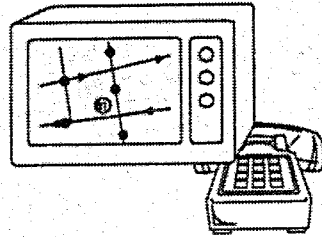


# **Choosing Smart Technologies**

## **A Guide for Busy Rural Paratransit Operators**

---

September 1996



Thanks to the following for their help in the preparation of this manual:

Technical consultant:

Don Larson, Larson Systems, Ames, Ia.

Project Advisory Committee:

John Whited, Iowa Department of Transportation

Peter Halloch, Iowa Department of Transportation

Carol Lewiston, Boone County Transportation

Tom Kane, Metropolitan Planning, Des Moines

Rick Mavis, Heartland Senior Services Inc. (Story County Transit)

Funded by the

Midwest Transportation Center

Iowa State University

Ames, Iowa, 50010-8263

Thanks also go to:

Eric Akunda

Patrick Pittenger

Himagiri Mukkamala

Anuradha Ramanathan

Madhu Midhe

Madhulika Singh

Lori Thomsen

Editor: Kim Shetter

The contents of this manual reflect the views of the authors, who are responsible for the facts and the accuracy of the information provided herein. This document is disseminated under the sponsorship of the US Department of Transportation's University Transportation Centers Program and the Iowa Department of Transportation in the interest of information exchange. The US Government and the State of Iowa assume no liability for the contents or use thereof.

# **Choosing Smart Technologies**

## **A Guide for Busy Rural Paratransit Operators**

*Prepared by*

Mary Kihl  
Michael Crum  
Duane Shin

Iowa State University

September 1, 1996

# Contents

Introduction	1
What are the Small Transit Property's Primary Needs and Concerns?	4
What Technologies can Address the Concerns of Small Paratransit Properties?	7
What Kind of Information does a Small Transit Property Need?	14
What are the Costs Involved in Acquiring Technologies?	19
Is the Technology Worth the Investment?	32
Are There Other Ways of Accessing the Technology Without Having Each Property Purchase it Individually?	49
How do we Select a Vendor or Integrator?	56
What are Possible Sources of Funds?	59
List of Acronyms	61
Bibliography	62
Appendix: Agency Technology Observations	64

# Choosing Smart Technologies

---



## Introduction

### **The demand for transit in rural areas and small towns is increasing.**

Enterprising operations have discovered demand among service-sector employees in scattered locations, children of two working parents traveling to after-school care, older residents clinging to homesteads in declining small towns, community college students, and outpatients with appointments in regional hospitals. A rural operator in Sweetwater, Wyoming, found that, with energetic marketing, ridership doubled in two years; an operator in Brazos County, Texas, noted a doubling of work-oriented trips and an operator in Rock County, Minnesota, found that children riders increased from 96 to 6,000 in 5 years while adult ridership tripled in the same period.

### **Increased ridership brings increased demands on fairly small fleets and overworked staffs.**

These challenges blunt the enthusiasm for opportunities for increased service and some expansion in revenue sources. Dedicated dispatchers who work long hours have “memo-rized the service area” can’t be replaced even for an occasional vacation, let alone sick leave or

retirement. General managers, focused on maintaining multiple sources of operating funds, have no time to test innovative techniques and service options. With almost the full fleet in operation, vehicle breakdowns wreak havoc with the schedule. Thoughts of a stranded vehicle in a remote rural location raise general alarm.

### **Innovative operators consider technology as a quick fix.**

The appeal of technologies that offer relief to dispatchers, track vehicles throughout the service area, or get a handle on vehicle maintenance, is unmistakable. Intelligent Transportation System (ITS) offers a menu of enticing options. Two technologies widely considered are Automatic Vehicle Location (AVL) which can assist in tracking all the vehicles in the fleet and dynamic scheduling which offers up-to-the minute scheduling. Enthusiasm is, however, tempered by limited funds, limited time for staff training, and no time to assess the relative advantages of the various technologies for individual operations.

### **Others are wary of the pitfalls of uninformed decisions.**

The tendency is sometimes to grasp low-cost options presented at a

technology fair, and then discover that they do not relate to other devices already in place or to postpone installation because of limited time for retraining. Storage closets collect last year's great expectations. Other properties decide to plod on with traditional overstretched system maintaining that the new technology cannot be cost effective.

---

## Choice and Decision Making

The focus is primarily upon small-town and rural operators. The expectation is that most of these operate in demand responsive mode and cover a fairly large low density service area. Preestablished schedules place some vehicles in particular communities on specific days of the week and group medical or shopping trips to larger communities follow a regular calendar. The expectation is that these systems operate with a considerable amount of regular subscription riders and that majority of riders call about 24 hours ahead to schedule trips. Last-minute trips and return pick-ups are accommodated as they can be wedged into the schedule. The assumption is also, however, that there are other general trips for the general public living in the area that are not being accommodated—regular work trips, last-minute shopping needs, personal recreational needs etc.

### Automatic Vehicle Location (AVL) or Dynamic Scheduling

The primary technologies reviewed in this manual: are dynamic scheduling and automatic vehicle location (AVL). Small town and rural transit operations are considering these two technologies as possible answers to problems related to operational efficiency and effectiveness. The hope is that one or both of these can help with:

- increasing performance
- last-minute scheduling

- limiting downtime due to maintenance problems
- reducing time in preparing reports
- coordinating transfers

Automatic Vehicle Location (AVL) is a technology used increasingly by trucking firms and larger urban bus companies to keep track of the location of their vehicles. With this aid it is possible to know within seconds the almost exact location (within 3 to 5 feet) of every vehicle. A display map frequently accompanies AVL and enables a dispatcher to watch the progress of vehicles in real time as they travel across their routes. Prolonged stops or route diversions are quickly observed. Icons representing the vehicles on the map as generally programmed to change color in case of emergency. For paratransit operations a dispatcher could easily find the location of the vehicle closest to a pick-up point and then request that driver to make the stop. Emergency help could be quickly dispatched to an exact location.

Dynamic scheduling is increasingly used by taxicab companies and paratransit operations to maintain an up-to-the-minute schedule for all the vehicles in the system. Interactive displays allow the dispatcher to change schedules to accommodate new pick-ups. Accompanying software enables the dispatcher to search for the schedule of the vehicle which is anticipated to be closest to a particular location, automatically insert the new pick-up, and make other necessary adjustments to the schedule. A networking function can assist the dispatcher in planning routes.

For regular riders, personal attributes and preferences can be associated with a name. These can impact the automatic scheduling of pick-ups. For example, a note that someone travels

This manual is intended to assist in decisions regarding smart technologies

with a wheelchair can add about 3 minutes to a pick-up. This information can also be used to advise drivers of special needs. When maps and schedules are relayed to drivers through an additional in-vehicle display on a Mobile Data Terminal (MDT), drivers automatically receive information and can adjust routes accordingly. Attributes can include billing information and can later be down loaded from the computer to assist in preparing invoices and reports.

#### **Manual sponsorship and development**

The manual is the result of a project funded by the US Department of Transportation (USDOT) and the Iowa Department of Transportation through the Midwest Transportation Center. All recommendations are, however, the responsibility of the study team.

The manual was developed based on information gained from several years of pilot tests using Automatic Vehicle Location, interviews with vendors and a substantial number of small town and rural transit operators who had acquired dynamic scheduling programs, and extensive reviews of evolving literature regarding Automatic Vehicle Location (AVL). Since many of the questions which small-town and rural operators raise relate to cost and payback time, a cost-effectiveness model is included in the manual along with some examples of possible applications. Actual experience with the application of AVL to rural or small-town service is limited, making evaluation based on existing real-world tests difficult. Hence, in generating some of the values included in the cost effectiveness model computer simulations of results of AVL applications were used along with real-world

numbers gained in interviews regarding use of dynamic scheduling programs. Also included in the manual are sections on how to select a vendor and how to find funding.

#### **Manual organization**

Managers of properties in rural areas or small towns frequently ask,

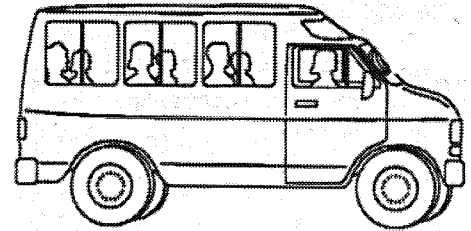
- What can technologies do for us?
- Why do we need new technology when our staff is comfortable and productive with our existing system?

This manual proposes a different set of questions. The ordering of these is important.

- What are our primary needs and concerns?
- What technologies can address those concerns?
- What kind of information does a small transit property need in acquiring technologies?
- What are the costs involved?
- Is the technology worth the investment?
- Are there other ways of accessing the technology without having each property purchase it individually?
- How do we select a vendor or integrator?
- What are possible funding sources?

These questions provide the organization for the manual. It steps through each of those questions as they relate to transit systems operating in rural areas or in small towns and hence provides a framework for decision making. Hopefully, transit properties will consider each of these questions before making a hasty decision regarding applications of smart technology.

# What Are Small Transit Properties' Primary Needs and Concerns?



## Rural Transit Systems Described

The majority of rural transit systems, particularly in the Midwest, operate in demand-responsive mode or in a type of route diversion in which the vehicles run in specific towns on specific days of the week. Most systems are small. The national average for community transportation systems is six vehicles and, although the fleet size is increasing, only 31 percent of all rural systems operate more than ten vehicles. Two thirds of the vehicles are vans or small buses. A survey conducted by Community Transportation Association (CTA) indicated that nearly half of the fleet has exceeded its life expectancy. The average vehicle travels 20,000 miles a year. Among Section 18 subsidized systems, 52 percent operate within a county, 21 percent are multi-county operations and 26 percent operate within towns or cities. A growing trend is toward coordinated regional transit systems. These have the advantage of a common flow through for state and federal funds and common purchasing for a set of rural counties while retaining the day-to-day operations of each individual system within the respective counties. The average rural county public transit operation

employs the equivalent of eleven full-time equivalency (FTE) employees, while the smallest agencies operate with only four FTE's and only two of these full time. One-fourth of all the people involved in operation of the Section 18 network are volunteers. (USDOT, FTA Status Report on Public Transportation in Rural America 1994).

Such operations differ markedly from the typical fixed-route operation in urban centers. Most operate demand-responsive systems with 24-hour advance reservations. Many have a heavy proportion of subscription riders.

## The Needs of Rural Transit Properties

The systems also differ among themselves. However, as the following list indicates, there are some common concerns.

