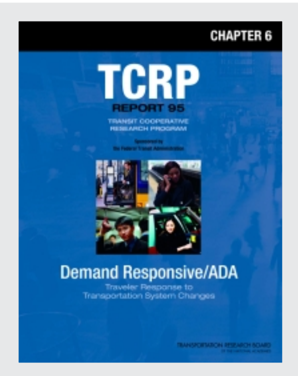

Traveler Response to Transportation System Changes Handbook, Third Edition: Chapter 6: Demand-Responsive/ADA

DETAILS

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TCRP REPORT 95

Traveler Response to Transportation System Changes

Chapter 6—Demand Responsive/ADA

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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 Urban Mass Transportation Administration—now 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 Academies, 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 any time. 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 the Transportation Research Board. 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. The TCRP results support and complement other ongoing transit research and training programs.

TCRP REPORT 95: Chapter 6

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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 National Research Council, the Transit Development Corporation, 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.

Special Notice

The Transportation Research Board, the National Research Council, the Transit Development Corporation, and the Federal Transit Administration (sponsor of the Transit Cooperative Research Program) do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the clarity and completeness of the project reporting.

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FOREWORD

By Stephan A. Parker
Staff Officer
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TCRP Report 95: Chapter 6, Demand Responsive/ADA will be of interest to transit and transportation planning practitioners, educators, researchers, and professionals across a broad spectrum of transportation and planning agencies; MPOs; and local, state, and federal government agencies.

Chapter 5, "Vanpools and Buspools," should be consulted for the vanpool form of paratransit—a complementary mode that may be paired with dial-a-ride for low-density suburbs transit service—and also for adaptation of vanpooling to ADA client needs.

The overarching objective of the *Traveler Response to Transportation System Changes Handbook* is to equip members of the transportation profession with a comprehensive, readily accessible, interpretive documentation of results and experience obtained across the United States and elsewhere from (1) different types of transportation system changes and policy actions and (2) alternative land use and site development design approaches. While the focus is on contemporary observations and assessments of traveler responses as expressed in travel demand changes, the presentation is seasoned with earlier experiences and findings to identify trends or stability, and to fill information gaps that would otherwise exist. Comprehensive referencing of additional reference materials is provided to facilitate and encourage in-depth exploration of topics of interest. Travel demand and related impacts are expressed using such measures as usage of transportation facilities and services, before-and-after market shares and percentage changes, and elasticity.

The findings in the *Handbook* are intended to aid—as a general guide—in preliminary screening activities and quick turn-around assessments. The *Handbook* is not intended for use as a substitute for regional or project-specific travel demand evaluations and model applications, or other independent surveys and analyses.

The Second Edition of the handbook *Traveler Response to Transportation System Changes* was published by USDOT in July 1981, and it has been a valuable tool for transportation professionals, providing documentation of results from different types of transportation actions. This Third Edition of the *Handbook* covers 18 topic areas, including essentially all of the nine topic areas in the 1981 edition, modified slightly in scope, plus nine new topic areas. Each topic is published as a chapter of *TCRP Report 95*. To access the chapters, select "TCRP, All Projects, B-12" from the TCRP website: http://www4.national-academies.org/trb/crp.nsf.

A team led by Richard H. Pratt, Consultant, Inc. is responsible for the *Traveler Response to Transportation System Changes Handbook, Third Edition*, through work conducted under TCRP Projects B-12, B-12A, and B-12B.

REPORT ORGANIZATION

The *Handbook*, organized for simultaneous print and electronic chapter-by-chapter publication, treats each chapter essentially as a stand-alone document. Each chapter includes text and self-contained references and sources on that topic. For example, the references cited in the text of Chapter 6, “Demand Responsive/ADA,” refer to the Reference List at the end of that chapter. The *Handbook* user should, however, be conversant with the background and guidance provided in *TCRP Report 95: Chapter 1, Introduction*.

Upon completion of the *Report 95* series, the final Chapter 1 publication will include a CD-ROM of all 19 chapters. The complete outline of chapters is provided below.

Handbook Outline Showing Publication and Source-Data-Cutoff Dates

General Sections and Topic Area Chapters (TCRP Report 95 Nomenclature)	U.S. DOT Publication First Edition	U.S. DOT Publication Second Edition	TCRP Report 95 Source Data Cutoff Date	TCRP Report 95 Estimated Publication Date
Ch. 1 – Introduction (with Appendices A, B)	1977	1981	2003[a]	2000/03/04[a]
Multimodal/Intermodal Facilities				
Ch. 2 – HOV Facilities	1977	1981	1999	2000/04[b]
Ch. 3 – Park-and-Ride and Park-and-Pool	—	1981	2003[c]	2004[d]
Transit Facilities and Services				
Ch. 4 – Busways, BRT and Express Bus	1977[e]	1981	2003[c]	2004[d]
Ch. 5 – Vanpools and Buspools	1977	1981	1999	2000/04[b]
Ch. 6 – Demand Responsive/ADA	—	—	1999	2000/04[b]
Ch. 7 – Light Rail Transit	—	—	2003	2004[d]
Ch. 8 – Commuter Rail	—	—	2003	2004[d]
Public Transit Operations				
Ch. 9 – Transit Scheduling and Frequency	1977	1981	1999	2000/04[b]
Ch. 10 – Bus Routing and Coverage	1977	1981	1999	2000/04[b]
Ch. 11 – Transit Information and Promotion	1977	1981	2002	2003
Transportation Pricing				
Ch. 12 – Transit Pricing and Fares	1977	1981	1999	2000/04[b]
Ch. 13 – Parking Pricing and Fees	1977[e]	—	1999	2000/04[b]
Ch. 14 – Road Value Pricing	1977[e]	—	2002–03[f]	2003
Land Use and Non-Motorized Travel				
Ch. 15 – Land Use and Site Design	—	—	2001–02[f]	2003
Ch. 16 – Pedestrian and Bicycle Facilities	—	—	2003	2004[d]
Ch. 17 – Transit Oriented Design	—	—	2003[d]	2004[d]
Transportation Demand Management				
Ch. 18 – Parking Management and Supply	—	—	2000–02[f]	2003
Ch. 19 – Employer and Institutional TDM Strategies	1977[e]	1981[e]	2003	2004[d]

NOTES: [a] Published in TCRP Web Document 12, *Interim Handbook* (March 2000), without Appendix B. The "Interim Introduction," published in Research Results Digest 61 (September 2003), is a replacement. Publication of the final version of Chapter 1, "Introduction," as part of the TCRP Report 95 series, is anticipated for 2004.

[b] Published in TCRP Web Document 12, *Interim Handbook*, in March 2000. Available now at http://www4.nas.edu/trb/crp.nsf/All+Projects/TCRP+B-12. Publication as part of the TCRP Report 95 series is anticipated for the second half of 2004.

[c] The source data cutoff date for certain components of this chapter was 1999.

[d] Estimated.

[e] The edition in question addressed only certain aspects of later edition topical coverage.

[f] Primary cutoff was first year listed, but with selected information from second year listed.

CHAPTER 6 AUTHOR AND CONTRIBUTOR ACKNOWLEDGMENTS

TCRP Report 95, in essence the Third Edition of the "Traveler Response to Transportation System Changes" Handbook, is being prepared under Transit Cooperative Research Program Projects B-12, B-12A, and B-12B by Richard H. Pratt, Consultant, Inc. in association with the Texas Transportation Institute; Jay Evans Consulting LLC; Parsons Brinckerhoff Quade & Douglas, Inc.; Cambridge Systematics, Inc.; J. Richard Kuzmyak, L.L.C.; SG Associates, Inc. (BMI-SG as of June 2003); Gallop Corporation; McCollom Management Consulting, Inc.; Herbert S. Levinson, Transportation Consultant; and K.T. Analytics, Inc.

Richard H. Pratt is the Principal Investigator. Dr. Katherine F. Turnbull of the Texas Transportation Institute assisted as co-Principal Investigator during initial Project B-12 phases, leading up to the Phase I Interim Report and the Phase II Draft Interim Handbook. With the addition of Project B-12B research, John E. (Jay) Evans, IV, of Jay Evans Consulting LLC was appointed the co-Principal Investigator. Lead Handbook chapter authors and co-authors, in addition to Mr. Pratt, are Mr. Evans (initially with Parsons Brinckerhoff); Dr. Turnbull; Frank Spielberg of SG Associates, Inc. (BMI-SG); Brian E. McCollom of McCollom Management Consulting, Inc.; Erin Vaca of Cambridge Systematics, Inc.; J. Richard Kuzmyak, initially of Cambridge Systematics and now of J. Richard Kuzmyak, L.L.C.; and Dr. G. Bruce Douglas, Parsons Brinckerhoff Quade & Douglas, Inc. Contributing authors include Herbert S. Levinson, Transportation Consultant; Dr. Kiran U. Bhatt, K.T. Analytics, Inc.; Shawn M. Turner, Texas Transportation Institute; Dr. Rachel Weinberger, Cambridge Systematics (now of Nelson/Nygaard); and Dr. C. Y. Jeng, Gallop Corporation.

Other research agency team members contributing to the preparatory research, synthesis of information, and development of this Handbook have been Stephen Farnsworth, Laura Higgins and Rachel Donovan of the Texas Transportation Institute; Nick Vlahos, Vicki Ruiter and Karen Higgins of Cambridge Systematics, Inc.; Lydia Wong, Gordon Schultz, Bill Davidson, and Andrew Stryker of Parsons Brinckerhoff Quade & Douglas, Inc.; Kris Jagarapu of BMI-SG; and Laura C. (Peggy) Pratt of Richard H. Pratt, Consultant, Inc. As Principal Investigator, Mr. Pratt has participated iteratively and substantively in the development of each chapter. Dr. C. Y. Jeng of Gallop Corporation has provided pre-publication numerical quality control review. By special arrangement, Dr. Daniel B. Rathbone of The Urban Transportation Monitor searched past issues. Assistance in word processing, graphics and other essential support has been provided by Bonnie Duke and Pam Rowe of the Texas Transportation Institute, Karen Applegate, Laura Reseigh, Stephen Bozik, and Jeff Waclawski of Parsons Brinckerhoff, others too numerous to name but fully appreciated, and lastly the warmly remembered late Susan Spielberg of SG Associates.

Special thanks go to all involved for supporting the cooperative process adopted for topic area chapter development. Members of the TCRP Project B-12/B-12A/B-12B Project Panel, named elsewhere, are providing review and comments for what will total over 20 individual publication documents/chapters. They have gone the extra mile in providing support on call including leads, reports, documentation, advice, and direction over what will be the eight-year duration of the project. Four consecutive appointed or acting TCRP Senior Program Officers have given their support: Stephanie N. Robinson, who took the project through scope development and contract negotiation; Stephen J. Andrle, who led the work during the Project B-12 Phase and on into the TCRP B-12A Project Continuation; Harvey Berlin, who saw the Interim Handbook through to Website publication; and Stephan A. Parker, who is guiding the entire project to its complete fruition. Editor Natassja Linzau is providing her careful examination and fine touch. The efforts of all are greatly appreciated.

Continued recognition is due to the participants in the development of the First and Second Editions, key elements of which are retained. Co-authors to Mr. Pratt were Neil J. Pedersen and Joseph J. Mather for the First Edition, and John N. Copple for the Second Edition. Crucial support and guidance for both editions was provided by the Federal Highway Administration's Technical Representative (COTR), Louise E. Skinner.

Frank Spielberg is the lead author for this volume: Chapter 6, "Demand Responsive/ADA." Contributing author for Chapter 6 is Richard H. Pratt. The primary development of this chapter took place in the Annandale offices of SG Associates, Inc., where projects benefited more than most realized from the influence of Mrs. Susan Spielberg. The authors dedicate this chapter in her memory.

Participation by the profession at large has been absolutely essential to the development of the Handbook and this chapter. Members of volunteer Review Groups, established for each chapter, reviewed outlines, provided leads, and in many cases undertook substantive reviews. Though all members who assisted are not listed here in the interests of brevity, their contribution is truly valued. A Chapter 6 review was undertaken by Review Group member Steven Polzin, and Charles Rutkowski stepped in to provide an additional outside review.

Finally, sincere thanks are due to the many practitioners and researchers who were contacted for information and unstintingly supplied both that and all manner of statistics, data compilations and reports. Though not feasible to list here, many appear in the "References" section entries of this and other chapters.

CHAPTER 6—DEMAND RESPONSIVE/ADA

CONTENTS

6 — Demand Responsive/ADA

OVERVIEW AND SUMMARY

Demand responsive transit, sometimes referred to as dial-a-ride or, more generally, paratransit, includes those services where a transit vehicle does not operate a fixed route, but rather calls at selected geographic points in response to specific service requests. Service may or may not be provided on a fixed schedule. Americans with Disabilities Act (ADA) services are a subgroup designed specifically for persons who, because of a disability, cannot access or ride available fixed route services. Traveler response and related information are presented in this chapter for both services open to the general public and ADA services intended for persons with disabilities.

Within this "Overview and Summary" section:

- "Objective of Demand Responsive/ADA Services" sets forth the generally accepted purposes of introducing demand responsive services.
- "Types of Demand Responsive Services" defines and describes the implemented or implementable types of service and service changes covered.
- "Analytical Considerations" offers guidance on the limitations of available research, and how that effects the confidence with which the information presented may be used.
- "Traveler Response Summary" highlights the travel demand findings for demand responsive/ADA services. It is not recommended that use be attempted of either the "Traveler Response Summary," or of the material which follows, without first absorbing the context provided by the first three sections of this "Overview and Summary" as a whole.

Following the four-part "Overview and Summary," greater depth and detail are provided:

- "Response by Type of Strategy" surveys traveler response information for each specific service approach and change, presented in terms of ridership, market shares and the like.
- "Underlying Traveler Response Factors" examines the interrelationships between service characteristics, demographics and demand.
- "Related Information and Impacts" presents special related subtopics.
- "Case Studies" expands on four instances of demand responsive/ADA applications.

The subject matter of this particular chapter is largely self-contained. Nevertheless, Chapter 5, "Vanpools and Buspools," should be consulted for the vanpool form of paratransit — a complementary mode that may be paired with dial-a-ride for low density suburbs transit service — and also for adaptation of vanpooling to ADA client needs.

Objective of Demand Responsive/ADA Services

The central objective of demand responsive services is to provide mobility via transit when:

- The density of demand is so low that the number of persons within the service area of a fixed route would not support the provision of adequate and economic conventional transit service.
- The individuals being served have mobility limitations or other conditions that, of themselves or in combination with other factors such as topography, distance or lack of adequate sidewalks, would prevent them from getting to and from a transit stop along a fixed route.

The first of these conditions applies to transit services open to the general public, although a related consideration is that Americans with Disabilities Act (ADA) requirements may be met concurrently using general public demand responsive services, a substantial economy in low demand density environments. The second condition applies specifically to provision of ADA services.

Types of Demand Responsive Services

Demand responsive/ADA services are described and defined here in terms of both "Modes of Operation" and "Types of Markets." For information on the prevalence and scope of demand responsive transit, see "Scale and Productivity of Demand Responsive Service" under "Related Information and Impacts."

Modes of Operation

Before describing types of markets served by demand responsive transit, the differentiation around which this chapter is organized, it is useful to identify the three basic modes of demand responsive operation — point-to-point, point deviation and route deviation.

Point-to-point. This strategy involves picking up one or more passengers at a given location, in response to a service request, and transporting the passenger(s) to a specific destination. If passengers traveling to or from other points are picked-up or dropped-off during the trip, this may be referred to as a shared service. Taxi services are typically point-to-point, non-shared services.

Point-to-point operations may function in several ways including:

- Many-to-many — Passengers are picked up at any point within a service area and transported to any other point within a service area. Services for persons with disabilities are typically operated in this manner.
- Many-to-one, one-to-many — Passengers are carried between a diverse set of origins (destinations) within a service area and a single destination (origin). Feeder services to or from a rail station are typically operated in this fashion, as are most services operated by human service agencies for client programs.
- Many-to-few, few-to-many — Passengers are carried between a diverse set of origins (destinations) and a limited number of destinations (origins).

- Few-to-few — Passengers are picked up at a limited number of pre-specified points (bus stops) and carried to any other stop within the service area. The intent is to provide service close to that offered by many-to-many operation, while reducing the number of operating variations through use of established stops. General public demand responsive services of this type have been proposed.

Point Deviation (or Checkpoint Deviation). This type of service is operated between two fixed endpoints, typically on a fixed schedule, and often over a general route defined by relatively widely spaced fixed stops. The vehicle will deviate up to some distance away from the route in response to a request to pick up or discharge passengers. In some cases, a "service zone" rather than a distance from a route is defined.

Route Deviation. This is a service operated between two fixed endpoints on a fixed schedule over a predefined route. Bus stops spaced in a manner typical of a fixed route are utilized. Vehicles may deviate off the route, however, in response to a passenger service request. The vehicles must return to the fixed route at essentially the same point from which the deviation was made, in order to serve the next bus stop. Route deviation is like point deviation with closely spaced checkpoints.

