TRANSIT COOPERATIVE RESEARCH PROGRAM

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TCRP Report 18

A Handbook for Acquiring Demand-Responsive Transit Software

Transportation Research Board

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A Handbook for Acquiring Demand-Responsive Transit Software

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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 Transit Association (APTA), *Transportation 2000*, also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

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

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at 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.

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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.

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FOREWORD

By Staff
Transportation Research Board

This handbook will be of interest to agencies engaged in managing and operating demand-responsive transit (DRT) services. The handbook is intended to assist DRT providers with assessment of software needs and procurement of software to meet those needs. It is intended to be useful to readers at all levels of computer literacy and to be applicable to DRT systems of various configurations and sizes.

Under TCRP Project A-6, *Software Requirements for Demand-Responsive Transit*, research was undertaken by a team headed by SYSTAN, Inc., to specify requirements for the development of future computer software to assist in the management and operation of demand-responsive transportation systems. An implementation handbook was developed to assist transportation providers in the procurement and implementation of such systems. To achieve the project objectives, the researchers conducted a comprehensive review of the literature and current practice related to computerization of DRT systems; reviewed and summarized federal legislation and regulations that directly affect DRT systems; prepared statements of needs and objectives for automating the management and operations functions of DRT systems; developed software specifications for each of the functions; and documented advance technology features. The information collected was used to develop a handbook to assist demand-responsive providers in their decisions about automating administrative and operating functions and in procuring software that meets the specifications.

The handbook provides a history of DRT service and describes how DRT works. The handbook also discusses DRT software, including a description of the existing state of the art based on a survey of DRT providers and experts in the field. A section on computer hardware is included for those who need a tutorial in order to use the handbook.

The handbook is one of three products developed under this project. The second product is a report directed at software developers. It documents the needs of DRT providers and translates those needs into guidelines that should ensure the development of useful software. A third product, the final report, documents the research results of the project. The final report would be of interest to researchers in the field. Both reports are unpublished, but are available on loan through the TCRP, 2101 Constitution Avenue, N.W., Washington, D.C., 20418.

CONTENTS

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The research described in this report was conducted under a Transportation Cooperative Research Program contract (Project A-6, entitled *Software Requirements for Demand-Responsive Transit*) by SYSTAN, Inc., with assistance from Logitrans, Inc., and Norm Y. Mineta International Institute for Surface Transportation Policy Studies.

The Principal Investigator for SYSTAN, and the principal author, was Roy Lave, CEO of SYSTAN, Inc. Roger Teal was the Principal Investigator for Logitrans, Inc. Patrisha Piras of the Mineta International Institute contributed materials to earlier reports. Juliet McNally of SYSTAN conducted survey analysis and Patricia Kaspar of SYSTAN performed technical editing prior to TCRP publication.

Many providers, vendors, and other experts generously contributed material used in this Handbook. While they are too numerous to name, many of their names appear in citations, quotes, and lists in the Handbook. The willingness to contribute to this undertaking demonstrates the spirit of sharing and community that exists among the transit and paratransit community and that makes research possible and fulfilling.

The author is also appreciative of and indebted to the TCRP Topic Panel consisting of Brigitte Benett, Capital Metropolitan Transit Authority (Austin, TX); Ray Boylston, North Carolina DOT; Sandra Draggoo, CATA (Lansing, MI); Roy Glauthier (chair) of DAVE Transportation Services, Inc.; Lawrence Harman, consultant; Naomi Ledé, Texas Southern University; Glenn Millis, NYC Transit Authority; Jack Reilly, Capital District Transportation Authority (Albany, NY); Nancy Senn, Milwaukee (WI) County; Peter Shaw, TRB; Denis Symes, FTA; Marjorie Walsh, consultant; and Nigel Wilson, Massachusetts Institute of Technology.

Finally, the author wishes to acknowledge the support and assistance of the TCRP Project Officer Stephanie Robinson. She accommodates the vagaries of research and the idiosyncrasies of researchers with uncommon grace and civility, and she provided insights that enhanced the research of this project.

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CHAPTER **1**

BACKGROUND, INTRODUCTION, AND SUMMARY

AUDIENCE

This Handbook is written for staff members and policy-makers of organizations (henceforth called "providers") that provide shared-ride, flexibly routed, on-demand transit service, called demand-responsive transit (DRT). It is intended to help them decide whether computerization of their operating functions would be beneficial and to assist them in the selection and procurement of the most appropriate software.

1.1 THE HISTORY OF DEMAND-RESPONSIVE TRANSIT

1.1.1 What Is DRT?

DRT services are those public transportation services characterized by the flexible routing and scheduling of relatively small vehicles (occupancy of four to 20 persons) to provide shared-occupancy, personalized transportation on demand (*1*, p. 9).[1] DRT belongs to a family of services called *paratransit*, which also includes conventional exclusive-ride taxis, ride-sharing, and bicycling. DRT is distinguished from conventional taxi service by its ride-sharing feature, which poses difficult control problems; however, when taxi service is offered as shared-ride service, it is a DRT service. Current usage interchanges the words paratransit and demand-responsive transit, but demand-responsive transit is the more precise term for the material in this Handbook so that it, or its abbreviation DRT, will be used throughout.

It is of historical interest to note that this name was not the preferred one by early writers in the field. For example, Bhatt and Kemp (*2*, p. 126) proposed dial-a-ride as a preferred name with the following argument:

> We have advisedly chosen to use the term *dial-a-ride* in preference to a number of other names which have been applied to this type of service. We prefer it to the terms *demand-responsive* and *demand-activated*, because the latter are more general and can be applied equally to taxicab and limousine service. We also prefer it to the name *dial-a-bus*, which implies a vehicle large enough to be called a "bus."

Since the term dial-a-ride could also be applied to taxi and limousine service, the argument for using dial-a-ride is not compelling. We believe DRT is the more descriptive term although dial-a-ride is a more marketable name for actual services and a number of them do include dial-a-ride in their names.

As originally conceived, a DRT system would accept telephone requests for both immediate and advance reservation service, develop a continually changing set of vehicle schedules (also known as vehicle tours) which would accommodate these trip requests, and route vehicles to the appropriate passenger origins and destinations in accordance with the schedule. Because both the trip requests and the vehicle scheduling and routing decisions were occurring in real time, the control problem became complex when any significant number of vehicles and trip requests were involved.

1.1.2 Role of DRT

DRT service has been one of the most significant service innovations in public transportation in the last two to three decades, but it is the rebirth of a much older service. Almost as long as there have been automobiles in the United States, they have been used as jitneys, originally offering an alternative to streetcar service. (The name "jitney" came from the slang word for a nickel, the typical jitney fare.) Most of these early services were regulated out of business by more politically connected transit operators fearing the competition. DRT had a rebirth in the United States in the early seventies with research on computer-controlled service and experiments in manually dispatched services. A count of current DRT services operating, including social service agency services but excluding conventional taxicab services, would yield several thousand. Collective riding in sedan vehicles is widespread throughout the world, especially in developing countries.

Although in theory DRT service is extremely user-friendly because of its door-to-door capability and semiprivate, comfortable vehicles, its adoption has not been widespread due to the relatively high cost of operation. DRT is a labor-intensive mode with costs comparable to the taxicab, due to inherently low passenger productivity (passengers per vehicle-hour). As a result, these services are most commonly operated by social service agencies to transport their clients or by transit districts, counties, and cities for persons with special needs or qualifying conditions. Nevertheless, in many rural and small towns in which labor rates are low, DRT provides the only transit in town.

[1] References are indicated by numbers in parentheses and are listed at the end of the chapters.

Most recently, demand-responsive paratransit service was promoted to prominence as a result of the enactment of the 1990 Americans with Disabilities Act (ADA) (*3*). The ADA put every U.S. transit agency into the DRT business by requiring fixed-route transit operators to provide complementary paratransit service for persons with disabilities within their service areas who are unable to use fixed-route services. The issue of high cost was set aside by a national policy which deemed that accessible transit is a civil right. The ADA mandate is causing expansion of the number of paratransit services and growth in the size of existing services. This growth, in turn, motivates the search for more cost-effective means of operating DRT because already financially troubled transit must find funds for new services. One promising means of improving the cost-effective performance of demand-responsive paratransit is the use of computerization and other information technologies.

1.1.3 Role of Computerization

Several functions required to offer demand-responsive operations—such as trip reservation, scheduling/dispatching, financial management, and reporting—lend themselves to computer assistance and can be greatly enhanced by computerization. In fact, the potential of the computer to make it possible to cost-effectively operate large demand-responsive transit systems for all users was a motivating factor for the study of scheduling/dispatching in academic and research circles in the early 1970s. The computers at that time were too expensive and too slow, and the several large systems that were implemented—in Haddonfield, New Jersey; Rochester, New York; and Santa Clara County, California—were discontinued by the eighties. Only the fully computerized system in Orange County, California, survived.

While the use of computer control may have diminished, the use of demand-responsive transit did continue in smaller towns and rural areas and in large cities to serve special populations such as persons with disabilities and the elderly. Eventually, the desire among operators to find better, more cost-effective methods led to the development of a market for software to serve the systems that did exist. As the systems evolved and became larger or more demanding of efficient operations, a demand for software evolved as well. This demand was filled by a number of products developed either by operators for their own systems or by consulting firms, academics, and researchers for sale in the general market. Today, software is available that runs on relatively inexpensive computers and serves both small and large systems with a variety of DRT functions. Several newly implemented systems utilizing sophisticated scheduling/dispatching software, automatic vehicle location technology, and digital communications may bring the original vision well within the realm of technical and economic feasibility.

In summary, from the inception of demand-responsive transit circa 1970, computer control of the core DRT functions—scheduling, routing, and dispatching of vehicles in response to trip requests—has been a key issue for this transportation service. The history of computer use is described in more detail in Section 3.2.

1.1.4 Current DRT Issues

The paratransit industry now has an increasingly varied menu of technological options from which to choose. Different vendors of DRT control software have different features and functions in their systems. They use different programming languages, operating systems, database systems, and networking systems to implement their packages, and they provide different levels of interfaces with other technological options. These other technological options have proliferated in recent years and include such technologies as: in-vehicle computers or mobile data terminals, vehicle location devices, mapping systems, interactive telephone systems, and wireless data communications. Each of these technologies holds promise for increasing the effectiveness of DRT service. However, they complicate each provider's decision concerning how many and which technologies are warranted.

Moreover, there are no industrywide standards or even expectations as to what features and functions a system should have or the degree to which it should interface with other software or hardware systems. This can make a decision to purchase one vendor's software more binding on future automation decisions than would be desirable in the best of all worlds.

The requirements of ADA-complementary paratransit add yet another level of complexity to this process. The potential need for determining trip-by-trip eligibility for service, and for providing certain service-level guarantees to ADA riders, poses additional functional requirements for DRT software. Vendors have adopted different approaches to fulfilling these requirements, and the ADA elements of their systems are usually tightly bound with their overall system design.

While a number of providers have navigated among these problems, there are still frustrated and unhappy providers who have unsuccessfully tried to use DRT software, and there are even more providers who believe computerization would be helpful but lack the resources and know-how for the task of selecting, acquiring, and implementing the technology.

In summary, several factors motivated the project to create this Handbook. The promise of the potential benefits of the use of software and the complementary technologies is a compelling reason to develop methods of analyzing and acquiring software. Since the software can be expensive and its benefits are uncertain, mistakes in selection can be expensive and demoralizing. Moreover, the acquisition and implementation process is difficult and laden with problems an agency must overcome. This Handbook is intended to help address these issues for both those acquiring new software and those updating software.

1.2 PURPOSE AND SCOPE OF THE HANDBOOK

> Selecting software is a difficult task that commits considerable resources and risks the integrity of the service on a single decision in an area in which many providers have little experience.

The purpose of the Handbook is to assist DRT providers in dealing with the complexities described above and, specifically, to assist demand-responsive providers in making their decisions about automating administrative and operating functions by helping them select, acquire, and implement software. Additionally, it is intended to assist the process of incorporating other automated technologies into DRT to realize the promise of current technologies for improving the operations of DRT.

The material in this Handbook focuses on software that performs the operations functions necessary to offer demand-responsive services. These are the services that operate automotive vehicles from sedans to small buses; that respond to individual riders' requests for services that pick up and deliver passengers to points usually designated by that passenger; and that attempt to carry multiple passengers at one time to increase productivity and decrease unit costs. The study does not include exclusive-ride taxis, although some of the software used for DRT service is related to taxi software.

Software that performs the following operations functions is included:

- Eligibility determination—verifying the eligibility of the person requesting the service;
- Trip reservation—taking the passenger's call, verifying eligibility, recording the date and time of the trip requested;
- Service scheduling—determining a pickup time for the passenger and conveying that information to the passenger;
- Vehicle dispatching—assigning a sequence of trip requests and times to a driver/vehicle combination;
- Vehicle routing—providing the precise street routing to the driver/vehicle; and
- Reporting—collecting, processing, and documenting the operational information required to manage the system and to report to those having oversight responsibility.

The study includes all of the functions mentioned above but concentrates on the scheduling and dispatching functions.

Software packages are on the market that perform the functions of accounting, invoicing, maintenance scheduling, purchasing and inventory control, planning, and project management. These administrative packages are often included in operations software. Reporting, for example, is included in almost all the operations software packages. Except for reporting, other administration functions are not explicitly discussed in this Handbook. The selection of these packages is not as difficult as selecting specialty software for DRT operations. Additionally, the impact of adopting administrative software is typically not as large and pervasive as is the impact of operational software.

Special purpose software is often required by certain new technologies, such as communications or automatic vehicle location. These technologies are included in the Handbook, but we do not explicitly deal with the special purpose software necessary to operate them.

It is not possible to present guidance for the selection and implementation of software without a discussion of computer hardware, so our work includes material on computers. Usually the hardware and software decisions must be made in concert. However, both buyers and vendors of software have embraced the personal computer as the preferred computer platform, so the decision is not as complex as it may be in other fields.

The needs for software and hardware are examined over about a 5-year horizon. This short time horizon was selected as an estimate of the rather short economic life of computer systems and software. It is expected that the rapid changes of the past decade will be replicated in the future as new technologies are integrated with operations software. However, a good deal of the Handbook material concerning procurement and implementation should have a much longer life.

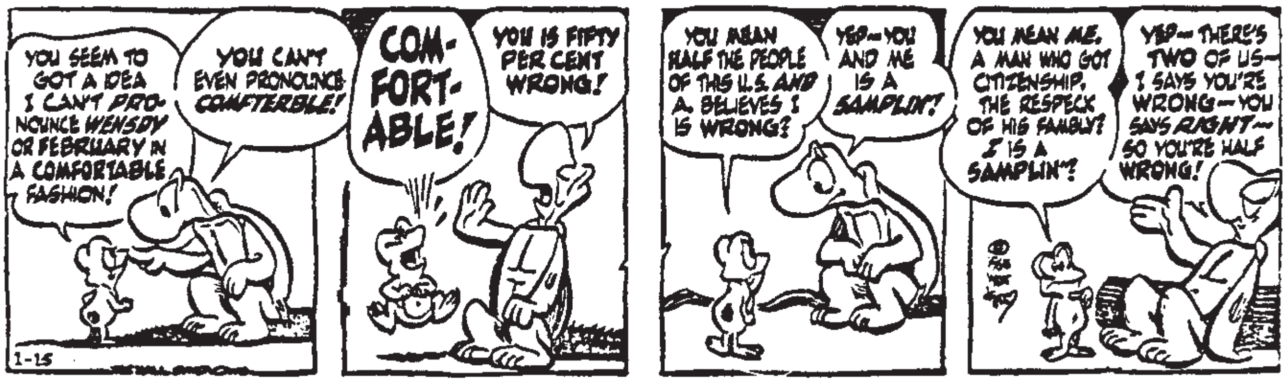
Although it does contain a list of vendors in the Appendices, the Handbook is not intended to be a consumer guide to specific software products by vendor or brand name. It is intended to identify the factors that should be considered when evaluating software packages and vendors of those packages. To understand the experiences of other users of the software, it is suggested strongly that you talk to these users. To help you do this, the Handbook provides a list of users of various packages whose vendors responded to our requests for references (see Appendix 6-A, at the end of Chapter 6).

The Handbook focuses on the acquisition decision, both whether or not to acquire and if acquiring, how to do so. It does not deal exhaustively with the issues of implementation but does provide selected implementation advice.

1.3 SOURCE OF INFORMATION IN THE HANDBOOK

1.3.1 Surveys

Information gathered in two surveys is used to describe the present and anticipated future use of computerization in paratransit (*4*). One is a survey of paratransit providers, and the second is a survey of 20 "experts" in paratransit. The providers' list was selected to include as wide a range of



experience as possible. The list of providers was identified from several sources. Persons on the list of experts surveyed were asked to identify exemplary systems of all sizes and with any degree of computerization. Additionally, providers identified in an earlier study (*5*) as having adopted certain paratransit innovations were included on the list. The list contained 347 providers, 119 of whom completed a mailed survey. The vast majority of systems surveyed are in the United States, although about 7 percent are in Canada, where DRT has been generally more advanced than in the U.S.

This process of selecting providers was not intended and did not result in a sample that can be considered representative of all paratransit providers. Rather it is a collection of exemplary systems which are sufficiently innovative and mature so that their staff would have thoughtful opinions on computerization.

The "experts" group consisted of persons with special knowledge of DRT service, including consultants, researchers and teachers, providers with extensive computer experience, software suppliers, and the TCRP panel. The mailing list was compiled from a list of paratransit experts maintained by SYSTAN and augmented by names from the mailing list of the Transportation Research Board (TRB) Committee on Paratransit. Of the 150 persons identified, 20 completed the survey.

1.3.2 Literature

The project included a literature search of the TRIS database and the transportation libraries at U.S. Department of Transportation in Washington, D.C., Northwestern University, and the University of California at Berkeley. Over 100 documents have been identified and are listed in the Phase I Report of this project (*4*).

1.3.3 Vendors

Information was solicited from more than a dozen vendors who claim to have paratransit scheduling/dispatching software. Additionally, demonstrations of the leading software products were viewed, and extensive interviews were held with members of the leading vendors' staffs. Some of the vendors on the list may have products that are not adequate for meeting ADA requirements or for integrating with other technologies and may not be viable in today's market. On the other hand, about a half-dozen companies seem to have market acceptance of their products and can be deemed to be viable based on their longevity, the number of installations of their software, the sophistication of their marketing including customer support, their plans for the future, and their understanding of the market. New vendors enter the market periodically; in fact, a new vendor entered the market as the Handbook was being completed, and two of the largest vendors merged.

1.3.4 Other Sources

Over the course of preparing the Handbook, the authors had many discussions with the major vendors of specialty software, many of the significant users, and the most active consultants in helping providers select software. Impressions from these discussions are included in the guidance presented throughout the Handbook.

Additionally, the authors have been involved in evaluating DRT software since the earliest demonstrations in Haddonfield, New Jersey, and Rochester, New York. Over the past two decades, we have developed our own impressions of the use of computers. Naturally, all the presentations in the Handbook have been selected and interpreted by the authors, and any shortcomings are our responsibility.

1.4 USING THE HANDBOOK

The most likely audience for the Handbook will be staff members and policymakers in the small (10 to 15 or fewer vehicles) to medium (10 to 50 vehicles) DRT provider agencies. (See Section 2.2 for a discussion of classifying DRT systems by the size of vehicle fleet and other measures.) The large providers (over 50 vehicles) have more limited choices for software, offered by fewer vendors. They also have either the staff capable of the acquisition analysis or the resources to hire the consultants to help. Moreover, the control problem is sufficiently complex that the need for computerization is obvious. Small agencies first have to decide if they need computers at all and then which software packages and which hardware. Although these agencies are resource-limited, inexpensive software packages exist that may provide an affordable means of getting started with software at little financial risk. Medium-sized systems have to decide what level of computerization is worthwhile and then must choose from a wide range of software from the simplest to the most complex. They, too, are probably resource-limited; yet they may have to spend a substantial sum for the appropriate software, so they bear a considerable financial risk from a bad decision. For these reasons, the medium-sized agencies may have the most difficult task in selecting software.

Individual readers of the Handbook are assumed to have a wide variety of experience levels, both with demand-responsive transit and with computers and computer software, ranging from almost none to those with advanced computer programming skills. We have tried to address all these readers by including primer material on both demand-responsive transit and computers. However, it is not the purpose of the Handbook to introduce either of these subjects to novice readers. Much of the material can be skipped by some readers. There are many cross-references among materials. Some redundancy is included to make the most significant sections stand alone for the convenience of readers who may have skipped previous material. Material that is thought to be of interest but is not essential to understanding is placed in footnotes. We have tried to provide guidelines at the beginning of each chapter concerning who we believe will find the material useful.

Understanding terms used in the Handbook is essential to using it. In this regard, it may be more difficult for readers who have experience since the usage of DRT terms does differ and there is no standard and universally accepted set of definitions. We define many terms when they are used and include an extensive glossary at the end of the Handbook, and we suggest it be used often. The glossary contains both computer and DRT terms. Where possible, terms have been adapted from other reports, glossaries and dictionaries (*5–10*). When we believed those sources to be inadequate, we supplied modified definitions.

The Handbook is organized into seven chapters. This first one provides background information on the project, a guide to the content, and a summary of the most significant recommendations. The second chapter defines and describes demand-responsive transit and identifies the functions required to offer the service and which are appropriate for computerization. Chapter 3 discusses DRT software, and Chapter 4 contains a tutorial on computer hardware. The fifth chapter contains a discussion of methods for ascertaining how much, if any, automation is warranted. All five initial chapters build toward Chapter 6, which describes the process of acquisition of software, which is the heart of the Handbook. It describes the steps and issues involved in selecting and acquiring software and provides guidance on implementation. Chapter 6 has two appendices—one contains a list of references for various software vendors, and the second contains two sample requests for proposals. The last chapter (Chapter 7) contains a discussion about complementary technologies that enhance the benefits of DRT software.

The references for the material in each chapter are listed at the end of each chapter. A complete bibliography on DRT software is contained in a different document, the Final Report of the project.

1.5 OUR MOST IMPORTANT ADVICE

We have summarized some of the most important advice contained in the Handbook and listed it in this section. It will not substitute for the full discussion contained in the places cited, but it serves to preview what is coming and summarizes what you should take away from reading the Handbook.

- Make sure you are doing the best you can with your existing operations systems and procedures before you spend money on computerized enhancements. Take the opportunity to reconsider the need for the things you have been doing and how you do them. Are the existing reports necessary? Are responsibilities clearly assigned? (Section 5.3.1)
- Don't assume that you are just computerizing your existing manual system. Computerization may be more effective if you change the way you do things and the way you organize the work. (Section 5.4)
- Carefully document in advance your needs (specifications) and expectations for the system you wish to acquire and make the specifications available to proposing vendors. (Section 6.2.2)
- Prepare your staff for new software by including them in the specification writing and assure that they will be well trained for the specific software. (Section 6.2.2)
- In some cases, a seat-of-the-pants decision to use software is justified, but for the most part, base your decision on analysis. (Section 5.2)
- When acquiring a computerized DRT package, you are blending software, hardware, and service. It is usually wise to make one vendor responsible for all three. (Section 4.3)
- Buy the capabilities you need now and will need in the next couple of years, or until you anticipate a major change in your service. (Section 3.5.4)
- Try to design your computer software to maintain flexibility to adapt to changes or to compensate for mistakes in estimating needs. (Section 3.5.3)
- Identify peers and talk to them about their experience with software and software vendors. If possible, talk to users of the actual software packages you are considering. (Section 6.2.4)
- Do not purchase anything you have not seen actually working in the field. Demonstrations do not count (*11*). (Section 6.2.4)
- If you can justify fully automated scheduling/dispatching software, evaluate the possible value of comple-

mentary technologies (Chapter 7). If you do add technologies, try to make one vendor responsible for the entire system.
- Good implementation takes time—be realistic about schedules and take the time necessary. (Section 6.3.2)
- The ability to move your files easily to new software and hardware is an important capability to allow updating or change if it becomes necessary. (Section 3.5.3)
- Don't pay or release the vendor until you are satisfied. Don't be satisfied until you know the system works under a variety of conditions. (Section 6.2.9)

As with most things in life, hard and fast rules are rare, and exceptions to any set of guidelines almost always exist. However, if you deviate from the suggestions on this list, you should have well-defined reasons for doing so.

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CHAPTER 2

DEMAND-RESPONSIVE TRANSIT

AUDIENCE

This chapter describes demand-responsive transit (DRT) and the functions required for DRT operations. It is intended as a primer for those not totally familiar with a functional view of DRT systems. It can be skipped or skimmed by readers who are familiar with this viewpoint, although you may wish to read it merely to be sure you know how we define the terms used in the Handbook.

2.1 OVERVIEW

DRT operations require a core set of functions which must be performed whether computer software is utilized or not. We call these the *operating functions.* These core functions are *trip reservations* (order taking and confirmation of a trip request), *scheduling* by assigning a pickup time to patron trip requests, and *dispatching* of vehicles to actually provide the promised service. For target market systems serving a restricted clientele, *eligibility determination* is an additional core function usually performed in combination with trip reservations. In some systems, actual street *routing* is calculated and given to the driver. Finally, *reporting* is also included as a core function because it is necessary to manage paratransit systems effectively and the information for reports comes from the other operating functions. A diagram indicating the relationship of these functions is shown in Figure 2.1. Paratransit software packages typically provide some degree of automation—up to and including full automation—for each of these functions.

In addition to the operating functions noted above, a number of administrative functions are required by DRT systems as well but they are not unique to DRT and general business or transit software is available to perform them. These functions include: accounting and invoicing, maintenance scheduling, purchasing and inventory control, and project management.

Computerization of DRT functions is the subject of the next chapter; however, references to computerization are made in this chapter when it is logical to do so.

2.2 CATEGORIZING DEMAND-RESPONSIVE TRANSIT SYSTEMS

2.2.1 Introduction

DRT systems come in a variety of configurations and sizes and operate under different passenger demand conditions. These factors will have an effect on the functionality required from software applications so that the software appropriate for a DRT operation is dependent on the type of service offered and the characteristics of the service area. This principle may become less significant in the future as vendors develop more robust software packages, but now some software seems to work better for some types of systems than for other types of systems. For you, the buyer of software, this fact creates two requirements: 1) you must identify the characteristics of your system in terms that make it possible to analyze how well a software package will work for you; and, 2) we recommend that you identify other systems, so-called peers, in other areas that are sufficiently similar to yours so that you can take advantage of their experience with software. The impact of each of these characteristics on DRT systems generally, and on software requirements specifically, is discussed in this section.

The characteristics that define a DRT system for the purposes of selecting hardware/software are the following:

- Number of vehicles—a measure of supply;
- Number of riders—a measure of demand;
- Ridership eligibility requirements, e.g., ADA services;
- Immediate, advanced, and subscription reservations—a measure of scheduling effort;
- Service area size and existence of barriers—a measure of scheduling effort;
- Trip patterns—a measure of scheduling effort; and
- Reporting requirements as a function of funding sources or other legal requirements.

2.2.2 Number of Vehicles

The number of vehicles in a fleet is an attractive measure of system size for our purposes because it defines the complexity of the scheduling/dispatching task and, in most cases, it is easily determined. As the number of vehicles in a DRT system increases, scheduling and dispatching become increasingly complex and burdensome in use of resources.

For purposes of relating software to DRT systems by size, three levels of vehicle fleets are considered. Small systems are those of 10 or 15 vehicles or fewer. Medium systems are those of 10 to 50 vehicles, and large systems are those with 50 or more vehicles.

However, vehicle fleet size is not always a definitive measure because many demand-response services are offered by

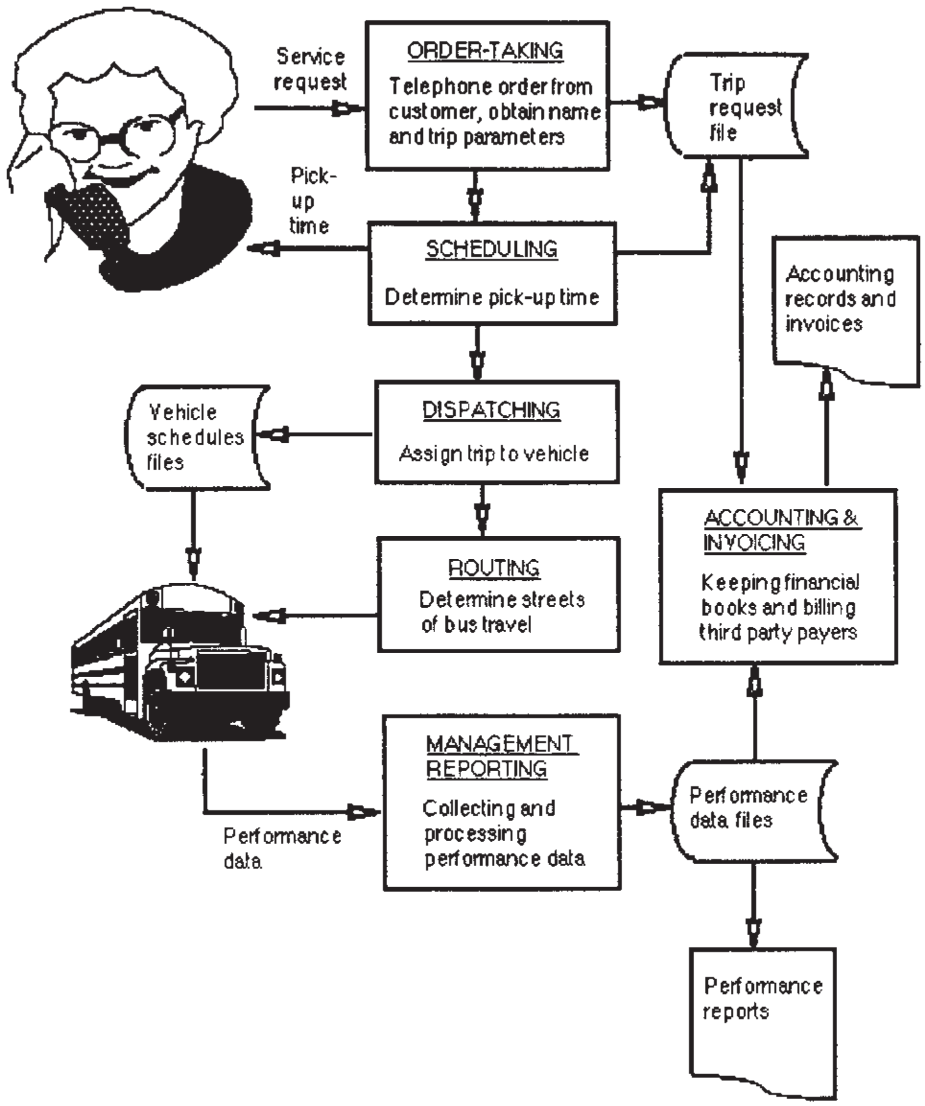

Figure 2.1 Overview of Functions of DRT Operations.

vehicles that the taxi operators share between an exclusive-ride service offered for their own account and shared-ride service under contract to a public or not-for-profit agency. While use of vehicle-hours or vehicle-miles as measures might help overcome the shortcoming of vehicle fleet size as a measure of supply, no guidelines are known to have been published to suggest how this more detailed data should be used. Therefore, the number of vehicles in the fleet will be used as a measure of size in this Handbook.

2.2.3 Number of Riders

Ridership, measured in trips per day or trips per year, is another measure of size that is typically recorded by providers. Ridership is a useful measure when used together with vehicle fleet size to suggest the level of automation required. However, not every rider places the same demands on the scheduling/dispatching function, and other factors must be considered simultaneously, as discussed in the section on reservations.

2.2.4 Ridership Eligibility Requirements

DRT systems can be categorized by whether their service is restricted to certain categories of individuals, called target market or restricted ridership systems, or is available to the general public, called general market systems. These ridership classifications are important for determining software needs. First, target market or restricted ridership systems impose an additional requirement on the paratransit software, namely to determine at the time of trip reservation whether the caller is eligible to use the service. Second, general public systems typically are used much more intensively than restricted ridership systems. Intensity of use is measured by demand density, i.e., trips per square mile per hour. The more intensively a system is used, the more demands are placed on the scheduling component of the paratransit software.

2.2.5 Immediate, Advance, and Subscription Reservations

There are generally two modes of reservations accepted depending on the response time of providing service. DRT systems may operate by taking reservations for immediate service—taxi-like response in 20 minutes to an hour—or advance (prescheduled) service to be provided at some time in the future, usually 24 hours or more. A special type of advance reservation service is called subscription because it recurs at regular intervals, usually daily for work trips. Immediate service has clear advantages for the patron, but it places the greater burden on the scheduling/dispatching function because of the limited time to calculate schedules. However, an immediate reservation mode is thought to have operating advantages since its use reduces cancellations and *no-shows* (instances when the rider does not show up), which occur fairly frequently in advance reservation systems. No-shows and cancellations waste vehicle time, causing reductions in operating efficiency, and require recalculating of the schedules, which places a burden on the scheduling/dispatching function. Subscriptions up to a level of half of all trips, as allowed under the ADA regulations, are usually seen as being desirable since the users are typically more reliable and do not cancel or fail to show up and thus form a solid core for planning vehicle trips.

Both immediate and advance service can be offered by a DRT service without conflicts. However, until recently, most DRT services offered advance reservation service as a means of rationing scarce capacity. Now with the passage of the Americans with Disabilities Act (ADA), which prohibits rationing, it is expected that more systems will offer immediate service, which has clear advantages to the users and which many professionals hypothesize has advantages to providers as well.

2.2.6 Service Area Descriptions

There are no standard means of categorizing the service areas in which DRT systems operate. While providers can generally define their areas as urban, suburban, rural, or a combination of these, descriptors of the difficulty of offering service based on geography, street layout, barriers, and the like are not well defined. A sometimes useful measure of service area is what is called the *demand density*, that is, the number of trips per hour per square mile. This can be useful for defining the complexity of the schedule/dispatch task—areas of high demand density offer the possibility that computerized scheduling can perform very much better than manual schedules because there are so many trip assignment possibilities that the computer can process better than a person. On the other hand, when demand density is low, a human dispatcher may be able to do as well as a computer. In fact, some providers report that some software does not seem to perform well in areas of low demand density. Finally, demand density can be a misleading measure in cases in which the service area is not homogeneous and demand density varies greatly within different parts of the service area. As a proxy for a more detailed analysis, the urban-suburban-rural classification can be used to identify your system.

2.2.7 Trip Patterns

A trip on a DRT system is determined by the passenger who selects both the origin and destination. When all trips made on a system are considered together, they may fall into certain patterns. If the provider places no constraints on the trips, they may form a random pattern consisting of many origins and destinations. This pattern is called *many-to-many* service. Often, however, there will be some destinations that are quite popular, such as hospitals, shopping areas, and the like. In these cases, the pattern would consist of many origins, presumably the homes of the patrons, and a few destinations. This service is called *many-to-few* and the return trip would be *few-to-many*. A service designed to serve a single destination, such as a senior center or a hospital, may serve only one destination—their facility. In this case, the pattern is *many-to-one*. These patterns are shown graphically in Figure 2.2, together with a representation of fixed-route service for comparison.

One of these patterns may emerge because of the patrons' choice of trips or because the provider limits origins and destinations. This fact makes it difficult to classify systems using trip patterns for purposes of determining performance and identifying similar providers. Providers may tell you that they offer many-to-many service because they are willing to serve any destination, but their actual patterns may be many-to-few because of passenger behavior, so they are not comparable to a true many-to-many system.

Pattern is an important characteristic of a service because many-to-many is much more difficult to schedule and dispatch than are many-to-few or many-to-one services and it will typically have lower productivity than the other two. Systems offering many-to-one or many-to-few destinations generate a much smaller burden on scheduling/dispatching than do systems offering many-to-many patterns.

There are two additional types of service that may be offered which are hybrids that combine features of fixed route and demand-responsive service. A service that operates on a fixed route but will make deviations from the route to make pickups and drop-offs is called *deviation from route* service. A service that arrives at certain points in the service area at scheduled times but is free to make pickups and drop-offs between those points is called *deviation from point* service. The essential difference between these two is that deviation from route must follow a fixed route and deviation from point need not. If there are no requests for demand service, both these services may look like a fixed route service. These two services are not as prevalent as the more unconstrained

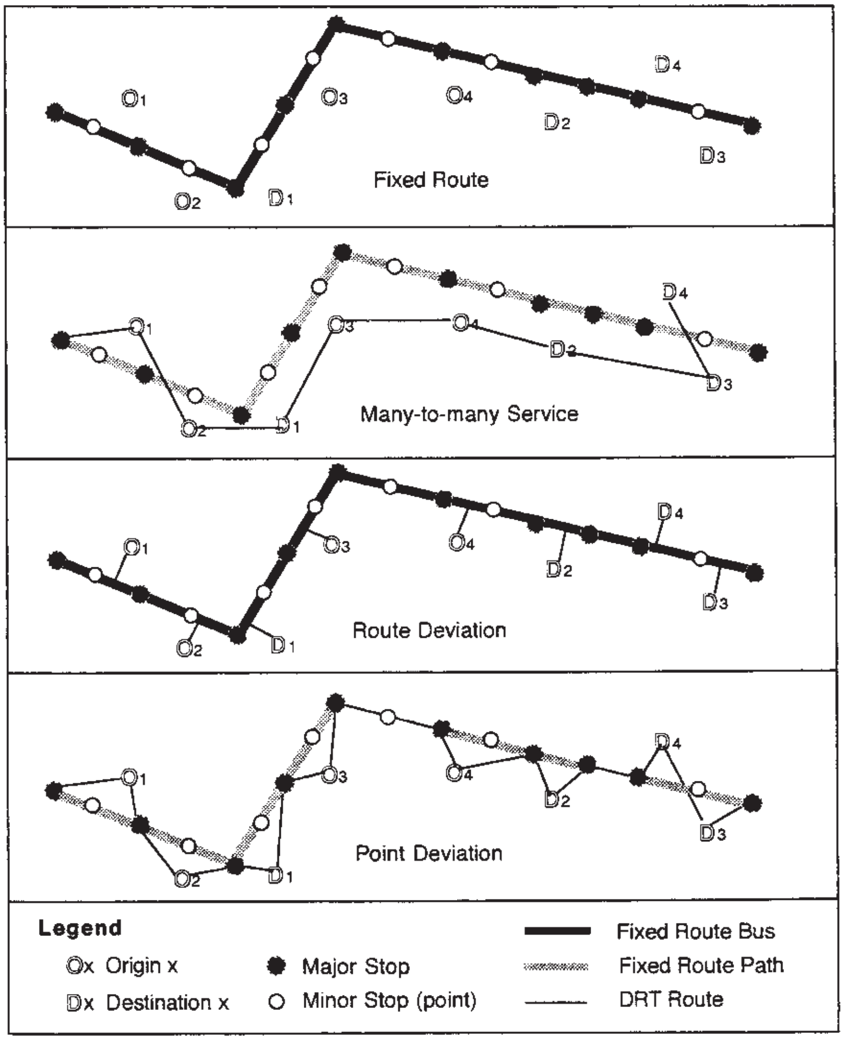

Figure 2.2 Patterns of DRT Service.

services, but they are thought to have underutilized potential that may be realized by better technology.

