TCRP

SYNTHESIS 53

TRANSIT
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Operational Experiences with Flexible Transit Services

A Synthesis of Transit Practice

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TRANSIT COOPERATIVE RESEARCH PROGRAM

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Operational Experiences with Flexible Transit Services

A Synthesis of Transit Practice

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TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213—Research for Public Transit: New Directions*, published in 1987 and based on a study sponsored by the Federal Transit Administration (FTA). A report by the American Public Transportation Association (APTA), *Transportation 2000*, also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA, the National Academy of Sciences, acting through the Transportation Research Board (TRB), and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at anytime. It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products.

Once selected, each project is assigned to an expert panel, appointed by TRB. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended end-users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

The TCRP provides a forum where transit agencies can cooperatively address common operational problems. TCRP results support and complement other ongoing transit research and training programs.

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The members of the technical advisory panel selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and while they have been accepted as appropriate by the technical panel, they are not necessarily those of the Transportation Research Board, the Transit Development Corporation, the National Research Council, or the Federal Transit Administration of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

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FOREWORD

By Staff
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Transit administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to the transit industry. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire transit community, the Transit Cooperative Research Program Oversight and Project Selection (TOPS) Committee authorized the Transportation Research Board to undertake a continuing study. This study, TCRP Project J-7, "Synthesis of Information Related to Transit Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute a TCRP report series, *Synthesis of Transit Practice*.

The synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

This synthesis will be of interest to transit agency staff responsible for vehicle operations and planning and to those who work with them in this regard. Staff can use this report to learn from the experiences of other agencies and to compare their experiences with those of others. It documents and summarizes transit agency experiences with "flexible transit services," including all types of hybrid services that are not pure demand-responsive (including dial-a-ride and ADA paratransit) or fixed-route services, but that fall somewhere in between those traditional service models. The report documents six types of flexible transit service: request stops, flexible route segments, route deviation, point deviation, zone routes, and demand-responsive connector service.

This report from the Transportation Research Board integrates information from several sources. It is based on data collected from a review of the relevant literature and a survey of transit agencies. Twenty-four transit agencies provided information. Survey responses were supplemented by follow-up interviews with transit agency staff and reference to service descriptions available on transit agency websites.

A panel of experts in the subject area guided the work of organizing and evaluating the collected data and reviewed the final synthesis report. A consultant was engaged to collect and synthesize the information and to write the report. Both the consultant and the members of the oversight panel are acknowledged on the title page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

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This study was managed by Donna L. Vlasak, Senior Program Officer, who worked with the consultant, the Topic Panel, and the J-7 project committee in the development and review of the report. Assistance in project scope development was provided by Jon Williams, Manager, Synthesis Studies. Don Tippman was responsible for editing and production. Cheryl Keith assisted in meeting logistics and distribution of the questionnaire and draft reports.

Christopher W. Jenks, Manager, Transit Cooperative Research Program, assisted TCRP staff in project review.

Information on current practice was provided by many transit agencies. Their cooperation and assistance was most helpful.

OPERATIONAL EXPERIENCES WITH FLEXIBLE TRANSIT SERVICES

SUMMARY

In response to growth patterns, economic trends, and social changes that have not favored traditional forms of transit service, researchers and transit planners have proposed services that combine features of conventional, fixed-route service and purely demand-responsive service. This synthesis project was conducted to gather information about the experiences of transit operators using these flexible transit services. For purposes of this synthesis, "flexible transit services" are considered to include all types of hybrid services that are not pure demand-responsive service (including dial-a-ride and Americans with Disabilities Act paratransit) or fixed-route service, but that fall somewhere in between these traditional service models.

The primary source of information for the synthesis is a written survey that was sent to 81 transit systems. Completed responses were received from 24 transit systems that operate 28 flexible services. The survey responses were supplemented by follow-up interviews with transit agency staff and references to service descriptions available on transit agency websites.

The synthesis analyzes six types of flexible transit service. In order of increasing flexibility these are request stops, flexible-route segments, route deviation, point deviation, zone routes, and demand-responsive connector service.

Flexible transit services are being used by more than 50 transit systems of all sizes and in all types of service areas throughout North America. According to the survey responses there are three applications for flexible services. In order of frequency, from most common to least common, they are discussed as follows:

- First, flexible services provide service in limited areas that are considered hard to serve for reasons of demographics, street layout, or community preferences.
- Second, they provide service in low-demand time periods. In cities with ample fixed-route service, flexible operation typically substitutes for fixed-route operation in limited areas. In some cities with more limited fixed-route service, flexible operation replaces the entire fixed-route network at certain times.
- Third, they provide the entire transit service for a small city, low-density suburban area, or rural area. In these cases, coordination or consolidation with paratransit service is a key feature of the flexible service.

The following are some of the key conclusions of the synthesis:

- Each flexible service is unique. There is as yet little standard practice that operators can turn to in designing flexible services.
- To balance efficiency and flexibility, operators strive to find the right balance between fixed-route operation and demand-responsive operation in each situation.
- Operators have developed strategies to reduce the inefficiency of demand-responsive operation in flexible services. In many cases, operators place limits on the degree of demand-responsive service that will be provided, or they give discretion to dispatchers or drivers in the way that they accommodate demand-responsive service requests.

- Although many flexible services require previous-day reservations for demand-responsive pick-ups or drop-offs, the experiences of other systems shows that much shorter advance notice requirements are possible, with or without the use of advanced technology.
- Fare surcharges for off-route service may be useful as a way to encourage riders to board and alight at established stops.
- Coordination with regional fixed-route networks and with paratransit service is an important component of most flexible service.
- Flexible service operated over an agency's entire service area successfully eliminates or reduces the expense of separate paratransit service.
- Trip sharing between flexible service and paratransit has the potential to reduce dependence on paratransit, although the actual cost savings from this strategy have not been determined.
- The fluid and discretionary nature of many flexible services makes it difficult to provide a succinct yet accurate service description in public information materials.
- In hard-to-serve areas, flexible services typically have relatively low ridership and productivity levels compared with that found in fixed-route service. This situation is not so much a reflection of inefficiency in the service method as a reflection of the inherent difficulty of serving these areas, or inherent limitations of demand owing to low density or demographics.
- If ridership on flexible services were to climb significantly above current levels, many systems would take it as an indication that the area could be better served with conventional fixed-route service.
- When transit agencies employ flexible operation for their entire transit service, it may have higher ridership and productivity than when flexible service is limited to hard-to-serve areas. In these cases, compared with potential fixed-route service in the same area, it is possible that deviations limit ridership and productivity, and increase passenger travel times. It also appears that the cost advantage of combining service to the general public and people with disabilities is an overriding concern for these agencies.
- The amount of time allocated for demand-responsive operation in flexible service varies (according to service type and agency objectives) from zero to all time exclusive of layover at a transfer point. Many agencies have no clear allocation of scheduled time at all. This appears to be an area where many agencies would benefit from additional guidance.
- Most flexible services are scheduled and dispatched without use of advanced technology.
- At most transit systems, drivers select flexible service assignments under a conventional bidding process, along with fixed-route assignments. Drivers do need some specific training to operate flexible service, which drivers bidding for this work may be required to complete. It is important that drivers understand the degree of independent decision making and passenger communication involved in flexible operation, so they can assess whether it is something they want to do.
- The research provided little evidence about specific training requirements for flexible service dispatchers. As in the case of paratransit, this appears to be an area where additional research and guidance would be useful.
- Most flexible services use some type of van or small body-on-chassis bus, either because these vehicles were judged appropriate or because they happen to be available. However, many operators would prefer to operate some other type of vehicle than the one being used.
- Many agencies have replaced flexible service with fixed-route services where they have determined that flexible operation is less attractive to riders than fixed-route service. However, interest in adding or expanding flexible service remains strong. Fourteen of the surveyed transit systems reported that they see future opportunities to implement new flexible services or expand existing ones.

CHAPTER ONE

INTRODUCTION

BACKGROUND

Public transportation services have traditionally been designed to serve concentrated travel patterns that allow for large numbers of people to be conveyed along established routes following set schedules. These services have worked well in densely built-up areas with strongly focused travel patterns, such as commuting to and from downtown areas. For at least the past 50 years, growth patterns, economic trends, and social changes have not favored traditional forms of transit service. Population and jobs have become more spread out. Economic and social changes have led to complicated personal activity patterns that require the most flexible possible personal mobility. Within the last 30 years, increasing social awareness has led to an understanding that many people, especially older people and people with disabilities, cannot use conventional public transportation and need other options.

Among the solutions proposed to help transit adapt to these changes have been multicentered transit networks using timed transfers and demand-responsive services such as personal rapid transit and dial-a-ride. Many proposals have in common attempts to make transit service more flexible, so that it can respond to changing demand; serve more spontaneous, amorphous travel patterns; and accommodate people who are unable to walk to and from bus stops and transit stations.

Multicentered transit networks have been widely adopted, but personal rapid transit has proved expensive and difficult to create, and it has so far seen only very limited application. Experience to date with the dial-a-ride concept has shown that it appears to have inherent limitations in efficiency that limit its applications to specialized service for older people and people with disabilities, as well as service to the general public in very small communities.

At least since the 1960s, practitioners have proposed services that combine features of conventional service and purely demand-responsive service (Cole 1968; Arrillaga and Mouchahoir 1974). One of the earliest documented experiments is the Merrill-Go-Round in Merrill, Wisconsin (Flusberg 1976; Mergel 1976), which used a "point deviation" mode of operation, as defined later in this report, and that is still operating. More recent research continues to propose flexible transit services as part of the toolkit to help transit operators address suburbanization and dispersed travel patterns (Cervero and Beutler 1999; Urbitran 1999).

Researchers have claimed a variety of benefits for flexible transit services, including increasing ridership (Flusberg 1976; Durvasula et al. 1998), more cost-effective and integrated service for people with disabilities (Multisystems Inc. and Crain & Associates 1997), combining the regularity of fixed-route service with the flexibility of demand-responsive services (Farwell 1998), serving areas with demand densities too high for door-to-door services but not high enough for fixed-route service (Pratelli 2002), and making transit more attractive to "choice" riders who have another mode of access (Potomac and Rappahannock Transportation Commission 2003). Rosenbloom (1996) interviewed 40 transit systems with flexible service and found that most of them had adopted flexible services as a way to remove or reduce the need to provide complementary paratransit mandated by the Americans with Disabilities Act (ADA). However, many of those systems were probably not in conformity with the ADA regulations.

Much of the literature about demand-responsive and flexible service has assumed that a high degree of automation would be a key element of its operation (Smith 1998; Durvasula and Priya 1999; Loukakos and Blackwelder 2000; Pratelli 2002). One of the key design issues in operating flexible transit is determining how much scheduled operating time needs to be reserved as slack time to accommodate demand-responsive service requests. Fu (2002) has shown how this problem can be approached using advanced mathematical simulation methods.

SCOPE AND METHODS

This synthesis project was conducted to gather information about the experiences of transit operators using flexible transit services, including the following:

- Kinds of flexible service in operation;
- Ridership markets;
- Ridership threshold levels found to make those services a viable alternative to traditional fixed-route service;
- Historical and funding contexts;
- Operating procedures and technology;
- Design factors and criteria, such as service area, headway, guaranteed stop locations, deviation sched-

uling, including "slack time," and real-time on-board requests;
- Costs and cost considerations;
- Staff training (e.g., drivers, schedulers, dispatchers, and controllers);
- Customer marketing and public information;
- Coordination and integration with paratransit service;
- Previous successes and failures; and
- Barriers and future opportunities.

For purposes of this synthesis, "flexible transit services" are considered to include all types of hybrid services that are not pure demand-responsive service (including dial-a-ride and ADA paratransit) or fixed-route service, but that fall somewhere in between those traditional service models. In other words, the services of interest have some established stop locations and/or some established schedule, combined with some degree of demand-responsive operation. Fixed-route services that allow flag stops (a common method of operation in rural areas and some small cities, and after dark in some larger cities) but that have no other flexible features have not been included.

In the preliminary phases of the research, more than 80 transit systems were identified that might be operating some type of flexible service. Sources for identifying these candidate systems included published literature; requests to Internet e-mail discussion groups maintained by APTA and by the TRB Committees on Paratransit and Transit Planning; personal contacts; and website searches. A written survey (Appendix A) was sent to a total of 81 transit systems. Twenty-five systems returned completed questionnaires, of which one was determined not to provide flexible service. Appendix B lists the transit systems that responded. The survey responses were supplemented by follow-up interviews with transit agency staff and references to service descriptions available on transit agency websites.

REPORT ORGANIZATION

This synthesis begins with an overview of expectations for flexible transit services as revealed by published reports and papers during the past 35 years.

- Chapter two provides a classification of flexible transit services that is used for analysis throughout the rest of the report and a picture of the extent to which flexible services are actually used, including how long they have been in operation.
- Chapter three describes design decisions that operators have made in their flexible services, including provisions for spontaneous use as in conventional transit, provisions for demand-responsive use, fares, and coordination with conventional services and paratransit services.
- Chapter four describes the roles in which transit operators have used flexible services as an element of their overall service planning. That chapter also reviews how flexible services have been marketed; performance standards, measurement, and experience; and the barriers that transit operators have faced in the past and the opportunities that they see in the future for flexible services.
- Chapter five concerns operational issues, including the allocation of scheduled time between serving fixed stops and demand-responsive service requests, scheduling and dispatching, staff selection and training, and choice of vehicles.
- Chapter six presents case studies of five systems, with additional detail about service design, some background and operating results, and lessons learned. The case studies were chosen because of their innovative character, performance, established history, likelihood of continuation, and availability of information.
- Chapter seven provides conclusions and suggestions for additional study.

CHAPTER TWO

STATUS OF FLEXIBLE TRANSIT SERVICES

Based on the completed surveys and later investigations, it was possible to confirm that 51 North American transit systems definitely operate flexible services. These systems are located in 20 states and 3 Canadian provinces.

The 24 transit systems that responded to the survey with information about flexible services are located throughout North America and operate in large urban areas, small cities, and rural areas. Table 1 shows the transit systems, any abbreviations, acronyms, or shortened names used to refer to them in this report, the principal city of each operator, and a brief description of their flexible services. Appendix C provides additional details about each of the flexible services at the surveyed transit systems.

TYPES OF FLEXIBLE TRANSIT SERVICE

According to the service descriptions provided by the surveyed transit systems, flexible services can be categorized as six service types. These six types, illustrated schematically in Figure 1, are as follows:

- Route deviation—Vehicles operate on a regular schedule along a well-defined path, with or without marked bus stops, and deviate to serve demand-responsive requests within a zone around the path. The width or extent of the zone may be precisely established or flexible.
- Point deviation—Vehicles serve demand-responsive requests within a zone and also serve a limited num-

TABLE 1
SUMMARY OF SURVEYED TRANSIT SYSTEMS

System	Principal City	Flexible Service Name	Brief Description of Flexible Services
Capital Area Transit (CAT)	Raleigh, NC	CAT Connector	Demand-responsive connector service in zones replaces most fixed routes evenings, nights, early morning. One daytime zone.
Central Oklahoma Transit and Parking Authority (COTPA)	Oklahoma City, OK	METRO Link	Point deviation replaces fixed route nights and Sundays. All-day point deviation service in an outlying area.
Corpus Christi Regional Transportation Authority	Corpus Christi, TX	Route 67 Bishop Driscoll	Rural route into Corpus Christi with demand-responsive pick-up areas in two rural communities.
Decatur Public Transit System	Decatur, IL	Decatur Public Transit System	Two on-call stops.
Fort Worth Transportation Authority (FWTA—The T)	Fort Worth, TX	Rider Request (mostly discontinued Oct. 2003)	Two to three fixed stops at transfer points to the fixed-route system, plus demand-responsive service in zones.
Greater Richmond Transit Company (GRTC)	Richmond, VA	Chesterfield LINK (discontinued July 2003)	Route deviation service for the general public also acting as paratransit in one suburban area.
Hampton Roads Transit	Hampton, VA	HRT On Call	On-demand route segments.
Lane Transit District (LTD)	Eugene, OR	Diamond Express	Rural route into Eugene–Springfield provides midday curb-to-curb service in the urban area.
Madison County Transit	Granite City, IL	EZ Ride (added Aug. 2003)	ADA subscription deviations. (Point deviation service added after completion of this research.)
Mason County Transit	Shelton, WA	None	Stops marked in schedule as requiring a request. Demand-responsive service in a corridor. Rural route deviation with flexible, informal deviation area, coordinated with areawide dial-a-ride.
Metro Regional Transit Authority	Akron, OH	Night zones Town Center Routes	Late night service from downtown to regular bus stops in three or four zones. Route deviation service mainly for reverse commutes.
Metropolitan Transit System (MTS)	San Diego, CA	Flex Routes 961–964	Route deviation with narrow bands.
Minnesota Valley Transit Authority	Burnsville, MN	Flex Routes 420 and 421 Local route 440	Route deviation in zones approximately 1-mi wide. Eight reservation stops near the route.
Napa County Transportation Planning Agency (NCTPA)	Napa, CA	St. Helena and Yountville Shuttles	Two route deviation services in small towns.

TABLE 1 (*Continued*)

System	Principal City	Flexible Service Name	Brief Description of Flexible Services
Ottumwa Transit Authority (OTA)	Ottumwa, IA	Ottumwa Transit Authority	Entire transit system is fixed route with some deviations.
Pierce Transit	Tacoma, WA	Key Loop (modified Sept. 2003), Orting Loop	Rural demand-responsive connector operated by paratransit vehicles.
Potomac and Rappahannock Transportation Commission (PRTC)	Woodbridge, VA	OmniLink	Entire local service is route deviation areawide service with bands around routes.
Ride Solution (ARC Transit)	Palatka, FL	Ride Solution	Fixed-route general public service built on demand-responsive consolidated human services transportation.
River Valley Metro Mass Transit District	Kankakee, IL	Bourbonnais Flex	Three fixed stops in a demand responsive area in one of three communities served.
Sarasota County Area Transit (SCAT)	Venice, FL	SCAT About	Demand-responsive connector service supplements a fixed route on Venice Island.
St. Joseph Transit	St. Joseph, MO	St. Joseph Transit	Citywide routes with deviations through the city, also serving as paratransit.
Tillamook County Transportation District	Tillamook, OR	Deviated Fixed Route	Rural routes with flag stops and an informal deviation area.
Tri-Met	Portland, OR	Cedar Mill Shuttle	Peak-period demand-responsive connector to a transit center.
Winnipeg Transit System	Winnipeg, Manitoba	DART	Suburban demand-responsive connectors in four areas with marked drop-off locations.

number of stops within the zone without any regular path between the stops.

- Demand-responsive connector—Vehicles operate in demand-responsive mode within a zone, with one or more scheduled transfer points that connect with a fixed-route network. A high percentage of ridership consists of trips to or from the transfer points.
- Request stops—Vehicles operate in conventional fixed-route, fixed-schedule mode and also serve a limited number of defined stops near the route in response to passenger requests. (Request stops differ from flag stops in not being directly on the route.)
- Flexible-route segments—Vehicles operate in conventional fixed-route, fixed-schedule mode, but switch to demand-responsive operation for a limited portion of the route.
- Zone route—Vehicles operate in demand-responsive mode along a corridor with established departure and arrival times at one or more end points.

Other terms have been applied in the past to some of these services. For example, demand-responsive connector service has been called "demand-responsive feeder service" (Multisystems Inc. and Crain & Associates 1997). Individual transit systems call these services by many different names and do not follow any standard naming practice. These categories are useful in describing the flexible services operated by the transit systems that responded to the survey. However, other designs are possible, as are many variations on the basic categories described in this report.

Table 2 shows the number of transit systems in the survey that reported each type of flexible service. Several of the 24 surveyed transit systems operate more than one type of flexible service and are counted in multiple categories; therefore, the total of service types reported is 28. In this tabulation, if a transit system operates multiple routes of the same type, it is considered one "service." Some of the services share characteristics of multiple categories, but they have been classified according to the feature that is most defining of that service.

By far the most common method of flexible operation is route deviation service, which is used at 12 of the 24 transit systems in the sample. A number of subtypes can be distinguished within this category:

- Deviations are incidental to a primarily fixed-route mode of operation, intended mainly for people with disabilities and older passengers who might otherwise need paratransit service. Ottumwa Transit Authority (OTA) in Ottumwa, Iowa, exemplifies this type of operation. The availability of deviations is communicated verbally, by drivers and by staff in community presentations. Deviations are usually limited to one or two blocks off the regular route. Approximately 2% of total passenger trips involve a deviation.
- Deviations are an essential and prominent feature of the operation, so that separate paratransit service for people with disabilities is not required, or it is provided by means of the deviations. St. Joseph Transit

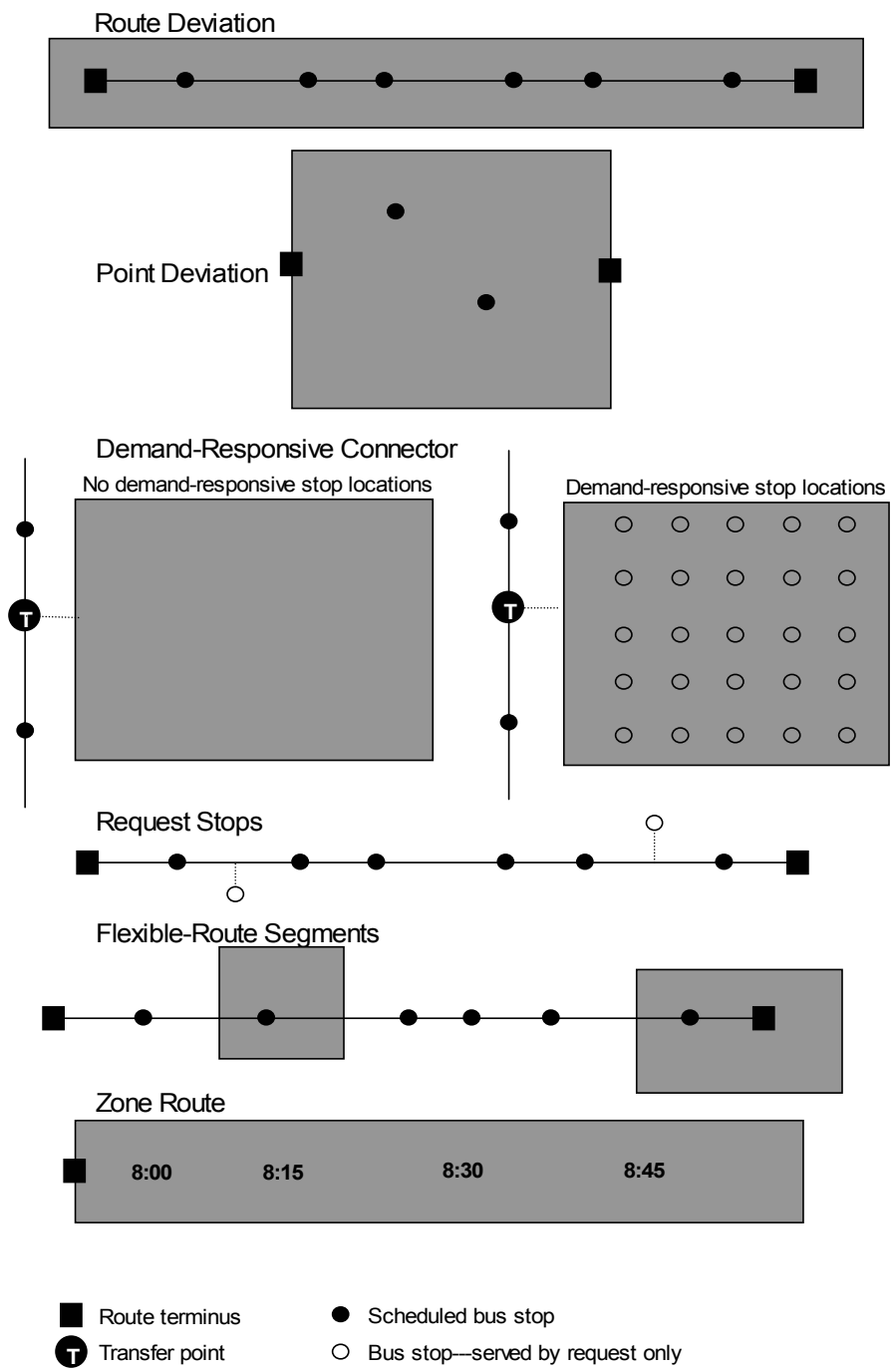

FIGURE 1 Flexible service types.