Point and route deviation services have been used when there are general demand corridors oriented toward a major generator, such as the center of a town or a shopping center, but the area for which coverage is required cannot be served by operating a single fixed route. Route and point deviation general public services have also been used in lieu of a fixed route in order to permit accommodating ADA related demand without a separate operation.

Any of the demand responsive services may be operated as point-to-point (individual addresses) or stop-to-stop (pre-designated boarding/alighting locations), although practically all are presently point-to-point when in the demand responsive mode. In turn, point-to-point services may be operated curb-to-curb (pick-up and drop-off on the roadway in front of an origin or destination) or door-to-door (driver escorts the rider to and from the doorway). General public service is typically curb-to-curb, while services for individuals with special needs may be curb-to-curb or door-to-door.

Types of Markets

Demand responsive services, using one of the operating patterns discussed above, may be deployed to serve a number of different types of markets. These include:

General Public, Urban Demand Responsive. This is the market of service operated in an urban (or more likely suburban) environment, available to all who wish to ride at an established fare. Persons wishing to travel must call ahead to request service. Calls are generally required at least two hours in advance of the requested trip time, but often the prior day. Return trips are usually scheduled at the same time. Many systems permit "standing orders" for regular trips, resulting in a near-"subscription" type of service.

General Public, Rural Demand Responsive. This is the corresponding service market in rural areas. Application of a demand responsive strategy to provide transit service is far more common in rural than urban areas, primarily as a result of the substantially lower demand densities and longer trip distances. Rural services are typically operated as many-to-one or many-to-few, with passengers gathered from dispersed origins and transported to specific destinations such as shopping areas, health centers and the like. Although rural services are often operated by social service agencies, with emphasis on taking agency clients to and from program activity sites, many such services are available for use by the general public as part of a coordinated system. Services are often restricted to specific times, for example, pick-ups at residences between 8:00 and 10:00 AM, or specific days, such as service on Tuesdays and Thursdays only.

Demand Responsive Feeders to Fixed Routes. A specialized market application of demand responsive services is their use for collection/distribution functions supportive of fixed route transit. The fixed routes may be either bus, such as in Norfolk, VA or Raleigh, NC; or rail, as in the case of CalTrain and Metro North commuter rail operations. The areas served by the demand responsive operation are typically limited to a specific set of neighborhoods or employment sites and are operated using a many-to-one strategy or point deviation.

ADA Complementary Services. Regulations implementing the Americans with Disabilities Act (ADA) require that some form of paratransit service be made available for persons who, because of a disability, cannot access or use conventional transit services. This complementary service must be available at the same times and in generally the same locations as conventional services. "Generally the same locations" has been interpreted as within 3/4 mile of a fixed route service. These ADA services are operated using a "call-for-service" system, typically as point-to-point dial-a-ride. Ridership is restricted to those who are certified as "ADA eligible" or who meet other criteria established by the transit operator.

Social Service Transportation. This is the market of service operated by or for a social service agency and available primarily or only to individuals who are clients of the agency and participating in agency programs. The time of travel and the destination of the trips are established by the agency rather than the traveler. Trips are almost always prescheduled. The operating strategy is many-to-one or many-to-few.

Analytical Considerations

Interpretation of traveler response to demand responsive transit is in many ways even more complex, and less well supported, than for fixed-route transit services. Variation in the service offered is inherently greater, available data bases are much more limited, and the history of observation is far shorter. Moreover, a lesser effort has been expended to monitor and understand paratransit travel behavior, both general public and ADA. All of this negatively impacts ability to readily synthesize and transfer knowledge between demand responsive transit contexts.

In addition to factors such as travel times and fares that affect ridership for all transit, demand responsive service introduces complexities related to:

- The requirement for and timing of pre-trip scheduling by the prospective rider.
- Routes and travel times that can vary day-to-day depending on demand.
- Eligibility requirements that, in some cases, restrict the class of riders that may be served.
- Numerous instances of supply constraints, particularly in the case of ADA services.

There is wide variation among systems in not only eligibility requirements for certain types of demand responsive services, such as ADA, but also in the stringency with which eligibility rules are applied. Observed use, particularly of ADA services, may be capacity constrained by available supply. When telephone calls for service are not answered, service requests cannot be accommodated, trips are missed because of resource constraints, and operators put aside promotion of overburdened and expensive to provide services, travelers are discouraged from system use. Such conditions are not readily apparent from most reported statistics.

"Before and after" data on the ridership results of changes in demand responsive service characteristics, and of introduction of new services, are scarce. Consequently, full use has been made of that which is available from controlled studies or detailed analyses sponsored by the Office of Service and Methods Demonstrations in the Urban Mass Transportation Administration (now Federal Transit Administration) during the 1970s and early 1980s. Much of the information related to topics such as provision of rural demand responsive services, and paratransit services required under the Americans with Disabilities Act, are derived in large measure from comparisons across several transit operations rather than through controlled observations of changes at a single agency. Other information is based on efforts to construct analytical models of travel behavior.

Although there are preliminary indications of operating efficiencies that may be gained with Advanced Public Transportation Systems innovations in demand responsive service request handling, information, and real time routing and scheduling, impacts on ridership of full-scale implementation can only be surmised. Related research to date has focused on technology development and application rather than investigation of ridership response, which it is early to assess in any case.

These various considerations argue that the users of this "Demand Responsive/ADA" chapter should:

- Use care, in developing estimates or expectations by means of analogy, to consider the effects of differing operating characteristics, eligibility requirements and capacity limitations along with locality-specific demographic and travel pattern factors.

- Take into account long-term changes in social programs, automobile ownership and availability, suburbanization of employment, and other relevant factors when using older data as a basis for anticipating future outcomes.

- Utilize conclusions drawn from comparisons across systems and research models with due caution, recognizing that observed and surveyed variations may be the result of unreported factors.

- Recognize that, for many types of evaluations, the state of the art in demand responsive/ADA travel demand analysis does not support much better than order-of-magnitude projections — the available information is most likely to be useful in assessing what might well work, or probably won't work, and which direction ridership is likely to move in response to contemplated changes.

Major case-specific concerns with respect to reliability of findings are highlighted, in the more detailed assessments following the "Traveler Response Summary," in connection with presenting the materials in question. Instances where the confidence that may be placed in reported findings is more than may immediately be apparent are also noted. Reference should also be made to the "Use of the Handbook" section of Chapter 1, "Introduction," for additional guidance on using the generalizations and examples provided in this *Traveler Response to Transportation System Changes* Handbook. Please note also that throughout the Handbook, because of rounding, figures may not sum exactly to totals provided, and percentages may not add to exactly 100.

Traveler Response Summary

Replacement of underutilized fixed route transit with demand responsive service, in appropriate settings, appears to have generally positive effects. Ridership is typically the same or greater so long as comparable levels of service are provided at not too high a fare. Introduction of demand responsive services in suburban areas without previous transit service has also been effective, with ridership taking about one year to begin stabilizing and two years to approach maturity.

Limited data suggest that utilization rates for urban, area-wide, general public demand responsive systems concentrate around 2 to 3 annual trips per capita, but range overall from 0.5 to 6 or 7 annual trips per capita. For rural passenger transportation systems, observed usage of the more typical operations is in the range of 2 to 5 annual trips per member of targeted elderly, low income and mobility-limited populations, increasing with higher service densities to ten or more times those values.

Demand responsive routes that provide primarily a feeder function for fixed route transit tend to have daily ridership in the range of 25 to 200 daily passenger trips. This applies for both residential area feeders and workplace distributor services.

ADA paratransit services have widely varying utilization rates, with one data set exhibiting an average of 0.24 annual trips per capita (total of able-bodied and disabled population). Various strategies to encourage ADA riders to switch to use of regular fixed routes have led to fixed route usage increases by the targeted disabled persons, but with little corresponding decrease in ADA paratransit use.

Ridership on demand responsive services is most directly related to the characteristics and size of the markets being served, as compared to the transit service per se. The primary service related factor is the amount of service provided, (vehicle-miles or vehicle-hours). Reported service supply elasticities are in the range of +0.5 to +1.8 for urban demand responsive services, and +0.6 to +1.1 for rural services, averaging +0.88 in both cases.[1] The limited number and manner of derivation of these elasticities suggest extra caution in their use, but they do appear to be comparable to conventional bus service coverage elasticities.

Travelers using demand responsive services are less sensitive to fares than service supply, with most reported fare elasticities in the general range of zero to -0.81, averaging -0.38. This average, essentially the same as for conventional bus service, is derived primarily on the basis of systems

[1] An elasticity of +0.88 indicates a 0.88 percent increase in transit trip demand in response to each 1 percent service increase, calculated incrementally. The positive sign indicates that the response moves in the same direction as the impetus, in contrast to price and fare elasticities, which are negative. An "elastic" value is 1.0 or beyond, and indicates a demand response which is more than proportionate to the change in the impetus. Elasticities reported in this chapter are thought to be log arc elasticities, unless otherwise noted, although there is some risk that individual fare "elasticities" may actually be shrinkage factors. (See "Concept of Elasticity" in Chapter 1, "Introduction," and Appendix A, "Elasticity Discussion and Formulae.")

open to the general public. Uncertainty is introduced by the small number of observations and by the anomalies among available findings, including reports of elastic response. Some evidence suggests that elderly and disabled travelers may not be very sensitive to fares when choosing between fixed route services and ADA paratransit.

Some limited ridership sensitivity to the days in advance of travel that a reservation must be made has been estimated, but there is practically no information on what the effects of real-time response to service requests might be. The top known performer in terms of riders per capita does happen to offer real time dispatching. Stated preference research suggests that reducing the advance reservation time for the initial trip may not be as important as reducing the wait for the return trip.

The reported productivity of demand responsive services measured in terms of passengers per revenue vehicle hour is typically lower than for fixed route, fixed schedule service alternatives, yet the cost per passenger and especially the total cost of providing service in a particular area tend to be less. This phenomenon results from the use by transit agencies of demand responsive services in environments of low demand density — those markets in which fixed route transit is at the greatest disadvantage. Additional cost savings can be achieved when use of general public demand responsive service obviates the need to offer a complementary paratransit service for persons with disabilities.

RESPONSE BY TYPE OF STRATEGY

Response to General Public, Urban Demand Responsive Services

Replacement of Fixed Route Service by Demand Responsive Service

Use of a demand responsive service strategy in place of fixed route, fixed schedule service has generally been adopted by communities or operators as a measure to contain costs rather than to improve service. In these instances, the overall cost of providing transit service or the cost per passenger of providing service on specific routes had risen over time to the point that some action was necessary, but termination of transit service was not an acceptable action. In these circumstances the actions taken have typically included not only a change in the service strategy, but also changes in passenger fares and the days and hours during which transit service is available.

The reported effectiveness of changing from fixed route to demand responsive service is somewhat mixed in terms of ridership attracted. Small to substantial ridership gains occurred in a majority of cases, and either stability after a period of adjustment or outright loss of ridership in other cases. In reported instances of substantial gains, very limited prior fixed route coverage may have been a factor, while substantial loss in one example may be attributable to other accompanying service reductions. Selected service changes and results are summarized in Table 6-1, followed by thumbnail sketches of the different operations and the ridership effects of conversion to demand responsive service.

Table 6-1 Response to Replacement of Fixed Route Bus Service with Demand Responsive Service

Place and Year Demand Response Service Introduced	Action	Change in Service Quantity	Change in Ridership	Other
Warsaw, IN (1995)	Change from fixed route to demand responsive with 3 scheduled points Operating hours extended "Deep discount" fare introduced; average fare *up* 12%	Service Miles: -24%	Ridership: +41%	300 riders per day 8 passengers per bus hour (1998)
Chippewa Falls, WI (1985)	Change from fixed route to shared ride taxi Service to Eau Claire eliminated Fare increased from $0.50 to $1.50	Service Hours: 10,417 per year Fixed Route 12,811 per year Demand Response	107,000 per year Fixed Route (1984) 34,600 per year Demand Response (1986)	
Hamilton, OH (1993)	Change from fixed route to point deviation demand responsive with timed transfer. Same fare	Same number of Service Hours	About 1,100 daily Fixed Route Initially 600 daily Demand Response After 1 year same as Fixed Route	6 (later 8) wedges with 1 vehicle @ All service terminated for unrelated reasons
Shakopee, MN (1984)	Change from fixed route to intra-suburb dial-a-ride service and vanpools for commuters		25-50 per day Fixed Route (1984) 130 per day Demand Response (1988)	0.32 passengers per vehicle mile (1988)
Norfolk, VA, Deep Creek territory (1981)	Change from fixed route to demand responsive Fare increased from $0.50 to $1.00 (after 6th month)	Service Hours: 300 per month for both Fixed Route and Demand Response	1,556 Fixed Route (Average month) 1,242 Demand Response (1st mo.) 1,617 Demand Response (6th mo.)	

Table 6-1 Response to Replacement of Fixed Route Bus Service with Demand Responsive Service (continued)

Place and Year Demand Response Service Introduced	Action	Change in Service Quantity	Change in Ridership	Other
Columbia, MD (1971)	Change from fixed route to demand responsive	See Table 6-2	60-80 per day Fixed Route 240 per day Demand Response	
Bay Ridges, Ontario (ca. 1970)	Change from fixed route to demand responsive (rail feeder)	See Table 6-2	109 per day Fixed Route 460 per day Demand Response	
Mansfield, OH (ca. 1969)	Change of 1 route from fixed route to route deviation	No change in frequency (30 min. headway)	+25% (approximately)	20%± used deviation service (15¢ extra fare)

Warsaw, Indiana. The Kosciusko Area Bus Service changed from fixed route to point deviation service in August 1995. At the same time, the service area and operating hours were extended and a "deep discount" fare structure was introduced.[2] Ridership increased 41 percent while total miles decreased 24 percent and fare revenue per passenger *increased* 12 percent. All buses are fully accessible so the agency was also able to eliminate costs related to ADA complementary services (Volinski, 1997).

The service area covers the communities of Warsaw and Winona Lake, Indiana, with a population of about 13,000 in an area of 20 square miles. Prior to 1991, service had been fully dial-a-ride. In 1991, the system converted to fixed route and experienced increasing costs and loss of ridership. The 1995 return to a demand responsive service is, in 1998, still viewed as successful — ridership is about 300 per day with productivity at about 8 passengers per bus hour (Kosciusko Area Bus Service, 1998).

Service is operated five days per week from 5:30 AM to 6:00 PM. Although described as point deviation, the service might more properly be characterized as point-to-point general public dial-a-ride. There are three fixed "points" — one in each of the downtowns and one at a shopping center — at which a bus will stop at a scheduled time once each hour. These scheduled stops are simply treated as service requests when the dispatch schedule is prepared.

The system has no required "call-ahead" time, although many trips are prescheduled. When a call is received for immediate service, central dispatch informs all buses in operation (five maximum) by radio. The drivers then communicate by radio and decide who will serve the

[2] Deep discount fare systems reward purchasers of bulk fare media with discounts but typically raise fares for cash fare patrons. See Chapter 12, "Transit Pricing and Fares," under "Response by Type of Strategy" — "Changes in Pricing Relationships" — "Discount Prepaid Fares."

request. About 80 percent of boardings are by some form of call-in with 20 percent at the scheduled stops. The typical rider is described as a poor, elderly, or disabled passenger.

Hamilton, Ohio. The Hamilton, Ohio (population 62,000) point deviation demand responsive system replaced eight fixed routes, which had been carrying about 1,100 riders per day. The entire system was converted to avoid the costs of a duplicative complementary paratransit service. A single pulse-point was established in downtown Hamilton where the point deviation routes came together on a timed-transfer schedule. The service area was divided into six (later, eight) wedges. A vehicle operated in each wedge, stopping at scheduled times at the downtown transfer point and a limited number of additional timepoints. The vehicles would also pick up and drop off passengers at any location within their assigned wedge and sometimes within adjacent wedges. Service hours and fares were the same as for the fixed route system. Passengers not traveling between timepoints were required to call a central dispatch at least one day prior to the desired travel day. Dispatching was partially decentralized; drivers could help each other.

The transition from fixed-route to fully demand responsive service proved difficult. The initial response overwhelmed the call processing system. Because potential riders had difficulty requesting trips or obtaining information on how to use the service, ridership initially fell to about 600 per day. By the end of the first year, however, ridership had returned to prior levels. Subsequently, for unrelated legal/financial reasons, the City of Hamilton terminated all transit services (Melaniphy, 1999).

