

<u>Implications</u>

Attitude surveys in Rochester and other locations suggest that transit unreliability (unpredictability) is a much greater problem than any of its other characteristics, including travel time and cost. Therefore, demand-responsive services will not dramatically improve service for reliability-conscious users, unless they can be made more reliable. If services cannot be made more reliable, they should be directed toward population groups or trip patterns that are not presently served by existing transit. Handicapped persons who are unable to use regular transit are such a group.

Relatively affluent commuters who rarely used transit were able to benefit most from PERT subscription service. Whether PERT-type services can attract large numbers of affluent users to transit is not clear from the Rochester experience.

1.4.2 Demand

Transit demand in terms of the number and type of riders depends on the quality and promotion of the services. This section assesses PERT demand levels and describes the impacts of marketing and promotion on demand.

The number of riders who use a service per day is the most simple measure of demand. For purposes of comparison to other systems, demand densities (commonly measured by riders per capita per day or riders per square mile of service area per hour) are more useful.

1.4.2.1 Demand Density.

Greece Findings

11. Before September 1976, the Greece DAB demand density (ridership per capita) was comparable to other dial-a-ride systems in the United States. Thereafter, demand density was lower than other systems, due in part to reliability problems.

12. Although DAB users were predominantly female and were transit-dependent in the sense that they did not drive, DAB attracted a diversity of users in terms of age, employment status, and trip purpose (Section 6.2.2 and Exhibit 1.15).

Stimulated by three service area expansions, by an increase in operating hours, by three week-long half-fare promotions, and by the elimination of two RTS bus routes during the off-peak period, DAB ridership grew rapidly during the first 18 months of operation and then leveled off at around 475 passengers per day. This average demand density of 2.2 passengers per square mile per hour (Section 6.1.1) was much lower than the 8.7 to 11.8 demands per square mile per hour estimated prior to project implementation (Section 4.3.1).

At its maximum, DAB ridership reflected a daily usage of about 6.9 passenger trips per 1,000 population. This is somewhat less than the median of 8.3 observed in 68 other demand-responsive systems (Appendix A.20). Nonetheless, when other factors were considered, Greece DAB service patronage was comparable. Ridership in the other systems was found to be correlated with the service area population and the number of hours the service operated. Using these data, Greece had a higher than average ridership, although the differences were not statistically significant.

EXHIBIT 1.15

GREECE USER AND TRIP CHARACTERISTICS

User Characteristics	Dial-A-Bus 10/17/73	Dial-A-Bus 2/21/74	Dial-A-Bus 6/6/75	Dial-A-Bus 6/14/76	Dial-A-Bus 12/16/76	Subscription 4/75
SEX:						
Male	19.3	21.8	28.8	26.6	17.7	48.4
Female	80.7	78.2	71.2	73.4	82.3	51.6
AGE:						
Under 18	13.3	28.8	20.3	29.4[a]	31.6[a]	12.1[c]
18 - 44	47.0	46.8	52.5	39.9[b]	32.4[b]	40.3[d]
45 - 64	27.7	18.9	19.9	18.9	22.1	47.6[e]
65 and Over	12.0	10.7	7.3	11.8	14.0	
DRIVERS LICENSE:						
Licensed	39.1	45.9	42.9	47.8	35.8	83.9
Not Licensed	60.9	54.1	57.1	52.2	64.2	16.1
HOUSEHOLD AUTO OWNERSHIP:						
0	15.4	17.1	20.1	21.7	27.3	4.0
1	54.8	52.8	44.6	47.9	44.7	61.3
2	{29.8 (2 and 3 or more)	{30.1 (2 and 3 or more)	22.5	20.3	20.5	27.4
3 or more			12.8	10.0	7.6	7.2
TRIP PURPOSE:						
Work	44.2	38.1	40.8	38.3	38.3	--
School	2.9	3.4	7.8	10.2	6.8	--
Shopping	22.9	35.5	27.2	25.6	30.9	--
Medical	14.3	6.8	4.6	7.7	1.2	--
Other	15.7	16.2	19.7	18.3	22.9	--
AVERAGE WORKERS IN HOUSEHOLD:	--	--	--	--	--	2.55

[a]Under 20 Years [b]20-44 Years [c]15-24 Years
[d]25-44 Years [e]45-65 Years

An analysis of the changes in demand following route rationalization indicated that about one-sixth of the total ridership (or two-thirds of the DAB transfer ridership) was composed of persons who previously had used the fixed-route system. Thus, it may be assumed that had the fixed-route buses been retained, DAB ridership would have been only about five-sixths as large as it actually was.

During 1976, severe vehicle breakdown problems resulted in a 21% decrease in DAB ridership compared with 1975. The number of persons requesting service, however, dropped only about 10%. The balance of the loss results from increases in no-shows and cancellations (from about 10% to 25% of all trips).

When the Dew-Ridge Shuttle and the zonal fare system were introduced in September 1976, average DAB ridership dropped by about 36%. Most of the lost riders were diverted to the Dew-Ridge Shuttle, which also attracted a small ridership that had not used DAB. Before the Shuttle service was initiated, 34% of the DAB riders had transferred between DAB and RTS. Of the DAB riders diverted to the Dew-Ridge Shuttle, 45% had formerly transferred between DAB and RTS buses. Dew-Ridge Shuttle service, then, was more attractive to riders who previously had to transfer to make their trip, even though they still had to transfer between the Shuttle and RTS buses. The transfer between these two fixed-route legs was more reliable (Section 6.1.1) than a transfer between DAB and fixed-route bus.

DAB catered to a diverse market (see Exhibit 1.14). Although roughly one-quarter of the users came from households without automobiles, almost 30% were from households with two or more automobiles. Likewise, one-third of the riders were employed, one-third were students, one-sixth were retired, and the final one-sixth were homemakers. A variety of age groups were represented, although females outnumbered males by three to one. Work trips comprised 40% of all trips; an additional one-quarter were shopping trips. Although 60% to 65% of the users did not possess a driver's license, only about one-third of the passengers could not have made their trip without DAB. About 40% reported that they used either DAB or RTS buses for most of their local travel, while 30% reported that they were usually driven by others for local trips (Section 6.2.2).

Work subscription ridership varied between 150 and 175 passengers per day during the winter and 100 to 125 during the summer, resulting in an observed demand of between 0.7% and 1.3% of all Kodak Park workers living in the service area. This usage is relatively small compared to the 6.5% of the 1970 working population who traveled to work by bus. Unlike DAB patrons, work subscription users were predominantly male, middle-aged, and affluent. Seventy-two percent of the users reported that they had never ridden RTS buses, and most would switch to driving or carpooling if PERT did not operate. Most riders used PERT because they came from households in which there were more workers than automobiles. Thus, work subscription service catered to a very different market than did DAB (Exhibit 1.15 and Section 6.4).

Irondequoit Findings

13. Irondequoit experienced lower demand densities than the average found in other systems throughout the demonstration (never exceeding 2.6 daily passengers per 1,000 residents). This was probably due to the higher fares charged and the availability of fixed-route service.

14. Most Irondequoit route deviation (Urban PERT, Summerville Shuttle) passengers were former RTS users. The majority of DAB and Loop Bus users were highly transit-dependent (Sections 9.9.1 and 9.9.2 and Exhibit 1.16).

DAB and the Loop Bus generated little demand; combined ridership on these two services did not rise above 140 daily passengers. Prior to PERT's introduction, four of the five RTS off-peak fixed-route lines carried more Irondequoit passengers during the five-hour midday period than both Dial-A-Bus and the Loop Bus. Although these services carried relatively few passengers, they served a highly transit-dependent group. Persons 65 and over made up 18% and 26% of the DAB riders responding to two surveys. Between 35% and 45% of the riders came from autoless households (Exhibit 1.16). Forty-five percent and 55% of the respondents said they used PERT or RTS for most of their local travel. A Loop Bus survey suggested that its market is even more transit-dependent, although the results are inconclusive because of the small sample size.

Riders on the Summerville Shuttle and Urban PERT were mainly former RTS users; few new riders were attracted. Reported data show that few persons used the route deviation options on either of these services, although errors in driver counting may have resulted in some underestimation. Urban PERT users felt little need to use the deviation option, since most lived fairly close to a bus stop. Most Urban PERT users were traveling to work, and apparently timed their trips well enough that waiting was not a problem. New users were not attracted to the service, perhaps because there was little promotion in the Rochester portion of the Urban PERT service area. The Summerville Shuttle made only small route deviations, and benefitted few users compared with the number of residents in its corridor.

EXHIBIT 1.16

IRONDEQUOIT USER AND TRIP CHARACTERISTICS

User Characteristic	Fixed-Routes (Before; Weekdays) Day (n=343)	Fixed-Routes (Before; Weekdays) Night (n=216)	Summerville 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)
Dates	3/76		8/76;12/76	8/76;12/76	11/76	12/76	3/77
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
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
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	--	--	--	--	--

[a] Two surveys averaged.