TABLE 2
TRANSIT SYSTEMS USING EACH TYPE OF FLEXIBLE SERVICE

Type of Flexible Service	No. of Transit Systems
Route deviation	12
Point deviation	3
Demand-responsive connector	6
Request stops	4
Flexible route segments	2
Zone route	1
Total transit systems reporting	24
Total service types reported	28

in St. Joseph, Missouri, illustrates this method of operation. The buses will deviate on request for any rider to provide curb-to-curb service to any address in the city, except for some cul-de-sacs, parking lots, and very steep or narrow streets. Passengers can register for ADA paratransit. However, in practice, ADA paratransit is the same as deviation service, except that ADA-certified riders pay a lower fare than the general public. Schedules allow ample time for deviations, and 24% of passenger trips involve a deviation.

- Definitions are provided in clearly defined zones or bands around specific routes. For example, the Metropolitan Transit System (MTS) in San Diego, California, operates four routes that provide deviations within one-quarter-mile bands on either side of the routes. The zones are shown on the route maps provided to the public. In this type of situation, deviations are provided mainly to increase coverage rather than to serve passengers with disabilities. Approximately 3% of passenger trips involve a deviation.

Seven transit systems reported operating demand-responsive connector service, making it the second most frequently reported method of flexible service. Some variations on this theme include the following:

- Service is provided between a transfer point and any safe address within a defined zone where fixed-route service is considered inappropriate or infeasible owing to street patterns. Portland Tri-Met operates a service of this type that provides peak-hour-only connections between the Cedar Mills area and the closest transit center.
- Service is provided between a transfer point and defined drop-off points. The Winnipeg Transit System in Winnipeg, Manitoba, provides a service of this type, operating mainly in low-demand time periods. Although drop-off points are defined, drivers do have the discretion to drop off passengers at home, and pick-ups are always made at passengers' homes. Akron, Ohio, provides a late night flexible service that uses three or four buses to take passengers from downtown transfer points to any bus stop normally served by the 30 routes that depart from downtown.

LENGTH OF EXPERIENCE OPERATING FLEXIBLE SERVICE

As shown in Figure 2, 5 of the 24 surveyed transit systems have been operating flexible service for more than 10 years, whereas the median length of operation is between 5 and 6 years. The OTA has operated flexible service since 1982, and Ride Solution in Palatka, Florida, has operated flexible service since 1988.

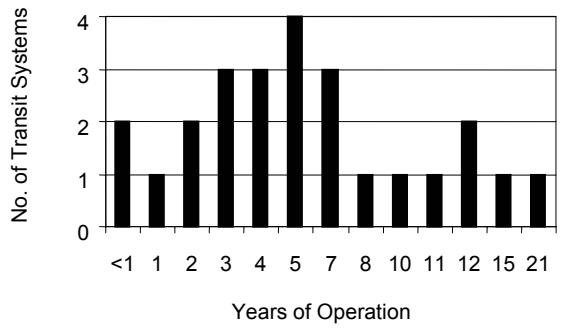

FIGURE 2 Years of flexible service operation (as of June 2003).

Although the survey results might be taken to indicate that interest in flexible service peaked a few years ago, other findings suggest that it continues to be strong. Several of the surveyed transit systems have implemented additional flexible services since the year they first began such services. Half of the surveyed transit systems indicated that they see further opportunities to implement or expand flexible services. In addition, there are several known, recently begun flexible services operated by transit systems that did not respond to the survey. A recent decline in implementation, however, may reflect a general drop in new transit services under tightened budgetary circumstances resulting from the economic downturn that began in 2000.

CHAPTER THREE

SERVICE DESIGN

Flexible transit services occupy a middle ground between traditional fixed-route transit service and dial-a-ride or paratransit. The wide variety of flexible transit services can be defined by the way that four elements of service design are established in this middle ground, as shown in Table 3 and explained as follows.

1. Where vehicles operate—Vehicles may operate along a defined route, as in fixed-route service, but also respond to service requests by diverging from the route. There may also be no route, but only a corridor or geographic area, in which case there is usually one or more fixed anchor points.
2. Boarding and alighting locations—Passengers may board and alight at established stops, which may be along a defined path or may be distributed within the area of operation. Alternatively, or in addition, passengers may often board and alight at other locations, for example, at any address that can be safely accessed by a bus or at street corners established in discussion with a driver or dispatcher.
3. Schedule—The times when vehicles will be at boarding and alighting locations are some mix of prescheduled times and times determined by demand. If there is a route or there are established route end points, then the times at stops on the route and at end points will usually follow a fixed schedule. Times at other locations are variable, although they are constrained by the portion of the schedule that is fixed.
4. Advance notice requirements—At fixed points served on a schedule, there is typically no need for passengers to request a boarding or alighting ahead of time, aside from minimal notice to signal a bus driver to make a stop for alighting. At other points, some type of advance notice is needed. Such notice may take the form of a request to the driver at the time of boarding, a call to a dispatch center or directly to the driver, or a subscription that constitutes a standing order for the same trip every day or every week.

The rest of this chapter is organized by headings corresponding to these four elements of flexible service design.

WHERE VEHICLES OPERATE

All of the services studied serve some fixed points or routes, plus a demand-responsive area or specific demand-responsive stops.

- Route deviation—Three-quarters of the route deviation services have a formal policy about how far the buses will deviate from the route. However, there is great variation in how the maximum extent of deviation is defined. As shown in Table 4, the extent of deviation formally permitted ranges from 0.25 to 1.5 mi. Two systems allow deviations within a city limit. In Napa, two small towns, with populations of 2,916 and 5,960, have deviation service throughout their very limited areas. In the case of St. Joseph Transit, the 44-square mile city is covered by seven routes, so the maximum required deviation is usually no more than a few blocks off the route.

  The remaining systems have more flexible or informal policies. In Ottumwa, deviations are limited to the immediate vicinity of routes. At Madison County Transit, each subscription deviation is negotiated with a group home or structured employer. The most flexi-

TABLE 3
ELEMENTS OF FLEXIBLE AND TRADITIONAL SERVICE DESIGNS

	Service Type		
Elements of Service	Fixed Route	Flexible	Dial-a-Ride or Paratransit
Where vehicles operate	On the defined route	A route plus off-route locations or areas, or a geographic area	A geographic area
Boarding and lighting locations	Fixed or flag stops	Some fixed stops plus other locations	Any safe location in the service area
Schedule	Fixed	Fixed at end points or time points on the route, demand-responsive at other locations	Depends entirely on trips requested
Advance notice requirements	Not required	Required at some locations	Always required

TABLE 4
MAXIMUM EXTENT OF DEVIATIONS FOR ROUTE DEVIATION SERVICES

Permitted Deviation Area	Transit System
0.25 mi from route	MTS
0.50 mi from route	Akron, Minnesota Valley
0.75 mi from route	PRTC, GRTC
1.5 mi from route	Tillamook
Zones (unknown distance)	Ride Solution
City limits	Napa, St. Joseph
Informal	Madison County, Mason County, OTA

Notes: MTS = Metropolitan Transit System; PRTC = Potomac and Rappahannock Transportation Commission; GRTC = Greater Richmond Transit Company; OTA = Ottumwa Transit Authority.

ible policy observed is in Mason County (Washington). In that very spread-out rural area, drivers have the discretion to accept deviations, which in a few cases are as far as 5 or 6 mi off the route.

- Point deviation—All three services classified as point deviation make demand-responsive pick-ups and drop-offs within marked zones. Because the number of fixed locations served is very limited, they do not provide a basis for defining the demand-responsive area. The size of the deviation area is determined for reasons such as the desire to serve a defined neighborhood or community, or dividing a larger area into sectors.
- Demand-responsive connector—The demand-respon-sive connector operations generally provide services within a clearly defined zone, generally a distinctive geographic area or neighborhood. Information about the size of the zones was not obtained. One unusual case does deserve mention. In Akron, the Metro Regional Transit Authority provides a Night Zone service in which three to four buses leaving downtown at 12:00 midnight, 12:30 a.m., and 1:00 a.m. provide demand-responsive service, dropping passengers off at any bus stop usually served by routes operating from downtown. In this case, the zones served cover most of the transit system service area. Red Deer, Alberta, operates a similar service, as did Lethbridge, Alberta, until increasing ridership brought a change to conventional fixed-route operations.
- Request stops—In request stop service, deviations are limited to a small number of specific locations near the usual route.
- Flexible-route segments—Both of the services with flexible-route segments allow demand-responsive boarding and alighting within community or city boundaries in the flexible portions of the route.
- Zone routes—Mason County Transit's zone route operates within a corridor with boundaries that are defined by the road network and natural barriers.

BOARDING AND ALIGHTING LOCATIONS

Flexible services typically allow two types of boarding and alighting: spontaneous boarding and alighting and demand-responsive boarding and alighting.

Spontaneous Boarding and Alighting

All of the reported services but one has at least one location where passengers can board and alight without some kind of advance notice. The term "advance notice" here means some kind of request to the driver or a dispatch center, beyond the momentary advance notice typically required to alert a bus driver that a passenger wishes to alight. Additional findings include the following:

- Route deviation—All 12 systems that use this type of service allow spontaneous boarding at regular stops along the route.
- Point deviation—The three services using point deviation allow for spontaneous boardings at a very limited number of scheduled stops.
- Demand-responsive connectors and zone routes—In the six reported demand-responsive connector services and the one zone route, spontaneous boarding locations are mostly limited to one or two points where the flexible service connects to the fixed-route network. However, serving the transfer points is typically the principal mode of operation, and the majority of passengers travel to or from a transfer point. Some of Winnipeg Transit System's Dial-a-Ride Transit (DART) routes have a fixed-route segment that is operated between the transfer location and demand-responsive zone. Passengers can board the DART bus without a reservation at all stops on this fixed-route segment.
- Flexible-route segments—In the case of routes with flexible segments, spontaneous boarding is permitted along the fixed-route portions of the service, which account for most of the route mileage. Of the two reported examples, both are lengthy routes that connect rural towns to a larger city.

The one service that does not allow any kind of spontaneous boarding is operated by Pierce Transit in Tacoma, Washington. The Orting Loop is operated using vehicles in ADA paratransit service. Although the loop connects to the fixed-route network, no vehicle is scheduled to depart at the transfer points unless a reservation has been received.

Demand-Responsive Boarding and Alighting

Within the formally or informally defined zones or areas where demand-responsive service is provided, most sys-

tems further limit the locations at which passengers can be picked up or discharged. At a minimum, possible locations are limited to places that can be safely served with whatever vehicle type is used. Often this assumption of safety is simply taken for granted and not explicitly stated in public information materials. In very rural areas, narrow and/or unpaved roads can make it impossible to serve many locations. For example, Pierce Transit assigns staff to survey requested pick-up locations to determine whether a bus can safely operate there and, if not, to determine a safe nearby pick-up point. In the customer brochure for its Flex service, the Minnesota Valley Transit Authority (MVTA) explains, "Please note that some locations are not accessible to FLEX buses. In such cases, the dispatcher will work with you to find an alternative stop close by."

Many systems further limit potential pick-up and drop-off points beyond the basic issue of safe locations. Such limitations reported included

- For its Night Zone service, the Metro Regional Transit Authority in Akron limits drop-offs to established bus stops. No demand-responsive pick-ups are provided.
- For its DART service, the Winnipeg Transit System discharges passengers traveling outbound from the transfer points at established DART stops that blanket the DART zones. Drivers have the discretion to drop off passengers at their residence if time permits. For trips inbound to the transfer points, passengers are picked up at home to minimize waiting at stops, especially in very cold weather.
- The Greater Richmond Transit Company (GRTC) specifies that non-ADA passengers cannot request a deviation within two blocks of the regular route.

Some systems negotiate convenient meeting points with passengers to minimize deviation time. For its OmniLink service, the Potomac and Rappahannock Transportation Commission (PRTC) advises passengers who want to schedule an off-route pick-up that, "A Customer Service Agent will work with you and try to route the bus closer to where you live or want to go—up to 3/4 mile off the route." The advisory goes on to note that, "You may be asked to get on or off the bus at a location that is within a few blocks of your origin or destination."

Request stop services are by definition limited to specific designated off-route stops.

SCHEDULE

Fixed Schedules

All of the flexible services have some fixed operating schedule. For route and point deviation, for request stop service, and for routes with flexible segments, the schedules list a series of time points with departures, as for conventional fixed-route service. For demand-responsive connector service, the fixed schedule is typically limited to departure and arrival times at the transfer point or points. For the single example of a zone route, the schedule consists of one established departure time each day. Other services that have been called zone routes also included approximate times in successive portions of the corridor of travel.

Flexible services are not generally implemented in settings that support frequent transit service. More than half of the reported services have minimum operating headways (i.e., most frequent service) of 1 h or more. Only one service could be described as frequent—Portland Tri-Met's Cedar Mill shuttle operates peak periods only, approximately every 15 min.

Demand-Responsive Schedules

For demand-responsive pick-ups, either a dispatcher or a driver will determine the appropriate sequence and approximate time of pick-ups. When that schedule is created and by whom will depend on advance notice requirements, as described in the next section. The demand-responsive schedule is constrained by the fixed-route schedule.

ADVANCE-NOTICE REQUIREMENTS

Boarding

To be picked up at a location away from the fixed, scheduled stops, passengers must request service through a dispatcher or directly with a bus driver. As shown in Table 5, the most common requirements are to request a pick-up sometime the previous day, or else sometime within the hour before service.

Within these categories there is considerable variation. Previous-day requirements include 4:00 p.m., 12 noon, and 24 h. Systems that accept short-notice requests include some that allow 30-min, 20-min, 15-min, and even 10-min advance notice. There is no obvious connection between service type and the length of the advance-notice period. Short-notice situations occur in small cities, large metropolitan areas, and rural areas. The availability of short-notice requests does not appear to be related to the use of advanced technology. Notably, all but one of the request stop services permits short-notice requests, because these deviations are typically small in number and easily accommodated.

A number of the systems allow some flexibility in the amount of advance notice required. For example, Mason

TABLE 5
ADVANCE NOTICE REQUIRED FOR DEMAND-RESPONSIVE BOARDINGS

	Service Type						
Advance Notice	Demand-Responsive Connector	Flexible-Route Segments	Point Deviation	Request Stops	Route Deviation	Zone Route	All Service Types
Less than 1 h	2	1		3	3		9
1 h	1		2				3
2 h					3		3
Previous day	2		1	1	4	1	9
At time of drop-off*		1					1
Informal					1		1
Not available**	1						1
Subscription only					1		1
Total	6	2	3	4	12	1	28

*For the return trip.
**Demand-responsive boardings not available.

County asks for previous-day notice, but will try to accommodate short-notice requests. St. Joseph Transit (Missouri) has no formal policy, stating that requests are taken whenever they fit into the fixed-route timetable.

Demand-responsive boarding requests are generally received by dispatchers rather than by drivers. Only the following three services reported that passengers request boardings with drivers:

- Winnipeg Transit System's DART (demand-responsive connector) services—passengers call a central number and their calls are routed to the appropriate driver's cell phone by an interactive voice response system. There is one vehicle per zone.
- Lane Transit District's (LTD, Eugene, Oregon) Diamond Express (rural routes with limited flexible operation in the urban area)—passengers arrange with the driver on the inbound trip for a demand-responsive drop-off and a later pick-up for their return trip.
- OTA (small town route deviation)—passengers can ask a driver for a deviation later in the day. The driver relays this information to the dispatcher.

Twelve of the 28 flexible services have policies concerning the maximum length of time before service in which they will accept a demand-responsive boarding request. Of those that have such a policy, the most common times are 14 days (three systems) and 2 days (four systems).

Twelve of the 28 flexible services accept subscription requests for demand-responsive boardings, that is, a standing order for the same trip on a repeated basis. This group includes most of the systems that have a stated maximum advance-request period.

Alighting

Generally, on services that permit short-notice boarding requests (typically 1 h or less), passengers can also request a demand-responsive drop-off with the driver at the time of boarding. These requests would typically come from spontaneous boarding passengers who boarded at a fixed stop. Demand-responsive alighting requests made at the time of boarding, if permitted, are accommodated only on a time-available basis. On systems that require longer advance notice for demand-responsive boardings, demand-responsive alighting requests usually have to be made through dispatch, with the same advance notice as for boarding requests.

In the case of demand-responsive connector services, the usual mode of operation for trips outbound from the transfer point is that passengers communicate their desired drop-off locations to the driver at the time of boarding. The driver then has to create a route that will serve all of the requested drop-off locations, possibly in combination with some number of boardings that have also been requested ahead of time.

LTD's Diamond Express uses on-board communication with drivers as the exclusive method of scheduling demand-responsive requests. Passengers who board on the fixed-route portion of the service in the rural towns on the midday trip can request demand-responsive drop-offs to be provided at the end of the trip within the urban area of Eugene–Springfield. At the same time they can schedule their return trip pick-ups.

FARES

Eight of the 24 reporting transit systems charge more for flexible service than for conventional service. These differ-

ences take various forms. Five of the 12 route deviation services charge extra for the deviations. The surcharges range from $0.10 in St. Joseph, Missouri (on top of a $0.50 base fare) to a 100% surcharge by the PRTC for nonelderly or nondisabled riders requesting a deviation (on top of a $1.00 base fare). In Napa, the Napa County Transportation Planning Agency allows riders boarding and alighting at stops to ride free, whereas those requesting a deviation pay $1.00.

Only one of the six demand-responsive connector services charges more than the conventional service at the same transit system. This occurs in Sarasota County Area Transit's SCAT About service on Venice Island. The same area is served by a fixed route that costs $0.50 and a demand-responsive connector that costs $1.00.

None of the request stop services charges extra for a deviation.

COORDINATION WITH OTHER SERVICES

Coordination with Fixed-Route Service

In most cases, flexible services are operated in conjunction with fixed-route services. Coordination is most important for demand-responsive connector services, which by definition have a connection to fixed-route service as one of their principal features. Although most of the demand-responsive connector services are scheduled to ensure a transfer to and from the connecting fixed-route service, only Capital Area Transit in Raleigh, North Carolina, guarantees these transfers by means of communication between drivers and dispatch.

Transfers are also an important feature of route and point deviation services that operate in very limited areas, and they act as connectors to larger fixed-route systems. For example, the San Diego MTS's four flex-route services operate on routes within neighborhoods considered to be difficult to serve with fixed-route transit services. Each of the routes makes connections to a much larger regional transit network. Transfers to and from the fixed-route network are scheduled and free. In general, where flexible services are provided in the context of a larger system, connections are provided, as in the case of other local routes.

Coordination with Paratransit

Because flexible service involves a demand-responsive component, the potential exists to coordinate it with paratransit service for people with disabilities. Many of the surveyed systems do coordinate, as summarized in Table 6. The following coordination situations can be distinguished:

- No paratransit—The entire system, or all the service in an area or time segment, is considered demand-responsive so that no separate paratransit is required under the ADA.
- Unified operation—Paratransit service is offered, but in practice it is provided by the identical vehicles that also provide the flexible service.
- Paratransit operation—The flexible service is provided by the paratransit operation.
- Separate, but coordinated—Paratransit is separate from the flexible service, but it is coordinated. For example, the two services are dispatched by the same staff, individual demand-responsive trips may be traded by the two services (trip sharing), or some of the same vehicles are used for the two services.
- Separate, not coordinated—The two service types are completely separate.

The following are descriptions of flexible services and types of coordination with paratransit.

No Paratransit

Under the ADA, complementary paratransit is required for all public fixed-route transit systems in the United States. Demand-responsive transit systems do not have to provide separate paratransit, although they do have to ensure that passengers who use wheelchairs receive service equivalent to that provided to other passengers. Flexible service is

TABLE 6
PARATRANSIT AND FLEXIBLE SERVICE COORDINATION

	Flexible Service Type					
Type of Coordination	Demand-Responsive Connector	Flexible-Route Segments	Point Deviation	Request Stops	Route Deviation	All Types
No paratransit			1		3	4
Unified operation					2	2
Paratransit operation	1					1
Separate, but coordinated	2	2	2		6	12
Separate, not coordinated	2			2	1	5
Total	5	2	3	2	12	24

considered demand-responsive service. The systems in the survey that use this method of operation are the Central Oklahoma Transit and Parking Authority, Mason County Transit, the PRTC, and Ride Solution (ARC Transit). In Oklahoma City, point deviation service replaces fixed-route service in the central area after about 7:00 p.m. on weekdays and on Sundays. At those times, separate ADA paratransit is not required. In Mason County all routes accept some deviations and there is coordinated general public dial-a-ride. PRTC and Ride Solution both use route deviation as the only method of operating local transit service.

Unified Operation

The survey found two examples of unified paratransit and flexible service operation. The transit system in St. Joseph, Missouri, which was described in chapter two, is the most comprehensive example. GRTC's Chesterfield LINK provides an example of a single route with unified paratransit. The route extends into a suburban area with no other transit service. Deviations are available but may be limited and buses will not always go all the way to the passenger's home or destination. Patrons can also become certified for ADA paratransit. Rules for the paratransit service are very similar to those for deviations, except that the fare is higher ($2.25 instead of $1.25), deviations within two blocks of the route are accepted, and service to the curb at the home or destination is always provided.