2.2.8 DRT Service Trade-Offs

The major choice in the design of DRT service is between efficiency and quality or level of service from the users' point of view. Service quality ranges from the most costly exclusive-ride taxi service, in which only one person rides at a time, to trips in which vehicles are shared, and each rider may have to ride longer than is needed for his trip while the vehicle drops and picks up other riders. Assigning many passengers to a vehicle at the same time results in efficiency due to minimizing the total vehicle miles traveled and the fewer vehicles required. However, high passenger loads lower the quality of the service by raising the average ride time and increasing the variability of promised pickup and arrival times. These trade-offs are usually determined by specifying minimum service levels in terms of the longest ride times allowable and the maximum lateness for a promised pickup or arrival. Within the constraints of these specifications, dispatchers will try to maximize the number of trips provided by each vehicle hourly.

2.2.9 Summary

In summary, the number of vehicles and the number of daily riders are the most significant variables for assessing whether you are a candidate for computerized scheduling/dispatching. Other factors that should be considered include reservation lead time and the density of the service area. The suggested analysis is covered in Chapter 5.

2.3 DEMAND-RESPONSIVE TRANSIT FUNCTIONS

2.3.1 Eligibility Determination

In many DRT systems, prospective patrons must meet certain eligibility criteria before they are permitted to utilize the system. These may involve age, physical condition, agency affiliation, and ADA certification. Whatever the criteria, only those who have previously been registered as eligible riders are allowed to utilize the DRT service.

In such systems, the software must be capable of determining at the time the prospective rider calls that this individual is eligible to use the system. This typically requires the computer to search a database of eligible patrons in an attempt to locate the individual who is requesting service. If individuals are found in the registration database, they can then make a trip reservation.

In systems serving ADA-eligible patrons, a further eligibility determination may be made, notably whether both the origin and destination of a patron's trip are within three-fourths of a mile of a bus transit route and a rail station. Also in ADA systems, the rider may be conditionally eligible for a trip, depending on both time-varying factors such as the customer's health and the weather, and semipermanent features such as the accessibility of sidewalks around a transit stop. Not all these factors can be determined objectively by a third party but the ones that can, such as accessibility, could be made by a scheduler using information that can be stored in the customer's database records. Whether it is wise for providers to have their schedulers make a determination of conditional eligibility is another matter.

Often eligibility determination is performed as part of the trip reservation or order-taking function, which is described next.

2.3.2 Trip Reservation (Order Taking)

The terms *trip reservation* and *order taking* are often used interchangeably, as they are in this report. In immediate response DRT systems, the term order taking is more appropriate, whereas in a prescheduled operation, a customer truly is making a reservation for service to be delivered at some point in the future.

In either case, the essence of this function is for the order taker/reservationist to obtain the parameters of the trip request from the patron—pickup point, drop-off point, desired pickup or delivery time, number of passengers, and any special requirements (such as wheelchair accessibility)—and then to communicate to the patron whether the system is able to accommodate the trip request with these specific parameters and, if so, when a vehicle will arrive. If the trip cannot be accommodated due to unavailability of resources for this specific trip request, the order taker/reservationist must indicate to the patron the reason for the problem. The reservationist must then interact with the customer and attempt to find acceptable trip times which the system is able to accommodate. If either initially or on subsequent attempts the trip reservation can be accepted, the order taker/reservationist then informs the patron of the estimated pickup time, typically using a time window rather than a single point estimate, e.g., 8:40 a.m. to 9:00 a.m.

2.3.3 Service (Trip/Vehicle) Scheduling

> Bad drivers do what they are told; good drivers fix the schedule.
>
> —Park Woodworth, Senior Planner,
> Seattle Metro

Scheduling is the process of inserting a trip request into an actual (for an immediate response operation) or provisional (for prescheduled operations) schedule in such a way that no system constraints are violated by the new schedule. *Scheduling is the core function which distinguishes DRT systems from other transit.* In conventional transit, buses are scheduled by the clock to predetermined origins and destinations, and patrons adapt to the schedules. In DRT service, the schedule adapts to patrons' desired timetables, origins, and destinations.

These system constraints typically involve maximum ride time, maximum wait time (for immediate response operations), and promised pickup and delivery times for those trips already scheduled. Once a trip has been scheduled, it has an estimated time of arrival (ETA)—usually a time window—at the patron's pickup location.

It is important to note that once the trip has been scheduled, the DRT system has entered into an implicit contract with the customer to deliver service as specified. That is, the system is pledging that it will accomplish pickup within a certain time window; delivery by a specified time, if this is one of the requirements of the trip; and a maximum ride time, which depends upon system policies—usually 45 to 60 minutes.

The process of scheduling individual trip requests while the customer is on the phone is called *interactive* or *on-line scheduling* by the industry. This term is used in this Handbook and refers to a scheduling system in which some means of accepting or denying a trip request is based on available system capacity and, if a request is accepted, an estimated time of arrival of the vehicle is given to the requester, usually within a specified time window. Although the actual assignment of this passenger trip to a vehicle tour (the sequence of pickups and deliveries) may not yet have been made or may subsequently be changed, the time window for vehicle arrival will not be changed except in unusual circumstances. Interactive scheduling is *not* real-time, or immediate, service. Interactive scheduling determines the pickup time immediately while the trip may be scheduled for any time in the future, contrasted to immediate service, which accepts requests for a trip as soon as possible. Real-time service requires interactive scheduling, but the converse is not true—many prescheduled operations use interactive scheduling.

The quote by Park Woodworth above reflects dependence on the driver for wisdom in changing schedules created by a process, either human or computer, that is not as in touch with the road as the driver is. It raises the issue of how much, if any, autonomy the driver will be allowed in systems using computers and technologies. There is a conflict between driver initiative and the ability of the dispatcher and computer to know the location of vehicles and to use that information for creating better schedules.

2.3.4 Vehicle Dispatching

Vehicle dispatching is the process of assigning an actual vehicle to a trip that has previously been scheduled by the system and communicating that assignment to the driver of the vehicle, including the order and time during the vehicle tour this patron will be picked up and dropped off.

Although the dispatching process places a trip onto a vehicle tour in a prescheduled operation, the vehicle tours may subsequently be revised and trips reassigned to other vehicles. Trip cancellations and no-shows will almost always require some alteration in the assignment. The dispatching process is responsible for accomplishing these dynamic trip-vehicle reassignments. In an immediate-response DRT system, trip reassignment may also occur, although it is somewhat less frequent because there are fewer cancellations (due to the high proportion of trips that are seeking immediate service). Whatever a system's mode of operation, every trip request must be assigned to a specific vehicle, and the driver of that vehicle must be informed of the sequence of addresses to visit to pick up and drop off patrons.

In real-time scheduling/dispatching, a new trip request can be added to an existing schedule and trip assignment. One way is to search for the best vehicle assignment for the new trip without changing any other assignments. This procedure will not necessarily find the best schedule/dispatch arrangement from a global point of view. It may be possible that a better arrangement exists if all assignments are thrown up in the air and made over again—a procedure called *dynamic rescheduling*, although it is more accurately called *dynamic redispatching* because vehicle assignments may be changed but the promised schedule of pickup times is maintained. This is accomplished by moving already scheduled trips from one vehicle tour to another, or creating an entirely new set of vehicle tours, within the constraint that pickup and delivery time windows cannot be violated. The purpose is to free up time on one or more vehicle tours, thereby enabling more trips to be scheduled and improving system productivity. The advantage of dynamic redispatching is that it may find better assignments than would be made by merely appending a new trip to an existing dispatch. The price paid is the time it takes to redispatch and to communicate frequently with the drivers. It may not even be possible to reschedule in a reasonable time, even by a computerized system. A compromise may be to redispatch after the addition of several new trips. It is not possible to say categorically whether dynamic redispatching is a worthwhile feature. The improved arrangements may not be real, given the normal uncertainties of meeting a schedule. Moreover, the ability to find better tours by rescheduling may be constrained for several reasons. Both promises to subscription patrons that they will get the same driver and the need to assign certain patrons to specific vehicles constrain the ability of redispatching to improve a given arrangement.

For ADA paratransit systems, in which trip requests can be made as many as 14 days in advance, these end-of-day schedule refinements may be done daily for future days on which significant numbers of trips have already been scheduled.

2.3.5 Vehicle Routing

The routing function finds the best route between pickup and drop-off points in terms of the sequence of actual roads taken. The theoretical routing task usually requires solving a mathematics problem called the *shortest path* problem, in which the shortest path may be measured in several different ways—mileage, operating cost, or speed of travel time. Approximate best routes could be prescribed by control room staff, based on their knowledge of the street network without the use of the mathematics, but they would just be substituting their knowledge for that of the driver, and it may or may not be superior to the driver's. The mathematical solution can be performed by a number of mathematical procedures, but performing routing in a system of a practical size requires automation.

2.3.6 Management Reporting and Statistics

While not a core function for the DRT control system per se, management reporting is clearly a key component of the overall DRT operation, as the management reports provide feedback on how effectively the system—and the software—are performing. Management reporting consists of collecting data on all major system processes and analyzing those data to provide system managers with indicators of the efficiency and effectiveness of various system processes. Such indicators as average length of time to book a trip, average ride time, average pickup time deviation, passengers per vehicle service hour, and the like are very important in telling management how well the system is operating. Most DRT software packages provide this information, although they tend to be weakest for indicators that depend on the collection of real-time operational data.

2.3.7 Accounting/Invoicing and Other Functions

Accounting/invoicing is not a function that is unique to DRT operations, but it is necessary to the operations. The other functions of maintenance, inventory, and purchasing, etc., are also not unique to performing DRT functions, and they may be integrated with operational procedures or performed as stand-alone procedures.

CHAPTER **3**

DEMAND-RESPONSIVE TRANSIT SOFTWARE

AUDIENCE

Every reader, even one with extensive DRT software knowledge, should peruse this chapter because we identify the terms used in subsequent discussions, especially in Chapter 6 on acquisition of software.

> The word software has been in widespread use since about 1960, when programs were first sold separately from the computer hardware on which they ran. Implying a malleability lacking in the machines themselves, the term refers to the instructions that tell computers what to do. The replacement of one set of instructions by another can produce protean changes, turning a tool for analyzing stock-market trends into a word processor, or an architect's electronic sketch pad into the control panel for an entire factory. Without detailed orders from a program, a computer can do nothing at all.
>
> —*The Software Challenge*, Time-Life Books, p. 19 (*1*)

3.1 INTRODUCTION

The earliest computers did not have software. The instructions that directed computer operations were wired into their electronic circuitry. Software came to exist when it was realized that instructions could be stored in the computer, in the same way as data are, so that they could be changed easily and each change or new application would not have to be wired into the computer.

DRT software, then, consists of the computer programs that perform one or more of the operations or administrative functions required to offer demand-responsive transit service. This chapter contains a summary of the history of DRT software, a tutorial on software, a description of how DRT software fits into the family of software, a summary of existing DRT packages, and users' evaluations of DRT software in general, not by specific package.

3.2 HISTORY OF DRT SOFTWARE

The history of DRT software can be viewed as consisting of several stages shown in Table 3.1. The descriptions are general and intended to describe the major stages of DRT implementation, but notable exceptions exist in each time period. In the early 1970s, there were two levels of DRT systems. One level consisted of a number of small DRT systems that could be controlled manually and were characterized by low ridership and a small vehicle fleet. They were small either because they operated in small towns and provided the only transit in town or, if they were in larger cities, they served restricted riders—such as elderly persons and persons with disabilities. While computerization might have helped control these small DRT systems, such software was not widely marketed, if it existed at all. Those providers who used computers probably developed the software themselves.

The second level of DRT systems was a vision more than a reality. The vision was of systems that would accept telephone requests for both immediate and advance reservation service, develop a continually changing set of vehicle schedules (also known as vehicle tours), serve passengers within a fairly small window of desired pickup and drop-off times, hold riding time in the vehicle below a reasonable maximum, and do all this with as few vehicles as possible.

The operation of DRT systems under these conditions poses difficult control problems in systems with many vehicles and large demand. The volume and speed requirements needed to handle a relatively high frequency of trip requests that would have to be assigned to many vehicles in a real-time operational setting was thought to be beyond a human dispatcher's capacity. For this reason, it was believed that computer control would be necessary. Computerization of the DRT control system represented the underpinning of the DRT concept as it was developed at MIT during the late 1960s and early 1970s. DRT was seen as a classic operations control problem for which an algorithmic solution was possible. Only algorithms[1] encoded in computer software could handle a control problem of this scope and difficulty. All the earliest major systems—Haddonfield, New Jersey; Rochester, New York; Santa Clara County, California; and Orange County, California—were predicated on computer control. The researchers at MIT and elsewhere devoted

[1] The precise meaning of the word "algorithm" is a computational procedure for solving a particular problem which is assured of discovering the best answer. In more popular use, it is sometimes used to describe a computational procedure which gives a good solution. We prefer the precise use and would use the word "heuristic" to describe a procedure which gives good or "near best" solutions.

TABLE 3.1 Stages of DRT Software Implementation

Time Periods	Service	Software	Computer
Mid '70s to early '80s	State-funded small systems in small towns (CA, MN, MI) Unrestricted ridership	Manually operated Computer not used	Manual
	Large demonstration systems (Haddonfield, NJ & Rochester, NY) or innovative service (Santa Clara Co., CA) Unrestricted ridership Immediate and advance reservation	Fully automatic Full functions	Mainframe and minicomputer
Mid '80s to present	Restricted ridership Advance reservation	Limited functions	Microcomputer
Present to future	ADA service Immediate and advance reservation	Fully automatic	Microcomputer Other technologies: AVL, MDT, digital communications, etc.

considerable attention to the development of such algorithms and their implementation in computer software (*2*). Much of the research and the demonstration of these early systems was financed by grants from UMTA, part of the U.S. Department of Transportation. Further, the early researchers anticipated that *several* automated technologies would be used by DRT systems *in addition to* the computerized reservation, scheduling, and dispatching system, notably radio frequency digital transmission of trip orders to vehicles, in-vehicle data terminals to display or print trip orders, a vehicle location system to keep track of actual vehicle positions, and computer database systems to store trip information and generate reports.

The early research and demonstration work established the technical feasibility of computerized scheduling and dispatching, but other factors held up the widespread adoption of computerization. First, the high operating cost of the large and costly mainframe computers that existed at the time made the service economically questionable. Additionally, a few years of experience with DRT revealed that the magnitude of the control problem in most DRT systems was much reduced from original expectations. This was largely because both the overall level and the intensity of demand (usually expressed as *demand density*, defined as trip requests per hour per square mile) was much less than anticipated. Therefore, the number of vehicles required was smaller than anticipated in many systems, and the control problem was not as complex. Some observers believe that demand fell short of expectations because of inadequacies in the service, due in part to shortcomings in both software and hardware. In some cases, such as Santa Clara County, high initial demand did materialize because of the refusal of the policy board to charge premium fares for the premium service. The software and the limited number of vehicles were not adequate to handle the demand. This swamping of the system together with other issues led to the termination of the service. In addition, many examples of well-functioning manually controlled DRT systems proliferated, further reducing the impetus for computerizing the DRT control function. Finally, federal funding of paratransit research in general, and computerization in particular, dried up with the leaner U.S. Department of Transportation of the early 1980s.

Nevertheless, the use of DRT systems continued to grow during the eighties, although the nature of these DRT systems was vastly different from the ones envisioned for fully automated control in the 1970s. They no longer utilized the cornerstone of the vision—real-time scheduling and dispatching of trip requests. They required their riders to make trip reservations at least one day in advance of their travel. Although many operators anticipated that advance reservation systems would have major advantages over immediate-response (real-time) DRT systems, in practice, this mode of operation has been associated with much lower service productivity (which translates into higher costs per passenger) and with more problematic software requirements. Despite these problems, advance reservation systems have become commonplace because they allow DRT operations to ration capacity easily, and they avoid at least some of the complexity of real-time scheduling and dispatching.

These less sophisticated DRT systems did form a market for computer software with more limited control capabilities. This demand was filled by a number of products developed either by operators for themselves or by consulting firms, academics, and researchers for sale in the general market. Many of these products had limited functionality. For example, virtually all of the scheduling/dispatching software developed for DRT during the 1980s was premised on an advance reservations regime. In fact, the 130-vehicle DRT system implemented in California's Orange County Transit District (OCTD), circa 1980, remained, until it was replaced in the mid-1990s by a new generation system, the most technologically sophisticated DRT system in the country, despite the vast improvements in computer hardware and software which have occurred in the general computer industry over the past decade.

As a result of these two major changes in DRT operations over the past 20 years—the virtual abandonment of fully automated control and the strong trend towards advance reservations systems—the technology of the typical DRT system existing today is quite different from that envisioned by the developers of this mode. Currently, there appear to be between 100 and 150 DRT systems that have installed computer software to automate at least some of their reservations/scheduling/dispatching functions. Even though some of the larger systems are quite sophisticated—the computer hardware is vastly more powerful, the software is better written, and the software-user interface is better—in most other aspects, today's typical *computerized* DRT system is, from a functional standpoint, still lagging behind the OCTD DRT system implemented a decade and a half ago.

Since the late 1980s, however, there has been a renewed interest in the application of computer software, especially multi-function software, to DRT scheduling. This renewed interest has been fueled by three developments. First, computer technology has become relatively affordable for DRT systems with the development of microprocessor-based computers and the remarkable cost reductions in computer hardware that have accompanied the development of a mass market. Second, a number of firms have developed software applications designed specifically for DRT systems; and although these applications vary substantially in their scope and functionality, they all attempt to automate, in whole or in part, the DRT control system.[2] Thus, a variety of software is available to automate the DRT control functions, ranging from almost generic off-the-shelf packages to sophisticated packages that need significant installation effort. Third, the Americans with Disabilities Act (ADA) has imposed new requirements and/or new demands on many DRT systems, and software can be of significant assistance in dealing with these new mandates.

As a consequence of these developments (and others), during the past few years substantial numbers of DRT systems have purchased computer software to automate—in whole or part—their control systems and other aspects of their operations. In addition, other technologies such as mobile data terminals, automatic vehicle location devices, in-vehicle computers, and map-based software systems—all with potential application to many DRT operations—have recently entered the commercial marketplace and have been the focus of interest by some DRT systems. The DRT industry is seeking to better understand how to incorporate DRT software and related electronic technologies into its operations, and is seeking software which will cost-effectively solve its central day-to-day operational control needs. So although the early vision of DRT has yet to be realized on any significant scale, this may change in the near future.

[2] Some of these developments can no doubt be traced to the early work in computerization, either directly through individuals who carried on the work or indirectly by demonstrating the feasibility of the ideas and procedures.

3.3 TYPES OF SOFTWARE

There are four types of computer software involved in computer use—operating systems, programming languages, utilities, and application programs. The software packages of interest in this study are a type of application program. This section may be skipped by those familiar with software, but it is a short tutorial section, and reading it will assure that the viewpoints we use are the same ones you have.

3.3.1 Operating Systems

Operating systems are master programs that coordinate the various hardware components and allow users of other programs to control the operations of the computer. Specifically, they control the microprocessor (the electronic unit that performs the computer's functions), the data transfer functions (input and output), the peripherals (printer, storage units, etc.), the random access memory or RAM (internal storage of data), and the like. Operating systems that you might have heard of include CP/M, DOS, OS/2, UNIX, and Macintosh OS. Since they are so closely related to hardware functions, they are discussed further in Chapter 4 on computer hardware.

3.3.2 Programming Languages

A programming language is a code, or set of instructions, used to communicate with the computer hardware. Instructions are arranged in programs prepared by people called programmers. The programs discussed below—applications and utilities—are prepared in a program language. Program languages you may have heard of include BASIC, C, COBOL, PASCAL, and FORTRAN.

3.3.3 Application Programs

The application software used in the operation and administration of demand-responsive transportation can be classified into three types—generic, special-purpose or specialty, and custom.

Generic software is designed to perform general functions but can be customized for a specific application by the user. Generic software includes the three workhorses of all personal computers—word processing, database management, and spreadsheets. Word processing programs are used to prepare text documents. Database management programs are designed to sort, organize, and retrieve large volumes of data and are therefore appropriate for client data files and the like. Spreadsheets provide a systematic way to perform many computations and to present the results. They are appropriate for processing accounting and performance data. Database and spreadsheet software have some overlapping capabilities as most modern spreadsheets have database capabilities, and databases have limited computational capabilities. These three categories are so widely applicable that they form a class by themselves, but, for purposes of this study, other software such as accounting and project management are also included in this class. Almost all DRT systems that use computers in any way will use one or more of these applications.

The generic packages are relatively inexpensive, costing between $100 and $500, and are easily used by people who are computer literate so that special training is not required. Particular applications of one of these generic programs may require some set-up work but they typically do not require any special computer programming knowledge (although some databases and spreadsheets do include programming languages). The first generation of commercially available DRT software was based on databases and spreadsheets that vendors or agency staff tailored for DRT applications. Some of these packages are adequate for small systems today, although you should make sure they are supported by their developers or someone else if you need support.

The second class of software consists of special purpose packages, called *specialty* here, developed for DRT applications and marketed to providers of DRT service in much the same way that transit vehicles and equipment are marketed with professional staffs that call on potential customers. The effective use of these software programs requires assistance in installing them and special training for your staff. They are more difficult to use than is off-the-shelf generic software, and the mistake of thinking they can be easily implemented is a major pitfall. Installation may require the setting of a variety of parameters that describe the provider's policy, operating policies, and environment; however, these programs do not require one-of-a-kind customizing. If special tailoring is desired, some software vendors may be willing to provide it as a separately priced option.

The software packages that are the focus of this study are the specialty packages developed especially for DRT service. These specialty packages can be further classified by the particular DRT function they perform.

Before DRT software was well established as a commercially available product, a number of agencies contracted or partnered with software programming companies to have software developed specifically for their DRT systems. Most of these are one-of-a-kind applications, usually called *custom* packages, although some of these efforts led to products that are now successful in the commercial market. Commissioning a customized package is still an option available to DRT providers, but it seems less necessary today as there are a number of competing products in the market that provide a range of capabilities. Customized or tailored software will, in most cases, be much more expensive than these commercial products.

Another type of custom software is created by adapting a generic package to DRT use—usually database and spreadsheet applications. In the classifications used throughout the study, the term custom is used for both adaptations of generic software packages and one-of-a-kind, specially prepared packages.

3.3.4 Utility Programs

Utility programs are software packages that perform a number of internal housekeeping or assistance functions, such as copying or organizing files, or other internal functions such as protecting data, verifying proper operations, and the like.

3.3.5 Other Classes of Software

Public domain software is that which is available free to users because ownership rights have been donated (or otherwise passed) to public use. Many application and utility programs that may be useful to DRT operators exist in the public domain, but we know of only one designed specifically for use in DRT operations—the SST3 package distributed by the University of Kansas (see Table 6.3).

3.4 STATUS OF SOFTWARE USE

3.4.1 Databases

A database is any collection of information stored in some logical arrangement so that the information can be retrieved. Any list of names, trips, and the like that is recorded and updated manually can be considered a database but because of the amount of information, the need to change entries easily and quickly, and the need to find elements quickly, computerization is an ideal way to maintain a database. (A description of the structure of a database is located in the Glossary under "Database.")

The most common computerized databases used in DRT operations are shown in Figure 3.1, which also indicates the frequency that the providers indicated they used various levels of automation—manual, generic, or specialty. The responses indicate that most databases are maintained manually.

Generic database software packages can be fairly easily tailored to the uses described in the figure. Advanced pack-

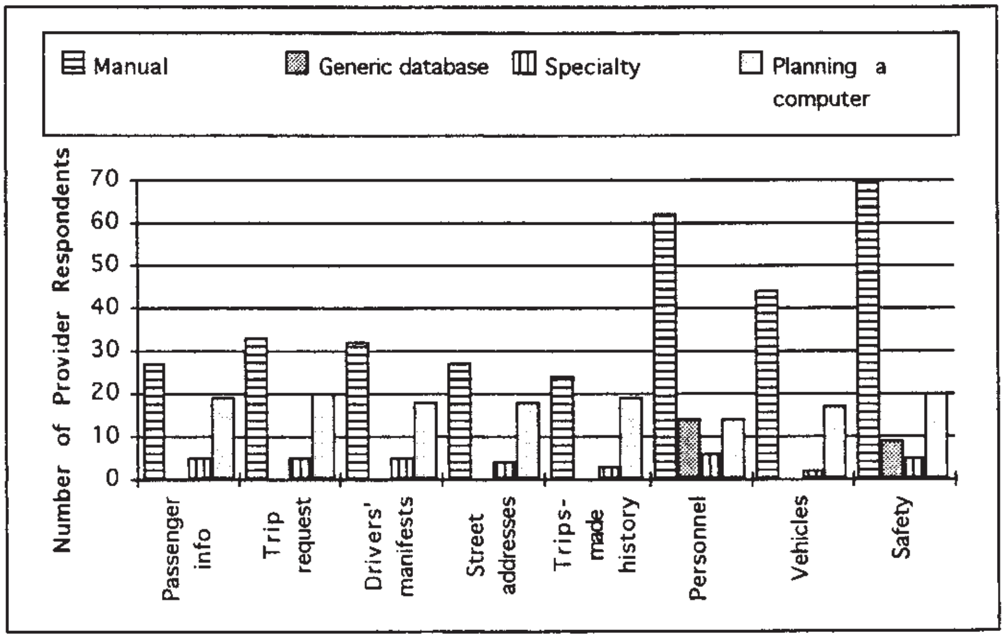

Figure 3.1 Computerization of Data Files.

ages include a programming language that allows the information in the database to be retrieved and manipulated to prepare reports or conduct analysis. Therefore, some of the DRT functions can be performed with generic databases. The use of these databases requires modest programming skills. Some of the software packages on the market are based on generic packages that have already been tailored to DRT functions. (For example, the aforementioned SST3 program for Small Transit Management Software—see Table 6.3—is written in a generic database called dBase III.) Most of the higher-level software packages integrate database capabilities into the software.

Surprisingly, respondents indicated that the DRT specialty software packages are used to a greater degree for database tasks than are the generic packages. This may be caused by the respondents' misunderstanding of the definitions of the terms used. Several DRT databases are written in the languages within generic database packages, but users might consider them to be specialty packages rather than generic ones. The fact that the "specialty" bars in the exhibit have similar heights suggests the hypothesis that those providers using specialty software tend to use the packages for many of the database tasks.

The passenger information database is one which contains a record for each registered passenger (or using passenger if no registration is required). The fields in each record provide everything that is known about the passenger, including mobility aids required, fare basis, eligibility for third-party payment, home address, etc. Computerization of the DRT passenger database is probably the first step taken by providers to use computers in operations. Computerizing databases first is a sound strategy because database installation is probably less disrupting to operations, requires fewer changes in procedures, and requires less training of staff than other computer applications. Moreover, the tailoring of a generic database for use as a customer list is relatively inexpensive and is quickly implemented. Whether the use of a computerized database for customer lists is worthwhile depends on the size of the customer list and the degree to which other functions are computerized. If a system's scheduling/dispatching function is computerized, many of the databases also will be computerized.

Many respondents did not answer the question concerning databases. It may be that they did not consider the records they keep in each of the specified areas to be formal files or databases, or they were misled because the word "computerized" was used in the title of the question which suggested that it only dealt with computerized files.

3.4.2 Computerization of Other Functions

The results of the survey of providers concerning the computerization of functions are shown in Figure 3.2. Manual performance is the predominant means of executing the four key functions of DRT service—due in part because most systems in the survey are small. It is more likely that software is used for the trip reservation function than the other three functions, but DRT specialty packages are used about equally in reservations, scheduling, and dispatching (the last four bars in Figure 3.2). Routing is the function that is least computerized and the one for which specialty software is least used.

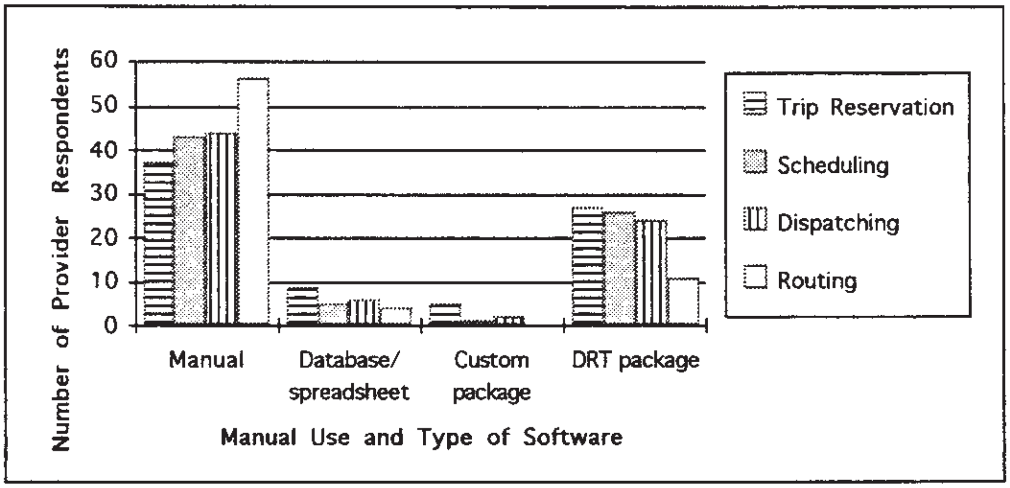

Figure 3.2 DRT Function by Software Type.

3.5 CHARACTERISTICS OF DRT SPECIALTY SOFTWARE

3.5.1 Levels of Automation

A hierarchy of levels of automation for the scheduling/dispatching function is shown in Table 3.2. It ranges from manual performance to fully automated using supporting technologies such as Automatic Vehicle Location (AVL). The first step above manual performance is the use of a generic package, such as a database or spreadsheet, which has been customized or tailored to fit a DRT function. Usually these packages perform the less complex paratransit functions of eligibility determination and recording trip requests and trip information—called low-end—and are written in a generic applications program. This software performs similarly to the generic software except that the screens, database structures, and supporting functions are tailored for paratransit applications.

The next level—which as a class we call high-end—includes specialty programs of varying levels of automation. The first level of specialty software is called computer-assisted, in which the computer will perform calculations and manipulations that provide information to a human scheduler/dispatcher who must make the actual scheduling and dispatching decisions by assigning trips to vehicles. In this case, the computer does not suggest assignments, although it may calculate a measure of merit for assignments proposed by the scheduler/dispatcher. The measures can be used to compare different assignments. The next level is automated scheduling/dispatching, in which the computer will generate the full schedule and dispatch arrangement without human intervention. A feature of some of these automated software packages is that the human scheduler/dispatcher may modify or override the machine-determined schedule/dispatch assignment.

The next level of automation introduces a simple but sometimes obscure feature of the scheduling/dispatching problem. Each time a trip is to be added to an existing schedule, a vehicle is reported late, or there is a cancel or a no-show, all trips should be rescheduled to find the optimal assignment of trips to vehicles. This is called dynamic scheduling. Whether this rescheduling is worth performing for each additional trip is an open question. It may be adequate to reschedule only periodically after a given number of new trips or some period of time has passed.

The last level of automation includes the use of DRT specialty software and the use of some other technology which enhances the benefit of the software. Other technologies would include vehicle location, digital communication, and others discussed in Chapter 7.

TABLE 3.2 Levels of Scheduling/Dispatching Automation

Manual - Performed without Computers
Customized Generic Software Packages
Specialty - Computer-Assisted
Specialty - Automated
Specialty - Automated with Dynamic Rescheduling
Automated with Other Technologies

3.5.2 Quality Characteristics

Clearly, the first necessary characteristic is that the software does what you want it to do. An additional aspect is ensuring that the software operates in all situations without errors, or “bugs,” as they are called in the software business. A number of respondents to the survey complained that one or another of the functions they desired does not work.

The providers’ evaluation of four additional features is shown in Figure 3.3. The features were evaluated by asking

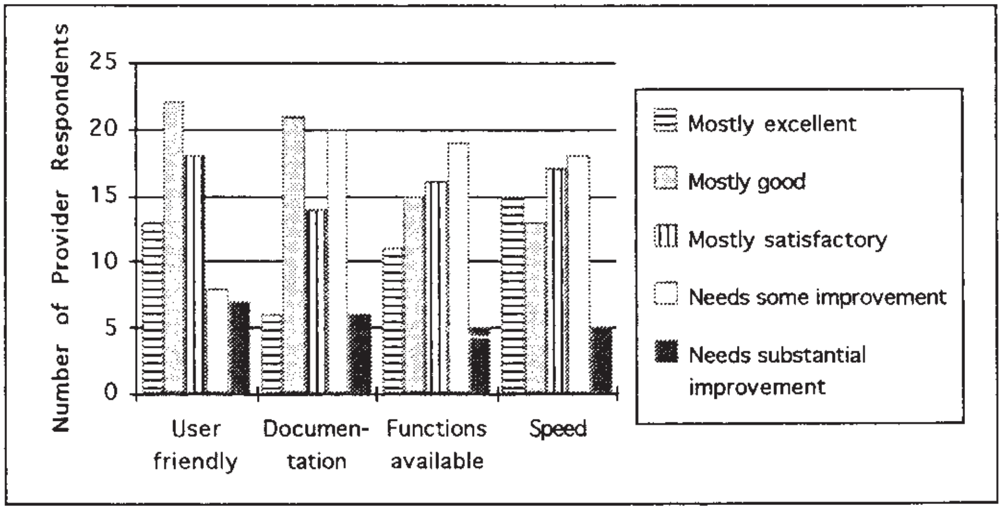

Figure 3.3 Evaluation of Software Characteristics.

respondents to rate them on the following five-point scale—"mostly excellent," "mostly good," "mostly satisfactory," "needs some improvement," and "needs substantial improvement." The characteristics rated were not explicitly defined but are thought to be generally well understood by software users as having the following definitions: *User-friendly* is the attribute of being easy to use without constant reference to user manuals; *documentation* refers to the written manual that accompanies the software; *functions available* refers to the number of functions performed by the software; and *speed* is the quickness with which the computer performs its tasks.

> Writing easy-to-use software is a communications craft. The successful software developer will learn the techniques and thought processes of writers, filmmakers, salesmen, teachers, journalists, and other professional communicators.
>
> —Paul Heckel, software developer/author (*3*)

Several factors contribute to user friendliness; Heckel (*3*) lists 30 *elements* of user-friendly software. The organization of the software is one such factor that includes the layout of computer screens, the arrangement of menus, the terms used, and the like. Activities should be on the computer screens where the user expects to find them, that is, all similar functions are together. Help information should appear on the screen when requested. Friendliness also is the ability to use different levels of sophistication as desired. It should be possible for a software beginner to use the elementary functions without being confused by the capabilities of a higher level. By the same token, a sophisticated user should be able to use the high-level capabilities without having to work through the more elementary functions designed for the beginner. In summary, user friendliness is the ability to use the software without reference to written materials.

The relatively positive response concerning the speed of software operation indicates that speed is not an issue for many users, but, on the other hand, there are a substantial number of users who consider it to be a shortcoming. This mixed reaction is explained by both the variety of computers and their speeds, and software in use.

The greatest number of positive responses—excellent or good—occurred in the "user-friendly" category. The "functions available" category was also rated positively, but again, a substantial number of respondents think it is a characteristic needing improvement. The weakest of the characteristics is "documentation," which may be a general characteristic of specialty software packages in any field during the early years of their commercial sales. Documentation improves as users provide feedback on its shortcomings.

The quality of software was also explored by asking respondents to evaluate the functional performance of the software that they use on a four-point scale—excellent, satisfactory, needs improvement, does not work. The latter category was added after pretests, when respondents indicated that it was needed. The variability of rating may be explained by the great differences among providers' needs and the fact that they were rating a dozen or so different software packages. A package that is excellent for one application may not serve another well.

The quality of the software's performance is shown in Figure 3.4. The number of respondents, rather than percentages, is shown in the graph. Questions that were answered by fewer people have smaller total bar heights. For example, routing was rated by the fewest respondents. The relative height among bars related to a function compared to the other functions indicates respondents' perceptions of quality. The reservations function received the highest positive rating, having the largest number of "excellent" responses, a relatively high satisfactory rating, and no "does not work" comments.