Chippewa Falls, Wisconsin. In 1985, the City of Chippewa Falls, Wisconsin replaced fixed route services with a shared-ride taxi service. The fixed route service that had been provided through a contract between the City of Chippewa Falls and the Eau Claire Transit Commission included both intracity service and service between Chippewa Falls and Eau Claire. The shared-ride taxi service was limited to travel within Chippewa Falls. The adult fare per trip was increased from $0.50 to $1.50. A reduced fare was offered for trips pre-arranged one or more days in advance. Vehicle-hours of service increased from 10,417 for the fixed route system in the 1984 year to 12,811 for the shared-ride taxi service in 1986. Ridership declined from 107,000 in 1984 to 34,600 in 1986.

Riders received both advantages and disadvantages when shared-ride taxi service replaced fixed route, fixed schedule operations. On the plus side, passengers were picked up and dropped off at origins or destinations; they did not need to walk to or from bus stops. Hours of service became 6:00 AM to 7:00 PM rather than 7:00 AM to 5:15 PM. On the negative side, passengers had to call for service. As noted, the base fare was increased from $0.50 to $1.50. Intercity service to Eau Claire was eliminated — much of the decline in ridership was attributed to this factor (Carter-Gobel Associates, 1987).

Shakopee, Minnesota. In 1984, Shakopee, Minnesota, replaced fixed route bus operation with vanpool service for commuters, and dial-a-ride service for all with trip origins and destinations within the city limits. ADA service continued to be provided separately. The estimated 1989 population of this third tier Minneapolis suburb was 16,000, with a gross population density of 571 persons per square mile; less than 5 persons per acre throughout.

As of changes made in March, 1988, subscription and advance call-in fares were $1.25 for adults, $1.00 for students and 75¢ for senior citizens. Fares for less than 24-hour notice were $2.00, $1.50

and $1.00, respectively. Marketing consisted of having the dial-a-ride phone number painted on the vans, and simple brochures mailed out once a year.

The fixed route service that was replaced by the combined dial-a-ride and vanpool services carried 25 to 50 riders daily. The average weekday ridership on Shakopee's dial-a-ride alone was about 130 passengers in the first three quarters of 1988; on the order of 2.2 to 2.5 rides annually per inhabitant. Weekday daytime ridership was 1/4 senior citizens, 1/2 students, and 1/4 other general public, the latter mostly peak hour intra-city commuter trips. Evening and Saturday service, added in January, 1988, attracted mostly students with extra-curricular activities in the evening, but about 1/2 other general public on Saturdays. Service productivity was 0.32 passengers per vehicle mile. The October, 1987 through September, 1988 farebox recovery ratio was approximately 17 percent (Pratt, 1989).

Norfolk, Virginia. In 1980, the Tidewater Transportation District Commission (TTDC), the transit agency serving Norfolk, Virginia, replaced several low productivity fixed route, fixed schedule routes in outer portions of the service area with demand responsive services known as Maxi-Taxi (later changed to Maxi-Ride). The demand responsive service operated as dial-a-ride within a designated service area and connected to TTDC's fixed route services for travel to other portions of the service area.

The fare for Maxi-Taxi was initially the same as it had been for the fixed route bus service and the revenue vehicle-hours operated per month was also either the same or not drastically different. The major changes were that riders had to place a telephone call to obtain service, and in return received curb-to-curb carriage.

The reported monthly ridership for Bus Route 14 in late 1980 was 1,680. The average monthly ridership on the replacement Ocean View demand responsive service for the first six months of 1981 was 1,348, ranging from 1,242 in January to 1,617 in June prior to a fare increase. These data suggest an initial drop in ridership of about 25 percent, recovering over a six month period to nearly the same ridership as was carried by the fixed bus route. Results on other lines varied. Ridership in the Deep Creek service area nearly doubled compared to fixed route performance, whereas in the Coronado area ridership was halved (Becker and Echols, 1983). Further information is provided in the case study, "Demand Responsive Service in Low Productivity Areas — Norfolk."

Other Observations.[3] Additional information on replacement of fixed route, fixed schedule operation with demand responsive service is provided by early dial-a-bus experimentation. Two of these early applications are summarized in Table 6-2 in terms of service characteristics and ridership, with comparison to the fixed route service replaced. In Columbia, Maryland, the prior fixed route service had an observed ridership of 60 to 80 per day. This increased to 240 per day when dial-a-bus service was instituted. The Bay Ridges, Ontario service change was accompanied by over a fourfold increase in daily ridership, from 109 to 460. This system provided feeder service to GO Train commuter rail, serving primarily commuters, and permitted riders to place "standing orders" (Navin, 1974).

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[3] A reporting newly available as of this chapter's publication indicates that "more transit agencies are experimenting with flex routing" (route deviation). An example given is Madison County Transit's Route 6, in Illinois, where a flex route replacement for a lightly patronized fixed route was showing average ridership gains after two weeks of operation (Urban Transportation Monitor, 2003).

Table 6-2 Columbia, Maryland and Bay Ridges, Ontario Dial-a-Bus Systems

	Columbia, Maryland		Bay Ridges, Ontario	
Service Parameter	**Original Transit**	**Dial-a-Bus**	**Original Transit**	**Dial-a-Bus**
Walk to Transit	5 minutes	1 minute	3 minutes	1 minute
Wait for Transit	10 minutes [presumably a 20 min. frequency]	50-60 minutes from time of call for service	5 minutes	1 minute [presumably with standing order]
Ride Time (In-Vehicle-Time)	15 minutes	18 minutes	8 minutes	5 minutes
Daily Ridership	60 to 80	240	109	460

Source: Navin (1974).

An early demonstration of route deviation service took place in Mansfield, Ohio; population 50,000 in the late 1960s. Mansfield had a timed transfer, fixed route bus system focused on downtown with a daily ridership of approximately 5,000. Small buses and vans operated on a 30-minute headway, circulating outward from downtown and back in about 25 minutes. The lightly used fixed route serving the Woodland neighborhood was modified to introduce route deviation demand responsive service. Passengers could call directly to the driver to request pick-up at any location in the zone for travel to downtown Mansfield or, when boarding in downtown, could simply tell the driver where he or she wished to be dropped off. The charge for an off-route pick-up or drop-off was 15 cents in addition to the basic 35 cent fare. Otherwise, riders boarded or disembarked at points along the designated route. Roughly 20 percent of the patrons requested the route deviation service. The increase in Woodland ridership was reported to be 25 percent (Navin, 1974; Pratt and Bevis, 1971).

Introduction of Demand Responsive Service into Previously Unserved Areas

The system size and rider attraction of demand responsive services introduced in previously unserved areas have varied widely. Service characteristics and results for selected instances are summarized in Table 6-3. Brief sketches of each operation and its ridership follow.

Santa Clara County, California. The largest application of general public urban dial-a-ride was probably a service offered in 1974-75 by the Santa Clara County Transit District. That service generated such great interest that the local phone company had to establish special emergency procedures to cope with the 50,000 to 70,000 phone calls attempted each day. Over a five month operating period from December 1974 to May 1975, dial-a-ride ridership, operated with between 39 and 75 vehicles in 18 areas in the County, grew from 1,200 per day to almost 6,700 per day (Carlson, 1976; Pott, 1976). The service was overwhelmed by and could not adequately serve the generated demand and was replaced with a network of fixed routes. Rough calculation of the demand response trip rate per capita indicates that it was in the low-normal range; the large demand was simply the result of a huge market. (Information on the subsequent fixed route performance — which exhibited substantial, long-term growth — may be found under "Comprehensive Service Expansion" in Chapter 10, "Bus Routing and Coverage.")

Table 6-3 Response to Introduction of Demand Responsive Service into Previously Unserved Areas

Place and Year Demand Response Service Introduced	Action	Service Quantity	Ridership	Other
Santa Clara County, CA (1974)	Dial-a-ride service in 18 areas in the County.	39 to 75 vehicles	1,200 per day – 1st month 6,700 per day – 5th month	Replaced by fixed route network
Eden Prairie, Chanhassen and Chaska, MN (1986)	Dial-a-ride service in three suburbs and a nearby shopping center following fixed route failure.	19,500 service miles in January, 1988	2,500 in January, 1988 Equivalent to 120 per day	0.13 passengers per vehicle mile (1988)
Prince William County, VA (1995)	Point deviation routes introduced in previously unserved area.	45 minute headway (generally)	104 per day – 1st month 1,000+ per day since July 1997	8.99 passengers per hour for five route system

The last remnant of dial-a-ride service in Santa Clara County, serving 125 daily rides at a cost of 22 to 25 dollars each, was terminated in 1998 (Bogren, 1998).

Eden Prairie, Chanhassen and Chaska, Minnesota. Southwest Metro, a joint operation by the Minneapolis suburbs of Eden Prairie, Chanhassen and Chaska, initiated dial-a-ride operation in 1986. ADA service was kept separate. The estimated 1989 population of these second and third tier suburbs totaled 49,000, with a gross population density of 645 persons per square mile and less than 5 persons per acre throughout. Dial-a-ride filled the gap left after failure of two out of three local fixed route bus lines, but for all practical purposes the market served was previously untapped. The dial-a-ride was focused on customers traveling internal to the three-city area as a whole and also to the Southdale shopping center and transit hub 4 miles from the boundary. Transfers to regional transit services were allowed but not promoted. Subscription and advance call-in fares were $1.00 for adults, 75¢ for students and 50¢ for senior citizens. Fares for less than 24-hour notice were $1.50, $1.00 and 75¢, respectively, with no guarantee of same-day service availability. Marketing cost was $100,000 in the startup year, reduced subsequently to between $35,000 and $50,000 per year, mostly for direct mail campaigns.

The January 1989 average weekday ridership on Southwest Metro's dial-a-ride was about 120 passengers, on the order of 0.5 rides annually per inhabitant after 26 months of operation. By way of comparison, the remaining fixed route local service carried about 33 weekday riders on the average weekday. Dial-a-ride ridership was about 15 percent senior citizens, 20 percent students, and 65 percent other general public. Other general public riders were thought to consist in large measure of blue collar workers using dial-a-ride in lieu of a second car; many were younger full time employees. Most riders were full time regular patrons, leading to an operation more like a subscription bus than pure dial-a-ride. The overall service productivity was 0.13 passengers per vehicle mile, with a farebox recovery ratio of 11.7 percent (Pratt, 1989).

Prince William County, Virginia. Prince William County is a primarily residential suburban area located about 25 miles southwest of Washington, DC. The County includes the cities of Manassas and Manassas Park. The 1990 population was 250,377 with a gross population density of 692 persons per square mile. For many years express commuter bus service had operated between Prince William County and Washington, DC, but there was no local intra-county transit service. In 1995, five point-deviation routes were introduced by the Potomac and Rappahannock Transportation Commission (PRTC). Three routes operated in the eastern portion of the County while two routes served the cities of Manassas and Manassas Park.

Each route operates between fixed endpoints on a fixed schedule (generally every forty-five minutes). Fixed, on-route stops are located along the route about every two-thirds of a mile and the buses must pass these stops on each trip. In addition, buses will deviate off the route by as much as three-fourths of a mile in response to a request for service. Requests are made by telephone call to the central dispatcher, who then relays appropriate instructions to the appropriate bus driver. Service operates five days per week from roughly 7:30 AM to 6:30 PM. The fare is 75¢. All vehicles are fully accessible. Separate ADA complementary service is not required.

Initially the vehicles were deployed during peak periods for a fixed route feeder service to Virginia Railway Express commuter rail (see "Response by Type of Service and Strategy" — "Feeder Routes" — "Residential Commuter Rail Feeders" in Chapter 10, "Bus Routing and Coverage"). These feeder operations were eliminated after several years due to lack of ridership. Concurrently, the service hours for the demand responsive service were expanded.

Average daily demand response ridership during the first month of operations, April 1995, was 104 for three routes. Since July 1997, the five route system has consistently exceeded 1,000 boardings per day with a productivity of 11.67 passengers per hour on the three eastern county routes and 8.99 passengers per hour for the entire five route system. Additional information may be found in the case study "Point Deviation Service in Outer Suburbs — Prince William County, Virginia."

Additional General Public, Urban Demand Responsive Service Information

Information on other 1990s urban general public demand responsive operations is listed in Table 6-4 (Casey et al, 1998; Rosenbloom, 1998). The first listed, Arcadia, California, employs advanced technology.

Phoenix, Arizona provides an example of using demand responsive service to provide mobility at times when low ridership is insufficient to support conventional bus service. In 1980 Sunday bus service was not being provided. A Sunday dial-a-ride taxi service was implemented in August of that year. Service hours were 8:00 AM to 3:00 PM. Service was obtained by calling the taxi operator; the required response time was 30 minutes. Ridership peaked at just over 1,400 per month both before and after a base fare increase from $1.00 to $1.50 accompanied by a zone fare increase from $0.25 to $0.50. The second ridership peak coincided with an extensive marketing campaign. Seniors, handicapped persons and children rode for half fare. Over 26 months, average ridership was 233 per Sunday, about 1,000 per month (Crain & Associates, 1983). Further details on this application are provided in the case study "Demand Responsive Service at Times of Lesser Demand – Phoenix."

Table 6-4 Ridership and Background Data for Additional Dial-a-Ride Services

City and State	Annual Ridership	Year	Other
Arcadia, CA	140,000	FY 1996	18-vehicle fleet with automatic vehicle location and computer-assisted dispatching.
Monrovia, CA (also serves surrounding areas)	100,000	FY 1996	7-vehicle fleet, manual dispatching, voice radio, no other technology.
Bismark, ND (two adjacent communities)	143,000 (450-550 per day summer, 650-700 winter)	1995	$1.25 in-town, $2.00 between towns, 24-hour advance reservation required, available 24 hours, 7 days a week.
Sisseton, SD (population under 30,000)	94,000	ca. 1995	Focused on special schools, medical facilities, stores, casinos. Originally designed for elderly. Will attempt real-time response but 24-hour advance reservation officially required.

Sources: California — Casey et al (1998); Dakotas — Rosenbloom (1998).

An annual rides per capita usage rate is available or can be readily calculated or approximated for six of the area-wide, urban, general public, five-to-seven-day-a-week demand responsive system examples in the United States. This information is summarized in Table 6-5.

Table 6-5 Annual Rides per Capita for Six U.S. Demand Responsive Systems

Service Area	Date	Annual Rides per Capita
Eden Prairie, Chanhassen, Chaska, MN	1988	0.5
Shakopee, MN	1988	2.2 to 2.5
Arcadia, CA	FY 1996	2.9
Sisseton, SD	ca. 1995	3.1
Hamilton, OH	ca. 1994	about 5
Warsaw, IN	1998	6 to 7

Response to General Public Rural Demand Responsive Services

Given the low density of demand for passenger transportation in rural areas, most general public rural services are operated in a demand responsive mode. In the early 1990s, it was estimated that about 6,000 agencies operated some form of demand responsive passenger transportation in the 2,400 rural counties in the United States. Rural passenger transportation services are often operated by social service agencies to transport clients to and from program activity sites. Many such services are also available to the general public as part of a coordinated system. In circumstances where a large proportion of the service requests are "standing order" trips, such as travel to work, regular trips to a health care facility, etc., the operation can approach that of a fixed route serving only advance requests — essentially a subscription service.

The demand for passenger transportation services in rural areas is driven primarily by demographics, with the key determinant being the size of the population groups most likely to require passenger transportation — those who are elderly, those with a disability and those with low incomes.

Several studies of the use of rural transit services have analyzed the effects of price and quality of service on ridership. Findings are summarized in Table 6-6. The analyses are based not on quasi-experimental studies of change in ridership on specific systems, but rather on comparative cross-sectional analysis of observed ridership on different systems. As a result, the elasticities identified may reflect both an unconstrained traveler response component and the effects of agencies matching the service supplied to the demand generated, or conversely, the effect of releasing supply limits on capacity-constrained ridership. Consequently, the higher service supply elasticities should be treated with extra caution. Service supply elasticities, and considerations affecting the advance reservation requirement elasticities, are discussed further under "Change in Service Parameters" within "Underlying Traveler Response Factors."