Paratransit Operation

Pierce Transit (Tacoma, Washington) operates a rural connector service using paratransit vehicles dispatched by the paratransit system. However, the service is considered a general public service that serves all passengers regardless of disability. One former service of this type was replaced by a new service that uses dedicated vehicles. However, those vehicles are still dispatched by the paratransit control center.

Separate, but Coordinated

The most common situation is that flexible service and paratransit are separate, but there is some degree of coordination. Joint dispatching, vehicle sharing, and trip sharing are all common. Systems not mentioned elsewhere in this section have separate but coordinated flexible service and paratransit.

Separate, not Coordinated

Situations where there is no coordination include request stop services and route deviation services that make very limited deviations (e.g., in San Diego, where deviations are limited to one-quarter mile). The Winnipeg Transit System does not actively coordinate DART demand-responsive connector service with paratransit service. However, some paratransit riders do choose the DART service instead of paratransit for some trips, especially in three zones where the connecting fixed routes are operated using low-floor buses. For those customers, DART is attractive because reservations require less than 1 h advance notice, whereas paratransit reservations must be made a day in advance.

CHAPTER FOUR

PLANNING AND MARKETING

The design of a flexible service follows from its intended role in a transit system's overall service plan, the circumstances that led to its introduction, and the objectives it is intended to serve. These factors are also connected to the way the transit system markets the service. In this context, marketing may mean promotion, as well as explaining the service and the image that is presented to riders and the community. In the ongoing planning process, operators monitor flexible service performance and review whether it continues to be the most appropriate service for an area.

ROLE OF FLEXIBLE SERVICE

Four different roles for flexible service have been identified, which are discussed in sequence. Examples are provided, illustrating the circumstances that led to introducing flexible service for each role. Table 7 provides a summary of the service types used in each role.

Primary Service in a Large Area

Five transit systems have adopted route deviation as their method of operation for the entire transit system. These are rural and small urban systems and one low-density suburban system that use deviations as a way of increasing coverage and serving passengers with disabilities with the same vehicles that serve the general public. Included are four systems that have no separate paratransit service or that feature unified paratransit and general public operation.

- Mason County Transit in Washington State initiated flexible operation as a result of limited operating revenue and a large, rural service area with a very dispersed population. The agency believes that flexible service addresses the needs of people with limited mobility and enables them to be integrated into the overall service.
- OTA in Iowa has a high proportion of elderly riders. The authority began to deviate its fixed routes to meet their needs and to help keep them independent, rather than their relying on ADA paratransit, as long as possible. OTA does have separate paratransit service.
- PRTC in Virginia used the route deviation method to enable it to create a new local transit system in a rapidly growing suburban area. Route deviation allowed the agency to provide service to all residents in a low-density area and to provide one service for all riders.
- Ride Solution in Florida was already operating coordinated demand-responsive transportation for human services agencies in a rural area, and it converted that system to a route deviation method of operating to accommodate the general public. Doing so let the system establish a public bus service in an area that would not otherwise have been able to support one.
- St. Joseph Transit in Missouri implemented flexible service following the passage of a transit tax, which included the caveat that all passengers would be treated the same. Initially, the city experimented with a method described as point deviation, in which demand-responsive vehicles pulsed at a downtown transfer point. The present route deviation service was implemented so that passengers could ride spontaneously.

TABLE 7
SERVICE ROLES AND SERVICE TYPES

	Service Type						
Role	Demand-Responsive Connector	Flexible-Route Segments	Point Deviation	Request Stops	Route Deviation	Zone Route	Grand Total
Primary service in a large area					5		5
Primary service in limited hard-to-serve area	4	1	3	3	6	1	18
Service at low-demand times in a large area	2		1				3
Service at low-demand times in a limited area	2	1		1			4
Total	8	2	4	4	11	1	30

Notes: Several transit systems have services that play different roles in different areas or at different times. As a result, the number of entries is larger than the number of services reported in earlier tables.

Primary Service in Limited Hard-to-Serve Areas

By far the most commonly reported use of flexible service is for limited hard-to-serve areas where the flexible service is the only transit service offered. Most of these services have operating hours typical of the transit agency's other local routes. Although the entire range of flexible service types is represented, most provide local service in neighborhoods and connect to a regional transit network. The motivations for using flexible service in these neighborhoods vary considerably, as illustrated by the following cases:

- Napa County Transportation Planning Agency in California operates route deviation services within two small towns in rural portions of its elongated service area, connecting to a regional trunk route. The choice of service method is dictated by the preferences of the individual communities.
- Capital Area Transit in Raleigh, North Carolina, implemented demand-responsive connector services when the city council adopted a policy to serve 90% of the city's residents. It was determined that several recently developed suburban areas were difficult to serve with fixed-route service and were provided demand-responsive connector service instead. Over time, all but one of the demand-responsive connectors has been replaced with local fixed-route connectors.
- MVTA in Minnesota implemented route deviation services in two portions of its low-density suburban transit authority to establish basic access and connections to express routes. MVTA chose route deviation because it would be faster than a route that served every location regardless of demand, and it allowed coverage of low-demand areas.
- The San Diego MTS has used route deviation operation as a replacement for general public demand-responsive services that had poor productivity. The flexible routes serve many more people than did the previous services, maintain some of the coverage of the former service, and provide a transition to eventual fixed-route service.

In two cases, flexible service is the only service to an area, but is limited to peak periods. For example, Portland Tri-Met's Cedar Mill Shuttle operates in a neighborhood where conventional transit is not feasible owing to hills, narrow and curving streets, and the lack of sidewalks. However, the neighborhood is close enough to a transit center with bus and light-rail service and limited parking that it makes sense for Tri-Met to provide a frequent peak-period connection.

Most of the request stop services provide the only available service to the limited off-route location where stops can be requested. These locations are hard to serve in the sense that they would require out-of-direction travel, but do not generate enough demand to justify the extra travel time on every trip.

Service in Low-Demand Times in a Large Area

Three transit systems provide nighttime flexible service that replaces fixed-route service in much of the service area. Doing so allows them to maintain service later at night than would be economical with the fixed-route network while providing good coverage. Some of these services also operate during early morning and weekend time periods. For example, in addition to the daytime connector service as described previously, Capital Area Transit operates demand-responsive connector service from 7:00 p.m. to 11:00 p.m. and from 4:30 a.m. to 5:30 a.m. At these times, the fixed-route network is pared down to a handful of routes, while several demand-responsive connectors maintain good coverage to neighborhoods (Figure 3).

Service at Low-Demand Times in a Limited Area

Four transit systems have flexible services that are further limited to specific time periods in specific areas, for example:

- LTD in Eugene, Oregon, helped two economically depressed rural communities beyond its district boundaries to design and contract for a service that would connect them to the urban area for essential services. To make the service more attractive and enable it to serve a wider segment of the community, it was designed to allow for demand-responsive drop-offs in the urban area on the midday trip only, but not on the two trips at commute times. At the same time, as riders arrange for the demand-responsive drop-offs, they can arrange for pick-ups for their return trips.
- Winnipeg Transit System in Manitoba, Canada, provides a high level of transit service until late at night in most of the city of Winnipeg. In certain parts of the city, especially in more recently developed areas, demand has not grown enough to support fixed-route transit service at nonpeak times. Therefore, to serve residents at these times, the city developed demand-responsive connectors that operate during various nighttime, weekend, and midday time periods. Because DART operates only at nonpeak times it can use available vehicles that are not needed on other routes.

Motivations for Flexible Service

The examples given show motivations for operating flexible service including the following:

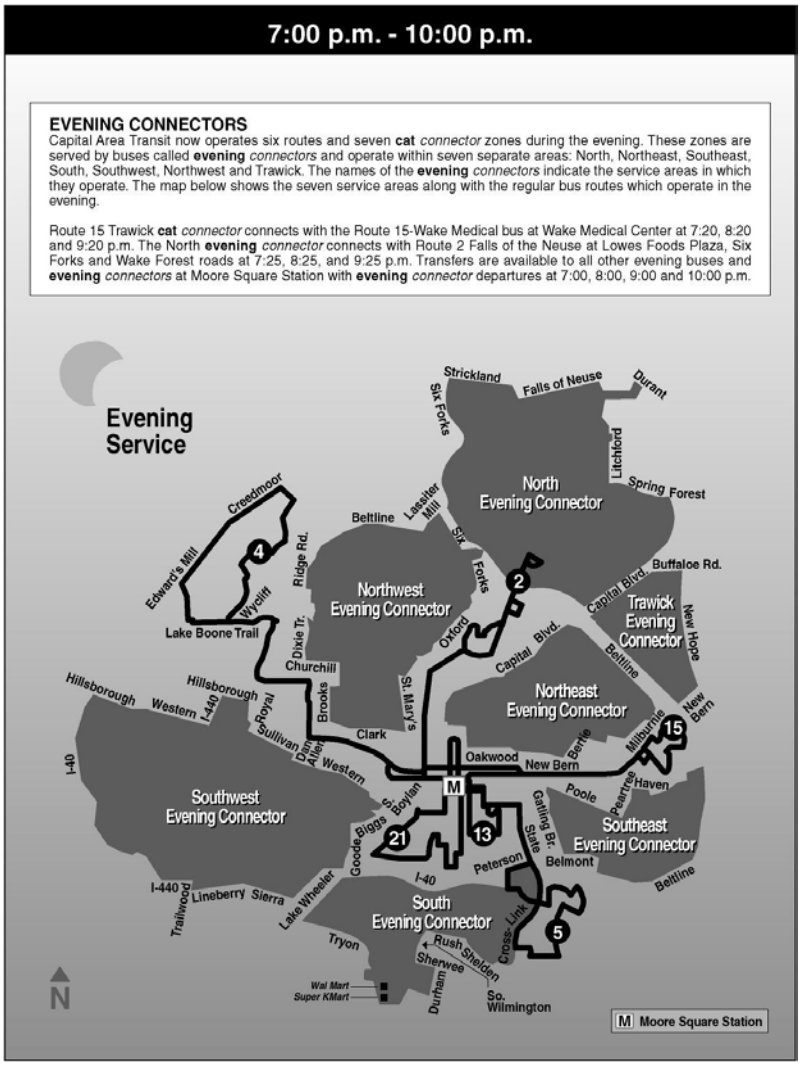

FIGURE 3 Evening demand-responsive connector service in Raleigh, North Carolina.

- Provide coverage to a spread-out, low-density area—Many operators have policy mandates and community priorities to cover as much of their service area as possible. Flexible service offers a way to provide such coverage in low-demand areas with dispersed origins and destinations at a reasonable cost.
- Serve low-demand times—Flexible service can make it possible to provide service at times when fixed-route service would not be efficient owing to low-demand levels, including nights, early mornings, at midday, and on weekends.
- Balance customer access and routing effectiveness—Given a transit systems' desire to serve as many points of interest as possible in a spread-out area, flexible service is seen as more effective than operating a fixed route that attempts to connect all potential points of interest regardless of actual demand.
- Reduce or eliminate the expense of separate paratransit service for people with disabilities—Where flexible service covers a large area, it can eliminate legal obligations under the ADA for complementary paratransit service, or at least reduce dependence on that separate service. In some settings, the cost savings from providing combined service for people with disabilities and the general public can be crucial in making transit service economically viable.
- Lay the groundwork for future fixed-route transit—As neighborhoods develop, flexible service can provide a transition between dial-a-ride or no service at all and conventional fixed-route transit service. Residents may be able to avoid buying second and third cars, and they may be more likely to use conventional transit when it is implemented. As demand patterns become clearer through flexible operation, efficient routes can be designed.
- Respond to community preferences and geography—Narrow streets, curving streets, or a strong sense of a community's being distinct from the other parts of the transit system service can lead a community to request service that uses small vehicles. Furthermore,

a lack of sidewalks, a poorly connected street pattern, or severe weather may put a premium on service that does not require passengers to walk to fixed bus stops.

MARKETING

The marketing methods used to promote and explain flexible services to the public are generally similar to those used for other local transit services. Information about flexible services is usually included along with other rider information in "bus books" and websites. The detail and sophistication of printed and on-line material are similar to that provided for other services.

Other methods used include specially designed brochures, presentations at service organizations and community meetings, appearances at special events such as community fairs, bus advertising, media releases, mailings, websites, information from drivers, and word of mouth. Public speaking engagements are often tailored to specific target groups such as seniors' organizations, schools, and homeowners associations.

The use of the media depends on the availability of suitably targeted media. The types of media used include news articles, paid advertising in newspapers, and newspaper inserts. Where the flexible service covers a large area, as in St. Joseph, Missouri, and Oklahoma City, general circulation newspapers have been used. In other cases, transit agencies are more likely to rely on community newspapers. Methods to distribute information to households include targeted mailings, newspaper inserts, and utility bill inserts.

A few systems do not feature the flexible aspects of their service in public information materials but rely primarily on drivers and word of mouth. For example, Akron Metro does not advertise the availability of route deviations at all, because schedules are not designed to accommodate deviations. However, regular riders of the routes that provide deviations are aware of the deviations and can request them. In Ottumwa, Iowa, OTA drivers suggest deviations mainly to older riders. In that small town setting, formal advertising is apparently not necessary. Furthermore, the deviations are intended to reduce dependence on paratransit, so the transit system prefers targeted outreach to the people who are the intended users of deviations.

The printed materials used by many systems illustrate the challenges of explaining flexible operation to passengers. As illustrated in chapter three of this report, the policies and methods of operation that define flexible services can be complicated. Conversations with staff and the information provided for this synthesis often indicate minor variations or flexibility compared with the official policies described in pocket schedules or rider guides. Passengers who use the flexible features are in frequent contact with dispatchers and drivers who are required to explain the service policies and often need to make decisions on the fly. As a result, passengers' understanding of how the system works will depend more on actual experience and what they hear from dispatchers and drivers rather than on printed or on-line service descriptions. In many cases, the printed materials are not clear on how far vehicles will deviate, how close vehicles will be able to get to a passenger's origin or destination, and how far ahead of time requests need to be made. This lack of clarity can reflect the dynamic and sometimes experimental nature of the service, plus the difficulty of providing a succinct and yet accurate explanation.

PERFORMANCE MONITORING AND STANDARDS

Reported Productivity

For this analysis, passengers per vehicle revenue hour (VRH) is used as a measure of flexible service productivity and performance. Just as they do for other transit services, transit systems actually use a variety of measures for tracking flexible service performance. Some of the measures reported included subsidy per passenger, boardings per revenue vehicle mile, and farebox recovery. Passengers per VRH is used here for two reasons. First, it is not affected by variations in cost structure among transit systems that may have resulted from regional variation in prices, use of contractors, or labor agreements—none of which is necessarily connected to the concept of a flexible instead of traditional service method. (Possible cost savings in flexible operation are discussed in chapter five.) Second, compared with measuring passengers per vehicle mile, measuring passengers per VRH recognizes that in a demand-responsive operation vehicle hours are more controllable than vehicle miles in operations planning.

The average reported productivity of flexible services is 6.7 passengers per VRH. Figure 4 shows the productivity of the all the reported services classified by service type. Several route deviation services stand out as having higher than average productivity. Three of these, PRTC (14.3 passengers per VRH), Mason County (18.2 passengers per VRH), and OTA (20.1 passengers per VRH), are systems that use route deviation for their entire transit service operations. The San Diego MTS, which carries 14.5 passengers per VRH on its flexible services, is the only system in this higher-productivity group that uses flexible service for hard-to-serve areas. In leaving out this group that stands apart from the rest of the reported services, more typical productivity was found to be in the range of 2 to 7 passengers per VRH.

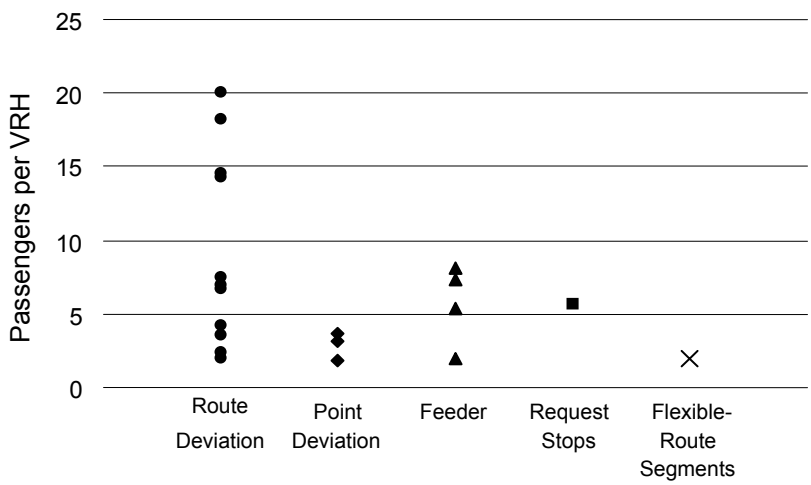

FIGURE 4 Productivity of flexible services.

Productivity appears to have some relationship to the degree of flexible operation. Figure 5 shows productivity and the percentage of ridership that involves a deviation; that is, a demand-responsive pick-up or drop-off, for 16 flexible services. The group of points plotted as having 100% deviations is demand-responsive connector services in which, by definition, every trip requires either a demand-responsive pick-up or a demand-responsive drop-off. All of the highest-productivity services have in common that a relatively small portion of their patronage involves a deviation. There are also a handful of services that report very low productivity despite a low percentage of deviation ridership. These are rural services that operate over very long distances. In leaving aside the rural services and the demand-responsive connector services, there appears to be some tendency for productivity to decline as the degree of demand-responsive operation increases.

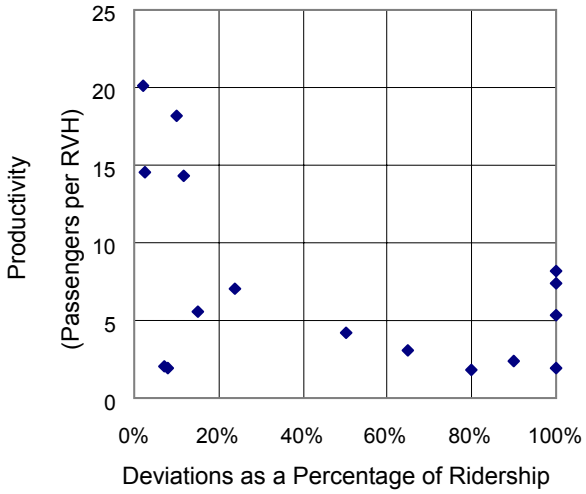

FIGURE 5 Productivity and percentage of deviations.

This should not, however, be taken to imply that the degree of demand-responsive operation is necessarily a determining factor for productivity. Other factors, such the type of service area, demographics, coordination with other transit services, and operating methods will no doubt play an extremely important role in every case.

In general, flexible services tend to have much lower productivity than fixed-route services at the same transit systems. This does not necessarily indicate that fixed-route service would perform significantly better than flexible service in the same situations. As discussed earlier, flexible services most commonly operate in those portions of a transit system's service area that are considered difficult to serve.

Performance Standards

Very few transit systems appear to have standards that define acceptable performance levels for flexible service. A number of the transit systems surveyed were not able to provide information about the performance of their flexible services separately from other services, because the two types of operations are too closely integrated to allow for convenient separation of performance measures. Twelve of the 24 transit systems reported that they do not have minimum required performance levels for flexible services. In some cases, the lack of a formal standard indicates a more flexible process for evaluating route performance. For example, one system reported that "Flex routes are evaluated for productivity along with other routes to ensure continuing relative productivity." In other cases, flexible service is provided to fulfill a policy mandate for coverage or because an area is judged to have critical needs even though demand is low. The few formal standards that were reported are listed in Table 8 along with the fixed-route standards reported by the same transit systems.

TABLE 8
STANDARDS FOR FLEXIBLE AND FIXED-ROUTE SERVICES

Transit System	Standard (passengers per VRH, except as noted)	
	Flexible Standard	Fixed-Route Standard
Sarasota County Area Transit	8.8 for combined flexible and fixed route for one grant-funded service	12–16
Minnesota Valley (request stop)	8–9	10–11
Fort Worth	$11–$13*	$3.50*
Minnesota Valley (route deviation)	5–6	10–11
Madison County (planned flex route)	3	6

*Subsidy per passenger.

Maximum Thresholds for Flexible Operation

As patronage increases, it is clear that at some point flexible operation becomes questionable. Depending on the type of patronage and service, there would be no time available for deviations, only a fraction of demand-responsive demand could be accommodated, or vehicles would run chronically late. Five transit systems cited maximum ridership levels above which they would not consider flexible operation to be a viable alternative to traditional fixed-route operation. These data are shown in Table 9. The Winnipeg Transit System stands out as estimating a much higher threshold for flexible operation than other systems. This may reflect Winnipeg's use of defined stop locations for demand-responsive drop-offs. River Valley Metro Mass Transit District and MVTA, which have high proportions of demand-responsive ridership, estimated similar, lower thresholds. Not surprisingly, MVTA estimated a much higher threshold for its request stop service, which is predominantly fixed-route in character.

Other transit systems provided more operational statements about maximum ridership thresholds. For example, the Fort Worth Transit Authority would look to convert to fixed-route operation when ridership patterns indicate a consistent number of boardings and alightings at identifiable stops. In contrast, PRTC would probably increase frequency or bus size before converting to fixed-route operation, because fixed-route operation would bring with it the need to provide ADA paratransit.

BARRIERS AND OPPORTUNITIES

Barriers to Implementation

Approximately one-half of the transit systems reported some barrier that has prevented them from implementing flexible services where they appeared to be appropriate. The most significant barrier has been a lack of funding, which was mentioned by five transit systems as having been a past barrier. In other cases, funding limitations were part of the motivation for implementing flexible service because flexible service offers an ability to provide lifeline coverage at a lower cost than fixed-route service, and it can help a transit system to avoid the expense of separate paratransit service.

Other barriers have included difficulty in defining how flexible service will be classified under a labor agreement, a union grievance concerning contracting out flexible service, and opposition by suburban jurisdictions to funding any kind of transit. Private property and access issues have been a problem at two systems. The Napa County Transportation Planning Agency has had to work with security and management to resolve conflicts with other vehicles on private property. In Mason County, private property issues have been a concern, as have access problems such as narrow roads and overhanging branches. Flexible service is often proposed as a solution for areas with streets that are inappropriate for large buses. Even so, the Fort Worth Transit Authority has found that the street network in some areas makes it difficult to implement any kind of service.

TABLE 9
MAXIMUM FEASIBLE RIDERSHIP ON FLEXIBLE SERVICES (passengers per VRH)

Transit System	Current Performance	Standard	Estimated Maximum
Corpus Christi	2.0	None	10
Madison County (planned flex route)	NA	3	8
Minnesota Valley (route deviation)	4.2	5–6	About 8
Minnesota Valley (request stop)	5.6	8–9	About 15
River Valley Transit District	3.1	None	7
Winnipeg	7.4	None	20

Notes: NA = not available.