*The need to increase service while not expanding the administrative budget*

- maximize the opportunities to hire part time and hourly workers
- limit worker stress, particularly among dispatchers

*The need to increase vehicle operating efficiency*

- increase vehicle performance
- regularize maintenance schedules

- anticipate problems requiring vehicle down time

*The need to increase operational effectiveness*

- respond to the needs of “will call” patrons
- increase the number of non-subscription riders
- permit real-time trip insertions
- reduce the time needed to schedule a trip
- reduce response time
- assure driver schedule adherence
- respond to the challenges of the Americans with Disabilities Act (ADA)
- permit interline transfers
- enable schedule adjustments

**Prioritizing Objectives and Needs**

Priorities differ among properties given the wide variation among rural transit systems in terms of size and extent of operation, nature of ridership, and even proximity to urban areas. For example, the following have been identified as primary concerns by paratransit providers:

- Difficulty in reaching drivers by radio in dead spots. (Wichita Kansas)
- Tracking Vehicle Maintenance (Boone County, IA, Transit Madison County Services)
- Assistance with dispatching demand-response calls (Heartland Senior Services, Ames, IA)
- Assistance with billing and reports (Wichita Transit Authority)
- Street supervision of drivers (Heartland Senior Services, Ames, IA)
- Increasing Ridership (Mayflower Contract Services, Rancho Cucamonga, CA)

Before making any decisions on the need for advanced technology, it is important that a rural carrier con-

duct a self assessment. What might be an ideal solution for one system might not be appropriate in another property in a neighboring county. Differences depend in part upon population characteristics and density in the service area, funds available, opportunities for trip destinations, experience and expectations regarding the system, and enthusiasm, experience, and creativity of the staff and general manager.

**Changing Expectations for Paratransit Software**

The contrast between the static type of data currently generated by demand-responsive transit software and the desire for dynamic, interactive software is apparent in the following summaries of results of a survey of 78 small transit providers conducted by Systan, Inc. in 1995.

**Current Reality**

*Ten software features most commonly used by demand-responsive transit properties are*

- Automatic retrieval of passenger data
- Recent ridership history
- Multi-user reservations
- Automatic rider eligibility check
- Name and address lists
- Geocoded addresses
- Keyword sort
- List of frequent destinations
- Manual override of computer generated schedule
- Name recognition of common places.

**Future Interests**

*Ten features more commonly desired by paratransit properties are*

- Fully computerized scheduling and dispatching
- Trip eligibility for ADA trips
- Vehicle location displayed on layered maps
- Answering “what if” questions
- Simulation training exercises

- Choice of performance criteria
- Online time of pick-up estimates
- Redundant reservation warning
- Problem passenger warning.

*When choosing the software, among the primary considerations are:*

- service requirements and expectations
- the extent of the service area and population density
- the technical ability of the dispatch and maintenance staffs
- the size of the transit system
- the data collection requirements
- the funding level available

### **Service Requirements and Expectations**

Properties with a fixed set of subscription riders would, for example, have less need to insert trips in real time than those that are serving a broad segment of the general public with a wide variety of trip purposes. Complementary paratransit operations trying to respond to the requirements of the ADA would have more pressure to respond to the needs of eligible clients within 24 hours than other completely demand-responsive rural operations.

### **Variation in Population Density**

Large sparsely settled service areas offer very different challenges than rather densely populated exurban areas. The potential for increased ridership with minor improvements in increases in efficiency are greater when density levels are higher and geographic area served is smaller. Multi-county operations offer additional levels of complexity both in extent of area served and in coordination of services.

### **Experience of Staff with Computers**

When a staff includes someone who is comfortable working with computer hardware, the possibilities for refin-

ing a system and offering training in-house are certainly possible. For other properties, the level of training provided with any acquisition of technology is absolutely essential. Access to a highly trained maintenance staff that is familiar with computer applications can make a major difference for a property considering AVL. The overall enthusiasm and inquisitiveness of the staff, especially the dispatcher, is critical to insuring a successful application. Without this key factor, the new technology will not even emerge from the box it came in.

### **Fleet size**

Much has been written about the importance of fleet size in terms of viability for acquiring advanced technology. Economies of scale certainly are an issue. There are, however, other factors of importance. This manual will discuss this issue farther.

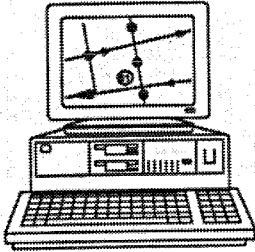
### **Reporting Requirements**

All public transit systems have extensive reporting requirements. The type and quality of data needed to fill in these reports is a major factor in selecting a technology. A wise decision can short cut hours of report preparation, while an unwise decision can result in staff that are overwhelmed with mountains of data that they don't know how to use.

### **Funding Level**

Funding is critical. Properties that have access to flexible funding can invest in high-quality technology that will ultimately streamline their operation. Others may be tempted to go with lower-cost options that may take hours of staff time to use effectively. Cost is not an ultimate determiner of quality, but it is important not to be quickly convinced that a bargain solution will "do the job."

# What Technologies Can Address The Concerns of Small Paratransit Properties?



## Real-Time Systems: AVL or Dynamic Scheduling

Most of the transit needs noted above can be addressed by AVL, which can track and report the location of all vehicles in the fleet as frequently as every other second. Vehicle locations are accurately reported in real time. Emergency vehicles or replacement vehicles can be directly dispatched on a moment's notice. Add-on sensors can also monitor the engine in real time and communicate those reports to the base station. With the aid of a real-time display map generated by an AVL system, trips can be inserted by the dispatcher and directly posted to the closest vehicle.

Dynamic scheduling also addresses many of these needs, at a somewhat lower cost. With the added features that distinguish dynamic scheduling from computer-assisted scheduling, drivers can geocode pick-ups and drop-offs and dispatchers can follow the progress of vehicles in terms of stops performed. Associated maps allow dispatchers to verify and note locations associated with stops or addresses of trip requesters. Trips can be scheduled and routed automatically. With add-on mobile data terminals (MDT) (small in-vehicle computers linked to the base station),

updated routes can be conveyed directly to drivers. The less costly MDT's convey messages in code while the more elaborate MDT's include a map showing optimal path routing.

### *Getting by with downloading data overnight*

If a property only needs to monitor its fleet and is content with information that is stored during the day and downloaded at night, it can probably manage with a simple fleet monitoring system. That involves an on-board computer that monitors vehicle performance. When the vehicle is in the garage overnight, the individual on-board computers can be probed and data transferred to a single base computer for analysis. Although alerts are not given in real time, areas for concern are marked and stand out when the data is analyzed. This can alert the staff about vehicles needing attention. Fleet management systems can also provide some information on drivers—consistency of performance, driving speed, etc. This approach provides no assistance with scheduling or tracking the fleet.

---

## **AVL systems can address the majority of concerns of small town and rural operators**

**AVL  
pinpoints  
vehicle  
location in  
real time**

### **AVL Systems can:**

- accurately pinpoint the locations of available vehicles in real time
- monitors vehicle schedule adherence
- reports real-time precise locations for emergency distress calls and vehicle breakdowns
- assists in on-time transfer.
- with an add-on Geographic Information System (GIS) display map, display real-time locations at the central dispatching office
- with on-board real-time display maps, enable drivers to adjust routes and insert "will call" pick-ups and schedule transfers
- with add-on vehicle performance monitoring, report vehicle condition in real time to dispatch
- with add-on enunciator it can announce key stops as required by ADA

### **Global Positioning (GPS)**

Most cities that are considering AVL systems for their transit systems are focusing on Global Positioning Systems (GPS) as the preferred approach to vehicle tracking. GPS functions by mounting receivers on vehicles. When each of these receivers "locks onto" at least three satellites, it confirms the vehicle's location using triangulation. The Defense Department has 21 satellites available for civilian use and usually four or five satellites are within range of any location. The additional satellites help to confirm the position of the vehicle. The exact real-time location is then communicated to the base station by radio. Systems are now typically building in a "differential correction" feature for GPS. The Defense Department frequently scrambles the signals sent out from its satellites, but transit systems can use differential correction to compensate for this scrambling by relating the recorded position to a standard location point. With differential correction the location of a moving vehicle can be pinpointed within three to five feet.

### **Display systems**

For paratransit systems, knowing the real-time location of all the vehicles in the fleet can help update a schedule, monitor the progress of the vehicles, indicate proximity to a transfer point, or determine exact location of the various vehicles vis a vis an inserted pick-up point. An additional alarm feature can alert a dispatcher to an emergency on board. Help can be quickly dispatched to the exact location even to a van broken down on a rural road in the midst of a snow storm. Another add-on can monitor the vehicle itself in real time and alert the dispatcher to problems before the vehicle actually breaks down.

### **Geographic Information Systems (GIS)**

The movement of the various vehicles can be displayed on a map back at the base station. This display helps the dispatcher note the exact location of all vehicles and determine which vehicle can most effectively pick up a last-minute caller. Map display software using Geographic Information Systems GIS programs are accurate and synchronized with the tracking GPS system. A number of GIS software packages provide user friendly menus to assist the dispatcher in following the path of a vehicle. Advanced GIS programs also propose an optimum route for the vehicle. Drivers can either be notified of route changes by radio or by using an on-board Mobile Data Terminal (MDT) which operates as a small on-board computer.

### **Reporting**

All AVL systems compile reports on performance and historical records regarding the progress of each vehicle. If needed, the exact location of a vehicle at any point in time can be verified.

## Dynamic Scheduling

Dynamic Scheduling is time-specific, rather than location-specific like AVL. Unlike AVL, it does not report the actual location of the vehicle, but rather it approximates the vehicle's location based on estimated travel time between points. Nevertheless, it addresses many needs of paratransit operators.

### Functions of Dynamic Scheduling Software

- inserts trips in near real time (as soon as a driver can be notified and respond)
- with add-on in-vehicle MDT's, immediately updates drivers on revised schedules and routes
- networks pick-ups and drop-offs automatically using the shortest path determined by preset parameters
- automatically updates transfer times which can then be reported to drivers by voice radio, cellular phone, or MDT's
- assists in monitoring schedule adherence and identifying slack time through downloaded reports

Dynamic scheduling automatically builds routes in real time

### Computer databanks serve as responsive address files

Computer databank systems are now being used increasingly by small paratransit properties to log names, addresses and attributes of regular clients. These same computer systems assist with client verification, record keeping, and billing. While these programs can assist the dispatcher in building schedules, the scheduling process (matching vehicles and trip requests) is still completed manually by most dispatchers for small paratransit operations. The complexity of this process generally necessitates at least a 24-hour advance trip request. Schedules are then developed overnight and distributed to the drivers. Inserting last-minute stops into these prearranged schedules is difficult.

### Computer scheduling programs operate with varying levels of automation.

Computer scheduling programs greatly enhance the function of the data bank. The level of automation in scheduling and dispatch ranges from minimal to fully automated. The lowest level of automation, computer-assisted scheduling and dispatch, involves building schedules for vehicles which are then dispatched manually. Any changes required by trip cancellations or additions are made manually. The next level of automation (dynamic scheduling) involves software that has the capability to modify the schedules and routes in real time. Schedules can be built practically automatically from a preexisting databank and last-minute trips can be inserted in near real time with the schedules adjusted as needed. This technology is widely used by taxicab companies and is increasingly being incorporated by paratransit operations as well.

Scheduling trips for paratransit operations is more complex than for taxi cab companies given the shared-ride nature of the trips. Nevertheless, several vendors have developed dynamic scheduling software specifically focused on paratransit. Several of these will be discussed later in the manual.