The other PERT services -- peak period and transit-dependent services -- served special groups. Although they filled specialized transit needs, their ridership was small compared to the general transit services in the area.

Implications

Demand-responsive services such as those implemented in Rochester cannot be expected to capture a major part of the travel market in a large urban area. PERT market shares were lower than those of the fixed-route system in Greece and Irondequoit, and it seems doubtful that such services could significantly boost the transit mode share of a large urban area having a fixed-route system. Rather, the role of demand-responsive services is to meet special needs not met by the regular fixed-route transit network. This is one major lesson learned by the RGRTA from the early Greece experience and affected subsequent systems implemented in both Greece and Irondequoit. Naturally, changes in gasoline prices and availability may change this user behavior in the future.

Several factors are hypothesized to affect DAB demand levels: (1) the level (quality) of service, (2) the fare, (3) the number of operating hours, (4) the service area size and whether the service area includes activity centers, (5) the availability of alternative transit services and their service levels, and (6) the demographic characteristics of the population served. The majority of these data were not available for the other systems studied, so it was not possible to accurately compare PERT demand with that of other systems. Nonetheless, the apparently low ridership was probably caused by the high fare (most of the other systems charged a base fare of $0.50 compared to PERT's $1.00 and $1.25), and the availability of alternative fixed-route services, especially in Irondequoit.

In small, self-contained towns without fixed-route service, a DAB system is more likely to attract a significant share of the transit market. Likewise, route deviation services may be more effective than those in Irondequoit when they penetrate more deeply into areas unserved by transit.

1.4.2.2 Latent Demand.

Greece and Irondequoit Findings

15. About one-third of all DAB trips would not have been made if DAB did not exist; roughly the same number

of trips were diverted from the automobile (Section 6.2.4 and Exhibit 1.17).

In response to questions concerning their alternative travel modes if PERT did not exist, between 20% and 30% of PERT users in Greece said they would not have made their trip, and 20% to 40% responded similarly in Irondequoit. The same survey results indicate that a similar number of users would have made their trip by car (by driving or being driven); between 4% and 14% of DAB users would have driven.

Implications

A DAB service can be expected to enhance the mobility and independence (freedom from having to be driven) for a substantial number of its users. Only a few of those who would have driven an automobile if the DAB service were not available will be attracted to DAB.

1.4.2.3 Fares, Marketing and Promotion.

Greece Finding

16: DAB ridership in Greece increased substantially during half-fare promotions. Significant portions of the new riders continued to use DAB after the promotions. Half-fare promotions were less effective in attracting subscription users (Section 6.8).

Reduced fare promotions occurring early in the project tended to be more successful than those undertaken later. The impacts of longer-term fare changes were generally difficult to gauge because of the concurrent timing of other major service changes. Although the data do not support statistically significant conclusions, fare change experiences suggest that the fare elasticity for demand-responsive services is slightly higher than the elasticity of one-third which is accepted for fixed-route services.

Irondequoit Finding

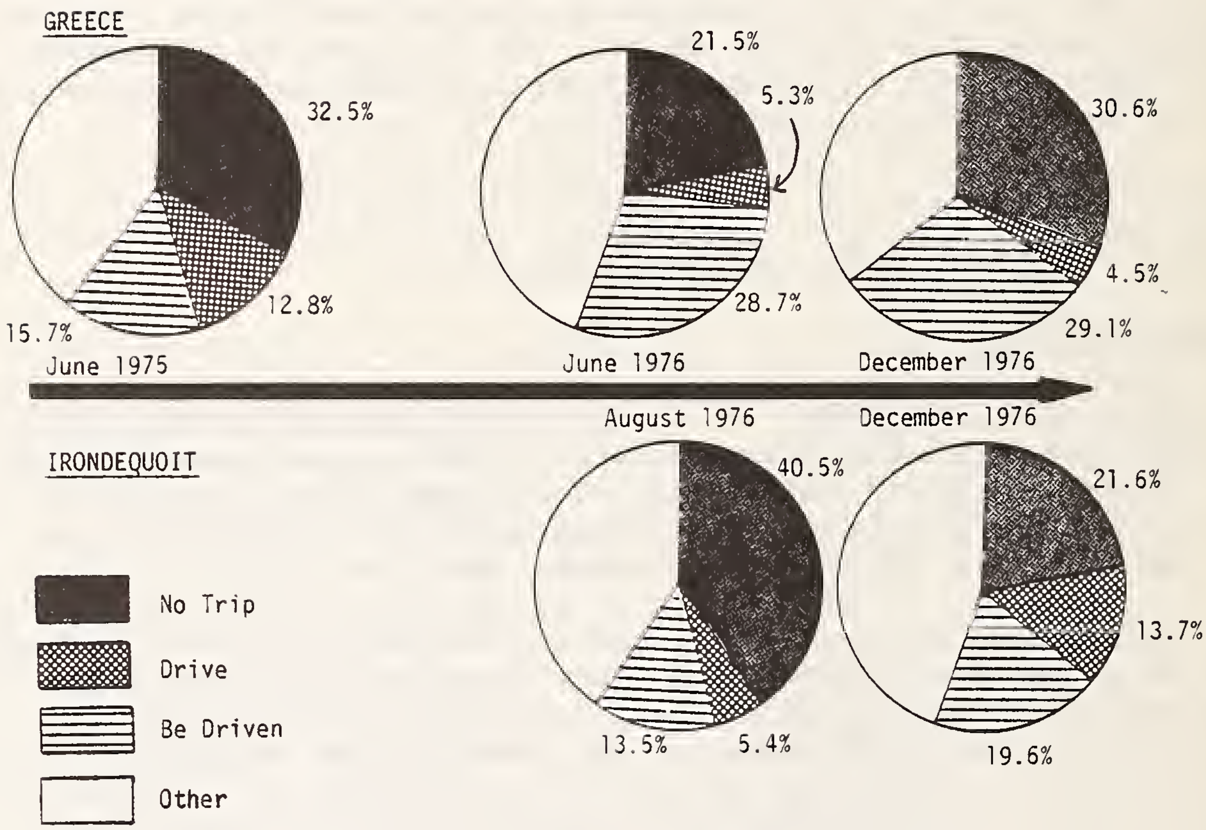
17: The effectiveness of the Irondequoit marketing program was limited by the complexity of the Irondequoit service package (Sections 4.2.4, 9.7).

The marketing program in Greece was more successful than neighboring Irondequoit in attracting PERT riders. The four week-long fare reduction promotions in Irondequoit failed to significantly boost low PERT ridership. There was some feeling among PERT management that the PERT program was too complicated to have been effectively initiated at one

EXHIBIT 1.17

ALTERNATIVE TRIP MODES IF NO PERT

(From On-Board Surveys)



time. A multi-page promotional booklet was necessary to include all of the appropriate user information. The problem of complexity was reinforced by major service and fare revisions every three to four months.

Implications

Fares are often set for reasons other than economic efficiency. Nonetheless, fare levels influence patronage considerably, and should therefore reflect a compromise between desired patronage, satisfactory service levels, and necessary revenue.

Strategies which price services at marginal costs seem worthy of consideration. Assuming that more costly services are of greater value to the user, this strategy may increase operating revenue. Under certain assumptions, economic theory postulates that such a pricing strategy will result in more efficient allocation of resources.

Reduced-fare periods can be useful promotional devices to attract riders to new services. If the services meet the needs of new riders, they will continue to use the services after fares are raised to pre-promotion levels. Complex service arrangements and fares will discourage service use.

1.4.3 Operating Efficiency

Operating efficiency attained when the maximum transit output is secured for the resources used. Both economic and non-economic efficiency are discussed in this section. Topics relative to the Rochester demonstration include vehicle productivity and costs, route rationalization, vehicles, and computerized dispatching. This section also compares Rochester DAB productivity and costs with hypothetical fixed-route systems and with other demand-responsive systems.

1.4.3.1 Vehicle Productivity and Costs.

Vehicle productivity is usually measured in terms of passengers carried per vehicle-hour. Passenger-miles per vehicle-hour are also used to account for differences in trip length between services.

Two cost measures are useful for assessing transit system performance. Cost per vehicle-hour is a measure of the cost structure in a particular service area. Cost per passenger combines productivity and the cost structure; it may also be used to compare cost per passenger with revenue per passenger to identify the subsidy required per passenger.

Greece Findings

18: Greece DAB vehicle productivity was much lower than had been predicted during system planning. No innovation undertaken during the time period covered by this report significantly improved vehicle productivity, with the exception of special services for the handicapped and elderly (Sections 3.2.2, 4.3.1, 7.2 and Exhibit 1.18).

19: Vehicle productivities in Greece were lower than but not significantly different from those of similar demand-responsive systems in other cities. Nonetheless, the DAB cost per passenger in Greece was higher than in other cities because of higher operating costs in Rochester (Appendix A.20).