Nine transit systems reported that they have discontinued flexible services or reduced the amount of flexible service provided. In some cases, these cuts stem from financial difficulties similar to those that have forced many transit systems to cut overall service. Hampton Roads and Madison County Transit cut dial-a-ride zones that had very low ridership. The Fort Worth Transit Authority eliminated most of its Rider Request services because of low ridership. In Richmond, GRTC cut route deviation services to a suburban area when demonstration funding came to an end and the suburban jurisdiction was unwilling to continue funding.

Capital Area Transit has converted most of its daytime demand-responsive connectors to fixed-route operation and is looking toward a service plan that will respond to passengers' preference to avoid transfers. Operations staff found it extremely difficult to coordinate a large network of demand-responsive connectors with fixed-route services using essentially manual methods. An attempt to obtain the technology to improve coordination was unsuccessful. In most cases, the fixed-route connectors have attracted more ridership than the demand-responsive connectors they replaced.

The Winnipeg Transit System reinstated fixed-route service in two areas where it had converted midday and Saturday service to DART operation. In each case, the coverage increase created by DART was not sufficient to compensate for the loss of convenience created by the need to reserve pickups. However, as noted before, Winnipeg continues to operate DART in four areas and is planning more.

Future Opportunities

Fourteen of the responding transit systems reported that they see future opportunities to implement new flexible services or expand existing ones. The most definite plans are those of Madison County Transit, which will implement three flex-route demonstrations in fiscal year 2003–2004. These services, featuring 2-h advance reservations within defined zones, will replace existing fixed-route services with marginal productivity in smaller villages and low-density suburban areas. The services will be operated with vehicles that currently provide ADA paratransit.

Three systems that use flexible operation for all their services would like to expand those services. Mason County Transit, which operates route deviation, request stop service, and one zone route, foresees opportunities to implement more zone routes. PRTC (Woodbridge, Virginia) plans to add weekend service and expand its service area. Ride Solution (ARC Transit) hopes to expand the base of human service agencies to which it provides coordinated service, which would increase the coverage of its general public service. Other future opportunities include the following:

- Rural and low-density areas (Corpus Christi Regional Transportation Authority);
- Low-density suburbs and small towns (GRTC);
- More request stops to serve low-demand neighborhoods off main routes (Hampton Roads Transit);
- Rural demand-responsive connector routes (LTD);
- Serving low-density portions of a possible expanded service area (MVTA);
- Daytime service in low-density fringe areas (Central Oklahoma Transit and Parking Authority);
- Employer markets and low-productivity rural areas (Pierce Transit);
- Low-density areas (SCAT);
- Replacing more dial-a-rides with flexible routes (San Diego MTS); and
- DART in three or four more neighborhoods (Winnipeg Transit System).

The barriers that transit agencies anticipate in implementing these flexible services are similar to those encountered in the past—principally funding. The San Diego MTS finds that in some suburban neighborhoods that are candidates for flex routes it is difficult to find suitable, convenient locations for ADA-compliant bus stops. Before expanding its flexible services, Pierce Transit needed to fine-tune its initial attempt at demand-responsive connector service. The initial service, because it was operated as part of the paratransit service, encountered some difficulties in public acceptance. A new service, using dedicated vehicles without the paratransit image and with defined stop locations, has met with better acceptance and will be used as a model for other areas.

CHAPTER FIVE

OPERATIONS

Operational issues connected to flexible services include allocating schedule time between fixed-schedule and demand-responsive operation; reservations, scheduling, and dispatch for demand-responsive operation; contracting; driver selection and training; and vehicle selection.

ALLOCATION OF SCHEDULED TIME

Flexible operation by its nature requires a fixed schedule that defines when vehicles will be at time points, but one that also leaves time for responding to demand-responsive service requests. The flexible service types can be ranked according to the degree of flexible and fixed-schedule operation inherent in their designs, as shown in Figure 6 and explained here.

- Request stops—None of the transit systems that operate request stop service provided a numerical estimate of the time allowed for serving request stops, reflecting the very limited degree of flexibility in this type of operation.
- Flexible-route segments—Of the two systems with flexible-route segments, one specifies, in its public timetables, the time for flexible operation. LTD allots up to an hour at the end of the inbound midday trip for curb-to-curb operation within the urban area, and another hour for curb-to-curb operation in the urban area at the beginning of the following outbound trip.
- Route deviation—Five systems operating route deviation service estimated the amount of time available for deviations in their schedules. The times ranged from 20 min out of every hour at St. Joseph Transit and Ride Solution, where demand-responsive operation is a prominent part of the service, to only 2.5 min per hour at San Diego MTS, where deviations play a much more limited role.
- Point deviation—Point deviation services, by definition, leave substantial amounts of demand-responsive time in their schedules, averaging 30 min out of every hour at the three systems that provided information.
- Zone route—The single reported zone route service has a single departure point for its one trip per day, so that all time is available for demand-responsive operation.
- Demand-responsive connector—Five transit systems that operate demand-responsive connector service provided schedule information. For each 60 min of

Mostly Fixed

Service Type	Degree of Fixed Scheduling	Time for Demand-Responsive Operation
Request stops	A complete route is scheduled	Time for a limited number of short deviations to known locations.
Flexible-route segments	A complete route is scheduled	Time for deviations to unspecified locations, but only within short portions of the route.
Route deviation	A complete route is scheduled	Time for deviations throughout the route to unspecified locations.
Point deviation	A few time points are scheduled	Most time is available for deviations.
Zone routes	One or two time points may be scheduled	All remaining time is available for deviations.
Demand-responsive connector	One or two time points may be scheduled	All time except layover at transfer points is available for deviations.

Mostly Demand Responsive

FIGURE 6 Scheduling considerations for flexible service types.

operating time, the demand-responsive connector services schedule 5 to 10 min of layover at the transfer points. The remaining time is used for demand-responsive operation.

DEMAND-RESPONSIVE SCHEDULING AND DISPATCHING

In most cases, demand-responsive scheduling and dispatching are accomplished through some combination of telephone reservations, printed manifests with lists of reserved deviations, voice radios and/or cell phones for changes or insertions on the day of operation, and scheduling on the fly by drivers in response to on-board requests. For same-day requests, some systems, such as Mason County Transit, give drivers the discretion to accept a deviation request or not, including requests made through the dispatch office. The OTA has the opposite division of responsibility: when drivers receive an on-board deviation request, they must obtain clearance to accept it from dispatch.

Half of the systems use some type of scheduling and dispatch software, similar to that used for paratransit scheduling. PRTC uses a customized version of a popular paratransit scheduling program created specifically to accommodate route deviation operation. This program creates a listing for each scheduled vehicle trip, with time points and fixed stops listed according to estimated arrival time, along with all reserved deviations. For 6 years, drivers received a paper manifest that included all deviation requests received by the previous day, and they received same-day requests by voice radio. Beginning in July 2003, the system began transmitting all planned stops by means of mobile data terminals (MDTs).

Nine transit systems use cell phones to communicate with drivers, either in combination with voice radio or exclusively. Two transit systems use cell phones instead of radios to communicate passenger requests to drivers because they offer more privacy than conventional radio transmissions. Several systems use cell phones for communication when vehicles are beyond radio range. The Winnipeg Transit System routes all passenger ride-request calls directly to drivers' cell phones by means of a touch-tone menu.

Five transit systems have MDTs for transmitting information between vehicles and dispatch. These systems have MDTs and automatic vehicle location (AVL) equipment installed in their entire fleets, and they use it for time checks, supervisory control, and emergencies. PRTC appears to be the only transit system currently using MDTs for flexible demand-responsive operations. Two transit systems that are planning to install or currently installing MDTs and AVL for use in flexible service dispatching are St. Joseph Transit and Madison County Transit. OTA has an AVL system that dispatchers can use to help determine if a vehicle is able to accommodate a deviation request.

Three transit systems rely entirely on drivers for all demand-responsive scheduling.

- On Akron Metro's Night Zone service, passengers board buses at the downtown transfer points without any reservation and tell the drivers what stop they want to go to. The drivers then make up a route to drop off all boarded passengers in an efficient manner.
- On LTD's Diamond Express, passengers traveling in bound to Eugene–Springfield from rural areas can tell the driver on the midday trip where they want to go in the urban area and also schedule a return pick-up.
- On Winnipeg Transit System's DART service, passengers request demand-responsive drop-offs when they board at the transfer point and use the cell phone connection described earlier to schedule pick-ups. Drivers use a simple graphical trip sheet (discussed in chapter six) to work out an efficient way to combine the requested drop-offs and pick-ups.

CONTRACTING AND OTHER COST-SAVINGS MEASURES

Thirteen of the 24 reporting systems contract for the operation of their flexible services (see Table 10). In most cases, contracting for flexible services appears to follow from contracting for other services: of the 13 that contract for flexible service, 7 contract all transit operations and another 5 contract for flexible service and paratransit. Most of the systems that do not contract for flexible service do not contract for any of their transit operations.

It might be expected that flexible service could be less expensive to operate than conventional transit service per unit of service (measured in vehicle miles or hours), owing to contracting, use of smaller vehicles, or driver wage differentials related to the use of smaller vehicles. On the other hand, the need to dispatch demand-responsive trips could make flexible service somewhat more expensive than fixed-route service. Unfortunately, from the limited data received, it was not possible to determine whether such differences exist. Four transit systems did report that they have some type of separate driver wage provisions but gave no details. A system that operates flexible service using its own drivers expressed concern about whether it would be possible to find drivers with the necessary skills to operate flexible service at lower wage rates than are paid drivers for fixed-route service.

TABLE 10
CONTRACTING FOR FLEXIBLE AND OTHER OPERATIONS

Contract Flexible Operations?	Contract Other Operations?	No. of Systems
Yes	All transit operations	7
Yes	Paratransit	5
Yes	Senior shuttles	1
No	Paratransit, possibly other specialized service	3
No	None, or not determined	6
Private operator		1
Not determined		1
Total transit systems reporting		24

STAFF SELECTION AND TRAINING

Most survey respondents indicated that drivers are selected to operate flexible service by the traditional process used for other services, which is typically a bid process based on seniority. A handful of systems indicated some special considerations. For example, the San Diego MTS reported that it uses the same requirements for flexible service and dial-a-ride. Two systems reported that they combine traditional bidding with a special training requirement. Pierce Transit requires that drivers qualify (by having completed the required training) as a paratransit driver, to operate flexible service. As will be described in chapter six, the Winnipeg Transit System requires drivers who select flexible service work to have special training. In the case of systems where flexible service is operated by a paratransit contractor, the drivers who can bid for flexible service will generally have been selected based on paratransit criteria, and they will have received paratransit training.

The transit systems that responded provided limited information about the specific training that drivers receive to operate flexible service. In those systems where the entire operation is flexible, all drivers receive the same training. Training topics that were mentioned included procedures for deviations and familiarity with the area of operation. In the case of request stop services, training for the optional stops would be similar to that provided for the rest of the fixed route, with the addition of procedures for accepting stop requests. Where systems operate throughout an area or zone, drivers would need a thorough knowledge of the street layout in that area.

Survey respondents provided only very general information about dispatcher training. This may indicate a situation similar to that which exists for paratransit operations, where curricula and standards for dispatcher training are far less defined than for driver training (Crain & Associates 1999).

VEHICLES

There is little discernable pattern in the vehicles used for flexible service. The great majority of systems use some type of van or small body-on-chassis bus. Except in the case of request stop services and some flexible services that constitute the entire transit service, vehicle sizes range from the 12-passenger vans used by Portland Tri-Met to 35-passenger transit buses used by Capital Area Transit. The OTA, where deviations are short and represent a small percentage of service, uses 42-ft Thomas buses, and Mason County Transit, which operates long-distance rural routes, uses buses of up to 40 ft in length. Considerations that transit systems reported in their choice of vehicles include availability as a result of vehicle use for other services, maneuverability on narrow streets, passenger loads, community perceptions and acceptability, and possibility of operation by drivers without a commercial driver's license.

Ten of the transit systems would prefer to operate some other vehicle type than the one being used. Problems mentioned about existing vehicles include that they are too large or too small, they lack amenities, and they are not sufficiently durable. [See Hemily and King (2002) for a comprehensive treatment of issues with vehicles typical of those used in flexible service.]

CHAPTER SIX

CASE STUDIES

Five transit systems with flexible services have been chosen for case studies. Included are more detailed service descriptions, operating methods, some history and background, and operating results. These case studies were chosen because of their innovative character, performance, established history, likelihood of continuation, and availability of information and are:

- DART at the Winnipeg Transit System;
- OmniLink Flex-Routes at PRTC in Virginia;
- Ride Solution in Palatka, Florida;
- Flex routes and reservation stops at the MVTA in Minnesota; and
- Route deviation service at OTA in Iowa.

DIAL-A-RIDE TRANSIT AT WINNIPEG TRANSIT SYSTEM

The Winnipeg Transit System operates four demand-responsive connector services that replace fixed-route service during periods of low demand. The services are known as Dial-a-Ride Transit or DART. The Winnipeg Transit System is a service of the city of Winnipeg, Manitoba. According to city statistics, Winnipeg is home to 633,000 people, approximately 55% of the population of Manitoba.

Information for this case study comes primarily from the detailed survey response to this synthesis provided by the city's manager of planning and schedules; a comprehensive evaluation of the first two DART services prepared by Winnipeg Transit System staff in 1997 (City of Winnipeg 1997); and route and schedule information on the transit system's website at http://winnipegtransit.com/. Where appropriate, material from these sources is incorporated verbatim. Supplementary information comes from a published case study by Cervero and Beutler (1999).

Some features that make DART especially noteworthy are the use of marked bus stops for demand-responsive service, an extremely well-documented history, good performance levels, and a particularly detailed and comprehensive planning and evaluation process.

Service Description

The Winnipeg Transit System operates a comprehensive network of 85 transit routes, including main-line, express, and suburban feeder routes, with a peak pullout of 440 buses. Buses run 365 days a year, usually from 6:00 a.m. until past midnight. A paratransit service called Handi-Transit provides demand-responsive service to people with disabilities.

The four DART services provide connections between a transfer point and destinations within a defined neighborhood zone, as well as trips between points within the zones. In each area, DART service is provided by a single 30-ft, low-floor transit bus. Each DART service is scheduled to meet an outbound bus arriving at the DART terminal on a main-line transit route from downtown. The DART terminal is usually located at a shopping center at the edge of the DART service area. Figure 7 shows passengers boarding a DART bus at the terminal.

FIGURE 7 Passengers boarding at DART terminal.

FIGURE 8 DART neighborhood stop.

At the DART terminal, outbound passengers with destinations in the demand-responsive service area transfer to the DART bus and, upon boarding, inform the bus operator of their final destinations. The bus operator then plans a route to deliver passengers to their destinations so that overall travel time is minimized for all passengers. Passengers wishing to travel inbound from their homes in the service area call the bus operator (who is equipped with a mobile phone) to reserve a trip. The operator then fits the requested pick-ups into the vehicle route. Reservations must be made at least 30 min before the pick-up time.

Passengers are picked up at their homes and dropped off at DART stops (or at their homes at the bus operator's discretion). DART stops are placed at a much higher density in the service area than are regular transit stops. Figure 8 shows a typical neighborhood DART stop. Providing home pick-ups is important for minimizing passenger wait times, especially in winter, because passengers can be given only approximate pick-up times when they reserve trips.

The DART services typically operate at approximately 50-min intervals from the DART terminal. Three of the four existing services are in suburban areas and operate during weekday evenings, Saturday mornings and evenings, and all day on Sundays and holidays. These services operate until midnight or later during the week. During other time periods, regular fixed-route service is operated in the same areas. The fourth service is in an area on the edge of downtown with a high concentration of the elderly. It operates during the midday on weekdays and throughout the day on Saturdays. The DART fare is the same as the fixed-route fare, and transfers to and from connecting fixed routes are free.

Operating Methods

The service map for DART 102 Southdale/Island Lakes (Figure 9) illustrates the method of operation. The Southdale neighborhood to the north and the Island Lakes neighborhood to the south are divided by Bishop Grandin, a high-speed, divided roadway (but not a freeway). The area served measures approximately 2 mi^2 (about 5 km^2). On weekdays, Route 16 operating from downtown Winnipeg (not shown) stops at Southdale Centre (a shopping mall) and continues through the neighborhoods to a terminus at stop number 127. Beginning at 7:18 p.m. on weekdays, Saturday mornings and evenings, and all day Sunday, Route 16 ends at Southdale Centre, and DART provides replacement service every 50 min. The full schedule of departures is given in Figure 10.

Passengers can board at Southdale Centre without a reservation. The map shows the 84 numbered stops that are the preferred drop-off points. Passengers who want to board within the DART zone call a reservation number that serves all four DART routes. An automated system asks the passenger to choose a DART service area by using the telephone touch-tone keypad, and it forwards the call to the DART bus driver in that zone.

Drivers use a graphical trip sheet to plan each trip from the transfer center (Figure 11). Before departing the transfer point, the driver colors in all stops where drop-offs have been requested, and marks with an X all addresses where a pick-up has been requested. To assist with marking pick-up locations, the map shows the beginning and ending house numbers on each street segment.

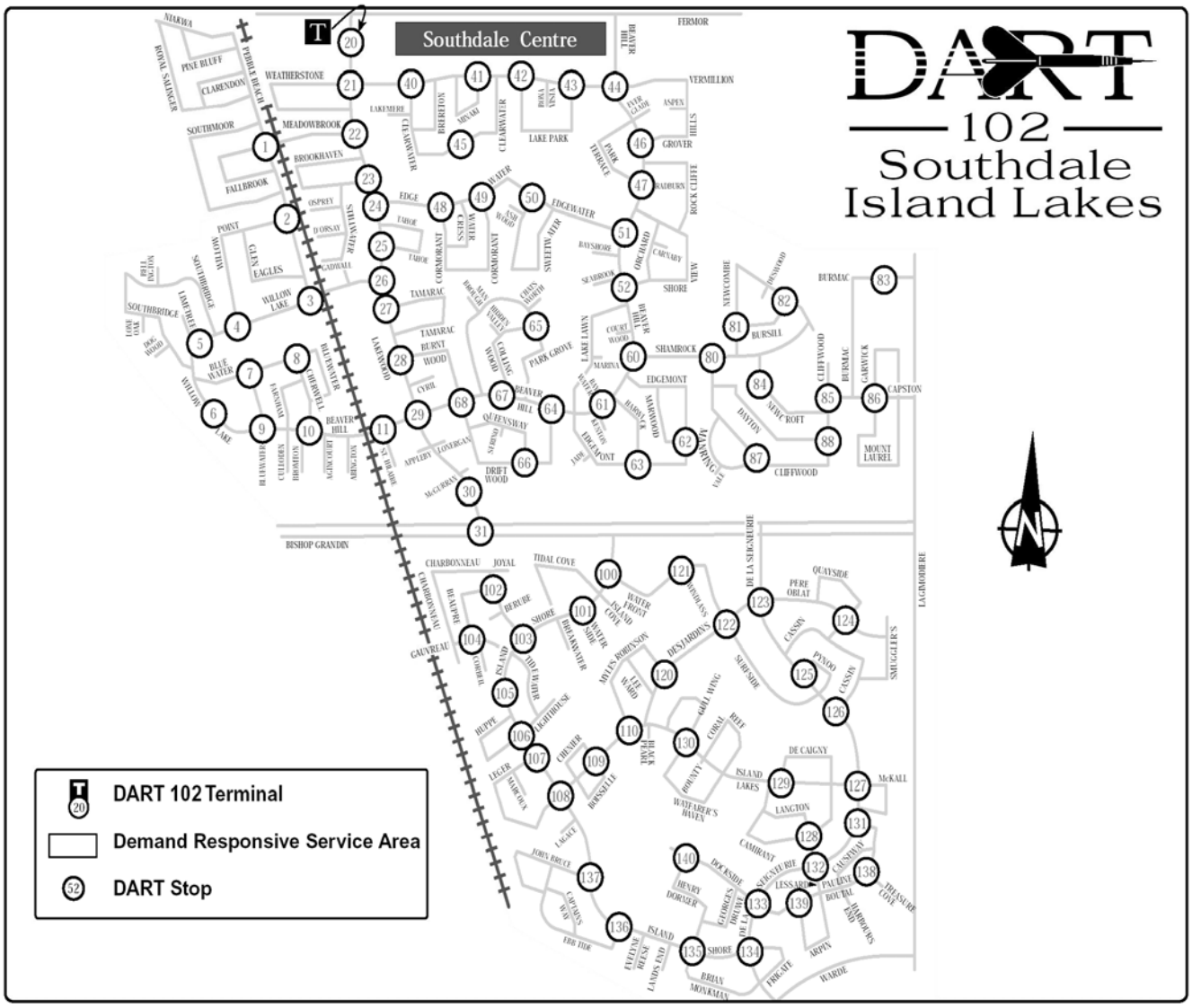

FIGURE 9 DART 102 Southdale/Island Lakes service area map.

For each schedule period, DART work assignments are included in the general bus operator sign-up. Bus operators who select DART work must attend special training for the service. Drivers are paid for the time they spend attending the training. The training involves classroom sessions that cover cell phone use, telephone courtesy, route planning techniques, and record keeping. In addition, time is spent in the field to learn the local geography of each service area. A number of extraboard operators are also trained to replace regular operators who might be sick or on vacation.

DART drivers receive the equipment needed for hands-free cell phone operation and are encouraged to safely use it. Personal use of the cell phones is discouraged and can be monitored by reviewing the bill from the service provider.

When DART began in 1996, it used 25-ft, 20-passenger, low-floor buses. Those buses were later replaced with 30-ft, 25-passenger, low-floor buses to provide better ride quality and to provide drivers with better maneuverability. The buses have two wheelchair positions and are equipped with wheelchair ramps. Although the newer buses are larger than those initially used, Winnipeg Transit staff report that residents still perceive them as small buses. The buses are part of a fleet that also provides downtown shuttle service and a number of feeder routes.

History and Background

Between 1974 and 1977, the Winnipeg Transit System operated a dial-a-bus experiment in two areas. Dial-a-bus provided trips to and from a transfer point and passengers' homes. It was popular, but as demand grew it became difficult to effectively service all the requested trips. As regional development continued, fixed-route service was

Weekdays	Saturdays	Sundays
Fixed-route	6:06	7:05
service	6:57	7:57
operates	7:44	8:49
until…	8:31	9:41
19:18	9:18	10:33
20:10	10:04	11:25
21:02	10:51	12:17
21:52	11:45	13:03
22:42	Fixed-route	13:48
23:32	service operates	14:33
00:32#	until…	15:18
	19:21	16:03
	20:10	16:48
	21:02	17:34
# Drop off	21:52	18:26
only. No	22:42	19:18
reservations	23:32	20:10
accepted.	00:32 #	21:02
		21:52
		22:42
		23:32 #

FIGURE 10 DART 102 Southdale/Island Lakes schedule (departure times from Southdale Centre).