### Dynamic scheduling automatically inserts requested pick-ups into established routes

Dynamic scheduling programs do not, in themselves, provide real-time tracking of individual paratransit vehicles. They derive vehicle location based on the typical travel times between nodes that have been previously geocoded. The call-taker enters the name, telephone number and any special needs of the traveler into the computer which then scans the

schedule to find the vehicle which should be closest to the pick-up point. The closest driver is notified by radio, cellular phone or via an in-vehicle mobile data terminal (MDT). Some dynamic scheduling programs include a networking function that plots the anticipated quickest path between the points identified by the caller. The new route can be either relayed to the driver or the driver could generate such a route himself or herself if the vehicle were equipped with a MDT with mapping capability. Drivers can report to base using standard message codes following each pick-up. This permits the dispatcher to correct for any variation between anticipated and actual trip travel time.

#### **Record Keeping**

Records stored in the on-board computer can later be probed and for record keeping, billing or to review driver performance. Since it is focused exclusively on scheduling, this technology cannot answer direct questions regarding vehicle performance.

#### **Fleet Management**

Widely used in the trucking industry, fleet management provides accurate, dependable information on vehicle performance. When combined with AVL, it can provide real-time readings on vehicle performance.

It is, however, not a substitute for either of the technologies that can assist with scheduling or vehicle tracking. With fleet management, data is logged during trips and downloaded when the vehicle returns to base. Although this does not provide real-time tracking, the reports contain sufficient information to schedule preventative maintenance and assess driver performance relative to others with similar routes and similar vehicles.

Fuel analysis reports monitor fuel consumption. For truckers, the reports are easy to read and can be collected over time to show trends and long-term performance summaries. The same kinds of information can be valuable for small rural demand-responsive operations that are managed without an in-house maintenance staff. Data is gathered by on-board sensors and downloaded to a computer at the base station. They are then analyzed by off-the-shelf software programs and presented in easy-to-read graphics. Such technology could assist a rural system in anticipating maintenance problems and help reduce possible breakdown in remote areas. If desired, fleet management systems can be linked with AVL systems to convey information on vehicle performance in real time.

While answering concerns about vehicles, this technology cannot, in itself, track vehicles or affect trip scheduling.

## Combination systems

Integrating dynamic scheduling with AVL maximizes the advantages achieved with each of the other technologies. Real-time vehicle locational information gained from AVL directly informs trip scheduling.

A combined system offers the opportunity to increase efficiency of operation along with more responsive scheduling.

- Trips are inserted in real time.
- With GIS display maps at the base station, exact location of vehicles is pinpointed.
- Schedules are automatically updated to accommodate real-time insertions or cancellations.
- Vehicle schedule adherence is monitored in real time.
- Precise locations of emergency distress calls and vehicle breakdowns are monitored.
- On-time transfer is assisted.
- With on-board real-time display maps, enable drivers can adjust routes and insert "will call" pick-ups and schedule transfers.
- With add-on vehicle performance monitoring, vehicle condition is reported in real time to dispatch.
- Precise trip data is available for analysis.

### Turnkey Linkage Program not yet Reality

At the current time, however, the computer software that will link these two technologies must be individually developed specifically for each property. Although the basic software needed to link a scheduling program with a GPS tracking program is not complex to develop, there is no turnkey product available. This has clear implications for cost.

### Systems Experimenting with Linkage

The *Advanced Public Transportation Systems, Update '96* reports plans of the Suburban Mobility Authority for Regional Transportation (SMART) paratransit system in Detroit, Michigan, to link AVL with scheduling software produced by Trapeze Software (formerly UMA Systems) TRAPEZE-QV. Community Transit of Delaware County, Pennsylvania, is implementing a sophisticated scheduling and software customized by Rides Unlimited from Paratransit Systems International, Inc. This is linked with MDT's in the vehicles through radio frequency communication. This will minimize the effect of no-shows and cancellations by immediately adjusting the schedule.

This system will also incorporate "smart card" identifiers for the regular passengers. This will assist in verifying trip eligibility and assist in billing multiple sponsors.

A combined system offers the opportunity to increase efficiency of operation along with more responsive scheduling

---

## Assessment

Since costs for these technologies differ considerably, it is critical for a property to assess priorities in the light of realistic expectations regarding the relative benefits to be derived from these different technologies. As Table 1 points out, neither scheduling nor tracking programs will alone address the full range of needs identified by demand-responsive operations. Scheduling programs cannot tell the dispatcher where the vehicles really are as they travel along the highway. They base schedule revisions on expected locations of vehicles given past experience. Vehicle locations can be updated by geocoding the locations of drivers calling back to base after each pick-up.

AVL tracking programs can pinpoint the exact location of a vehicle in real time. The display map associated with an AVL tracking program can greatly assist a dispatcher in scheduling. The dispatcher can observe which vehicle is actually closest to a caller. It is up to the dispatcher to notify the driver of the inserted pick-up. AVL also provides precise information on driver performance and overall systems performance. As an added feature, advanced tracking programs can also monitor the condition of vehicles and report their condition in real time.

Lower-cost independent fleet management programs monitor the condition of each vehicle and can assist in preplanning maintenance and in logging the condition of vehicles.

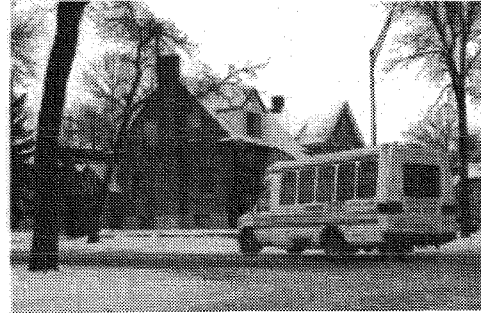
Since data recorded is typically downloaded back at the base station, they do not offer a real-time alert. They would, however, respond to the expressed need of a small operation that finds it difficult to monitor its fleet.

In choosing a technology, it is also important to select programs and packages that can be augmented later with additional features and needs and funding availability change. A combined system may be an ultimate goal, but funding may require an incremental approach. It is essential to select products that will allow adding on other features at a later date.

**Table 1: Does Technology Meet Needs Identified by Rural Transit Operators?**

<i>Needs of Paratransit</i>	<i>Need Met by Scheduling?</i>	<i>Need met by AVL?</i>
maximize opportunity to hire part-time workers	yes, call takers can be employed instead of multiple dispatchers	limited impact
limit worker stress	yes, greatly reduces time spent in scheduling	yes, full knowledge of fleet relaxes anxiety
increase vehicle performance	minimal impact	yes, tracking provides opportunity to improve performance
regularize maintenance schedules	no impact	add-ons do track vehicle operation
anticipate problems requiring down time	no impact	add-ons do track vehicle operation
respond to needs of "will call" patrons	yes, automatically, a major benefit of system	yes with help of dispatcher
increase number of nonsubscription riders	yes, impromptu trips can be accommodated	yes with help of dispatcher
permit real-time trip insertions	yes, easily	yes with help of dispatcher
reduce time to schedule trips	yes, major reduction in scheduling time	some decrease in scheduling time, particularly same-day scheduling
reduce response time	yes, some improvement	yes, major improvement
assure driver schedule adherence	yes, with help of driver call in	yes, a major benefit
respond to ADA	can track eligibility and special needs	yes, add-on enunciator can announce major intersections
permit interline transfers	limited help	major assistance in this area
enable schedule adjustments	yes, automatic updates possible	yes, adjustments possible after analyzing data.

# What kind of information does a small transit property need?



What kind of information does a small transit property need? When a transit agency is investigating the purchase or lease of a dynamic scheduling and/or AVL system, it often must upgrade its computer system, both the hardware and the software. Some smaller transit agencies may be looking at moving from a total manual system to computerization. In either case, the agency should give considerable thought to its more general information needs. Most of the vendors that offer the smart technologies for transit operations also offer more general management information systems capabilities. Some will also offer the option of developing a system tailored for the transit operator.

functions saves time, improves accuracy and frees staff for more productive work. Second, improved and more timely operating data allows the transit agency to measure and increase its operating efficiency or productivity and service effectiveness.

Before identifying and discussing accounting/financial and operations information systems, a general overview of management information systems is provided.

---

## Management Information Needs

The purpose of this section is to provide a discussion of the general and fundamental management information needs for a small transit operation. Two general categories of information will be addressed:

- accounting/financial information
- operating information.

Computer technology provides important benefits to the agency in these areas. First, the ability to automate numerous accounting

## Management Information Systems (MIS)

A management information system (MIS) is one that provides information required to support management decision making. In an environment of rapid change management requires the production and accumulation of selective, strategic information and knowledge that support its decision-making responsibilities.

Information systems and computer usage seem to develop through three distinct stages:

- (1) Record keeping
- (2) Operations
- (3) Strategic planning.

### Key Benefits

The corresponding key benefits and time frame for attaining benefits for a transit operation are:

- Reduced costs (mainly clerical), improved speed, and accuracy: payoff occurring immediately if system is working and effective
- Improved service, improved vehicle and employee scheduling and control, and reduced cost of operation: payoff occurring in one to three years
- Improved information, forecasting and decision -making: payoff occurring in five to ten years.

### Computer Applications

Computers and information systems can be applied in all the functional and activity areas of a business: marketing (e.g., sales forecasting and analysis, marketing planning, product management, etc.), finance (e.g., financial planning and budgeting, cash management, credit management, etc.), personnel (e.g., payroll, labor analysis, training and development analysis), production/operations (e.g., equipment and personnel scheduling, maintenance scheduling, operating control systems, inventory or parts management, etc.), accounting (e.g., general ledger accounting,

accounts payable/receivable, cost and tax accounting, etc.), and other activities (e.g., strategic planning, research and development, operations research, purchasing, etc.).

For small transit operations the accounting/financial information systems and operations information systems represent fundamental areas where automation can generate significant efficiencies. They are discussed in depth below.

### Accounting and Financial Information

Accounting information systems include: operational accounting, management accounting, property accounting, cost accounting, tax accounting, and budgeting. Financial information systems include: cash management, portfolio management, credit management, capital budgeting, financial forecasting, financial requirements, and performance analysis.

### Personnel Information

Another important information set that links directly to both accounting/financial information systems and operations information systems concerns personnel data. Personnel information systems include: personnel record-keeping, employee skills inventory, training and development analysis, compensation analysis, payroll and labor analysis, and personnel requirements forecasting.

### Primary Output

The primary data files and the reports or output are:

*Accounts Receivable:* a record of money owed, to stimulate prompt payments from timely and accurate statements: provides management with information to control credit and expedite collection. The output includes:

Information systems and computer usage seem to develop through three distinct stages:

- 1) record-keeping
- 2) operations
- 3) strategic planning

- daily register of invoices
- daily record of adjustments and cash receipts
- preparation of customer statements
- summaries of due and post-due accounts
- balance reports for collection expedition where necessary (delinquency notices are also given)
- charts of accounts
- trial balance sheet
- income and expense analysis reports.
- year-end financial statements

*Accounts Payable:* a record of money the business owes to elicit prompt payments and consequently good relations; management derives information for decisions on payments, expenses, purchases and cash requirements. The output includes:

- the accounts payable transaction register
- payment checks
- cash disbursements reports
- cash requirements reports (unpaid vouchers and/or invoices)
- purchase analysis reports
- accounts payable summary data
- lists of vendors' names, addresses, purchases and paid items

*Payroll:* the database is the regularly updated payroll master file whose inputs are time cards, attendance records, employee compensation and payroll adjustments; necessary for prompt, accurate employee payment and reporting to management, employees and agencies. The output includes:

- payroll transactions and data summary
- earning statements
- paychecks
- tax reports (including W-2 and other tax forms preparation)
- labor analysis reports
- report on vacations, holidays, sick days

*General ledger:* a consolidator of information from all modules above.