Over the 121-week period of analysis (Chapter 7), DAB vehicle productivity averaged 4.9 passengers per vehicle-hour, with an estimated 13.6 passenger-miles per vehicle-hour. This was much lower than the ten passengers per vehicle-hour estimated during the planning process. It was, however, comparable to other dial-a-ride systems, two-thirds of which carried between five and eight passengers per vehicle-hour (Appendix A-20). DAB vehicle productivity was nearly constant throughout the project, although the drop in demand during 1976 lowered productivity until vehicle supply was adjusted several months later.

Work subscription service vehicles carried an average of 6.7 passengers per vehicle-hour and an estimated 22.8 passenger-miles per vehicle-hour, while school subscription service carried 15.3 passengers per vehicle-hour and logged an estimated 16.8 passenger-miles per vehicle-hour.

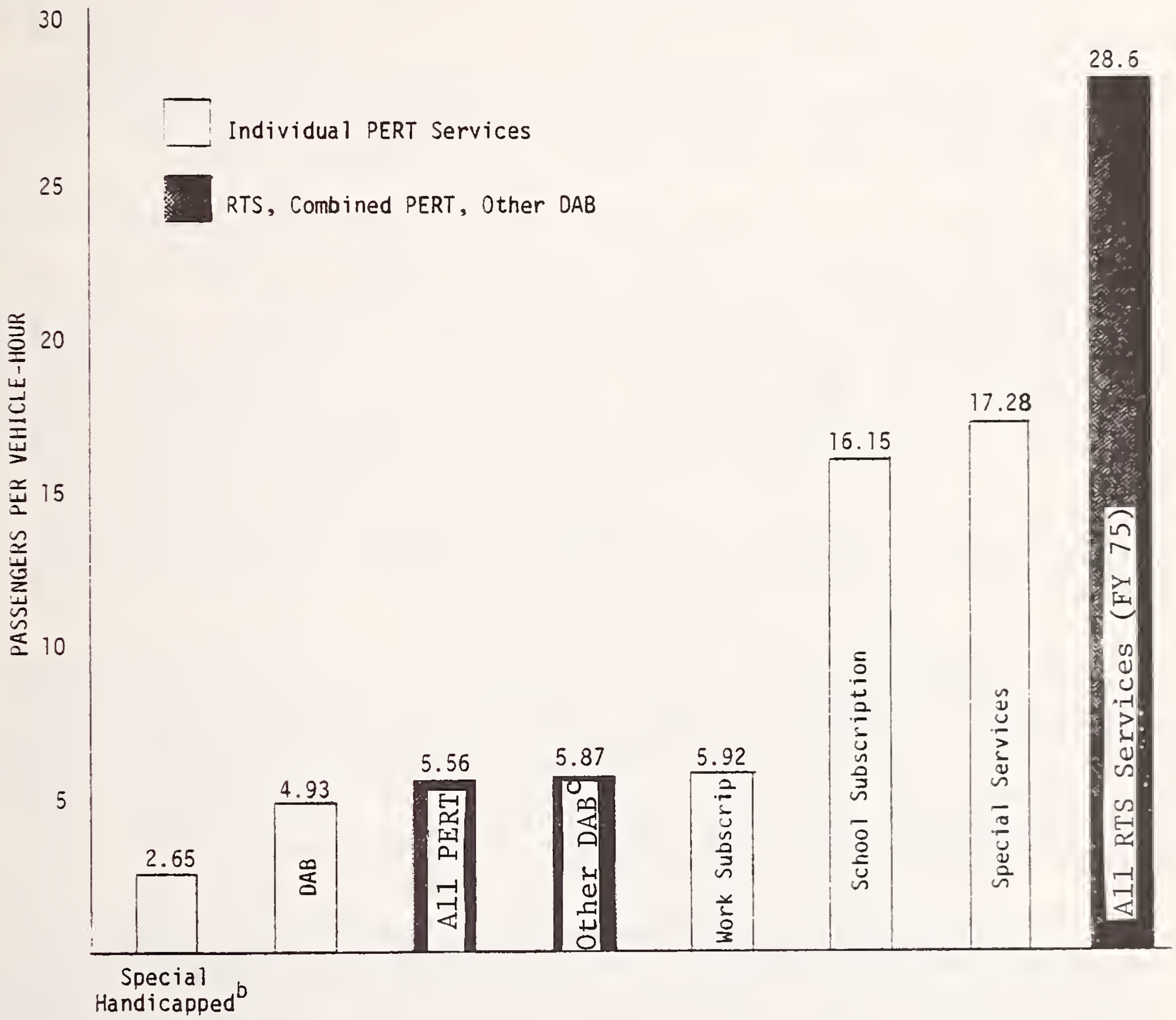
The highest vehicle productivity was achieved by the special services, with an average of 21.2 passengers per vehicle-hour. Due to the many changes in special services over time, the estimate of trip lengths and passenger-miles for those services is difficult. Some notion of trip length can be gained from data on the three shoppers' specials, which generated about 63 passenger-miles per vehicle-hour. These vehicles were by far the most popular of the special services.

At 2.7 passengers per vehicle-hour, the special handicapped service had the lowest productivity of all PERT services. Nonetheless, trips by the handicapped were longer (8.5 miles average) than those of the other services, so that 22.5 passenger-miles were generated per vehicle-hour.

EXHIBIT 1.18

AVERAGE VEHICLE PRODUCTIVITIES[a] BY SERVICE TYPE (GREECE)

(9/9/74 - 6/21/75)



[a] Data from Exhibit 7.1.

[b] Data from 6/23/75 to 3/27/76; not operated before this time.

[c] Data from 44 U.S. General Market DAB Systems.

When the Dew-Ridge Shuttle was introduced in September 1976, DAB vehicle productivity dropped to less than four passengers per vehicle-hour. The productivity of the Dew-Ridge Shuttle, however, rose to nearly ten passengers per vehicle-hour in early 1977, resulting in an overall improvement in PERT productivity (Section 7.2.2). A revision of the PERT handicapped service in late 1976 also substantially boosted its vehicle productivity.

At $18.25, the average hourly cost of operating a PERT vehicle was comparable to the cost of operating an RTS fixed-route bus. Almost half of this cost was made up of drivers' wages and benefits. PERT costs contrasted sharply with the much lower taxi costs (see Finding 29).

The marginal cost of each additional DAB passenger was about three-quarters of the average cost (a region of increasing returns to scale). This marginal cost was sufficiently high that very large increases in demand would have been necessary to substantially lower the cost per passenger (Section 7.3). Fares were less than the estimated marginal cost for all PERT services. Only about one-fifth of the total cost of the PERT services was recovered, although the subscription and special services recovered more than one-third of their costs. Although fares were related to the service cost, the more expensive services had the lowest operating ratios (revenues/costs).

The September 1976 and January 1977 service changes, including the introduction of the Dew-Ridge Shuttle, were expected to improve revenue recovery, but they were only marginally successful. Although DAB fare increases boosted that service's revenues, Dew-Ridge fares were much lower than DAB fares, causing overall revenue to increase only slightly (Section 7.2.2).

The available evidence suggests that the policy of route rationalization (in which DAB replaced fixed-route services having low productivity) did not reduce net transit expenditures. Furthermore, the consequent loss in transit ridership resulted in higher costs per passenger for the DAB service than had been incurred by the fixed-route services that were replaced (Section 7.4).

Operating costs per vehicle-hour were about twice the average of the other systems studied. All PERT cost components were higher than the average of the other systems. The proportional difference in driver salaries was apparently less than for such items as capital depreciation, maintenance, control room costs, and management, especially during 1976 and 1977.

Irondequoit Findings

20: PERT's shuttle and route deviation services attained vehicle productivity levels comparable to the fixed-route system they replaced (Section 10.2 and Exhibit 1.19).

21: DAB vehicle productivities in Irondequoit were significantly lower than DAB productivity in neighboring Greece and other DAB systems (Section 10.2 and Appendix A.20).

Since PERT services were operated primarily during the off-peak period when transit demand is low, PERT vehicle productivity was expected to be lower than that of the regular fixed-route buses (Exhibit 1.19).

Those services which directly replaced RTS services (Summerville Shuttle, Urban PERT, Routes 14 and 23) generally operated at vehicle productivity levels (passengers per vehicle-hour) that were comparable to the RTS service they replaced. However, DAB, the Loop Bus and the subscription services operated at much lower productivity levels, and had correspondingly higher unit costs.

In Irondequoit, vehicle productivity did not rise much above three passengers per vehicle-hour, whereas 85% of 38 other DAB systems have productivities above four. This difference was partly a result of the very low demand density in Irondequoit. Nevertheless, after accounting for Irondequoit's low demand density, vehicle productivity was still statistically well below that achieved in other systems (Appendix A.20).