Table 6-6 Rural Demand Responsive Service Elasticities

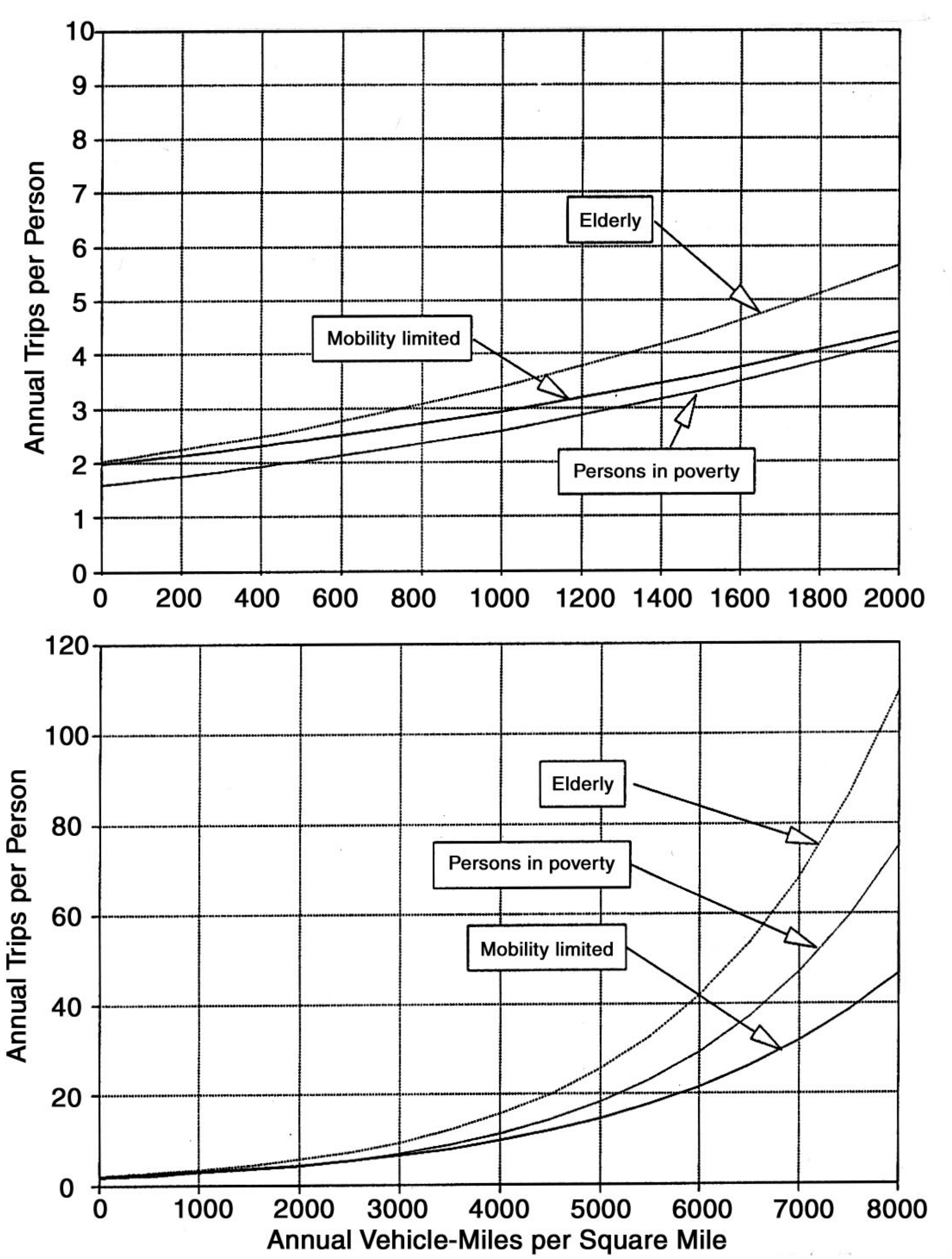
Market Segment	Service Factor	Elasticity
Elderly Riders (Lago and Burkhardt, 1980)	Monthly Vehicle Miles Days in Advance Reservation Required	+0.786 - 0.107
High Probability Transit Riders (Burkhardt and Lago, 1978)	Annual Vehicle Miles Days in Advance Reservation Required	+1.099 - 0.217
Total Ridership (Multisystems, 1984)	Transit Vehicles per Square Mile	+0.619
Trips (McIntyre et al, 1986)	Vehicle Hours	+1.0

Sources: See parenthetical entries in first column.

TCRP Project B-3 examined the observed usage of rural passenger transportation services in thirty-nine counties across the nation chosen to be representative of typical population density and service characteristics. For many of these services but not all, no fare was charged. The ridership on services restricted to persons enrolled in specific programs, or to clients of specific agencies, was excluded from the analysis. Thus the trip rates reported are for travel on services open to any trips by either the general public or all persons within a particular market segment, such as the elderly.

A set of relationships between the demand for service and the vehicle-miles of service per square mile of service area, i.e., the service density, was derived. These relationships, differentiated by type of patron, are illustrated in Figure 6-1 (SG Associates, 1995a and b).

Figure 6-1 General Public Rural Demand Responsive Ridership as a Function of Service Density



Note: Use first chart for 0 to 2,000 annual vehicle miles per square mile, and second chart for 2,000 to 8,000 annual vehicle miles per square mile.

Source: SG Associates (1995b).

The services in these counties exhibited wide variations in markets served, trip lengths, and service quality. The analysis found a small but positive relationship between observed ridership and the quantity of service provided. It was, however, difficult to separate cause and effect — whether there was greater ridership because of more service, or whether more service was being provided in response to greater demand.

Within the range of most observations, less than 2,000 annual vehicle-miles per square mile, a close to linear relationship was found for each of the three defined markets. In the "mobility limited" and "persons in poverty" markets, the relationships equate to approximately an additional 1.2 trips per person per year for each 1,000 annual vehicle-miles per square mile added. The corresponding relationship for the "elderly" market equates to approximately 1.8 trips additional per person per year for each 1,000 added annual vehicle-miles per square mile. Per capita trip rates were seen to rise sharply above 2,000 annual vehicle-miles per square mile, to and beyond the point of implying an "elastic" response to service, but this finding was based on limited data.

Response to Demand Responsive Feeders to Fixed Routes

Demand responsive services operating as feeders to fixed routes are typically used to provide coverage to lower density areas adjacent to or at the outer end of a fixed route transit corridor. These services can be "distributor" oriented (taking travelers from a fixed route to dispersed employment sites) or "collector" oriented (bringing travelers from dispersed residential areas to the fixed route).

Demand responsive distributors from commuter rail service have been used in Connecticut and New Jersey and from the Light Rail line in Santa Clara County, California. Two Santa Clara County distributors that employ a mix of fixed route and demand responsive service carry in the range of 80 to 160 riders per day (Cervero et al, 1995). Information on paratransit distributors, some of which may have demand responsive characteristics, is provided in Chapter 10, under "Response by Type of Service and Strategy" – "Feeder Routes" – "Employer Shuttle Rail Feeders."

Demand responsive feeders to commuter rail service have been used in the Chicago suburbs and New Jersey. An example is New Jersey Transit Route 977 connecting Lawrence and West Windsor with the Princeton Junction rail station (not to be confused with the multipurpose fixed route discussed in Chapter 10, "Bus Routing and Coverage"). Implemented in 1994-95, it provides five daily morning peak commute period trips which first call at two stops in Lawrence and then offer demand responsive service from West Windsor to the station. Routing in West Windsor varies daily based on customer reservations. Ridership was 7,700 annually as of 1996-97, with a 22.7 percent farebox recovery ratio. For those considering driving to the Princeton Junction station, time on the waiting list for a station parking space approaches two years (Michael Baker et al, 1997). An early dial-a-bus application to commuter rail feeder service in Bay Ridges, Ontario was discussed under "Replacement of Fixed Route Service by Demand Responsive Service" in the section "Response to General Public, Urban Demand Responsive Services." It attracted 460 passenger trips per day.

Demand responsive services at the outer ends of fixed route bus services are used in Norfolk, Virginia and Raleigh, North Carolina. The Norfolk area services carry roughly as many local passengers as transfer passengers and are described under "Replacement of Fixed Route Service by Demand Responsive Service." An experiment using taxicabs as feeders to a fixed route bus was conducted in St. Bernard Parish, Louisiana in 1976, attracting over 1,000 rides per month (Urban Institute, 1979). Taxi service has been used in Arlington County, Virginia as feeders to/distributors from Washington, DC's MetroRail system at times of low demand.

Service information and ridership for selected demand responsive feeders to fixed routes are summarized in Table 6-7.

Table 6-7 Demand Responsive Feeders to Fixed Routes

System / Date	Peak Service	Non-Peak Service	Daily Riders
Distributor from Light Rail			
Santa Clara County 1994 (Cervero et al, 1995)			
IBM	Fixed Route	Demand Response 15 Minutes or Less	160
Kaiser	Fixed Route and Demand Response	Fixed Route and Demand Response	85
Distributor from Commuter Rail			
Norwalk, Connecticut (Urbitran Associates)			
Merrit 7	Point Deviation	Point Deviation	60
Feeder to Commuter Rail			
Peterborough, Canada 1975 (Miller, 1977)	Taxi Service		215
West Windsor, New Jersey (NJT Route 977) 1996-97 (Michael Baker et al, 1997)	Point Deviation		30
Feeder to Fixed Route Bus			
St. Bernard, Louisiana 1976 (Urban Institute, 1979)	Taxi Service		Over 1,000 per month

Sources: See parenthetical entries in first column.

Response to ADA Complementary Services

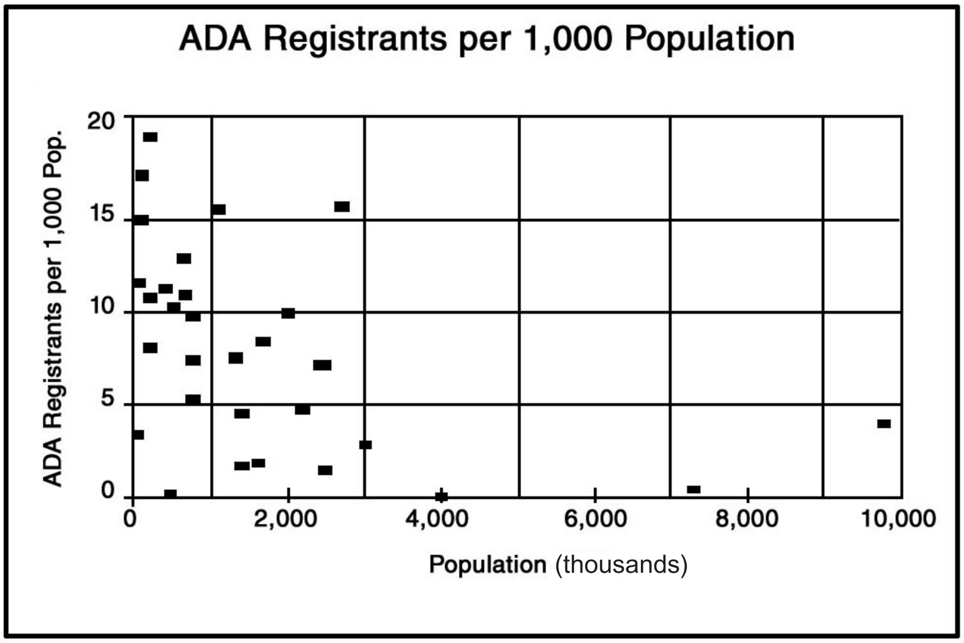
There are many factors that affect the demand for and use of ADA complementary services. These include the age distribution characteristics of the population, characteristics of the transit service area such as topography and availability of pedestrian facilities, relative ease of use of the fixed route services by persons with disabilities, and the ADA eligibility certification practices adopted by the individual transit agency.

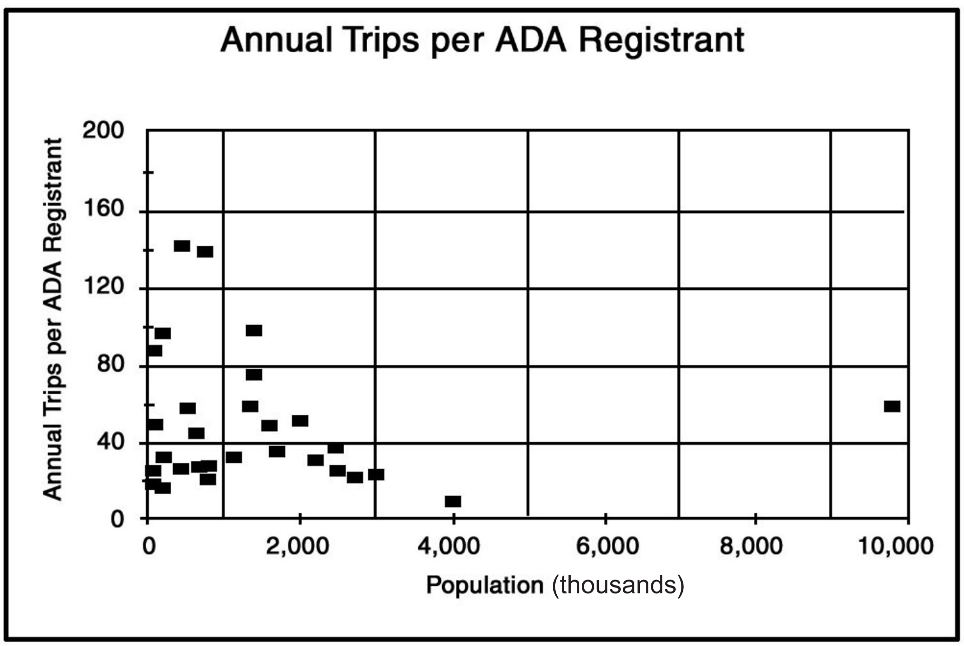
In many cities, demand responsive paratransit services targeted primarily to senior citizens or persons with specific transportation needs, like dialysis patients, were in operation prior to passage of the Americans with Disabilities Act. Agencies that operated such services have, for the most part, been reluctant to deny use of ADA-mandated complementary paratransit services to pre-existing classes of eligible users, even though many of the individuals involved would not meet a stringently applied ADA eligibility standard. Similarly, agencies have tended to continue offering paratransit in previously served geographic areas, even though the ADA implementing regulation would permit reduced geographic coverage. The variation in eligibility for use of paratransit services thus introduced, coupled with failure of many operators to keep detailed records of travelers' eligibility status, makes it especially difficult to assess how the number of ADA eligible trips varies in response to the availability of service.

Description of travel demand for ADA paratransit services is often done in terms of ADA registration rates per capita and trip rates per registrant. Multiplied together, these two rates give trips per capita. Data from the Census and various household surveys suggest that about 5 percent of households will have one or more members with a disability that makes it difficult for them to use public transportation. Not all of these persons, however, will meet ADA eligibility criteria or will seek such certification.

Data from a *TCRP Synthesis 30* sample of 32 small to large cities reveal ADA registration rates (per 1,000 population) that range from almost zero to nearly 20, as shown in Figure 6-2. The weighted average for the areas included in this sample is 4.93 ADA registrants per 1,000 population. The median value is about 7.7 registrants per 1,000. The same data set reveals a wide variation in annual rates for ADA trips per ADA registrant, ranging from near 20 trips per year up to 135 per year. The weighted average value is 48.3 while the median value is about 36.5 ADA trips per year per ADA registrant (Weiner, 1998). The average registrant rate and average trip rate per registrant can be used to compute an overall average (for the widely variant results) of 0.24 annual trips per capita for ADA paratransit services, including both able-bodied and disabled persons in the population data base.

Figure 6-2 ADA Registrant Rates and Trip Rates per Registrant





Source: Developed from tabulations in Weiner (1998).

On most ADA paratransit systems, frequent riders may place standing reservations for service, becoming "subscription" riders. ADA registrants in Chicago, for example, may obtain subscription service if they make the same trip at least 3 days a week (Chicago Transit Authority, 1998). In the 32 city *TCRP Synthesis 30* sample, 18 systems reported the percentage of ADA paratransit trips made on a subscription basis. Excluding two systems reporting no subscription trips, the median value is 48 percent of all trips served on a subscription basis. Two-thirds of the systems that take subscriptions (92 percent of those reporting) fall in the 25 to 53 percent range (Weiner, 1998). Averages for the systems taking subscriptions, constructed by taking various approaches to treatment of imprecise-looking survey responses, vary from 42 to 45 percent subscription trips. Pace in suburban Chicago has taken the subscription concept one step further by establishing "ADvAntage" vanpools for disabled riders (see "Pace Vanpool and Subscription Bus Programs in Suburban Chicago" in Chapter 5, "Vanpools and Buspools").

Advanced Public Transportation Systems are beginning to be applied in ADA paratransit service. Ann Arbor, Michigan serves approximately 150 clients a day using 8 lift-equipped vehicles with integrated computer-aided dispatch, automated scheduling and advanced communications. About 400 ADA clients a day not requiring lifts are served by taxi. The Santa Clara County, California paratransit provider has 65 vehicles equipped for automated scheduling and dispatching. The system supports interfacing with fixed route transit for eligible clients and real-time transfer schedule monitoring. No tally of mixed mode trips is available, but shared rides have increased from 38 to 55 percent, and total fleet size has been reduced from 200 to 130 vehicles in the face of a growing clientele (Casey, 1998).

Social Service Transportation

Transportation is provided by a vast array of social service agencies to enable eligible persons to participate in agency program activities. Most such transportation is akin to school bus transportation. Program clients are transported to and from the program location at times established by the agency. Some social service agencies will also transport program clients to activities of the client's choosing, such as shopping, as part of program transportation service. Ridership on social service agency transportation services is related primarily to program enrollment rather than service factors.