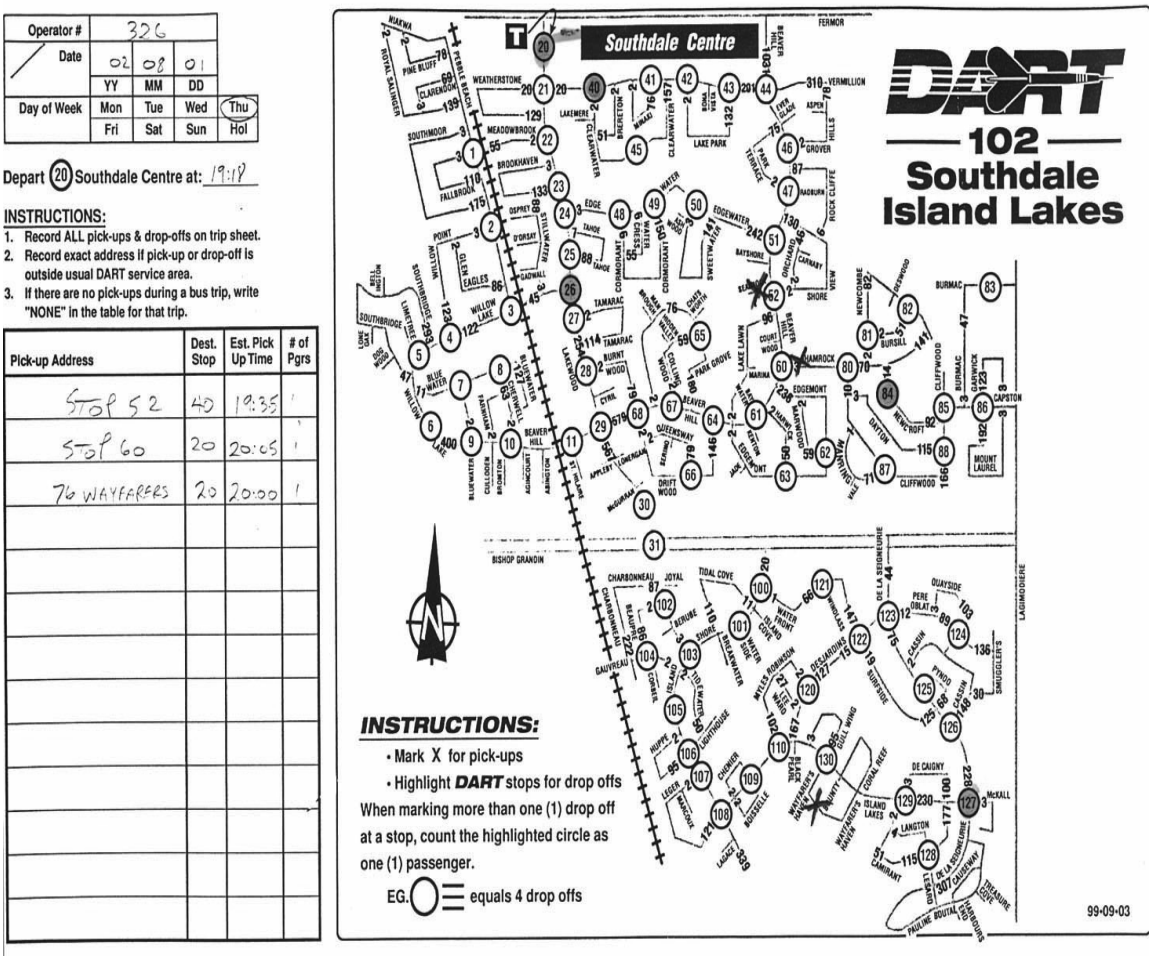

FIGURE 11 DART driver trip sheet.

eventually extended to the built-up areas and dial-a-bus was discontinued. Reviewing this experience, staff concluded that

- Demand-responsive service is an effective approach to develop ridership in small, but growing low-density residential areas.
- Demand-responsive service works well when the level of transit demand is relatively low. At higher levels of demand, better service at lower cost can be provided by fixed-route transit.

By 1996, changing circumstances led to renewed interest in alternatives to fixed-route service. DART was first implemented in June 1996 as a trial demonstration on two routes, DART 101 St. Amant/Plaza Drive and DART 102 Southdale/Island Lakes. A written demonstration plan prepared by Winnipeg Transit staff in March 1996 describes the situation that led to implementing DART. Development in Winnipeg has been characterized by construction of low-density residential areas with circuitous street systems at the edges of the city. Suburban employment has also grown, and major regional shopping centers have expanded. Extending transit service to areas of low-density development is difficult owing to circuitous street networks, which create pockets of isolated development and indirect, inconvenient pedestrian access to potential transit routes. Low densities, traffic congestion, and the circuitous street network require lengthy transit routes with long running times that can be operated only at infrequent intervals and that provide a low level of service for passengers.

Although the city is able to justify extending peak-period service to most areas of recent development, budgetary limitations make it difficult to maintain adequate service at other times. Staff were concerned that households would tend to purchase second and even third automobiles before transit service expansion could be completed, and that this would limit the potential to attract additional ridership when service was ultimately expanded.

In considering options for DART, staff determined that a flexible approach was needed, one that used fixed-route service at times when demand was high and demand-responsive service at other times. The DART concept built on the earlier dial-a-bus experience, a survey of six other demand-responsive operations (five in Canada and one in Virginia), and technological advances developed since the time of the dial-a-bus experiment. The principal innovations were (1) using marked stops for drop-offs to simplify the scheduling of drop-offs and (2) taking advantage of cell phone technology and touch-tone-activated call routing to eliminate the need for a separate dispatching function.

Potential riders are provided the following detailed information about how to use DART:

- An informational brochure and a detailed how-to-use pocket timetable were distributed to each household in each service area immediately before service start-up.
- A detailed map of the service area showing the locations of DART stops and detailed how-to-use information are posted at each DART terminal. One of the terminal information signs is shown in Figure 12.
- A detailed map of the service area showing the locations of DART stops is posted in each DART bus, on the back of the panel behind the bus operator. This map provides a convenient reference for passengers when informing the DART operator of their destination DART stop.
- The DART phone number is posted prominently on the DART bus destination signs and on the street signs designating the DART stops.

In addition, the transit system website includes detailed information about how to use each of the four DART services.

After some initial adjustments, the DART experiments were determined to be cost-effective, operationally feasible, and popular with riders. The initial two services were made permanent and extended to weekends. Since 1997, four more DART services have been started, of which two were converted back to fixed-route operation, and two continue to operate. The two DART services that were discontinued were midday and Saturday services in areas where the reduction in walking time provided by DART compared with that for fixed-route service was not sufficient to compensate for the inconvenience of needing to reserve trips. The city is considering implementing DART service in three or four additional areas.

Outcomes

The four DART services carried 75,000 passengers (unlinked boardings) in calendar year 2002 and operated 10,165 VRH, for an average productivity of 7.3 passengers per VRH. Productivity on individual routes ranged from a low of approximately 5 passengers per VRH to a high of 15 passengers per VRH. Productivity varies considerably among individual DART vehicle tours. Buses leaving the DART terminals early in the evening often carry 15 to 20 passengers. Later in the evening, when demand is lower, buses carry 3 to 5 passengers per trip.

Winnipeg Transit staff estimated that DART service can carry a maximum of approximately 20 passengers per hour. At the time of evaluation, the existing service was close to its limit during the early evening hours and also during the day on Saturday. However, demand was not expected to grow much during those hours.

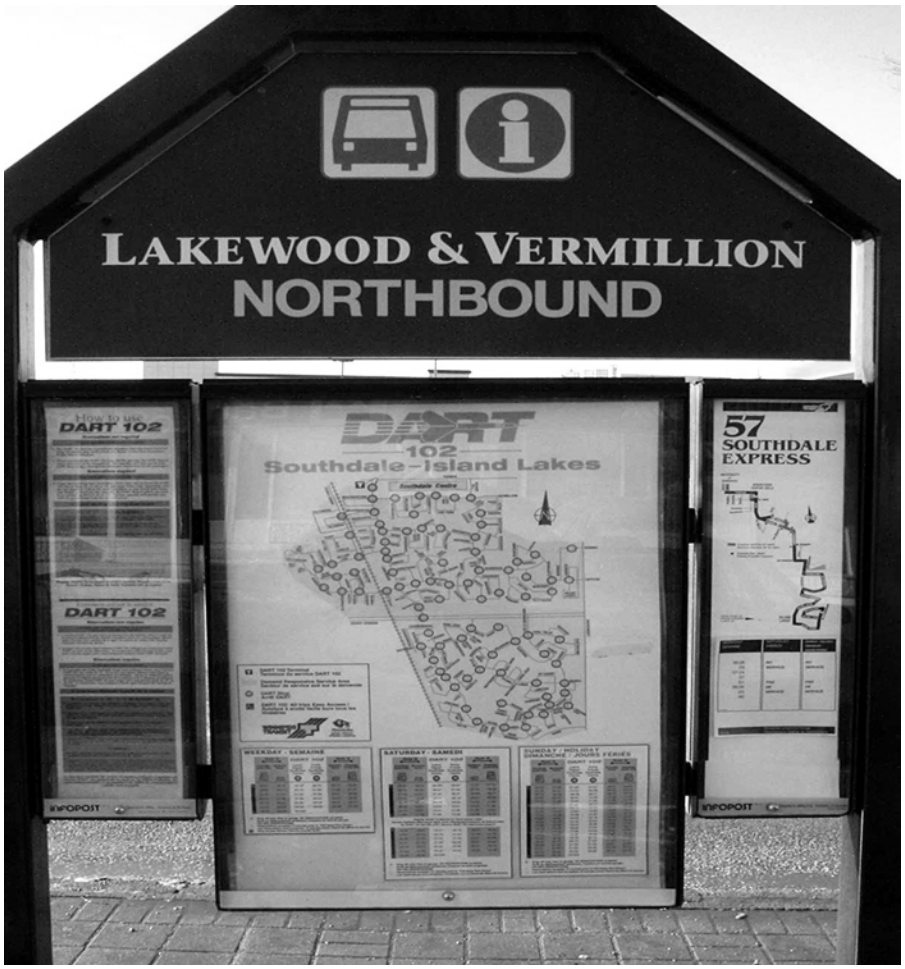

FIGURE 12 DART terminal information sign.

For purposes of evaluation, the transit system's main consideration was that DART was more cost-effective than fixed-route service in a low-density area because it could serve a much larger geographical area than fixed-route service could using the same resources. A key point in this line of reasoning is that the city council has established service level warrants that the transit system strives to meet in a cost-efficient manner. From this point of view, the relatively low productivity of DART services is a confirmation that demand-responsive service is more appropriate in these times and areas than fixed-route service. DART uses the same number of vehicles as the prior fixed-route services. Because DART operates only off peak, it does not add to the transit system's peak vehicle requirement. Additional positive considerations are that DART makes it possible to provide service with minimal intrusion in neighborhoods by the larger transit vehicles used for fixed-route service, and it addresses public concerns about large buses with few riders.

Most trips are provided to and from the transfer points. Because weekday service on three of the four DART services is limited to evenings, most trips begin at the transfer point and do not involve a reservation. For example, during the demonstration period, which had very limited daytime service, 75% of trips on DART 101 began at the transfer center or another timed departure point at the opposite side of the DART area, and 68% of trips on DART 102 began at the transfer center. During midday periods, a higher percentage of trips originate within the DART area, including trips between points within the DART areas.

The 1997 DART evaluation included a passenger survey, which found a mostly positive response to the service. Very large majorities of passengers indicated that drivers answered calls promptly, that passengers were able to get convenient pick-up times, that the reservations procedure was "easy" or "just right," that passengers were picked up on time, that there were enough DART stops, that the directness of trips provided on DART service was either "very direct" or "just right," and that drivers were courteous and helpful.

The evaluation of the initial DART services found that DART users were generally typical of the service areas, which had above-average concentrations of young people.

In general, users were a broad cross section of age and gender: 53% female and 47% male, 29% age 18 and under, and 69% age 19 to 64. In the 18-and-under age group, users were mostly women. In the passenger survey, young women reported that the short walking distances provided by DART made public transit safer to use. Key user groups include workers returning home from jobs in the downtown area and young people returning home from evening activities.

One negative feature of the cell phone reservations system is that it is possible for a customer to receive a busy signal if the driver's cell phone is already in use. In these cases, the customer must call the main DART phone number again. However, the passenger survey indicated that busy signals were infrequent, and no complaints were received about them.

Drivers who participated in meetings to discuss DART service provided positive feedback. The drivers are a self-selected group who choose to operate this kind of service. Compared with the situation for fixed-route service, DART provides an opportunity for an operator to practice a broader range of skills on the job. In addition to using customer relations and driving skills, the operator must do route planning and scheduling, and must provide customer information while the service is in operation. In effect, the bus operator provides a community-based transit service in each DART service area. DART provides an opportunity for the operator to deliver more personalized service to customers. Bus operators on DART are paid at the same rate as those operating fixed-route service.

Because Winnipeg experiences severe winter weather, the evaluation of DART specifically examined winter driving conditions. Average operating speeds are generally lower in winter than in summer. Despite this and despite higher ridership levels in winter, schedule adherence remained good, and there were few late arrivals at the transfer point. In very extreme conditions, DART buses were restricted to the fixed-route alignment through the DART areas. In these situations, passengers made arrangements with the bus drivers to walk to the nearest stop to be picked up.

OMNILINK FLEX-ROUTES AT THE POTOMAC AND RAPPAHANNOCK TRANSPORTATION COMMISSION

PRTC operates a network of route deviation services as the exclusive mode of local transit in its service area. PRTC serves the counties of Stafford and Prince William in the outer Virginia suburbs of Washington, D.C. PRTC describes the service as "flex-route" and uses the service name OmniLink. Information for this case study comes from the survey response provided by PRTC's director of planning and operations; a service description provided by the same source ("PRTC's Innovative Local Transit Services . . ." 2003); information provided by PRTC for a case study that forms part of the National Transit Institute's course, "Planning Flexible Community Transit Services: Planning, Operations, and Technology" (Nelson\Nygaard 2003); and service descriptions on PRTC's website at http://www. omniride.com/link/.

Distinctive features of PRTC's experience are that flex-route services constitute the entire local transit system, there is a major focus on using information technology (ITS) to improve flexible service operation, and there is an emphasis on serving people with disabilities with the same service used for other riders.

Service Description

PRTC operates flex-route service on five routes using 13 peak vehicles. On each route, buses stop at marked stops and can also deviate up to three-quarters of a mile on either side of the route in response to service requests. Three-quarters of a mile is the same distance as in the ADA requirement for complementary paratransit around fixed routes. However, PRTC's flex-routes are general public service. PRTC does not operate separate ADA paratransit.

There are also a limited number of on-demand stops close to the main routes. Omni-Link service operates from 5:30 a.m. to 10:30 p.m., Monday through Friday. Until 7:30 p.m., two routes operate on 60-min headways, and three routes operate on 45-min headways. After 7:30 p.m., headways are doubled.

Passengers wanting an off-route stop are required to call PRTC at least 2 h in advance between 7:00 a.m. and 7:00 p.m.; however, PRTC advises that "for best results, reservations should be made 1 to 2 days in advance." PRTC limits the number of off-route requests that will be accepted on each vehicle trip and advises passengers that they may be asked to get on or off the bus at a location that is within a few blocks of their origin or destination, because some locations are not accessible to OmniLink buses. Passengers whose requests cannot be accommodated are advised to ask for a different time or walk to a bus stop. Passengers can request service to one of the on-demand bus stops when they board.

The base fare for OmniLink is $1.00 per trip or $2.25 for a day pass (half-price for riders 60 years and older and those with disabilities). There is a deviation surcharge of $1.00 per trip, except for riders 60 years and older and those with disabilities.

Operating Methods

The route map and schedule for PRTC's Dale City flex-route, shown in Figures 13 and 14, illustrate the method of

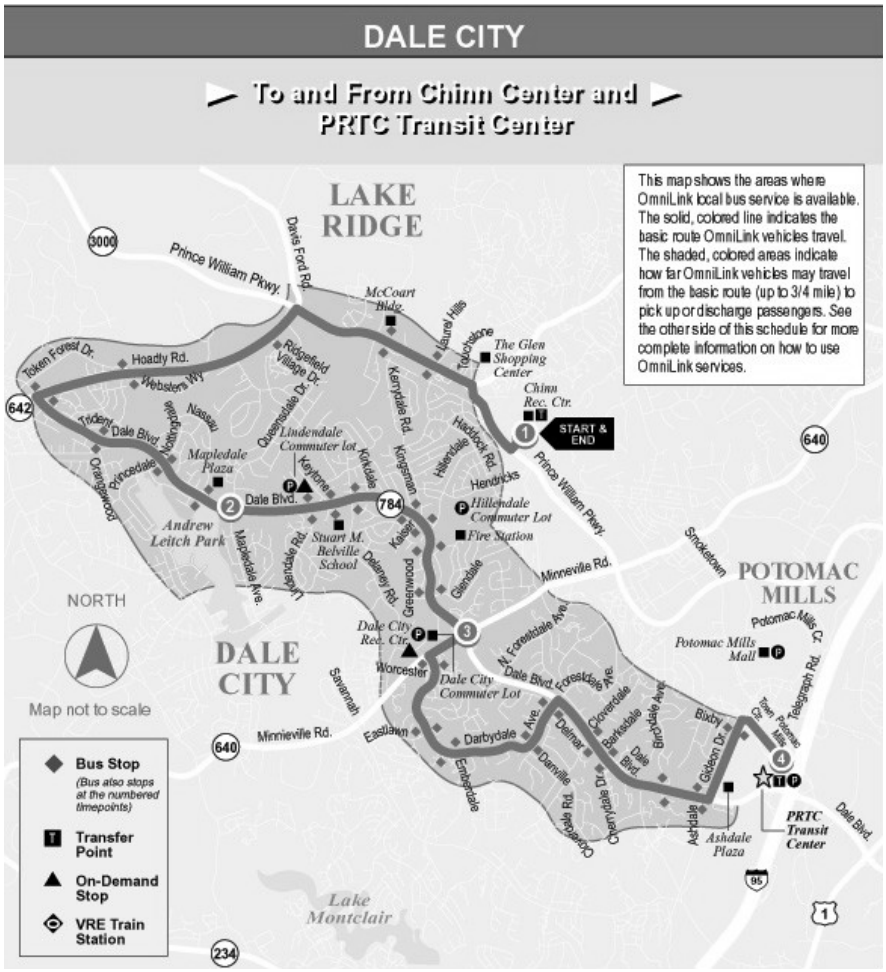

FIGURE 13 OmniLink Dale City flex-route map.

operations for OmniLink. The 13-mi-long Dale City route is one of three flex-routes that operate in eastern Prince William County. It operates every 45 min using two buses. At the PRTC Transit Center it meets the two other routes in this area. Schedules indicate times at the four numbered time points. In addition, each bus stops at all the marked stops, which are shown by diamonds on the route map. Boarding passengers can also request service to the two on-demand bus stops, shown by triangles on the route map.

On receiving a request to a point that is not near an existing bus stop, customer service agents (CSAs) establish off-route pick-up and drop-off locations that are a reasonable distance from those requested, at points that are efficient to serve and that allow the bus to continue making forward progress along the route. The CSAs use a customized version of a popular paratransit scheduling program to schedule off-route trip requests. The software includes mapping capability to view off-route trip locations, and it enables the CSAs to determine whether a given trip has sufficient slack time to accommodate a request.

Since June 2003, vehicles have been dispatched by means of MDTs (mobile data terminals), which list all bus stops and off-route trips. The buses are equipped with Global Positioning System (GPS) transponders that allow the MDTs to calculate estimated arrival times, to aid in improving on-time performance. The MDTs also can display a built-in map with suggested routing to aid in servicing off-route trips and returning to the route. The information is also transmitted to dispatch, and exception reports are provided to identify vehicles that are or are expected to be excessively late. Before June 2003, requests received a day or more ahead, along with subscription off-route trips, were shown on printed manifests provided to the drivers. Off-route pick-ups scheduled in response to same-day requests were dispatched to drivers by voice radio.

To increase operating efficiency, buses do not have to return to the route at their point of departure as long as they serve all fixed stops. Operators have the freedom to select the route they drive between stops when deviations are required. The average stop spacing is a little under 0.5 mi (or about 0.75 km). Approximately 12% of OmniLink passenger trips entail a deviation on one or both ends. The

WEEKDAYS						
[1] Chinn Center	[2] Mapledale Plaza	[3] Dale Blvd & Minnieville Rd	[4] PRTC Transit Center	[3] Dale Blvd & Minnieville Rd	[2] Mapledale Plaza	[1] Chinn Center
5:47 AM	6:00 AM	6:10 AM	6:35 AM	6:54 AM	7:05 AM	7:17 AM
6:32	6:45	6:55	7:20	7:39	7:50	8:02
7:27	7:40	7:50	8:15	8:34	8:45	9:02
8:12	8:25	8:35	9:00	9:19	9:30	9:42
8:57	9:10	9:20	9:45	10:04	10:15	10:27
9:42	9:55	10:05	10:30	10:49	11:00	11:12
10:27	10:40	10:50	11:15	11:34	11:45	11:57
11:12	11:25	11:35	12:00	12:19 PM	12:30 PM	12:42 PM
11:57	12:10 PM	12:20 PM	12:45 PM	1:04	1:15	1:27
12:42	12:55	1:05	1:30	1:49	2:00	2:12
1:27	1:40	1:50	2:15	2:34	2:45	2:57
2:12	2:25	2:35	3:00	3:19	3:30	3:42
2:57	3:10	3:20	3:45	4:04	4:15	4:27
3:42	3:55	4:05	4:30	4:49	5:00	5:12
4:27	4:40	4:50	5:15	5:34	5:45	5:57
5:22	5:35	5:45	6:10	6:29	6:40	6:52
6:07	6:20	6:30	6:55	7:14	7:25	7:37
7:37	7:50	8:00	8:25	8:44	8:55	9:07
9:07	9:20	9:30	9:55	10:14	10:25	10:37

FIGURE 14 OmniLink Dale City flex route schedule.

basic schedules include approximately 20% slack time to accommodate off-route trip requests. The buses are medium-duty, 28-passenger, body-on-chassis vehicles with wheelchair lifts and the ability to accommodate two passengers in wheelchairs. PRTC is currently acquiring the funds to replace these buses with heavy-duty, low-floor transit buses.