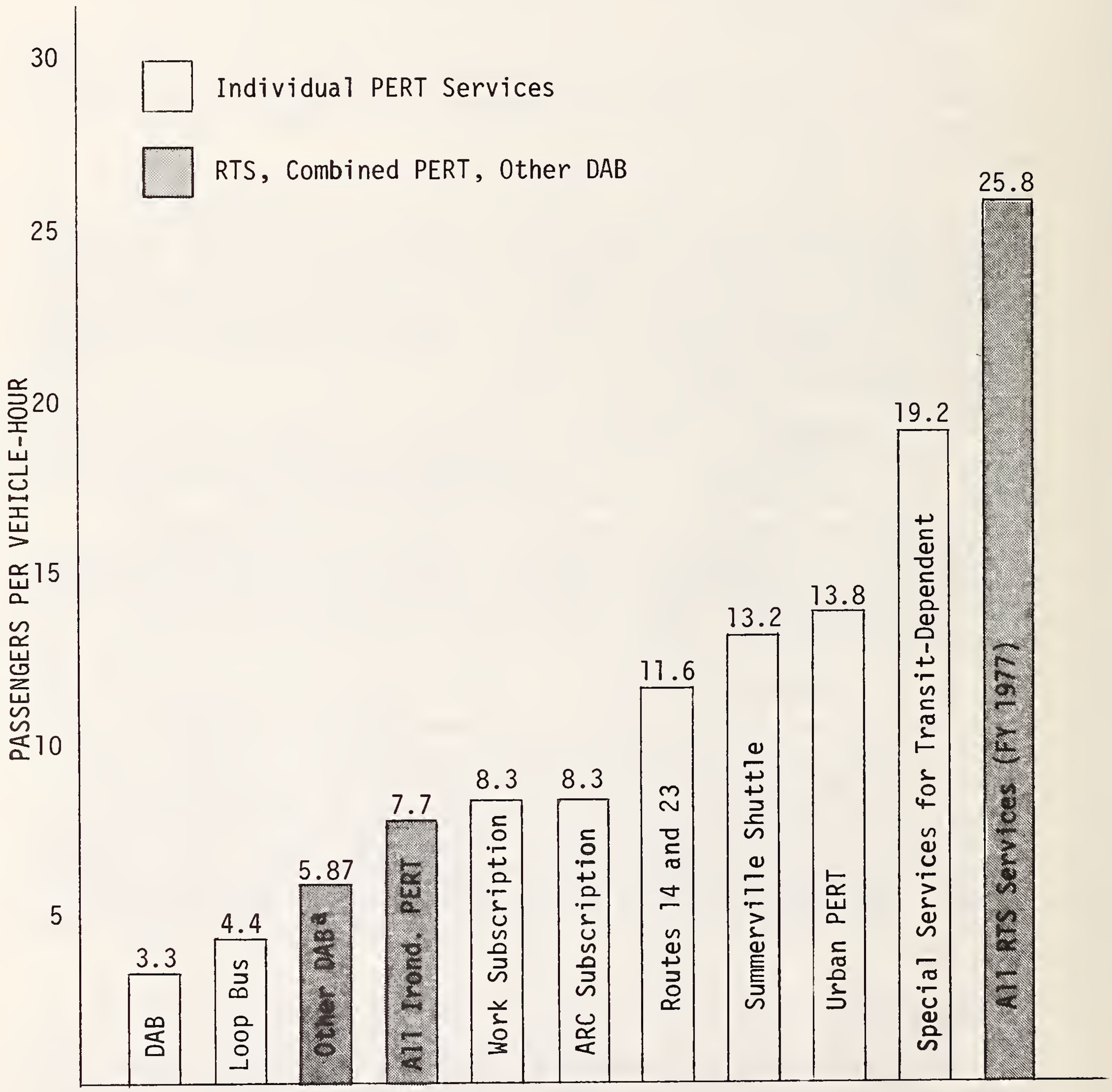
PERT operating costs per vehicle-hour in 1976 and 1977 exceeded RTS costs by about 20% because of the larger control room operation, a greater management effort, and larger capital expenditures. This resulted in costs per passenger of between $1.50 and $3.00 on the PERT subscription and fixed-route services, costs over $5.00 per passenger on the Loop Bus, and costs exceeding $7.00 per passenger on DAB. Because of their high load factors, the special group trip services for the transit-dependent had the lowest unit cost.

Implications

Non-subscription demand-responsive services operate at lower levels of vehicle productivity than operators expect of fixed-route services. DAB service can be justified in areas of low demand density where its productivity would be higher than fixed-route systems offering comparable levels of service. In an integrated transit system, where DAB

EXHIBIT 1.19

AVERAGE VEHICLE PRODUCTIVITY BY SERVICE TYPE (IRONDEQUOIT)
(9/13/76 - 12/31/76)



[a] Data from 44 U.S. General Market DAB Systems.

services act as feeders to fixed-route services, an evaluation of DAB alone would be misleading, since DAB may increase the productivities of the fixed-route services by expanding coverage and hence ridership. As demonstrated in Rochester, subscription and special group services have the potential of attaining productivities comparable to those of fixed-route services.

The cost of providing PERT services in Rochester exceeded that experienced in other demand-responsive transit systems. This was a result of several factors, including (1) a union-negotiated driver wage scale and benefits package which prohibited part-time drivers, (2) large capital expenditures for new buses required to supplement an inadequate basic fleet, (3) the acquisition of sophisticated communications equipment, and (4) an extensive management effort prompted by the experimental nature of the demonstration. The absence of these factors in other demand-responsive systems results in lower costs than those experienced in Rochester. Other jurisdictions may find it advantageous to invite competitive bidding for the services, as RGRTA has done in its extended demonstration. Several paratransit management companies have demonstrated their capabilities to operate demand-responsive systems. Local taxicab operators are also sometimes able to provide shared-ride services. In addition, contracts can be negotiated to include productivity incentives (see Finding 29).

1.4.3.2 Route Rationalization.

Route rationalization refers to the strategy of replacing off-peak or other lightly-used fixed-route services with DAB. The theory underlying this strategy is that such substitution will reduce costs, increase coverage, or both.

<u>Greece Finding</u>

> 22: The route rationalization strategy in Greece increased most travel times (Section 5.3.6), and contributed to a loss of transit riders (Finding 6) and a shift of trips to the peak period. The vehicle-hours needed to provide the service increased, with a resulting increase in cost (Sections 6.3.5 and 7.4).

Although a comprehensive data base for a thorough analysis of route rationalization does not exist, the transfer ridership data that are available suggest that about 67% of the former off-peak riders did not shift to the DAB services that were substituted for the off-peak fixed-route services. It is not clear whether these former riders stopped traveling, shifted their trips to peak periods when the fixed-route buses were still operating, or made their trips by different modes. What may be concluded is that the majority of the previous users did not use DAB as a direct substitute for fixed-route service. Although the available data do not indicate why the riders did not shift to DAB, surveys (Section 6.3.4) did indicate that the majority of those who did shift to DAB were dissatisfied with it. It is hypothesized that many users were discouraged by the inconvenience of the transferring required to use DAB as one leg of a trip to or from downtown Rochester.

The effect of route rationalization on transit costs in Greece is unclear, because DAB service area and operating hour extensions coincided with route rationalization. Nonetheless, it appears that the additional DAB vehicle-hours attributed to route rationalization slightly exceeded the number of RTS vehicle-hours eliminated. Since DAB and RTS operating costs per vehicle-hour were nearly equivalent, an increase in vehicle-hours would indicate a corresponding increase in total operating costs. The use of vehicle-hours as a cost indicator may require some modification, because some costs would be incurred whether a service is offered or not. For example, the capital costs of RTS buses would not be eliminated by reducing the number of routes or service hours, because the buses are needed for peak period service. Furthermore, union regulations may not permit potential savings in drivers' hours or salaries to be realized.

The Dew-Ridge Shuttle service was established in September 1976 to correct some of the adverse impacts of route rationalization. The Dew-Ridge service attracted only a few new transit users; most of its riders were diverted from DAB. However, transit reliability was enhanced, especially for passengers transferring from RTS, and the Dew-Ridge line's vehicle productivity was significantly higher than that of DAB.

<u>Irondequoit Finding</u>

> 23: The replacement of two off-peak fixed-route services with the route deviation Summerville Shuttle produced a 23% cost reduction and shifted about half the fixed-route riders to other modes or to peak-period service on the same fixed routes. Transit service quality decreased for some users (Sections 8.3.6, 9.3, and 10.4).

Route rationalization was used less extensively in Irondequoit than in Greece. Two parallel off-peak routes in Irondequoit (Routes 5 and 7) were replaced by a single route deviation service (the Summerville Shuttle) during the off-peak period. A large portion of the Route 5 corridor was no longer served because of the substitution. Although the number of vehicle-hours in service were halved by this substitution, actual costs were reduced by a lesser amount because of the need to deadhead the larger RTS buses to and from the garage.