- Outputs include:
- transaction lists

### **Operations Information Systems**

The type of operating data that is needed is determined by the productivity or efficiency measurements and standards utilized by the transit agency as well as its service standards. The smart technologies usually accumulate such data. The transit agency should specify the format and aggregation level (e.g., by vehicle or vehicle-type; by time period—hourly, daily, weekly, monthly, per year; by passenger-type—subscription, will call, reservation; by service type—fixed route, paratransit, ADA, door-to-door, curb-to-curb) of these data to the information systems vendor as some customization of the software is often required.

*Examples of performance and productivity measures include:*

#### **Performance Standards**

- passengers per hour
- ride time
- passengers per mile
- complaints
- wait time
- road calls
- wait time deviation
- on-time performance
- accidents

#### **Productivity Measures**

- cost per revenue hour
- miles per gallon of fuel
- cost per revenue mile
- cost per vehicle mile
- cost per passenger
- cost per vehicle hour
- miles between road calls
- average no. vehicles scheduled per hour
- miles between accidents
- passengers per revenue hour

- maintenance cost per vehicle mile or vehicle hour
- passengers per revenue mile

#### Operating Data

- total operating cost
- number of ADA riders
- vehicle miles
- number of shared rides
- revenue miles
- number of single rides
- vehicle hours
- cancellations/no-shows
- revenue hours
- one-way trips
- fuel consumption
- round trips
- maintenance cost
- booked trips
- number of riders
- will calls

The key point is that each transit operator must identify the performance measures and standards that are used to evaluate and control his or her system and determine the type and level of data that are needed to construct these measures.

#### Technology Types and Considerations

Choice of the appropriate technology is frequently based on advice from friends and business associates, computer magazines, and computer salespersons. Accounting firms are also valuable guides to procurement of software appropriate to specific business needs.

Software can be bought off-the-shelf or customized. There are multiple off-the-shelf software packages available for accounting and data management. Future as well as immediate needs of the firm should influence one's choice of software.

Some considerations in choosing a system include:

- the cost of installation and training (over and above the purchase cost of the software/hardware)
- length of training required (long training may create or indicate problems)
- system limitations
- system flexibility (easy to make changes? compatibility with other systems?)
- ease of use (menu-driven?)
- system security and reliability
- system capacity (can system accommodate present and future needs?)
- documentation on use of system (including description of files, trouble shooting information and explanation of error messages)
- post-purchase support (in the form of hotline, training and seminars, upgrades/revisions at low cost)

For a small transit operation the issue often revolves around selecting a variety of software programs which can address these various needs or trying to meet several needs with a single purchase.

Some of the more popular off-the-shelf software packages include:

#### Accounting Software

- Quicken
- Managing your money
- Dac Easy
- Great Plains accounting
- SBT VisionPoint
- Quickbooks
- Business Works
- Peachtree Accounting

#### Payroll Software

- Abrapay
- CBS payroll software
- Bass Payroll system
- Protym Systems

**Too much data can overwhelm while just enough good data can move an agency to new levels of efficiency**

It is easy to become inundated with data or to underuse aspects of software that can offer considerable time savings. Report generation then becomes a time consuming task of sifting through piles of data to find the relevant measures for reports. One additional time consuming task is data entry. With overstretched employees who are absorbed in day to day functioning of an operation it is tempting to put off data entry until the report is almost due or the invoices must be sent out.

#### **MIS with dynamic scheduling and AVL**

With dynamic scheduling programs much of the relevant accounting and financial information as well as operations information is entered into the system at the same time as trips are scheduled. Personal attributes of riders include invoicing information and that is automatically logged at the same time as the trip is scheduled. Operating data is also readily retrievable at the end of each day or compiled over a reporting period. This data can then be associated with standard productivity measures. All operators who had acquired dynamic scheduling remarked about reduction in time spent in report preparation.

The software associated with an AVL tracking system is also most capable in generating an oversupply of data. It can automatically provide up-to-the-minute detail regarding vehicle performance which can then be stored and compiled during regular reporting periods, and associated with standard productivity measures. AVL software does not, however, record information associated with passengers. Although some cities are experimenting with attaching passenger counters to the AVL equipped vehicles, that is not a typical option. What is possible, however, is to issue

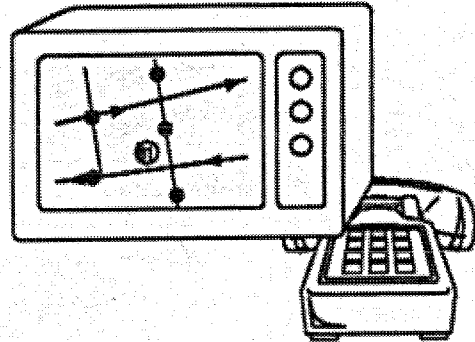
smart cards, ID cards with computer chips including personal attributes such as invoicing information. The card reader for these smart cards could be programmed to note the exact GPS location of the vehicle as each passenger boards the bus. This combination will provide performance data associated with passenger travel.

The lower cost fleet master can also supply needed information on vehicle operation. In fact, that is its major function.

It is essential to know whether accounting software can accept data in the form supplied by the selected smart software package. Otherwise time saved in data collection can be lost in data transcription.

Neither dynamic scheduling nor AVL can assist with personnel information or payroll generation. Monitoring driver performance is a function of AVL, but that information is more valuable in job assignment and performance reviews than in payroll generation.

# What are the Costs Involved in Acquiring Technologies?



There is no simple answer to this complex question. Since advanced technologies require customization, no off-the-shelf cost estimate is possible. Even if it were, it would no doubt need considerable adjustment given the wide variety of small demand-responsive properties that might be considering applications. What is most appropriate in one setting would be an unfortunate expenditure of funds in another.

*Rural transit operations differ significantly in terms of:*

- area and population density served
- mix of service types
- rider characteristics and purposes served
- size and composition of the fleet
- size and experience of the staff
- existing maintenance programs
- proximity to other service areas
- funding level available

The following sections offer a range of costs and a set of parameters that individual properties can consider in light of their own unique attributes. A discussion of how to determine level of benefits or payback follows.

## AVL

Rural systems are just beginning to experience the benefits of AVL

Application of AVL to rural paratransit operations is still in the initial phases. Some properties, such as that in Santa Clara County in California, are moving ahead with installation of an AVL system that will interface with the current scheduling program. SMART in Southeastern Michigan has an AVL system that is being integrated with its scheduling system. Smart DART near Minneapolis is moving ahead with plans to install AVL to complement their scheduling program. More often, however, AVL is installed on paratransit operations linked with an urban bus system. For example, Des Moines now has GPS AVL installed on its paratransit fleet. In Houston, Texas, a radio-location, subscriber-based AVL system is installed on all 153 of its paratransit vehicles. Plans are also proceeding for a shared system in Cedar Falls, Iowa. This GPS system, being developed by Rockwell, will serve emergency services in Cedar Rapids and the Cedar Rapids fixed route bus system, but it will also include the LIFTS paratransit operation in Linn County. Experimental applications demon-

strate that AVL can be successfully installed in independent rural transit operations. For example, the Sonoma County paratransit system, near Santa Rosa, California, has two buses equipped with GPS to help monitor schedule adherence. In Boone, Iowa, a similar limited experiment helped locate vehicles that might be ready to handle will-call pick-ups. The ARTIC project in rural Minnesota will ultimately provide an AVL system for a large geographic region in the northern part of the state. It will be shared by the rural transit operation and emergency systems providers.

*Why are there still limited examples of applications to rural systems?*

- Questions about benefits to rural demand responsive systems
- Concerns about costs

### Benefits of AVL

The benefits to rural systems are not widely known. Much of the discussion regarding AVL has focused on schedule adherence and transfer, which are of critical importance to an urban fixed-route system. Those issues seem less relevant to demand-responsive

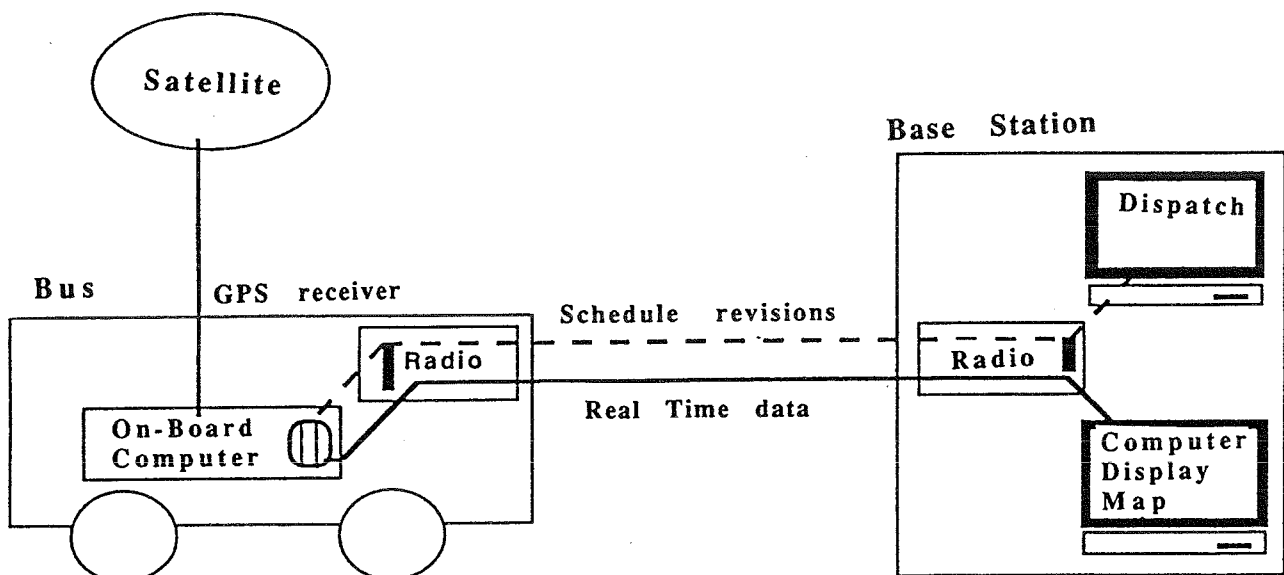


Fig. 1: GPS - Tracking Model

systems in rural areas that serve primarily regular subscription riders. Rural operations are more interested in monitoring vehicle location for safety reasons and for inserting trips as needed. Strict schedule adherence is less relevant.

#### **Cost Concerns are Key**

The primary reason for a limited number of applications is, however, concern about costs. There is no simple answer to this complex issue. Since advanced technologies require customization, no off-the-shelf cost estimate is possible. Even if it were possible, it would need considerable adjustment given the wide variety of small demand-responsive properties that might be considering applications. What is appropriate in one setting is an unfortunate expenditure of funds in another.