TCRP Project B-3 collected data on rural social service program transportation demand and program participation rates. The best estimator of the number of trips associated with a social service program is the number of program participants. In general there is a direct linear relationship between the number of individuals eligible for and participating in a given social service program such as senior nutrition, and the demand for passenger transportation. Table 6-8 presents the suggested relationships for estimating the number of participants in various program types using readily available census data. Table 6-9 presents relationships for estimating the number of annual trips by program participants. Used in sequence, these relationships allow estimation of "program trips;" in other words, trips made by persons enrolled in social service programs traveling to and from destinations chosen by the program agency at times set by the agency (SG Associates, 1995a and b). There is apparently no comparable information available for urban social service program transportation demand. Anticipated TCRP Project B-28, "Forecasting Demand for ADA Complementary Paratransit Services," seeks to fill this gap with research slated to begin in FY 2004.

Table 6-8 Methodologies for Estimating Rural Social Service Program Participants

	Best Estimation Technique		If Best Data Unavailable, Use…	
Program Type	Criteria	Formula	Criteria	Formula
Developmental Services: Adult	All	Age 16 & Above × 2.15	All	Total Population × 1.76
Case Management	All	Mobility Limited 16-64 × 29.8	All	Total Population × 0.50
Children	All	Total Population × 1.08	All	---
Pre-School	All	Total Mobility Limited × 13.2	All	Total Population × 0.56
Group Home	<1,500 Mobility Limited	Total Mobility Limited × 10.96	<30,000 Total Population	Total Population × 0.54
	≥1,500 Mobility Limited	Total Mobility Limited × 2.28 + 5.78	≥30,000 Total Population	Total Population × 0.22 + 10.9
Headstart	<1,500 Families in Poverty	Families in Poverty × 56.1	All	Total Population × 3.30
	≥1,500 Families in Poverty	Families in Poverty × 26.6 + 46.0		
Headstart: – Home Base	All	Families in Poverty × 18.1	All	Total Population × 1.12
Headstart – Other	All	Age 3 to 4 × 123	All	Total Population × 2.81
Homeless Transport'n.	All	Population in Poverty × 24.6	All	Total Population × 3.50
Job Training	All	Age 16 to 59 × 5.60	All	Total Population × 3.66
Mental Health Services	<1,700 Mobility Limited	Total Mobility Limited × 30.3	All	Total Population × 1.61
	≥1,700 Mobility Limited	Total Mobility Limited × 52.9 - 40.4		
Mental Health Services: Case Management	All	Age 16 to 64 × 8.40	All	Total Population × 4.89
Nursing Home	All	Age 75 & above × 28.7	All	Total Population × 2.03
Senior Nutrition	All	Age 75 & Above × 72.2	All	Total Population × 3.57
Sheltered Workshop	<15,000 Population Age 16 to 59	Age 16 to 59 × 2.94	<20,000 Total Population	Total Population × 1.75
	≥15,000 Population Age 16 to 59	Age 16 to 59 × 1.01 + 23.8	≥20,000 Total Population	Total Population × 0.69 + 22.3
Substance Abuse	All	Total Population × 0.87	All	---
ALL OTHER PROGRAM TYPES: Develop estimate on case-by-case basis.				

Note: EXPRESS ALL POPULATION FIGURES IN THOUSANDS OF PERSONS

Source: SG Associates (1995b).

Table 6-9 Methodologies for Estimating Rural Social Service Program Trip Rates

	Best Estimation Technique		If Annual No. of Days Unavailable, Use...	
Program Type	Criteria	Formula	Criteria	Formula
Development Services	< 25 Participants	# Participants × 358	–	–
	≥ 25 Participants	# Participants × 430 – 1,686	–	–
Developmental Services:	All	# Participants × 39.2	–	–
Case Management				
Pre-School		# Participants × 224	–	–
Group Home	< 10 Participants	# Participants × 2.05 × # of Days	< 12 Participants	# Participants × 615
	≥ 10 Participants	# Participants × 1.42 + 5.94 × # of Days	≥ 12 Participants	# Participants × 291 + 3,760
Headstart	All	# Participants × 263	–	–
Headstart: – Home Base	All	# Participants × 0.16 × # of Days	All	# Participants × 30.5
Headstart – Other	All	# Participants × 1.86	–	–
Job Training	All	# Participants × 137	–	–
Mental Health Services	All	# Participants × 347	–	–
Mental Health Services: Case Management	All	# Participants × 6.35	–	–
Nursing Home	< 50 Participants	# Participants × 9.10	–	–
	≥ 50 Participants	# Participants × 12.5 – 173	–	–
Senior Nutrition	All	# Participants × 248	–	–
Sheltered Workshop	All	# Participants × 1.58 × # of Days	All	# Participants × 384
ALL OTHER PROGRAM TYPES: Develop estimate on case-by-case basis.				

Source: SG Associates (1995b).

UNDERLYING TRAVELER RESPONSE FACTORS

Ridership on demand responsive services, as on fixed route transit, is a function of the size and composition of the market served and of the cost and quality of service offered. The total ridership on any particular demand responsive service is influenced primarily by the size of the target markets and secondarily by attributes of the service offered. In many cases, the market eligible to use a demand responsive system is deliberately constrained; for example, a service may be open to use only by the elderly or persons with disabilities. For these groups, the available travel choices may be more limited than for the general population. The choice may be "no trip" rather than use of another mode. The elasticities of demand for market segments with limited travel choices are likely to be quite different than those of market segments not subject to such restrictions.

Nevertheless, for individual travelers, the choice to use a specific service (traveler response) is at least partially related to cost and service attributes. For demand responsive services, the "service attributes" are more complex than the headway and travel time factors that define fixed route operations. Demand responsive service attributes that affect a traveler include items such as the time in advance of travel that one must call to book a trip, the ability to schedule a trip at the desired time, and the efficiency of the routing and dispatching algorithms that determine how long a given trip is likely to take. The effect of changes in these and other service parameters are discussed here.

Change in Service Parameters

Change in Advance Reservation Time Requirement

Demand responsive services, because they are by design intended to respond to changing demand for service, do not operate each day over a fixed route on a fixed schedule. The driver's duties and the vehicle's path differ not only from day-to-day, but from hour-to-hour. To provide transit management with sufficient time to develop vehicle routings and driver manifests, it has been the general practice to require travelers to make a service request (to book a trip) one or more days in advance. Since this requirement imposes significant advance planning on the traveler, trips are likely to be limited to those related to prescheduled activities, such as work, a medical appointment, or a regular shopping trip.

A comparative analysis of demand responsive rural transit services in Pennsylvania yielded a model that suggests demand is inelastic (elasticity of -0.217) with respect to the number of days in advance that a reservation needs to be made (Burkhardt and Lago, 1978). The data used in that analysis included systems with advance reservation requirements ranging from four to fourteen days. Even the least restrictive requirement in the sample (4 days) is long enough that casual or impulse trips would likely be discouraged. Because even a 24-hour advance reservation requirement does not cross the threshold of allowing spur of the moment trips, this model would not be appropriate for use in estimating the effect of anything approaching real-time response to service requests. (See "Change in Dispatching Technology or Procedures" below.)

Change in Dispatching Technology or Procedures

The availability of ever more powerful desktop computers has permitted the advance reservation time to be reduced. Several software packages that provide either full or partial automation of the vehicle routing/dispatching problem are now in use. These systems enable agencies to at a minimum adhere to the "no more than one day advance reservation" requirement for complementary paratransit services offered to comply with the Americans with Disabilities Act.

More advanced dispatching systems, coupled with automated vehicle location (AVL) systems that keep track (in real time) of the position of each vehicle in a paratransit system, offer the promise of real-time dispatching so that call-ahead times can be reduced from days or hours to minutes. Reductions of this magnitude in the required "pre-booking" time could be expected to have a greater effect on demand than changes in the number of days in advance of a trip that a reservation must be made, since impulse trips could be accommodated, truly reducing need for travelers to pre-schedule activities.

One demand responsive operations software system under development will allow on-board computers to "talk" to each other and "bid" for an incoming trip request based on cost to serve it (Casey et al, 1998). Interestingly, this is what the drivers of the Kosciusko Area Bus Service in Warsaw, Indiana do by radio, such that their operation may presage the service (and response) that will be possible on a larger scale with Advanced Public Transportation Systems. The Kosciusko Area Bus Service, with an annual rider per capita rate to 6 to 7 trips, has a high ridership rate compared to most other systems, but there may be a number of reasons for this. (See "Response by Type of Strategy" — "Response to General Public, Urban Demand Responsive Services" — "Replacement of Fixed Route Service by Demand Responsive Service" for Kosciusko Area Bus Service operational and patronage information.)

A stated preference survey and modeling analysis involving riders of a dial-a-ride service provided for senior citizens, disabled persons, and young children attending school provides additional insights. The existing service required 24-hour reservations for the initial pickup, while the return trip was provided within one hour. Reducing the initial trip advance reservation requirement to 15 or 30 minutes was found to be much less important than reducing the wait for the return trip. It was estimated that reducing the return trip wait from an hour would increase ridership by 17 percent if a 30 minute wait was offered, and 24 percent if a 15 minute return trip wait could be achieved. This same analysis estimated an 11 percent ridership gain for a 10 minute travel time saving (Ben-Akiva et al, 1996).

Use of Advanced Public Transportation Systems should improve service reliability in addition to reducing traveler waiting and riding times. The corresponding traveler response would be engendered not directly by the dispatching technology, but rather by the ability of transit agencies to respond more quickly and consistently to service requests.

Change in Service Supply

The service elasticities presented earlier in Table 6-6 for rural general public demand responsive service range from +0.6 to +1.1 for service supply measures including vehicle hours, vehicle miles and vehicles per square mile. These elasticity estimates were all developed based on cross-sectional data, an approach that brings with it the warning that the elasticities identified may reflect not only a traveler response component, but also the effects of agencies matching service supplied to generated demand (see "Response by Type of Strategy" — "Response to General Public Rural Demand Responsive Services").

Indeed, urban data from Chicago show that close to a half of all persons using Chicago's paratransit service on other than a subscription basis report no, little, or only occasional success in making a trip reservation. The 1998 CTA paratransit reservations survey also shows that 55 percent of those unable to book a trip at the desired time reported inability to make the trip by other means (Chicago Transit Authority, 1998). Unsatisfied demand such as this will quickly be absorbed if the effective capacity of a demand responsive service is increased by adding vehicles and drivers or by enhancing call taking and dispatching procedures.

These caveats notwithstanding, service hour elasticities based on quasi-experimental before and after data from five of the Norfolk area's urban demand responsive services, all open to the general public, average the same (+0.88) as the rural service elasticities. The Norfolk service elasticities range from +0.5 to +1.8 (Comsis, 1985). This very limited data is thus suggestive that average demand responsive service elasticities are at least as high as for conventional bus service, higher than average fixed route transit frequency elasticities (+0.5), and probably around the middle range of fixed route service coverage elasticities (+0.6 to +1.0). As with conventional bus services, the variability of service elasticities for demand responsive transit is substantial.

Change in Fares

Change in Fares for the General Public

The market segments and market areas served by demand responsive systems tend to be different than the areas and markets to which fixed routes are oriented. While some demand responsive services are targeted to the general public over a wide area, such as in Warsaw, Indiana and several Minneapolis suburbs, the markets are often more specialized, such as commuters to a specific office park complex, or persons with disabilities. Moreover, the markets typically have lower demand densities. Travelers using demand responsive services in these particular environments might be expected to have fewer choices and, hence, exhibit less sensitivity to price or service factors. This remains a supposition, however, that is unsupported by presently available empirical data. At least for changes in fares and service supply for the general public, the limited available data do not seem to indicate lower than normal overall sensitivities. The available data also suggest that the sensitivity to service supply, although probably not to other service factors, is greater than the sensitivity to fares.

Observed data from 1980s fare changes on seven of the Norfolk area's demand responsive services show log arc elasticities of transit trips to fare ranging from -0.16 to -0.64 (Comsis, 1985). These plus demand responsive service and paratransit fare elasticities from the 1970s (Dygert, Holec and Hill, 1977; McGillivray, 1979), are provided in Table 6-10. Although there is wide variation, the average observation (-0.38) is of the same order-of-magnitude as fare elasticities observed for fixed route services.

Table 6-10 Demand Responsive and Other Paratransit Fare Elasticities

Location	Service Type	Fare Elasticity
Norfolk, VA	Dial-a-ride taxi	-0.16 to -0.64
Ann Arbor, MI	Dial-a-ride vans	-0.44
Benton Harbor - St. Joseph, MI	Dial-a-ride vans	-0.09
Levittown, NY	Shared-ride taxis	-0.81
Danville, IL (full fare riders)	Shared-ride taxis	-0.54
Bay Ridges, Ontario	Dial-a-ride rail feeder	0.00

Sources: Comsis (1985); Dygert, Holec and Hill (1977); McGillivray (1979).

Demand responsive (Maxi-Ride) services are still operated in the Norfolk area as of 1999. There are now six Maxi-Ride territories. In some territories, the cash fare is the same as for fixed route operations, $1.50, while in others the fare is $3.00. The "average fare" in either case is considerably less than the cash fare since it reflects use of the service by persons taking advantage of one of the reduced fare media offered, or persons qualifying for a reduced fare. In very broad terms, use of Maxi-Ride by zero or one car ownership households ranges from three trips per 1,000 households per revenue-hour per household at an average fare of $0.50 to about one trip per 1,000 households per revenue-hour per household at an average fare of $1.50 (SG Associates, 1998). This finding may be equated to a decrease in patronage of 66 percent for a fare increase of 200 percent. The corresponding log arc fare elasticity is -1.0; the threshold of an elastic response. Still other data for two of the 1980s Norfolk dial-a-ride fare changes (Becker and Echols, 1983) can be used to construct alternative fare elasticities which range from -0.27 to -1.13. (For further detail on Norfolk see the case study "Demand Responsive Service in Low Productivity Areas — Norfolk.")

The limited extent of fare elasticity data for demand responsive services, and the existence of results ranging from no response to elastic response, do impose uncertainty on the apparent finding that the elasticities for services open to the general public are similar to those for conventional bus transit. Nevertheless, lacking better information, that seems to be the best working assumption.

Change in Fares for ADA Clientele

For certain market segments, specifically the elderly or persons with disabilities who qualify for use of ADA paratransit, travelers may have a choice between using a demand responsive service and a fixed route service. The choice decisions for these groups involve particularly complex trade-offs between price and service factors. A traveler may access a fixed route, fixed schedule service without prearrangement. Trips are available on a published schedule, typically no less frequently than once per hour, so travel can be scheduled at the traveler's convenience. The cost of a trip is no more than the "standard" fare and is often half of the standard fare during non-peak hours. A walk to and from a bus stop from the trip origin and destination will be required, however. For a demand responsive service, a one day in advance prearrangement is typically necessary, and the traveler may need to shift his or her time of travel. The fare charged will likely be twice the "standard" fare for a fixed route trip, although fares for some riders may be subsidized through a social service program. The transit vehicle will, on the other hand, pick-up a traveler at his or her trip origin and deliver the traveler to his or her destination.

The fares charged for ADA services affect both the number of transit trips making use of the ADA services and, at least in theory, the choice by ADA eligible persons between available fixed route or complementary paratransit services. Figure 6-3 (Koffman and Lewis, 1997) addresses the first of these effects, showing per capita ADA paratransit trip rates as a function of paratransit fares charged for several areas. An experience in Sheboygan, Wisconsin, is also relevant. There, a 1995 fare increase more than doubled fares for ADA paratransit riders, to $2.50 a ride. The resulting ridership loss exhibits a log arc elasticity of -0.36, two-thirds of that shown by non-ADA riders, whose fares were increased somewhat less. The decline in ADA ridership was unexpected, as smaller ADA fare increases in neighboring cities had shown no effect. Subsequent public input revealed that the ADA paratransit fare had been pushed beyond the level of affordability for many, for example, "facilitated employment" riders reported being faced with paying more to access their work than the cash allowance they received (Billings, 1996; elasticity computations by Handbook authors).