The Summerville Shuttle carried only about 45% of the former off-peak demand on Routes 5 and 7. Most of the remaining users switched to other transit modes or to peak-period service on Routes 5 and 7. This diversion of ridership to the peak period is undesirable, considering the peaking problems faced by many large transit operators.

Implications

The PERT experience suggests that DAB services should be used to supplement rather than replace established fixed routes. Transit-riding habits in most cities have been based on a traditional route structure, especially in the older Eastern cities where the transit network has existed for over a century and only the travel modes have changed. Land use patterns and residential choice decisions have been based on the existence of these routes. From a transit management perspective, it may not be advisable to discontinue existing routes, because in many cases these routes have served the core transit market for many years. Abrupt service changes may provoke protests and divert riders. Radically different service types introduced at different times of day may also confuse riders. In addition, the use of small buses to provide demand-responsive service during off-peak hours requires that the larger buses used during the peak period be deadheaded to and from the garage. Unless satellite storage facilities are available, this will further increase operating costs. If both fixed-route and demand-responsive services coexist, however, habits may change gradually so that in the long run demand-responsive services may come to be preferred over fixed-route services.

Integrating DAB and fixed-route services in Rochester was hindered by poor transfer coordination (see Finding 9). This problem is not unique to demand-responsive and fixed-route integration. Except for the peak periods, when headways are short, transfers between fixed-route buses are also inconvenient. This inconvenience was intensified by the cold climate of Rochester. Other jurisdictions with large fixed-route systems should emphasize the development of an effective transfer strategy if separate demand-responsive services are introduced.

Route deviation can increase transit coverage by fixed-route buses. In some cases, existing layover time may be sufficient to allow time for deviations at no extra cost. Three problems limit the use of route deviation. First, the service may be difficult to provide with the large buses that are used on regular fixed routes. In addition to maneuverability problems, there is some opposition to the operation of large buses on residential streets. Second, route deviation as a standard feature on fixed routes requires all off-peak drivers to be familiar with the local street system. The training effort required would be substantial. Finally, unless there is slack time in the schedule, deviations would reduce the performance of fixed routes, since time must be allowed for deviations that typically contribute fewer riders than those boarding at fixed stops.

1.4.3.3 Vehicles.

Greece and Irondequoit Findings

> 24: The relatively few vehicles of each type that comprised the PERT fleet do not provide sufficient data to confidently rate the differences among them. The Twin Coaches were superior to other vehicles when they were new; however, the Dodge vans and minibuses performed consistently better than average, and the GMC vehicles performed above average. In general, however, problems with vehicle breakdowns persisted (Section 5.2.2).
>
> 25: During 1976, maintenance problems had a very negative impact on service quality and system effectiveness, and caused a continual shortage of vehicles in good working order (Sections 5.2.3 and 8.2.3).

Vehicles from eight different manufacturers were used to test different types, so the best vehicle could be selected for future expansions. Several of the vehicles proved to to be of very low quality, and are no longer manufactured. Others were prototype vehicles that were expected to have "bugs." Moreover, PERT management did not have direct authority over maintenance; it was managed and performed by RTS staff. The RTS maintenance staff had difficulty maintaining PERT vehicles. The personnel were accustomed only to maintaining the large General Motors diesel buses. Moreover, the demonstration was implemented while the new RTS garage was being built, further disrupting maintenance procedures. In addition, severe winter weather exacerbated the reliability problems (Section 3.3.4). These problems were compounded by the diversity of vehicles.

Implications

The findings related to vehicles cannot be generalized; the severe vehicle reliability problems in Rochester may not occur in other areas. It is clear, however, that because of the sensitivity of service reliability to the vehicle supply, considerable attention to vehicle maintenance is warranted in all demand-responsive services. A transit maintenance department accustomed to large diesel buses may need extensive training to effectively maintain a fleet of smaller gasoline-powered buses. Other jurisdictions contemplating demand-responsive services should be aware of potential maintenance and breakdown problems. They should select a single vehicle which they are confident they can maintain, and should actively train their maintenance organization for the vehicle or vehicles selected. Spare ratios of 25% to 30% for small bus fleets may be more appropriate than the 15% to 20% generally kept for regular buses.

Organizations sometimes select buses for DAB service which provide more than adequate capacity, because they then have the flexibility to use them for other services. Nonetheless, it may be judicious to use vans, as was done ultimately in Rochester, on the assumption that private sector maintenance experience can be used. Alternatively, vans may be a low-capital-cost means of providing back-up for small buses.

1.4.3.4 Computerized Dispatching.

Greece and Irondequoit Findings

26: The implementation of computerized dispatching took several months, during which network coding errors were discovered and the dispatching algorithm was fine-tuned to reflect local requirements (Section 4.3.1).

27: Computerized dispatching was successfully implemented and generated a high level of service under conditions of low demand, but its effectiveness under high demand conditions has not yet been established. Its ability to increase vehicle productivity has also not been determined (Sections 5.3.4 and 8.3.3).

Computerized dispatching of DAB vehicles required several months to implement in Greece, but only a few weeks were required in Irondequoit, where the experience gained in Greece was applied. During the Greece implementation, street network coding errors, system response time delays, and hardware failures contributed to poor service. Computerized dispatching also coincided with the vehicle breakdown problems, further complicating the situation. A full evaluation of the impacts of computerized dispatching was consequently hampered by vehicle unreliability and the drastic reduction of DAB demand caused by service cutbacks.

In February 1977, the implementation of computerized dispatching in Irondequoit demonstrated the system's ability to control two service areas. In 1975 in Greece and in the fall of 1976 in Irondequoit, service quality under computerized dispatching generally improved compared to service quality under manual dispatching. Nonetheless, the impacts of computerized dispatching were difficult to measure. By 1977, vehicle reliability had improved substantially, but Greece DAB was operating in a smaller service area and carrying less than one-third of the riders carried in 1975 under manual dispatching. Both DAB services were operating at lower vehicle productivity levels than when manual measurements were made. In Irondequoit, the available data suggest that the improvement in vehicle reliability and the decrease in vehicle productivity accounted for around 40% of the noted service quality improvements (Sections 5.3.2, 5.3.4, 8.3.1 and 8.3.2). The remaining improvement was not necessarily due to computerization.

DAB demand in both Greece and Irondequoit was too low to test the performance of computerized dispatching systems in large-scale, high-demand situations. The Greece DAB system averaged 20 service requests per hour, a number that a single manual dispatcher could easily handle; Irondequoit demand was even lower. Thus, computer-dispatched DAB service did not have sufficiently high demand densities to demonstrate its potential advantage over manual dispatching.

Implications

Dispatching fewer than eight vehicles can be effectively performed by a single highly-skilled dispatcher. The high initial cost and inevitable phase-in problems of computerization outweigh its potential benefits to such systems. The inevitable phase-in problems overshadow the potential benefits of computerization to such systems. On the other hand, the success of larger DAB systems often depends on effective computerization, unless isolated service areas can be created with each handled by a single dispatcher. Greater coordination and cost savings are possible with a computerized system in such high-demand systems, although the concept could not be tested in Rochester. System reliability problems and substantial costs suggest that a dedicated in-house computer is usually preferable to a time-sharing operation.

Computerized dispatching also supports a more sophisticated management information system than a manually-operated system is able to provide. Demand and supply data are tabulated automatically, thus simplifying the recordkeeping process. In addition, data that are expensive to collect manually, such as service quality measurements and origin/destination information, are continuously available under a computerized dispatching system. Another benefit of computerized dispatching in Rochester was the bank of easily-accessible tour information generated by the computer; quick access to such information enabled the order processors to more effectively interact with customers. Although these advantages would be realized in a system of any size, they become more significant in larger systems.

1.4.3.5 DAB Compared to Fixed-Route Service and Other Demand-Responsive Strategies.

Greece Finding

> 28: For the 1975 steady-state demand experienced in Greece, a system of fixed routes providing full coverage to the Greece service area and generating travel times approximately equal to those of DAB would have been slightly more costly per passenger than DAB. If demand were about 10% higher, the fixed-route system would have cost the same per passenger as DAB. The services are not equivalent, of course, since DAB offers the convenience of door-to-door service while fixed-route buses allow users to plan their trips according to a fixed schedule (Section 7.6).

An analysis of hypothetical fixed-route services in Greece suggests that either five routes with average headways of 30 minutes or eight routes with headways of 40 minutes would have provided a level of service comparable to DAB for non-transfer trips to activity centers located along one edge of the service area (Ridge Road). The eight-route alternative would have insured that all service area residents live within one-quarter mile of a fixed route, although this depends on the actual street layout of the routes. For the same number of riders carried by DAB during 1975, the average fixed-route cost per passenger would have been about 10% higher than the DAB cost per passenger.