The next most positively rated function was reporting, receiving the second-highest number of "excellent" ratings, the highest total of "satisfactory" ratings, and no "does not

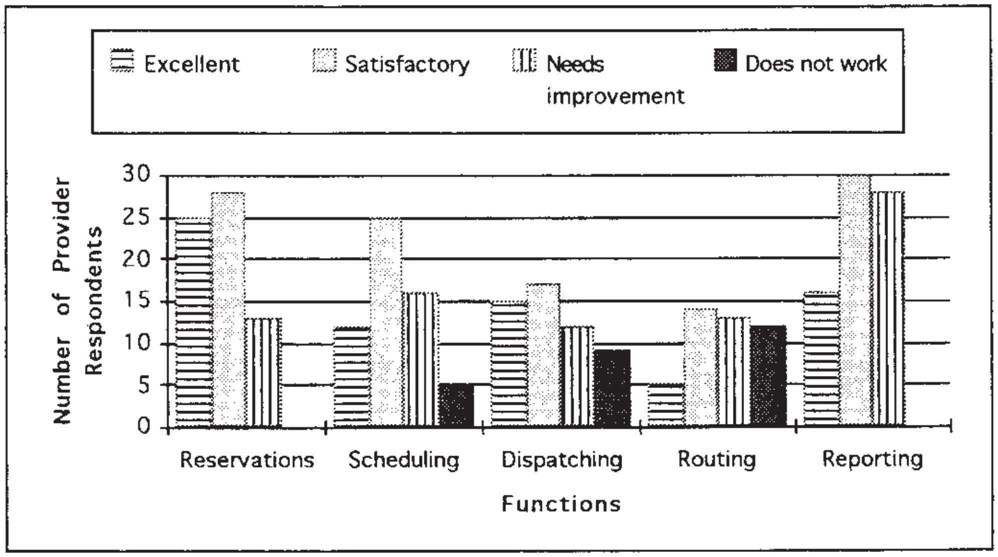

Figure 3.4 Quality of Software by Function.

work" comments. However, it also received the highest level of "needs improvement" responses, suggesting that some software packages need improvement. Shortcomings with reporting capabilities were also a complaint heard during user interviews.

The order of quality rating for the remaining three functions was scheduling, dispatching, and routing. This was also the order of the total number of respondents providing a rating, a direct relationship to the number of software packages offering the functions. All three received some "does not work" comments.

A possible shortcoming of the observations made here may be due to confusion about the definitions of the four functions. Foreseeing this issue, each function was defined in the body of the questionnaire. However, the results may still be corrupted by the respondents' preconceived definitions that were different from the definitions provided.

3.5.3 Other Characteristics

Several other characteristics of software are important. The most important is flexibility or the ability to adapt to changes in operations procedures, demand levels, the size and structure of the service area, and reporting requirements. You do not want your software to constrain either your ability to improve the service you offer or your ability to access the information you need to manage.

Portability is the ability to move your operations to new software and/or hardware. Many users have expressed frustration at having selected the wrong software and then feeling locked in, without the ability to change because of the cost and difficulty of starting over with a new package, and perhaps a new vendor. You could move to new software more easily if you could translate your passenger and trip database files to the new software and if you could use the same hardware. Therefore, the use of standard file formats (discussed in the next paragraph as well) and standard (IBM-compatible) personal computers is a positive attribute to be sought in the software you acquire. Specifically, you will want to specify to vendors that the data files used are in or can be translated to a common database format.

The other side of the portability coin is standardization. As markets mature, standardization usually follows. For example, software for personal computers now comes in essentially two versions: DOS (IBM-compatible) and Macintosh-compatible (we are getting ahead of the organization of the Handbook here as this material is covered in Sections 4.1.2 and 4.1.3). Files of data for these two systems are easily interchangeable. Vendors may resist portability early in the development of a specialty software package because they want their own systems to set the standard for the industry. In fact, the marketplace actually sets standards by what people buy most often. The marketplace set DOS as the standard for personal computers (see Section 4.2.2).

Another desirable characteristic is compatibility of the software with other software that you might use, including databases, spreadsheets, and word processing. Compatibility allows sharing data among DRT software and other application software, transferring data to new software and the like. Most DRT packages now provide this important ability.

Finally, and obviously, the cost of the software is an important characteristic. The users' rating of price versus value from the provider is shown in Figure 3.5. Like many other ratings from the survey, the majority of users find the prices reasonable, but there are a significant number who believe improvement is needed.

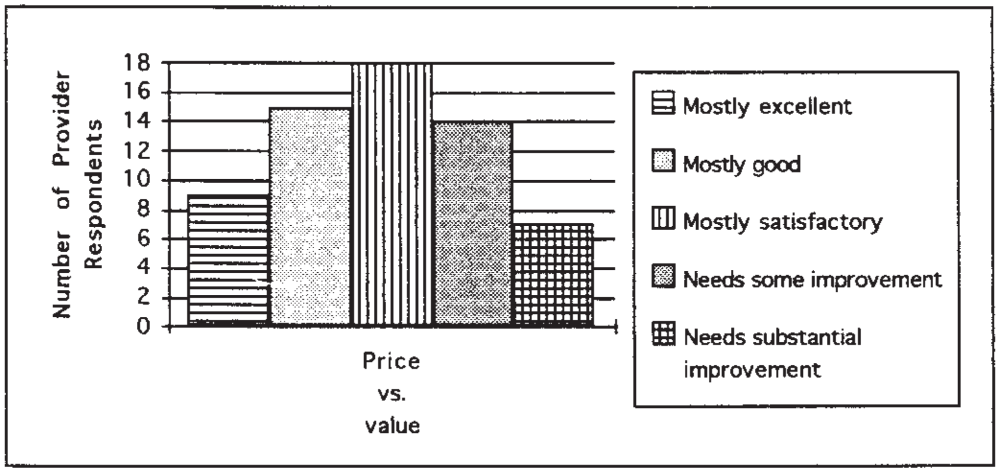

Figure 3.5 User Evaluation of Software Price Versus Value.

3.5.4 Useful Life of Computer Software

How long does software last? With regular support from the vendor (see Upgrades in Section 3.7.2 below), a software package can perform for as long as you are providing a similar paratransit service using similar computer hardware. More likely, hardware advances may make software obsolete, so the life of software is determined by the economic life of the computer you are using. Computers do wear out in the sense that replacing failed components becomes more expensive than replacing the entire computer. Moreover, the cost of personal computers has fallen so rapidly that new ones are bought for added features before the old ones are broken in. The result of rapid advances means that it may become impossible to find replacement equipment since vendors have limited ability to service older machines. While the old software may operate on the new version of the hardware, it may not operate as well as software designed for the new machine. Unless your paratransit service changes and requires new software, you will typically consider replacing software when you replace hardware.

Historically, then, your time horizon for needing vendor support is 5 to 8 years. Upgrading software to new equipment may be greatly aided by vendors who will be aware of the need to provide new versions of their software on new hardware. However, it may be appropriate to investigate the software market when new hardware is considered. Of course, maintaining a relationship with a vendor who has served you satisfactorily has advantages as well.

3.6 FUTURE OF DRT SOFTWARE

3.6.1 Software Use

Of the 78 respondents who answered the questions concerning whether they performed DRT functions with software or manually, 13 systems, or 17 percent, were planning to replace the software they were using, and two of the 19 who used no software were planning to acquire software for the first time. One interpretation of these numbers is that the agencies that can use software beneficially are already using some software packages and they are now seeking better software.

3.6.2 Improvements in DRT Software

The expert respondents were asked for an assessment of the improvements in software that are likely in the future. The majority of expert respondents believe that software will improve substantially in all characteristics during the next 5 years (Figure 3.6). Examining the category of “great improvement” suggests that more experts believe that *speed* of operation will improve relatively more than improvements in the other characteristics. This is not a particularly enlightening observation, given the history of microprocessor speed increases, but the responses to this question provide a benchmark for the assessment of improvements in other characteristics.

Combining the responses in the categories of “great” and “some improvement” indicates that all but a few of the respondent group believe that: (1) the number of functions included in the software will improve, (2) the software will become more user-friendly, and (3) documentation will improve—in that order of intensity.

3.6.3 Future Enhancements in the Functions of DRT Software

The DRT functions explored are divided into operating and management software. The experts anticipate enhancements in all the functions listed in the following order

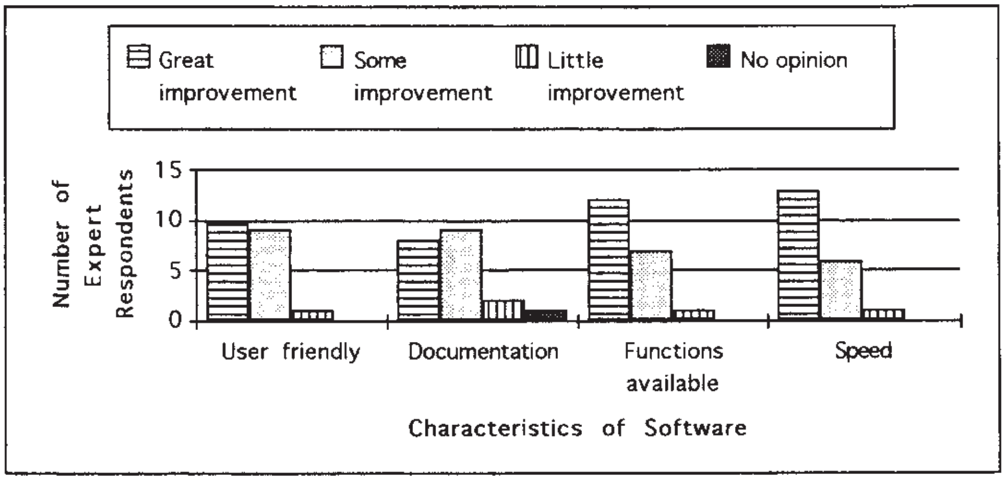

Figure 3.6 Future Improvements in DRT Software Characteristics.

of responses—scheduling, dispatching, trip reservations, routing, and management reporting (Figure 3.7). The experts also expect enhancements in management software in the following order: purchasing/inventory, accounting, invoicing, maintenance scheduling, and project management (Figure 3.8).

3.7 CHARACTERISTICS OF DRT SOFTWARE VENDORS

3.7.1 Nature of the DRT Software Market

Paratransit software is developed and sold by private companies which exist in a competitive marketplace. It is important to describe the structure of the paratransit software market because the characteristics of that market, and the market participants, have major impacts on the nature of DRT software and its pricing. Without an understanding of market realities, it is difficult to appreciate the obstacles to the emergence of more standardized paratransit software and to different software pricing practices.

There are three key characteristics of the paratransit software market. First, it is small—very small. It is unlikely that even 150 paratransit software packages are sold in a year's time, and the actual number is probably fewer than 100. Second, the firms that develop and market paratransit software are small—very small by the standards of corporate America. Only a handful of these firms employ more than 20 people, and the larger firms typically derive most of their revenues from other product lines. The annual revenues of these firms (or the organizational units involved in public transportation) are measured in the millions of dollars or hundreds of thousands of dollars, not in the tens of millions. Third, the organizations that purchase paratransit software are dependent on public sector funds to sustain their operations, are not profit-making entities, and are usually highly constrained financially. Their investments in technology (other than new vehicles) are typically infrequent.

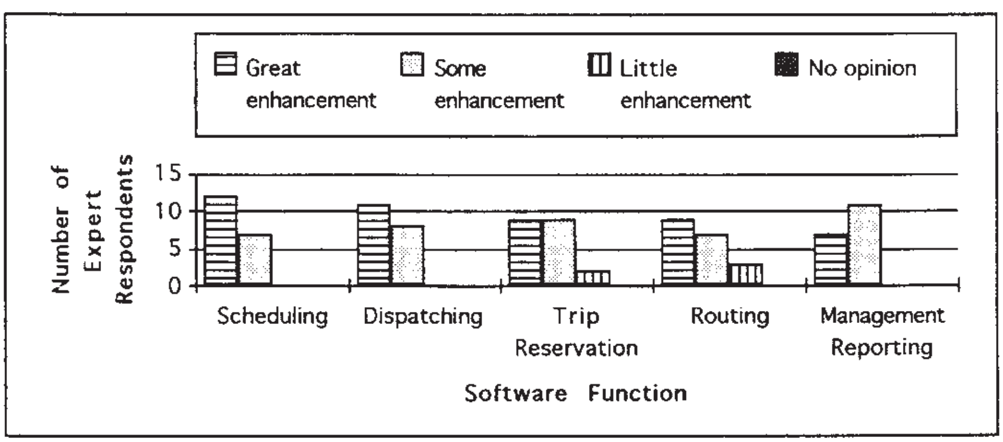

Figure 3.7 Enhancements in Future DRT Operating Software.

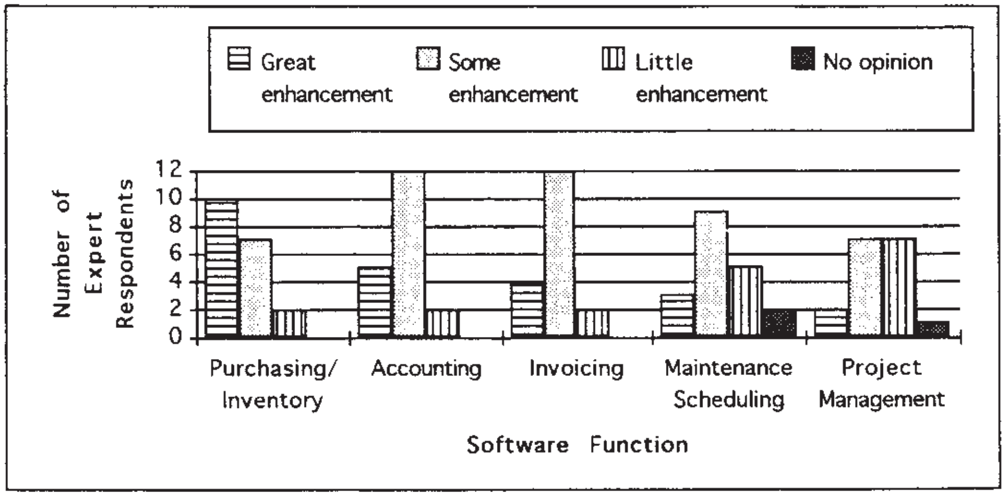

Figure 3.8 Estimated Enhancements in Future DRT Management Software.

These three characteristics, taken together, create a situation in which it is unlikely that quantum improvements in paratransit software will occur in a short time frame, or that prices will be reduced significantly from current levels. Firms serving the paratransit software market cannot expect to sell large numbers of units annually because the market is so small. As a result, these firms are likely to remain small unless they can generate substantial revenues from other product lines. Constrained in organizational size by the size of their market, they do not have abundant funds to allocate to new development activities. Firms serving this small paratransit software market are likely to put significant resources into product improvement only to the extent necessary to meet client requirements (to close a sale) or to keep clients satisfied. Unless a client is willing to pay for a particular feature, or demands it as a condition of a sale, it will only be added as time and internal resources permit. Consequently, new development proceeds relatively slowly.

In a market such as this, software prices must be maintained at relatively high levels because unit sales are limited. Each firm needs substantial revenue from each sale to generate sufficient overall revenues to remain in business. In contrast, a mass-marketed piece of software like a spreadsheet or database system may sell for less than $250, but its annual sales will be in the range of hundreds of thousands (or more) of units. Despite these low unit prices, the large volume of purchases will generate enough revenue to sustain an organization of significant size. This is not possible in the paratransit industry.

Because the paratransit software market is populated predominantly by small firms with limited revenues, the firms tend to specialize in a particular software technology or set of core technologies, and usually do not have wide-ranging capabilities. They may be well-versed in only a single operating system (DOS/Windows, UNIX, etc.), capable of using only two or three software platforms for development, and perhaps may not be fully versed in the intricacies of networked applications. If the purchasers of paratransit software were to decide collectively that they would only buy software which, for example, ran on the UNIX operating system, several of the current market participants would be hard-pressed to make the transition to UNIX in a timely fashion—or at all. The result of this limited capability of vendors to provide their software on many platforms means that your decision concerning software is in reality a combined decision about both the software and the hardware.

The point of this discussion is that the paratransit industry is unlikely to see quantum changes in paratransit software. The simple reason for this is that the paratransit software providers do not have the resources—or the prospects of readily obtaining them—to sustain the level of development required. Given this reality, the guidelines for paratransit software developed elsewhere in this report typically use current product offerings as the point of departure, not some idealized software which does not currently exist.

3.7.2 Technical Support

Technical support consists of three elements—training, technical assistance including help in problem resolution, and periodic release of software improvements called upgrades. The user evaluation of *training* and *support*, assumed to be technical assistance, is shown in Figure 3.9. Both attributes receive high ranking as indicated by the majority rankings in “mostly excellent,” “mostly good,” and “mostly satisfactory.” Nevertheless, a significant number of respondents indicated that some or substantial improvement is needed.

Training. Training of your staff is a necessary part of using paratransit software even for those who are computer literate. Such training may be included in the price proposals

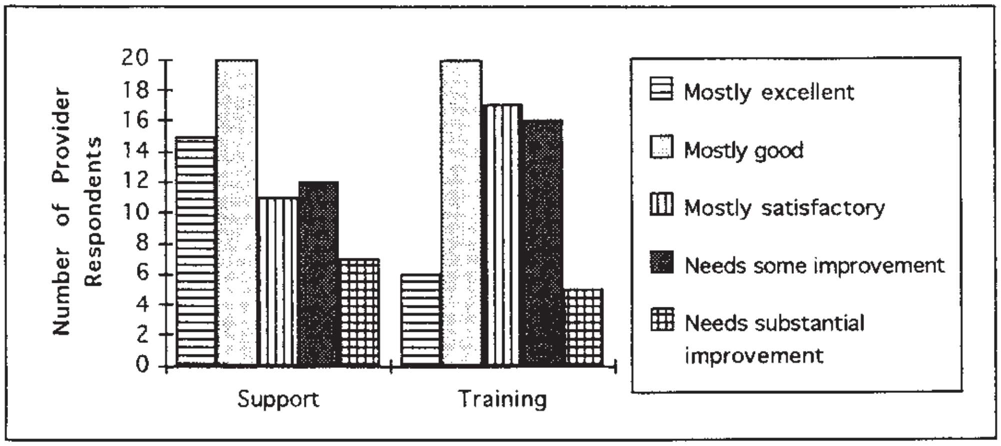

Figure 3.9 Evaluation of Support Provided by Software Vendors.

by vendors. The vendor's commitment may include the number of days of training, the number of your staff persons trained, and the location of the training. Training may also include the provision of printed training manuals for subsequent reference.

Technical Assistance. When you need help in operating the software or when you have a problem, you will turn to the vendor for assistance. This assistance may be provided as part of an annual maintenance contract, which provides a prescribed amount of technical assistance as well as other support, or assistance may be paid for on a fee-for-service basis.

The means of technical support is also important because when you need help, you may need it quickly. Promised response time is therefore an important attribute. Many problems can be solved by obtaining help over the telephone. More difficult problems may require the technician to look at the state of your system. This may be done in some cases by a communication connection directly between your computer and the vendor's computer using a telephone connection and a modem, which translates the computer information for telephone communication. Finally, sometimes a visit by a technician may be the only means of correcting the problems. Some or all of these methods may be offered by vendors.

Upgrades. Upgrades are improvements or the addition of new capabilities (and sometimes corrections) that are made to the software by vendors and made available to users. While vendors are obligated to fix problems, they are not necessarily obligated to provide improvements to old customers, so they may charge a fee for upgrades, either on an individual basis or as part of a maintenance agreement that includes technical assistance as well as upgrades. If vendors are obligated to provide technical assistance, they may want to provide upgrades to every customer so that there is only one version of their software in use to simplify the support task.

Often upgrades are made at the request of an existing or new customer, or they may be made at the initiative of the vendor. Upgrades may be offered on an ad hoc basis, although some vendors have a policy of offering them regularly, say, once a year.

The disadvantage to both user and vendor is that each time a new package is distributed, it can contain new bugs. Moreover, upgrades must be installed, a process that can introduce problems unless the vendors provide a fail-safe means of upgrading—one which preserves all of your prior parameter settings and data.

3.7.3 Strength and Stability

An important characteristic of vendors, and one in which they differ, is their financial strength and stability. It is important because you want the vendor to be around and capable so that it can provide the technical support you need after you acquire the software. These attributes are discussed in Section 6.2.5, which discusses the task of judging vendor capabilities during the acquisition process.

3.7.4 Software Vendors of the Future

The majority of experts surveyed believe there will be improvements in all vendor characteristics (Figure 3.10). "Price" seems to have received the strongest estimate of improvement, followed by "support" and "training." This is consistent with the rating by providers who believe "support" is the greatest strength of vendors.

3.8 FEATURES OF DRT SOFTWARE

3.8.1 Introduction

DRT software can be viewed as a bundle of capabilities designed to execute the functions necessary to offer DRT service. The listing of these capabilities, which we call *features*, can serve as a checklist for determining the features that you specify in your requirements for the software you purchase. This section contains an alphabetic listing and a description of the most significant of the possible features contained in

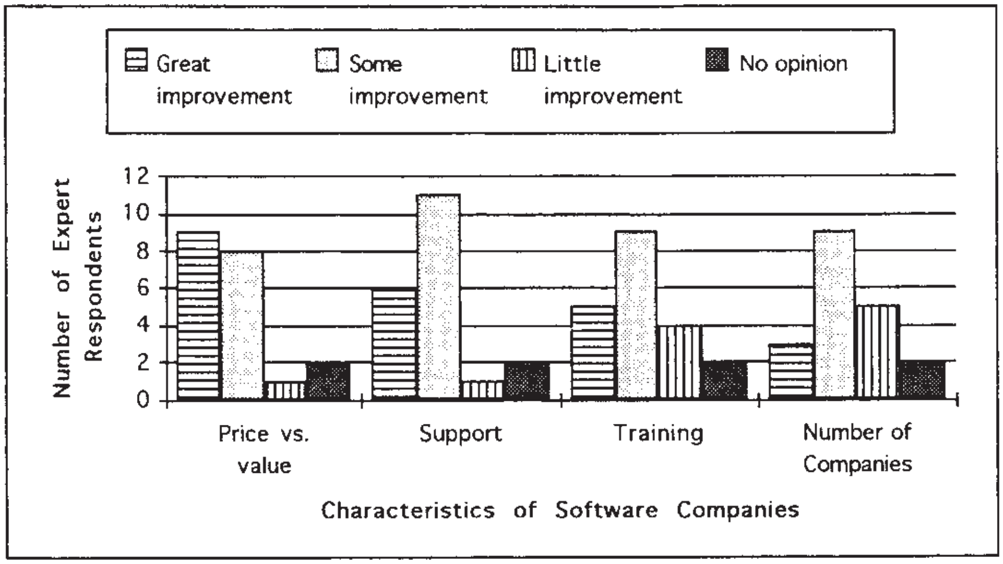

Figure 3.10 Future Improvements in DRT Software Vendors.

DRT software. The features are defined in Appendix 3-A of this chapter.

3.8.2 Perceived Importance of Features

Respondents were asked to indicate what features they currently use and those they want in their future software (see Tables 3.3 and 3.4). Table 3.3 contains a list of 60 software features in the order of number of respondents that have the feature in their current software. The column labeled "Currently Using" indicates the number of providers that use the feature. The column labeled "Want in Future" indicates the number of providers who want the feature in future software.

TABLE 3.3 Ranking of Software Features Currently Used

Rank	Capabilities	Currently Using	Want in Future
1	Automatic retrieval of passenger data	65	50
2	Tracks recent ride history	56	54
3	Multi-user reservation processing	52	49
4	Automatic rider eligibility check	49	58
5	Partial name/address entry	49	53
6	Geocoded addresses	46	57
7	Keyword search and sort capability	46	54
8	Frequent destination list	45	55
9	Manual override of computer-generated schedule	44	57
10	Name recognition of common places	43	54
11	User-defined fields available	42	48
12	User name & date stamping	41	47
13	Performance data calculations	38	60
14	On-line time (pickup, etc.) estimates	36	63
15	On-line address verification	36	56
16	Trip eligibility check (for ADA trips)	35	66
17	Redundant reservation warning	35	62
18	Variable vehicle parameters (number, seating, etc.)	35	59
19	Ad hoc report formats	35	50
20	Batch scheduling/dispatching	34	54
21	Multi-tiered security	31	40
22	Choice of performance criteria (ride/wait times, etc.)	30	64

(*continued on next page*)

TABLE 3.3 Ranking of Software Features Currently Used (Continued)

Rank	Capabilities	Currently Using	Want in Future
23	Personalized passenger loading times	30	58
24	Automatic fare calculation	30	40
25	On-line "help" available	29	55
26	Billing codes	29	28
27	Problem passenger warning	28	61
28	Pop-up menus/multiple windows	28	61
29	Automatic vehicle selection for passenger special needs	28	56
30	Immediate (real-time, like taxis) reservations & scheduling	28	55
31	Vehicle speed as a function of traffic, time, geography	28	51
32	Remote terminal access	27	46
33	Import/export ASCII files	27	38
34	Fully computerized scheduling and dispatching	26	68
35	Computerized vehicle route selection	26	57
36	Automatic purge of inactive registrants	26	56
37	Import/export to spreadsheet	24	57
38	Validity checks on all inputs (completeness, legitimacy, etc.)	23	58
39	Import/export to word processor	22	50
40	Group trips	22	38
41	Trips displayed on layered maps	17	64
42	Call-back list generated	17	51
43	Section 15 reports	17	50
44	Flexible invoice formats	17	37
45	TIGER file compatibility	17	36
46	Passenger prioritization possible	16	44
47	Zonal system	16	38
48	Support for brokering (several operators)	15	53
49	Split billing	15	33
50	Batch billing	14	28
51	Simulation training capability	13	65
52	Allows "what if" questions	12	65
53	Paratransit transfers	12	49
54	Flagging of costly trips	9	57
55	Fixed route transfers	9	44
56	Vehicle location on layered maps	8	66
57	Federal HHS report	8	30
58	Automatic call-back confirmation and change of schedule	7	55
59	Automatic in-vehicle data capture	4	55
60	Electronic Document Interchange	2	32

APPENDIX 3-A. DESCRIPTION OF SOFTWARE FEATURES

Ad hoc report formats—Usually, DRT software packages that include reporting will include the ability to generate a number of reports in a predetermined format. This feature allows the user to specify additional report contents and format.

Allows "what if" questions—The software allows easy testing of the impact of various alternatives by determining the impact of changes in the parameters (such as travel time), trip data, assignments, and the like.

Automatic call-back confirmation and change of schedule—Calls are made to patrons who have scheduled trips to confirm the trip or to apprise them of any change in the pickup time.

Automatic fare calculation—Automatically calculates the fare for each rider based on whatever parameters determine fares, i.e., type of rider, distance, time of day, class of service, etc.

Automatic in-vehicle data capture—Records and saves relevant data to be used for calculating performance statistics, including travel and waiting times, distances, and the like. Several levels of automation may be provided, some of which require the driver to input data such as location and passenger identifications.

Automatic purge of inactive registrants—Periodically, the file is searched to identify registrants who have not used the

TABLE 3.4 Ranking of Software Features Wanted

Rank	Capabilities	Want in Future	Currently Using
1	Fully computerized scheduling and dispatching	68	26
2	Trip eligibility check (for ADA trips)	66	35
3	Vehicle location on layered maps	66	8
4	Allows "what if" questions	65	12
5	Simulation training capability	65	13
6	Choice of performance criteria (ride/wait times, etc.)	64	30
7	Trips displayed on layered maps	64	17
8	On-line time (pickup, etc.) estimates	63	36
9	Redundant reservation warning	62	35
10	Problem passenger warning	61	28
11	Pop-up menus/multiple windows	61	28
12	Performance data calculations	60	38
13	Variable vehicle parameters (number, seating, etc.)	59	35
14	Automatic rider eligibility check	58	49
15	Personalized passenger loading times	58	30
16	Validity checks on all inputs (completeness, legitimacy, etc.)	58	23
17	Geocoded addresses	57	46
18	Manual override of computer - generated schedule	57	44
19	Computerized vehicle route selection	57	26
20	Flagging of costly trips	57	9
21	Import/export to spreadsheet	57	24
22	Automatic purge of inactive registrants	56	26
23	Automatic vehicle selection for passenger special needs	56	28
24	On-line address verification	56	36
25	Frequent destination list	55	45
26	Immediate (real-time, like taxis) reservations & scheduling	55	28
27	Automatic call-back confirmation and change of schedule	55	7
28	On-line "help" available	55	29
29	Automatic in-vehicle data capture	55	4
30	Keyword search and sort capability	54	46
31	Tracks recent ride history	54	56
32	Name recognition of common places	54	43
33	Batch scheduling/dispatching	54	34
34	Partial name/address entry	53	49
35	Support for brokering (several operators)	53	15
36	Vehicle speed as a function of traffic, time, geography	51	28
37	Call-back list generated	51	17
38	Automatic retrieval of passenger data	50	65

service in a specified length of time, eliminating those users from the file.

Automatic retrieval of passenger data—Entering a passenger's name on the reservation form may cause the passenger record to be retrieved from the passenger database and, in some cases, inserted into the reservation form.

Automatic rider eligibility check—Entering the passenger's name on the reservation screen causes the software to check to determine if the person is eligible. This may be a check to determine if he or she is registered or a more sophisticated procedure of determining if the person and this trip are eligible for ADA service.

Automatic vehicle selection for passenger special needs—Entering the passenger's name limits the selection of potential vehicles to only those which have the capability of meeting the passenger's special needs. For a fully automated system, this would be done automatically; for a computer-aided system, only feasible vehicles would be offered to the scheduler.

Batch billing—Allows for organizing and totaling the costs of riders according to their sponsors, to bill the sponsors for all trips taken in some time period with one invoice.

Batch scheduling/dispatching—Determining schedules for a set of many trips all at one time, as opposed to scheduling individual trip requests as they are received.

Billing codes—Codes may be assigned to trips or to passengers so that summaries of costs, trip frequencies, and the like may be calculated.

Call-back list generated—A list of future riders, together with their telephone numbers, is generated so that confirmation calls can be expeditiously made on the day of the trip to reduce no-shows.

Choice of performance criteria (ride/wait times, etc.)—Allows the user the flexibility to specify various statistics or measures to be captured and calculated, describing the performance of the system.

Computerized vehicle route selection—Selection of the routes—the street-by-street path between two points—by the computer program.

Electronic Document Interchange—Has provision for transmitting to other computers over telephone wires or other connectors data accumulated concerning service, passengers, and status of the software.

Federal HHS reports—Produces reports required of DRT services funded under programs of the U.S. Department of Health and Human Services.

Fixed route transfers—Includes in the trip planning the meeting of fixed route bus schedules to facilitate transfers between DRT service and fixed route buses.

Flagging of costly trips—The identification of trips that are costly to serve because they cannot be served by a vehicle serving other trips or because they are unusually long.

Flexible invoice formats—The ability to tailor the content and format of invoices for DRT service to meet the needs of the providers or the paying agency.

Frequent destination list—A list for each passenger of his or her most frequent destinations. This information aids the telephone communication and, if the information can be automatically transferred to the trip order, speeds up the reservation process.

Fully computerized scheduling and dispatching—The computer software determines the schedule and the trip assignments to vehicles with no human intervention.

Geocoded addresses—Addresses identified with specific map location codes are necessary for some scheduling algorithms and are useful for trip planning in a manual system.

Group trips—Vehicle trips consisting of several passengers traveling from the same origin to the same destination.

Immediate (real-time, like taxis) reservations and scheduling—DRT service that responds quickly to requests for service, for instance in 20 minutes to 1 hour from the time of the request.

Import/export ASCII files—The ability of a software package to read and write in a standard format called American Standard Code for Information Interchange (ASCII), pronounced *ask-ee*.

Import/export to spreadsheet—The ability of the software to read and use information from spreadsheet software and to write information so that it can be used by spreadsheet software.

Import/export to word processor—The ability of the software to read and use information from word processing software and to write information so that it can be used by word processing software.

Keyword search and sort capability—The ability to search for any and all passengers who have a common characteristic, such as mobility aids or destinations; can be useful for grouping trips or helping passengers.

Manual override of computer-generated schedule—The ability to manually change schedules/dispatches generated automatically by DRT scheduling/dispatching software.

Multi-tiered security—A method of restricting user access to selected portions of the software and databases, ranging from allowing access to use and change the entire computerized system to allowing access to only one function or database.

Multi-user reservation processing—Reservation taking and scheduling/dispatching can be accepted by more than one human reservationist, without conflicting with one another, to create compatible schedules.

Name recognition of common places—Beginning to type a place name causes the software to call up a list of candidate names with similar spelling. Some software may actually enter the alternatives in the place name field. May be redundant with most frequent destination list stored in passenger database.

On-line address verification—Verifies each address entered by checking to see if the street exists, is unambiguously identified (asking for Avenue, Street suffix when needed), and the number is valid for the street. Cannot discover all errors but will flag many mistakes.

On-line "help" available—Assistance is available on the screen while using the software.

On-line time (pickup, etc.) estimates—Estimates of passenger pickup times are calculated by the software at the time a reservation is taken. In low-end software, the estimate will not be based on an actual vehicle assignment. In high-end software, a vehicle assignment may be made at the time a reservation is taken.

Paratransit transfers—The software has the capability of scheduling two paratransit vehicles so that a transfer can be made between the two when it is required to complete a trip, as in a system in which vehicles are constrained to particular zones. It is also possible that transfers may be scheduled when it is advantageous from an operating efficiency point of view, although it is not known if any software packages contain this capability.

Partial name/address entry—Entering part of a name or address causes the software to suggest completed names to speed up the processing. This is a feature that exists in some generic packages.

Passenger prioritization possible—Passengers are assigned a priority level so that those with a higher priority would receive more favorable pickup and ride times. This feature is probably not allowed in a purely ADA service, but ADA patrons could be assigned a higher level of service in systems that service both ADA patrons and others.

Performance data collection—Collects and calculates a variety of the most common performance measures used to monitor and evaluate DRT service.

Personalized passenger loading times—Accounts for the actual historical loading time for each known passenger when estimating the trip times for scheduling purposes.

Pop-up menus/multiple windows—A menu of activities from which the user can choose appears when the user selects a heading with a mouse or a function key. A feature of user-friendly software found in software with a graphical user interface, as in Apple Macintosh and DOS Windows.

Problem-passenger warning—Entering passenger's name causes the software to indicate that the passenger is a problem passenger, perhaps because of special needs or on-board behavior. This allows the scheduler to notify the driver, limit the types and numbers of other riders, or the like.

Recent ride history maintained—A record of recent rides is kept that may be useful to speed up making trip reservations, auditing performance, or planning group trips.

Redundant reservation warnings—An indication is provided if a duplicate trip reservation is made at a time which is close to an existing reservation.

Remote terminal access—Access to the computer over telephone lines or other connections is possible from terminals or computers located elsewhere.

Section 15 reports—Software that collects and calculates the information that is required to be reported by transit systems that receive federal government funding.

Simulation training capability—Software that can simulate operations of a DRT service, for training reservationists or schedulers/dispatchers or for evaluating different operating procedures; the same idea as an airplane flight simulator.

Split billing—Allocation of the cost of a trip to several passengers sharing the trip so that different sponsoring agencies can be billed for their clients. The allocation should be based on some logical methodology, such as trip miles.

Support for brokering (several operators)—The ability to dispatch trips to different vehicle operators by considering allocation criteria that are a function of the operators.

TIGER file compatibility—The ability of the software to read and use information from TIGER files and to write information in TIGER file format.

Tracks recent ride history—See *Recent ride history maintained.*

Trip eligibility check (for ADA trips)—Verifies that a patron making a trip request has been certified as eligible for the service and that the trip is an eligible trip.

Trips displayed on layered maps—Trips are displayed graphically on the computer screen on a background map showing street networks; various levels of magnification and detail (layers) of maps can be called up at the user's discretion.

User-defined fields available—The ability to add discretionary information to the passenger files to tailor service or perform special analysis.

User name and date stamping—Information entered into the software is labeled with the name of the computer user and the time and day it is entered, to enable auditing for errors, identifying the need for training, and rectifying unauthorized users.

Variable checks on all inputs (completeness, legitimacy, etc.)—Information entered into the software is checked for completeness, accuracy (when it can be compared to information already stored), and legitimacy (when it can be tested against logical norms, e.g., a 200-mile trip is questionable).

Variable vehicle parameters (number, seating, etc.)—The ability to distinguish differences among vehicles so that the specific capacity and capability of vehicles can be accounted for when dispatching.

Vehicle location on layered maps—The locations of vehicles are displayed graphically on the computer screen on a background map showing street networks; various levels of magnification and detail (layers) of maps can be called up at the user's discretion. Location can either be estimated by the software, reported by the driver, or measured by a technology called Automatic Vehicle Location (AVL).

Vehicle speed as a function of traffic, time, geography—Vehicle speeds used by the software for scheduling/dispatching are calculated based on other factors rather than taken as a system-wide constant. Various levels of sophistication are possible, from simply assigning a speed to a particular road link to changing the speed based on weather, time of day, etc.

Zonal system—An operating procedure which assigns vehicles to operate in designated zones.

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CHAPTER **4**

COMPUTER HARDWARE

AUDIENCE

The first section of this chapter can be skipped by readers who have experience with computer hardware. If the following description makes sense to you, you may wish to skip Section 4.1.

> *Requires a 386/25 computer, math coprocessor, MS-DOS 3.3, 8Mb RAM, 20Mb disk space, VGA, and a mouse.*

The remainder of the chapter describes the results of the survey of DRT users and experts concerning hardware used currently and planned for the future.