In general, when AVL was initially being installed in large urban systems, costs seemed prohibitive. Now, however, with the technology more readily available, costs are declining. More rural systems are considering AVL.

#### **Assumptions**

Although there are a variety of approaches to AVL, the one that seems most generally applicable to rural areas is GPS.

Sign-post technology, which monitors vehicles as they pass fixed beacons, has been widely used in urban areas, but would not be appropriate for the flexible routing and wide area covered by rural transit systems. Rural systems do not usually have access to a ground-based system using radio towers. That approach has been helpful for small transit properties in urban areas that buy subscriptions from private companies that monitor vehicles of a variety of different unrelated firms.

Hence the assumption is that rural transit properties will be using GPS. The discussion also is focused on a fifteen-vehicle fleet, the size frequently found in rural county-wide systems.

#### **System Components**

The diagram in figure 1 provides an overview of the system involved. The basic concept involves the following steps.

- The moving vehicle receives GPS signals via its GPS receiver
- A simple on-board computer processes the stream of data received
- Those processed signals are conveyed to the base station via a radio
- Signals are retrieved at the base station via a matching radio unit (with antenna, radio and modem)
- The data is conveyed to a host computer at the base station at predetermined intervals
- The host computer extracts the latitude and longitude of each point from the long stream of data conveyed in the GPS file and converts latitude/longitude into their respective XY coordinates
- The XY coordinates are read into a Geographic Information System software program that shows the points on the display screen
- The dispatcher observes the display, performs a network program and assigns additional trips to the appropriate vehicles
- Requests for new pick-ups and revised schedules can be relayed to the drivers either by voice radio or a Mobile Data Terminal which can also show relay maps of revised routed or other key information regarding the new passenger's needs.

The more costly on-board computers that fixed route systems use to insure up to the second schedule accuracy are generally not essential for rural demand-responsive systems.

**With dynamic scheduling, the greatest benefit is reduction of stress in the office**

### *Base station*

The base station where the dispatcher sits should be equipped with:

- A computer work station with the capabilities of a Pentium processor. With two colored monitors one can provide an overview map of the entire system while the other can zoom in on particular trouble points. This setup will work well with MapInfo and some other mapping software. Other more powerful GIS mapping programs, such as InfoCAD, require a separate Windows NT computer workstation.
- GPS receivers range in price from about \$2,000 to about \$6,000, depending on the strength of the instrument. For a small fifteen-vehicle fleet, the lower cost option should be satisfactory. These do need to be compatible with the GPS receivers in the vehicles.
- Radios vary widely in cost and features. They form the hub of the communication link and considerable discussion surrounds the selection of the radio. A digital radio is preferred, but more costly than the analog radios currently used to monitor the fleet. If an analog (voice) radio is used, vehicle location packets will need to be received in between conversations with the drivers. A data radio tied into an existing communication network is the least costly option.
- The laser printer prints reports and schedules.
- A differential GPS base station with an interface to the radio is increasingly important. It enables the dispatcher to correct for the system scrambling injected by the US Department of Defense, which owns the GPS satellites.
- An uninterrupted power supply maintains the tracking even if there is a power failure.

- GIS (Geographic Information System). GIS is optional, but it provides the display map that transit operators expect will show vehicle tracking. The figure of \$1,500 for a GIS site license is sufficient for a choice of software, as Table 2 indicates. Table 2 compares several different characteristics of different GIS programs.
- Installation is a key element. The integrator must install the system and provide training in how to use it.

### *In-vehicle equipment*

The onboard equipment in each vehicle parallels that in the base station:

- a receiver and a processor are sufficient to receive data on positions and relay those to the base station.
- A digital radio is important in one-way communication to the base station regarding position.
- The optional MDT, is a small onboard computer that enables the base station to communicate directly with the vehicle. The cost and quality of MDT's vary considerably. Some have a one-line display with room for codes relating to frequent messages; others have two-line displays, and some even display maps indicating optimum routes for pick-ups. Any MDT's will require two-way communication, necessitating a more powerful radio connection.
- Again, installation is important.

**Table 2: Capabilities of various GIS software systems**

<b>Software/ Function</b>	<b>ArcCAD/ ArcView 2.0</b>	<b>AtlasGIS</b>	<b>InfoCAD Desktop</b>	<b>MapGraphix</b>	<b>MicroGDS</b>
<b>Map Conversion</b>	Digitize directly in AutoCAD	Digitize directly. Import TIGER, DIME and ASCII.	Digitize in AutoCAD and import readily with DXF	Digitize directly or import AutoCAD	Digitize in AutoCAD and import readily with DXF
<b>Computer- Aided Design (CAD)</b>	AutoCAD is the leader and the access to ArcInfo	Limited capability, but satisfactory for municipal map	Precise coordinate geometry and powerful drafting	Excellent drafting in user-friendly environment	Dependent upon imported maps
<b>Data Base (DB)</b>	Limited internal DB, but imports to DBaseIV and others with new release	Internal DB and imports Excel, Lotus and ASCII files	Internal DB is robust and easily accessed	No internal DB. Live link to 4th Dimension or Fox Pro with full RDBMS	Internal DB supplemented with a live link to Excel, Lotus and MSWord
<b>Standard Query Lan- guage (SQL)</b>	Full Boolean capability	Full Boolean capability in a query builder	Full Boolean capability in a query builder	Outside in the RDBMS	Full Boolean capability
<b>Thematic Mapping</b>	Strength from the CAD base, but not the best. Potential use of ArcView 2.0 is superb.	Designed as a desktop mapping program to excel in this realm	Excellent theme builder, but awkward output process	Layered system with Zoom capability permits quick map products	Excellent theme builder, but awkward output process
<b>Operating System (OS)</b>	DOS	DOS	Windows NT	MacOS	Windows NT
<b>Software Cost (\$) for city for each computer</b>	\$2995, \$995 plus \$100 for support and maintenance. \$369 for DBaseIV.  Total: \$1464	\$495 plus \$195 for Script Visual Basic and \$295 for Import/Export module. \$349 for Excel.  Total: \$1334	\$2995 plus \$50 for maintenance and \$150 for support  Total: \$3195	\$1200 plus \$295 support and maintenance. \$250 for 4th Dimension  Total: \$1495	\$3000 plus \$225 support and maintenance. \$349 for Excel  Total: \$3574

**Notes:**

- Digitizing: The function of building a locational database reflecting the specific service area.
- AutoCAD: A drawing program that can create the map image.
- Boolean logic: Enables the map to relate to other databases.

### **Costs**

Table 3 gives general cost figures for the various components of an AVL system for a demand-responsive operation. Figures, which were derived from conversations with vendors and integrators (firms that assemble the system components and install a working system), were adapted to the rural setting. They provide an idea of relative costs, but would need to be carefully reviewed in the context of an individual site. All AVL systems are customized to fit the needs of individual properties

### **Additional considerations**

#### *Communications*

Given the wide area served by rural paratransit, it is not possible to receive and send locational data from a single base station for a county wide system, let alone a multi-county system. Some sort of repeater (radio signal relay) system is necessary. However, the purchase and installation of multiple repeaters adds considerably to the cost involved. Each repeater needed to be equipped with a base center tracking unit and a separate full duplex radio. It may be possible to reduce the cost of leasing space for the repeater by sharing space at the chosen location.

A lower cost alternative would be to pay a monthly service charge for using an established radio network. This would also help to shortcut the long wait for approval for authorization to use a radio frequency. Most paratransit properties already do have an arrangement with a local radio network supplier in order to use existing two-way radios. Transmission of GPS location formation could be an added on to existing costs.

In the future, cellular telephones will provide a viable way of relaying data.

Costs are now, however, too high to be of interest to the small transit operator. The operator has to pay for each connection even though it only takes a few seconds to relay a GPS position. Perhaps in the future, telephone companies will consider partnering with the small operator and open up this avenue for data communication.

One other communication device now used in rural areas is a pager. While this cannot relay locations, it can help in reducing the need for MDT's or costly radios for communicating with the drivers.

#### *Mapping Displays*

Mapping display systems at the base station are a major asset associated with AVL systems. They are, however, not integral to the tracking system itself. Hence the choice of map display program becomes an additional consideration. The above cost stream includes a range of \$1,500 to \$3,500 for GIS software. This cost range is much more affordable even one year ago. Any of these GIS programs would insure that the vehicle location is accurately represented on a display map.

Some small transit agencies have elected using lower cost tracking systems that do not include an accurate GIS map. The maps they use are more of a background piece upon which bus locations are approximated, rather than an accurate indication of location. Table 3 indicates a variety of considerations in selecting among GIS software.

For a rural system with limited technical expertise, a primary consideration will be whether the software is user friendly. The map display is the element of the system that the dispatcher sees and uses. The rest of

the GPS system should be transparent if all is working as it should. It is, however, also important that the map can link effectively with GPS and scheduling programs. For example, a number of smaller systems have gone with MapInfo which has a user-friendly display. However, because this software does not have a relational data base, it is more difficult to link data stored in other programs with it.

**Table 3: Cost estimates for AVL System Components**

		<i>Range of costs</i>	
<i>AVL system components</i>		Low	High
<b>Base Station</b>	Pentium computer and peripherals with 2 color monitors (20")	\$4,000	\$5,800
	second mapping computer (windows NT operating)		7,000
	1 GPS receiver and tracking unit	2,000	6,200
	data radio at control station	2,500	5,200
	laser printer	750	1,200
	differential GPS base station with interface to data radio		8,400
	uninterrupted power supply	720	720
	software development	5,000	7,000
	GIS software license	1,500	3,500
	installation	4,000	9,000
<b>Total Base Station</b>		<b>\$20,470</b>	<b>\$54,020</b>
<b>In-Vehicle</b>	vehicle tracking units (receiver and processor)	\$1,000	1,700
	1 GPS receiver		
	1 GPS processor		
	MDT units (optional)	850	2,000
	digital radio	1,000	1,000
	installation charges	400	780
	<b>TOTAL per VEHICLE</b>	<b>\$3,250</b>	<b>per vehicle 5,480</b>
<b>Total for 15 Vehicles</b>	<b>\$ 48,750</b>	<b>82,200</b>	
<b>Other</b>	Training	\$3,000	10,000
	Communications RADIO NETWORK charges @\$55-100 a month x 12	\$660	per year \$1,200
<b>Total</b>		<b>\$72,880</b>	<b>\$147,420</b>

---

## Dynamic Scheduling

In recent years the number of small paratransit properties investing in automatic scheduling programs has increased dramatically. The *Advanced Public Transit Systems State of the Art Update '96* lists 147 paratransit properties using computer-assisted scheduling programs, while two years ago the 1994 State of the Art Update '94 listed only 41 paratransit properties with computer scheduling programs. The complementary paratransit requirements of the Americans with Disabilities Act (ADA) no doubt stimulated increased interest in computer-assisted lists of clients. The computer programs make it possible to verify client eligibility. However, there is concern that some of the computer-assisted programs do not allow trip-by-trip verification of eligibility as is required by the ADA, let alone provide for real-time trip scheduling. Hence the Transportation Research Board commissioned a study of computer dispatching programs. The study, completed by Roy Lave of Systan, Inc., developed a handbook to assist transportation providers in procuring such systems.