The hypothetical system analysis was based on the assumption that fixed-route ridership would be equal to that of DAB ridership. About 20% of the DAB demand in Greece was for many-to-many service; the remainder was for many-to-few or many-to-one services. The 80% non-many-to-many demand, and perhaps some of the many-to-many demand, could be served efficiently and effectively by a fixed-route system (assuming that each fixed route would serve the major Greece activity centers and could also be well coordinated with other fixed routes providing service to downtown Rochester). Fixed-route service alone could not offer the personalized door-to-door service desired by the remaining users. Nonetheless, a fixed-route service could attract riders who were not attracted to a DAB service. This premise is supported by the fact that a sizeable group of fixed-route riders did not switch to DAB when Route 10 and 14 service was cut back (rationalized). Many of these users were probably discouraged by the inconvenience of transferring when traveling downtown by DAB.

It is thus possible that an extensive system of fixed-route buses in the Greece service area would have attracted more riders than the DAB service carried. The fixed-route system could carry additional passengers at very little additional cost. The fixed-route alternative becomes more cost-effective than DAB when demand is more than 10% higher than demand for DAB service.

A similar analysis of the Irondequoit service area was not conducted because of the existing fixed-route system, and also because DAB demand in Irondequoit consisted mainly of trips that would not be taken on the fixed-route system. The question of whether DAB or fixed routes should be used to provide transit coverage was an appropriate question to study within the context of the Greece service area; the question was irrelevant in Irondequoit.

Implications

Systems combining many-to-many service with many-to-few and many-to-one services may be able to achieve higher productivities than those restricted to many-to-many service alone. Jurisdictions faced with the selection of the most appropriate transit system should consider a wide range of service types. Such services include radial as well as circumferential fixed routes, shuttles, route deviation, point deviation, and subscription, as well as many-to-many, many-to-few and many-to-one demand-responsive services. Greater overall efficiency and higher-quality service may be achieved by the physical separation of the service components. For example, mixing many-to-many passengers with many-to-few passengers could lower service levels for the many-to-few passengers even further than if the many-to-many passengers were transported in separate vehicles.

One of the many-to-many service objectives identified in transit literature is the collection of information on demand patterns for use in refining integrated service design. The DAB service performed this function in Greece, supplying information which allowed system redesign in September 1976, from many-to-many service to a combination of services. One disadvantage of this method of demand determination is that demand is a function of service quality, and a many-to-many service may generate more or less ridership than would be generated by alternative systems. Nevertheless, the strategy is worthy of consideration by other jurisdictions.

A fixed-route equivalent can always be structured as an alternative to any proposed DAB service. Therefore, transport planners must choose between the convenience of DAB's door-to-door service and the relative predictability of fixed-route service. Different market segments will prefer one service over another, and the system designer must tailor the services to meet these preferences (see User Attitudes Toward Transit, Finding 10).

1.4.3.6 Comparison of Taxi Service and PERT Service.

Greece and Irondequoit Finding

> 29: Because of the low productivities and high operating costs of the PERT services, demand-responsive service costs were higher than exclusive taxi service provided at prevailing rates (Sections 7.2, 10.2 and Exhibit 1.20).

Because taxi service was available to all potential PERT users, it provides a useful alternative for a comparative analysis with PERT costs. Since taxis are operated with a profit motive by the private sector, it is assumed that taxi fares reflect the full cost of providing service and that they can be compared to the full cost of providing PERT services (excluding the consideration of tips).

In calculating the cost of taxi service, the size of the average group that used PERT was employed, as indicated in Exhibit 1.20. The comparative cost figures suggest that, in every case except Urban PERT, taxi service would be less expensive for the operator than PERT service. These results, however, must be interpreted in light of the fact that the quality of ride provided by an automobile (taxi) is different from that provided by a bus, and will therefore impact the potential demand as well as the type of user attracted to a taxi-based service.

Since taxi fares typically depend only on distance traveled, a charge for transporting more than one passenger can presumably be divided among the members of the group, thus providing an incentive to form groups for travel. As there was no group fare discount on PERT services, except for DAB, there was no motivation to form traveling groups. Therefore, larger groups and lower user costs could be expected if PERT users were to switch to taxis.

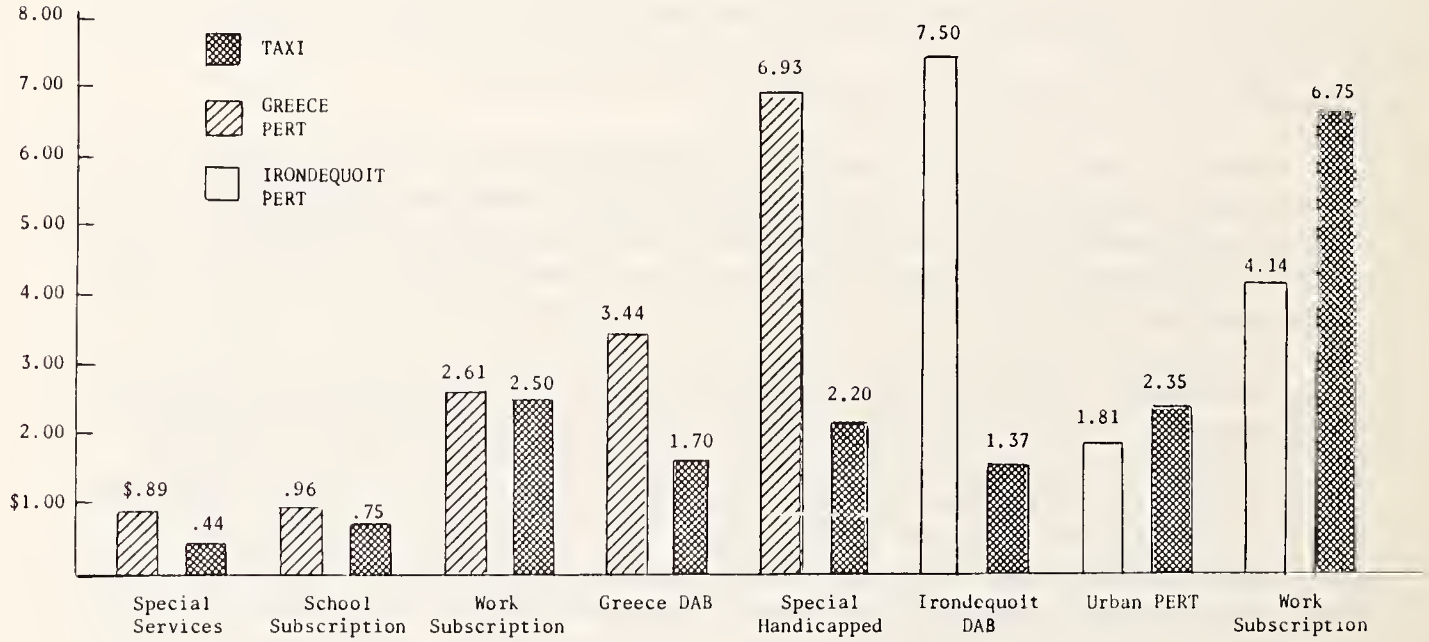
Implications

An alternative to creating a new transit operation or to assigning demand-responsive services to an existing

EXHIBIT 1.20

COST PER PASSENGER FOR GREECE AND IRONDEQUOIT PERT AND TAXI

(By Service Type)



Greece costs are from the second cost period (9/74 - 6/75), except for the handicappod service which is from period 3 (see Exhibit 7.5). The actual group sizes used to calculate taxi costs are:

- Special Services: 5, the taxi capacity; actual group size was 18.
- School Subscription: 1.6
- Work Subscription: 1.03
- DAB: 1.3
- Special Handicapped: 2.7

Taxi costs based on 60¢ for the first 1/6 mile; 10¢ per additional 1/6 mile.

Irondequoit costs are from the third cost period (9/13/76 - 12/31/76), and group sizes used are:

- DAB: 1.5
- Urban PERT: 1.2
- Work Subscription: 1.0

Taxi costs based on 75¢ for the first 1/7 mile; 10¢ per additional 1/7 mile.

Work subscription costs per passenger exclude Park-and-Ride passengers carried on return trip from Xerox.

transit operator would be to contract with taxi or other operators for the provision of public transit or paratransit service. The difference between the desired user fare and the taxi operator's required fare could be met by a subsidy from public funds. This arrangement is the basis for the new demonstration in the Rochester suburbs of Henrietta and Brighton, and is also being tried in other jurisdictions. Possible abuses of the subsidy arrangement by taxi operators can be controlled through the use of centralized dispatching.

1.4.4 Service for the Transit-Dependent

Greece Finding

> 30: The transit-dependent population in Greece was well served by PERT, as measured by the number of riders and their satisfaction with the service (Sections 6.6, 6.7 and Exhibit 1.21).