> The processor's solid state switches don't click,
> No gears, cogs or levers to rattle or tick.
> The screen output is silent and still;
> No movement betrays this numerical mill.
> The machine without motion must finally demand,
> As it grows more aware that it lacks arm and hand,
> An effector to give its thoughts body and force,
> And what will it choose? Why, a person, of course!
>
> —*Sing a Song of Software,*
> Leonard J. Soltzberg, 1984 (*1*)

Drawing by Sidney Harris: reprinted by permission.

"Everybody needs candy. Everybody needs stationery. Everybody needs microcomputers."

4.1 HARDWARE PRIMER

This section contains a brief description of computer hardware terms and concepts. The decision concerning what hardware to buy is usually dictated by the software so that you, the buyer, do not need a separate evaluation of hardware and may take the vendor's advice if you are buying a software/hardware package. If you already have a machine, the vendor will advise you concerning its adequacy and whether you need to upgrade or replace it. Hardware knowhow is useful, however, so that you are not totally at the mercy of the vendor or if you want hardware with capability beyond that required by the DRT application so that you can apply it to other functions.

4.1.1 Classification of Computers by Size

Historically, computers are discussed in at least four sizes which, in order of cost, speed, computational precision, and storage capacity, are: mainframes, mini-computers, work stations, and personal computers (PCs). Rapid development of technology has lifted the capabilities of all computers so that the PC of today is equivalent to the mainframe of a decade ago, obscuring the dividing lines among these classes. Accompanying the leaps in technology have been plunges in cost so that PCs and work stations, communicating over networks of wires, together satisfy the demands of the bulk of the market.

4.1.2 Types of PCs

As the survey results cited in Section 4.2 will show, PCs are adequate to control and manage the vast majority of DRT systems. There are two main types of PCs—those that are compatible with a standard created by IBM, called compatibles or IBM-compatibles, and those that are not compatible. The noncompatibles are now mainly those machines having the brand name of Macintosh, until 1995 made only by Apple Computer, Inc., which now allows other manufacturers to make Macintosh-compatibles. To confuse identification somewhat, the abbreviation PC is sometimes used to distinguish IBM-compatibles from other personal computers. Since there is no DRT software developed for the Macintosh, we use the term PC to refer to IBM-compatible machines.

Even the term personal computer is not as accurate as it used to be. It was coined when the machine was dedicated to one user sitting at the keyboard. Now it is possible that machines on the same network may share files and computational capability, so that a user may not have total control over the PC he or she is using.

4.1.3 Operating Systems

PCs can also be classified by the operating system they use. The operating system is simply software that provides the brains of the computer, controlling all operations and the flow of information. We discuss operating systems in this hardware chapter because, without them, the computer is just a pile of metal and plastic.

The operating system called DOS dominates the IBM-compatible market so much so that IBM-compatible machines are sometimes referred to as DOS machines. IBM also markets a competing operating system called OS/2. When you buy an IBM-compatible PC, it is likely that it will come with a DOS operating system, although other operating systems will also operate it. Most notable is a system called UNIX, which was developed by AT&T. UNIX is intended to be a universal operating system that can be used on computers of all sizes. Currently available from the software giant Microsoft is an augmentation of the DOS operating system called Windows. Windows provides DOS with a graphical capability, whereby the user chooses commands, starts programs, lists files, and the like by pointing to pictorial representations (called icons), rather than the user-unfriendly written commands inherent to DOS. Windows is the DOS-based machine manufacturer's competitive response to the Macintosh operating system, which has used a graphical user interface for 15 years or more. Now a new Windows version is available called Windows 95. It is likely that DRT software vendors will begin to make their programs available in Windows 95 in the near future.

Macintoshes come with an operating system developed by Apple that is referred to as Macintosh OS. The Mac OS runs only on Macintoshes, and other operating systems do not run on Macs because Apple uses a unique combination of software and hardware to perform the operating system functions.

4.1.4 Components of a Computer

Computers consist of a number of physical components, each with a specific function (Figure 4.1). The complete description of a particular computer consists of the listing of each of the components which, in turn, identify the machine's capabilities. A typical description is the following one, which is an actual requirement for a DRT software package:

> *Requires a 386/25 computer, math coprocessor, MS-DOS 3.3, 8Mb RAM, 20Mb disk space, VGA, and a mouse.*

Usually the first component described is the name of the microprocessor, in this case a 386. The microprocessor is the electronic circuitry that performs computation and controls data flow—the primary operations of the computer. Other microprocessors that are currently being marketed in PCs are named 286, 486 and Pentium, in increasing order of computational power. The number after the slash signifies the speed of the microprocessor, in this case 25 megahertz. You don't need to understand the meaning of that designation but only that you would need a computer with a microprocessor speed of 25 megahertz or greater. Microprocessors are currently available that run at well over 100 megahertz, and they get faster regularly. The "math coprocessor" indicates that the

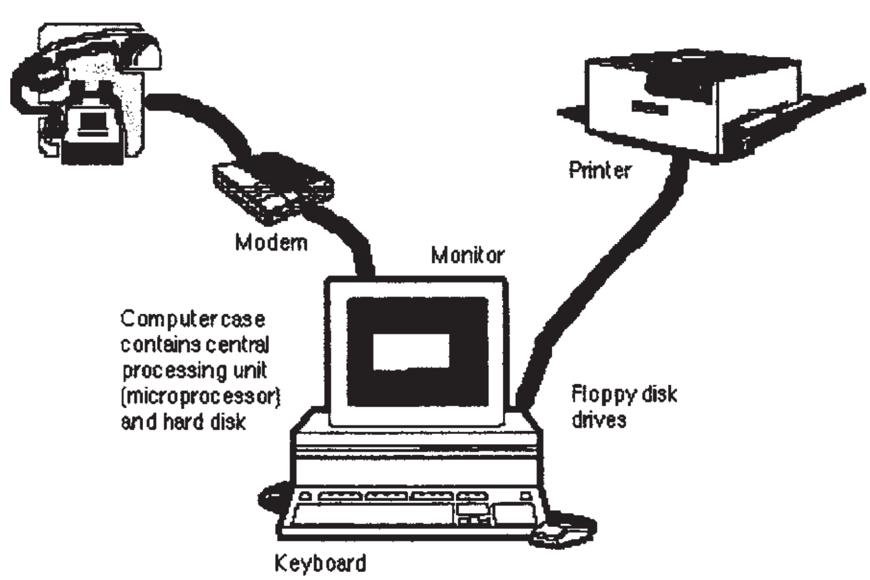

Figure 4.1 Hardware Components of a Personal Computer.

computer has a second microprocessor, this one specially designed to assist the main microprocessor by performing certain mathematical functions faster than the main microprocessor can alone. Microprocessors are often called "chips."

"MS-DOS" indicates the operating system is the version of DOS produced by the Microsoft company. As software is improved, vendors append a version number to their brand names, in this case version 3.3. Minor modifications are indicated by the number after the decimal; major new releases are indicated by the number before the decimal.

The next component is the RAM (random access memory), a fast, temporary storage used for storing software programs and data while the computer is running. RAM sizes are indicated in megabytes of capacity, in this case 8. A megabyte is about 500 pages of text data. As software becomes more powerful, it also requires larger RAM. All but the smallest packages require 4 megabytes of RAM, 8 megabytes is usually suggested currently, and up to 128 megabytes is possible.

Permanent storage, the next component of interest, serves as a file cabinet storing the programs and data that may be used over time. As the computer is running, the data and programs required for that session are shifted from the permanent storage to the RAM. Permanent storage is most often a hard disk, so called because the information is stored on a rigid metal disk that is coated with a magnetic substance. The user cannot see the disk (or disks) as it is permanently enclosed in a case. In the example of the specifications given above, it is a hard disk (not explicitly stated) with a 20-megabyte capacity, a low capacity by today's usage. Hard disks of 1,000 megabytes (called a gigabyte) are common. Another type of permanent storage is magnetic tape which is something like audio or video tapes. When used in PC systems, tape storage is usually a secondary or backup storage rather than the primary permanent storage, because data retrieval is much slower from tape than from disk.

There are several types of disks that are transportable and are inserted into PCs to read programs into and data into and out of PCs. Floppy disks, which are inserted into the computer, have been the most common means of buying programs or transferring data among computers. They are called floppy because they are flexible, a characteristic that distinguishes them from hard disks. The current standard is a 3.5-inch disk encased in a rigid case. The previous standard was a 5.25-inch disk encased in a flexible case so that it was truly "floppy." The new standard for inputting program and prerecorded standard data sets has become the CD, the optical disk system that also serves as a medium for recorded music. As of this writing, CDs are primarily input devices for reading data into the computer. As CD systems are advanced so that systems which write on the disk can be included in PCs, they will no doubt become the standard means of input and output. A floppy drive is an essential part of a DRT computer system. A CD drive for use in DRT systems now is a bit of a luxury unless you also want to use various databases or other programs that are distributed on CDs. But we advise that you either acquire or be able to add a CD for the time when it will be the standard.

Drawing by Sidney Harris: reprinted by permission.

"No wonder he never forgets. He has a bubble memory with a storage capacity of 360 megabytes."

The next designator is the monitor or computer screen. "VGA" indicates a high-resolution monitor standard developed by IBM. If DRT software uses monitor-displayed maps, a high-resolution monitor may be required.

"Mouse" refers to the device moved by hand that moves a cursor around the screen to select commands or files when an operating system using a graphical user interface is used.

Other hardware units that may be required include a modem, a device for translating the signals on a telephone line (analog) to a signal a computer uses (digital), which enables computers to share data sent over telephone lines. Modems are used to connect to on-line information services and networks, of which the Internet is the giant. In the case of DRT systems, modems are used to connect your computer to the software vendor's computer so that the vendor can troubleshoot quickly and remotely. Vendors may also distribute program upgrades and bulletins by modem.

Some means of backing up, i.e., duplicating all databases and files in case the original is destroyed, is essential both for legal and efficiency reasons. If the loss of a database would impede operations or replacement would be costly, then it should be backed up. Usually backup storage devices should have high-storage capacity so that entire days of operations can be conveniently stored. Backup data can be stored on floppy disks, hard disks, magnetic tapes, or other devices. Several types of storage devices with removable cartridges specially designed for backup storage are on the market. Portable backup devices are useful because they can be stored securely away from the system so that fire, earthquake, or other calamities would not cause the loss of all data.

Some of the hardware described above may be built into the computer, and some may be attached. Any additional piece of equipment attached to the PC is called a peripheral. The most common peripheral is the printer. Printers vary greatly in the quality of the product, but usually any printer will suffice for a DRT system, and you are free to select the quality you desire. Sometimes the designation "120 characters" is indicated, meaning a printer able to print a line containing 120 characters, which was considered a wide carriage in the days when printers were like typewriters. With modern laser and inkjet printers, the print size can be scaled at will, so the carriage width is not applicable.

PCs have a nasty habit of occasionally expressing their personalities by destroying your data, much like an unhappy child who throws your dishes. Therefore, anything stored permanently on hard disk and anything being operated upon which is held in RAM must be duplicated on some other storage medium. The most common method is to use the hard disk to back up RAM and to use floppy disks or tape media to back up the hard disk. Additionally, a printed hard copy of the data is also a backup, but it is not as convenient to use to correct errors since it is not directly machine-readable.

Another example of a hardware requirement specified by a software vendor is:

> *IBM-PC or compatible, MS-DOS/Windows, hard disk, FoxPro for Windows.*

The new element in this description is the specification of FoxPro, which is a generic database application program. This indicates that this DRT package is an example of one written in or using a generic program.

4.2 DRT HARDWARE USE

4.2.1 Microprocessors

Respondents were asked which computer they currently use (the first bar in the graph in Figure 4.2) and what their likely future hardware will be (the second and third bars). The answers indicate that the most popular computers are personal computers using the 486 microprocessor, followed by personal computers containing the 386 microprocessor. However, the use of the 386 machines will decline as they are replaced by the computers using the Pentium microprocessor, few of which were in use at the time of the survey. Present 486 users plan to keep those machines, but new users will probably opt for a machine with the Pentium chip unless they are on tight budgets, because 486-based machines are less expensive. Work stations, which are the third-most-used computers today, will also decline in use, as will mainframe computers.

It is clear that today's users expect personal computers to be the workhorses of DRT computation in the future. The microprocessor of choice may change, since the state of the microprocessor art changes constantly, leading to rapid obsolescence. However, DRT vendors have expressed the opinion that the 486 and the Pentium are sufficiently powerful for the software they are contemplating in the near future. This

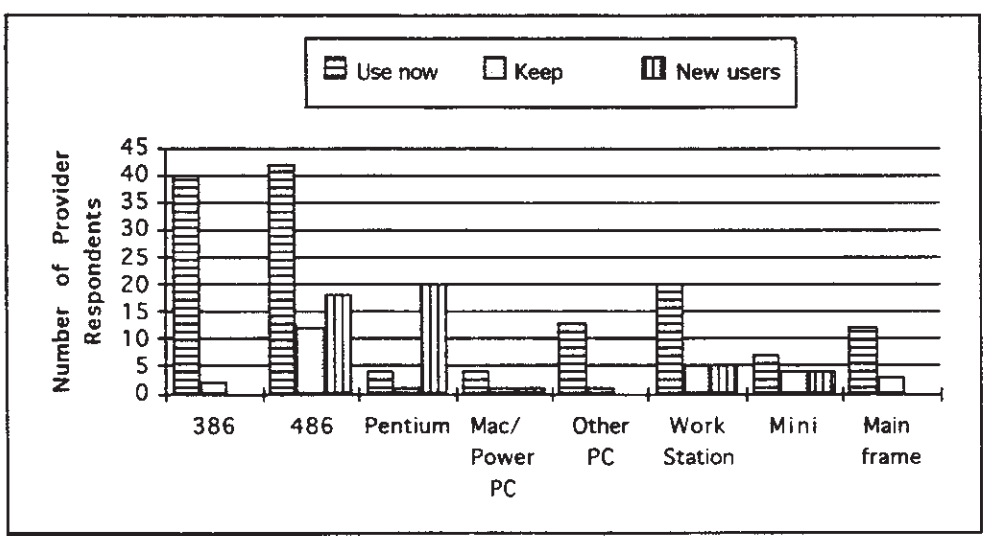

Figure 4.2 Computer Hardware Used and Planned.

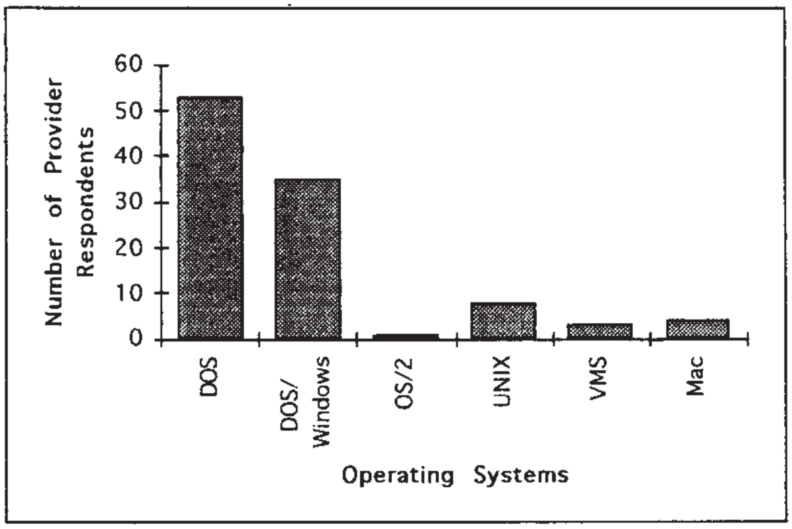

Figure 4.3 Operating Systems Used.

too may change as both available technology and the demands of the DRT market evolve.

4.2.2 Operating Systems

The survey of DRT providers (Figure 4.3) demonstrates that the most common operating system is DOS, followed by DOS/Windows. DOS/Windows will probably become the most common system in the near future as more vendors prepare software to take advantage of Windows. Four other operating systems—OS/2, UNIX, VMS (the system used by machines manufactured by DEC Corporation), and Mac OS—are used by a few providers.

4.2.3 Networks

Local area networks (LANs) are combinations of hardware and software that allow sharing of programs and data among personal computers, either at the same or at remote locations. About 62 percent of the respondents use networks and three-quarters of those indicate that they use a network called Novell. The next most popular network is Lantastic, a distant second with just over 7 percent of respondents reporting its use. Twenty-three of the 31 operators who contract for service use a network shared with the contractors that provide their services.

4.3 ACQUIRING HARDWARE

Your selection of DRT software will probably dictate the minimum hardware needed. Therefore, the microprocessor type and the operating system will be determined by the DRT software you select as the best for your needs. Some software may even dictate the brand of computer but it is more likely that you will have the choice of many brands. If an IBM-compatible is required, you are free to select the brand. While there may be differences in quality among different brands, or the vendors would like you to believe there are, computer hardware is like other commodities. Different brand names will have the same components such as microprocessors, disk drives, etc. You need to specify memory size, speed, and other peripheral hardware. You also have the flexibility to specify a greater capability in the hardware than is required by the software if you have other uses for the hardware, or you determine that a greater speed may be economically justified for your application.

Because of the commodity-like nature of hardware, it can be purchased by competitive bid or, unlike DRT software, can be purchased off the shelf. Some software vendors will sell the combined package of hardware and software and turn over an operating system to you. This is called a turn-key acquisition. This option has the advantage of making the vendor responsible for proper operation of the entire system and avoids finger-pointing between the software and hardware vendors if the system does not work.

> Make the contractor responsible for all aspects of the installation. This avoids potential conflicts if problems arise.
>
> —*Brad Christian, Assistant Transit Manager*
> Stanislaus County Transit (*2*)

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CHAPTER 5

HOW MUCH AUTOMATION?

CONTENT AND AUDIENCE

Computers are useful for tasks requiring rapid, accurate calculations on large amounts of data. These capabilities are needed to perform the functions required of DRT operations. This chapter deals with the issue of whether or not to computerize, and if computerization is worthwhile, what level of computerization is warranted. It is intended for all readers.

5.1 THE CASE FOR AUTOMATION OF DRT SERVICE

In a paper written early in the development of ideas about the automation of DRT systems, Professor Nigel Wilson (*1*) made the following case for automation of DRT service:

> Principal factors arguing for computer control are as follows:
>
> 1. Decisions are more effective,
> 2. Larger systems are feasible, and
> 3. Features can be extended.
>
> The basic argument is that "better" decisions can be made by a good computer control procedure than by a good dispatcher, particularly in large systems. Specifically, service attributes desired by passengers can be provided more consistently and at improved levels by computer dispatching for a given number of passengers and vehicles (hence, productivity). The superior performance could be translated into a more attractive service resulting presumably in increased ridership or into a reduced vehicle fleet size with the quality of service preserved. In either case, higher productivities should be achieved by a computer-dispatcher system than by a similar manually dispatched system. This advantage increases with system size as the limit of a single manual dispatcher is approached. Effectively this manual-dispatcher limit bounds the economies of scale that may be achieved as the manual system expands. Further economies of scale may be achieved through computer dispatching. Extended features that computer control may make feasible include automatic billing, simultaneous provision of distinct services, automated interfaces with customer, and vehicle communication system.

The argument for automation today is the same one. Professor Wilson also saw the role of automation with respect to the use of complementary technologies 20 years ago, a promise that is only being realized today (see Chapter 7).

5.2 DECIDING WHETHER AND HOW MUCH COMPUTERIZATION IS WORTHWHILE

There are several bases for the decision concerning whether or not to computerize your DRT administration and operations. The decision can be made without specific and detailed analysis, based on the experience of others and on faith that computers will help. For agencies having large fleets, the no-analysis decision is probably correct. By the same logic, the smallest agency usually can justify the acquisition of personal computers for strictly administrative matters, maybe even only for word processing. Once a computer is in-house, relatively inexpensive software, such as databases or spreadsheets, can be applied to DRT operations. We believe that almost all agencies with several vehicles and several hundred riders can justify a computer for some DRT functions.

The difficult decision is whether the relatively expensive scheduling/dispatching software is warranted. Operators of fleets of 50 vehicles or more, offering immediate response service to 1,000 passengers daily in an unzoned service area, can safely assume that they need a software package that provides the fully automatic scheduling. However, if they assign vehicles to zones within their service area or if they run a high percentage of subscription trips, analysis may be required to determine if expensive software is warranted. For smaller agencies, specific analysis may be warranted to determine if the relatively more expensive scheduling/dispatching software is worthwhile. Usually, systems with about 10 vehicles carrying 150 trips per day will warrant at least a computer-assisted software package (see Table 3.2).

High-end specialty DRT software may cost between \$50,000 and \$100,000, which appears to be a high price when its value cannot be established with certainty before installation and use. However, it should be remembered that this software may become a major management and decision tool for operating a DRT system with an annual budget of several millions. Therefore, the effort to make a good decision is well worthwhile. In the words of a TCRP panelist, "It is not like buying a \$100,000 parts washer in the maintenance shop."

This chapter starts by examining the experience of providers with computerization and concludes with an analytical discussion of issues for each DRT function. Several means of analyzing the decisions concerning scheduling/dispatching are discussed.

5.3 REPORTED BENEFITS OF COMPUTERIZATION

The experience of other providers who have computerized is useful in helping you make a determination of whether you should consider computerization. The results of the survey of providers concerning the impacts of computerization are presented here to aid your decision.

5.3.1 Impact on Staff

The impact on control room staff following the adoption of software was explored with a question asking for a rating of the strength of the impact in four areas, on a five-point scale defined by the terms “significant increase,” “some increase,” “no change,” “some decrease,” “significant decrease.” The tabulation of all respondents is shown in Figure 5.1.

The vast majority of respondents indicated that software had no effect on staff size. The few that indicated that software had an impact noted that increases in staff were more prevalent than decreases. These results support the hypothesis that changes in staff size usually do not accompany the adoption of software.

On the other hand, respondents indicated that staff skills necessary to operate in a computerized environment increased substantially, due to software use. None of the respondents thought that software use reduced the level of staff skills required. It is not clear if the adoption of software requires replacement of staff with persons with greater skill levels or if the very fact of using software is considered to be a more highly skilled endeavor, even if performed by the same staff. It is clear that you must take steps to ensure that your staff is equipped to use your new software.

Many respondents indicated that the use of software eased the task of management. Additionally, respondents generally cited an increase in job satisfaction due to software. These are both positive but difficult-to-quantify benefits of computerization.

5.3.2 Impact on Service

The impact of software on three service measures—productivity, quantity of service, and quality of service—is ranked on the same five-point scale used to rate the impact on staff (Figure 5.2). All three measures were deemed to increase substantially, and decreases were cited in only a few cases. Productivity was thought by the most respondents to increase, followed by quantity of service and then quality. Note that productivity and quantity are essentially the same result; that is, increases in productivity should allow the offering of either more trips with the same resources or the same number of trips with fewer resources.

In general, you can anticipate that the quantitative benefits of computerization will be productivity increases and not decreases in staff size. However, it should be observed that productivity increases can lead to decreases in the number of drivers required.

5.3.3 Summary of Survey Findings

In summary, users report that computerization raises productivity which, in turn, should lower the cost of operations. Respondents also report that computer use raises the quality of service. Concerning internal operations, users report that computerization does not impact the size of the staff, but

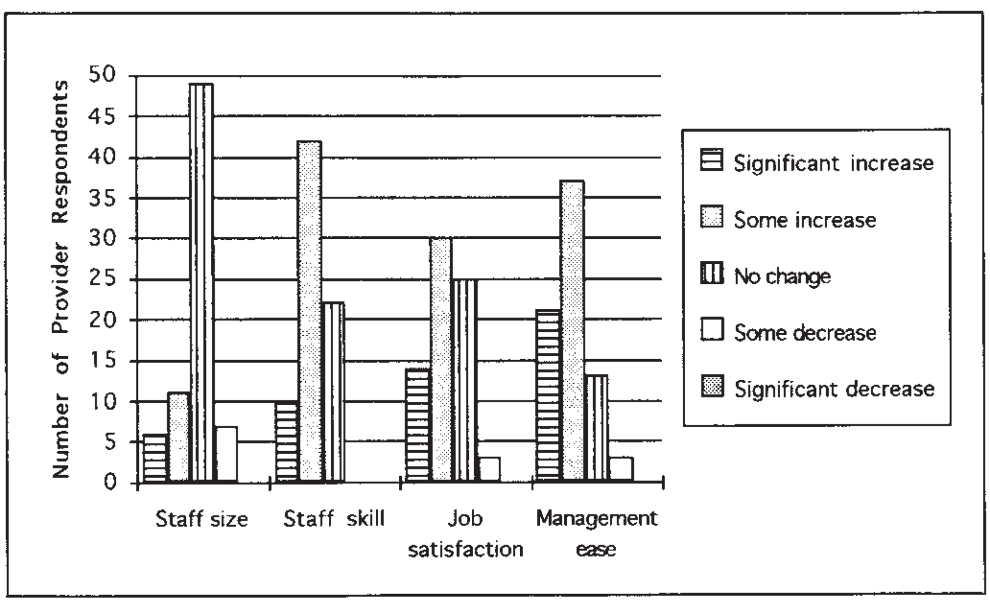

Figure 5.1 Impact of Software Use on Staff.

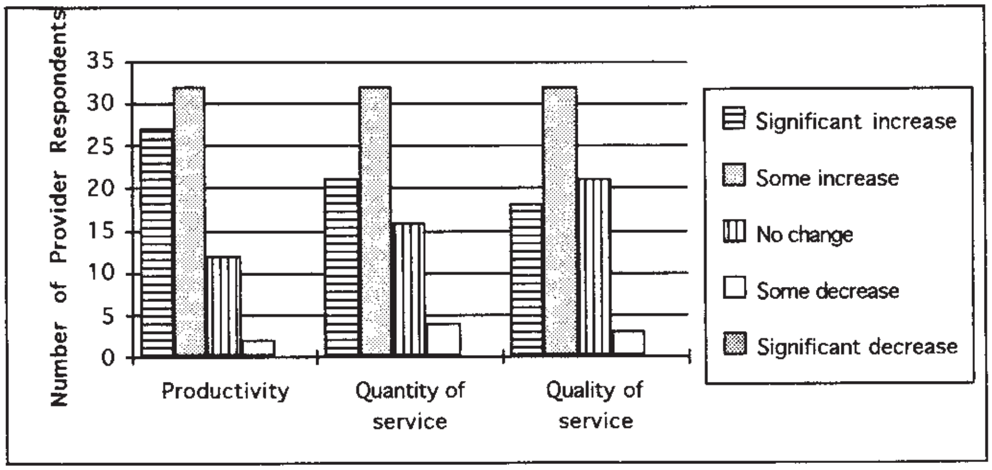

Figure 5.2 Impact of Software Use on Service.

does increase the skill level required and improves the level of job satisfaction. The survey contained no information on the acceptance or rejection of computers by the staff, but issues should be similar to the reaction of staff persons to change in any organization. Some people will resist any change, some resist computers specifically, and some will enthusiastically accept change. The advice to management is to recognize that computerization is a concept that may have to be sold to their staff.

5.4 ANALYSIS OF THE BENEFITS OF COMPUTERIZATION

5.4.1 Introduction to Benefits Analysis

In the last section, the experience of other providers was examined. In this section, we discuss how to examine the performance of your own scheduling/dispatching procedures, to ascertain if they can be improved. The intent of the analysis discussed here is to help you make an early decision on whether to further consider computerization before the effort of investigating vendors is undertaken. After examining vendors and their products, you might still decide not to proceed because you are not sold on actual products or vendors.

As a prologue to considering computerization, you should ask the question, "Can I do better without computerization or other technologies?" The first step in the search for better performance is to study the existing methods in an attempt to discover those improvements that can be implemented without capital expenditures.[1] In other words, it is first necessary to ensure that you are getting the most from your present resources. It often happens that improvements are made concurrent with computerization that, if made without computerization, would account for most of the improvements possible. Preparation for computerization requires a discipline that, if applied without the computer, would lead to improvements. It is possible that these procedural improvements are sufficient so that the additional benefits of computerization do not warrant the costs.

The analysis of present operations is done with techniques from disciplines of Industrial Engineering, Systems Engineering, and Systems and Procedures. Much of it is a common-sense application of detailed examination. Flow diagramming is also a useful tool for examining procedures. Exploring these techniques is beyond the scope of this Handbook; we suggest reference to textbooks or handbooks on any of the subjects mentioned above.

The issues involved in computerization are discussed for each DRT function in the remainder of this chapter. The emphasis is on the function of scheduling/dispatching, which presents the greatest challenge to the decision process.

5.4.2 Eligibility Determination

The determination of eligibility of a patron can be done independently of the other paratransit functions and can therefore be computerized without regard to the computerization of other functions. Database use requires listing all registered users. In a system with no computerization, this is merely a hard-copy list of registered patrons. Computerization is achieved by putting this list in a database software package, which allows retrieval of patrons' information by entering the person's name in the computer. Any of the generic database packages will serve this function.

It is sensible to computerize the eligibility function if any of the subsequent functions is also computerized. If nothing else is computerized, it is beneficial to computerize this if the

[1] A related postulate states that the greatest improvement from computerization can be achieved by ignoring the present methods and designing the computerized system from scratch. This usually is expressed as a criticism of existing software packages for not rethinking the entire process of offering DRT services and rather just computerizing the present manual systems. This may or may not be a valid criticism, but no one has yet demonstrated the radical new approach for more effective use of computerization, although some proposals have been made (*1*).

number of patrons is very large. Manipulating a lengthy hard-copy list delays the order-taking process.

5.4.3 Order Taking

As discussed previously, the use of computerized order taking depends somewhat on whether computerized scheduling/dispatching is warranted. If it is, computerization of order taking is a by-product of the scheduling/dispatching software, and essentially all scheduling/dispatching packages offer the function.

If computerized scheduling/dispatching is not warranted, computer-aided order taking may still be desirable as a recording device so that a manifest can be prepared for transmittal to the drivers. The computer plays no computational role and is used merely as a word processor.

Both generic software and specialty software can be used for order taking. Essentially any generic database software package can be adapted for order taking. Additionally, a number of vendors offer order-taking software which is relatively inexpensive, costing under $1,000.

On the other hand, if your system would benefit from computerized scheduling/dispatching, discussed in the next section, then you will probably get computerized order taking in the package, and the decision of whether to computerize depends on the value of the whole package.

5.4.4 Scheduling/Dispatching

While scheduling and dispatching can be performed separately, it does not make sense to do so in computerized systems. One of the advantages of computerization is to perform the functions jointly so that the times promised to patrons are based on dispatching, that is, the assignment of the trip to an actual vehicle. Therefore, we discuss the functions jointly as scheduling/dispatching, often referred to as scheduling, when deciding if computerization is warranted, because they will occur in a single package.

The collective experience suggests that you are a candidate for scheduling/dispatching software if you have more than 10 vehicles and deliver 100 to 200 nonsubscription trips daily. However, as the data in Figure 5.3 indicate, there are much smaller systems that use specialty paratransit software, although it is not known what level of software is used. Manual operation is the most prevalent means for small fleets, and a significant amount of generic software is used for such tasks as producing the manifests.

What are the benefits of the use of high-end scheduling/dispatching software? There is scientifically collected and analyzed empirical evidence identifying the quantitative benefits of computerized scheduling/dispatching. One large vendor reports that in its experience, computerized scheduling/dispatching will improve productivity by 0.2 to 1.0 passenger per vehicle hour, depending on all other factors. Taking the lower number in a 10-vehicle fleet suggests that, on the average, computerization would add one passenger per hour to the productivity. Cost savings accrue when the number of vehicles in service can be reduced. An average of one passenger per hour may or may not save one vehicle, depending on whether there is substantial peaking of demand. On the other hand, if the high range of an increase of one passenger per vehicle hour is achieved in a 10-vehicle fleet, then an additional 10 trips per hour are possible. Ten trips an hour usually suggests a two-vehicle saving or more, which can be substantial. For example, using some back-of-the-envelope calculations, if it costs $40,000 a year to operate a vehicle, a two-vehicle saving is an annual saving of $80,000, which may pay back the cost of a high-end scheduling/dispatching software package in 1 to 2 years or better. Bear in mind that this analysis is done using estimates and averages and does not apply to any given application. If the rules of thumb suggest that computerization may

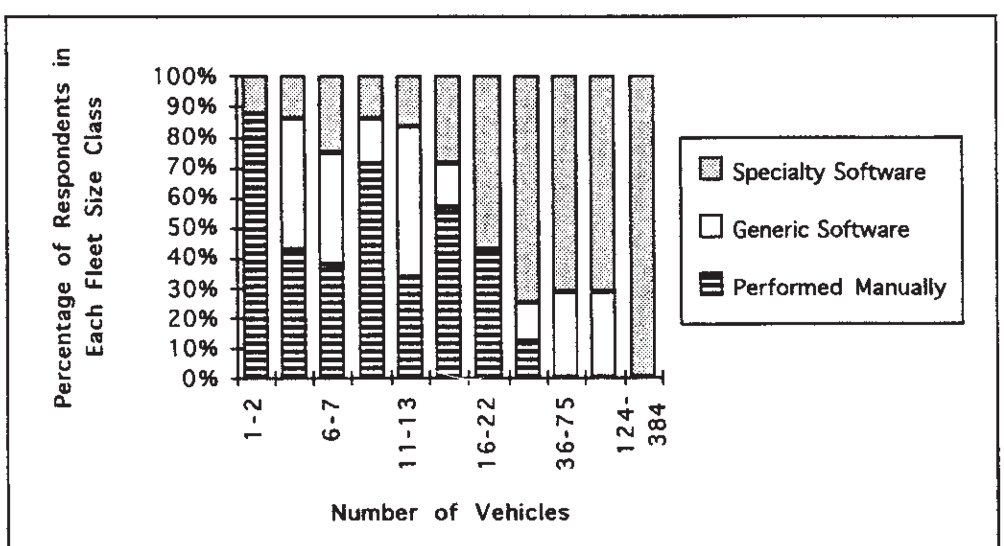

Figure 5.3 Relationship of Fleet Size and Software Use.

be beneficial to you, then you should undertake analysis of your own experience.

To analyze your operations, collect statistics on performance for a number of days of operation. Try rearranging the tours actually used to find out if they can be improved. While finding the best tours during operation may not be possible because of time constraints, in an analysis with no pressures, it is possible to examine many alternative tours. One useful way of performing this analysis would be to ask vendors to run a number of days using the data you have recorded so you can compare their tours to your actual data to answer the question concerning how much improvement you might achieve from actual software. This is not a perfect test as the probabilistic nature of paratransit operations allows for uncertainty in the analysis. However, you can have some confidence in the results if one scheduling/dispatching method continually outperforms the other.

You can also analyze your tours manually by searching in a trial-and-error fashion for better trip assignments, although the computations will be very tedious. You should use some means of randomly generating actual trip times. (A random number table will work.) If you have good computer modeling skills within your staff, you might consider developing a computerized simulation of your system to determine better tours. Some consultants also perform this analysis, although it may be sufficiently costly that only large systems can justify it. The paradox is that those who can afford the analysis need it the least, since the decision to computerize in large systems is easier to justify because the potential benefits can be so large.

The use of scheduling/dispatching procedures in an immediate-response mode is greatly enhanced by a precise knowledge of the location of vehicles. This has led some professionals to conclude that the real benefits of immediate-response DRT service will occur when scheduling/dispatching is integrated with Automatic Vehicle Location (AVL) technologies. Since AVL is a relatively expensive technology at the time of this writing, full benefits of this combination may only be available to large systems now or when the cost of AVL technology declines. However, more will be known about the benefits and costs of AVL soon because several agencies are installing systems integrating AVL and automated scheduling/dispatching (see Table 7.1).

Another issue pertaining to automated scheduling/dispatching is the problem of selecting software that performs the function well. The procedures that perform scheduling/dispatching and routing are complex mathematical ones that seek not just an acceptable course of action but an optimal course of action. Unfortunately, the quest for the optimal course of action consumes too much time, even when computerized, to be practical under the time constraints of DRT operations. Therefore, the procedures in current use settle for near-optimal solutions. Given all the other uncertainties and inaccuracies in real-world operations, the differences between the optimal and the near-optimal should be insignificant. On the other hand, the differences in the procedures used by different vendors to find the near-optimal may be significant, as may be the time required to apply their procedures. The problem for you, the buyer, is to discern what is worthwhile and which vendor can best provide it. The objective, comparative research necessary to analyze the procedures of different vendors has not yet been done by any appropriate organization.

5.4.5 Routing

Remember that the routing function prescribes the best path between points in terms of the actual roads taken (accounting for one-way streets, congestion, and the like), not merely the sequence of points. The routing task is performed by finding the best vehicle routes among drop-offs and pickups, where “best” can be defined as the lowest cost or the fastest. The best route is found by mathematical procedures that are sufficiently complex so that computerization is the only practical way to perform the function. So if you want to find the best routes, you will need a computerized procedure to do so.

Theoretically, the best vehicle routes are by-products of the scheduling/dispatching function if it is performed in a fully automated mode. Therefore, if scheduling/dispatching is fully automated, you will likely get routing for no additional cost. The question then is whether you actually use the routing information by conveying it to drivers or not. You may choose not to use computer-generated routes and instead let the drivers choose routes, for several reasons. It takes communication time and capacity to transmit this information to the drivers. Moreover, you may feel that the drivers can do as good a job or nearly as good a job as the computer because they may have more timely information on road conditions. Even if you think the computer routes may be better, you may consider route selection a prerogative of the driver, on the theory that route selection makes the driving job more meaningful.

If the schedule/dispatch function is performed manually or in a computer-assisted mode, routes will not be generated, and finding them would require a separate software package. It seems unlikely that routing performed without fully automated scheduling/dispatching would be warranted. The normal vendors of demand-responsive transit software may not even make a stand-alone routing package available, but other vendors may. Specifically, school bus scheduling software vendors would have routing-only packages.