This assessment is focused on the more advanced types of scheduling programs, those which permit near-real-time trip insertions and design and redesign routes to accommodate the new trips. That type of software is much less common and is available only from a small group of vendors. Several vendors were contacted and interviewed: Multisystems (Midas), Automated Business Solutions (PtMS), and On-Line Data Products (PASS), Paratransit Systems International, (Rides Unlimited) Comsis and Trapeze. Two of the vendors, Automated Business Solutions and On-Line Data Products, provided demonstration disks that demonstrated the versatility of their programs. The other provided brochures and identi-

fied customers whom the study team subsequently interviewed. The responses of the clients interviewed are included in the appendix of this manual. Although all software pieces are directed toward the paratransit operation, their features differ considerably. Software costs are in part reflective of the level of sophistication in the programs and in part reflective of the amount of customization required for installation.

### *Functions of dynamic scheduling programs*

In general, paratransit scheduling programs perform the following functions :

- Client registration
- ADA validation
- Trip reservations
- Billing
- Scheduling for subscription trips.

The additional features of dynamic scheduling programs are:

- near-real-time automatic scheduling
- optimum path routing

To accomplish these tasks, the locations of callers and drop-off points are geocoded and associated with a base map. An optimal trip path between points is identified either automatically or on command. With fully automatic programs, the telephone call taker simply accepts the call by "pushing a button" and the geocoded location is assigned to a schedule automatically. With an add-on MDT, the appropriate driver is also notified automatically.

In less elaborate programs, the selection of route and driver is not automatic. Instead, the computer assists the dispatcher by identifying possible options.

Among the companies interviewed, only Trapeze is actively working on an

interface between its scheduling program and an AVL tracking program. Trapeze Quo Vadis programs are completely customized and hence more expensive than the others. They are also fully automatic. Since this project was begun, On-Line Data Products has merged with Trapeze, but PASS is still marketed independently to smaller transit agencies.

---

## **Fleet Management**

This technology is presented as an option primarily for those rural systems that regard vehicle maintenance and operation as their top priority. Fleet masters, which are usually installed on trucks, can be installed on paratransit vehicles. They monitor all aspects of the vehicle's operation and generate detailed reports that can be downloaded from the vehicles in the service garage and used to build maintenance schedules, anticipate mechanical difficulties, and improve operating efficiencies.

Cost per unit of a fleet management system would be about \$2,500. Installed on 10 vehicles, the cost would be \$25,000. Such a system could interface with AVL at a later date if the architecture is compatible.

---

## **Combined AVL and Dynamic Scheduling**

As indicated above, there is no off-the-shelf product that will link these two technologies. Both SMART in Detroit and the Santa Clara system are moving toward the linkage by developing custom software that will link the two different products in their specific setting. The sequencing and subsequent linking of these two technologies is a consideration.

One approach is to begin with a dynamic scheduling program that involves geocoded origin and destination points and routing capabilities

and then add to that the AVL, which would identify the real-time location of the vehicle. That real-time vehicle location could then update the scheduling program when inserting a trip. The scheduling program would then redesign the route for the driver. The GIS AVL display map that charts the moving vehicles would substitute for the schedule planning and routing maps associated with the scheduling program. AVL functions such as identifying the exact location of stranded vehicles and vehicle monitoring would operate independently of the scheduling program. Information from the AVL would be imported into the scheduling program only as it impacts future scheduling.

An alternative approach is to begin with the AVL system and then add on a scheduling program. This would focus primarily upon real-time scheduling. Trips would be directly assigned to vehicles actually operating in an area or zone and schedules would be built accordingly. Routes would be designed "on the fly" by the scheduling program, which would feed the information to the drivers. Such a combination would not need some of the sophisticated add-ons associated with the scheduling program. Geocoding, for example, would be handled automatically through the AVL system rather than by having drivers call in and having positions verified.

Larson Systems in Ames, Iowa, proposed an experimental effort that would link these two technologies, assuming that the selected scheduling program is in D-base format. There would be an additional cost for developing the software.

Table 4 shows a low-cost estimate for a small 10-15 vehicle fleet with AVL and a scheduling program. The figures shown are at the low end of the scale,

**Table 4: Low-cost estimate for small 10- to 15-vehicle fleets with AVL and a scheduling program**

<b>BASE Station</b>		
same content as with AVL option	\$20,470	
1 more Pentium computer for scheduling	2,200	
<b>total base station</b>		<b>\$22,670</b>
<b>Each vehicle:</b>		
same as AVL option	3,250	
x fifteen for 15 vehicles		48,750
scheduling software license	25,000	
linkage software	10,000	
<b>total software</b>		<b>35,000</b>
<b>Training</b>		
scheduling and AVL	5,000	5,000
<b>Installation charges</b>		
<b>One-time cost</b>		<b>\$111,420</b>
<b>Recurring costs</b>		
Radio networking (add on to existing network) \$600 to \$1,200 annual		
maintenance agreements \$4,000 annual		

primarily because of the experimental nature of the development and testing of the linkage software. With state-of-the-art scheduling software, this cost could quickly escalate by \$15,000 to \$20,000. The overhead charges of well-established transit AVL integrators could also add considerably to this cost.

these technologies frequently note extraneous factors that have impacted an evaluation. Such factors as a change in client group or service area, administrative changes, or major changes in the local employment picture can greatly impact any effort to attribute changes to the introduction of a technology.

### **Benefits Derived**

Benefits derived from investing in these technologies differ among properties that have installed them. They also remain somewhat anecdotal at this time, given limited consistent reports. Even properties that do report experience in using

Those changes that have been reported fall primarily into the categories of improved efficiency in operation, improved service (reduced time in advanced reservation, more accurate timing for pick-up and delivery, accommodation of inserted calls), and increased general ridership.

The next section of this manual offers a benefit-cost analysis to help in the decision-making process. However, benefits are sometimes clearer when presented in terms of actual experience.

**Case Studies:  
Dynamic  
Scheduling**

Over the two years that this study has been ongoing, the project team conducted numerous telephone interviews with small transit operators.

Initial calls in 1994 found very few properties that were using any form of computer scheduling. At most they had a computerized data list of subscribers with attributes. Upon receiving a call, dispatchers noted the requests on sheets of paper and then consulted the list overnight to preplan the routes for the next day. Long-term dispatchers actually used recall far more often than the database in organizing trips. Drivers were given the list of pick-ups that were planned to fit within half-hour windows. Emergencies or “will-call return trips” were arranged through an open broadcast to drivers over two-way radios. Billing was a time-consuming process involving manual generation of invoices to the various agencies subsidizing individual travelers. Non-subscription trips could be handled only with difficulty and only on a space-available basis. Drivers called into base to report any no-shows or major changes in trip timing. In some agencies drivers were required to call in with each pick-up and a magnet board manually reported progress on each of the routes.

Although there was some curiosity about more advanced scheduling programs, only the largest properties were even considering them. Costs, time in retraining, and the perspective of “If it is not broke, why fix it?”

limited interest. AVL was perceived only as a costly experiment for urban areas.

Times have changed. Small properties are now using not only computer-assisted scheduling programs but dynamic real-time scheduling programs. Nevertheless, in interviews conducted during summer, 1996 all properties mentioned the costs involved. A dynamic scheduling program costs between \$40,000 and \$65,000 including installation and training. Extra licenses and costs for maintenance agreements are add-ons that are sometimes not immediately considered. Although it is hard to quantify benefits, most are glad they made the switch.

*A representative sample of those interviews follows. A summary table of additional interviews conducted within the last six months is included as Appendix I.*

*Madison County, Illinois*

This property, with 25 vehicles, was the first US installation of Trapeze Quo Vadis in 1993. The system operates in a 1000-square-mile service area, where 60 percent of the trips are rural. The average trip is about 10 miles long. There are plans to add AVL in October. They are already using Mobil Data Terminals and find them most helpful in communicating with drivers. When the GPS base station is functional in October, these MDT's will offer real-time data communication with the base station and onboard GPS receivers will communicate vehicle movement in real time.

Since adding the dynamic scheduling, they note considerable increases in service efficiencies. Cancellations, which amount to 12 percent of their trip requests, are now immediately filled with real-time call-ins. While the

**With dynamic scheduling, the scheduling time is reduced from 8 hours to 8 minutes**

ridership previously was 1.8 passengers per hour, it is now 2.2 passengers per hour. Before acquiring dynamic scheduling, they averaged 400 passengers a day and now have increased that to 550 passengers a day. Another dramatic improvement is in scheduling time. Before dynamic scheduling they were unable to take any next-day trip requests after 2:30 P.M. Now, however, they can schedule up to 5 P.M. and can even book rides on Saturday. They have been able to effect all these service improvements without adding any dispatchers. In fact, a less-trained call taker can log each trip directly upon receiving the call. The dispatcher focuses on communications with the drivers and handling nonroutine issues. They did pay extra for a full display map, but find that they rarely use it. The scheduling program has a suppressed internal map which it uses to plan the trips to geocoded locations. With this automation, stress level in the office has greatly decreased.

#### *New Haven, Connecticut*

They just installed their Trapeze system last October after visiting two other properties (Charlotte, North Carolina, and El Paso, Texas) that had different dynamic scheduling programs. They are a larger system with 100 vehicles performing 8,000 rides a month. With this new system they have weathered two service expansions with no reduction in ridership and are convinced that ridership will now increase with the larger pool of potential riders. Their objective was to permit real-time trip scheduling, which they had not been able to do before. The system has really improved its scheduling. Now only 50 percent of the readership is subscription. Scheduling windows, which were 1/2 hour before, are now down to 15 minutes or less, thereby cutting back on slack time. In addition, call takers now take less than

1/2 minute with each client, less than half the time it used to take. This greatly enhanced the response time for trip reservations.

By buying as part of a package bid with two other properties, New Haven increased its buying power and was able to get a price break on purchase of both hardware and software.

#### *Golden Empire Transit in Bakersfield, California*

They have had PASS installed for 1-1/2 years on their nine vans and have now worked out the "bugs." Training has taken a while and they would suggest a two-part training period: an initial phase to learn the system, and a follow-up period after the property had some experience with the system. Plans are to move toward same-day service in fall, 1996. By using the PASS system they have identified gaps in their schedules caused mainly by cancellations and no-shows. Real-time scheduling will enable the property to fill these gaps and increase service. With the scheduling program, they already note a 10 percent decrease in trip length and a 10 percent reduction in vehicle travel time.

#### *Antioch, California*

This property operates at great efficiency. With 10 vehicles they serve 250 passengers a day, 3.4 per hour. They perform 22,000 revenue miles a year in a 225-square-mile service area. Since installing PASS, they have increased their total ridership about 40 passengers a day. Trip denials are down from 2.2 a day to only 1.2 a day. The reporting functions work well for them and they can now document on-time performance. A major benefit is the ability of a less experienced call taker or receptionist to log calls. The salary of a call taker is half that of an experienced dispatcher. The call taker can help relieve the stress in the office

by taking over routine tasks performed by a dispatcher.