The PERT special services and the special handicapped service were provided primarily for the elderly and handicapped populations of Greece. Because of its door-to-door characteristic, DAB is believed to have been highly valued by these residents. In the June 1976 on-board survey, the elderly (age 65 and over) rated DAB more highly than did other groups in terms of comfort, safety, predictability, and cost but about the same as the others in terms of convenience and speed (Exhibit 1.21). Fewer than 20 elderly persons completed the attitudinal section of the survey form, however, resulting in statistically insignificant findings. Nevertheless, in an extensive fixed-route survey in Irondequoit, bus service was rated consistently higher by the elderly than by other groups (Appendix A.10 and A.11). The elderly tended to use DAB slightly more often than did younger persons, but they comprised approximately the same proportion of both DAB ridership and regular fixed-route ridership services during the off-peak period.

Special handicapped service began in June 1975 and transported about 16 passengers per week. Although the fact is not well publicized, the service was available for elderly as well as handicapped persons. Only a few people accounted for most of the ridership. During two months in 1976, for example, three persons made 80% of all the special handicapped service passenger trips. Only one of these required a vehicle with a wheelchair lift.

Special handicapped service was costly because one vehicle was usually devoted to each round-trip. In addi-

EXHIBIT 1.21

COMPARISON OF GREECE DIAL-A-BUS CHARACTERISTICS

WITH MOST COMMONLY USED MODE[a]

		SURVEY GROUP		
		ELDERLY[b]	ALL OTHERS	TOTAL (includes persons not indicating their ages)
	Sample Size	14-19	231-268	
	Comfort	1.89	2.11	2.10
CHARACTERISTICS	Safety	1.86	2.23	2.22
	Convenience	2.47	2.51	2.52
	Speed	2.89	2.95	2.95
	Cost	2.47	3.08	3.05
	Predictability	2.94	3.23	3.22

Notes:

1 = much better; 5 = much worse

[a]Results of the June 1976 On-Board Survey.

[b]The number of riders rating the different attributes varied between 14 and 19, a sample too small to provide statistically significant results.

tion, deadheading to or from the service area was usually necessary. Consequently, vehicle productivity was only about 2.7 passengers per vehicle-hour and 1.0 trips per vehicle-hour, resulting in a cost per trip of around $19.00. Only about one-eighth of those costs were recovered from revenue. This trip cost exceeded that of a wheelchair taxi, which offered the additional convenience of helping a patron in and out of the building.

In order to improve its coverage and productivity, the PERT handicapped service was revamped in October 1976. At this time, the service became scheduled, the fare was reduced to 50 cents, and the northern portion of the City of Rochester was included in the handicapped service area. Following the delivery of new wheelchair vehicles in January 1977, the PERT director of special markets conducted an extensive marketing effort targeted at organizations serving the handicapped. Ridership rose rapidly and by April exceeded 150 passengers per week, of whom about 25% were wheelchair passengers. Vehicle productivity also increased to about 2.4 trips per vehicle-hour, a 140% increase. Nonetheless, the net cost per passenger remained the highest of all the PERT services.

Several special group trips were offered in Greece, but the tri-weekly or bi-weekly Shoppers' Specials which served the elderly housing developments on upper Lake Avenue accounted for the overwhelming majority of all special trip passengers. About 175 one-way passengers per week used these trips, compared with a total of approximately 560 residents, age 62 or over, in the two housing developments. The fare was either free or 25 cents, making the service financially attractive to its users. Because of the relatively high vehicle productivity (averaging 21 passengers per vehicle-hour) and the partial financing of the services by local merchants, the Shoppers' Specials recovered a higher portion of their costs than any other PERT service. Thus, the Shoppers' Specials appear to have been greatly appreciated by their users and were also the most productive components of the PERT system.

Irondequoit Finding

31: Irondequoit elderly and handicapped residents were well served by PERT (Sections 9.1 and 9.2).

The PERT many-to-few service for the handicapped, described above, was jointly introduced in Greece and Irondequoit nearly one year before the other PERT services were implemented in Irondequoit. In September 1976, group trip services for the elderly and handicapped were also introduced in Irondequoit. These included a weekly special from an elderly housing site to a nursing home where daycare was provided, a biweekly special to a shopping mall, and several smaller operations. These services took considerable marketing effort to organize, but once started they operated rather efficiently because of their high load factors. Although these services were minor relative to the daily PERT service operations, they served the population group with the greatest mobility needs.

Transit-dependent groups comprised a greater proportion of the Irondequoit DAB and Loop bus ridership than they did for other transit services in the area, suggesting that these groups have a greater need for locally-oriented transit and doorstop service than other transit users do (Section 9.2).

Implications

Demand-responsive services, especially those offering door-to-door service, can provide significant mobility improvements to such transit-dependent groups as the elderly and handicapped. Wherever possible, trips should be aggregated so that group trip services can more efficiently serve the demand. The market for such group trips is limited, however, and other services may be required to fully serve the transit-dependent market (see Findings 28 and 29). The issue of whether these services are offered by existing transit organizations, contracted operators, or subsidized taxis should be considered by each locality planning services for the transit-dependent.

1.4.5 Institutional Arrangements

Greece and Irondequoit Findings

32. Demonstration authority and responsibility were so highly fragmented that it may have negatively impacted service.

During the early 1970's when the PERT system was being planned, RGRTA staff and RTS upper management disagreed over the objectives of transit development. RGRTA staff members viewed PERT as a cost-effective means of expanding transit coverage into previously-unserved suburban areas and as a substitute for inefficient fixed-route services. RTS upper management viewed PERT as an expensive expansion method that would significantly worsen rather than improve RTS's financial situation and that would divert needed resources from fixed-route services. Thus, RTS -- which embodied the transit management experience in Rochester -- would not take full responsibility for PERT management, and the demonstration contract called for management of the PERT services by MIT. (See footnote, Section 4.3.1.)

Organizational problems developed for a number of reasons. MIT was responsible for services provided by RTS, yet it had no authority over RTS. The on-site management personnel did not have full decisionmaking authority, since many could only be made by MIT personnel in Cambridge, who had the proper overview of both the evaluation and service objectives. As a result, management directives were developed without sufficient interaction between MIT and the PERT employees responsible for their implementation. In addition, the ultimate authority for decisions rested with the RGRTA project committee. Although the committee usually accepted management's recommendations, the need for committee deliberation on small matters was cumbersome. These factors were compounded by the resignation of the RGRTA Executive Director, who had fostered the PERT concept and taken a strong leadership role since the beginning of the service. Satisfactory coordination between the various parties was not achieved until the demonstration's second year.

Implications

Transit innovations such as demand-responsive services must have the full support of the organizations responsible for their implementation. In particular, established transit operators may be unwilling to take responsibility for demand-responsive services. They may also view proposals for such services with suspicion, perceiving the diversion of resources needed for the establishment of a quality fixed-route system. If outside groups are required to assist in operations, they should have on-site decision capability and the authority to execute their responsibility.

33: The quest for service improvements resulted in frequent service and fare revisions which hindered use, user acceptance, and data collection (Section 4.3).

By early 1977, virtually everyone involved with PERT -- from control room workers to the RGRTA commissioners -- felt that too many service and fare changes had been implemented during the project's life. PERT employees and customers were often confused about the services offered, fares, sign-up rules, and similar matters. Many of the changes were made during periods of chronic vehicle shortages, which hindered their smooth implementation and acceptance by users. Many potential users were undoubtedly discouraged from using the service because it was altered so often.

The changes in service arrangements also made evaluation difficult. In some cases, cause-and-effect relationships could not be ascertained because several changes were made at one time. In other instances, the period between one change and the next change did not allow time for adequate data collection. These conflicts between the search for viable services and evaluation of what has been tried are present in most demonstrations, but they were more pronounced in Rochester due to the number of innovations in the overall demonstration.

Implications

Constant service and fare changes impede the formation of a "transit habit" among users. Incremental implementation of new services is preferable to the wholesale revision of the existing services. Simple fare systems appear to generate greater user acceptance than do more complex ones.

> 34: The Rochester demonstration suggests that a large, unionized, traditional transit operator may have difficulty offering effective demand-responsive services.

The high cost of demand-responsive operations in Greece relative to operations in other cities (see Appendix A.20) was partly due to the high union wage scale for RTS drivers. PERT costs were markedly higher than those of the transit systems of other communities for which data are available. The high relative cost per passenger of PERT services was the focus of a series of RGRTA deliberations regarding the future of PERT as the demonstration neared its end. Outside contracting of PERT services was evaluated and implemented in two new suburban service areas.

PERT managers differed in their assessment of the extent to which effective transit operations were hindered by the regulations and practices in the local union contract. The problems experienced by PERT may have been caused by the lack of individual employee motivation rather than by the structural arrangement fostered by the union.

The causes of the maintenance problems with the small vehicles are not entirely clear, but both the maintenance crew's inexperience with small buses and RTS management's feeling that fixed-route reliability had a higher priority than DAB reliability were probably contributing factors (see Finding 24).