5.4.6 Management Reporting and Statistical Analysis

One of the great advantages of computerization is that the information concerning performance can, in most cases, be easily captured and transformed to any reporting format that is desired. This is not a free by-product because it requires input of some information, but once computerized, the production of statistics and reports should become routine. Compared to the sophistication required of the scheduling/dispatching and routing task, reporting may be considered to be a mundane function. However, every DRT provider needs management information and almost all must submit reports for legal or contractual reasons, whether it be to a board of directors or to meet federal Section 15 requirements. For these reasons, reporting is an extremely important function.

In the earlier days of computerization of the DRT functions, providers appreciated the reporting capabilities even when the software did not perform the other functions very well. This suggests that automation of reporting, even if no other function is computerized, may still be worthwhile and should be considered.

Given the importance of reporting and the relatively straightforward nature of the function, it is surprising that at the time of this writing, providers using specialty software are complaining about the inadequacy of the reporting capabilities of some packages. This is a matter that will likely be improved, as is indicated in the projections of the future improvements described in the next section.

5.4.7 Other Functions

Other functions that can be performed with software assistance include accounting, invoicing, maintenance, purchasing and inventory control, and project management. These are not uniquely DRT functions as are the ones discussed above, and they are functions that many businesses perform. Therefore, greater varieties of generic software that perform these functions are available from many vendors at relatively low costs. In addition, some specialty DRT vendors market packages for these functions, and some of them may be integrated with the DRT operational software discussed above. Finally, vendors that sell to the transit industry but do not have DRT specialty software also offer packages performing these functions.

If you opt for a generic package and also use DRT specialty software, you will want to be able to use the relevant data from the specialty package without reentering it into a different computerized form. For this reason, you want a specialty package that will produce the data in standard formats that can be read by generic packages.

REFERENCE

1. Wilson, N. H. M., "Coordination and Control of Paratransit Services." *Paratransit, Special Report 164,* Transportation Research Board (1975) p. 174.

CHAPTER **6**

ACQUIRING DEMAND-RESPONSIVE TRANSIT (DRT) SPECIALTY SOFTWARE

CONTENT AND AUDIENCE

This chapter contains a discussion of the principles of procurement, provides a procedure for the acquisition of specialty paratransit software, and discusses a few of the most significant issues arising during the implementation of specialty software. It is the major topic of the Handbook and is intended for every reader.

6.1 PROCUREMENT PURPOSE, PROCESS, AND PRINCIPLES

The purpose of the procurement process is to find a vendor who is willing and able to provide and service software meeting your specifications, and then to consummate a contractual arrangement to acquire the software. The process varies according to the complexity of software being acquired. Purchasing low-end software is similar to purchasing generic software. Acquiring high-end software—that which performs calculations intended to assist or automatically perform the scheduling/dispatching—is a more complex task and is the main subject of this chapter. This introductory section reviews the process of buying generic software, contrasts this with the acquisition of high-end specialty paratransit software, and presents general principles of procurement.

6.1.1 Procuring Generic Software

Usually, you don't buy software in the same sense that you buy a computer or a book. Most commonly, you purchase a license to use software. Licensing is a device whereby the vendor attempts to maintain some control of the use of software. Usually, the vendor wants to ensure that each software package is used on only one computer system and is not copied and shared among employees, friends, and family, or sold to third parties. When using any of the three words *procuring, buying,* or *acquiring,* we refer to either licensing or outright purchase, depending on the terms offered by the vendor. A generic software license almost always includes documentation of the software and usually includes after-sale technical support.

Buying generic software for personal computers is a simple and low-risk venture. You may start by seeing an ad for a package that interests you. If the price is less than a good meal in your favorite restaurant, you complete and send an order form with your credit card number. If it's a little more pricey, you may seek a review of the software in a magazine or visit your friendly retailer, ask questions, and read the fine print on the package before purchasing.

After purchasing the package, you bring it home and, if you are experienced and the package is thoughtfully prepared, you can usually start using it quickly without spending a lot of time studying the manual. You might rip off the shrink-wrap, put the disks in the computer, and execute the program that installs the package on your computer. If you are more cautious or less experienced, you first flip through the user's material until you find the section that tells you how to install the software and execute the installation instructions. You then execute the program and begin to use it. If you have a problem, you resort to reading the appropriate parts of the manual. It is rumored that there are people who buy generic software and read the entire manual before they touch the computer. We have never known such a person. Sometimes it is only when you read the manual that you find that this software doesn't run well on your machine. Then you have to decide whether to upgrade your machine, remove conflicting software, or return the package for a refund.

Over time, you learn how to use more and more of the features by exploring and reading the manual. When you really get stumped, you may call the software vendor or developer for technical support. If that doesn't help, you go to the ultimate authority—your kids. Reasonably priced courses in software-use proliferate so that you can learn to use most common packages in the classroom.

Generic software is usually available from several vendors, so if the package you desire is an expensive one, you may seek price bids from two or more vendors and select the lowest bid. If the software is available at retailers, you may compare the prices of different retailers, which is another kind of bidding process. In general, bidding is used to acquire a standardized good or service when price is the only factor or the most significant factor.

6.1.2 Procuring Specialty Software

Procuring specialty software differs, depending on the level of software sophistication. Low-end software, which performs the less complex paratransit functions of eligibility determination and recording trip requests and trip information, is acquired in much the same way as generic software. That is, the software is provided without including training or support in the purchase price. Low-end DRT software differs from generic software in that there may be only one source vendor for each package.

When acquiring high-end paratransit software, the first thing to do is to forget what you know about buying generic software. This is not a "rip-off-the-shrink-wrap-and-away-we-go" process. When acquiring specialty paratransit software, you are not only buying software, you are forming a partnership with the software vendor that is intended to bring you the benefits of computerization. A good vendor will also see the relationship as a partnership. If you haven't used specialty software in your organization, you are committing to a learning process and are adopting a technology which may also change the way you do things. You are paying a sufficiently large sum of money so that even if you have trouble using it, you can't very well put the software on the shelf and forget about it.

Federal procurement processes (*1*) list a number of alternative procurement processes: 1) invitation for bid; 2) sole source; 3) small purchase; and 4) request for proposal. "Invitation for bid" (also known as "low bid") is used when there are several suppliers competing to provide identical goods, such as buying a fleet of Stanley Steamer automobiles, a generic software package, or any products that accomplish essentially the same functions. "Sole source" procurement is buying from one source without competitive bidding when there is a compelling reason for dealing with one source. Buying the right to use Mickey Mouse as a trademark would have to be done with the owner of those rights. "Small purchase" acquisition is a simplified process the federal government allows for purchases under $100,000 (formerly $25,000).

To purchase specialty paratransit software, you will use various forms of the "request for proposal" (RFP) process. A proposal is different from a bid. RFPs are used when the product or service desired is not standardized, the vendors have some flexibility in how they meet the purchasers' needs, and the price and scope of services are subject to negotiation. RFPs are usually used to acquire services but are appropriate for purchasing specialty software, which is both a product and a set of services. The RFP is a written specification of your terms. In response, a vendor submits a proposal, which is a set of their promises to you if you purchase their software. Unlike a request for a bid, price is only one of many factors. You are acquiring both a product and a number of services: training, implementation, technical assistance, and continuing software enhancements over time.

6.1.3 Principles of Competitive Procurement

The principles shown in Table 6.1 are guidelines designed to make procurement effective for the purchaser and fair to the vendors. Naturally, any such list is not to be rigidly applied as there may be good rationale for exceptions. If exceptions are made, the reasons should be explicitly identified and scrutinized.

The procurement process should be a dispassionate, objective, and comprehensive means of selecting software that best meets your needs and desires. It should provide safeguards against becoming captivated by surface glamor or the personalities of the vendor's staff. Unlike buying something like a new car, where almost any brand would give you transportation, the wrong software may be totally useless. In other words, the downside of a bad decision is a costly mistake.

TABLE 6.1 Principles of Software Procurement

Provide complete and unambiguous information concerning software needs to each candidate vendor;
Request and obtain the same set of information from each candidate vendor;
Allow vendors to exercise creativity in meeting your needs, when appropriate, by specifying **what** needs to be done rather than **how** it should be done;
Allow candidate vendors sufficient time to prepare a proposal;
Describe the selection process and timeline to the vendors;
Explain the criteria for evaluating the proposals to the vendors;
Include a dispute resolution process in case of conflict with the losing or winning vendors;
Consult with all those persons in your organization who will interact with the software product; and
Specify requirements which do not favor any vendor except for reasons that pertain to their product and service.

6.1.4 Contract Service Providers

It is not uncommon for the contract service providers (those firms which provide DRT service under contract) to want to use software of their choosing. If you believe that you have identified the best software for your application, you might require its use in the request for proposal to service providers. Those providers that are not willing to take responsibility for total service quality presumably will not bid or will ask for an exemption. Those who have experience with the software you want presumably will propose and take responsibility for total service quality. The point is that you want the contract provider to take responsibility for the entire service. You do not want to impose software and allow them to exclude from their responsibility any problems arising due to the software. Our guidance, in all aspects of DRT service, is that you should make a single vendor responsible for all aspects of performance. This may be a problem if you have a software package up and running and plan to contract with a provider—either a new provider or for the first time. Either consider only providers who are willing to take responsibility for the software performance or scrap the software and let the service provider select the package it prefers. You don't want the service provider to be able to point to the software as an excuse for performance beyond its control.

6.2 TASKS FOR BUYING SOFTWARE

6.2.1 Introduction

Buying software by an RFP process can be seen as series of tasks, as shown in Table 6.2. The order in which these tasks are performed may vary depending on which procurement method is used. In actual application, there may be backtracking to previous tasks as new information is collected. Each of these tasks is discussed in this section. Much of the information contained in this section is not unique to acquiring specialty software and applies to procurement of many other goods and services. Available references on procurement may provide useful background information.

We have not listed a step for analyzing your present process in a search for improvements that do not require acquisition of technology (as discussed in Sections 5.2 and 5.3) because it is not an acquisition step. Nevertheless, we emphasize that the rationalization of existing procedures is an essential task that should be undertaken before the acquisition of software/hardware.

6.2.2 Identify Your Needs and Develop Specifications (Task 1)

> If you don't know where you are going,
> you will get there, but you won't know it.
>
> —Anonymous (apologies to Yogi Berra)

Clearly you want to buy a software package that does what you need, so you need to specify the neeed capabilities and features. You must carefully document specifications to ensure that they have the blessing of the relevant users in your organization and that you can convey your needs clearly to the vendors. This is a difficult task which, if not done well, will likely result in selecting an inappropriate software package.

We have listed the definition of needs as the first task, but it is a good idea to survey what is available in the market at the same time. Knowing what is available ensures that you will not unintentionally constrain your vision about your needs by not recognizing what is already possible. On the other hand, an understanding of what is available will ensure that you are realistic about what is possible. Therefore, we suggest you familiarize yourself with the software (Task 3) before you finish defining your needs. Examine the list of paratransit functions in Section 2.3, understand them, and determine which are important to you. You should

TABLE 6.2 Tasks for the Procurement of DRT Software

1. Identify Your Needs and Develop Specifications
2. Identify the List of Vendors
3. Identify Available Software Capabilities
4. Identify Potential Vendors' Strengths and Policies
5. Prepare the Request for Proposal (RFP)
6. Notify the Vendors
7. Evaluate the Proposals and Select the Final Vendor
8. Write the Contract

also identify the features (Section 3.8) that you want in the software.

When defining your needs, it is a good idea to learn the language spoken by users and developers of paratransit software. The material in Chapter 3 on software is intended to help you develop this language. Knowledge of the language allows your description of needs to be translated readily to the capabilities of existing software. You should be able to read a vendor's brochure and know what they mean by each capability and feature offered. In some cases, it may be desirable to understand the inner workings of the procedures used in the software to accomplish each function, but this may require more effort than it is worth.

It is unlikely that you will be able to get or afford all the features and capabilities that you want. Moreover, there even may be conflicts among some of the features. Therefore, you need to make a list of all the features and capabilities you would like and to rank them by importance or at least rank them on some scale such as the following four-point scale:

Essential—absolutely must have the capability;
Desirable—would include it if it is available at low cost and does not cause other problems;
Discretionary—of some use but of low importance so would take it if it does not add to the cost; and
Unneeded—do not need it even if it is available at no additional cost.

Use the list of features discussed in Section 3.8 as a checklist for developing your specifications. This information can be conveyed to vendors when you ask for proposals. Tell them the needs that must be met and indicate features of less importance that would accrue to their benefit in the evaluation of proposals if they can provide them.

Let every user of the software and everyone on the staff who has a vested interest in its performance participate in this ranking process. Even though we believe there should be one final decision maker, obeying the organizational imperative that the buck should stop at one desk, many participants should have input. Ideally you would like to develop a consensus, but you may not totally satisfy all users. For one thing, users are more concerned about capabilities than they are costs. But you would like to enlist their support and commitment, whatever is purchased, to make it work. To do this, you will need a process of staff education and consultation, which starts with the needs identification and continues through all the tasks of acquisition and implementation. Enlist those involved to help define needs, to learn about the software, and to help in implementation.

When you define needs, you may have a tendency to do things more or less as you do them now. You would like the new process to be familiar and comfortable, but it may not be the right criterion. A common criticism of some DRT software is that it automates manual procedures and thereby forfeits the real advantages of using computers. Our advice is not to treat your present procedure as a constraint on your selection of software. Rather, you might consider the present methods as desirable to maintain, but not essential.

Written specification of needs should be prepared, regardless of what method of procurement is used. If a written request for proposal is prepared, which is recommended, the specifications become part of that document. If negotiations are to be conducted, the specifications are the checklist for agreeing to the capabilities.

6.2.3 Identify the List of Vendors (Task 2)

Identifying the candidate vendors is the easy part of acquisition—the hard part is identifying the best vendor for you. See Table 6.3 for information on software and vendors compiled by trade associations, universities, and other organizations. While some of these organizations update their lists regularly, any list will become dated, so your search for vendors should include visiting trade shows and noting the advertisements in the various trade magazines.

Both the American Public Transit Association (*2*) and the Community Transportation Association of American (*3*) have compiled information that includes paratransit software. The APTA directory includes user contacts as well. Others also have compiled or regularly compile lists, for example, the University of Kansas Transportation Center (*4*), Centers for Microcomputers in Transportation of the University of Florida (*5*), and the University of North Carolina (*6*). The New York State Department of Transportation has conducted a survey of low-cost software. A number of consultants specialize in helping paratransit providers select software. Specific references in this Handbook to individuals would be a good starting place to find individual consultants, and many of the large consulting firms may have appropriate skills within their staffs.

A final word on possible vendors. Part of the transportation software industry provides software to the taxicab operators. Traditional taxi scheduling/dispatching is mathematically a simpler task, even though it may involve many more vehicles because it does not require the ability to share rides. Vendors of taxi software may try to sell their software for shared riding. Some may adapt it to be a satisfactory shared-ride product, but many can be eliminated early in your identification of vendors.

6.2.4 Identify Available Software Capabilities (Task 3)

At some point, you need to identify the capabilities of the various software packages; the point at which it is done will depend on the path you use for acquisition. Ultimately, of course, evaluation of the capabilities will determine which software you purchase. If identification is early in the process, its purpose is to decide which firm will be invited to

TABLE 6.3 Sources of Information on Software and Vendors

Passenger Transport, weekly newsletter, and
Software in Transit Handbook, guidebook
American Public Transit Association
1201 New York Avenue, NW
Washington, DC 20005
Voice: 202/898-4000
Fax: 202/898-4070
Internet: http://www.apta.com

Community Transportation Reporter, monthly magazine
"Community Transportation Software" (November 1994) p.10.
Community Transportation Association of America
1440 New York Avenue, NW, Suite 440
Washington, DC 20005
Voice: 202/628-1480
Fax: 202/737-9197
Transit Hotline: 800/527-8279
Bulletin Board (TAP-IN): 202/628-2537
Internet: http://www.ctaa.org/ctaa/resource.html

1995 Catalog, annual publication
McTrans, Center for Microcomputers in Transportation
University of Florida
512 Weil Hall
Gainesville, FL 32611-6585
Voice: 904/392-0378
Fax: 904/392-3224
Bulletin Board (McLink): 904/392-3225
Email: mctrans@ce.ufl.edu
Internet: http://www.mctrans.ce.ufl.edu or
http://www.mclink.ce.ulf.edu

PCs in Transportation Software Directory (June 1994), loose-leaf notebook or computer disk
PC-TRANS, The University of Kansas Transportation Center
(Also published a magazine, ***PC-TRANS***, in the past.)
2011 Learned Hall
Lawrence, KS 66045-2962
Technical hotline: 913/864-5655
Fax: 800/245-8760
Bulletin Board: 913/864-5058
Email: pctrans@kuhub.cc.ukans.edu

State of New York
Department of Transportation
Albany, NY 12232
Gary Sorvari or Russell DeJarnette
518/457-8335
Fax: 518/485-7563
(Identified several DRT software packages for small providers costing under $1,000)

bid or with which firm you will negotiate. No matter when it is done, identifying capabilities is a bit of a detective's job.

The vendors themselves will provide information on the capabilities of their packages. Remember, this is marketing information designed to make their product look good. Many vendors demonstrate their software at trade shows or will do so at either their place or yours by arrangement. An efficient way to gather information and to see a demonstration is at a trade show sponsored by one of the various trade associtions. In one day, you can often view several of the most widely installed packages. You may not see the smaller vendors at these shows, but viewing three or four demonstrations may be a good way to start your selection process by familiarizing yourself with some of the options that are available.

A few vendors distribute demonstrations on computer floppy disks, but others do not like this format because they prefer to meet potential customers face-to-face. For those unfamiliar with software such as a computerized scheduling package, a demonstration disk may be a excellent way, not only of evaluating a particular package, but also of learning about software packages in general. When viewing any demonstration, you should remember that a demonstration is created as a marketing effort, not necessarily a discerning test of the software. Nevertheless, viewing a demonstration is useful to get an impression of the "look and feel" and to learn about the software, although it does not substitute for seeing the software in actual operation. Some demonstration disks may be programmed to guide you through the features of the software. Others are real operating software that allows you to use your own data, which provides a better test of the software. In fact, you may be able to compare your own schedules with schedules generated by the demonstration disk. However, this may not be easily done, since you must calibrate the software for your own environment (see Section 6.3). Inexpensive demo disks are available for two software packages through PC-TRANS (see Table 6.3).

Benchmarking is a technique used to evaluate the relative performance of software by measuring the computer processing time or the user effort (in, say, keystrokes) required for the software to perform various functions. Computer trade magazines often evaluate generic software and hardware by comparing and publishing measures of performance. There is no known comparable analysis of DRT software. Although proposals for such a study on DRT packages have been discussed and proposed over the years, no such study is known to have been done.

The conventional advice to buyers is that you should identify peer DRT systems, systems that are similar to yours, that are operating the software of interest to you. This is almost a universal recommendation by those who offer advice for acquiring software, and it is a good one. We suggest that you talk with as many peer or near-peer users as you can identify. The list of users for each vendor contained in Appendix 6-A will help you start these contacts. What you may find is that different users may have diametrically different opinions of software packages. You may even wonder if they are talking about the same package. The reason is that the users have different services, service areas, needs, hardware, and expectations. While this may at first be a confusing exercise, eventually you will gain some wisdom about where the software works best.

Peer analysis is not without problems and shortcomings. Identifying a true peer is difficult, as no two paratransit systems are the same. There may be no combination of a provider who has a system like yours and is using the software of interest to you, although this situation is changing as more and more installations are coming on-line. Finally, this process limits the evaluation to those software vendors who have a significant number of installations and closes out the newcomers, as is discussed in the next section. Nevertheless, talking to the man or woman who actually uses one is imperative.

You also have the option of asking vendors for specific information on their products by issuing a specific request for information or a request for qualifications (not to be confused with a RFQ since that is the acronym for "request for quotation" that we have called a request for bid above). Such a request can be as general or as specific as you like. One reason for issuing a request would be to ask vendors to address a particular concern or question you have about their product. This means that each request for information would be different for each vendor. Different treatment of different vendors, however, may be a violation of your procurement policies (see Table 6.1). If so, you could request the same information from each vendor.

Identify capabilities near the time you are planning to acquire the software since capabilities constantly change as vendors regularly improve their products.

6.2.5 Identify Potential Vendors' Strengths and Policies (Task 4)

Since you are buying not only a software package, but also a timestream of services, you must be concerned that the vendor will be capable of providing those services over the time period you expect to use the software.

Specifically the services you want include

a. Staff training,
b. Implementation assistance,
c. On-going technical assistance, and
d. Software enhancements (upgrades) over time.

You will have a contract obligating the vendor to provide the specified services, but a contract does not guarantee performance, it only guarantees a claim for penalties for the failure to perform. At best, it will allow you to reclaim some of the costs. If the vendor goes out of business, you may not even reclaim costs. Therefore, you need to judge the vendors' ability to perform the contract and the quality of that performance by assessing the prospective longevity and strength of competing firms. The first two services are offered immediately after purchase so there is not a great risk of a change of condition in the vending firm. The issue is whether vendors can provide services over the future time period that you will be using the software (see Section 3.5.4).

The indicators of strength and longevity include the following variables:

- Staff size,
- Number of installations,
- Age of company,
- Financial stability—profitability/income,
- Diversity of products,
- Quality of support staff,
- Quantity and quality of staff training provided,
- Technical support policy, and
- Upgrading policy.

While the size of the staff is a measure of capacity to provide services, a large staff is not a necessary condition, and a number of small paratransit software vendors have successfully supported their software over many years. However, firms dependent on the skills of a few founder/owners are probably more risky than larger firms that have made the transition to a professional, hired staff. (This topic is revisited at the end of this section.)

The number of installations, or users of the software, is an indication of strength and is also a measure of the likely level of software improvements that will be made over time. Each of their installations can be viewed as a source of ideas for improving the software. Likewise, the age of a company is an indication of staying power and future longevity, especially when it has a large number of installations.

Financial stability measured by profitability or gross sales is an indication of vendor strength and staying power. This information may not be publicly available but can be requested in proposals.

Staying power and strength are also indicated by diversity of the products offered by vendors since companies with several products have some insurance against changes in any single market. Several companies offering paratransit software also offer a variety of other transit-related software for operations, planning, accounting, and the like. Some firms offer software in totally unrelated application areas.

The quality of the support staff is important but may be difficult to determine. You can request resumes of technical support staff and evaluate their experience and their tenure with the vendor. You may also ask other customers of the vendors to comment on the quality of the training provided.

Training should be evaluated by the number of training days offered, the number of your staff that will be trained, whether the training will include time on your own system after it is installed (your place or theirs), and the quality of the instruction. Quality can best be judged by talking to other users, or better, by sitting in on training offered to other users.

Technical assistance should be judged by the amount that is available for the cost and by the response time. Upgrades are judged by the number of times they are issued and their cost.

How do you determine the difference, and is there one, between what the vendor promises and what will be delivered? You include what you can in the contract, of course, but you also seek assurance of performance by evaluating two sources of information. First is the experience of other users, which we have discussed. Second, you ask the vendor for its records of the performance of its software in actual use, which it may maintain for its management purposes. Be aware that it may not wish to share these records for legitimate competitive reasons, and the information it does share may be selected to be favorable to it.

Before we leave the topic of vendor evaluation, it should be noted that our discussion is probably biased in favor of well-established, large vendors with a large installed base of packages. Clearly, if every purchaser applied these criteria, no new vendors could enter the market and the dynamism in competitive markets brought by innovative products and creative ideas would be lost. Since, historically, new single-product firms have entered the market and have been successful, some agencies will find it advantageous to not require these indicators of strength of their vendor and will opt for what they see as a product that is better for them. These agencies are those which can take a risk because they are economically strong or they have appropriate in-house skills. This is the classic choice between the large firm and the small firm, with pros and cons on both sides. Selection may be as much a matter of your business philosophy as it is any other criteria. In summary, for most agencies this is not a matter of concern; most should buy a proven product because they do not have the staff and resources to support software. Those who have considerable computer and software skills on staff may wish to work with a smaller software vendor for a number of reasons, one of which is getting a package tailored to their needs. They are experienced enough to know what they are doing. Most users should go with the proven.

If you decide that the desired software package is offered by a firm that has uncertain staying power, you should consider other sources of support, in-house or from third-party firms. Specifically this means that it is desirable to have available to you the programming skills necessary to work on the program code. In this case you should contract with the vendor to provide you the fully documented “source code” for the software you acquire. The source code is a listing of computer instructions in a format that can be modified by competent computer programmers. Usually, source code should be made available in a standard, higher-level computer language. The documentation should be sufficiently detailed and complete, containing the descriptions necessary so that a competent programmer can modify the code.

In addition to measures of strength and stability, the vendor’s policies of support and upgrading should be identified and compared to your needs during the evaluation of vendors. These factors were discussed in Section 3.7.

6.2.6 Prepare the Request for Proposal (Task 5)

The request for proposal should be sufficiently complete so that bidding vendors can prepare a thoughtful document responding to your needs. RFPs consist of several parts as indicated in Table 6.4. Samples of the scope of work from actual RFPs are shown in Appendix 6-B.

The most important section of an RFP contains your software specifications. These specifications were prepared when you documented the list of your needs (Task 1) above and were enhanced or improved based on the knowledge you gained when examining actual software products and vendors (Task 3). There may be an issue of proprietary secrecy in the matter of the scheduling/dispatching function. If your staff is knowledgeable about the approaches to performing scheduling/dispatching, they might want to know how the vendors solve the problem, that is, what algorithm is used. On the

TABLE 6.4 Sample Outline of a Request for Proposal

Table of Contents

BACKGROUND
Introduction
- Status of Purchaser
- General Requirements
- Summary of Proposal Process

Description of Purchaser's System
- Existing Services
- Service Area
- Organization
- Current Operations Control (manual or software used)

SCOPE OF WORK
Functional Requirements
- Function-by-Function Requirements (including functional performance specifications)
- Hardware Requirements (if any not dictated by software requirements)
- Overall System Software Performance Specifications
- Process of Software Acceptance Testing

Other Requirements
- Technical Support
- Documentation
- Training
- Maintenance and Warranties
- Compatibility Requirements
- Bonds, Insurance, and the Like

Cost Information Formats

VENDOR CAPABILITY AND EXPERIENCE DESCRIPTION
- Vendor Description, Experience, and Staff

ADMINISTRATION AND LEGAL

Vendor Selection Process
- Selection Timetable
- Proposal Format Required
- Evaluation Methods and Criteria
- Allowable Provider Personnel Contacts During Proposing

Provisions and Clauses
- (Sample contract is best)

Mandatory Forms and Documents (Include a checklist of documents required)

other side, if the vendor believes that its procedure is a trade secret, it may not want to reveal the actual procedure even if the process has been published. Just letting competitors know which algorithm a vendor uses may be more than it wishes to reveal. If possible, focusing on actual performance measures may be a means of resolving this conflict.

The rest of the RFP includes background information on the agency, information on the administration and timing of the procurement, the persons to be contacted, the means of evaluating the proposals, and the terms to be included in the final contract. The inclusion in the RFP of the actual contract terms that will be used is helpful.

Two types of bonds are used in procurement—proposal and performance. The proposal bond is a guarantee that requires a payment to you if the vendor selected fails to sign a contract for the terms they included in their proposal. It is used to ensure that proposals are serious ones. Proposal bonds are not common partially because they may impose a considerable hardship on vendors since they may be hard to obtain. Generally, these bonds are not needed because if the winning vendor does not follow through, a runner-up is usually available with a comparable offering. Performance bonds are discussed in Section 6.2.9 on contracting, where the competitive impact of bonds is discussed.

We recommend that when you begin to think about procuring software, you note the announcements of RFPs in *Passenger Transport* (see Table 6.3) and take advantage of the experience of your peer providers just as you should for evaluating vendors. Send for the RFPs and follow up with calls to the agencies to understand their reasons for the inclusions in their RFP. There is a wealth of knowledge to be gained from those who have preceded you.

6.2.7 Notify the Vendors (Task 6)

At some point in the procurement process, you need to notify vendors that you are going to conduct a procurement. This communication may be done in one of the three ways discussed below. These methods of acquisition require essentially the same tasks, but in different orders depending on the number of prospective vendors considered at various stages. The most common method is to announce the proposal publicly and issue it to all requesters. However, if you have already identified a small set of preferred vendors that you would like to invite to bid, you may target the request to this list and not accept proposals from others. Finally, you may feel that you know enough about vendors and their products to begin negotiation with a single preferred vendor. By using any of these three methods, you are embarking on the process of communication with vendors that will end with a contract with one of them.

A few pros and cons of the alternative methods are discussed here, but you should refer to documents on procurement for a comprehensive analysis of the procurement options. One topic not covered here is the regulations imposed on procurement if you are using federal funding. You may also have your own preferences or dictates based on the procurement experience and policies of your agency. Nothing special about software procurement dictates that you use one means of procurement over the others.

Broadcast the RFP. The RFP can be provided to any and all firms that might be interested. This is usually done by issuing public announcements in trade magazines, mailing to whatever vendor mailing list your agency already has, or using the list you developed in Task 2 above. Some agencies are legally bound to use this means of procurement either by their own rules or the regulations of third-party funding sources, especially the federal government.

There are two drawbacks with this process of procurement. You may receive responses from vendors whose software is not competitive. The work of processing these noncontenders is nonproductive. This is not such an important consideration in the current DRT software market because there are not that many vendors, and your specifications themselves will cause self-screening among potential vendors. Second, the vendors look with less favor on a broadcast RFP because of the smaller odds of selection, which may lead them to not compete as strongly as they would if they were selected to be one of a few contenders. This probably affects the small vendors more than the large ones but in any event is not a serious drawback of broadcasting the RFP.

An option within the RFP process is to broadcast a draft of your RFP, asking potential vendors to comment on the RFP but not to present proposals yet. The purpose of issuing the draft is to ensure that the RFP contains no fatal flaws and that it is a reasonable request. Vendors may respond in a self-serving fashion, attempting to influence the RFP to be more favorable for them. However, it is likely that this process may suggest modifications that are desirable from your point of view. This process may also be used as part of a prequalification process (see next section). Moreover, written questions are usually accepted from vendors after the issuance of an RFP, and written answers are prepared by the agency staff and then distributed to all those who have requested an RFP. This question-and-answer process could be merged with the draft RFP process, with the answers to the questions incorporated into the final version of the RFP.

Target the RFP. A targeted RFP is sent to a selected list of competing vendors that have been determined to be qualified. Prequalification may be based on a written request for qualifications sent to a list of vendors, or it may be based on information collected from generally available information and discussions with other users.

Reducing the list of vendors invited to submit a proposal is an attempt to be efficient in the selection process by conserving both your time and effort and the effort expended by potential vendors. There is no point in going through the exercise with vendors who have no realistic chance of being selected based on information gathered in Tasks 3 and 4.

The shortcoming of this approach is that a vendor who is not prominent and could be overlooked may have just the software package for your operation or, more likely, a vendor who is willing to make an especially attractive offer for marketing reasons may be passed over. However, if the investigatory work of Tasks 3 and 4 is done well, this is a small risk.

Negotiation. While negotiation may occur after a competition based on the RFP process but before a contract is signed, the term is used here to describe a procurement process that does not require vendors to submit competitive proposals. Rather, based on information obtained in Tasks 3 and 4, you identify the single vendor you believe has the best product and can give you the best support, and you undertake to negotiate a contract with it. The process of negotiation will generate the terms and specifications that would otherwise have come from a proposal.

Negotiating is based on a selection process that leads to the identification of a single or a ranked list of potential vendors. While you should document your specifications in preparation for negotiation as you would for a competitive bid, you ask for a proposal from only one vendor either before, after, or during face-to-face negotiations. If you cannot strike a satisfactory arrangement during negotiations with the preferred vendor, negotiations can be terminated and begun with the second-ranked vendor and so on. This process keeps competitive pressure on the vendor during negotiation.

The total effort in vendor assessment probably does not vary a great deal in any of the methods of procurement since due diligence is always necessary. Negotiation may be a quicker process because it eliminates the time lapsed to allow vendors to prepare the proposals and time required to schedule and hold oral presentations and evaluate different proposals.

6.2.8 Evaluate the Proposals and Select the Final Vendor (Task 7)

Agencies use a wide variety of evaluation methods and processes; some are simple and others complex. Any framework that allows the systematic comparison of alternative packages and capabilities of competing vendors is recommended, whether it includes an attempt at quantitative scoring or not. In the final analysis, the selection is a somewhat subjective process that includes assessments of difficult-to-quantify factors, such as vendor responsiveness and the personality of the vendors' support persons.

Often panels of "objective" persons conduct the evaluation and make recommendations to whatever policy board has the final authority to commit the agency. Generally these procedures violate the management principle that the person who will be responsible for performance of the software should have the authority to select the vendor. Typically, public or quasi-public agencies subordinate this management principle to prevent favoritism or fraud in the procurement. However, it seems more sensible to use a panel of staff persons that will be involved in using the software rather than a so-called "objective" panel of persons who have no responsibility for the operation of the software.

Often specific criteria are used to evaluate vendors' proposals. These criteria should be determined early in the process, probably in Task 1 when needs are defined. A sample of criteria is shown in Table 6.5.

The evaluation of the vendors includes more than just an evaluation of their proposals. Three other important factors that should be included are references from other users, performance measures, and user-friendliness (ease of software use). References are obtained by calling other users as has been emphasized elsewhere in the Handbook. Performance measures and user-friendliness are determined by actually using the software. Performance measures are quantitative and can either be specified as required levels (minimum or maximum) or merely ask for the actual performance numbers. Performance requirements or measures may be applied to individual DRT functions or to the overall system performance. An example of system-level performance requirements is shown in Table 6.6.

Formal scoring processes are commonly used in the evaluation. This approach requires the panel members to assign quantitative scores to the evaluation criteria, which are summarized to identify a rank for proposing vendors. There are many ways of summarizing the scores. Some procedures will assign a weighting of the criteria to reflect importance before summing scores. If this process is used, the panel should be wary of a shortcoming. Focusing on the scoring of individual criteria sometimes obscures the overall assessment—that is, the failure to see the forest for the trees.

Sometimes agencies will require that vendors appear before a panel to provide an oral presentation of their proposals and capabilities. This is a useful process for assessing the people with whom you will actually work. The same result can be achieved by less structured interviews and site visits.

It is possible that the proposal will raise technical questions which your staff is not appropriately trained to answer. You should determine beforehand how you will handle these issues so that the process is not delayed while you seek answers. Possible sources of help are other users, consultants, or members of your community who have appropriate training. Not-for-profit agencies often seek to bring technically trained persons on their boards of directors for this kind of help.

TABLE 6.5 Proposal Evaluation Criteria

1. Compatibility with other software used by the purchaser.
2. Adequacy and effectiveness of the applications software in response to the requirements specified.
3. Compatibility of implementation schedule.
4. Qualifications and experience of the firm.
5. Capabilities and experience of vendor personnel.
6. Proposed costs.
7. Quantity of support — training, technical assistance, and upgrades (may be combined in the cost analysis).
8. Consistency with other policies of the purchaser, e.g., location of firm, minority business goals, company citizenship, etc.
9. Quality of proposal presentation.

TABLE 6.6 Example of System Performance Requirements

Search and confirmation of each trip availability for any date shall be available with a maximum response time of 5 seconds for up to 10 active workstations.
Capacity to handle over 15,000 clients without any appreciable degradation of overall system performance.
Ability to schedule 11,000 daily trips.
Ability to schedule in batch 3,000 trips in one hour.
— from Western Reserve Transit Authority RFP, Youngstown, OH, October 1994

6.2.9 Write the Contract (Task 8)

The preparation of a written contract, which you should of course use, is the function of whatever procedure you usually use to prepare legal documents. The contract is the legally binding description of both the services and the capabilities of the software that you are acquiring so it should be complete. It should include the payment schedules, the features and performance of the software, the support from the vendor firm, the schedule for installation and training, and penalties for nonperformance. Usually both the requests for proposals and the vendor's proposal are incorporated into the contract.

> Do not pay the contractor until all tasks required to be finished under each scheduled payment have been completed. Require the contractor's written verification that all necessary tasks have been completed at each payment step.
>
> —Brad Christian, Assistant Transit Manager, Stanislaus County Transit (*7*)

Several means of enforcing the contract can be built into the contract terms. All or partial payments can be withheld until the installation is accepted. An example of a fairly tough payment schedule is shown in Table 6.7. Another approach is to require a performance bond, which ensures repayment by the bonding company of the contract amount if performance does not meet specifications. Both bond requirements and withholdings increase the cost to the vendor, which it will pass on to you if it can. Both may also limit the competition for your contract by ruling out small firms, either because they cannot carry a long-term account receivable or they are unable to purchase a bond. You may consider the competitive impact to be either positive or negative, as a vendor's ability to meet these terms is a sign of strength, but by ruling out smaller firms, you limit the options available to you.

Specific daily penalties for poor or late performance can also be built into the contract. A penalty clause requires that each task should have a specific completion date which is changed only by mutual consent and for a valid reason.

Most importantly, the contract must explicitly, comprehensibly, and unambiguously the define the responsibilities of you and the vendor. Such a document should include all tasks, tests, reports, meetings, schedules, deadlines, performance criteria, time on site by individuals with specific skills, etc.

In closing, it should be observed that when both parties have experience with and confidence in each other, casual contractual agreements can work just fine. If you choose that path, you should do so with full awareness that you are taking a risk. Contracts are usually not needed when things go well. Contracts are needed to prevent the worst when things go badly. Vendors can change in midstream due to many factors, among which are business or financial troubles, changes in management, or changes in ownership. Protect yourself, your organization, and your patrons.