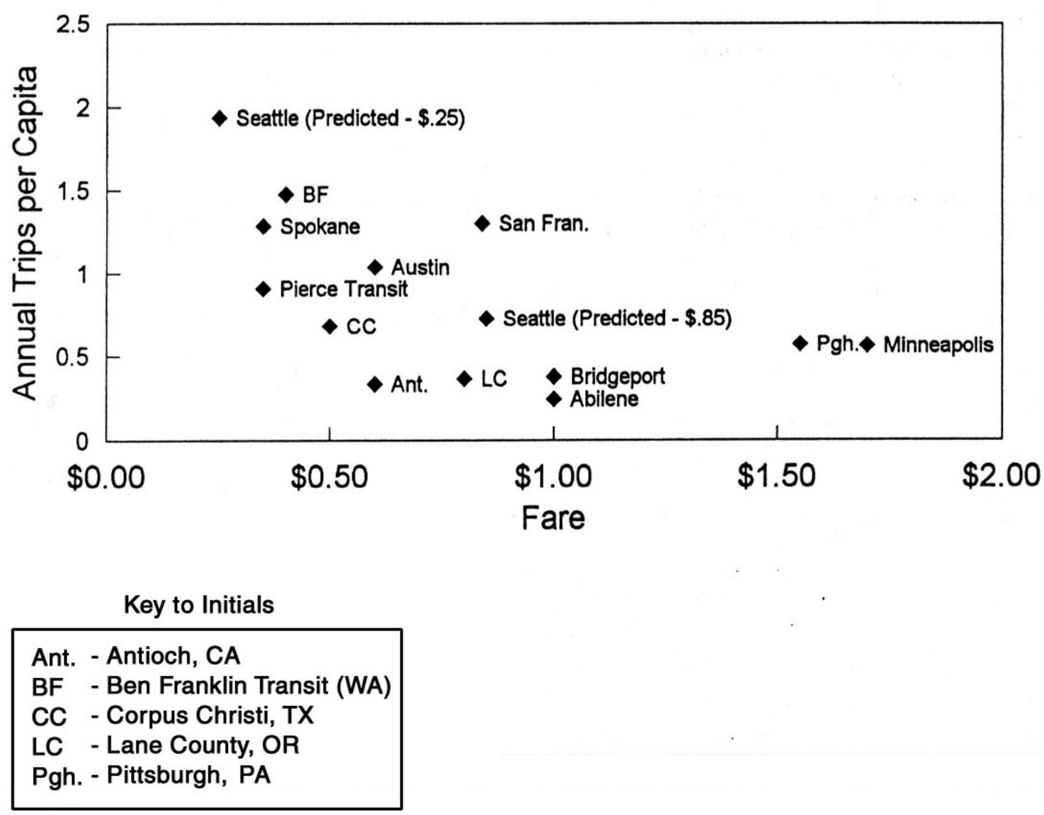
The second of these effects — possible shifting between paratransit and fixed route buses — was examined in a recent analysis based on Sacramento, California survey data. Revealed preference modeling indicated that elderly and disabled travelers are not very sensitive to fares when making the choice between demand responsive and fixed route services. Response to fare differentials between fixed route and ADA paratransit services was estimated to be quite price inelastic, with an elasticity of -0.16 (Franklin and Niemeier, 1998). Similarly, although a closely controlled experiment in Ann Arbor, Michigan found a doubling to tripling of ADA eligible rider usage of fixed route services in response to free fare, any effect of the free fixed route fares on use of ADA paratransit was small (see "Encouraging Use of Fixed Routes Instead of ADA Paratransit" within the "Related Information and Impacts" section).

Change in Eligibility Requirements

For many demand responsive services, particularly those operated in conjunction with a social service program (for example, congregate meals for the elderly), use of the service is limited to those who are clients of the social service program. Similarly, complementary paratransit services operated in fulfillment of the requirements of the Americans with Disabilities Act are typically available only to persons who meet the eligibility requirements established by the operating agency.

Actions that impose eligibility requirements that are more restrictive limit the size of a market and directly affect existing riders. More liberal eligibility requirements increase the size of the potential market, but will not necessarily result in proportional changes in ridership.

Figure 6-3 ADA Trip Rates per Capita for Selected Systems with Differing Fares



Source: Koffman and Lewis (1997).

Changes in Vehicle Type

The characteristics of the vehicles used to provide a transit service (e.g., standard bus, van, perimeter seating, forward-facing seating, etc.) may affect a traveler's perception of service quality and, to some degree, the likelihood that the traveler will choose a specific service. While focus groups and passenger surveys have shown rider preferences for various vehicle characteristics, no studies have been found that identify a controlled study of changes in ridership related to vehicle type. It may be surmised that, across a broad range of factors, traveler response is inelastic with respect to vehicle type.

A possible exception may be the introduction of low-floor buses. Unlike vehicle features that are primarily cosmetic, a low floor enhances the accessibility of the service and may, therefore, permit use by a previously excluded market.

RELATED INFORMATION AND IMPACTS

Scale and Productivity of Demand Responsive Service

Demand responsive services are operated not only by agencies engaged in providing public transportation, but also by many social service programs as an adjunct to the program's primary goals. Transit agency data are available from the National Transit Database. In 1996, 484 of 541 reporting U.S. transit agencies provided or purchased fixed route bus service, while 482 provided or purchased demand response service (FTA National Transit Database, 1996). [4]

Operating data for social service agencies is not compiled nationally. However, it is known that over 5,000 agencies have received Federal Transit Administration funding under the Section 16(b) program to purchase vehicles for client transportation. These services tend to be demand responsive. Together, transit and social service agencies under the purview of the Florida Commission for the Transportation Disadvantaged totaled 426 transportation operators statewide in 1998, serving 603,661 transportation disadvantaged individuals making 36,609,800 trips annually. Of these, almost half were identified as demand response (16 percent), advance reservation (33 percent) or stretcher trips (0.2 percent), the remainder being fixed route (50 percent) or school bus trips (1 percent) (Florida Commission, 1999).

National statistics indicating the characteristics and scale of the transit operator segment of demand responsive service operations are provided in Table 6-11 for the 541 transit agencies included in the 1996 National Transit Database. Comparison is provided with the total public transportation operations of the 541 agencies. Services open to the general public and ADA demand responsive services are lumped together in these statistics. Clearly, however, the ADA services dominate.

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[4] *TCRP Report 98*, published subsequent to the development of this chapter, provides statistics from a survey of both agencies in the National Transit Database and smaller demand responsive transit (DRT) providers that recently received federal grants. Among 28 ADA complementary services, the mean for average trips per day was 335 and the mean for vehicles operated was 22. Similarly, for 30 general urban DRTs the trips per day mean was 521 and the vehicles operated mean was 30. For 32 rural, small city, and community DRTs, corresponding means were 277 trips per day and 17 vehicles operated. Wide variation was found within the survey sample (Schofer et al, 2003).

Table 6-11 Characteristics and Scale of Demand Response Services Operated by Transit Agencies

Measure	Value for Demand Responsive	Percent of National Transit Total
Operating Expense	$750.1 million	4.6
Vehicle Revenue Miles	307.9 million	11.2
Vehicle Revenue Hours	21.4 million	11.6
Vehicles Operated in Maximum Service	12,779	17.4
Unlinked Passenger Trips	55 million	0.7
Passenger Miles	391 million	1.0

Source: Federal Transit Administration National Transit Database (1996).

The productivity of urban demand responsive services varies considerably and is related to the size of the service area, the density of demand, agency operating practices and whether the service is available to the general public or only to certain classes of eligible users. Productivity rates reported by several systems serving the general public market with demand responsive service are given in Table 6-12. Certain operating practices such as acceptance of subscription (standing) reservations may significantly increase productivity. Productivity of paratransit services provided for specific client groups may be further distorted by the many to one nature of the trips or the prescheduling of group trips associated with clients such as senior citizen centers and group homes.

Table 6-12 Example Demand Responsive General Public Service Productivity Rates

System	Area Characteristics	Trips/Hour
Ashtabula, OH	Small City	8.72
Hamilton, OH	Small City	4.82
Merrill, WI	Small City	10.72
Prosser, WA	Rural Area/Central Town	2.84
Prince William County, VA	Suburb of Major City	7.95

Source: Farwell (1998).

Even the productivity that can be achieved by a fairly "pure" paratransit service is governed not only by the previously mentioned size of service area and trip density, but also by factors such as average trip duration and dwell time at stops required to serve patrons with specific needs. In the 1970s, there were several simulation studies (Wilson et al, 1970, for example) that explored vehicle assignment schemes in relation to these and other factors. The new research documented in *TCRP Report 98* "Resource Requirements for Demand-Responsive Transportation Services" and the accompanying software provide a methodology for determining the number of vehicles required given service area size, trip demand and operating policies (Schofer et al, 2003). (See the "Additional Resources" section for further information.)

Figure 6-4 illustrates the cumulative frequency function of reported passengers per revenue vehicle hour for demand responsive services operated by systems with fifty or fewer vehicles derived from FTA's National Transit Database for 1994. Most of these demand responsive services are public, in the limited sense that a potential patron need not be an agency client or enrolled in a social service program, but most are also restricted to specific eligible individuals and do not serve general public riders. The range is from about 0.5 to 9.2 passengers per hour with a median value of 3.3.

Encouraging Use of Fixed Routes Instead of ADA Paratransit

While, in theory, any person capable of using an existing fixed route service for a specific trip can be deemed "non-ADA eligible" for such trips, few transit agencies have been willing to apply such stringent eligibility criteria or to undertake the administrative burden of making trip-by-trip eligibility determinations. None-the-less, a transit agency has strong incentives not only to operate fixed route services in a way that accommodates disabled riders, but also to promote use of fixed route services by persons who are eligible for ADA services. The cost of providing complementary paratransit service for a given trip may be quite high, with per trip costs exceeding $20 not unusual, while the marginal costs of accommodating a disabled rider on an existing fixed route trip are essentially zero.

In August 1995, the Ann Arbor Transportation Authority (AATA) in Michigan reduced the fare for disabled persons using regular route services from $0.35 to free fare. The fare for a paratransit trip was $1.50, twice the regular fixed route fare. The experiment was repeated in April 1996. In both cases, the ADA ridership on fixed route buses was over 3 times as large as had been observed in the same month the two previous years and much greater than ridership in the prior month. However, there was no strong effect on paratransit ridership; it was reduced perhaps by 2 to 3 percent (Levine, 1997). Thus the objective of significantly reducing costly ADA service usage was not realized. The ridership results are shown in Table 6-13.

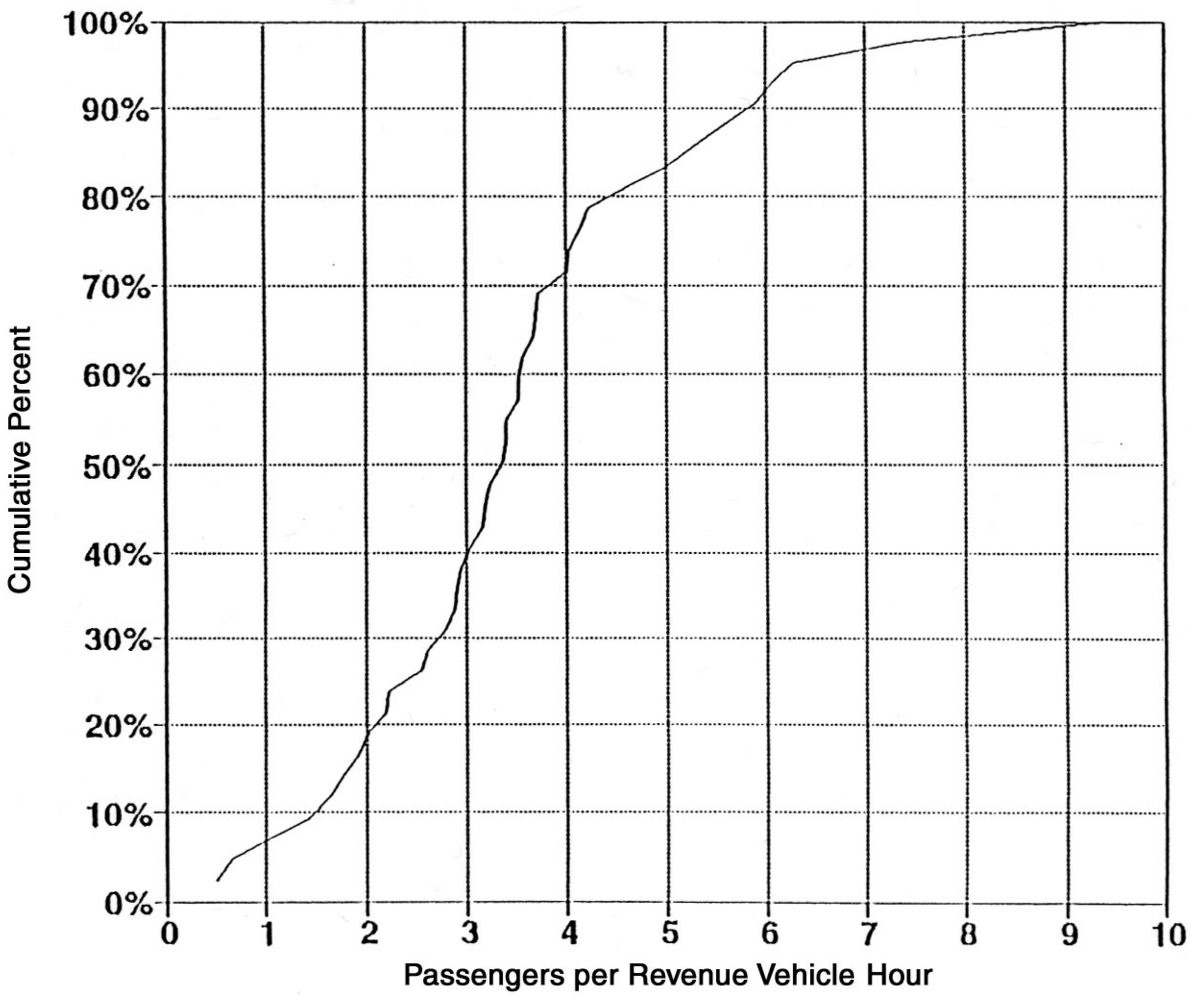
Table 6-13 Effect of Change in Ann Arbor Regular Route Fares for Disabled Persons

Month	Fixed Route Fare For ADA Eligible Riders	Fixed Route Ridership For ADA Eligible Riders	Paratransit Ridership	Total
July, 1994	$0.35	2,600	14,600	17,200
August, 1994	$0.35	3,000	15,000	18,000
July, 1995	$0.35	3,150	16,000	19,150
August, 1995	Free	10,565*	16,300	26,865
March, 1995	$0.35	4,050	18,000	22,050
April, 1995	$0.35	3,700	15,800	19,500
March, 1996	$0.35	5,066*	17,900	22,966
April, 1996	Free	11,208*	17,000	28,208

Note: Ridership data marked with "*" taken from table in the source document. All other data estimated from charts in the source document.

Source: Levine (1997).

Figure 6-4 Demand Responsive Service Productivity for Purchased Service



Note: Systems with 50 or fewer buses.

Source: Developed from National Transit Database, Federal Transit Administration (1994 Report Year).

Additional information relating to the Ann Arbor experience is provided in the case study "Promoting Use of Fixed Route Services by Persons with Disabilities — Ann Arbor, MI."

Several operators have tried training persons with disabilities to use fixed route bus service. These efforts seem to consistently produce increases in use of fixed routes by disabled persons, sometimes substantially. A 1991 wheelchair user training effort in Phoenix, Arizona resulted in a 75 percent increase in wheelchair user ridership on the targeted fixed route. In Dayton, Ohio, ongoing training of 180 wheelchair users annually has led to a 40 percent increase in wheelchair boardings (reaching about 2,000 boardings per month). Training of 180 Austin, Texas residents with various disabilities in 1994 and 1995 led to 65 percent becoming occasional users and 29 percent becoming frequent users of fixed route services. However, the effect on paratransit usage in Austin was unclear. In a dozen similar demonstration projects sponsored by Easter Seals and the U.S. DOT, few were able to show much diversion from paratransit, although the gains in mobility evidenced by increased fixed route usage were positive developments (Rosenbloom, 1998).

Service Development and Time Lag

When a transit service is introduced into a previously unserved area, some time is required for the market to develop. Potential riders must become aware of the service and adjust their travel behavior if they wish to make use of it. Figure 6-5 illustrates the ridership growth pattern observed over the first two-and-half years of operation of the Prince William County, Virginia OmniLink point-deviation services. These data suggest that it takes about a year for ridership to begin stabilizing, and about two years overall to reach a more or less mature level. This pattern is a fairly common outcome for new transit services of many types and thus may be considered representative of likely ridership development time lag, at least for new services open to the general public.