Implications

If it is true that operators may face at least passive resistance to demand-responsive systems among their staff, they should consider organizational separation of the demand-responsive services. One method of separation that may also offer cost savings is to contract for the services through existing taxi operators or firms specializing in contract transit. Nonetheless, separation may impede the coordination of services, thus defeating the objective of integration. Therefore, the institutional and organizational arrangements for offering demand-responsive transit service warrant considerable analysis and the participation of all concerned parties.

1.4.6 Environmental Impacts

Greece and Irondequoit Finding

> 35: PERT operations had no significant impact on energy consumption or air quality as measured by vehicle-miles traveled (Sections 7.5 and 10.5 and Exhibit 1.17).

Since new trips generated by DAB were partially offset by the number of trips diverted from automobile travel (Finding 15, Exhibit 1.17), DAB introduced a slight increase in vehicle-miles traveled. Work subscription service eliminated a small number of vehicle-miles traveled. In both cases, the changes in vehicle-miles were a small fraction of total vehicle-miles traveled in Rochester.

Implications

Jurisdictions considering new DAB services should not anticipate a decrease in vehicle-miles traveled, since any diversion from automobile use will be matched by new trips by the transit-dependent. Subscription services may reduce vehicle-miles traveled, since they replace either driven or chauffeurred automobile trips. Changes in vehicle travel from both subscription and DAB are likely to be small relative to the total number of trips made. It is unlikely that demand-responsive services can substantially decrease the total vehicle-miles traveled in an urban area, unless there are new constraints on automobile use. Even so, the services can offer improved mobility to people permanently or temporarily without access to automobiles in sparsely populated areas where frequent fixed-route transit service is uneconomical.

1.5 SUMMARY OF IMPLICATIONS FOR OTHER AREAS

The primary objective of UMTA's Service and Methods Demonstration Program is to gather information on transit experiments at specific sites, document these experiences, and thereby aid all transit decisionmakers in their search for more effective transit services through improved methods and service innovations. The Rochester experience generated a number of findings, which are discussed in the sections entitled "Implications." This section summarizes these implications, which will affect the decisions of transit planners and operators in other areas of the United States.

1.5.1 Coverage

Because they are flexible, door-to-door demand-responsive systems offer the potential for providing service to every resident of a service area. Rather than allowing this politically attractive feature to dominate system selection, however, it may be desirable to install paratransit services that combine demand-responsive and fixed-route features to provide a more cost-effective and affordable service which can be sustained through the "ups and downs" of fiscal cycles. Other jurisdictions faced with the selection of the most appropriate transit system should consider a wide range of service types. Such services include radial as well as circumferential fixed routes, shuttles, route deviation, point deviation, and subscription, as well as many-to-many, many-to-few and many-to-one demand-responsive services.

The travel patterns which develop in many-to-many services may provide the basis for the design of more productive integrated services.

Demand-responsive services, especially those offering door-to-door service, can provide significant mobility improvements to transit-dependent groups such as the elderly and handicapped. Wherever possible, trips should be aggregated so that special group trip services can more efficiently serve the demand. The market for such trips is limited, however, and other services may be required to fully serve the transit-dependent market.

1.5.2 Reliability

The reliability of small buses may be an endemic problem threatening the reliability of DAB services utilizing these vehicles. Demand-responsive services are more sensitive to vehicle reliability than fixed-route services.

Therefore, other jurisdictions contemplating demand-responsive services should be aware of potential maintenance and breakdown problems common to small buses. They should select a single vehicle that they are confident they can maintain, and then actively train their maintenance organization for that vehicle. Small bus fleets usually require more spare vehicles than do conventional larger fleets.

Organizations sometimes select DAB vehicles with more than adequate capacity, because they can also be used for other services. It may be judicious in these cases to consider vans, so the private sector maintenance experience with these vehicles can be utilized. Alternatively, vans are a low-capital-cost means of backing-up small buses. Because they are flexibly dispatched, demand-responsive systems have uncertain arrival and drop-off times; users of these services will find it harder to schedule their trips than fixed-route system users do. A trade-off clearly exists between DAB's doorstop convenience and areawide coverage and the schedule reliability of a fixed-route bus.

Additional surveys suggest that the unreliability (lack of predictability) of transit is a much greater problem than any factor, including travel time or cost. This suggests that demand-responsive services will not dramatically improve service for reliability-conscious users, unless the service can be made for more reliable. If they cannot be made more reliable, service should be oriented to population groups or trip patterns currently unserved by transit, such as the transit-handicapped who are unable to use conventional transit.

1.5.3 Travel Times

As a general rule, operators initiating demand-responsive services in uncongested suburban areas should not expect those services to generate average travel times significantly less than those experienced by fixed-route alternatives, even when fixed-route headways are as long as one hour. Travel times may be reduced when transfers are required on the fixed-route systems. Moreover, demand-responsive travel times will usually be two to three times those required by automobile travel for the same trip.

Transfers are an annoyance to users; this annoyance is not commensurate with the actual time it takes to make the transfer. Therefore, system designers should focus on providing fast, convenient and comfortable transfers when they are required, as they are when fixed-route and demand-responsive systems are integrated.

1.5.4 Fares

Fares in Rochester were higher than those charged by most dial-a-ride systems and, although the difference was not statistically significant, the per-capita demand levels were somewhat lower. While demand is no doubt sensitive to fares, DAB can be considered a premium service among users, and higher fares than are usually charged for fixed-route buses are warranted and can be used to tailor demand to supply.

Promotion of services by fare reductions can be effective if done in the early phases of system operation. Complex fare arrangements are disliked by users, and may impede system use.

1.5.5 Demand

Demand-responsive services cannot be expected to capture a large part of the travel market in a large urban area, and it seems doubtful that such services could significantly boost the transit mode share of a large urban area having a fixed-route bus system. Instead, their role should be to meet special needs not satisfied by the regular fixed-route transit network, such as short trips, trips not served by the fixed-route network, and trips for those unable to access fixed routes. On the other hand, in small, self-contained towns without a fixed-route system, a DAB system is more likely to serve a significant share of the transit market.

Substituting DAB service for fixed-route services having low ridership has been identified as a possible role for DAB. This tactic may not be accepted by users in cases where fixed routes have existed for many years and land use patterns depending on the fixed routes have developed. This is especially true if a transfer from the new DAB service to other fixed routes is required for many of the trips previously made on fixed routes without a transfer.

1.5.6 Costs

The cost per passenger of DAB systems operating under prevailing union-contract work rules and wage rates may be higher than the cost of the same trip by exclusive-ride taxis. This suggests that contracting for the provision of DAB services with private operators has some cost advantages. This alternative is suggested by examining the experiences of many DAB and shared-ride taxi systems throughout the country.

On the other hand, subscription and special group services have the potential to attain productivities and unit costs comparable to those of fixed-route services. It is sometimes possible to find outside parties willing to subsidize special group services, such as trips by the elderly to shopping centers.

1.5.7 Computerized Dispatching

Computerized dispatching methods have proven to be viable and reliable. Dispatching DAB systems of fewer than eight or ten vehicles, however, can be effectively performed by a single skilled dispatcher. The success of larger DAB systems may depend upon effective computerization. Greater coordination, cost savings, and better service can be made possible by a computerized system, although more experience with these systems is required before such benefits can be assured. System reliability problems and costs suggest that a dedicated in-house computer is probably preferable to a time-sharing operation.

Computerized dispatching also provides a more sophisticated management information system than a manually-operated system. Computerization provides better tour information for the order processors, enabling them to interact with customers more effectively.

1.5.8 Institutional Factors

Established transit operators may be reluctant to take responsibility for demand-responsive services. They may view such services as a diversion of the resources needed to establish a high-quality fixed-route system. Yet, to be successful, demand-responsive services must have the full support of the organizations responsible for their implementation.

If operators will face at least passive resistance to demand-responsive systems among their staff, organizational separation of the services should be considered. One method of separation that may also offer savings is to contract for the services through existing taxi operators or firms specializing in contract transit. On the other hand, separation may impede service coordination, thus defeating the objective of integration. Therefore, the institutional and organizational arrangements for offering DAB services warrant considerable analysis, with the participation of all related parties.

1.5.9 Environmental Impacts

Paratransit services can be expected to have little impact on environmental quality. Any diversion from automobile travel will be offset by the greater number of trips generated by the availability of the new service, especially new trips made by the transit-dependent. Vehicle-miles traveled are just as likely to increase as decrease, but in either case, the change will be small compared to the magnitude of total travel.

1.5.10 Implementation Factors

The carefully planned, incremental implementation of new services is preferable to wholesale service revision. Incremental expansion allows the provider to make adjustments to previous plans in response to unanticipated demand and other implementation experiences. Constant ad hoc service and fare changes, however, impede the formation of transit habits among users.

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