6.3 IMPLEMENTATION ISSUES

6.3.1 Impact of Computerization

Anticipation of the impacts of the use of computerized procedures is useful so that you can take the steps that might overcome possible problems or take advantage of positive possibilities. These impacts were described in Section 5.2. For example, the survey results suggest that while you will not have to increase or decrease your staff size, the skills of your staff may have to be increased. Therefore, you will have to undertake staff training and upgrade your job descriptions. Increases in productivity are also likely. This means that you will be able to either reduce your fleet size or increase the rides available. In either case, you should prepare for these changes.

6.3.2 Implementation Tasks and Advice

Implementation of high-end software packages takes time; vendors suggest that it takes at least 6 weeks and may take up to 6 months. Before the reasons that this time is needed are discussed, it is important to recognize that during this period you will not be able to depend on the new system to operate your service. Therefore, you will need to find the resources necessary to install the new system at the same time as you operate service with your current methods. It is also advisable to operate both the old and new systems for a period after the new system is fully operational. The reason for this is that glitches may arise in the new system due to new situations that were not tested during the installation testing. It is not possible to test all situations in a finite time. The alternative is to be able to bring up the old system quickly while the new system is fixed.

TABLE 6.7 Example of a Payment Schedule

Task	Milestone	Payment
Complete initial installation and customization. Convert existing data. Operate 60 days without incident. Continue to debug and fine tune as needed.	Installation	80%
Operate 90 additional days without incident.	Conditional Acceptance	10%
Operate 180 additional days without lost data, corrupted records, system downtime due to software failure. Improve productivity to approach - if not exceed - 3.5 passenger/hour and reduce vehicle requirements.	Acceptance	10%

The first task is to get the new software, and computers if they are new, set up and operating. This just determines that everything turns on and that the software runs through whatever test the vendor performs, but it doesn't mean that it works with your data. Usually, this is the task of the vendor. In cases where the software vendor and the hardware vendor are different, there is the issue of coordination at this point. If you obtain the software and hardware from the same vendor, the vendor may do this testing at its own facility.

Transferring the data from your existing system into the new system is a task that is on the project critical path. The information needed to be transferred includes the customer database, the road network, and the description of the vehicle fleet. If your previous system was computerized, this might be a straightforward task of machine-to-machine transfer. However, if the data in the previous system are not in standard data formats, that which essentially all modern software uses, this may be a more time-consuming task. Transferring a manual database to a computerized system requires manual data input, which can be time consuming, costly, and mistake prone.

The longest task may be setting the parameters that describe your streets, vehicles, traffic, and other local conditions to the new software. Two examples of parameter setting commonly cause difficulties. Setting of the average vehicle speeds on different road links and under different conditions of traffic or weather is a sometimes difficult task that may require a trial-and-error process during actual scheduling/dispatching. The second sometimes troublesome task is to obtain an accurate street map or coordinate system describing your service area. Developing a map from scratch is a time-consuming and tedious task. Our advice is to make the vendor responsible for the map. A poor map will lead to operating problems that could also be caused by software shortcomings. Rather than have disputes over the cause of problems, make the software vendor take responsibility for everything. This may not be a satisfactory piece of advice if you already have a computerized map that was prepared at great expense so that you want to use it. In this case, you might try to use it, but be aware of the pitfall.

The last task is to train your staff on the new system at your site. Even before the formal training starts, you should begin to orient your staff to the changes. A useful way to do this may be to ask the vendor to provide videotapes of the system in use at other sites as probably it is not economical to take your entire staff to those sites. Training at an off-site location may have been done before the system is on your site, but on-site training is desirable. Training probably is not on the critical path and can be done while you are setting the system parameters.

Consider providing staff incentives for active participation in training. Talented scheduler/dispatchers may be reluctant to change because they are rightfully proud of the job they do and they may not believe a computer can help. You do not want to lose these people as their skills are still important. You need to convince them of this fact.

The contractor should assign a specific project manager responsible for implementation and he or she should be the exclusive point of contact for you (unless the project manager fails to perform, at which time you would contact the vendor management). If you can know who this person is to be when you are evaluating proposals, his or her quality can be considered in the selection. At the beginning of the implementation, you should go over the RFP, the proposal, and the contract with the project manager to be assured that everything that is required of the vendor is understood. It is suggested that the project manager contractually be obligated to respond to problems in a fixed time period, say 24 hours.

APPENDIX 6-A

LIST OF USER CONTACTS FOR SOFTWARE VENDORS

Some vendors listed do not provide scheduling/dispatching or other operating software. They are listed here, in italics, because they offer related products and hence sometimes appear in published listings of vendors in such a way that you cannot tell whether they offer software or not. Therefore, to save you time in compiling a list, we indicated in the second column the products the non-software vendors do provide.

References are not listed for all vendors because the DRT providers surveyed did not happen to use some vendors' software, and the vendors themselves did not provide references in spite of repeated requests. In these cases, you should contact the vendors themselves for references. An "at symbol" (@) after the agency name indicates that the agency has experience with both the software package listed and at least one other package as well.

Although On-Line Data Products is now a subsidiary of Trapeze Software, we have left them as separate vendors since, as of this writing, most of their installations are individual and not of a common software package.

Vendor	Software Name	Provider	Provider Contact	Provider Location	Provider Phone
Advanced Transit Solutions		Easy Lift	Ernesto Paredes	Santa Barbara, CA	(805)568-5118
		SMAT/SMOOTH	Betty Fisher	Santa Maria, CA	(805)928-5624
Aleph Computer Systems, Inc.		FASTRAN (Fairfax County)	Steve Yaffe	Fairfax, VA	(703)324-7075
		Barwood Transportation	Lee Barnes	Kensington, MD	(301)984-8294 x204
Amherst Computer Associates	PAX-1				
Applied Systems Institute, Inc.	*SMART Cards*				
ATE Management & Services Co., Inc.	*APS (only used in systems managed by ATE)*				
Automated Business Solutions, Inc.	PtMS - Paratransit Management & Scheduling/ FAS - Fully Automated Scheduler	Ozark Public Transit	Amanda Waite/ Taunya Kopke	Fayetteville, AR	(501)443-2700
		Special Services Transportation Agency	Ed Bigelow	Colchester, VT	(802)655-7880
		Greater Attleboro Transit Authority	Frank Gay/ Sandra Mulcahy	Attleboro, MA	(508)226-1102
		Mountain Empire Older Citizens	Mike Henson	Pennington Gap, VA	(703)546-2530
		Western Maine Transportation	Gene Skibitsky	Mexico, ME	(207)364-3639
Automated Dispatch Services, Inc. (ADS)	EMTrack	Dade Metro Transit Agency	Chris Sizemore	Miami, FL	(305)375-5675
		Handi-Van Transportation	Masi Neff	Miami, FL	(305)751-1236
		Manatee County Area Transit	Chuck Firestone	East Bradenton, Fl	(813)747-8621
		Zuni Transportation (has AVL)	George Azor	Miami, FL	(305)266-0403
Bar Harbor Software, Inc.		W-HCA	Barbara Donovan	Milbridge, ME	(207)546-7544
BISPAC					
Business Technology Group, Inc.					
Computer Systems Integration, Inc.					

Vendor	Software Name	Provider	Provider Contact	Provider Location	Provider Phone
Computer Technology International	SCOOTER; SCOOTER/ AVL	Regina Transit	Beverly DeJong	Regina, Saskatchewan Canada	(306)777-7815
COMSIS Mobility Services, Inc.	CTPS - COMSIS Trip Planning System	Grand Rapids Area Transit Authority	Steve Kantz	Grand Rapids, MI	(616)456-7514
		Blacksburg Transit Authority	Kevan Danker	Blacksburg, VA	(540)961-1185
		LANTA Metro Plus	Tom Procoppio	Allentown, PA	(610)432-3577
		Regional Transportation Authority	Cindy Denbow	Portland, ME	(207)775-1431
		East Bay Paratransit Consortium	Marc Soto	Oakland, CA	(510)287-5000
		Jacksonville Transportation Authority	Drew DeCandis	Jacksonville, FL	(904)396-1814
CTS Software, Inc.	Rural paratransit scheduling and information management system	Indian River Council on Aging	Tom Fritz	Vero Beach, FL	(407)569-0760
		Garrett Transportation Service	Loring Young	Oakland, MD	(301)334-9431
		CTSA of Placer County	Bonnie Pecharic	Auburn, CA	(916)888-7481
		Nassau County Council on Aging	Steve Arseneau	Fernandina Beach, FL	(904)261-0700
		Mayflower/Laidlaw	Terry Reynolds	Southeastern U.S.	(910)295-9050
Decision Sciences, Inc.	Quick-Route	Spokane Transit Authority	Denise Marchioro	Spokane, WA	(509)325-6000
Easy Street Software, Inc.	EasySuite/ EasyTrips EasyHub	Rogue Valley Transportation District	Doug Pilant	Medford, OR	(503)779-5821
		Greater Pinellas Transportation Management System	Bud Williams	St. Petersburg, FL	(813)586-2811
EDGAR Management Consultants, Inc.	*Builds tailored transportation hardware/ software systems*	Durham Transportation	Larry Durham	Austin, TX	(512)343-6292
		Laidlow Transit Services, Inc.	Dennis Garden	San Francisco, CA	(415)695-5728
GIRO, Inc.		Toronto Transit Commission	Agnes Csorsz	Toronto, ON Canada	(416)393-2631
		Société de Transport de la Communauté urbaine de Montréal	Serge Bélanger	Montréal, PQ Canada	(514)280-6262
GMSI, Inc.	*Mobile Data Terminals (MDTs)*				
Henson, Mike	Fleet Management System	Coordinated Area Transportation Services (CATS)	Vickie Patterson	Fishersville, VA	(540)886-2499
Innovative Software Designers	Dispatch Manager	Flagler County	Bob Parsons	Flagler, FL	(904)437-7390
		Caravan	Eric Harrison/ Ray Chaffin	Juneau, AK	(907)586-4482
		Dial A Ride	Jerry Alexander	Sidney, OH	(513)498-8117
		UCP Transportation	Peter Siskin	Hartford, CT	(203)236-6201
		Ogemau County Public Transit	Shirley Buck	Ogemau, MI	(517)345-5790
		Seattle Metro	Gloria Simon	Seattle, WA	(206)721-3433
		CTS	Marion Mark	Gainesville, FL	(904)334-1604

Vendor	Software Name	Provider	Provider Contact	Provider Location	Provider Phone
International Road Dynamics Inc.	Transview 3.0	(new product)			
Ketron Division Bionetics Corporation	*PARMIS (Software is no longer for sale; support existing customers only.*	*Citibus*	*Chris Phelps*	*Lubbock, TX*	*(806)767-2383*
Keystone Information Systems, Inc.					
Micro Dynamic Corporation	CADMOS Pro+, Dr. Dispatch				
Mentor Engineering	*Mobile Data Systems*				
Mobile Computer Systems, Inc.	PC-Dispatch/Para-transit/ ROUTESMART	Yellow Transportation	Mark Joseph	Baltimore, MD	(410)727-7300
		Yellow Cab	Allen Weatherilt	Clearwater, FL	(813)726-9776
		Y.C.N. Transportation	Richard Armour	Norwood, MA	(617)762-0901
Multisystems, Inc.	MIDAS-PT	Berks Area Reading Transportation Authority (BARTA) @	Bob Rimby	Reading, PA	(610)921-0601
Navigation Data Systems Inc.	*Fleet-Trak (AVL System) and mobile data systems*				
On-Line Data Products	PASS	King County Metro ACCESS Transportation	Janey Elliott	Seattle, WA	(206)689-3115
		Capital District Transportation Authority@	Thomas Guggisberg	Albany, NY	(518)482-4199
		Eastern Contra Costa Transit Authority@	Jeanne Krieg	Concord, CA	(510)754-6622
		Houston Metro Transit Authority METROLIFT	Jim Laughlin	Houston, TX	(713)739-4986
		LA County Project ACCESS	Shelly Lyons	Los Angeles, CA	(213)270-6000
		Paratransit, Inc.@	Linda Deavens	Sacramento, CA	(916)454-4191
Paratransit Software	PARRAS (mail order sales)				
Paratransit Systems Int'l., Inc.	Rides Unlimited	Clallam Paratransit	Eric Engleke	Port Angeles, CA	(206)452-1397
		Mason County Dial-A-Ride	Dan Morrissey	Shelton, WA	(206)427-5033
		British Columbia Transit	Mike Davis	Victoria, BC	(604)385-2552
		Mayflower Contract Services	Mike Kopaczew-ski	Honolulu, HI	(808)841-4322
		Mayflower Contract Services	Elizabeth Diaz	Fresno, CA	(209)291-2555
PC-TRANS	SST3				
Philip G. Dorcas and Associates	PSP-25, CSP-25				
Scandia Transport Systems, Inc.	Planet				
Sweet Computer Services, Inc.					
TelerideSage Limited	*Fixed route software only*				

Vendor	Software Name	Provider	Provider Contact	Provider Location	Provider Phone
Trapeze Software Inc.	Trapeze QV	Sun Metro	James W. Peterson	El Paso, TX	(915)534-5840
		MCT/ACT	Lisa Underwood	Madison Cty., IL	(618)874-7433
		Orange County Transportation	Mark Maloney	Orange, CA	(714)560-5597
		VIA Metropolitan Transit (will have AVL)	Leonard Zych	San Antonio. TX	(210)227-5371
		Housatonic Area Regional Transit District (HART)@	Lewis May	Danbury, CT	(203)744-4070 x131
Trimble Navigation	*AVL Equipment*				

APPENDIX 6-B: SAMPLE RFPS

Two examples of Requests for Proposals (RFPs) are contained in this appendix as models for preparing software specifications—Everett Transit in Everett, Washington, and Capital Metropolitan Transportation in Austin, Texas.

CAPITAL METROPOLITAN TRANSPORTATION AUTHORITY

2910 East Fifth Street
Austin, Texas 78702
Tel: 512/389-7496
Fax: 512/389-7452

Software Requirements

A Integrated scheduling/dispatching/registration/cancellation

1. Schedule trips on-line with the ability to manually adjust a schedule as needed. The on-line scheduling capability must be integrated with dispatch, reservations, and cancellation.
2. Provide ride confirmation while the passenger is on the line. The system will have the capability to limit specific users to only auto route, with password override capability.
3. Capable of batch scheduling to optimize end-of-the-day on-line scheduling. In this rescheduling process, any trips previously assigned would not be removed from the schedule, and any time change would be within the limits of the original trip request.
4. Capable of batch scheduling to build “What if” scenarios.
5. The on-line scheduling and the batch scheduling algorithms should route and schedule the trips with the following parameters:

   ADA requirements; pickup time; origin and destination of each trip, open window time; dead head time; type of reservation (subscription, demand-response . . .); shared-ride nature of the service; type of day (service hours); passenger disabilities; passenger needs (attendant, escort, dog guide); couple, group traveling together; time loading range (wheelchair, ambulatory, single passenger, group . . .); type of vehicle (space available in each vehicle); address restriction (i.e., only a sedan can reach some locations). The system manager should be able to modify the weight of the different parameters.
6. Be able to perform trip booking for subscription, demand-responsive, same-day trips, and be able to handle round trips, one-way-trips and multi-leg trips.
7. Display on the screen, vehicle assignments showing pick-ups and drop-offs for each vehicle in the order to be carried out.
8. Implement new ADA regulations. To include but not be limited to accommodating reservations up to 14 days in advance, 5 PM cut off for next day reservation, and subscription trips during any given time of the day shall be less than or equal to 50% of total scheduled trips. The system should be able to flag clients living within a ¾-mile fixed-route corridor.
9. Determine optimal routes to reduce in-vehicle travel time, to reduce vehicle mileage, and to minimize dead head time.
10. Provide on-line, fixed-route alternate service information and route alignment of all nearby fixed-route service to the reservation clerk. The software shall be able to import data from the Trapeze software.
11. Propose available or alternate travel service if a trip cannot be accommodated within the specified time range. If these alternatives are unacceptable, the request made on the same day can be logged on a standby list.
12. Automate the same day passenger standby list and the open return trips. The system shall have the capability to automatically check unscheduled trips as cancellations are made and alert the dispatcher if one or more of those trips can be accommodated. The system should enable manual adjustment of schedules.
13. Optimize scheduling of subscription trips prior to the day of operation and place on hold subscription for certain periods of time (i.e., vacation).

14. Eliminate passenger scheduling inefficiencies, such as double booking and incorrect entries. Display a pop-up window of all reserved trips for a client on the service date of the current trip at the completion of each reservation.
15. Provide the necessary dispatching tools for making daily operational decisions, such as dealing with open returns, same day standby trips, canceled trips, no-shows, late clients, or vehicle breakdown. The dispatch screen will be color coded so that cancellations and insertions occurring within the hour will be displayed as red and/or flashing.
16. Be able to perform "What If" scenarios for schedule modifications without affecting an existing schedule.
17. Improve response efficiency to "Where's my ride?" calls, driver location checks, and dispatcher responses to delayed passengers' questions.
18. Be able to duplicate a travel request between the same origin and destination on different days or at different times. Provide simplified reservation duplication for couples and groups traveling together. The duplication should include only relevant information for the new trip.
19. Provide carry-over of origin and destination addresses for linked trips, and provide the capability to flip the home origin and destination addresses.
20. Provide displays of all reservations by an individual passenger so that individual and/or collective cancellations can be easily made. The inquiry display will be able to be sorted by name, time, run number, origin address, or destination address.
21. Provide internal data check to avoid sending a vehicle that does not meet the needs of the passenger's disability.

B Client registration and reporting/billing

22. Register passenger special needs clearly.
23. Track requested trips not accommodated.
24. View all the trips for an individual customer (monthly, weekly, daily).
25. Display passenger's eligibility on screen with capability of alerting the clerk of eligibility suspensions. Manual override capability of this function is necessary.
26. Direct outputs to different printers. For example, cancellations to the dispatcher's printer, run sheets to either scheduler's or dispatcher's printer. This function should be controlled by the system manager.
27. Develop a run sheet that lists the addresses of customers based on run by ordered pickup and drop-off time in the order to be carried out. Run sheet will also list the map page and coordinate of each pickup and drop-off.
28. Provide speed keying features for call-taking process.
29. Enable the use of "hot" keys to provide a list of values for field entries to speed data entry, such as recalling data that has been entered previously.
30. Automatically check inconsistent data entries, such as negative mileage.
31. Provide passenger reservation log field to track the time of customer's first trip request for passengers that require original requested time (ADA). If the passenger's trip is more than 1 hour from the requested time, the system will prompt the reservation agent to enter whether or not the passenger was satisfied with the time provided.
32. Provide on-line help to control screen keys and to explain which action is expected from the user.
33. Provide comments lines as necessary for specific fields. For example, a field to note the "special needs" of certain clients and the automatic transfer of this information to run sheets.
34. Provide an ADA-eligibility field as well as a field indicating the desire or requirement of an aide or escort.
35. Enable queries to be performed on all fields with the ability to give specific selection criteria ranges and sorting options.
36. Provide availability of professional quality and customized report formats to the staff without consultant assistance. For example, a report on the percentage of scheduled subscription trips versus demand response by time period for a selected range of dates shall be an easy report to generate, review, and edit on the screen and to print.
37. Be able to report year-to-date, month-to-date, and weekly.
38. Generate reports that track and bill clients' sponsors.
39. Report trip information (first requested time, trip inside or outside ADA boundaries, unmet demands).
40. Generate reports that track and report trip modifications and the nature, time and source of the modifications.
41. Generate reports that track STS performance and productivity for a variety of user-specified measures.
42. Enable the production of labels, custom letters and, mailing for no-shows and excessive cancellations.
43. Enable easy-to-implement and user-friendly maintenance of modifications to the codes file (disability code, sponsor code, etc.).

C Geographical Information Systems (GIS)

44. Display on the screen the STS service area street maps.
45. Locate client and/or commonly used location on a street map.
46. Display vehicle itineraries (actual traveling path).
47. Calculate and display distances between locations (pickup-to-pickup, pickup-to-destination).
48. Be able to receive periodic GIS data updates from Atlas GIS.

D Operating environment

49. Be accessible from work stations located at multiple sites and by multiple users.
50. Possess security features that enable selective access to data (add, modify, delete, inquire
should be available on an individual or group level.
51. Be capable of archiving and retrieving data from the new system without leaving the system or shutting it down.
52. Enable easy transfer of existing databases, client files, table codes, and addresses to the new system.
53. Provide, at no additional charge, software escrow agreement for the computer software source code to protect CMTA operation if anything should happen to On-Line Data Products, Inc.

System Performance Requirements

54. The system should be designed for 24 hour per day, 7 days a week operation.
55. Search and confirmation of each trip availability for any date shall be available with a maximum average response time of 10 to 45 seconds for up to 30 active workstations.
56. Capacity to handle over 12,000 clients without any appreciable degradation of overall system performance.
57. Ability to process over 4,000 trip requests per day.
58. Ability to cover a 500-square mile service area.
59. Ability to schedule in batch 3,000 trips in one hour.

Hardware Requirements

60–61. Nota bene: Hardware requirements listed in the RFP have been intentionally omitted here because they were excessively lengthy.

Other requirements

62. Provide the necessary hardware and install on-site the software with the network operating system necessary to connect all the workstations. CMTA will be responsible for the installation of all the workstations and will provide the cabling and the necessary peripheral equipment.
63. Be responsible for the transfer of all existing information to the new system, for CMTA's service area mapping and for the address matching verification.
64. Perform on-site testing during and after complete installation, provide CMTA with test reports. The test reports shall contain the description of all tests performed, the results obtained, and any required modifications necessary as a result of testing and installation.
65. Provide software warranty and hardware warranty (full parts and labor on all equipment) for one year starting at the acceptance of the installation at no additional cost.
66. Provide hardware and software user manuals for each workstation.
67. Provide 24-hour customer support for no less than one year from the date of acceptance at no additional cost.
68. Provide on-site maintenance for no less than one year from the date of acceptance at no additional cost.
69. Provide CMTA staff training at Capital Metro. The vendor should organize the training to match Special Transit Services shifts schedule. The vendor will provide training in all aspects of the program that employees will be required to use; levels of training should include programmers and technical support staff, staff who will be entering and updating program information and performing system management, and end users. The vendor will provide CMTA's appointed personnel with the necessary training to support and maintain all hardware and software related to the installation.
70. Provide a full illustration of the database structure and report generation capabilities.
71. Customize all input screens (content and format) and reports according to STS' needs. During the implementation period STS' system administrator will on-site define the customizations needed with an authorized representative of the vendor.
72. Provide contingency plans (disaster/recovery planning).
73. Complete the system implementation within 120 working days after notice to proceed.
74. Ability while giving taxi voucher reservation to get information on the passenger disability, the passenger needs, the distance of the trip.
75. Provide a method to enter landmark or "shorthand" names for locations. When the reservation clerk enters the landmark, the system shall provide the replacement information.
76. Indicate to the reservation clerks—at the time of the reservation—and to the dispatchers the designated pickup location (i.e., Main building with several access points).
77. Ability to produce run sheets with abbreviated driving instructions.
78. Display multiple windows or access different information and data screens without losing order data.
79. Provide policy help screens that enable the reservations clerk to access policy and procedures database.
80. Ability to schedule on-going trips: passenger needs to make short stops—from 10 to 15 minutes—at the drugstore or at the bank, for example.
81. Ability of the software to communicate with Mobile Data Terminals.
82. Ability of the software to communicate with Automatic Vehicle Locator.
83. Ability of the software to communicate with Card Reader device.

. . . .): this access

EVERETT TRANSIT SYSTEM

3225 Cedar Street
Everett, Washington 98201
Tel: 206/259-8803
Fax: 206/259-8945

SECTION 2.0 SCOPE OF WORK

2.01 INTRODUCTION

Everett Transit provides demand-responsive, non-fixed route paratransit services to elderly and disabled riders within Everett Transit's fixed-route service area. The purpose of this service is to meet the specialized transportation needs of the elderly and disabled community within the City of Everett and comply with the requirements of the Americans with Disabilities Act (ADA).

2.02 DESCRIPTION OF PRODUCT

The required product is a computer hardware and software package which will enable Everett Transit to schedule and dispatch its specialized transportation service with the highest degree of efficiency possible in light of the continuous growth in demand for these services. The product must also ensure compliance with the ADA in making available these services to those eligible under the law.

The proposer must satisfactorily demonstrate that the proposed product is currently fully operational at other locations under similar conditions to those expected at Everett Transit, which include but are not limited to size of service area, number of clientele, number of trips taken, number of service hours operated, number of fixed routes operated in the service area, geographical features of the service area, and traffic conditions within the service area. The product must have been in operation at these other locations for a sufficient length of time to be determined a dependable software system.

2.03 BACKGROUND

Everett Transit currently provides approximately 3700 trips per month with 11 body-on-chassis type mini-buses. This figure is up from 3400 trips per month during 1992 and is expected to grow to 4100 trips per month and 13 vehicles by 1997. Service is operated seven days per week.

All functions of operations are performed in-house. Of particular interest to this request for proposals are the functions of scheduling, dispatching, client registration, reservations, and reporting. Client registration/database information is currently maintained in Ashton-Tate dBase IV.

2.04 CONTRACT PERFORMANCE STANDARDS—SYSTEM FEATURES AND CAPABILITIES

A. The system must be able to perform scheduling and dispatching functions without limits on the number of vehicles, passengers or size of the service area.

B. The system must assist the user in complying with the requirements of the Americans with Disabilities Act (ADA).

C. The system must have the ability to perform routing in a "next day mode" as well as "same day mode" and allow the user to schedule trip assignments or request computer assistance.

When operating in "next day mode" the scheduling person must have the ability to automatically assign pre-scheduled or standing ride requests to a specific vehicle or route by having the system or the user make the assignment. As these requests are scheduled, the system must be able to identify where vehicles have extra time and are in a position to accept trip insertions in the existing route schedule. The system must be able to operate in "next day mode" up to 14 days in advance of the date the trip is reserved and confirm ride availability at the time the ride request is made.

The system must be able to identify client eligibility status and determine options to transfer capable riders between paratransit vehicles and/or fixed route vehicles/schedules. The system should know both routes and schedule times for fixed route service and cue the user that a transfer option is possible, allowing the user to determine if the passenger is to be transferred or routed by paratransit vehicle only. The system should be able to identify options for combined routing involving both paratransit and fixed route vehicles. If needed, the system should identify whether or not the fixed route bus is wheelchair lift equipped.

The system should be able to identify trips that do not naturally fit with the existing work structure and when increased efficiencies could be gained by removing them from the system for transport by other means such as taxis, etc. The user must be able to override the system and reinsert the trips.

When operating in "same day mode" the system must have the ability to schedule trip requests as they are received or allow the user to make trip assignments to vehicles. The user must be able to see both pick-up and drop-off locations on the map where routes have extra time and are in the same geographical location in order to insert trips into existing routes. The map must have a fixed route overlay with zoom capability. The map should have a Thomas Brothers or equivalent coordinate overlay with coordinates listed on driver manifests to assist in locating addresses quickly.

When route interruptions occur (cancellations, road failures, etc.) the system must recalculate each route to determine new pick-up and drop times for each trip affected and cue the user where changes will result in vehicles arriving late for an appointment, later than requested arrival, or outside the pick-up window.

D. The system must be fully menu-driven and provide a "help" display for each menu item and each function within the system.

E. The system must accommodate "subscription service" (i.e., trips taken by the same client with the same origin and destination one or more times a week on the same day or days of the week). The system should alert the user when the number of "subscription trips" reaches 50% of total service and identify if excess capacity exists within the system at that time. When a subscription is canceled, the system must scan for trips already posted up to 14 days in advance to prompt the user for determination in canceling those trips.

F. The system must utilize city-maintained and updated GIS file computer mapping for geocoding. Vendor should identify how it proposes that geocoding takes place.

G. The system must be able to interface with the following systems in the region for purposes of client file information and data sharing:

Seattle Metro
Pierce Transit
Intercity Transit J
Kitsap Transit
Community Transit

All of the above agencies are using the Pass System by On-Line Data Products.

H. The system must be able to identify customer within ten categories with room for additional categories for expansion. When necessary the system must cue the user if the requested ride exceeds available service in terms of service hour span, days of service availability, or number of trips/service hours within a specified time period for that category.

CATEGORIES

- IA. FULL ADA CERTIFIED RESIDENT: Unable to use fixed route, even if route is accessible. Resides within service area.
- IB. FULL ADA CERTIFIED NON-RESIDENT: Unable to use fixed route, even if route is accessible. Does not reside in service area.
- IC. SENIOR CITIZEN RESIDENT: Over the age of 61 and resides within service area.
- ID. SENIOR CITIZEN NON-RESIDENT: Over the age of 61 and does not reside in service area.
- IIA. CONDITIONAL ADA CERTIFIED RESIDENT: Able to get to and use fixed route accessible bus, but route is not lift equipped. Resides within service area.
- IIB. CONDITIONAL ADA CERTIFIED NON-RESIDENT: Able to get to and use fixed route accessible bus, but route is not lift equipped. Does not reside within service area.
- IIIA. CONDITIONAL ADA CERTIFIED RESIDENT: Able to ride fixed route (non-accessible buses) but unable to get to it. Resides within service area.
- IIIB. CONDITIONAL ADA CERTIFIED NON-RESIDENT: Able to ride fixed route (non-accessible buses) but unable to get to it. Does not reside within service area.
- IIIC. CONDITIONAL ADA CERTIFIED RESIDENT: Able to ride fixed route (accessible buses only) but is unable to get to it. Resides within service area.
- IIID. CONDITIONAL ADA CERTIFIED NON-RESIDENT: Able to ride fixed route (accessible buses only) but is unable to get to it. Does not reside within service area.

I. The system must record service suspension data and cue the user when a customer is in a service suspension status, or when the entry of service data constitutes a total number of offenses requiring consideration for service suspension.

J. The system must provide fields for two customer addresses: one mailing address and one street service address, both of which must interface with Everett's ARC/INFO database structure.

K. The system must recognize common origins/destinations by name designation cross-referenced with actual addresses. The system must also provide information on request, listing the 5 most frequently traveled to destinations for each client during the previous 30 days. When clients request transportation to destinations that they are capable of getting to by fixed route, the system must cue the user that the client can access fixed route for that trip. When letter designation codes are used, the pop-up window and driver's trip report must show the name of the facility and the street address.

L. The user must be able to define and adjust parameters within which reservations and scheduling functions occur, to include vehicle seating configuration, length of trips (minutes), number of subscription trips at a given point in time, specific days of the week that service is available, service hour parameters and the number of service hours or trips allocated to clientele in one of the categories referred to in paragraph H above. These parameters must be checked by the system as users schedule trips throughout the day. When a parameter is exceeded through the manual scheduling process, the operator must automatically be alerted and asked if override is desired prior to continuing the process.

M. The system must be accessible by remote terminal from other Everett Transit designated terminals and facilities.

2.05 FUNCTIONAL REQUIREMENTS

Passenger Registration: The system must provide for a customer database that will verify the client's eligibility when entering the customer's name or number code. In some cases only a partial name will be entered and the system must provide help in locating the correct client. The system must transfer as much data as possible from the client file to the call file each time the user accesses the system. Statistical data about the customer must be displayed on the screen at call entry time as well as defaults (i.e., pick-up address, telephone number, equipment needs, eligibility status, number of no shows, etc.). The database must allow the user to add and maintain other fields in the database.

Customer registration requires the following information:

1. Client identification number
2. Client name: Last, First, Middle Initial

3. Home address:
   - Name of apartment building or complex
   - Door or apartment number
   - Street
   - City
   - ZIP code
4. Mailing Address:
   - Name of apartment building or complex
   - Door or apartment number
   - Street
   - City
   - ZIP code
5. Telephone number (including area code):
   - Home
   - Work or extension number
6. Date of Birth
7. Sex:
   - Male/Female
8. Eligibility status (permanent or temporary):
   - Eligibility code
   - Eligibility renewal date
9. Caregiver or emergency contact:
   - Name
   - Name of apartment building or complex
   - Door number
   - Street
   - City
   - ZIP code
   - Relationship to client
10. Disability type (permanent or temporary):
    - Visual
    - Hearing
    - Speech
    - Development
    - Mental
    - Neurological
11. Special handling requirements (driver or vehicle):
    - Comment field with special instructions
12. Mobility Requirements:
    - Wheelchair
    - Manual
    - Motorized (4 wheel/3 wheel/oversized)
    - Special features (additional loading time, etc.)
    - Wheelchair control (good, jerky, needs assistance)
    - Personal care attendant
    - Service animal
    - Requires standing lift
    - Walker
    - Cane
    - Braces
    - Prosthesis
    - Crutches
    - Oxygen
    - Other
13. Service Needs:
    - Curb to curb
    - Don't leave alone
    - Visually assured entry
    - Door to door
    - Other
14. Communications preference:
    - Language
    - Lip read
    - Written
    - Braille
    - Audio tape
15. Registration information:
    - Date application received
    - Date information was sent to doctor for verification
    - Date information was returned
    - Registration date
    - Doctor's name
    - Doctor's address
    - Doctor's telephone number
    - Doctor's fax number
    - How senior citizen age verified
16. Subscription service:
    - Pick-up address
    - Pick-up time
    - Day(s) of week
    - Destination address
    - Destination appointment or arrival time
    - Return pick-up time
    - Return destination arrival time
    - Comments
17. Suspension data (total over a specified period of time):
    - Number of late cancellations
    - Number of no shows
    - Number of verbal or physical abuse complaints
    - Number of latenesses (not ready)
    - Number of other
18. Fixed route accessible destinations:
    - Destinations that client can travel by fixed route to
19. Frequent customer destinations (previous 30 days):
    - List of 5 most frequently traveled-to destinations by client

2.06 RESERVATIONS

Digital Map: The user must be able to find the address location of a trip request quickly, and automatically place the location on the map. The map must contain street segments with names and address ranges for each segment and identify road and water boundaries, area zones, fixed routes, and Thomas Brothers or equivalent map coordinates. The system must check pick-up and drop-off locations upon entry to determine zone allocation of service days and hours. The user must be prompted when entering trips outside specified limits and must be able to override the boundary or service hour warning if desired.

The system must allow both import and export of ASCII data files. In addition to the transfer of ASCII data, the system must include the capability to import and export graphic data in two ways:

1. Explain and illustrate interface with AUTO CAD, Everett ARC/INFO GIS database structure or other mapping/GIS programs. Must be possible to show the layout of a shopping center on a corner, an apartment complex, etc. There must be a “zoom” feature that, when turned on, will allow the zoom level to show the shopping center but will “appear” only when zoomed in, for example.
2. Any map display must be exportable in the form of a CGF file and imbedded in, for example, a Word for Windows document as a figure.

2.07 CALL ENTRY

As a trip request is received, the user must be able to enter the client name or number on the screen and have the system automatically fill in the following information:

- Verification of registration and suspension status.
- List of all other trips scheduled by client for the same day.
- First and last name (system to complete if last name is entered).
- If more than one client of same name, system to display options.
- Telephone number.
- Eligibility status.
- Caregiver or emergency contact.
- Disability type.
- Special handling notes.
- Mobility requirements.
- Service needs.
- Communication preference.
- Client history (number of rides, no shows, trip denials, etc.).
- Pick-up address (including apartment or building name and number). (If different from normal, the user must be able to change the pick-up address on a trip-by-trip basis.)

The system must provide pop-up windows for the user to input the following information:

Name
Trip date
Pick-up time
Pick-up location
Appointment time
Destination address (system must prompt if client can use fixed)
Return time
Number of guests
Personal care attendant

Once dispatched, the system must automatically reverse the direction and show the destination address as the pick-up on the return trip.

The system must prompt the user when canceling an originating trip to determine if the return portion of the trip also needs to be canceled.

The system must provide default shields to minimize key strokes and must maintain an “abbreviations” file containing user-defined abbreviated names for common pick-up and drop-off locations. When an unknown or misspelled street name, etc., is entered, the system must display a list of close matches. When the user selects an entry from this “pop-up window” list, the data entered must be corrected by the system automatically.

System operating speed should be no more than five (5) seconds to access a file or execute a command. The total length of time required to input and schedule the ride on a vehicle should average no more than 2 minutes.

2.08 TIME CALCULATIONS

Calculation features must include: An average speed of travel that can be user-adjusted by time of day, driver and routing used.

Computation of distances between points, taking into consideration the shape of the service area, road, bridge and water boundaries and other barriers to straight line calculations of distance.

Allowances for each vehicle to have a user input multiplication factor for speed (faster drivers, vehicles that make longer routes and thus travel faster, etc.).

An accurate estimated time for travel to indicate arrival time and drop-off time to ensure on-time performance, taking into consideration water, bridges and other barriers.

Ability for the user to set or change parameters to indicate a pick-up and drop-off window. The user must be prompted when vehicles will be outside the window.

Additional time assigned for certain equipment necessary (i.e., wheelchairs, etc.). This must be user-defined and automatically assigned.

2.09 SCHEDULING

The system must allow trip reservation calls to be processed from the current day, up to 14 days in advance and maintain a database of standing orders (subscription trips). It must allow the user to add, delete and change information in the database. The database must indicate whether the standing order is for every day of the week or specific days. In “next day mode,” the user must be able to choose when to build a route file from 1 to 14 days in advance by building routes with standing orders and inserting non-standing trips as they are requested.

When trip requests are entered into the reservation system and verified, the system must identify the origin and destination locations on the digital map and allow the user three options:

1. Computer schedule now
2. User schedule now
3. Computer schedule later

Computer Schedule Now: The system must assign the trip request to the best vehicle that satisfies the requirements of the reservation, taking into consideration all previously scheduled trips and standing orders for the requested date.

User Schedule Now: Must allow the user to view all routes graphically and select the vehicle on which to assign the trip request. The display must show all routes built from previously scheduled trips and standing orders.

Computer Schedule Later: The computer must position the trip request on the map as an unassigned origin and destination pair of points which the user can either schedule or have the computer schedule now or in the future.