History and Background

PRTC was created in 1986 to develop and operate transit services in a rapidly growing suburban area approximately 20 mi southwest of Washington, D.C. Until 1995, PRTC's services consisted of express commuter bus and commuter rail service, primarily into Washington, and a rideshare matching program. OmniLink service was begun in 1995 in response to requests for local transit service.

PRTC determined that conventional transit service would not be attractive to riders in its low-density service area. The area has grown rapidly in recent decades, with pockets of development connected by an irregular and often circuitous road network. The area has no downtown and no major travel pattern focus other than Washington, D.C. An affordable transit route network would not reach many residential areas. Streets often lack sidewalks, so that walking to bus stops would be difficult. In addition to noting these difficulties, PRTC realized that providing conventional local transit service would also bring with it a requirement to provide ADA-complementary paratransit service.

The flex-route concept was seen as resolving these difficulties. The deviation component made it possible to provide service throughout the service area, as well as to combine service for the general public and people with disabilities. The deviation component also addressed the difficulty of customers walking to bus stops along streets without sidewalks. A further attraction of flex-route service was that it responded to a desire by human services agencies in the area for additional capacity to serve their transportation-disadvantaged clients.

OmniLink service began in April 1995. It was adjusted and expanded later the same year and several times since then. Initially, deviation requests were only accepted 24 h in advance. Reservations were taken in one phone call, all trips for the day were then scheduled, and customers were then called back with detailed information on their reserved trips. In October 1997, the advance reservations requirement was shortened to 2 h, taking advantage of a re-

cently installed automated scheduling system, and off-route trips were scheduled and confirmed in one phone call.

Information Technology at PRTC

PRTC began automating the operation of OmniLink in 1993 when the service was in the planning stages. PRTC's Smart Flex-route Integrated Real-time Enhancement System project, known as SaFIRES, was established to schedule demand-responsive and prescheduled service, dispatch flex-route trips to OmniLink vehicles by means of MDTs, automatically track vehicle locations using GPS, and provide dispatchers with real-time information about on-time performance.

Initially, PRTC assumed that ITS technologies were necessary to operate flex-route service successfully. However, because technologies were not ready by the time on-street operations were scheduled to begin, the system operated for the first few years in a completely manual mode. Approximately 3 years after service initiation, PRTC began using a customized version of a widely used paratransit scheduling product as part of its day-to-day operation. Development and integration of the remaining ITS components were delayed, largely as a result of the bankruptcy of PRTC's then commercial communications provider.

PRTC credits the automated scheduling system with allowing the minimum reservation lead time to be reduced from 24 h to 2 h by allowing CSAs to negotiate and schedule reservations with riders in one phone call.

The ITS project was restarted in October 2001 when PRTC solicited proposals for high-technology enhancements to its local bus flex-route service. PRTC awarded a contract to a team of four technology companies in January 2002, and began using the new system full-time in June 2003. According to PRTC, it works as follows:

- A driver log-on triggers the downloading of the route to the MDTs on board buses, using a wireless cellular digital packet data network.
- The MDT is a ruggedized Windows-based computer system that uses a 10.4-in. color touch screen to display the combination of fixed-route stops and flex-route deviations in chronological order. Color coding highlights the deviations from the fixed-route stops.
- When a deviation stop is at the top of the list, the driver leaves his or her route and drives to the stop location. Drivers who do not know how to get to the address can press a button to show a color map on the MDT screen, with the deviation stop plotted in the center. Pressing another button on the map screen causes the MDT to calculate a "suggested route" and highlight the streets from where the bus is located (its GPS position is shown on the display) to the deviation stop. After completing the pick-up or drop-off, the driver can have the MDT calculate and display on the map the suggested streets to return to the fixed route.
- For fixed-route stops and time points, the MDTs use a built-in GPS capability to detect that the bus has arrived. The screen then enables the driver to enter the number of passengers boarding or alighting. These ridership data are transmitted for stop analysis. As each fixed-route or deviated stop at the top of the list is completed, it is removed from the list and the remaining stops scroll upward to the top.
- The MDTs also allow the drivers to send messages to dispatch. These are frequently used canned messages or messages typed using the keyboard provided on the touch screen. Dispatch can send messages to the drivers that pop up on the driver's display as well as cancellations and insertions (add-ons) to modify the driver's route in real time.
- The MDT also transmits AVL and schedule adherence data back to dispatch every 2 min (parameters are changeable). At dispatch, the location and on-time status are plotted on maps shown on workstation monitors. Vehicle icons show the location, direction, and color-coded on-time status. Filtering shows, for example, "only the vehicles running late," resulting in only red vehicle icons being displayed on the map. The system is integrated with the routing and scheduling software.

The project was scheduled to be integrated with electronic fareboxes in late 2003. According to PRTC, the ITS project has produced the following benefits:

- Improved ability to provide customers with information about vehicle arrival times,
- Improved ability to track vehicle schedule adherence and take corrective action,
- Improved emergency response capability,
- Simplified driver record keeping, and
- Implemented easier navigation to off-route destinations for drivers.

Outcomes

By its second full year of service, OmniLink was carrying 1,044 passengers per day, or 8.7 passengers per VRH. Individual routes were carrying between 5.2 and 12.7 passengers per VRH. Ridership grew slowly for several years, rising rapidly again in fiscal year 2001–2002, when evening service was added. In fiscal year 2002–2003, the system carried 14.2 passengers per VRH, with individual routes carrying between 4.7 and 20.7 passengers per VRH.

In the first full year of operation, 25% of trips provided involved a deviation. Subsequent efforts at route refine-

ment and rider education efforts reduced the deviation percentage to approximately 15%. In December 2002, PRTC implemented a policy reducing the number of off-route requests accepted on each vehicle trip. This change was adopted in response to chronic lateness that was the result of increasing traffic congestion and ridership. Currently, approximately 12% of trips require a deviation.

PRTC continues to regard flex-route service as a successful method of operation in its service area. The agency reports that 74% of riders "like" or "very much like" the flexible aspect of the service, even though 76% do not use deviations. More than two-thirds of riders use the service to commute to local jobs, and 34% have a car available. From a financial perspective, PRTC estimates that converting to separate fixed-route and paratransit operations would require an operating budget increase of at least 50%. If ridership continues to increase, making it difficult to sustain flexible operation, the agency would most likely increase service frequency rather than change the mode of operation.

RIDE SOLUTION IN PALATKA, FLORIDA

In Putnam County, Florida, ARC Transit, Inc., a subsidiary of the ARC of Putnam County, operates a flexible service called Ride Solution. Putnam County is located in northeastern Florida, approximately 50 mi south of Jacksonville and 40 mi east of Gainesville. Its 2000 census population was 70,423 in 722 mi^2. The largest incorporated area in the county is Palatka, with a 2000 population of 10,033. The median household income of Putnam County in 1999 was $28,000, making it one of the poorest counties in Florida.

Information about the service was provided by the director of ARC Transit. Additional information about the use of technology for Ride Solution comes from a recent report from the FHWA, *Rural Transit ITS Best Practices* (Conklin 2003). Ride Solution's distinctive characteristics are that it is a general public flexible service that is built on coordinated human services transportation, and that it serves a very low-density, low-income, rural area.

Service Description and Background

Ride Solution is the designated County Transportation Coordinator (CTC) for Putnam County. In the CTC capacity, it provides coordinated transportation for multiple human services agencies, including the state Medicaid agency, programs for the elderly, services for people with developmental disabilities, and job access. Ride Solution was first designated as the CTC in 1984, and it has been operating flexible service since 1988. Ride Solution's flexible service consists of three components:

1. Subscription service for human service agencies, 70%;
2. Individual reservation trips for Medicaid recipients, 20%; and
3. General public service in the form of walk-ons at bus stops, 10%.

Ride Solution operates six routes, including one within the city of Palatka, two that connect to other communities in the county, two that connect to neighboring counties, and one that can be used only by reservation for medical trips. Although the routes are constructed on the basis of the needs of the human services agencies, they are all open to the general public and, except for medical runs, can be boarded at any published stop without a reservation. Reservations for medical trips must be received by noon the previous workday.

Operating Methods

Ride Solution service is provided using a staff of 31 full- and part-time drivers, 2 operations staff, 8 support employees, and 3 maintenance employees. The fleet consists of 42 vehicles ranging in size from 8 vans that carry 8 seated passengers and 1 or 2 passengers in wheelchairs to 4 school bus-type vehicles that can carry 32 seated passengers and 3 passengers in wheelchairs.

Because of Ride Solution's large service area, drivers need a very good knowledge of their area of the county to operate flexible service. Similarly, the agency finds that it takes a new scheduler the better part of a year to be able to work independently.

Ride Solution is one of the most technologically advanced rural operators in Florida. Its vehicles are equipped with MDTs and AVL, and the dispatch office uses proprietary software developed by a local consultant to help it with routing and scheduling. Ride Solution considers the scheduling software as having been an important factor in making it possible to establish its flexible services. The MDTs and AVL are used primarily for payroll timekeeping. A project to enable monitoring of automated schedule compliance is still in process. Communications with vehicles is accomplished by voice radio and by cell phones when vehicles are out of radio range.

Outcomes

Ride Solution provided 135,922 passenger trips to 6,865 total individuals in 2001. In other words, the average rider made approximately 20 trips on the service over the course of the year. As a measure of productivity, the agency tracks trips per driver hour, which averaged 2.4 in 2001. Because

most of the patronage is prescheduled, this productivity most likely reflects the rural nature of the service area, which requires traveling long distances.

Ride Solution staff believes that using the human services-consolidated transportation as a foundation made it possible to establish transit service for the general public in an area where it would otherwise probably not be possible. The system does not depend on general public ridership for its base of support. However, dependence on human services funding does make the service vulnerable in other ways. Ride Solution has sustained several recent funding cuts, which have forced it to reduce service. In the long run, however, the agency sees opportunities to expand flexible service by bringing in additional human services agencies.

FLEX ROUTES AND RESERVATION STOPS AT THE MINNESOTA VALLEY TRANSIT AUTHORITY

MVTA operates a network of transit routes, including two in route deviation mode and one in a request stop mode. MVTA is the public transportation agency for five suburbs located approximately 15 mi south of Minneapolis and St. Paul: Apple Valley, Burnsville, Eagan, and Rosemount in Dakota County; and Savage in Scott County. MVTA's flexible services illustrate two modes of operation particularly well. Information for the case study comes from the survey response of MVTA staff and service information on MVTA's website at http://www.mvta.com/.

Service Description

MVTA operates 21 transit routes, including local routes, commuter express routes into Minneapolis and St. Paul, shuttles that connect to the express routes, and reverse commute routes. Three major transit centers also include park-and-ride facilities. Paratransit service is provided by a separate agency under contract to the regional provider, Metro Mobility.

MVTA designates Routes 420 and 421 as flex routes. Both routes have a series of fixed stops that are served in sequence according to an established schedule, and also deviate to serve requests within approximately one-half mile of the primary route. Passengers can board at any of the stops without a reservation, and they can request deviations through MVTA's dispatch center. Riders are encouraged to schedule deviations 1 day ahead, but same-day reservations are accepted on a space-available basis up to the time of the trip. MVTA accepts deviation reservations up to 2 days in advance, between 7:00 a.m. and 4:00 p.m., Monday through Friday, and it also accepts standing orders for repeated deviations. At the time of boarding, riders can also request to be dropped off at an off-route location. There is a $0.50 surcharge for off-route service on top of the regular base fare of $1.00 or the senior or disabled passenger's fare of $0.50.

Route 440 is designated as local service. It operates in conventional fixed-route and schedule mode, but also serves eight reservation stops at locations near the route, where access by pedestrians is limited. The reservations policies are the same as for the flex routes. There is no extra charge for service to or from the reservation stops.

Operating Methods

MVTA's pocket schedule for Flex Route 420 helps to illustrate how the flex routes work (Figure 15). The basic route runs 5.5 mi between Rosemount Plaza and Apple Valley Transit Station, where it connects with five other MVTA routes. The central portion of the deviation corridor is 1 mi wide from north to south. According to MVTA staff, the scheduled running time of 30 min per trip leaves "ample time for deviations." Between 6:00 a.m. and 6:30 p.m. there are 10 trips in each direction, Monday through Friday, with no service between 9:25 a.m. and 2:25 p.m.

In addition to the route end points, all buses stop at one of the two time points marked by open squares and also at four designated "flag stops" marked on the map by black circles. A third time point (Galaxie Library) is always served on some trips and by reservation only on others. A fifth flag stop, near the Apple Valley end of the route, is served only on Rosemount-bound trips. The average stop spacing is almost 0.8 mi. With the limited number of stops, and long distances between some stops, this service occupies a middle ground between the route deviation and point deviation categories, as defined in chapter two.

Deviations are permitted within the marked shaded area that averages 1-mi wide but is not always centered on the route. MVTA's policy on deviation locations, as stated in the pocket timetable, is as follows:

> If you cannot get to a flag stop or time point, or if your destination is not close to a stop, you may still use the *FLEX* by calling our reservation line at (952) 882-6000. The dispatcher will work with you to reroute the vehicle closer to where you live or want to go. Please note that some locations are not accessible to *FLEX* buses. In such cases, the dispatcher will work with you to find an alternative stop close by.

In many cases, serving a deviation would bring the bus back to the route beyond the point at which it left the route.

Figure 16 is a detail from the route map for Route 440. The segment pictured is approximately 2 mi long and includes six of the eight available reservation stops, marked

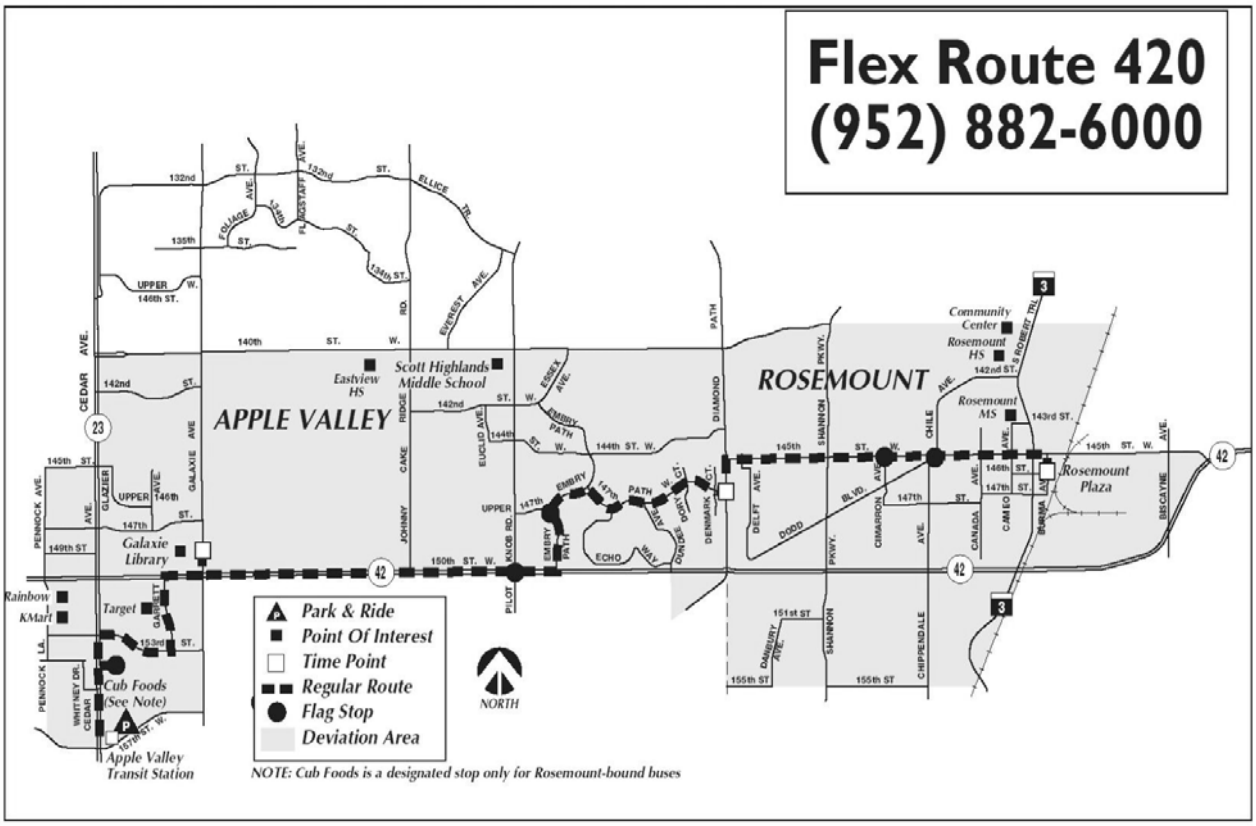

FIGURE 15 MVTA Flex Route 420.

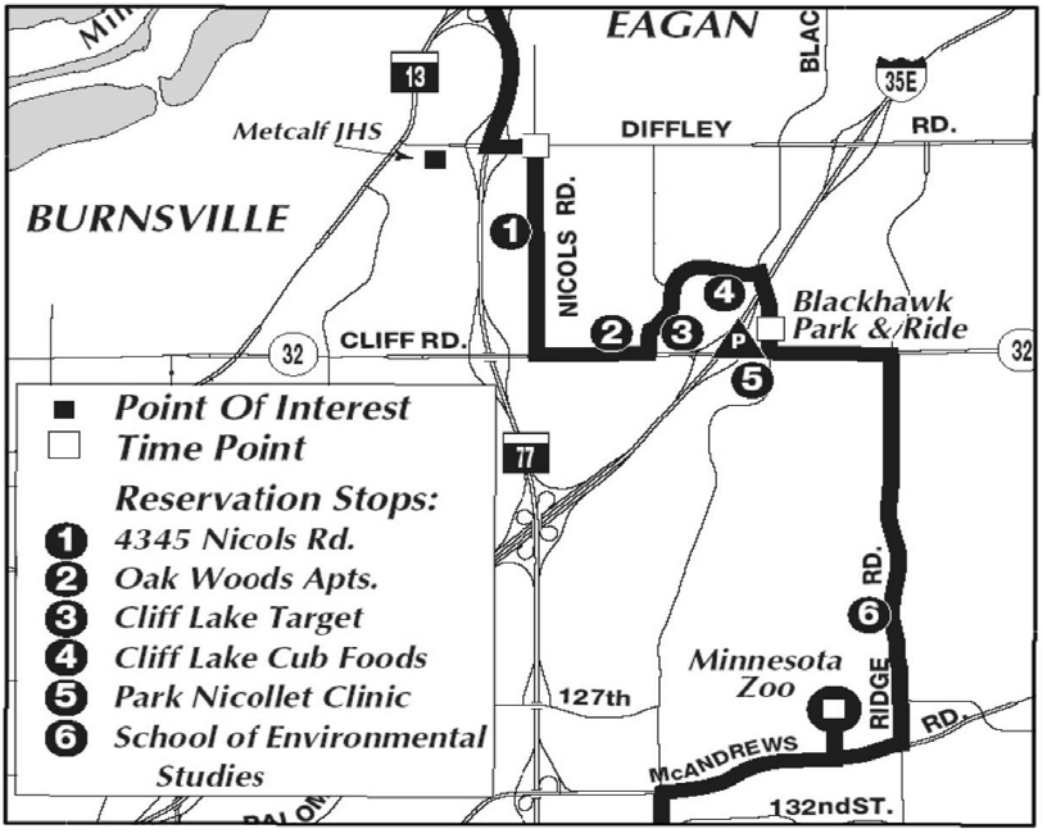

FIGURE 16 MVTA Route 440 detail.

on the map by black circles numbered 1 through 6. The entire route runs approximately 14 mi between the Mall of America, where it connects with the regional transit provider, Metro Transit, and the same Apple Valley Transit Station served by Flex Route 420. The reservation stops include an apartment complex, a discount department store, a supermarket, two medical clinics, a school, and a library. Route 440 operates six southbound trips and seven northbound trips, with a 2-h gap during midday. When a Route 440 bus deviates to serve a reservations stop, it always returns to the route at the point where it left.

Each evening, the dispatcher prepares manifests for the flex route and Route 440 drivers that include those deviation requests already received. Deviation requests received on the day of service are communicated to the drivers by means of cell phones. Cell phones are used because they provide more privacy than voice radio, which is used for normal dispatching functions. In regard to technology, MVTA has concluded that, with at most three buses in flexible service, there is no value to extensive high-technology installations. MVTA planners believe that a competent dispatcher can adequately manage the small number of vehicles and modest level of reservation requests. MVTA does use some computer tools to keep track of requests and scheduled rides, but it does not link these tools to any sort of automated dispatch system.

All of MVTA's services are operated by three contractors, including two private companies and Metro Transit. The contractor that operates the flex routes does not apply any special criteria to selecting drivers for this service. A few drivers have chosen not to work flex routes because they feel uncomfortable with the level of decision making required. In general, however, MVTA finds that the ability to perform the flex routes is within the overall minimum abilities of the contractor's drivers. Driver training for the flex routes includes orientation to the street network and major destinations within the flex areas; review of fare policy differences; and procedures for pick-up deviations, missed pick-ups, same-day scheduling, and on-demand scheduling of drop-offs. Most of the contractor's drivers undergo this training eventually. Training for Route 440 is very similar to training for fixed-route operation, except that route familiarization includes the reservation stops.

Flex-route dispatching is performed by the same staff that dispatch other services. They are trained in procedures for taking reservations and how to determine when a trip is full; that is, when no additional deviation requests can be accepted.

Both flex routes and Route 440 are operated using 25-ft cutaway vehicles that can carry 16 seated passengers and 2 passengers in wheelchairs. Because of route interlining, some trips on Route 440 use 35-ft low-floor buses. MVTA considers the small buses appropriate in size for Route 440, but would prefer to use smaller buses for the flex routes if the 25-ft vehicles were not also needed for other services.

When the flex routes were first introduced, the buses were wrapped to give them a unique identity. Currently, MVTA simply markets them as part of the "family of services" concept that encompasses everything from the flex routes to high-frequency express routes using articulated buses and over-the-road motor coaches. The pocket timetables include detailed and specific information about how to use the flex routes.

History and Background

The MVTA is one of six independent transportation agencies formed in the late 1980s under state legislation that allowed outer-ring suburbs of Minneapolis and St. Paul to opt out of centrally provided transportation services. Flexible services were introduced in 1998 to address specific issues in parts of the service area. In the areas served by flex routes, fixed-route service had low ridership owing to long travel times caused by the need to connect all the major trip generators and attractors. By comparison, MVTA planners feel that the flex routes allow a faster trip, because every location need not be served on every trip unless there is a ride request. Flex routes also allow coverage of low-demand areas that could not be effectively served by the fixed route. In the case of Route 440, the reservation stops developed from a need to provide more convenient access to certain locations that had difficult pedestrian access, such as a school that is set well back from the road without a sidewalk.