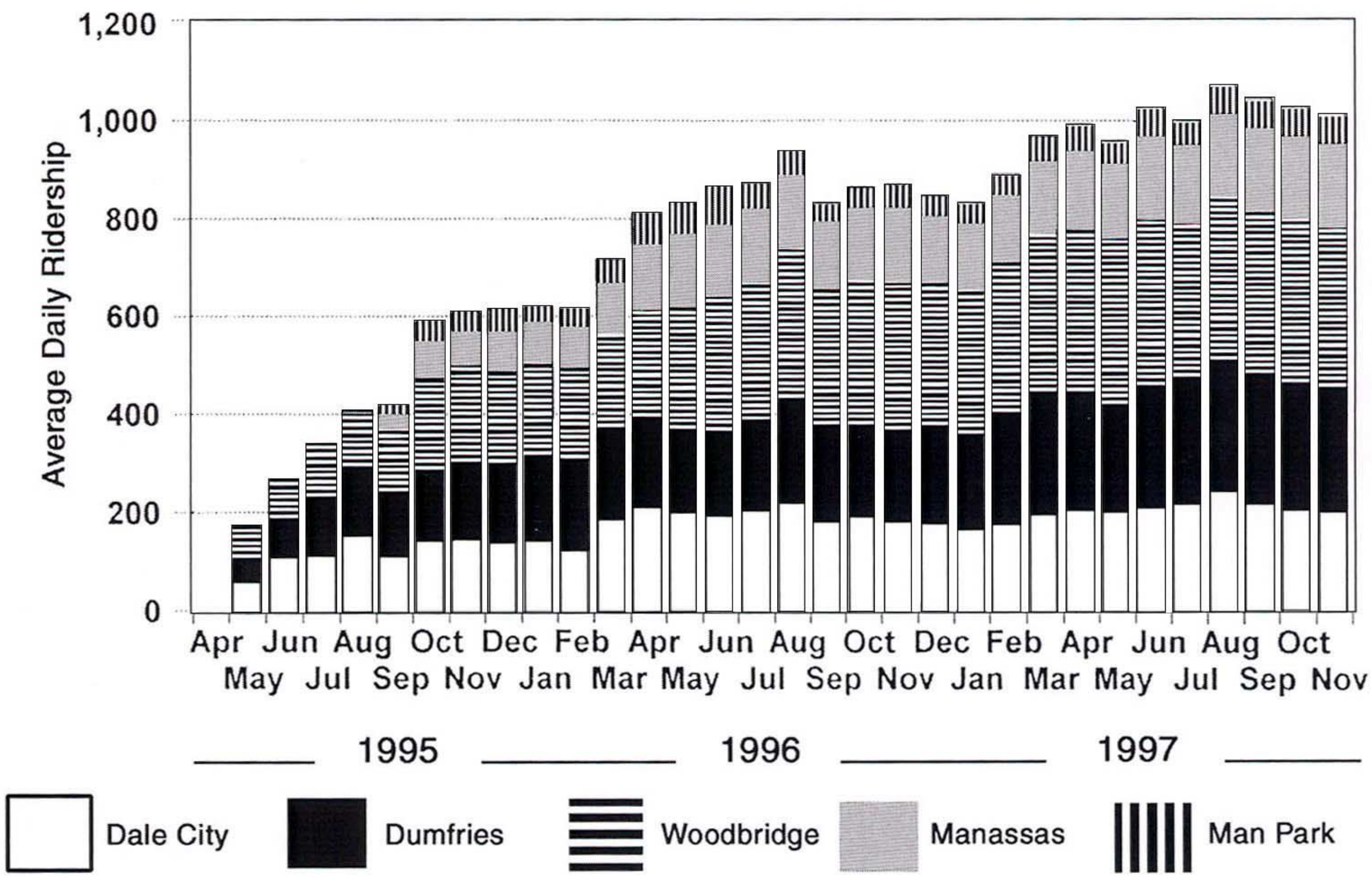
In the particular case of OmniLink point-deviation service, ridership on the three lines opened first increased from about 20 percent of matured ridership in the first month to 50 percent in the fourth month. Results for initial months of any new transit service are known to vary widely, however, even when expressed relative to matured ridership. Thus these values are only broadly suggestive of possible outcomes elsewhere.

Demand Responsive Service Rider Characteristics and Alternative Modes

General Public Services

In some cases, characteristics of ridership on general public dial-a-ride services are not that much different from services with eligibility restrictions, covered next, although more employed persons might be expected on weekday services. In Warsaw, Indiana, for example, the typical rider is thought to be a poor, elderly, or disabled passenger (Kosciusko Area Bus Service, 1998). This is probably typical of rural areas and communities. Of surveyed riders using the Phoenix Sunday dial-a-ride service, eight out of ten had no car, 77 percent had no driver's license, and the typical rider was a female senior citizen with limited income (Crain & Associates, 1983). (See the case study "Demand Responsive Service at Times of Lesser Demand — Phoenix" for further detail.)

Figure 6-5 Prince William County, Virginia, OmniLink Point Deviation Service Ridership Growth



Source: PRTC Monthly System Performance Reports.

The general public dial-a-ride services in the relatively well-to-do outer Minneapolis suburbs of Shakopee, Eden Prairie, Chanhassen and Chaska, Minnesota had senior citizens as 15 to 25 percent of their weekday daytime riders, students as 20 percent (primarily from private schools) to 50 percent, and other general public for the remaining 25 to 65 percent. Evening service in Shakopee attracted mostly students with evening extra-curricular activities. Saturday service riders were divided more or less evenly between senior citizens and students on the one hand and other general public on the other (Pratt, 1989).

Surveys soon after introduction of OmniLink service in Prince William County, Virginia identified primary OmniLink travel purposes as work (29 percent), shopping (26 percent), medical (15 percent) and social-recreational (11 percent). Surveys at the end of the first year found 61 percent of the riders to be female, 79 percent under 45 years of age, and 64 percent having less than a $25,000/year salary. Some form of automotive travel was the prior mode for 72 percent; 21 percent drove alone, 29 percent were car passengers, and 22 percent had used taxis (Rosenbloom, 1998). Other data specifically identified as being for OmniLink demand response patrons indicate 22 percent formerly drove alone to work and 19 percent formerly drove alone to shop (Michael Baker et al, 1997). It is not clear whether or not some of the Prince William County rider survey data includes the roughly one in four of total OmniLink demand response and fixed route patrons who used the fixed route commuter rail feeder component of the overall service.

Logically, occurrence of trips not made previously should be significant for new demand responsive services. Reported information on this appears to be universally lacking, however.

Eligibility-Restricted Services

Demand responsive services with rider eligibility restrictions obviously cater to persons with the defined characteristics, typically persons with disabilities, or other transportation disadvantaged clientele. The defined characteristics will vary according to the objectives or legal mandate of the system. Results of different approaches are illustrated by the client characteristics presented in Table 6-14.

The Florida passenger characteristics data in Table 6-14, being statewide, reflect a full gamut of eligibility requirements. Extra caution must be applied in interpreting the Florida percentages, however, since each individual is assigned to only one category, even though many undoubtedly fit into several. Also, the Florida data is for a 50-50 mix of paratransit and fixed route transit disadvantaged riders (Florida Commission, 1999). In Winston-Salem, North Carolina, the target population is senior citizens, people with disabilities, and young children going to school, especially Head Start. The rider characteristics presented in Table 6-14, based on a survey of 272 riders, reflect this emphasis (Ben-Akiva et al, 1996). The Chicago client mix reflects a more narrow application of federal ADA requirements. Although not reported, presumably all the riders at least nominally meet the criterion of being unable to access or use conventional transit services because of a disability. Note the virtual absence of children as Chicago paratransit clients, in contrast to Florida and Winston-Salem.

Table 6-14 Characteristics of Social Service and ADA Demand Responsive Clients

Florida Statewide[a]		Winston-Salem		Chicago ADA	
Category[b]	**Percent**	**Category[c]**	**Percent**	**Category[c]**	**Percent**
Age 60 and over	33%	Age 65 and over	59%	Age 65 and over	60%
Disabled	17	Disability	61	Disabled	n/a
Age under 16	23	Age under 12	12	Age 17 and under	0.2
Low Income[d]	14	Not employed	98	Less than $10,000[e]	55
Other	13			(see text for more)	

Notes: [a] Includes disadvantaged program users of fixed route transit (50%) and school buses (1%).
[b] Passengers assigned to one of the indicated categories only.
[c] Multiple categories may apply to individual passengers.
[d] Below published National Poverty Level.
[e] Annual household income.

Sources: Florida — Florida Commission (1998); Winston-Salem — Ben-Akiva et al (1996); Chicago — Chicago Transit Authority (1999).

Additional rider characteristics data from Chicago's 1998 annual survey, based on roughly a 50 percent sample survey of registered paratransit customers with a 41.4 percent return (524 responses), indicate that 80 percent of the respondents were female. More than half of the registrants 65 and older were 75 or older (32 percent of registrants), and 20 percent had a household income of less than $5,000 per year. A steadily increasing percentage, 52 percent in 1998, lived alone, and another 26 percent lived in two-family households. Of the responding registrants, 78 percent lived in a household that lacked a personal vehicle (Chicago Transit Authority, 1999).

Table 6-15 lists the trip purposes of social service and ADA passengers for the same three areas. However, in this case, the Chicago ADA data pertain only to attempted travel by registrants for which they were *unable* to secure timely paratransit service due to insufficient supply. Since 49 percent of Chicago registrants report pre-scheduling some, most, or all of their trips as subscription trips, which require a minimum trip frequency of three per week, it may be assumed that the purposes of trips successfully made are more oriented toward repetitive travel such as work and education/training trips (Chicago Transit Authority, 1998 and 1999).

As noted earlier, 55 percent of Chicago ADA registrants unable to book a trip at the desired time reported inability to make the trip by any other means. Of the 45 percent who found alternative transportation, the means utilized were regular taxi (21 percent), accessible taxi (4 percent), a special CTA Taxi Access Program (5 percent), fixed route service (7 percent), social/health agency service (7 percent), private car (36 percent) and other (20 percent). Since the "Other" category includes responses like "friend," "relative" or "neighbor" as helpers, private car may well be the underlying means within this category as well (Chicago Transit Authority, 1998).

Table 6-15 Trip Purposes of Social Service and ADA Demand Responsive Clients

Florida Statewide		Winston-Salem		Chicago ADA (see note)	
Category	**Percent**	**Category**	**Percent**	**Category**	**Percent**
Employment	18%	Employment	less than 5%	Work	8%
Edu./Training	24	Educational	26	Religious	12
Medical	32	Medical	57	Medical	62
Nutritional	6	Shopping	6	Shopping	5
Life Sustaining	6	All other categories	less than 5% each	Social/Recreational	7
Other	14			Other	6

Note: Chicago trip purpose data are ONLY for ADA trips that the prospective passenger tried but failed to schedule due to ADA service capacity constraints. See text for alternative modes used.

Sources: Florida — Florida Commission (1998); Winston-Salem — Ben-Akiva et al (1996); Chicago — Chicago Transit Authority (1998).

Impacts on VMT, Energy, Environment, Costs

The primary applications of demand responsive operations are the provision of transit service in situations where the density of demand is low. These include both low densities due to the geographic spread of development and low densities due to service to a limited market group. In either case, because demand density is low per trip, ridership will also be low. As a result, the presence or absence of transit service will have little effect on automobile use and, therefore, only minimal impacts on automobile related vehicle miles of travel (VMT), energy consumption or emissions.

The use of a demand responsive service strategy to serve all riders in lieu of separate fixed route and complementary ADA paratransit can yield significant savings for transit operating agencies in small cities and low density service areas. The Potomac and Rappahannock Transportation Commission estimated that use of the point deviation service strategy for OmniLink service in Prince William County, Virginia, resulted in an annual saving of $462,000. Without a demand responsive strategy, the annual budget of about $688,000 would have been on the order of $1.1 million to cover the cost of two separate services (Farwell, 1998).

Madison Metro in Wisconsin has converted its “service routes” to point deviation operation. (A service route is a fixed route designed primarily for the elderly and other transit dependents, sacrificing direct routings in order to link sites such as elderly housing with locations where relevant goods and services can be obtained.) Madison’s point deviation vehicles will deviate to serve ADA eligible riders, while non-ADA riders may board or alight the bus only at designated stops. In 1996, Madison Metro reported cost savings of $800,000 on a total ADA budget of just over $4,000,000 (Larsen, 1998). Wichita Falls, Texas converted its entire fixed-route system to route deviation to comply with ADA requirements. Buses will now stop anywhere along a route. Actual route deviation pickups require a request made a day in advance. The estimated savings of not having to operate complementary ADA paratransit was between $750,000 and $1,000,000 per year (Volinski, 1997).

ADDITIONAL RESOURCES

Transit Cooperative Research Program's *TCRP Report 3*, "Workbook for Estimating Demand for Rural Passenger Transportation" (SG Associates, 1995b) provides a step-by-step methodology for estimating the demand for passenger transportation in rural areas. *TCRP Report 9*, "Transit Operations for Individuals with Disabilities" (EG&G Dynatrend and Crain & Associates, 1995) covers a broad range of topics related to serving persons with disabilities, including demand responsive service operating strategies, and summary descriptions of services operated and the observed ridership. *TCRP Report 24*, "Guidebook for Attracting Paratransit Patrons to Fixed-Route Services" (Ketron, 1997) outlines step-by-step procedures for estimating the travel demand of ADA eligible persons and the proportion who would choose fixed route services of specified characteristics, and for establishing facilities and programs that enable ADA eligible persons to use fixed route services.

Two key reports have been published since the primary development of this chapter. *TCRP Report 91*, "Economic Benefits of Coordinating Human Service Transportation and Transit Services" (Burkhardt, Koffman, and Murray, 2003) examines the net economic benefits associated with various strategies and practices for service coordination. Related topics such as ADA rider training are included. *TCRP Report 98*, "Resource Requirements for Demand-Responsive Transportation Services" (Schofer et al, 2003), provides a methodology for determining the number of demand responsive transit (DRT) vehicles required given service area size, trip demand and operating policies. The report and accompanying "Background Document" provide several tables of observed DRT ridership and service characteristics. The analysis software provided (NU DRT) produces vehicle-hours and vehicle-miles estimates that allow computation of productivity measures.

CASE STUDIES

Demand Responsive Service in Low Productivity Areas — Norfolk

Situation. In the late 1970s, several member jurisdictions of the Tidewater Transportation District Commission (TTDC), the transit agency for the Norfolk, Virginia metropolitan area, perceived that the costs of supporting transit service were increasing. They instructed TTDC to either find ways to reduce costs or to terminate the service. TTDC staff proposed replacing the existing fixed route services with demand response (dial-a-ride). Initially, this was rejected by the local jurisdictions since it was perceived as providing a premium, taxi-like service. Fixed route services were terminated, but restored several months later, at higher cost and lower ridership, after public complaints. Following the award to TTDC of a grant under the National Ridesharing Demonstration Program and a state experimental project grant for the purpose of developing a shared-ride taxi program, the local jurisdictions agreed to permit TTDC to establish demand responsive service territories.

Actions. Twelve territories were established in which demand responsive dial-a-ride service would be provided by taxi companies under contract to TTDC. Three of these were in rural satellite communities; five were in low density suburban areas; and four were in urban areas. Three of the suburban territories replaced low productivity fixed routes. One of the urban territories replaced a fixed route all day; the other three provided night service, either replacing fixed routes or restoring a previously terminated night service.

The base fare on TTDC's fixed routes was $0.50. Fares for the demand responsive services were $0.50 for most of the urban services, $1.00 for the suburban services and $2.00 for the rural services.

Analysis. The project as conceived by TTDC and the sponsoring agencies focused primarily on demonstrating the feasibility of reducing transit service costs by contracting with private taxi companies. Much of the analysis and evaluation focused on cost and institutional issues. As the project evolved, however, TTDC changed the amount of service provided in some territories to better match demand and increased the fares in some territories to reduce subsidy costs. Ridership changes resulting from these actions were captured as part of TTDC's routine data collection and the overall demonstration evaluation effort.

Results. Comparison of demand responsive services (Maxi-Taxi) with previously operated fixed routes (bus) are presented in Table 6-16 on the basis of monthly data.

Table 6-16 Comparison of TTDC Demand Responsive Services with Previous Fixed Routes

	Service Hours	Cost	Passengers	Revenue	Deficit	Deficit per Passenger
Deep Creek						
Bus	n/a	$4,460	1,170	$526	$4,134	$3.53
Maxi-Taxi	n/a	$6,947	2,041	$2,042	$4,905	$2.42
Ocean View						
Bus	300	$8,940	1,556	$570	$8,370	$4.98
Maxi-Taxi (Jan. 1981)	300	$4,200	1,242	$522	$3,678	$2.96
Maxi-Taxi (June 1981)	300	$4,830	1,617	$566	$4,264	$2.64
Coronado						
Bus	112	$3,024	1,858	$651	$2,373	$1.28
Maxi-Taxi (Jan. 1981)	155	$2,170	714	$300	$1,870	$2.62
Maxi-Taxi (June 1981)	120	$2,079	929	$325	$1,754	$1.89

Note: All data are monthly.

Table 6-17 summarizes fare and service changes during the demonstration, the weekly patronage effects, and the computed log arc elasticities.

More... The taxi operators in the region perceived TTDC's demand responsive service as a threat to their business. All but one company declined to submit a bid to operate the service. TTDC renamed the service from Maxi-Taxi to Maxi-Ride. After several years, TTDC determined that Maxi-Ride could be operated at less cost by its paratransit division than by a private company.

The three rural routes attracted very little ridership and were terminated in March 1981. The urban night services were also terminated due to low ridership and increasing subsidy costs. Services in the other areas were adjusted (i.e., fare increases, service reductions) but were retained beyond the end of the demonstration period.