The system must verify that the vehicle selected has the appropriate specifications to successfully perform the requested trip and prompt the user if it does not.

Once the trip request is assigned to a specific vehicle by the computer or user, the scheduling system must perform the following steps:

Calculate an estimated time of arrival (ETA) window. This calculation must include the distance between locations, the time necessary to board and disembark passengers, routing, and a table indicating average vehicle speeds.

The system must prompt the user when vehicles will be outside their window.

The ETA calculation must recognize bodies of water, bridges, and other obstacles around which vehicles must be routed.

Search for opportunities to route more efficiently by making bus-to-bus transfers between paratransit vehicles or to and from fixed route schedules. The system must verify that the client can make the transfer and the vehicles involved meet the required specifications. No more than one transfer should be made on a single trip.

Verify that by placing the trip reservation on a specific vehicle, other trips previously assigned to that vehicle will still be on time. If not, the affected trip(s) must be brought to the immediate attention of the scheduler. The scheduler is to have the option of having the system automatically reassign affected trips to other available vehicles to optimize scheduling. The system must also verify that ride times on the vehicle are not extended beyond specified limits and prompt the user with an option to override when this occurs.

Assign the vehicle and sequence number for both the pick-up and drop-off activities.

Assign a unique identification code to each activity.

Update the route display to show the addition of the origin and destination points to the vehicle's schedule.

The user must have the ability to request that the system suggest an appropriate vehicle route insertion, or pick from a list of ranked alternatives.

If the user chooses to leave certain trip requests unassigned and forgets to assign them, the system must warn the user to do so after a specified amount of time and/or before shutting the system off.

If a trip request is entered where both the origin and destination are not shown on the screen, the display must automatically redraw to include both locations.

The user must be able to insert a break activity at any point in the sequence of events for a vehicle. The system must also allow for preset breaks at a time assigned by the user or automatically within a user-defined time period (10 minutes for every 120 minutes of scheduled work, for instance).

The user must be able to remove a vehicle from service and have the system show any previously assigned trips to that vehicle unassigned. Additionally, the system must allow the user to reassign the trips to another vehicle. The user must be able to unassign trips individually and reassign them to another vehicle. If the user cancels or changes the appointment time on a trip, the system must recalculate the remainder of the assignments on that route.

The system must allow the user to immediately confirm ride availability for requests that fit with the existing trips and standing orders. Unassigned trips that do not fit existing route patterns must be placed on a waiting list for trip confirmation and route building at a later time.

2.10 DISPATCHING

The computer system dispatch screen must display pending pick-ups and drop-offs, sorted by time, for each vehicle in service. In addition to pick-up and drop-off information, the dispatch screen must display the vehicle number, number of passengers on the vehicle, promised arrival time, estimated time of arrival and any special circumstances. The user must be capable of scrolling quickly through the information on the screen to determine the status of any vehicle in service. If a vehicle is running late, the system should warn the user immediately.

The user must be able to view a graphic presentation on screen to see the route map of a vehicle when desired. The system must also allow for the creation and use of user-defined symbols and colors to assign to vehicles in service.

The user must be able to mark a trip as complete. The system must then automatically perform the following functions:

Remove the stop location from display.

Log the current time and mileage as the time for completion of the activity (for later comparison to ETAs).

Remove the stop location from the vehicle route network.

Add the trip to the history database for the current day.

The system must provide a pop-up window which provides client residence access information so that dispatchers can quickly respond to drivers' questions.

2.11 MOBILE DATA TERMINAL (MDT)

The system must include MOBILE DATA TERMINALS for each Paratransit revenue vehicle (approximately 13 vehicles) to allow coach Operators to push a button and register when passengers are picked up and dropped off as well as the corresponding mileage for each pick-up and drop-off. It must also interface with Everett Transit's radio system and operate on an internal timer to register data when the radio is busy. In addition, the MDT system should:

Allow the dispatcher to download a vehicle's daily work schedule to the vehicle, via the radio system, at the beginning of the work shift.

Allow the dispatcher to, throughout the day, add or delete pick-ups and/or drop-offs to the vehicle's schedule via the radio system.

Allow the vehicle Operator to register the time and mileage when departing or arriving at the Service Center (beginning and end of work schedule).

Allow the vehicle Operator to view at least two trips per screen.

Allow the vehicle Operator to communicate with the dispatcher via the MDT by typing in messages and sending to dispatcher via radio system burst.

System is to include a visual signal to vehicle Operator of incoming message. The visual signal should remain on until the Operator resets. The intent of this clause is to insure that Operator is aware of all incoming information.

Proposer's bid is to include proposed installation cost of all MDT's into vehicles and interface with scheduling software.

The MDT units shall have a minimum of ten (10) user-defined/changeable code keys to allow the vehicle Operator to quickly communicate with the dispatcher and/or to register information into the reporting/MIS system. Example of codes:

- Unable to locate address
- Unable to locate client at address
- Client canceled at door
- On rest break
- In yard, available
- Vehicle breakdown

2.12 REPORTING/MIS

The system must contain a full report generating capability to produce custom reports specified by Everett Transit, and must be able to perform ad hoc reporting and data sorts as required. The system must also have simple data import and export capabilities to standard microcomputer software packages such as Excel for Windows, Word for Windows, Borland DBase4, Quattro, and Paradox. Some of the report requirements are as follows:

Tables and Graphs:

1. Daily, weekly and monthly tables/graphs in hourly segments (half hour during peak periods) reflecting:
   - Vehicle slack time (stationary time not needed to position for next pick-up).
   - Number of vehicles with 30 or more continuous minutes slack.
   - Subscription passengers on board.
   - Total passengers on board.
   - Number of sub-contracted trips (taxi, etc.).
   - Hours of service (total # of vehicles out).
   - Subscription trips per hour.
   - Total passenger trips per hour.
   - Average wait for pick-up, (wait for scheduled pick-up).
   - Longest wait for pick-up.
   - Percentage of on time pick-ups.
   - Average delayed arrival (arrival after scheduled time).
   - Longest delayed arrival.
   - # of passengers late for appointment.
   - Average ride time.
   - Longest ride time.
   - Denied trip requests (by reason for denial).
   - Denied real time trips (will-call returns and originating).
   - # of will-call returns.
   - Split figure on advance request and same day request as well as combined for all categories.
   - # no shows, cancels and CADs (canceled at door).
   - Total number of wheelchairs.
   - Average number of wheelchairs (per vehicle, per day).
2. Daily totals and average weekly and monthly totals for above which are split by ADA Certified and Not ADA Certified passengers. Numbers should reflect both number of individual passengers and total rides by category.
3. Daily list of all pick-ups and deliveries showing client system activity in chronological order with the following headings:
   - Client name and address.
   - Scheduled pick-up time.
   - Actual pick-up time.
   - Scheduled drop time.
   - Actual drop time.
   - Vehicle number.
   - Driver's name.
   - Client eligibility status.
   - Client disability code.
   - Number of guests (including PCA).
   - Dispatch ID code.
   - ADA code.
   - Scheduler comments.

4. Daily, weekly and monthly breakdowns showing the following in ADA and non-ADA categories plus combined totals:
   - Mileage and percentage
   - Miles per passenger and vehicle hour
   - Service hours and percentage of total
   - Passenger trips per vehicle service hour
   - Denied trips and percentage of total by disability code
   - Total trips provided and percentage
   - Total unduplicated riders and percentage
   - New clients and percentage of total
   - Total registered customers and percentage
   - Disabled trip category
   - Senior category
     Total trips
     Percentage of total trips
     Totals by age group by year
   - Deadhead miles per vehicle (to and from first and last pick-up/drop-off)
   - On request list of clients with no activity during previous 60-day period.

Other Reports:

1. Driver's manifests with access comments.
2. Client file lists which can be retrieved individually, by letter or in full.
3. Coach Operator hours and payroll reports which are limited to specific field searches and run quickly, to include:
   - Payroll hours by driver (sign-in/sign-out) and totals.
   - Service hours (the difference between leave garage and return to garage less breaks and vehicle prep time).
   - Revenue hours (the difference between first pick-up and last drop-off).
4. Vehicle data reports (in/out of service, miles, etc.)
   Vehicle trip summary
   Vehicle mileage summary
5. Standardized reporting of Section 15, monthly, quarterly and annual trip statistics as required.
6. Daily reports by route (or run number) that reflect:
   All Operators assigned to the run for that date.
   All vehicles assigned the run for that date.
   Client file information for customers on run for that date.
7. Other ad hoc and custom reports and data sorts yet to be determined.

2.13 HARDWARE ENVIRONMENT

All software and hardware (MDTs) provided by vendor are expected to be compatible and able to interface with Everett Transit's existing computer environment which consists of:

2—Compaq Deskpro 4/66xe
256K cache memory
8 MB RAM
5.25 floppy
3.5 floppy
Hitachi SuperScan 20 monitor

1—Compaq Desk pro 486/50
256K cache memory
8MB RAM
5.25 floppy
3.5 floppy
Hitachi SuperScan 20 monitor
All computers have Windows and are part of a Novell network.

Vendor will be responsible for installation, testing, training, and maintenance of all equipment/software purchased from it.

2.14 TECHNICAL SUPPORT

The proposer must state the type of support given during the installation process as well as on-going support after the system is on-line.

Technical support must be available at all times during the system operation. When system problems arise it is required that the vendor respond within 30 minutes if reported between 5:00 a.m. and 7:00 p.m. Pacific Time (standard or daylight savings) on weekdays. During evening hours, weekends and holidays, the vendor will be required to respond within 3 hours of the time the problem is reported.

If the problem impairs operation of the system, the vendor must make every effort to provide a program fix within 12 hours, or provide a means for the system to work around the program. The contractor shall have the ability to test program problems in the same network environment that exists at the work site.

It is expected that during installation, testing and for a period of 180 days running on-line with this system, the vendor shall provide unlimited telephone support seven (7) days a week between the hours of 5:00 a.m. and 7:00 p.m. Pacific Time (standard or daylight savings).

2.15 DOCUMENTATION

Everett Transit requires documentation on the standard operating procedures of the system. This documentation must be user friendly and easily understood by system users. The documentation must be in a format that can be used by Everett Transit staff for training of new employees as well as a reference document.

2.16 TRAINING

The proposer must present a training program and implementation schedule. The training program must specify the type of training, number of hours and number of staff in each training class. Computer simulation modules that are part of the system are a preferred method of training.

2.17 MAINTENANCE AND WARRANTIES

The proposer must state all applicable maintenance and warranties of the proposed hardware and software.

2.18 PROPOSAL FORMAT

Everett Transit requires each proposer to answer the following questions in its response to assist in evaluating the product. These questions do not represent a complete list of requirements and the lack of a question or reference to any specific part of the RFP does not relieve the proposer of responsibility to comply with the full requirements of the Request for Proposal. Items not identified in a specific question should be addressed in the “other” category of this questionnaire.

2.19 IN SERVICE LOCATIONS

Please provide a list of locations and contact personnel where your product is currently in operation. The list should specify the following information for each location:

- Length of time the product has been on-line at location.
- Geographical features of the service area.
- Size, shape of the service area.
- Number of clientele served.
- Number of trips provided per month.
- Number of service hours provided per month.
- Number of vehicles in operation.
- Number of fixed routes operated within the service area.
- MDT System in use.
- GIS or mapping system in use.
- Database and structure in use.

2.20 REGISTRATION

1. Describe the client registration function of your system.
2. How many registrants (clients/riders) can your system hold?
3. How many one-way trips can your system register each day?
4. Describe how your system handles conditional eligibility criteria (clients eligible for service only under certain conditions).
5. Describe how your system can be customized to accommodate the categories referred to in this document. How long is the process and what are the major variables affecting the timeline?
6. What registration information does your system maintain on each client? Can it be customized? How long is the process, and what are the major variables affecting the timeline?
7. How can your system limit access to portions of the registration database and what are the levels of access? Can access to portions of the client information screens, such as confidential medical information, be limited to selected users?
8. How many screens are involved in your registration file?
9. How long does it take to input an entire client registration file?
10. From what types of files can your system convert client information?
11. How does your registration system interface with your scheduling and dispatching system?
12. Can your system interface with other systems in the region (most systems are using ON-LINE, Pass) for the purpose of client file information and data sharing?

2.21 SCHEDULING AND DISPATCH

1. Describe the scheduling and dispatching function of your system.
   - Does it operate while the client is speaking with the scheduler or are trips scheduled and dispatched in batch mode?
   - What information is the call taker or dispatcher required to provide to schedule a trip?
   - Describe the trip choices offered by the system to the dispatcher.
   - What criteria are dispatcher choices based on? How does your system measure the most effective or cost-efficient trip?
   - Describe how your system schedules trips up to 14 days in advance. Does it operate in same day/next day mode?
   - How does the system route?
   - Can the system auto-route as well as let the user route? Explain the process.
   - How does the system interact with the user to track vehicle location and slack time?
   - How does the system calculate travel time and assign trips to vehicles?
2. How long does it take for your system to schedule a trip: While the client is speaking with the scheduling person? In batch mode (trips per hour scheduled)?
3. How long does it take your system to access a file or execute a command?
4. Describe the speed and flexibility available in your system and whether it allows the scheduler to accept

calls and assign the rider to a seat on a specific vehicle during the call.

5. Describe your system's ability to accommodate and integrate subscription service (trips taken by the same client with the same origin and destination three or more times a week on the same days of the week), demand response service (trips scheduled 24 hours in advance), and immediate response or same day trip insertion.
6. How does your system handle real time demand changes and service interruptions such as cancellations, will-call returns, road failures, etc.?
7. Describe how the system tracks and updates changes in the availability of vehicles and Operators.
8. Can your system identify opportunities to transfer passengers between two paratransit vehicle routes? If this function does not exist, can it be customized, how long will it take, and what are the variables affecting the timeline? Cost as a separate option if outside the standard package rate.
9. Can your system identify opportunities for transfer between fixed route and paratransit vehicles? Does it have fixed route overlay and can it identify fixed route schedule times (can it determine if a specific fixed route is lift equipped)?
10. Describe any speed or "hot key" functions your system provides and how they work. Also describe any defaults the system provides to cue the user that an error or established limit violation has occurred. Of particular interest are the following items:
    - Trip exceeds available service hours.
    - Prompt when trip is outside service hours.
    - Exceeds trip limits.
    - Client on or entering suspension status.
    - When subscription service reaches 50% of total.
    - Vehicle seating or wheelchair space availability.
    - When vehicles are out of their window, late, etc.
    - Transfer option exists (between paratransit or fixed route).
    - Trip recommended for sub-contract (does not fit routes/schedule).
    - Client has reserved other trips this date.
    - Prompt to cancel return trip when origination is canceled.
    - Prompt that file shows client can ride fixed route for trip.
    - Speed key to change eligibility code (trip-by-trip).
    - Length of trip violation.
    - Unassigned trip must be assigned.

If your system does not contain any of the above functions, identify which ones. Can they be customized? How long will it take and what are the variables affecting the timeline? Cost as separate option if outside the standard package rate.

2.22 SYSTEM REQUIREMENTS

1. Does the system utilize city-maintained and updated GIS file computer mapping for geocoding?
2. Describe how your system can interface with known automated fixed route trip planning and customer information systems. List any systems that you are currently interfacing with.
3. Will your system operate on Everett Transit's existing hardware?
4. Does your system run on a network? What kind?
5. What information do you require from the user to establish and install your system?
6. What is the timeline for establishing a new system in a new area? Provide both an "aggressive" schedule and a "conservative" schedule for implementation.
7. What are the major variables affecting how long it takes to implement a new installation of your system?
8. Describe, in detail, the security available with your product.
9. Describe how your product handles transaction process.

2.23 REPORTING

1. Describe the standard reports produced by your system.
2. Describe or list the actual trip statistics tracked by your system (i.e., number of lift trips, number of rides, delays, trip denials, etc., by time of day, etc.).
3. Describe any Report Write products that are available for your software.
4. Does your product provide Query by Example or Query by Forms?
5. Describe the system's capabilities to track, process and report complaints and commendations, if any.
6. Describe how the report function of your system can be customized to meet any or all of the specific requirements of this document.
7. Describe and provide an example of your system's reporting for Section 15 requirements.
8. Describe how your system computes service hours.

2.24 TECHNICAL SUPPORT

1. What support is provided in the purchase price of your product?
2. What are your support hours in Pacific Time (standard or daylight)?
3. Do you provide a toll-free number for user support?
4. Do you have a bulletin board, CompuServe forum, etc.?
5. Describe any available training/consulting services, especially those available locally.
6. Describe any on-line help that is provided with your product.
7. Describe any tutorials provided with your product.

8. Describe other documentation provided with your product.
9. Describe additional support and training services available outside the standard cost package as a separate cost option.

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CHAPTER **7**

COMPLEMENTARY INFORMATION TECHNOLOGIES

CONTENT AND AUDIENCE

This chapter contains an introduction to information technologies that complement and enhance the use of scheduling/dispatching software. It is written for readers not familiar with the use of technology in DRT systems.

7.1 OVERVIEW

We have been discussing the automation of the operations and administration functions of DRT service. When you consider automating these functions, it is appropriate to consider also several other technologies. Recent improvements in the functionality, ease of use, and cost of several electronic technologies have made it much more feasible to utilize them cost-effectively in DRT systems. The following five technologies are most frequently mentioned as logical additions to a sophisticated DRT software package:

- Radio frequency (RF) data communication,
- Mobile data terminals and mobile computers,
- Vehicle locator devices,
- Mapping software/geographic information systems, and
- Card-based data storage and transfer media.

These technologies have the potential to increase the productivity of DRT operations by reducing operating costs or increasing capacity. They all complement the use of DRT specialty software for operating functions and may have a synergistic effect when used together. However, most of them require a significant capital expenditure so that their use is not an automatic "yes" decision. Cost-benefit analysis is required to determine if they are worthwhile (*1*,*2*).

The use of these technologies is similar to automating operations functions in that each one will require the installation of specialty software. They differ in that the hardware used in each technology is not a standard PC but rather is special hardware that embodies the technology. In many cases, you will not even be aware that software is involved, and the software decision is not a separate one but is part and parcel of the hardware selection.

7.2 TECHNOLOGIES

7.2.1 Radio Frequency Communication

Traditionally, DRT dispatchers have communicated with vehicle drivers using voice radio. This system works adequately in small and medium-sized fleets, but when the fleet becomes large, radio system capacity becomes a major issue with voice radio communication. Particularly if the DRT system possesses a single radio channel, there is simply inadequate channel capacity to communicate dispatch messages to drivers. Obtaining additional conventional radio channels is typically difficult or impossible in metropolitan areas, although 800MHz and 900MHz trunked radio systems offer an alternative; but these systems charge on a per-use basis, and DRT systems may not be able to afford the usage charges, which can amount to many thousands of dollars annually for a system with a large fleet.

Taxi systems have contended with this problem for many years, and many large taxi fleets have responded by installing digital data communication systems for their radio systems. Rather than a human dispatcher using voice radio to communicate dispatch orders to drivers, the dispatch order is transmitted on the radio channel as a digital string of data to a receiving unit in the taxi vehicle. Radio frequency (RF) modems communicate the data.

The wireless revolution is the backdrop against which developments in radio frequency modem technology are occurring. RF modems work on the same principle as telephone modems. Digital information (the 0's and 1's of binary data) is encoded by a device into an analogous signal (the human voice transmitted over a telephone line is an example of such an analog signal). The signal can then be transmitted over a communications medium to a decoding device at the other end of the connection, where it is converted back into digital data. (The term "modem" is derived from "*mo*dulation" and "*dem*odulation," which are the processes involved in encoding and decoding this analog signal.) The difference is that an RF modem uses radio waves rather than the physical medium of a telephone line to carry the signal from one location to another. Because radio frequency channels are inherently more "noisy" than telephone channels, and because of regulatory restrictions on the bandwidth of the carrier signal, RF data transfer is invariably a slower, more error-prone mode of data communication than using telephone lines. For example, telephone modems capable of transmission rates of 9,600–28,800 baud (approximately bits per second; see Glossary) are now commonplace, whereas most RF modems do not operate at data transfer speeds higher than 4,800 baud.

Although RF modems are slower and more expensive than telephone modems, they are becoming increasingly available at reasonable costs and at relatively high speeds. 4,800-baud RF modems with significant data storage capacity and intelligence can be purchased for several hundred dollars, and 2,400-baud RF modems for significantly less. RF modem prices are less than the cost of the radio with which the modem interfaces. When purchased in conjunction with mobile data terminals or mobile computers, the cost of RF modems is further reduced. Thus, cost barriers to the use of digital data communication for DRT operations are becoming less serious. Moreover, within the near future, it is possible that relatively affordable 9,600-baud RF modems will begin appearing in the market.

The advantage of digital data transmission for DRT is that it makes more efficient use of the limited-capacity radio channel when passing dispatch messages. In addition, if real-time data (other than simple status information) are to be efficiently returned from the vehicle to the control center, digital data communication is essential. The developments in RF technology, therefore, complement developments in the area of mobile computers and data terminals; the in-vehicle devices serve as the terminals to generate and receive the digital data transmitted by RF modems. Together, they enable a cost-effective digital communications system for DRT.

7.2.2 Mobile Data Terminals and Mobile Computers

The revolutionary advances in microcomputer-based devices has made possible the development of relatively powerful and inexpensive in-vehicle display and processing units. These devices are typically classified as mobile data terminals (MDTs) or in-vehicle computers (also referred to as on-board computers or mobile computers). The distinction between these two types of devices is becoming increasingly blurred by improvements in price-performance of MDTs. To the extent that there is a meaningful distinction, it is that MDTs are display devices with limited processing and storage capabilities, whereas in-vehicle computers are full microprocessor-based computers customized for the vehicular environment and have the ability to interact with the user.

Mobile data terminals have become widely available for transportation applications in a variety of configurations, with a range of performance characteristics. MDTs are now extensively used in the taxi industry with computerized dispatching systems. The MDTs include or are attached to an RF modem to transmit and receive messages. MDTs used in the taxi industry typically have a simple microprocessor, limited functionality, and a small amount of memory, usually just enough to hold a handful of dispatch messages. Simple MDTs (such as older models used in the taxi industry) are highly limited in the amount of data they can transfer from the vehicle to the central computer, sometimes no more than a few bytes of status information.

More powerful versions of MDTs, with enhanced internal processing and storage capabilities, are commonly marketed to the paratransit industry. At their most basic, MDTs function as the receiving and display devices in the vehicle for digitally transmitted messages. Beyond that functionality, there is a wide variation in the capability of MDTs relative to processing capability, amount of memory, programmability, and modem speed. As would be expected, the performance capability of the MDT unit is directly related to its price.

MDTs appropriate for DRT systems typically cost $1,100 to $1,400 installed per vehicle for the in-vehicle hardware and firmware (software embedded in the microprocessor). The cost includes an attached or embedded RF modem for the MDT. Such MDTs are capable of storing and subsequently displaying multiple dispatch messages (passenger pickup and drop-off addresses and instructions), of recording and temporarily storing certain types of information about each passenger pickup and drop-off, and of interfacing with other electronic devices in the vehicle, such as automatic odometers, vehicle location devices, and card readers.

Mobile computers are based on relatively powerful microprocessors, are approximately the same size as a large car radio, and include memory, storage capability, a keypad with varying numbers and types of keys, a display terminal, possibly a built-in or attached printer, and some type of digital communications link to the central computer. This can be either an on-line real-time communications connection using an RF modem or a batch end-of-day data transfer using a computer cable, infrared data transfer, or even a telephone modem connection (after the computer is removed from the vehicle). Data transfer using card media is also possible with some mobile computers. Mobile computers can also be connected to other devices useful in the transportation environment, such as automatic vehicle locator units, automatic odometers, and card reader/writers.

When used in a DRT application, in-vehicle computers collect data generated in the course of operations, process data, display messages to drivers, and communicate digitally with a host computer system. Mobile computers can also be hand-held computers. Rather than being mounted in the vehicle, a hand-held computer is simply used inside the vehicle. Such devices typically lack the on-line communications capability of in-vehicle computers and communicate to a host computer at the end of the day via a "cradle" device into which they are plugged. Cradle units can be installed in the vehicle and connected to an RF modem, but this is uncommon to date. General-purpose hand-held computers may be less expensive than in-vehicle computers designed specifically for mobile applications, not counting the cost of cradle units (which can be a significant expense).

The advantage of mobile computers is that by placing computing power directly in the vehicle, it becomes possible to create more robust and flexible applications than with a simple MDT. In-vehicle and hand-held computers can run complex software, handle sophisticated automated fare collection, and communicate with a host computer using an RF modem. Moreover, a DRT system that deploys mobile computers in its vehicles has decentralized intelligence and does not need to rely on the central computer for all information and decisions. For example, an entire day's worth of schedules can be loaded into the in-vehicle computer at the beginning of the day, and the driver can then work semi-independently, except for changes or additions to the schedule, which are communicated from the dispatcher via an RF modem. (The more advanced MDTs, which increasingly resemble in-vehicle computers, have similar capabilities.) Such an application automates the driver's work, yet minimizes the use of the data communication channel, which is often a scarce and/or expensive resource. As another example, an automated fare system can be implemented, with all fare-related data—including billing information—being collected and stored in the mobile computer and then communicated digitally to the central computer.

Although the cost of acquiring these capabilities has declined significantly over the past five years, it is still relatively expensive. MDTs can be acquired for $1,150 to $1,700 per unit, including RF modem, automatic odometers, transmission transducers (necessary for an automatic odometer to function), and installation. In-vehicle computers would probably cost a few hundred dollars more. In addition, a DRT provider will need to acquire a communications server and communications software to handle digital data communications between the central control system and the mobile units. This will cost an additional $4,000 to $30,000, plus the cost of computer hardware to host the communications system. If trunking radios have to be acquired because of inadequate conventional radio coverage or performance, these will be an additional several hundred dollars per unit, plus usage charges, for an 800MHz or 900MHz trunk radio system. For a 50-vehicle operation, the total cost could range from as little as $65,000 to over $175,000 if new radios need to be acquired.

To date, only a small number of DRT systems have invested in mobile data terminals and the associated RF data communication system they require. The reasons appear to have little to do with technological risk. At least two DRT software vendors will sell turnkey software/MDT systems to an operator, the technology is mature, and the systems have performed adequately in actual operations. The reason for the slow rate of adoption appears to be the cost of the technology relative to its perceived economic benefits.

For a 50-vehicle system, the cost of an MDT system and the necessary RF data communication infrastructure can easily exceed the cost of a DRT software package. But the software package provides the basic value of the combined system; the scheduling and dispatching software can operate without the MDT system, but not vice-versa. Thus, financially constrained DRT organizations have a difficult time justifying the cost of the additional level of automation, unless they are inherently oriented towards technological solutions.

The price tag alone is rarely the entire issue when it comes to purchasing an MDT system, as every DRT system must regularly replace its vehicles, and such expenditures are many times those of the cost of an MDT system. It is simply that the added value of an MDT system is uncertain unless a DRT operator is experiencing serious radio capacity problems. An MDT system can reduce control-room costs, but the savings are not of the magnitude to pay back the expenditures on the system in a short period of time. Moreover, many current DRT systems rely predominantly on subscription trips and advance reservations. Most operations are prescheduled, which means that drivers begin their day's activities with much of their schedule already determined, ostensibly minimizing the need for real-time trip insertions and schedule modifications. In practice, of course, schedule changes are made throughout the day, but the key point is that most contemporary DRT systems do not rely on real-time scheduling and dispatching. This reduces the value of an MDT system.

The reasons that MDTs have proliferated in the taxi industry are that these systems clearly reduce control-room costs in the taxi environment, and they reduce radio-capacity problems for large systems. Further, the nature of taxi service is almost totally real time. Most DRT systems do not share the same characteristics.

7.2.3 Automatic Vehicle Location Devices

The ability to locate vehicles precisely can be of significant value to DRT systems that use computerized scheduling and dispatching. By knowing the location of vehicles at the time of vehicle assignment (i.e., assigning a specific trip request to a specific vehicle), it may be possible to improve the productivity of the system, as the proximity of a new trip request to a vehicle's current actual location on its tour can be better exploited. Until recently, however, vehicle location technology was rather expensive, and no actual DRT system had ever utilized so-called automatic vehicle location (AVL) technology.

AVL technology has become markedly more cost-effective during the past few years as the result of two developments. First, a U.S. government system of geopositioning satellites (GPSs) has achieved adequate coverage of the continental United States; full coverage is available 21–24 hours per day. This satellite system, originally developed for defense purposes, continuously broadcasts highly accurate positioning information; the satellite signals can be received by any antenna tuned to the appropriate frequencies. The use of these signals is free, as the U.S. government provides the entire GPS infrastructure. The location information that can be computed by receiving signals from multiple satellites is highly accurate, to within 50 meters of the true location without signal correction techniques, and to within 5–10 meters using correction techniques that are implemented in more advanced AVL units.

Second, the cost of GPS receiver units has declined significantly over the past four years. Complete GPS receivers can now be purchased for several hundred dollars, and a GPS antenna costs an additional $100 or so. More significantly, circuit board GPS units—which actually contain all of the logic components of the GPS receiver—can be integrated into or interfaced with an in-vehicle computer or the more advanced types of MDTs, for an installed cost of $200 to $500 per unit. This includes the cost of the antenna. Such a solution provides all of the functionality needed for a GPS-based vehicle location system.

These developments make AVL technology relatively affordable to DRT systems. An end user can purchase the in-vehicle component of AVL technology (mapping and control software is also necessary for a functional system) for $500 or less per vehicle when the GPS receiver is integrated with other in-vehicle electronic components.

AVL systems based on GPS technology are now well-established in the market and will, in all likelihood, become the dominant AVL technology. While other types of AVL technology exist, systems based on GPS appear generally superior in accuracy and cost-effectiveness. An alternative to establishing one's own GPS-based AVL system is to buy into AVL systems that have been established in a number of large metropolitan areas. These systems, of which the best known is probably the Teletrac system, are based on a network of fixed-point antennas to locate vehicles containing receiving/transmitting units, which communicate via paging technology. These latter systems, however, are only viable in large metropolitan areas that can support a dense network of antennas and can share the infrastructure cost among many users.

In addition, although buying into an established AVL system such as Teletrac avoids most of the potential problems associated with developing one's own system, the disadvantage is the pricing structure. With a GPS-based AVL system, most costs occur at the outset, in purchasing the hardware and software. In systems exemplified by Teletrac, users are charged a fee per transaction. The relatively high cumulative charges make this technology potentially less cost-effective than GPS-based AVL systems.

AVL systems have been adopted by only a handful of DRT operations, for essentially the same reasons as the slow rate of adoption of MDT systems. A list of a sample of DRT providers who are using AVL for DRT service is shown in Table 7.1. Commercial transportation operators (such as package delivery and trucking companies) have invested in AVL technology because they derive economic benefit from knowing precisely where their vehicles are when making vehicle assignment decisions (e.g., which vehicle to send for a residential pickup). But given the characteristics of many contemporary DRT operations—low productivity, lengthy dwell times due to passenger characteristics, predominantly prescheduled operations—the value of real-time vehicle location information is relatively low. AVL systems also tend to be more technologically challenging, and somewhat more prone to complications. Simply stated, if a DRT operation does not make most of its scheduling and dispatching decisions in real time, the economic rationale for investment in AVL technology is limited.

7.2.4 Mapping Software/Geographic Information Systems

Using AVL for DRT applications depends on interfacing location information with mapping software. When a vehicle's location can be plotted on a map—whether displayed or not—the quality of dispatching and real-time scheduling may improve, by providing the trip assignment algorithm with exact vehicle location information at the time of trip assignment/reassignment. When the location is displayed, a human dispatcher has the information to make better trip assignments and reassignments.

Both mapping software and geographic information system (GIS) software have now become widely available and affordable. Mapping software geocodes addresses, using a latitude/longitude coordinate system; the software determines whether addresses actually exist and plots address locations on an electronic map. Distances between two points can be calculated, streets and address locations can be viewed on a computer screen, and data files of street addresses and attributes can be managed. GIS software does all of this and more, providing comprehensive ability to manipulate, analyze, and manage databases that are based on spatial data.

In general, computerized DRT systems require mapping software, not full GIS ability. DRT systems must geocode addresses, calculate distances between points in a service area, calculate travel times between points using distance information and some knowledge of the street network, and, on occasion, display vehicle and passenger location on a computer screen. Computerized DRT systems need such capabilities, even if they do not use AVL technology, but these capabilities are essential for AVL deployment.

Some software vendors have developed integrated AVL-mapping applications for the transportation industry, and mapping software and map files are widely used for transportation applications. One of the leading DRT software systems uses an industry-leading mapping package as an integral part of its system; this same mapping package has been interfaced with AVL systems in other (non-DRT) applications. The DRT software vendor provides AVL application software for $12,000, which includes the ability to "see" DRT vehicles moving about the service area in real time as part of an overall AVL system.

City of Albuquerque Transit and Parking Department
Albuquerque, NM
Linda Dowling - data manager
505/764-6105
Sheran Matson - paratransit manager
505/764-6165
(As of this writing in June 1996, the system is expected to be operational in 6 months.)

Ann Arbor Transportation Authority (AATA)
Ann Arbor, MI
Chris White
313/677-3922

Capital District Transportation Authority
Albany, NY
Cary Roessel
518/482-4199
(This is a signpost system requiring electronic boxes streetside and is more appropriate for fixed-route.)

Metropolitan Transit Authority of Harris County: METRO
Houston, TX
Kevin McGreevy
713/739-4614

Outreach, Inc.
San Jose, CA
Roberta Gardella
408/436-2865

SMART
Troy, Michigan
Ron Risto
810/362-0924

Department of Public Works
Stanislaus County, CA
Brad Christian
209/525-6552

Tidewater Transit District Commission
Norfolk, VA
Karen Haushalter
804/640-6223

Winston Salem Transit Authority
Winston Salem, NC
Nedra Woodyatt
910/727-2000

The technology to provide precise and useful vehicle location information to either control room personnel or a DRT software application itself now exists via this combination of mapping software and AVL devices. For a relatively modest investment, an organization can incorporate this capability into its suite of software and hardware technologies.

7.2.5 Card-Based Data Storage and Transfer Media

Cards to store data, transmit the data to another device, and potentially alter their stored data, are potentially important for paratransit operations. By issuing to users cards with identification and, possibly, fare information, DRT providers can partially or fully automate collecting information on user transactions and vehicle operations.

There are essentially three types of cards relevant to DRT systems. The most basic is a read-only card, which uses magnetic stripes (mag-stripe) or bar codes to store and transmit the information on the card. This type of card can store a limited amount of data—typically fewer than 100 characters—and the data cannot be altered once it is placed on the card. Bar-code strips can be attached to cards and then replaced by another strip, but the data on each strip cannot be changed. Mag-stripe and bar-code cards are most useful for storing simple identification and status information, which can be retrieved when the passenger or driver swipes the card through a card reader or scans a bar-coded card with a bar-code reader.

A more sophisticated card is the memory card. This card has an area on which data can be written and then read by a card reader, but the data can be altered after the initial writing. Memory cards are useful when data on the card need to be alterable but the card is not a data-processing device. An example is an ID card that also contains stored fare value. The stored value can be decreased each time a passenger boards a vehicle and swipes the card through a card reader/writer.

The most sophisticated card is the smart card. A true smart card is one with an embedded microprocessor, as well as an area for data storage. Most current smart cards can store 1,000–3,000 bytes (50–150 pages) of data. The embedded microprocessor is what gives the smart card its "smarts"—actually processing data just like a computer chip. Relatively few smart card applications to date, however, take full advantage of this capability. Most do little more than perform simple functions, such as incrementing and decrementing numeric data stored on the card. One key attribute of the smart card is the additional security it provides relative to conventional magnetic-stripe technology—it is possible both to encode data and to prevent access to the data on the card without appropriate security permission. The combination of security and internal processing capability makes smart cards ideal as "electronic purses," loaded with stored monetary values that are subsequently reduced as each transaction occurs. The stored value can also be increased at point of contact with the system if additional funds have been deposited into the cardholder's account for this purpose.

The major disadvantage of smart cards is their cost. They require a more complicated card reader—actually a reader/writer—than do magnetic-stripe cards, and this device costs a few hundred dollars per unit. In contrast, a magnetic-stripe card reader typically costs less than $25. In addition, the smart cards themselves are relatively expensive, currently costing $6 to $12 each, depending on features (such as photo ID), for 8K- to 16K-bit cards. Magnetic-stripe cards and bar-code cards cost much less than $1 per card (unless a photo ID is involved), and memory cards typically cost $4 to $5 per card.

Some paratransit organizations have expressed serious interest in using cards to help automate the collection of passenger trip data and to use as fare media. If there is no need for the information stored on the card to be processed internally, simple memory cards or magnetic stripe cards are adequate. Magnetic-stripe cards provide read-only storage and can hold relatively little data; but they are adequate for storing customer ID numbers, fare-category information, and similar types of data that may need to be collected for each passenger transaction. Memory cards can contain relatively large amounts of data, which can be altered on the card (or new data written to the card), thus enabling them to be used for two-way data transfer. In addition, proximity card readers are available for memory cards, for prices ranging from $350 to $500. These card readers require no physical insertion of the card into the card reader/writer, as is the case with magnetic stripe cards or conventional smart cards.

Card-based data/fare collection systems are less mature for DRT operations than either MDT/RF data communication or AVL technologies. A variety of possible configurations exist, but no one approach has demonstrated any significant market appeal to date. With the exception of magnetic-stripe card readers connected to an MDT or in-vehicle computer, no off-the-shelf solution exists without technological uncertainty. A relatively ambitious attempt by the Regional Transportation Authority and the Chicago Transit Authority to implement a data/fare collection system using hand-held computers and smart cards was abandoned following quality control problems with the card readers embedded in the hand-held computers. Various factors other than the hardware problems (eventually eliminated by replacing the original hand-held computers) ultimately led to the demise of the project, including technological complexity and a potential mismatch between operator capabilities and system requirements.