This property has been particularly pleased with the responsiveness of PASS to calls for maintenance and are pleased that they bought the maintenance agreement.

*Sun Dial Transit in Indigo, California*

Sun Dial Transit is similarly very satisfied with the PASS system, which it has been using for two years. Although there was an immediate reduction in productivity because of a steep learning curve, they are now back up to their productivity level before introduction of the system. They note that they were also able to increase inserted trips. They can anticipate slack time and readjust trips accordingly. They too have noted the reduced stress in the office, which translates into less sick leave and less comp time, but mostly just a better work environment.

Plans are to add AVL to the system in fall, 1996, as part of a broader cooperative agreement. Sun Dial is not convinced that AVL will add significantly to the positive measures that it has already experienced.

savings of \$1,575,000 in capital costs and \$400,000 in operating costs. This enabled them to amortize their investment in AVL in two years. A study by the National Urban Transit Institute concluded that an AVL system must reduce fleet size by 2.3 percent if the property is to break even. Reductions at that level are very difficult in a small transit company that has all vehicles deployed.

Nevertheless, AVL can identify slack time which can then be reassigned and thus can reduce wait times. An experiment with GPS equipment installed on one vehicle that was hauling subscription riders identified 5 to 10 minutes of slack time an hour. It is true that additional passengers would need to be situated along the route of the demand-responsive bus route to make good use of that slack time. However, identifying this potential for increasing efficiency in an already very productive service offers the possibility of either retiring a vehicle or not acquiring an additional vehicle. If AVL could pinpoint an average of 10 minutes of slack per hour per day for 6 buses, that could quickly accumulate, making possible some policy options. Following the National Transit Institute guideline, a ten-bus fleet would only need to retire one bus for 1/4 of a day a week, thereby saving on operating and maintenance costs, or redeploy it to alternative revenue-generating rider publics, to begin to pay for the investment.

Radio or cellular telephone communication charges associated with the base station link to drivers could also generate very real savings. One urban transit property reduced its voice communication by 40 percent after adding AVL. Savings at this level may not be possible or even desirable in rural areas, but small firms can generate savings in this area also.

**Case Studies:  
AVL experience**

It is more difficult to find fully operational examples of small transit properties that have experimented with AVL. As indicated above, few small demand-responsive properties have gone beyond the planning phase.

Reports of benefits from larger operations include Kansas City, which has had a signpost AVL system for more than five years. They report fleet reduction as a by-product of a more efficient system. They were able to reduce the fleet size by 3.5 percent, cutting 7 of 200 buses. That led to a

**Kansas City  
reduced fleet  
size by 3.5  
percent with  
AVL**

# Is the Technology Worth the Investment?

---

A benefit-cost analysis of the potential investment in smart technologies indicates to the transit operator whether the investment is a prudent one and is also useful when seeking funds from public authorities. The basic principle is simple—determine the dollar value of the benefits produced by the technologies and compare it to the projected total cost of the technologies. Though obtaining accurate cost estimates can be a challenge (some estimates were presented earlier), the primary difficulty is determining the dollar value of the benefits.

---

## Quantifying Benefits

Benefits accrue to the transit agency (e.g., increased operating efficiency), the employees of the transit agency (e.g., better work conditions), passengers (e.g., improved on-time performance), and the community (e.g., enhanced mobility for citizens). The calculation of these benefits is not a straightforward process as most are only potential benefits. The attainment of these potential benefits depends on several factors such as how the transit agency utilizes the smart technologies and how passengers respond to service improvements. Also, some of the benefits are of an intangible nature, but may be quite significant. As a recent USDOT report

notes, “A complete assessment cannot consist only of a simple revenue and cost analysis, but requires considering the non-monetary elements, as well. However, it may well be possible that relatively predictable and quantifiable monetary benefits alone could justify the system, and additional benefits would simply make the system all the more attractive.”

*The primary purposes of this section are:*

- (1) to identify the major quantifiable benefits of the smart technologies and to present estimates of their magnitudes based on interviews and case studies of current users
- (2) to discuss some of the intangible, or less tangible, benefits, and
- (3) to define and illustrate the most common financial measures used in benefit-cost analysis.

To date relatively few small or rural transit systems have implemented AVL technologies, and a number just have dynamic scheduling. One gap in the current state of the art is the lack of an off-the-shelf system that integrates dynamic scheduling and AVL. While greater efficiencies could be gained by integrating the two, the transit operators using only dynamic scheduling have still achieved some operating improvements. Through

telephone interviews we were able to obtain estimates of their increase in vehicle utilization and ridership due to dynamic scheduling. These estimates will be utilized in the illustration of benefit-cost analysis.

### Key Quantifiable Benefits

The key quantifiable potential benefits of dynamic scheduling and AVL systems are:

- reduced dispatching and scheduling cost
- decreased vehicle operating costs,
- increased revenues resulting from better service quality.

Some important though less quantifiable benefits of the smart technologies include enhanced mobility of the citizenry, improved information for management decision-making, and non-transportation community services. The technology costs include acquisition, training, and maintenance costs. A brief discussion of each type of benefit and cost is provided before the benefit-cost assessment methodology is illustrated.

### Benefits Over Time

Because benefits and costs occur over several years, future dollar values are often discounted to reflect the time value of money. The most common approach to benefit-cost analysis by private sector firms entails calculating the net present value of both costs and benefits. A financial measure that is particularly appropriate for public agencies is the payback period. Both of these methods will be demonstrated in this section.

### Overall Benefits

Dynamic scheduling and AVL systems provide *optimal vehicle routing on a real-time basis*. The dynamic scheduling software includes a program that creates vehicle schedules such that passengers are picked up and delivered to their destinations on time and

the vehicles travel the least number of miles in providing this service. Known passenger demand (e.g., subscribers, calls received at least one day in advance) can be entered in the computer at the beginning of the day and vehicles will be scheduled in the most efficient manner. AVL permits new demand (i.e., will calls received during the day) to be assigned to vehicles in an optimal manner. As new passengers phone in, they are entered in the computer. The dynamic scheduling system considers the current locations of the vehicles and the known demand for the rest of the day, and assigns these new passengers to the appropriate vehicles. As each new passenger is assigned, it is possible that all vehicle schedules will change. This is the nature of real-time systems. The potential benefits are discussed below.

### Reduced Dispatching Cost

Dynamic scheduling requires far less time than manual scheduling. Rural paratransit operators using an automated scheduling system report that scheduling known demand takes about 15 minutes (that is, the time it takes to enter the demand in the computer) compared to about eight (8) hours to do so manually. The time saving for will calls depends on the number of will calls per day.

Most rural paratransit operators indicate that one person has primary responsibility for dispatching. When that person is not available (e.g., due to vacation or illness), the time required for scheduling increases substantially. Automated scheduling reduces the agency's dependence upon one individual.

The cost saving results from reduced labor cost (wages) incurred for dispatching. Because transit agencies are usually lean operations with

The benefits of investments in technology include both quantifiable dollar savings and intangible benefits in terms of improved service quality

respect to number of staff, an automated scheduling system does not mean a reduction of staff. Rather, the scheduler or dispatcher is freed to perform other work.

#### **More Efficient Scheduling**

A major benefit of dynamic scheduling over manual scheduling is the development of more efficient schedules. That is, dynamic scheduling systems produce vehicle schedules that require fewer vehicle miles to serve the passenger demand. As a result, the transit agency experiences a decrease in operating costs that are related to vehicle miles, such as fuel, driver, and maintenance costs. If vehicle utilization increases substantially, it may be possible for the transit agency to reduce its fleet size and, thus, vehicle capital cost (though this would be unusual for smaller transit systems).

#### **Benefits in Safety**

The AVL component of the system also may produce safety benefits, especially for rural paratransit systems.

Precise knowledge of a vehicle's location is critical in the event of a medical emergency for a passenger (and most helpful in the event of a vehicle problem). Though these situations are, hopefully, too infrequent and too random to include in a benefit-cost analysis, transit operators may want to inquire about reduced premiums from their insurance companies.

The cost savings from improved vehicle utilization can be calculated by multiplying the estimated reduction in vehicle-miles by the operating cost (e.g., fuel, driver, and maintenance) per vehicle-mile. The operating cost per vehicle-mile may be

calculated by dividing the annual expenditures on operations and maintenance by the total number of vehicle-miles generated during the year.

#### **Increased Revenue**

The smart technologies should permit the transit agency to provide better service quality, particularly on-time pick-up of passengers and shorter transit time (due to fewer total vehicle-miles). However, estimating the impact of improved service on passenger demand and, thus, revenues is perhaps the most difficult challenge to forecasting benefits. How current passengers react to service improvements and the ability to attract more passengers as a result of service improvements are affected by several factors including the population base in the service area, the number of rider denials due to inability to meet riders' service needs, the purpose of bus trips, the availability of alternative transportation, and so on. Estimates of ridership increases from current users of smart technologies will be used in the illustration of the benefit-cost methodology. Obviously, each transit operator should come up with her or his own estimate based on the characteristics of the population served. A more conservative approach would not include the ridership impact in the financial analysis, but include a discussion of its potential in the funding proposal.

#### **Intangible or Hard-to-Measure Benefits**

The benefits of increased ridership or retained ridership resulting from improved service quality are generally much greater than just the increase in revenue for the transit agency. Improved transportation service benefits both the community and the individual who utilizes the public transit system.

### **Enhanced Mobility**

The enhanced mobility provided to an elderly patron may be the difference between the patron living at home or residing in an adult care facility. Because public funding of adult care facilities is often substantial, the enhanced mobility provides a real (potentially large) cost savings to society.

### **Increased Availability of Information**

The smart technologies also increase information availability that can be used to improve the management of the transit system and to meet federal or state data filing requirements. A USDOT report notes that the basic elements of a dynamic scheduling/AVL system allow the transit agency “to analyze cumulative data to see how the routes, schedules, and operations in general could be improved within the policy guidelines of the agency. The results should be improved tailoring of supply to demand, more efficient fleet and personnel deployment, and better working conditions for employees.” The same report identifies other benefits that can be attained with additional optional smart technology elements, such as vehicle sensors and automatic passenger counters, that would not add much to the cost of the technology if included in the specifications of the enhanced database at the planning stage. An area where significant gains can be attained is vehicle maintenance planning. Improvements here will result in better vehicle performance and reliability and, thus, lower cost and/or better service quality.

### **Complement Communications of Emergency Services**

Finally, the USDOT report cites a nontransportation community benefit of a transit AVL system that was noted in one of its case studies. Drivers of AVL-equipped vehicles with

good communications systems can function as an important complement to police, fire, and emergency personnel.

Again, there may be other intangible or hard-to-measure benefits that a transit operator can identify. While it is not possible to include these factors in the hard numbers benefit-cost analysis, it is certainly worth listing and discussing these positive aspects in the proposal to the funding agency.