Table 6-17 TTDC Demand Responsive Fare and Service Changes, Ridership Response, and Elasticities

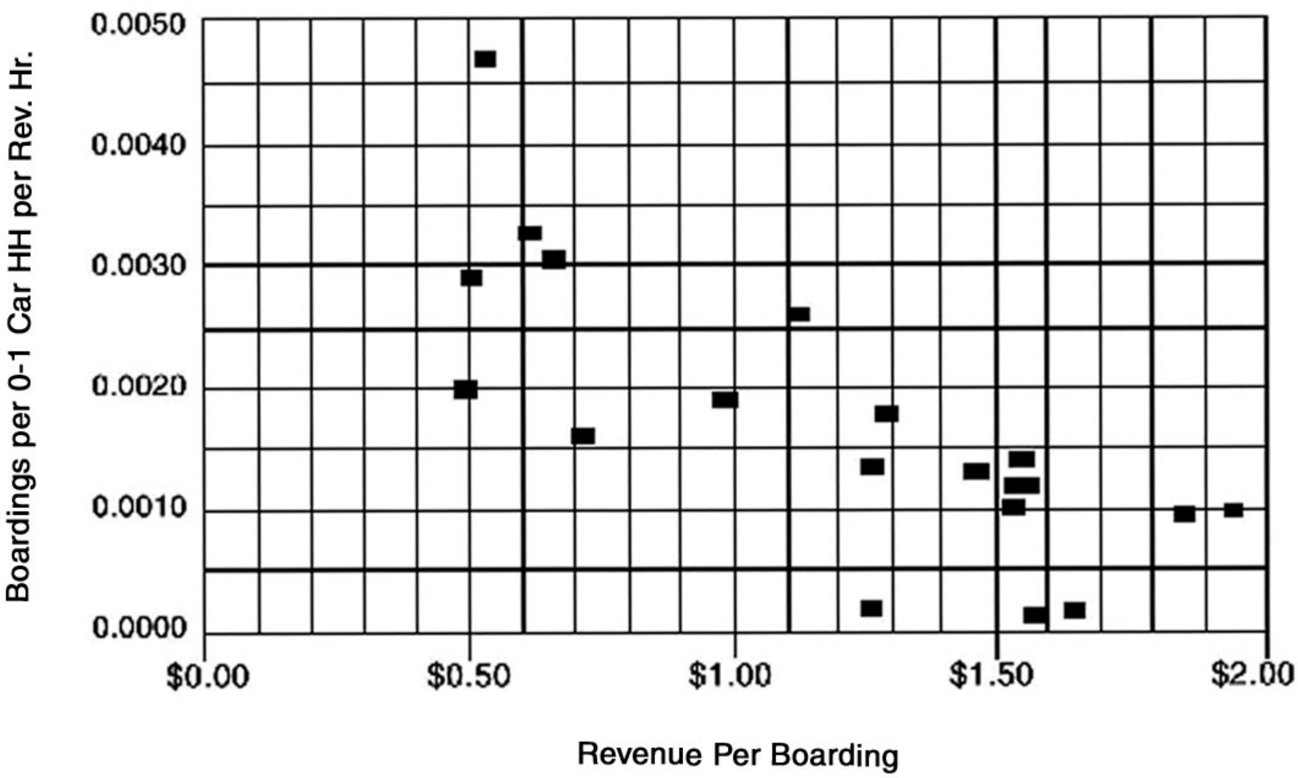
	Change in Service Hours				Change in Fares			
Territory	**Weekly Hours and Riders**	**Before**	**After**	**Log Arc Elasticity**	**Fare and Weekly Riders**	**Before**	**After**	**Log Arc Elasticity**
Churchland	Hours Ridership	156 414	78 282	+0.554	Fare Ridership	$1.00 252	$1.50 214	-0.403
Bowers Hill					Fare Ridership	$1.00 170	$1.50 159	-0.165
Great Bridge	Hours Ridership	114 180	85 139	+0.881				
Portsmouth	Hours Ridership	72 344	54 298	+0.499	Fare Ridership	$0.50 272	$1.50 184	-0.356
Hampton Blvd.	Hours Ridership	70 221	35 137	+0.690	Fare Ridership	$0.50 133	$1.00 85	-0.646
Ocean View/ Bayview	Hours Ridership	140 307	240 806	+1.791	Fare Ridership	$0.50 377	$1.00 299	-0.334
Coronado					Fare Ridership	$0.50 217	$0.60 209	-0.206
Deep Creek					Fare Ridership	$1.00 390	$1.50 303	-0.623

Note: All data are weekly.

In 1998, TTDC operates Maxi-Ride in seven territories. Various call taking and dispatching systems have been used. The current system involves the use of a cellular phone on each bus, with the driver serving as the call taker and dispatcher. The Maxi-Ride services have been integrated into TTDC's timed-transfer system, with the service in each territory operating between transit centers where it connects each hour with one or more fixed routes. The path of each demand response vehicle between the transit centers is determined by the driver as needed to meet service requests. The cash fare in three of the territories is $1.50 — the same as the fixed route cash fare. In four of the territories, the cash fare is $3.00. Various multi-ride fare media and reduced fare categories are provided by TTDC so the revenue per boarding in all territories is less than the cash fare.

An analysis conducted for TTDC in 1997 attempted to assess the effect of the higher fare on Maxi-Ride patronage. Ridership per target market (i.e., boardings per low auto ownership household) vs. revenue per boarding for each Maxi-Ride territory over three years (1994, 1995, 1996) is shown in Figure 6-6. The implied log arc elasticity of demand with respect to fare is about -1.0.

Figure 6-6 Greater Norfolk Maxi-Ride Service Use Versus Cost to User — Low Car Ownership Households



Source: SG Associates (1998).

Sources: Comsis Corporation, "National Ridesharing Demonstration Program: 'Maxi-Taxi' Services in the Tidewater Region of Virginia." DOT-TSC-UMTA-85-16. U.S. Department of Transportation, Urban Mass Transportation Administration, Washington, DC (July 1985). • Becker, A. J. and Echols, J. C., "Paratransit at a Transit Agency: The Experience in Norfolk, Virginia." *Transportation Research Record 914* (1983). • SG Associates, Inc., "Maxi-Ride Fare Analysis, Draft Report." Tidewater Transportation District Commission, Norfolk, VA (January 1998).

Point Deviation Service in Outer Suburbs — Prince William County, Virginia

Situation. Prince William County is a primarily residential area with a 1990 population of 250,377 located about 30 miles southwest of Washington, DC. Transit service for commuters to Washington, DC is provided by Virginia Railway Express commuter rail and the OmniRide commuter bus service operating in high-occupancy vehicle lanes on I-95. The developed area of Prince William County had a 1990 population density of 2,700 persons per square mile and a street pattern typical of suburban areas developed since 1960 with a relatively sparse road system. Prior to 1995, there was no intracounty transit service.

Action. OmniLink, the service developed and implemented in 1995, consists of two components operated by the Potomac and Rappahannock Transportation Commission. One component consists of peak period fixed-route feeder service to Virginia Railway Express Commuter Rail. The other component, the subject of this case study, is a point deviation service funded, in part, as an Intelligent Transportation Systems (ITS) operational test. There are five point deviation OmniLink routes — three in the eastern portion of the County and two in Manassas / Manassas Park. Services operate on a fixed schedule — a 45 minute headway — with routes timed to pulse at a common location. The vehicles used are 22 seat, 2 wheelchair tie-down, body-on-chassis buses.

Each point deviation "route" operates between fixed endpoints along a corridor defined by widely spaced "stops" (about 0.62 miles on average). In the absence of off-route requests, buses operate along a set route generally in the center of a 1.5 mile wide service corridor. Buses serve each fixed bus stop in sequence on every run. Buses will deviate off the central route to any point in the corridor to pick up or drop off a passenger who has called in a service request. The policy for call-in requests was two hours in advance of the time one wished to be picked-up. In practical terms, the advance notification requirement needed to be only about 20 minutes. Persons boarding and alighting at bus stops did *not* need to call OmniLink.

The ITS demonstration included installation of a GPS based automated vehicle location system for all buses and the development of real-time scheduling and dispatching software with the ultimate intent of "en route" response to service requests. That system was not fully operational at the time of the reported analysis, so that order taking was computer assisted, but dispatching was still a manual function. Even with a manual system, however, service requests with lead times as short as two hours were regularly accommodated.

Analysis. Data on ridership, costs and other aspects of the services were collected by the Potomac and Rappahannock Transportation Commission as part of routine service monitoring.

Results. Ridership on OmniLink grew from 2,071 in April 1995, the first month of service, to 23,680 in October 1997. Boardings per service hour for the three routes in the eastern portion of

Prince William County grew from 7.95 in May 1995 to 11.67 in August 1997. For the system as a whole, productivity was just under 9.0 passengers per hour. As of April 1998, ridership in eastern Prince William County was averaging 11.8 boardings per vehicle service hour on the three routes: two averaging 13.5 boardings per vehicle service hour and the third averaging 8.5.

The dispatch/customer service center processed 6,439 calls in April 1998. Of these, 28 percent were for general information, and 72 percent were to make ride requests. Of the total monthly ridership in April 1998 (23,733), 9.5 percent were one-time call requests, 10.0 percent were subscription requests and the remaining 80.5 percent were casual trips (persons boarding at bus stops).

The operating cost per trip in April 1998 for the eastern Prince William County routes averaged $3.23 and was $2.87 for the two most efficient routes. The true benefit of the flex-route service as operated by the PRTC is that separate ADA paratransit service is not needed as the flex-routes serve both ADA demand and general public demand in one system by treating all requests equally. Thus, the PRTC, in the first year of operation, for the services in eastern Prince William County, mitigated the need to operate an additional 6 vehicles operating 52 daily service hours, and thereby saved $462,000 relative to the actual annual budget of $688,000 by operating as a flex-route system.

More... The development, installation, and testing of the ITS system had largely been completed in 1998 and the system was in the evaluation phase. The OmniLink service was using the GPS based AVL system to track vehicle location, feed trip booking and dispatching decisions, send manifest information to the drivers and collect passenger activity data from the drivers via mobile data terminals on board each vehicle.

Sources: Farwell, R. G. and Marx, E., "Planning, Implementation, and Evaluation of OmniRide Demand-Driven Transit Operations: Feeder and Flex-Route Services." *Transportation Research Record 1557*, Transportation Research Board, Washington, DC (1996). • Farwell, R., "Evaluation of OmniLink Demand-Driven Transit Operations: Flex-Route Services." *Transportation Quarterly*, Vol. 52, No. 1 (Winter 1998).

Demand Responsive Service at Times of Lesser Demand — Phoenix

Situation. In 1980, the City of Phoenix, Arizona had a population of 800,000 in a developed land area of 180 square miles. Phoenix Transit System provided service to about 166 square miles, operating weekdays and Saturdays. Sunday service was not provided. Three weekday demand responsive (dial-a-ride) services in less dense portions of the city were provided by a taxi operator under contract.

Actions. The City of Phoenix began a Sunday, city-wide dial-a-ride (DAR) taxi service on August 31, 1980 to provide Sunday daytime public transportation as an alternative to initiating more costly fixed route bus service. Service hours were 8:00 AM to 3:00 PM. To obtain service, customers called the DAR office, a local taxi operator. A one-zone fare was $1.00; additional zones cost $0.25. Seniors, handicapped persons and children rode for half fare. Service was provided by up to 17 vehicles and one wheelchair van. The City of Phoenix contracted with Arnett Cab Service, Inc. to provide the DAR service. Arnett billed the City of Phoenix based on the number of vehicle-hours in service minus collected fares. The required response time for a call for service was 30 minutes. Ninety-four percent of calls were served within this period.

Analysis. A federally sponsored evaluation was conducted on the basis of monitoring of operations, ridership and costs, along with rider surveys.

Results. DAR ridership rose rapidly the first three months, hitting a high of 1,425 riders per month in January 1981, then began a general decline in February. Following a fare increase from $1.00 to $1.50 for the base and $0.25 to $0.50 for zones in June 1981, ridership leveled off at about 700 riders per month in September 1981. Ridership again began an upward climb in March 1982, coinciding with an extensive marketing campaign, hitting a new high of 1,441 riders in August 1982. Average ridership over the entire 26-month period (through October 1982) was 233 per Sunday, about 1,000 per month.

Survey data indicated the DAR service was meeting the needs of a truly needy segment of the population. Ninety-five percent of the riders indicated the service was very important or important to their transportation needs. Eight out of ten DAR riders did not have a car and 77 percent had no driver's license. The typical Sunday DAR rider was a woman age 65 or older with a limited income.

Most riders used the Sunday service to make a round trip — an average of 125 separate persons were served each Sunday — and over half said they used the service each Sunday during the month. The most common trip purposes were church attendance (29 percent) followed by shopping (23 percent) and visiting (18 percent).

More... The DAR system operated with a productivity rate of 2.1 passenger trips per hour, a subsidy level of about $6,400 per month, and a farebox recovery rate of 13.4 percent. Total cost per passenger trip was $7.67; subsidy cost per passenger trip was $6.64. The City of Phoenix and the taxi operator together monitored productivity factors to determine the number of vehicles placed in service. Although the economic incentive for the operator was to increase fleet size and thereby increase billings to the city, his attitude was one of cooperation with the city in order to provide service at a reasonable cost.

Annual subsidy cost for DAR taxi ($87,000) at the then current demand levels was considerably less expensive than the estimated cost of providing minimum level fixed route Sunday service ($886,000). Whereas demand responsive service ridership at the average subsidy per passenger of $6.64 averaged 233 trips per Sunday, Phoenix Transit estimated that the minimum fixed route operation would have attracted 4,300 trips per Sunday at a subsidy per passenger of $3.50. Costs for the DAR service were only higher on a per passenger basis, although total costs would have increased if more passenger trips were served. The lower total cost on the DAR system was primarily a result of less service and lighter ridership than would be expected for a fixed route service.

Source: Crain & Associates, Inc., "Phoenix Transit Sunday Dial-a-Ride." UMTA-MA-06-0049-83-7. U.S. Department of Transportation, Urban Mass Transportation Administration, Washington, DC (August 1983).

Promoting Use of Fixed Route Services by Persons with Disabilities — Ann Arbor, Michigan

Situation. Regulations implementing the Americans with Disabilities Act require that transit agencies provide a complementary paratransit service for persons who, by reason of their disability, cannot use the fixed route transit services. The cost of serving a passenger with paratransit is typically far greater than accommodating the same rider on an existing fixed route bus. The per trip subsidy in 1996 estimated by the Ann Arbor Transportation Authority (AATA) of Michigan was $6.19 for taxi-based paratransit and $41.19 for trips served by a paratransit van. AATA sought to reduce paratransit costs by removing barriers to use of the fixed route services by persons with disabilities and encouraging persons using paratransit to try the fixed route system.

Actions. During 1995-96, AATA instituted experimental programs designed to induce greater use of fixed route services by persons with disabilities. These included:

- Free fare on the fixed route services for persons with disabilities during August 1995 and April 1996. The regular fare structure was:

AATA Fixed Route Cash Fare:	$0.75
AATA Fixed Route Disabled Fare:	$0.35
AATA ADA Paratransit Fare:	$1.50

- Providing informational materials to acquaint a sample subset of persons using paratransit with the fixed route services, along with a request that these persons use the fixed route services "when possible."

Analysis. Data on use of the fixed route system by persons with disabilities during both free-fare and non-free-fare months were available from farebox counts. Data on use of paratransit services were available from trip reservation records. Data were analyzed for the period May 1993 to April 1996. A regression model was developed of the monthly use of fixed route services by ADA eligible persons.

Results. The fixed route free fare had a significant effect on use of the fixed routes by persons with disabilities. Ridership in the free-fare months was about 3.5 times greater than in the same months of the two previous years. The absolute increase in trips by persons with disabilities in the free-fare months was about 5,000 over what would have been expected without the free fare. Most of this increase appears to have represented additional trips rather than a shift from paratransit. The monthly reduction in paratransit trips due to the free fare was estimated to be 489.

The informational and fixed route use encouragement program was found to have no effect, as shown in Table 6-18.

Table 6-18 Results of Informational and Fixed Route Use Encouragement Program

	Monthly Average Paratransit Trips		Percent Change
	Before	After	
Experimental Group	5,961	6,029	+1%
Control Groups	5,872	5,820	-1%

The group receiving the informational materials actually exhibited a slight increase in paratransit use, but the difference between the experimental and control groups is not significant.

More... The free fare appeared to have some lasting effect, with use of the fixed route system by persons with disabilities continuing at a level 33 percent higher than historic trends in the months following August 1985.

Source: Levine, J. C., "ADA and the Demand for Paratransit." *Transportation Quarterly* Vol. 51, No. 1 (Winter 1997).

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FTA	Federal Transit Administration
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