Outcomes

The two flex routes carried 17,300 passengers in 2002, with a productivity of 4.2 passengers per VRH. Route 440 carried 17,900 passengers, with a productivity of 5.8 passengers per VRH. These performance levels are well below MVTA's system average of 25.6 passengers per VRH, which includes the express and commuter routes. On the flex routes, slightly less than 50% of passenger trips require a deviation. On Route 440, staff estimated that less than 15% of passenger trips use the reservation stops.

MVTA staff would prefer to see the flex routes operating at 6 passengers per VRH or more, and they would prefer to see Route 440 operating at 8 to 9 passengers per VRH. MVTA's subsidy per-passenger standard for its other local route services is equivalent to 10 to 11 passengers per VRH. Although the productivity of the flex routes is below MVTA's desired levels, the agency's policy commitments include serving areas with small numbers of riders with great needs. The agency believes that there is a fundamental

need for transit services in the areas being served by flex routes, and that the flex routes provide better coverage than fixed-route service and better productivity than conventional dial-a-ride.

ROUTE DEVIATION SERVICE AT THE OTTUMWA TRANSIT AUTHORITY

OTA operates a fixed-route transit system with limited deviations, primarily for older passengers. The system illustrates the kind of practical flexibility, with relatively informal rules, that is possible in a small town setting. Ottumwa is a city of 25,000 people in 16 mi^2 in southeastern Iowa. People age 65 and older make up 19% of the population, and account for a high proportion of transit ridership. The nearest large city, Des Moines, is approximately 90 mi away. Information for the case study comes from the survey response of OTA's transit administrator, supplemented with technology information from Conklin et al. (2003).

OTA is a department of the city of Ottumwa. It operates a local transit system within the city and also acts as the designated provider of coordinated human services transportation in a much larger 10-county region. The local transit system consists of route deviation service using eight 42-ft buses and ADA-complementary paratransit using two vans. The routes operate on 50-min headways during the midday and on weekends, and 40-min headways during peak periods.

According to the transit administrator, OTA's basic service design is fixed route and fixed schedule. However, in an attempt to accommodate customers with special needs, the agency created a deviation system. Customers may call the office and request a deviation. Drivers may receive direct requests and have been instructed to radio them to the office for final approval. In some cases, drivers receive a request for a deviation for a return trip later in the day, which the driver then relays to the office. This flexible mode of operation has been in use since 1982.

There is no formal policy concerning how far off the route a bus will deviate. In most cases, deviations are no more than one or two blocks. Examples include pick-ups or drop-offs at the front door of a business or residence. Deviation requests can be accepted with as little as 10 min advance notice. The deviations are used primarily by older passengers and people with disabilities to get closer to their destinations. The deviations permit these customers to remain independent and avoid having to use ADA paratransit. There is no extra charge for deviations.

From the point of view of the transit system, the deviations also help to control ADA paratransit costs. Because the same person dispatches the local fixed-route service and the ADA paratransit service, it is possible to have the two services share trips.

The availability of deviations is not formally marketed. However, in their presentations, staff routinely mentions the availability of deviations, and drivers can suggest deviations to customers. Beyond these sources, passengers learn about deviations by word of mouth.

OTA does not formally track the number of deviations it makes, but it was estimated to be about 2% of total ridership. The current low deviation percentage partly reflects a recent redesign of some routes to serve areas of new development. At the time of the redesign, staff examined the history of deviations and made adjustments that reduced the number of deviation requests. Because OTA is able to maintain productivity of 20 passengers per VRH, it appears that deviations do not seriously affect the performance of the system.

OTA has been active in pursuing technology to help operate transit services. An AVL system and MDTs help in coordinating the far-flung services that OTA operates in the surrounding region. For the local transit service, the dispatcher is able to use the AVL display to help determine if a deviation is possible or if a deviation can be used to serve a paratransit service request in a timely manner.

CHAPTER SEVEN

CONCLUSIONS

Flexible transit services are being used by transit systems of all sizes and in all types of service areas throughout North America. Transit agencies operate flexible services to (1) provide cost-effective coverage to spread-out, low-density areas; (2) serve low-demand time periods; (3) balance customer access and routing effectiveness; (4) reduce or eliminate the expense of separate paratransit for people with disabilities; (5) lay the groundwork for future fixed-route transit; and (6) respond to community preferences and geography.

- *The role of flexible service*—In order of frequency from most common to least common, the applications for flexible services are

  1. Provide service in limited areas that are considered hard to serve for reasons of demographics, street layout, or community preferences.
  2. Provide service in low-demand time periods. In cities with substantial fixed-route service, flexible operation typically substitutes for fixed-route operation in limited areas. In some cities with more limited fixed-route service, flexible operation replaces the entire fixed-route network at certain times.
  3. Provide the entire transit service for a small city, low-density suburban area, or rural area. In these cases, coordination or consolidation with paratransit service is a key feature of the flexible service.

- *Unique service designs*—Each flexible service is unique. There is as yet little standard practice that operators can turn to in designing flexible services. In response to local circumstances, each operator creates its own variations with respect to the degree of flexibility and fixed operation as reflected in the geographic extent of deviations that are possible, advance-notice requirements for demand-responsive service, numbers and layout of stops where spontaneous boardings and alightings are possible, and use of established locations for demand-responsive pick-ups or drop-offs.
- *Balancing efficiency and flexibility*—Operators' experiences indicate the importance of finding the right balance between fixed-route operation and demand-responsive operation in each situation. Traditional fixed-route service provides efficiency in the sense of serving concentrations of passengers with a minimum of resources and establishing efficient schedules based on the relative predictability of vehicle travel times on a fixed alignment. It provides convenience in the sense of offering passengers predictable service that can be used spontaneously, without the need to make prior arrangements. On the other hand, demand-responsive operation provides what might be called "coverage efficiency." This is the ability to serve dispersed origins and destinations at reasonable cost, especially in low-demand situations, without unnecessary detours to stops where there may or may not be a demand for service on a given trip. Demand-responsive operation offers convenience in the form of the reduced need for riders to walk to bus stops and wait for a vehicle, especially where walking is dangerous owing to a lack of sidewalks, in cold weather, or at night.
- *Efficiency strategies*—Operators have developed strategies to reduce the inefficiency of demand-responsive operation. These strategies include negotiating convenient meeting points for pick-ups and using established stop locations for drop-offs. Convenient meeting points, as at the Potomac and Rappahannock Transportation Commission, appear to improve the efficiency of vehicle routing. Established stop locations, as in Winnipeg (Winnipeg Transit System), can make the routing problem simple enough to eliminate the need for a dispatching function separate from drivers. The use of established stop locations, at least in the United States, is far less common than has been reported for flexible services in other countries. A review of flexible services conducted by the Winnipeg Transit System in 1996 found several Canadian systems that use established stops to organize demand.
- *Limited or discretionary flexibility*—The operation of many flexible services uses limited or discretionary flexibility in the way that dispatchers or drivers accommodate demand-responsive service requests. In addition to the use of established stops, examples include limiting the number of off-route requests accepted per vehicle trip, accepting last-minute requests (including those made at the time of boarding) but only on a space-available basis, and reserving the right to pick up or drop off passengers several blocks from their actual origins or destinations.
- *Advance-notice requirements*—Although many flexible services require previous-day reservations for demand-responsive pick-ups or drop-offs, the experience of other systems shows that much shorter ad-

vance-notice requirements are possible, with or without the use of advanced technology. Nine of the 28 flexible services surveyed accept demand-responsive service requests with less than 1 h of advance notice. Such short advance-notice requirements greatly increase the convenience of flexible service for passengers.

- *Fares*—Fare surcharges for off-route service may be useful as a way to encourage riders to board and alight at established stops. Fare surcharges are being used for eight of the flexible services surveyed. The transit agencies reported no difficulties in administering these surcharges.
- *Coordination with fixed-route networks*—Most flexible services serve limited portions of a large service area and provide connections with a regional network. As a result, scheduling needs to allow sufficient time to provide reliable transfers. In a system that has multiple flexible services connecting to a fixed-route network, ensuring reliable connections can be extremely difficult.
- *Coordination with paratransit*—Most flexible services are either coordinated or consolidated with paratransit services. Consolidation is a viable strategy only in large-area services, but coordination is widely used, most commonly in the form of joint dispatching, vehicle sharing, and trip sharing. In the case of complete consolidation, flexible service successfully eliminates the expense of separate paratransit service. Coordinated dispatching and vehicle sharing offer operational efficiency and convenience, because the necessary dispatching skills and appropriate vehicle types for paratransit and flexible service are similar. Trip sharing has the potential to reduce dependence on paratransit, although the actual cost savings from this strategy has not been determined.
- *Marketing*—Some operators have devoted extensive resources to promoting new flexible services, and they provide detailed public information materials explaining how to use flexible features. Others rely mainly on word of mouth and communication between drivers and passengers. The fluid and discretionary nature of many flexible services often makes it hard to provide succinct yet accurate descriptions of services.
- *Ridership and productivity*—In hard-to-serve areas, flexible services typically have relatively low ridership and productivity levels compared with those of fixed-route service, generally in the range of 2 to 7 boardings per vehicle revenue hour. Such numbers appear to reflect the inherent difficulty of serving these areas, or inherent limitations of demand owing to low density or demographics, that is, more than reflecting inefficiency in the service method. Few systems have minimum standards for performance of flexible service. However, if ridership were to climb significantly above current levels, many systems would take it as an indication that the area could be better served with conventional fixed-route service. Several transit agencies that employ flexible operation for their entire transit service have much higher than average ridership and productivity, in the range of 14 to 20 passengers per vehicle revenue hour. In these cases, it is possible that deviations limit ridership and productivity. However, the cost advantage of combining service to the general public and people with disabilities is an overriding concern for these agencies.
- *Allocation of scheduled time*—Flexible operation requires a fixed schedule that specifies when vehicles will be at time points, but one that also leaves time for responding to demand-responsive service requests. The amount of time allocated for demand-responsive operation varies according to service type and agency objectives, from zero to all the time, exclusive of layover at a transfer point. Many agencies have no clear allocation of scheduled time at all. The allocation of scheduled time could be an area where many agencies would benefit from additional guidance.
- *Demand-responsive scheduling and dispatching*—Depending on the importance of deviations in service design, demand levels, and operating environment, provisions for demand-responsive scheduling and dispatching range from the simplest arrangement of leaving those provisions entirely to drivers to much more elaborate arrangements with centralized scheduling using specialized software. In some cases, the use of centralized dispatching and software appears to reflect that these resources are available from a paratransit operation. Although some systems have plans for digital communications with automatic vehicle location, only two transit systems surveyed were currently making any use of such tools for demand-responsive dispatching in their existing flexible service operations. This holds true even in transit systems that have these tools installed in their fleets for routine supervisory control. At least in the case of demand-responsive connector services, the experiences of some systems indicate that it is possible to design a service so that drivers can schedule efficiently on their own, even at relatively high ridership levels.
- *Cellular telephones*—Cellular telephones are used for communicating demand-responsive service requests in many systems for several reasons, including considerations of privacy, limited radio range, and the ability to route calls directly from passengers to drivers. None of the agencies indicated any problems from the distraction of talking on a cell phone or drivers' making inappropriate personal use of the phones. This may be an area where further investigation would be useful.

- *Staff selection and training*—To operate flexible service, drivers need to have a thorough knowledge of the area in which they must provide demand-responsive service or in some cases specific stops that are served on a demand-responsive basis. In addition, they need to be well versed in whatever procedures apply to scheduling and dispatching of demand-responsive trips. Operators reported no problems with driver assignments using conventional bidding by seniority. However, it is important that drivers understand the degree of independent decision making and passenger communication involved in flexible operation, so that they can assess whether it is something they want to do. The research provided little evidence about specific training requirements for flexible service dispatchers. Staff selection and training appear to be an area in which additional research and guidance could be useful.
- *Contracting*—Most flexible service is operated by contractors, usually because all of a transit agency's service is contracted or because flexible service is operated by a contractor that does other work, especially paratransit. No examples were found of transit agencies that contract only for flexible service.
- *Vehicles*—Choice of vehicle is commonly based on availability as a result of vehicles being used for other services, maneuverability on narrow streets, passenger loads, community perceptions and acceptability, and the possibility of operation by drivers without a commercial driver's license. The result is that most flexible services use some type of van or small body-on-chassis bus. Many operators would prefer to operate some other vehicle type than the one being used. Problems mentioned with existing vehicles included that they are too large or too small, lack amenities, and are not sufficiently durable.
- *Barriers and opportunities*—The primary barrier to implementing flexible services where transit agency staff feel they would be appropriate is a lack of funding. In some cases, transit agencies have replaced flexible services with fixed-route services. These are situations where staff has determined that flexible operation is less attractive to riders than fixed-route service in particular service areas. However, interest in adding or expanding flexible service remains strong. Fourteen of the surveyed transit systems reported that they see future opportunities to implement new flexible services or expand existing ones.
- *Suggestions for further study*—Because there are no established planning or design guidelines available to help transit planners, creating flexible services currently requires a willingness to experiment. Providing such guidelines may be useful to speed adoption of flexible services where they would be appropriate. Such guidelines might specify the following:

  - Useful data to collect, plan, and design flexible service;
  - Types of flexible service that are appropriate for various land use and demand patterns;
  - Procedures for scheduling, including appropriate amounts of slack time to allow for demand-responsive operation;
  - Operating procedures, vehicles, and technologies that are appropriate for various service types, levels of service, and institutional settings;
  - Appropriate training for dispatchers and drivers; and
  - Considerations for performance monitoring and evaluation.

Several transit systems mentioned using cell phones for communicating some or all demand-responsive service requests. Considering safety concerns about the use of cell phones while driving, it would be useful to know more about effective procedures for using cell phones and under what circumstances their use is advisable or necessary.

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GLOSSARY

ADA (Americans with Disabilities Act)—1991 Act that contains provisions on the acquisition of accessible vehicles by public and private entities, requirements for complementary paratransit service by public entities operating a fixed-route system, and provision of nondiscriminatory accessible transportation service.

AVL (automatic vehicle location)—Computer-based vehicle tracking based on location technology, such as the Global Positioning System.

CDPD (cellular digital packet data)—Technology, using existing cellular telephone infrastructure, that detects idle air time and sends small packets during this idle time. CDPD users are charged on a per-packet basis, so they are not paying for time that is unused.

Complementary paratransit—Specialized demand-responsive service provided for people who cannot use fixed-route transit or rail service owing to a disability, meeting specific comparability requirements as established by the ADA. The service is called "complementary" because it complements fixed-route service; that is, it provides additional service needed to make the entire system usable by people with disabilities.

Curb-to-curb service—Demand-responsive service that picks up and delivers passengers at the curb or roadside nearest their origin or destination. Passenger assistance is not provided other than for actual boarding and alighting.

Demand-responsive—Characteristic of transit service in which vehicles are routed according to passenger boarding and alighting requests.

Demand-responsive connector—Transit service where vehicles operate in demand-responsive mode within a zone, with one or more scheduled transfer points that connect with a fixed-route network. A high percentage of ridership consists of trips to or from the transfer points.

Deviation—Vehicle movement that departs from a fixed route to respond to a passenger boarding or alighting request.

Dial-a-ride—Form of demand-responsive public transportation without fixed stops or fixed schedules, in which vehicle routing is determined entirely in response to passenger service requests made by telephone or similar means.

Dispatching—Process of monitoring vehicle operations and issuing instructions to drivers by radio or similar means to make adjustments to a preplanned schedule. In a demand-responsive transit system, dispatching typically includes changes to the schedule of pick-ups and drop-offs owing to no-shows, traffic delays, vehicle breakdowns, etc. In a system that permits short-notice trip requests, the processes of scheduling and dispatching may merge.

Door-to-door service—Demand-responsive service that picks up passengers at the door of their place of origin and delivers them to the door of their destination. The driver escorts or physically assists passengers between the vehicle and door of the origin or destination. Door-to-door service provides a higher level of assistance than curb-to-curb service. Sometimes the term is used loosely as a synonym for "demand-responsive service."

Fixed-route service—Conventional transit service in which buses operate along published routes according to a published timetable. Although the route or schedule may vary by time of day, it does not vary in response to requests from passengers. Stops may be only at designated points or at flag stops.

Flag stop—Location on an established rail line or fixed route that is not a station or marked bus stop, but at which vehicles will stop to board or discharge passengers on request.

Flexible-route segment service—Transit service in which vehicles operate in conventional fixed-route, fixed-schedule mode, but switch to demand-responsive operation for a limited portion of the route.

Flexible transit services—Transit services that are not pure demand-responsive service (including dial-a-ride and ADA paratransit) or fixed-route service, but that fall somewhere in between these traditional service models. Flexible transit services have some established stop locations and/or some established schedule, combined with some degree of demand-responsive operation.

GPS (Global Positioning System)—Technology using signals transmitted from a network of satellites in orbit to determine locations on earth.

Headway—Length of time at a stop between buses following the same route. Short headways correspond to high-frequency service, whereas long headways correspond to low-frequency service.

Human services agency—Government or not-for-profit organization that provides services for essential needs such as medical care, income support, housing, education, training, and public health, typically for people requiring help because of age, disability, low income, or similar reasons.

Human services transportation—Transportation provided by or on behalf of a human services agency to bring people participating in the agency's programs or services to those programs or services.

ITS (intelligent transportation systems)—Advanced technologies applied to various aspects of transportation to enhance mobility, energy efficiency, and environmental protection.

IVR (interactive voice response)—Software application that accepts a combination of voice telephone input and touch-tone keypad selection and provides appropriate

responses in the form of voice, fax, callback, e-mail, or other media. IVR is usually part of a larger application that includes database access.

MDT (mobile data terminal)—Display unit, usually consisting of a screen and keys, which is used to communicate data between a dispatch office and the driver of a transit vehicle. Sometimes also refers to an integrated on-board device that combines an MDT with a vehicle logic unit and other devices such as GPS, a communications interface, or smart card reader.

Paratransit—Most commonly used to refer to specialized demand-responsive service provided for seniors and people with disabilities, especially ADA-complementary paratransit. Historically the term has been used to refer to a variety of shared-ride transportation services other than conventional transit service, usually using small vehicles.

Personal rapid transit—Fixed-guideway transit using vehicles smaller than typical of a rail transit operation, with the capability of driverless, automated operation. As originally conceived, personal rapid transit would also include demand-responsive operation.

Point deviation—Transit service in which vehicles serve demand-responsive requests within a zone and also serve a limited number of stops within the zone without any regular path between the stops.

Productivity—Measure of the quantity of desired results produced per unit of resources applied. In transit, it is commonly measured using passenger trips per vehicle revenue hour or similar measures.

Request stop service—Transit service in which vehicles operate in conventional fixed-route, fixed-schedule mode and also serve a limited number of defined stops near the route in response to passenger requests. Request stops differ from flag stops in not being directly on the route.

Route deviation—Transit service in which vehicles operate on a regular schedule along a well-defined path, with or without marked bus stops, and deviate to serve demand-responsive requests within a zone around the path. The width or extent of the zone may be precisely established or flexible.

Scheduling—In a fixed-route service, the process of assembling vehicle runs to provide service according to a published timetable. In a demand-responsive service, the process of determining the path and schedule of vehicles in the system so that they serve the trips that have been requested. In a system that permits trips to be requested on short notice, the process of scheduling may be merged with dispatching.

Slack time—Amount by which the time scheduled for a process exceeds the time required for its completion. In demand-responsive or flexible transit, slack time refers to time in a vehicle schedule that is available to schedule a deviation or an additional passenger stop without affecting the rest of the schedule.

Standing order—See “Subscription.”

Subscription—In demand-responsive transit systems, a reservation to receive service at a recurring time or times every week.

Trip—May refer to a vehicle trip, which is a vehicle movement from one end of a route to another, or a passenger trip, which is a movement of passenger from origin to destination. Sometimes the term is also used to indicate unlinked passenger trips, which are passenger boardings on transit vehicles.

VRH (vehicle revenue hour)—Span of time when a vehicle is available for carrying passengers, including layover and recovery time, but excluding deadhead time to and from a vehicle storage location or break location, or between routes. Also called a vehicle service hour.

Zone route service—Transit service in which vehicles operate in demand-responsive mode along a corridor with established departure and arrival times at one or more end points. Approximate times in zones within the corridor may also be indicated.

TRANSIT AGENCY ABBREVIATIONS AND SERVICE NAMES

CAT—Capital Area Transit (Raleigh, North Carolina)

COTPA—Central Oklahoma Transit and Parking Authority (Oklahoma City, Oklahoma)

FWTA—Fort Worth Transportation Authority

GRTC—Greater Richmond Transit Company

LTD—Lane Transit District (Eugene, Oregon)

MTS—Metropolitan Transit System (San Diego, California)

MVTA—Minnesota Valley Transit Authority (Burnsville, Minnesota)

NCTPA—Napa County Transportation Planning Agency (Napa, California)

OTA—Ottumwa Transit Authority (Ottumwa, Florida)

PRTC—Potomac and Rappahannock Transportation Commission (Woodbridge, Virginia)

SCAT—Sarasota County Area Transit (Jacksonville, Florida)

The T—FWTA

Tri-Met—Tri-County Metropolitan Transportation District of Oregon (Portland, Oregon)

APPENDIX A

Survey Questionnaire

TRANSIT COOPERATIVE RESEARCH PROGRAM

Synthesis Topic SB-09

OPERATIONAL EXPERIENCES WITH FLEXIBLE TRANSIT SERVICES

Questionnaire

PURPOSE AND BACKGROUND

Your cooperation is requested in compiling a synthesis of the current use of flexible transit services. This synthesis aims to help transit systems understand how the appropriate use of flexible service may help them accomplish their missions.

For purposes of this project, "flexible transit services" includes all types of hybrid services that are not pure dial-a-ride service (including ADA paratransit) or fixed-route service, but that fall somewhere in between these traditional service models. In other words, the services of interest have some established stop locations and/or some established schedule, combined with some degree of demand-responsive operation. This definition includes route deviation services and other service types. If your agency operates flexible transit service, please complete this questionnaire and return it by mail or fax to:

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Tel: (415) 284-1544 E-mail: dkoffman@nelsonnygaard.com
Fax: (415) 284-1554

An electronic copy of the questionnaire is available at http://www.nelsonnygaard.com/flexible.

Person completing this questionnaire

Name and Title:_____

Name of Agency:_____

Address:_____

In the following questions, multiple responses are permitted: for each question that calls for choosing a response, circle the letters of all the answers that apply.

PART 1—SERVICE DESIGN

1. Briefly describe your flexible service(s). (If you operate more than one type of flexible service, please describe each type of service separately. Attach any brochures or marketing material that may be helpful.)