Several relatively low-risk approaches to card-based fare/data collection exist, but as with MDTs and AVL systems, the economic benefits of any approach appear uncertain for most DRT operators. The major reason is that card-based systems are premised upon a relatively expensive hardware device that is either the card reader itself or an interface to the card reader. Consequently, the value of automated fare/data collection may not be commensurate with the costs of the required technology, particularly in view of the low productivity of DRT systems.

7.2.6 Telephone-Based Technologies

Two advances in telephone technology seem to have potential for DRT operations. The ability to identify the caller's telephone, or to have the caller enter a code which would trigger the search of the database for the caller, would seem to have the potential to save the reservationist's time when answering the call. It may also prove to be automation overkill.

The second interesting technology is the use of menus and caller-entered data without or prior to speaking to a human reservationist. A telephone tree would be used to solicit information from patrons ("Press 1 if you wish to schedule a new trip," "Press 1 if your trip will begin from your home residence," etc.). Automatic telephone order taking, scheduling, and dispatching is not an untried concept. In Europe it was demonstrated in the form of a streetside kiosk from which passengers would call for service. It has the potential for completely automatic scheduling and dispatching without any human assistance.

7.3 STATE OF ART OF TECHNOLOGY USE

Relatively few of the 119 respondents to the survey of providers indicate that they use one of the subject technologies (Figure 7.1). However, a significant number are "planning to acquire" one or more technologies.

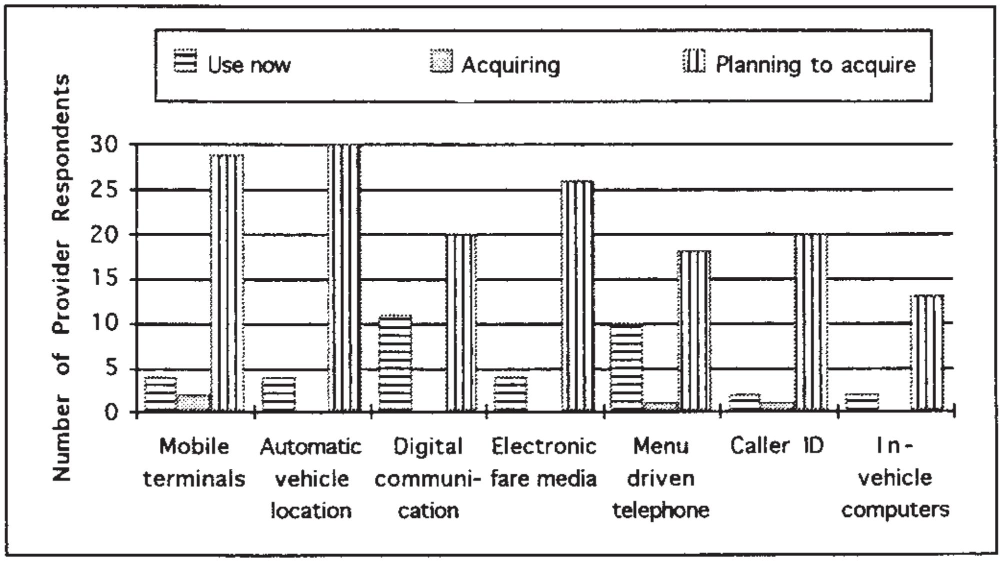

Figure 7.1 Technology Used and Planned.

Judging the future use of a technology can be estimated by adding the number of present users to the number acquiring or planning to acquire the technology. Automatic vehicle location (AVL) will be the most-used technology and is therefore likely to have great impact on the algorithms used to perform scheduling and dispatching. AVL will displace digital communications, which will remain in second place.

The popularity of these technologies can be seen by recognizing that AVL, the most popular technology after computer use, will be adopted by only 34 systems out of the 119 respondents to the questions. This suggests that DRT service will not be quickly transformed by these technologies, and computer use will remain the most prevalent technology.

7.4 LOOKING INTO THE CRYSTAL BALL— THE FUTURE OF DRT AUTOMATION

If other industry experience is a reliable guide, automation of DRT functions will beget higher levels of automation in the coming years—at least for those DRT operations that have taken the initial steps in automation by utilizing software to handle their scheduling and dispatching requirements. The technologies discussed above—mobile data terminals and RF data communication, AVL systems, and card-based data/fare collection systems—are likely to be one direction for additional DRT automation. These products exist today and can be adopted with limited technological risk. But the continual advances in functionality and price-performance of microprocessor-based technologies for data processing and communications make it likely that other forms of automated technologies will also be adopted by some DRT systems.

One promising direction for future automation is decentralizing certain control room functions to the driver of the DRT vehicle. Vehicle locations would be known via AVL technology and caller ID used in conjunction with a GIS database to establish the location of an incoming trip request. (The telephone voice response system intercepts the incoming call and directs trip reschedules and cancellations to a control room reservationist.) Then trip requests could be routed directly to the appropriate vehicle—using cellular phone links—and the driver could create the appropriate pickup and drop-off sequencing of passengers. How the driver records origin and destination information (manually on paper or key-entered into an on-board computer) and what safety concerns arise when the vehicle is in motion are an issue in this scenario. Another way in which the driver could play a more prominent role is to call back the passenger when the vehicle is within a few minutes of the passenger's location, thereby possibly reducing dwell time, as passengers would be ready when the vehicle arrived.

Scenarios in which the driver asserts a larger role in the operation assume one or more of the following technologies on the vehicle: on-board computing power, AVL devices, cellular phones, RF data communication, and RF modems. In addition, a GIS capability at the control center may be required.

Another potentially promising technological direction is toward greater automation of the reservation function. This can be as modest as telephone systems to automate part of the reservation process as discussed in the last section. In more ambitious systems, reservations are made on-line using a computer or terminal (airlines are experimenting with on-line consumer access to their reservations systems). As the Internet and World Wide Web expand in both presence and performance over the next several years, this access to reservations systems may become quite common. Such automation assumes a fully computerized reservations and scheduling capability and a GIS capability. While this would seem to have significant potential for cost saving, it is a use of technology that involves the passenger to a greater degree than others we have discussed and may therefore cause resistance to acceptance. Since many users of DRT service have functional difficulties, the interaction with a known voice may be a desirable part of the service. Therefore, although it is not likely that on-line reservations will ever totally replace the person-to-person reservations process, a substantial percentage of reservations activity might be handled in this fashion.

Additional automation can also occur on the operations side of the reservations process, by providing automated telephone call-backs to passengers with vehicle status information. When vehicles are running late, patrons can be informed, and when they are within a certain distance of the pickup point, patrons can be notified. This assumes the use of AVL technology, RF data communication, and an automated voice response telephone system.

7.5 ISSUES OF ACQUIRING COMPLEMENTARY TECHNOLOGY

The key issue in acquiring complementary technologies for DRT is risk management. This Handbook has presented you with a blueprint for navigating the DRT software procurement process to help you achieve the best possible outcome for your organization. While there is risk inherent in purchasing specialized software such as that for DRT, the fact that many other organizations have engaged in this process and that there exist vendors with a relatively large installed base helps minimize this risk. The situation is not the same when you seek to incorporate other technologies into your operation.

For you to successfully acquire and integrate other technologies with a DRT software package, you must manage four types of risk. They are the following:

- Knowledge risk,
- Technology risk,
- Vendor risk, and
- Integration risk.

Knowledge risk refers to your lack of knowledge about how a particular technology works, about an organization's capabilities, or about how best to integrate different technologies into a coherent system. In other words, knowledge risk is everything you and your organization don't know about achieving the outcome you desire. Knowledge risk also refers to the possible illusion that you can eliminate risk from the technology acquisition and integration process. Risk elimination is a relatively common goal of public agency managers, as they do not believe "failure" is an acceptable outcome of technology procurement and implementation. But the belief that risk can be eliminated when dealing with technology is a fallacy, for risks can merely be managed. Even standard technologies do not always perform as expected. Personal computers have hard drives fail, printers malfunction, vehicles break down when in service.

The best approach to managing knowledge risk is to acquire as much knowledge as you can about the technologies you are considering, and to recognize that implementation will be—at least initially—less than trouble-free. If you design a technology acquisition process premised on problems occurring, you must do two things. First, choose technology partners (vendors) who you believe are not merely competent but also committed to solving problems collaboratively. Second, make contingency planning an integral part of your approach. This means you formulate plans to deal with the problems that may occur and work through the problems to an improved situation. If you adopt this approach, the likelihood of a successful outcome is quite high.

Technology risk is the possibility that the technology you are implementing will not perform as expected. For the complementary technologies described in this Handbook, technology risk is limited. These technologies are relatively mature in one or more applications so outright failure is highly unlikely, unless you are purchasing an entirely new product by an untested vendor. More likely, the technology will not live up to your expectations. The best way to manage this risk is to establish expectations in line with current reality for the technology. Investigate how this technology performs in other DRT systems or similar applications. Do not expect substantially more, despite what a vendor may claim.

If this is an entirely new application of a technology, be prepared for technology problems, perhaps major problems. You must understand that benefits can be gained only by taking risks, as off-the-shelf technology designed precisely for your application does not exist. If your organization is not prepared to accept a certain level of risk, you should not acquire any technology until it is totally mature and has achieved wide-scale acceptance. This means you also forgo the benefits of such technology, but for some organizations, risk avoidance is more important than improved functionality or performance. Is your organization prepared to accept the risk that the technology won't function perfectly, at least initially?

Vendor risk is the possibility that the organization from whom you acquire the technology will not perform as expected. This is different from technology risk in that it is already assumed that the technology will not function perfectly at the outset (if it does, it is a pleasant surprise). Vendor risk occurs for two reasons.

First, the vendor may be small, relatively new, and with limited financial staying power. Vendors with such characteristics may have a difficult time responding to serious problems that occur during the implementation; the diversion of resources to your problem could put the company itself at risk. In addition, such companies may simply go out of business within a year or two of the time they implemented the product in your system, leaving you without support for the product you acquired. Under these circumstances, why deal with a vendor with such characteristics? For the simple reason that in a small market niche such as DRT technology, such a vendor may have the best technology at the lowest prices—large, established hardware and software companies may have no interest in the market niche or any products designed to serve its requirements. In addition, many substantially sized companies began life under these less-than-ideal circumstances and parlayed their technological expertise and customer responsiveness into highly successful businesses. Their early customers often benefited disproportionately, receiving excellent service and prices.

Second, vendor risk derives from not understanding the vendor's capabilities. A firm that can produce a particular hardware product does not necessarily have the expertise and experience to integrate the product successfully with a software system with which they have no prior experience. It is important that you understand precisely what the vendor can and cannot do, and not anticipate that your project will be trouble-free if the vendor has never implemented the same system previously. This does not mean a vendor is a bad choice because it has not previously done exactly what you want; it does mean you can expect some problems to occur and should be prepared to work with the vendor to solve these problems. As technology has become more complex, it is tempting to believe that an organization that can master a particular technology can easily solve many other related technological problems when, in fact, that is often not the case.

Vendor risk is best managed by soberly assessing the managerial and technical capabilities of prospective vendors, and evaluating those capabilities relative to the price and performance of the technology they are offering. To achieve the best outcome, risk may be necessary—but vendor risk should always be known in advance, not discovered late in the implementation process.

Integration risk is the possibility that when you attempt to integrate two or more technologies, the result will be much less than expected, even though each technology in isolation works perfectly well. In large, complex systems, integration risk is always present because the system has never been assembled in exactly the same way previously.

Integrating the component technologies for DRT with DRT software systems presents some integration risk, depending on the specific combination of technologies and software. You can purchase an integrated DRT software and MDT system that presents little integration risk per se because the specific combination of software package and MDT units has been implemented in other settings. However, integration risk may still be present if characteristics of the RF environment are sufficiently different from these other settings that they pose new problems never encountered before in implementing the technologies. In general, however, incorporating MDTs into a DRT software system poses limited integration risks for certain MDT and software products. There is somewhat greater integration risk for AVL and card-based technologies combined with DRT software, due to the more limited experience with these types of system integration.

To manage integration risk, you need both specific objectives for the system and expertise in understanding how the components of the system will work together. The specific objectives help ensure that your expectations are established at the beginning of the process, so both you and the vendor(s) understand what you expect the system to do. It may be that your objectives for the system are not realistic—the vendors will usually inform you that this is the case. You then must develop realistic and achievable objectives before you can proceed with acquiring the technology and implementing a system. Expertise is essential to develop and integrate the technology but it does not have to be your organization's expertise. In selecting one or more vendors to implement these new technologies in your DRT system, you should probably place a high priority on a vendor's demonstrated ability to understand how the different components work together and to manage the integration process. If your organization has implemented new technologies previously, you will already have an appreciation of the knowledge and effort necessary to bring a new system into being. You will want to select vendors who have a similar level of appreciation for and experience with this process.

The key issue in adopting any of these DRT component technologies into your system is to recognize that you are taking at least a limited risk. Even if everything goes smoothly in the implementation, the benefits you expect from the new technology may not occur. With the recognition of risk, and the determination to manage it successfully, comes the ability to make the trade-offs between risks and rewards that will enable your organization to decide intelligently whether to invest in new technology in light of the potential benefits it can yield.

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APPENDIX A

GLOSSARY AND ACRONYMS

Accessible—The extent to which transportation vehicles and facilities are free of barriers and usable by persons with disabilities, including wheelchair users.

Advanced Public Transportation (APT) Program—The name of an FTA program for *Intelligent Transportation Systems (ITS).*

Advance Reservation Service—DRT reservation timing regime that requires requests for reservations to be made 24 hours or more in advance; also called *Prescheduled Service*.

Algorithm—A formula or set of steps for solving a problem (usually mathematical) that ensures that the solution is the best one possible. An algorithm must be unambiguous and must stop when the best solution is calculated.

Americans with Disabilities Act of 1990 (ADA)—Federal civil rights law that enables persons with disabilities to participate fully in society, live independently, and be economically self-sufficient.

Application Program—A program designed to perform practical tasks, such as accounting, statistical analysis, vehicle scheduling, word processing, and the like.

Area Population—The number of residents in the base service area.

ASCII—Acronym for American Standard Code for Information Interchange. A standard for representing the characters of the alphabet, numerical digits, punctuation, and various symbols in binary code (1's and 0's). An ASCII text file is a plain text file.

Automatic Vehicle Location (AVL)—Electronic communication system for tracking and reporting the location of vehicles to a central dispatching center.

Backup—A copy of a program or data made for protection, in case the original is damaged.

Batch Processing—Scheduling a number of trip requests all at one time.

Baud Rate—A measure of the data transfer speed of a modem which is close to, but not exactly, bits per second; usually 2,400, 9,600, 14,400, or 28,800.

Benchmarking—Evaluating the relative performance of software by measuring the computer processing time or the user effort required for the software to perform various functions.

Benefit-Cost Analysis—An analytical technique that compares the societal costs and benefits (measured in monetary terms) of proposed programs, projects, or policy actions. Identified losses and gains experienced by society are included, and the net benefits created by an action are calculated. Alternative actions are compared to allow selection of one or more that yield the greatest net benefits or highest benefit-cost ratio.

Bit—Binary digit. The basic unit of computer data, either 0 or 1.

Broker—Organization that identifies and matches potential user's needs with available transportation services. Although a broker usually does not operate services directly, it may provide advice and information, whether technical, financial, or organizational, as well as regulatory and institutional assistance.

Bug—An error in software (or hardware) that causes a program to malfunction.

Byte—A unit of storage equivalent to one alphanumeric character (letter or number) recognized by computers as a single unit; in most computers equivalent to 8 bits.

Call-back—Demand-responsive transit service telephone operator's notification to customer that vehicle is arriving on schedule or will be delayed.

Caller Identification—Telephone system that identifies the telephone number or name of the caller.

Central Processing Unit (CPU)—The microprocessor that does the computing and controls the flow of information in the computer.

Chip—An electronic circuit etched onto a piece of silicon. A chip can be a microprocessor or a memory device.

Citizen Advisory Committee (CAC)—An organized group of local people who supply their ideas and input to, for example, a particular transportation study or plan, a transit or paratransit operation, or a government agency.

Compatibles—Personal computers that are compatible with personal computers manufactured by IBM.

Computer-Aided System—Demand-responsive transportation service in which some, but not all, control center functions are performed using a computer. Also referred to as computer-assisted.

Computerized Dispatching—Procedure for assigning demand-responsive transit customers to vehicles and the scheduling of vehicles by electronic equipment using a predetermined algorithm.

Contracting; Contracting Out—A procedure followed by many organizations to let certain parts of the operation to private contractors, instead of having their own employees perform the work. A frequent rationale for contracting is the idea that the work can be performed more efficiently and with less expense to the main organization.

Coprocessor—A special-purpose processor that assists the main microprocessor by performing certain operations, most commonly graphics and precision computation.

Cost—The outlay or expenditure made to achieve an objective.

Cost-Effectiveness Analysis—An analytical technique used to choose the most effective method for achieving a program or policy goal. The costs of alternatives are measured by their requisite estimated monetary expenditures. Effectiveness is defined by the degree of goal attainment and may also (but not necessarily) be measured in monetary terms.

Cost Efficiency—A quantitative measure of efficiency or how well something contributes to the attainment of goals and objectives measured against its cost. For transportation systems, cost efficiency is usually measured as the ratio of the cost of a system to the level of service. Examples of four major unit cost measures that might be used (either separately or together) to determine cost efficiency are total operating cost per vehicle hour, total operating cost per vehicle mile, total operating cost per passenger trip, and total operating cost per passenger mile.

Count—1. A process that tallies a particular movement of people or vehicles past a given point during a stated time period. It may be a directional or a two-way value and is also known as a *traffic count*. 2. A volume of people or vehicles.

Curb-to-Curb Service—A service that picks up and delivers passengers at the curb or roadside, as distinguished from door-to-door service. Passenger assistance is not rendered other than for actual boarding and alighting.
Custom Software—Software package modified specially to the specifications of one user.
Database—A collection of information, organized for easy analysis and retrieval. Consists of individual data elements, each of which is called a *field.* A collection of fields related to one entity, such as a passenger, is called a *record*. A collection of records is called a *file*.
Data Element—A single item of information such as a rider's name; also called a *field*. A collection of data elements makes up a *record.* See also *Database.*
Demand—1. The quantity (of transportation) desired. 2. In an economic sense, a schedule of the quantities (of travel) consumed at various levels of price or levels of service offered (by the transportation system).
Demand-Actuated Transportation System—Another term for *Demand-Responsive Transit* but also may refer to a system of small vehicles operating on a guideway network, for example, an elevator.
Demand Analysis—A study of the factors that affect demand, performed by collecting data and using various analytical techniques to understand demand.
Demand Density—Intensity of trips generated, usually measured in trips per hour per square mile.
Demand-Responsive Transit (DRT)—Generic term for a range of public transportation services characterized by the flexible routing and scheduling of relatively small vehicles to provide shared-occupancy, personalized, door-to-door, curb-to-curb, or point-to-point transportation at the user's demand; implies existence of a coordinated dispatching service; also called *Flexible-Route* service or *Demand-Actuated* transportation.
Destination—1. The point at which a trip terminates. 2. In planning, the zone in which a trip ends.
Deviation from Checkpoint—Demand-responsive transportation services that make regular scheduled stops at designated checkpoints but are free to provide door-to-door service between checkpoints.
Deviation from Route—Demand-responsive transportation service in which a normally fixed route bus will leave the route upon request (within a defined service area) to serve patrons not on the fixed route.
Dial-a-Ride (DAR)—A demand-responsive system in which curb-to-curb transportation is provided to patrons who request service by telephone, either on an ad hoc or subscription basis. It is also known as dial-a-bus (DAB) when buses are the vehicles used.
Digital Data Communications—A regime for communicating digital data (0s and 1s) that can communicate voice data as well by translation at both the sending and receiving ends.
Disk, Diskette—A disk made of magnetic or optical etched material that is the most common medium for recording and storing data; floppy disk or hard drive.
Disk Operating System (DOS)—The operating system used in IBM PCs and compatibles.
Dispatcher—In demand-responsive transportation, the person who assigns the vehicles to customers and notifies the appropriate drivers, and who may schedule and route vehicles and monitor their operation.
Dispatching—1. In DRT systems, the process of assigning a sequence of trips to a vehicle. 2. Relaying service instructions to drivers.
Distance, Trip—1. Linked—The distance traveled on a linked trip, that is, the distance from the point of origin to the final destination, including the walking distance at trip ends and at transfer points. 2. Unlinked—The distance traveled on an unlinked trip, for example, a trip on a single vehicle.
Diversion Trip Assignment—A trip assignment technique that allocates trips to alternate routes on the basis of the relative times or distances (or both) involved.
Documentation—Written material accompanying a software program designed to teach how to use the program and containing reference information.
Door-to-Door Service—A service that picks up passengers at the door of their place of origin and delivers them to the door of their destination. This service may necessitate passenger assistance between the vehicle and the doors.
DOS—Disk Operating System; a particular operating system for personal computers (see *Operating System*).
Downtime—1. A brief period during which workers are unable to perform their tasks, while they wait for vehicle replacement, repair, parts or supplies, etc. 2. A payment made to employees for such lost time. 3. A period during which a vehicle is inoperative because of repairs or maintenance.
Drop-Off—Vehicle stop to allow a passenger to disembark.
Effectiveness—1. In transportation, the correspondence of provided service to intended output or objectives, particularly the character and location of service; in other words, producing the intended result (doing the right things). 2. In transit, the degree to which the desired level of service is being provided to meet stated goals and objectives; for example, the percentage of a given service area that is within the desired 1/4 mi. (0.4 km) of a transit stop.
Efficiency—The ratio of output (e.g., level of service provided) to input (e.g., cost or resource usage), that is, providing the desired result with a minimum of effort, expense, waste, and so on (doing things right).
Electronic Fare Media—Technologies for collecting fares electronically; includes magnetic cards and smart cards.
Eligible Population—The number of residents of the service area who are eligible to ride a specialized transit system.
Expansion slot—See *Slot.*
Fare—1. The required payment for a ride on a public transportation vehicle. It may be paid by any acceptable means, for example, cash, token, ticket, transfer, farecard, voucher, or pass or user fee. 2. A passenger who pays a fare.
Few-to-Few—A service that picks up passengers at a limited number of origins and delivers them to a limited number of destinations.
Few-to-Many—Demand-responsive transportation that serves a few preselected origins, typically activity centers or transfer points, and any destination, such as homes; reverse operation of *many-to-few* service.
Field—See *Database.*
File—Comparable to a file cabinet holding data pertaining to a particular topic, for example, clients, vehicles, employees. A file contains a group of *records*, comparable to file folders. See also *Database.*
Fleet Size—Total number of vehicles dedicated to transportation service in a service area, although some may not be operating or operated; also referred to as *total vehicle fleet.*

Function—Reserved in this Handbook to refer to such DRT functions as trip reservation (including eligibility determination), scheduling, dispatching, routing, reporting, and DRT administration.

Generic Software—Programs that can be used as multipurpose tools, rather than having specific applications. Word processors, spreadsheets, and database managers are the most common examples.

Geocoded—Coding of spatial information, such as a street address, with geographic coordinate information that unambiguously defines the location in a system to allow determination of distances among points.

Geographic Information System (GIS)—An information system capable of processing and displaying geographic descriptions, a map, or the nodes and links of a network.

Gigabyte—Measure of amount of data; approximately 1 billion bytes; 1,000 megabytes.

Graphical User Interface—Operating system that uses small cartoons called icons to represent documents, programs, or commands; the icons can be clicked upon with a hand-held instrument, called a mouse, to initiate actions.

Hard Drive—A large-capacity data storage device containing one or more disks driven by a motor contained in a sealed case.

Hardware—The physical components of the computer, as opposed to the programs or software.

High-end—Used in reference to DRT software to mean multiple-purpose packages that perform several DRT functions in an integrated fashion. See *Low-end.*

Immediate Service—DRT service providing immediate (as soon as possible) response to a request for service, usually within an hour; also called *Real-Time Service.*

Intelligent Transportation System (ITS)—The use of one or more microelectronics-based technologies to enhance a transportation system for the convenience of the rider or the efficiency of management.

Intelligent Vehicle and Highway System (IVHS)—Same as *ITS.*

Interactive Scheduling—Providing patrons a service pickup time, or time window, during the same telephone call they made to request service.

In-Vehicle Computer—An on-board computer or a terminal with computation capabilities.

In-Vehicle Terminal—See *Mobile Data Terminal.*

Jitney—Public transportation rendered in small or medium-sized vehicles that are licensed to render that service at a fixed rate or fare for each passenger. The vehicles operate on fixed routes along public ways, from which they may deviate from time to time in response to a demand for service or to take passengers to their destinations, thereafter returning to the fixed route. The scheduling and organization of this type of system vary among jurisdictions. It is used extensively in cities of developing countries that have inadequate transit service.

Latent Travel Demand—The number of trips that would probably be made during a defined period of time by vehicles or passengers along a particular route or corridor under specified conditions, for example, at certain fare or service levels.

Level of Service (LOS)—For paratransit, a variety of measures meant to denote the quality of service provided, generally in terms of total travel time or a specific component of total travel time.

Limousine Service—Demand-responsive public transportation service on an exclusive basis, provided in a vehicle that is licensed to render that service for hire at rates of fare agreed upon by the operating licensee, its agent, or the chauffeur and the passengers.

Local Area Network (LAN)—A system of hardware and programs for connecting microcomputers to each other and allowing them to share programs, data, and other devices (peripherals).

Low-end—Used in reference to DRT software to mean single-purpose packages, most often for database management. See *High-end.*

Macintosh—Brand name of a personal computer manufactured by Apple Computer, Inc., which competes with IBM-compatibles but uses different microprocessors and a different and proprietary operating system.

Mainframe Computer—Large, multiuser, multifunction computer.

Manual Dispatching—Demand-responsive transportation service that operates without the assistance of automatic data-processing equipment.

Many-to-Few—Demand-responsive transportation service that serves any origin, such as a home, and a few preselected destinations, typically major activity centers or transfer points.

Many-to-Many—Demand-responsive transportation that serves any origin, such as a home, and any destination within a service area.

Many-to-One—Demand-responsive transportation that serves any origin, such as a home, and only one destination, such as a shopping center or commuter rail station; also called *gather service.*

Mapping Software—Software capable of displaying geographic descriptions, a map, or the nodes and links of a network. Similar to GIS but without the extensive database capabilities.

Megabyte—Measure of the amount of data; 1 million bytes; about 50 pages of data.

Megahertz—A measure of the speed of a computer's operation, signifying a million cycles a second.

Menu—A list of commands that typically can be executed by moving a pointer to the desired command.

Menu-Driven—Programs that are operated by selecting from menus of commands.

Menu-Driven Telephone Information System—Telephone answering system in which the callers select from voice menus to direct their calls to a desired location.

Microprocessor—An integrated circuit that performs computations and controls the flow of information in a computer. The type of microprocessor used is one of the most common means of describing a personal computer.

Minicomputer—Computer of a speed and size between a personal computer and a mainframe computer.

Mobile Data Terminal (MDT)—An in-vehicle piece of equipment that receives and sends digital messages and displays the messages on a screen.

Modem—Modulator-demodulator; a device that translates computer data into signals to be sent over a telephone line and converts incoming signals back into a form understood by the computer.

Mouse—A manually operated device that moves a cursor, or pointer, around the screen to select commands or files; used in an operating system with a graphical user interface.

Multiuser—A computer that can be used by several operators at a time, from separate keyboard terminals.

Network—See *Local Area Network.*

Off-the-Shelf—Commercial software that is widely available in retail stores.

One-to-Many—Demand-responsive transportation that serves only one origin, such as a shopping center or transit terminal, and many destinations, such as homes; also called *scatter service*; reverse of *many-to-one.*

Operating System—A master software program that allows the computer to run software applications and controls the flow of data within the computer and between the computer and its peripherals. Examples are DOS, UNIX, Mac OS, and OS/2.

Order Taking—The function of recording a passenger's request for a trip and the details of the trip. A part of the trip reservation function that also includes eligibility checking.

Origin-to-Destination—Service in which the passenger-carrying vehicle will not stop along the way to pick up additional passengers.

OS/2—An operating system for IBM-compatible computers.

Package—A group of programs distributed as one product.

Paratransit—Those forms of intraurban passenger transportation that are available to some or all of the public, are distinct from conventional transit (scheduled bus and rail), and can operate over the highway and street system. Includes taxis, limousines, carpools, bicycles, and the like.

People with Disabilities—People who have physical or mental impairments that substantially limit one or more major life activities. In the context of transportation, the term usually refers to people for whom the use of conventional transit facilities would be impossible or would create a hardship.

Performance Measures—Any measures or statistics used to evaluate the efficiency or effectiveness of a transit service.

Peripherals—Add-on devices that are plugged into the computer, such as disk drives, printers, modems, scanners, and the like.

Personal Computer (PC)—Originated as a nickname for the IBM Personal Computer but is commonly used to refer to small, single-user, desktop computers.

Pickup—Vehicle stop to allow a passenger to board.

Platform—Another name for a computer system including both hardware and software.

Point Deviation—Public transportation service in which the transit vehicle is required to arrive at designated transit stops in accordance with a prearranged schedule but is not given a specific route to follow between these stops. It allows the vehicle to provide curbside service for those who request it.

Port—An outlet on a computer through which the computer communicates data to peripherals, such as printers or modems, or into a network.

PowerPC—Name of a type of personal computer containing a microprocessor that is compatible with both DOS and Apple's operating system.

Prescheduled Service—See *Advance Reservation Service*.

Program—A collection of commands to the computer to be executed as a group.

Providers—Used exclusively throughout the Handbook to mean organizations that provide demand-responsive transit service.

Purpose, Trip—The primary reason for making a trip, for example, work, shopping, medical appointment, recreation.

Random Access Memory (RAM)—A chip containing the operating memory of a computer holding the programs and data that are currently involved in operations.

Real-Time Service—See *Immediate Service*.

Record—A basic component of a file containing all pertinent information about a particular entity, such as a rider, vehicle, etc. See also *Database*.

Report—A document containing an arrangement of data elements selected and arranged to aid decision making or to meet an external requirement.

Request for Proposal (RFP)—The document that specifies a purchaser's needs for a product or service and asks vendors to propose providing the product or service.

Reservation Function—In DRT systems, the process of taking a call for service, verifying eligibility of the caller, recording the date and the information about the trip requested. The information is recorded on a form, called the reservation form, which may either be on paper or on a computer screen.

Ridership—The total number of passengers who use a transit service during a specified period of time, expressed as hourly, daily, monthly, or yearly ridership.

Route—Fixed path traversed by a transit vehicle in accordance with a predetermined schedule; the combination of street and road sections connecting an origin and destination.

Route Deviation—Public transportation service on an exclusive basis that operates along a public way on a fixed route (but not on a fixed schedule). The vehicle may deviate from the route occasionally in response to demand for service or to take a passenger to a destination, after which it returns to its route. It is a form of paratransit.

Routing—In DRT systems, providing the precise street path to a driver/vehicle.

Rural Area—An area, village, town, or community that is not a part of a designated urban area. An area that has a population of less than 50,000.

Same-Day Service—DRT reservation regime that responds to a request for service within the same service day but not as quickly as immediate service; for example, a system that responds in 2 to 4 hours.

Schedule—A listing of every trip provided on a transit route during the hours of service, including specific stopping points or major loading areas.

Scheduling—Giving a request for a trip an estimated time of pickup.

Scheduling Function—Control center activity that assigns vehicles to trips.

Scheduling, Interactive—Scheduling a trip request while the customer is on the phone.

Scheduling, On-Line—See *Scheduling, Interactive*.

Scheduling, Real-Time—See *Immediate Service*.

Slot—A connection in a computer for plugging in boards that add functions or capabilities, such as additional memory, a modem, coprocessors, etc.

Smart Card—A tiny computer enclosed in a case about the size of a credit card.

Software—Programs and languages used to communicate to computer hardware the tasks to be performed.

Software, Public Domain—Software that is available free and can be used without payment to the author.

Software, System—Software supporting application programs, including the operating system, programming languages, and utilities.

Software, Utility—Programs that perform housekeeping functions that enhance the use of the computer and increase control and flexibility of computer use.

Source Code—The original language in which a software program is written. If a program is changed, the source code is changed.

Specialized Transportation (Transit)—Transit services provided for persons needing special assistance to be able to use transit, such as persons with low incomes or disabilities, seniors, and the like.

Spreadsheet—A program used to set up, manipulate, and perform computation on the numbers in large tables (matrices) of numeric and alphabetic information.

Subscription Bus Service—Paratransit service provided by advance reservations for the same trip over a long period of time (typically a.m. and p.m. work or school trips); sometimes referred to as buspool if operating in a many-to-one or one-to-many mode.

Subscription Van Service—Service similar to that provided by a subscription bus, except that the van may be privately owned, leased from a public or private company, or provided by the employer. The driver is usually a member of the group.

System Software—See *Software, System.*

Target Population—Those persons who actually need and will likely use a specialized transportation service. This is a smaller group than *Eligible Population.*

Taxicab Service—Demand-responsive public transportation service on an exclusive basis, in a vehicle licensed to render that service; also called *Exclusive Ride Taxi* or *Taxi Service.*

TIGER Files—Files produced by the U.S. Bureau of Census that contain digital map data of the U.S. Files display basic map features, such as streets, railroads, rivers, etc.

Transfer—1. An instrument (paper, ticket, or token) issued to a passenger that allows changing from one transit vehicle to another, according to certain rules. 2. Moving between vehicles to complete a trip.

Transit-Dependent—Having to rely on transit services instead of the private automobile to meet one's travel needs.

Transportation Brokerage—Coordination of transportation services in a defined area. The transportation broker often centralizes vehicle dispatch, record keeping, vehicle maintenance, etc., under contractual arrangement with agencies, municipalities, and other organizations. It is possible to serve both social service agency and general public transportation needs under the same management/operation by using the transportation broker concept.

Transportation System—1. A system that provides for the movement of people, goods, or both. 2. A coordinated system made up of one or several modes serving a common purpose, the movement of people, goods, or both.

Trip Purpose—See *Purpose, Trip.*

Trip Reservation Function—See *Reservation Function.*

UNIX—A standard operating system that operates on all sizes of computers.

Urbanized Area—Central city with population of 50,000 or more, including the surrounding closely settled area.

Vehicle Miles—The total number of miles traveled by transit vehicles in a given period of time.

Vehicle Service Hours—Total number of hours that each vehicle is available and ready to respond to trip requests, including layover time.

VGA—Video graphics display; a high-resolution video standard for IBM-compatible machines. Older standards are CGA and EGA.

VMS—Operating system for Digital Equipment Corporation.

Will-Call—Immediate response on schedule.

Window—An area of the monitor screen used to display menus, different applications, or portions of one application.

Word Processor—A program for entering, editing, and formatting text documents.

Work Station—A single-user minicomputer.

Zone—A portion of the service area specified for a particular fare charge, elimination of a fare, or service level.

ACRONYMS

ADA	Americans with Disabilities Act of 1990*
APT	Advanced public transportation*
APTA	American Public Transit Association
AVL	Automatic vehicle location*
CTA	Chicago Transit Authority
CTAA	Community Transportation Association of America
DHHS	Department of Health and Human Services, Federal
DOA	Department of Agriculture, Federal
DOS	Disk operating system*
DOT	Department of Transportation, Federal; also U.S.DOT
DRT	Demand-responsive transit*
FTA	Federal Transit Administration
GIS	Geographic information system*
IBM	International Business Machines
ITLA	International Taxicab and Livery Association
ITS	Intelligent transportation system*
IVHS	Intelligent vehicle and highway system*
LAN	Local area network*
LOS	Level of service*
MDT	Mobile data terminal*
MIT	Massachusetts Institute of Technology
NYCTA	New York City Transit Authority
OCTD	Orange County Transit District
PC	Personal computer*
RAM	Random access memory*
RF	Radio frequency
RFP	Request for proposal*
TAC	Transportation Accounting Consortium
TCRP	Transportation Cooperative Research Program
TRB	Transportation Research Board
TRIS	Transportation Research Information Services
TSC	Transportation Systems Center, U.S.DOT, Cambridge, MA
UMTA	Urban Mass Transportation Administration; previous name for the FTA
U.S.DOT	United States Department of Transportation

*See Glossary for a definition of these terms.

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APPENDIX B

VENDOR DIRECTORY

A vendor directory as submitted by the research agency is not published herein. See Table 6. 3 for sources of information on software and vendors. For information on the products, see Appendix 6-A at the end of Chapter 6.

THE TRANSPORTATION RESEARCH BOARD is a unit of the National Research Council, which serves the National Academy of Sciences and the National Academy of Engineering. It evolved in 1974 from the Highway Research Board, which was established in 1920. The TRB incorporates all former HRB activities and also performs additional functions under a broader scope involving all modes of transportation and the interactions of transportation with society. The Board's purpose is to stimulate research concerning the nature and performance of transportation systems, to disseminate the information that the research produces, and to encourage the application of appropriate research findings. The Board's program is carried out by more than 400 committees, task forces, and panels composed of more than 4,000 administrators, engineers, social scientists, attorneys, educators, and others concerned with transportation; they serve without compensation. The program is supported by state transportation and highway departments, the modal administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation.

The National Academy of Sciences is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Bruce M. Alberts is president of the National Academy of Sciences.

The National Academy of Engineering was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. William A. Wulf is interim president of the National Academy of Engineering.

The Institute of Medicine was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Kenneth I. Shine is president of the Institute of Medicine.

The National Research Council was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purpose of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Bruce M. Alberts and Dr. William A. Wulf are chairman and interim vice chairman, respectively, of the National Research Council.

Abbreviations used without definitions in TRB publications:

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