   Name(s) of service(s):_____

   Description(s): _____

   _____

   _____

   _____

2. In what year did your agency begin operating flexible service?_____

3. Which of the following best describes the operating method of your flexible service(s)? (If a service combines multiple methods, circle all that apply.)
   a. Fixed-route and schedule with limited off-route deviations mainly for passengers with disabilities
   b. Fixed-route and schedule with off-route deviations on request for the general public
   c. Demand-responsive operation connecting to conventional fixed-route at a timed transfer point
   d. Vehicles operating in fixed-route mode switch to some form of flexible operation for a portion of their route or in a designated area
   e. Fixed-route operated only on request
   f. Other:_____

4. Can passengers be picked up without a called-in request or prior reservation?
   a. No
   b. Yes, at any established stop along a route
   c. Yes, at a fixed-route transfer location
   d. Yes, at a limited number of designated locations within a demand-responsive service area
   e. Other:_____

5. Can passengers request demand-responsive pick-ups (i.e., pick-ups at locations away from a scheduled stop or route)?
   a. No
   b. Yes, through a dispatch center
   c. Yes, directly with drivers (e.g., by cell phone)
   d. Yes, by prior subscription or standing-order reservation
   e. Other:_____

6. Where will passengers be picked up for a demand-responsive service request?
   a At any safe location within the designated area of service
   b Only at designated points within the area of service
   c. Other:_____

7. Compared to the desired time of the pick-up, when are demand-responsive service requests accepted?
   a. At least _____ before the time of service
   b. No more than _____ before the time of service

8. Can passengers request demand-responsive drop-offs (i.e., at non-prescheduled locations)?
   a. No
   b. Yes, through a dispatch center
   c. Yes, by prior reservation made directly with the driver
   d. Yes, with the driver at the time of boarding
   e. Yes, by prior subscription or standing order
   f. Other:_____

9. Where will passengers be dropped off for a demand-responsive service request?
   a. At any safe location within the designated area of service
   b. Only at designated points within the area of service
   c. Other:_____

10. Compared to the desired time of the drop-off, when are demand-responsive service requests accepted?
   a. At least _____ before the time of service
   b. No more than _____ before the time of service

11. How is/are the demand-responsive service area(s) defined (e.g., a band around a route, a zone marked on a map, etc.)?
   _____
   _____
   _____

12. At scheduled departure points what is the average headway, in minutes, between vehicles?
   a. Peak periods: _____
   b. Midday: _____
   c. Evenings: _____
   d. Nights: _____
   e. Weekends: _____

13. During what types of hours does the flexible service operate?
   a. Similar to fixed-route base level of service
   b. Midday
   c. Evening
   d. Night
   e. Early morning
   f. Weekends

14. Is there any difference in fare structure for flexible service and local bus service?
   a. No
   b. Yes. If yes
      Flexible service fare(s):_____
      Local bus fare(s): _____

PART 2—SERVICE COORDINATION

15. How is the flexible service coordinated with conventional fixed-route service?
   a. Scheduled transfers
   b. Guaranteed transfers based on coordination in real time by drivers and/or dispatchers
   c. Free transfers
   d. Other:_____

16. In the area(s) with flexible service, do you also provide separate specialized paratransit for people with disabilities? (See also next question on this subject.)
   a. Yes
   b. No

17. Is the flexible service coordinated with specialized paratransit for people with disabilities in any of the following ways?
   a. Shared use of vehicles
   b. Scheduled or dispatched by the same staff
   c. Trip sharing: individual trips may be traded between services
   d. Other:_____

PART 3—PLANNING AND MARKETING

18. In what types of areas is flexible service provided?
    a. Urban
    b. Established suburban
    c. Low-density or recently developed suburban
    d. Small town
    e. Rural

19. Describe the role of the flexible service in your overall service plan.
    a. Primary service in a large area
    b. Primary service in limited "hard-to-serve" areas
    c. Replaces conventional service during low-demand times in a large area
    d. Replaces conventional service during low-demand times in limited areas
    e. Other: _____

20. What types of riders are the principal users of the service?
    a. Commuters
    b. Students
    c. Seniors
    d. Youth
    e. People with disabilities
    f. Other: _____

21. Please describe the circumstances that first led to introducing flexible service (e.g., financial circumstances, ridership trends, development, construction, service expansion, local politics, etc.). _____
    _____
    _____
    _____

22. Currently, what are the objectives or goals served by flexible service?
    _____
    _____
    _____
    _____

23. Please describe any special methods you have used to market this service and to educate the public about how it works.
    _____
    _____
    _____
    _____

PART 4—PERFORMANCE MEASUREMENT AND STANDARDS

24. Basic service statistics:

	Flexible	Conventional
Annual ridership (unlinked boardings):	_____	_____
Annual vehicle revenue hours:	_____	_____
Peak vehicles operated:	_____	_____
Time period of these data:	_____	_____

25. What is the productivity, measured as boardings per vehicle revenue hour, on your flexible services? (If this measure is not available, provide another measure and state what it is.)
    a. Poorest performing service: _____
    b. Best performing service: _____
    c. Average: _____

26. Is there a minimum ridership level that you consider necessary for retaining a flexible service? If so, what is it? (If possible, please state ridership in terms of boardings per vehicle revenue hour.)

    _____

27. Is this minimum level different from your minimum threshold for local bus services? If so, in what way is it different?

    _____

28. Is there a maximum ridership level above which you would not consider flexible service to be a viable alternative to conventional fixed-route service? If so, what is it?

    _____

29. What is the average operating cost for your flexible services, and how does this compare to similar measures for other services? (If possible, please state operating cost as operating cost per vehicle revenue hour.)
    a. Flexible: _____
    b. Conventional fixed-route, local, bus: _____
    c. General public dial-a-ride: _____
    d. Specialized paratransit: _____

30. Are any of the following used to control the operating cost of your flexible services?

	Used for flexible? (mark if yes)	Used for other services? (please indicate which)
a. Contracting	☐	_____
b. Special driver wage provisions	☐	_____
c. Sharing vehicles with other services	☐	_____

PART 5—OPERATIONS

31. Please describe how any of the following types of equipment or materials are used to manage demand-responsive operations. (Mark each item that is used and describe briefly the procedures that apply to it.)

    a. Voice radio_____
    _____
    b. Digital communications to/from mobile data terminals_____
    _____
    c. Cell phones_____
    _____
    d. Printed manifests or trip sheets_____
    _____
    e. Manual mapping aids for planning vehicle tours_____
    _____
    f. Scheduling and dispatch software_____
    _____
    g. Interactive voice response telephone system_____
    _____
    h. Internet_____
    _____
    i. Automatic vehicle location_____
    _____

32. In a typical hour (60 minutes) of vehicle operation in flexible service, approximately how many minutes are allotted for:
    a. Traveling between scheduled stops, including serving passengers at these stops: _____
    b. Serving demand-responsive service requests: _____
    c. Recovery time: _____

33. Please describe any special training provided to personnel that operate flexible services that are different than the training provided to staff that operate other services.
    a. Drivers:_____
    b. Schedulers or dispatchers:_____

34. How are drivers selected to operate the flexible service?
    _____

35. What type(s) of vehicles is/are operated in flexible service (e.g., make, model, seating capacity, lift/ramp equipped, wheelchair capacity)?
    _____

36. Why were these vehicles selected? Do you consider them appropriate?
    _____

37. Which of the following describes the use of vehicles for flexible service?
    a. Specific vehicles are dedicated to flexible service.
    b. Vehicles used in flexible service are also used in other services. Which services?_____

PART 6—BARRIERS AND OPPORTUNITIES

38. Have you encountered any barriers that may have prevented you from implementing flexible service in places where it appeared to be appropriate?
    a. No
    b. Yes. Please describe:_____

39. Do you see any further opportunities to implement flexible services?
    a. No
    b. Yes. Please describe:_____

40. Do you foresee any barriers that would have to be overcome in order to implement these services?
    a. No
    b. Yes. Please describe:_____

41. Have you had to discontinue any flexible services?
    a. No
    b. Yes. To what do you attribute the failure of this service?_____
    _____
    _____
    _____

42. To what do you attribute the level of success that you have had with flexible service?_____
    _____
    _____
    _____

43. Is there anything else you would like to add that may be helpful to other transit systems considering flexible services?_____
    _____
    _____
    _____

Thank you for your help.

APPENDIX B

Transit Systems Responding to the Survey

ARC Transit, Palatka, Florida
Capital Area Transit, Raleigh, North Carolina
Central Oklahoma Transit and Parking Authority, Oklahoma City, Oklahoma
Corpus Christi Regional Transportation Authority, Corpus Christi, Texas
Decatur Public Transit System, Decatur, Illinois
Fort Worth Transportation Authority, Fort Worth, Texas
Greater Richmond Transit Company, Richmond, Virginia
Hampton Roads Transit, Hampton, Virginia
Lane Transit District, Eugene, Oregon
Madison County Transit, Granite City, Illinois
Mason County Transit, Shelton, Washington
Metro Regional Transit Authority, Akron, Ohio
Metropolitan Transit System, San Diego, California
Minnesota Valley Transit Authority, Burnsville, Minnesota
Napa County Transportation Planning Agency, Napa, California
Ottumwa Transit Authority, Ottumwa, Iowa
Pierce Transit, Tacoma, Washington
Potomac and Rappahannock Transportation Commission, Woodbridge, Virginia
River Valley Metro Mass Transit District, Kankakee, Illinois
Sarasota County Area Transit, Venice, Florida
St. Joseph Transit, St. Joseph, Missouri
Tillamook County Transportation District, Tillamook, Oregon
Tri-Met, Portland, Oregon
Winnipeg Transit System, Winnipeg, Manitoba, Canada

APPENDIX C

Brief Descriptions of Reported Flexible Services

DEMAND-RESPONSIVE CONNECTOR SERVICES

Capital Area Transit, Raleigh, North Carolina

Service Name: CAT Connector.

Description: Demand-responsive connector service in zones replaces most fixed routes evenings, nights, and early mornings. One urban area has daytime demand-responsive connector service.

Demand-Responsive Operation: Passengers request pick-ups within the zones by calling dispatch at least 1 h in advance. Passengers boarding at transfer points inform the driver of their desired drop-off location at the time of boarding.

Basic Adult Fare: $0.75 (same as regular fixed-route service).

METRO Regional Transit Authority, Akron, Ohio

Service Name: Night zones.

Description: At 12:00 midnight and 12:30 a.m., four buses leave the downtown transfer center and at 1:00 a.m., three buses leave downtown. Each bus serves all the stops normally served by routes in one sector of the service area.

Demand-Responsive Operation: Passengers board the bus assigned to the sector that includes their desired destination stops and inform the driver of their desired stops. Each driver makes up a route that covers the requested stops.

Basic Adult Fare: $1.00 (same as regular fixed-route service).

Pierce Transit, Tacoma, Washington

Service Name: Key Loop, Orting Loop.

Description: A demand-responsive connector operates in rural areas, using vehicles that are a part of the paratransit system so that no resources are used if there are no calls for service.

Demand-Responsive Operation: All rides must be booked 1 to 5 days in advance.

Basic Adult Fare: Free (local bus service costs $1.25).

Note: After the research for this project was completed, the Key Loop was replaced by Route 113 Bus Plus, which serves 9 scheduled stops and 16 request stops, with service every 2 h.

Sarasota County Area Transit, Sarasota, Florida

Service Name: SCAT About.

Description: Service to Venice Island is provided by one fixed route and a demand-responsive connector that meets the fixed route once an hour at a transfer point.

Demand-Responsive Operation: Reservations made by 2:00 p.m. the previous day and at least 24 h in advance are guaranteed. Others are served on a space-available basis.

Basic Adult Fare: $1.00 for demand-responsive service, $0.50 for the fixed route on the island.

Tri-Met, Portland, Oregon

Service Name: Cedar Mill Shuttle.

Description: During peak periods, a demand-responsive connector provides service to and from a transit center approximately every 15 min.

Demand-Responsive Operation: Most trips are repeat trips by registered passengers. Reservations are also accepted a day ahead and up to 30 min before service if space is available.

Basic Adult Fare: Same as other services, $1.30 for one zone or $1.60 for multiple zones including transfer privileges.

Winnipeg Transit System, Winnipeg, Manitoba

Service Name: DART.

Description: Demand-responsive connector service is in four zones with established drop-off locations. Three zones operate evenings, Saturday morning, and all day Sunday. One zone operates middays on weekdays and all day Saturday. DART operates in areas or times with low demand and or circuitous street patterns.

Demand-Responsive Operation: Passengers request drop-offs when they board at the transfer point with the fixed-route system. Drop-offs are mostly limited to marked stops. Pick-ups at home are requested by calling the drivers (one per zone) via cell phone at least 30 min in advance.

Basic Adult Fare: $1.75 (transfers between DART and fixed-route buses are free).

FLEXIBLE-ROUTE SEGMENTS

Corpus Christi Regional Transportation Authority, Corpus Christi, Texas

Service Name: Route 67 Bishop Driscoll.

Description: A route connecting two rural communities with downtown Corpus Christi makes scheduled pick-ups at one location in one community and two in the other, and also operates in demand-responsive mode within the area of the two communities before proceeding to a scheduled terminus in town. The process is reversed for outbound trips.

Demand-Responsive Operation: Passengers request demand-responsive pick-ups by calling a dispatcher up to 1 h before the scheduled pick-up time.
Basic Adult Fare: $1.00 for all trips.

Lane Transit District, Eugene, Oregon
Service Name: Diamond Express.
Description: A route connecting a rural community to Eugene–Springfield provides curb-to-curb, demand-responsive drop-offs and pick-ups within Eugene–Springfield for the midday runs only.
Demand-Responsive Operation: Passengers inbound from Eugene–Springfield from rural areas can tell the driver on the midday run where they want to go in the urban area and also schedule a pick-up for the return trip.
Basic Adult Fare: $2.50 (no extra charge for curb-to-curb service).

REQUEST STOPS

Decatur Public Transit System, Decatur, Illinois
Service Name: Decatur Public Transit System.
Description: Two routes provide scheduled service to two off-route stops at peak times and by request at other times.
Demand-Responsive Operation: Passengers call dispatch for a pick-up or request a drop-off with the driver. Requests are accepted on short notice as long as there is enough time to schedule the deviation.
Basic Adult Fare: $0.75 (no extra charge for request stop service).

Hampton Roads Transit, Hampton, Virginia
Service Name: HRT On Call.
Description: Short segments on two routes are operated only in response to riders' requests.
Demand-Responsive Operation: Passengers request on-call service at most 30 min and at least 15 min in advance either by calling dispatch or requesting directly with the driver.
Basic Adult Fare: $1.50 (no extra charge for request stop service).

Mason County Transportation Authority, Shelton, Washington
Service Name: Mason Transit.
Description: Rural routes covering very long distances require a call ahead or request on the bus to serve certain stops that are off the highway or hard for the driver to see.
Demand-Responsive Operation: Passengers call dispatch or request a drop-off with the driver.
Basic Adult Fare: Free within Mason County, $1.00 for regional routes (no surcharge for call/request stops).

Minnesota Valley Transit Authority, Burnsville, Minnesota
Service Name: Local Route 440.
Description: A conventional fixed route has eight stops near the route that are served only by passenger request. The request stops serve major destinations that have poor pedestrian accessibility from the regular route.
Demand-Responsive Operation: Pick-ups must be requested by phoning the dispatch center at any time before the bus arrives in the area. Drop-offs may be requested with the driver on the bus.
Basic Adult Fares: $1.25 non-rush hour, $1.75 rush hour. There is no surcharge for deviations.

POINT DEVIATION

Central Oklahoma Transit and Parking Authority, Oklahoma City, Oklahoma
Service Name: METRO Link.
Description: Point deviation services replace fixed-route services nights and Sundays in five zones, and operate all day in one outlying area.
Demand-Responsive Operation: Buses make scheduled stops at a very limited number of fixed points. Pick-ups are scheduled by calling dispatch by 4:00 p.m. the previous day.
Basic Adult Fare: $1.25 per zone to maximum of $2.50 per trip (local bus fare is $1.25).

Fort Worth Transportation Authority, Fort Worth, Texas
Service Name: Rider Request.
Description: Demand-responsive service in specified zones, with two to three scheduled stops in each zone, mostly at transfer points with fixed routes.
Demand-Responsive Operation: Demand-responsive service scheduled by subscription and requests made through a dispatcher at least 1 h in advance.
Basic Adult Fare: $1.25 (same as local bus fare).
Note: This service was discontinued in 2003 after several years of operation. One remaining Rider Request service operates as a demand-responsive connector.

River Valley Metro Mass Transit District, Kankakee, Illinois
Service Area: Bourbonnais Flex.
Description: A route serves two end points and one other stop at scheduled times, and demand-responsive requests within the village of Bourbonnais.
Demand-Responsive Operation: Passengers request pick-ups by calling dispatch at least 1 h in advance; drop-offs may be requested on board the bus at the time of boarding. Buses serve demand-responsive request by stopping at the nearest corner.
Basic Adult Fare: $1.00. There is no surcharge for deviations.

ROUTE DEVIATION

ARC Transit, Palatka, Florida

Service Name: Ride Solution.

Description: Four rural intercity routes and one route within the city of Palatka are constructed on the basis of the needs of the human services agencies and are all available to the general public at any published stop without a reservation.

Demand-Responsive Operation: The human services agency component operates in demand-responsive mode (primarily based on subscriptions) between the bus stops.

Basic Adult Fare: $1.00. Demand-responsive service is sponsored by participating human services agencies for their clients.

Greater Richmond Transit Company, Richmond, Virginia

Service Name: Chesterfield LINK.

Description: Routes serve a suburban jurisdiction with demand-responsive deviations within three-quarter mile bands around the routes. Service for the general public and ADA paratransit is provided by the same routes.

Demand-Responsive Operation: Deviation requests are made through a dispatcher at least 1 day in advance.

(This service was discontinued in July 2003.)

Madison County Transit, Granite City, Illinois

Service Name: Madison County Transit.

Description: Local fixed routes are modified on selected trips to accommodate ADA paratransit subscription riders.

Demand-Responsive Operation: Deviations are scheduled only on a subscription basis. After research for this project was completed, MCT began a point deviation service called EZ Ride, consisting of general public dial-a-ride, serving a geographically defined zone, including eight fixed points within a zone and three more outside the zone. All trips must be reserved by telephone at least 2 h in advance. Each pick-up or drop-off away from one of the 11 fixed points adds $0.50 to the $1.00 base fare.

Mason County Transportation Authority, Shelton, Washington

Service Name: Mason Transit.

Description: Rural routes covering very long distances allow deviations to the extent that they can be accommodated in schedules. Drivers have discretion on whether to accept a deviation, and policies about the extent of deviations are informal. These deviations plus general dial-a-ride serve the general public—there is no separate ADA paratransit.

Demand-Responsive Operation: Passengers request deviations through dispatch at least 1 h in advance or with the driver on the bus.

Basic Adult Fare: Free within Mason County, $1.00 for regional routes (no surcharge for deviations).

Metropolitan Transit Development Board, San Diego, California

Service Name: Routes 961–964.

Description: Four routes will deviate up to one-quarter mile.

Demand-Responsive Operation: Passengers request deviations through dispatch at least 2 h in advance or with driver on the bus. Buses will deviate to any location in the designated deviation area that can be safely served.

Basic Adult Fare: $1.00

METRO Regional Transit Authority, Akron, Ohio

Service Name: Town Center Routes.

Description: Four routes serving outlying portions of the county can deviate up to one-half mile from the route. Deviations are not publicized and are provided at the driver's discretion.

Demand-Responsive Operation: Most deviations are subscriptions. Requests for deviations can be made with 24 h notice.

Basic Adult Fare: $1.00.

Minnesota Valley Transit Authority, Burnsville, Minnesota

Service Name: Flex Routes 420 and 421.

Description: Within a suburban transit network, two routes operate on established routes within zones that define permissible deviations ranging from roughly one-quarter mile to 1 mile. The routes serve low-demand, spread-out areas.

Demand-Responsive Operation: Pick-ups must be requested by phoning the dispatch center at any time before the bus arrives in the area. Drop-offs must be requested with the drive on the bus.

Basic Adult Fare: $1.00 on route, $0.50 off-route surcharge.

Napa County Transportation Planning Agency, Napa California

Service Name: St. Helena and Yountville Shuttles.

Description: Route deviation services are provided in two small towns, operated by the countywide operator in response to local preferences. Both services connect to a regional route.

Demand-Responsive Operation: Deviation requests are made by phoning 20 min in advance. Deviations are provided anywhere within each of the two towns.

Ottumwa Transit Authority, Ottumwa, Iowa

Service Name: Ottumwa Transit Authority.

Description: Small town fixed-route service provides limited deviations near the routes to accommodate custom-

ers with special needs and reduce dependence on paratransit.

Demand-Responsive Operation: Deviations are requested at least 10 min in advance by calling dispatch or asking the drivers, who radio dispatch for final approval.

Basic Adult Fare: $1.00. No extra charge for deviations.

Potomac and Rappahannock Transportation Commission, Woodbridge, Virginia

Service Name: OmniLink.

Description: Areawide local transit service consists of scheduled routes that deviate up to three-quarters of a mile.

Demand-Responsive Operation: Off-route pick-up requests are made by calling dispatch at least 2 h in advance. Passengers are picked up within a few blocks of their requested location.

Basic Adult Fare: $1.00 on route, $2.00 off route.

Note: Off-route surcharge was added in October 2003. There is no off-route surcharge for elderly and disabled riders.

St. Joseph Transit, St. Joseph, Missouri

Service Name: St. Joseph Transit.

Description: A network of routes serves the city of St. Joseph. Deviations are available to any safe address in the city.

Demand-Responsive Operation: Deviations can be scheduled by calling dispatch at any time before the desired time of service, by subscription, or with the driver at the time of boarding.

Basic Adult Fare: $0.50 plus $0.10 per deviation.

Tillamook County Transportation District, Tillamook, Oregon

Service Name: Deviated Fixed Route.

Description: Rural routes with flag stops and an informal deviation area.

Demand-Responsive Operation: Deviation requests can be made through dispatch at least 2 h in advance or with the driver at the time of boarding.

Basic Adult Fare: $1.00 per zone (maximum three zones). There is no surcharge for deviations.

ZONE ROUTE

Mason County Transportation Authority, Shelton Washington

Service Name: Mason Transit.

Description: One trip per day leaves from Shelton (the principal city of the county) and provides drop-offs and pick-ups within demand-responsive corridor defined by natural barriers and the road network. Most trips are to or from Shelton.

Demand-Responsive Operation: Passengers request service in advance through dispatch. Pick-ups and drop-offs are at passengers' homes and at informal meeting points.

Basic Adult Fare: Free.

Abbreviations used without definition in TRB Publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ITE	Institute of Transportation Engineers
NCHRP	National Cooperative Highway Research Program
NCTRP	National Cooperative Transit Research and Development Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
TCRP	Transit Cooperative Research Program
TRB	Transportation Research Board
U.S.DOT	United States Department of Transportation