### **Benefit-Cost Analysis**

A general model for benefit-cost analysis (BCA) and an illustration of how to conduct a BCA are presented in the following sections. Benefit and cost estimates used in the illustration were generated from interviews conducted with current technology users and technology vendors. All underlying assumptions (e.g., for the inclusion or exclusion of specific costs, the choice of a rate of return on capital for determining present values of benefits and costs) are discussed. Additionally, a BCA will be conducted for two technology acquisition scenarios: purchase and lease.

### **General Model for BCA**

As noted at this beginning of this section, BCA entails forecasting the initial cost or investment in the new technology and the stream of future net benefits (i.e., benefits less any additional costs incurred in obtaining these benefits) expected to result from the new technology. The net benefits occurring in the future must be expressed in present value terms because of the time value of money (i.e., a dollar three years from now does not have the same purchasing power as a dollar today) and the opportunity cost of capital (i.e., if money was not spent on the new technology, it could have been used elsewhere and generated some returns or benefits). The net present value of net benefits is then compared

to the initial cost of the new technology to determine if the expenditure is a financially sound one.

### **Steps in conducting a Benefit-Cost Analysis**

1. Determine the cost of the technology.
2. Estimate the additional annual costs that are associated with the new technology.
3. Estimate the technology annual savings (e.g., operating efficiency gains, increased revenues) created by the new technology.
4. Estimate the net annual savings resulting from the new technology (i.e., subtract step 2 amount from step 3 amount) for each year.
5. Determine the appropriate number of years for which net annual savings will be calculated: a recent analysis of smart technologies for transit systems published by the USDOT used six years, since the system may be obsolete or need replacement at that time.
6. Determine the appropriate minimum attractive rate of return on capital (for discounting future benefits and costs to their present value) — the USDOT report referred to above suggests 10 percent per year is typical for a transit agency.
7. Calculate and sum the net present value of net annual savings (determined in step 4). For example, the present value of net savings in year 1 would be: net savings  $(\$)/(1 + \text{rate of return on capital})^1$ , or net savings  $(\$/1.1$ ; the present value of net savings in year 2 would be: net savings  $(\$/1.1)^2$ , or net savings  $(\$/1.21$ ; the present value of net savings in year 3 would be: net savings  $(\$/1.1)^3$ , or net savings  $(\$/1.331$ ; and so on.
8. Compare the initial cost of the new technology to the net present value of future benefits. This indicates whether the investment is a good

one considering only those benefits and costs that are quantifiable.

### **Examples of Application of Benefit-Cost Analysis**

Three examples of BCA using the above process are presented next. Examples 1 and 2 illustrate a BCA for the purchase of the dynamic scheduling technology only. The cost and expected benefits data used in these examples are based on information provided by technology vendors and current users of the technology.

Example 1 uses more conservative estimates of benefits representative of some of the interviewed current users of dynamic scheduling. Example 2 assumes more significant benefits such as those achieved by the more successful interviewed current users. Each example is split into two parts—part A includes just the projected operating efficiency gains and part B adds projected ridership and net revenue gains. The two parts are then combined to show total expected improvements arising from use of dynamic scheduling.

Example 3 illustrates a BCA for the purchase of AVL technology only. The key quantifiable benefit of the AVL system is greater utilization of the fleet due to better knowledge of vehicle location. We ran a simulation of a rural paratransit system to determine how much slack time might be generated if AVL was implemented. The simulation provided a very conservative estimate of slack time because it was performed on a van that served only prescription riders. Yet, it was shown that precise vehicle location information would free up 10 minutes per hour for that van. For the calculation of benefits in Example 3 we utilize a conservative estimate that one (1) passenger could be picked up for every two (2) hours of bus service.

**Benefit-Cost Analysis  
Example System  
Profile**

*Transit System Operating Data*

Fleet size = 15 buses

Ridership (trips) per year = 91,000

Total bus-miles per year = 250,000

Total bus-hours per year = 16,000

Average revenue per  
passenger-trip = \$4.20  
(includes fare + subsidy)

Operating cost per bus-mile:

fuel	= \$0.09
maint.	= .15
insur.	= .06
total	= \$0.30

Driver wage per hour = \$6.50

Dispatcher salary = \$16,000 per year

---

*Technology Cost Data*

Dynamic Scheduling (software,  
training, implementation) + MDTs  
for each bus

Software, training, and implementa-  
tion cost = \$60,000

Cost of MDTs = \$820 per bus

Total investment for 15-bus fleet =  
 $\$60,000 + 15(\$820) = \$72,300$

---

*Other Required Data*

Life of Technology = 6 years  
(from USDOT report on AVM)

Discount rate for public agencies =  
10% (from USDOT report)

---

**Example 1:  
Benefits arising from  
Dynamic Scheduling**

In order to illustrate the calculation of benefits arising from use of dynamic scheduling systems it is easier to divide the analysis into two parts.

Part A shows how the operating efficiency gains from dynamic scheduling can be calculated. Part B provides an analysis of increased ridership benefits. A proposal for funding of dynamic scheduling would include both of these sets of benefits (i.e., combine Parts A and B).

The benefit estimates in Example 1 reflect the lower end of the percentage gains realized by successful users of dynamic scheduling among those we interviewed. These conservative estimates of increased efficiency in operations (reduced bus-miles and driver hours) and increased ridership are “phased-in” over six years.

Net Present Value (NPV) of cost = investment in Dynamic Scheduling = \$72,300 (We can ignore maintenance and operating cost of systems according to USDOT report as these are offset by administrative savings in report preparation and other areas).

**NPV of benefits**

*Method: calculate operating cost savings per year and discount to present value in following manner*

$$\text{Year 1: annual savings}/(1.1)^1 = \text{annual savings}/1.1$$

$$\text{Year 2: annual savings}/(1.1)^2 = \text{annual savings}/1.21$$

$$\text{Year 3: annual savings}/(1.1)^3 = \text{annual savings}/1.33$$

$$\text{Year 4: annual savings}/(1.1)^4 = \text{annual savings}/1.46$$

$$\text{Year 5: annual savings}/(1.1)^5 = \text{annual savings}/1.61$$

$$\text{Year 6: annual savings}/(1.1)^6 = \text{annual savings}/1.77$$

**Part A  
Benefits in Operating  
Efficiencies**

The following operating efficiency gains were provided by interviewed users of dynamic scheduling.

**Annual savings**

(1) Reduction in dispatcher time from eight hours per day to about 15 minutes. This frees up dispatcher to do other work. Thus, the agency is essentially adding a new employee for no additional cost.

Savings = \$16,000 dispatcher salary per year \$16,000

(2) Reduction in bus-miles and hours = 5%  
(assume 2% first three years and 5% last three years since benefits take time to achieve).

Savings for each of Years 1-3:

Total miles x percent reduction in mi. x  
operating cost per mi.  
 $250,000 \times .02 \times \$0.30 =$  \$1,500

Total hours x percent reduction in hr. x driver  
cost per hr.  
 $16,000 \times .02 \times \$6.50 =$  2,080  
Subtotal= \$3,580

Total savings for each of Years 1-3 = \$19,580

Savings for each of Years 4-6:

$250,000 \times .05 \times \$0.30 =$  \$3,750  
 $16,000 \times .05 \times \$6.50 =$  5,200  
Subtotal = \$8,950

Total savings for each of Years 4-6 = \$24,950

NPV of benefits per year:

Year 1:  $\$19,580/1.1 =$  \$17,800  
Year 2:  $\$19,580/1.21 =$  \$16,182  
Year 3:  $\$19,580/1.33 =$  \$14,722  
Year 4:  $\$24,950/1.46 =$  \$17,089  
Year 5:  $\$24,950/1.61 =$  \$15,497  
Year 6:  $\$24,950/1.77 =$  \$14,096

Total NPV of benefits = \$95,386

**Summary**

NPV of Costs = \$ 72,300  
NPV of Benefits = \$ 95,386

*On the basis of financial analysis of operating efficiencies alone, the benefits exceed the cost.*

However, this analysis has not included possible revenue impacts for the agency nor has it included cost savings to passengers due to improved service performance.

**Part B  
Includes Benefits from  
Increased Ridership**

This part analyzes the increased ridership that arises from better scheduling. It looks at agency benefits but does not include savings to passengers due to less waiting time, faster transit time, etc.). Estimates of increased ridership were derived from our interviews of current users of dynamic scheduling and one case in USDOT report.

We assume here a passenger and revenue growth of 3 percent over base year for each of first three years after technology investment and 5 percent over base year for each of Years 4-6. As the revenues of increased ridership are offset somewhat by increased cost of serving more riders, this has to be reflected in the analysis. To be conservative in our benefits estimate, we will assume that the number of bus-miles and hours will increase by 3 percent and 5 percent, respectively, over these time periods.

Years 1-3:

Passengers per yr. x Growth rate = No. of new riders

$$91,000 \times .03 = 2,730 \text{ increase in riders}$$

Increase in riders x Average revenue per rider = Increase in revenue

$$2,730 \times \$4.20 = \$11,466 \text{ increase in revenue}$$

Years 4-6:

$$91,000 \times .05 = 4,550 \text{ increase in riders}$$

$$4,550 \times \$4.20 = \$19,110 \text{ increase in revenue}$$

Years 1-3:

Total bus-miles in base year (after 2% reduction) x Growth rate x Operating cost per bus-mile = Additional cost per year for increase in bus-miles

$$250,000 \times .98 \times .03 \times \$0.30 = \$2,205$$

Total hours in base year (after 2% reduction) x Growth rate x Driver cost per hour = Additional yearly cost for increase in hours

$$16,000 \times .98 \times .03 \times \$6.50 = \$3,058$$

$$\text{Total additional cost} = \$5,263$$

Years 4-6:

$$250,000 \times .95 \times .05 \times \$0.30 = \$3,563$$

$$16,000 \times .95 \times .05 \times \$6.50 = \$4,940$$

$$\text{Total additional cost} = \$8,503$$

Additional revenue per year - additional cost per year

$$\text{Years 1-3: } \$11,466 - \$5,263 = \$6,203$$

$$\text{Years 4-6: } \$19,110 - \$8,503 = \$10,607$$

$$\text{Year 1: } \$6,203/1.1 = \$5,639$$

$$\text{Year 2: } \$6,203/1.21 = \$5,126$$

$$\text{Year 3: } \$6,203/1.33 = \$4,664$$

$$\text{Year 4: } \$10,607/1.46 = \$7,265$$

Year 5:  $\$10,607/1.61 = \$6,588$   
 Year 6:  $\$10,607/1.77 = \$5,993$   
 Total =  $\$35,275$

Total Net Present Value of Benefits from Operating Efficiency Gains (from Example 1, Part A) and Increase in Ridership:

\$95,386 operating efficiency gains  
 \$35,275 increased net revenues  
 \$130,661 total NPV of benefits

Summary: NPV of benefits = \$130,661  
 NPV of costs = \$ 72,300

*Benefits of technology greatly exceed the cost of technology (i.e., almost double the cost).*

**Example 2:  
Includes Observed  
Benefits**

In this example we will use estimated benefits from those interviewed current users of dynamic scheduling who have achieved greater success. The transit system data and cost of dynamic scheduling system remain the same.

**Annual savings**

(1) Reduction in dispatcher time  
 Savings = \$16,000 dispatcher salary per year

(2) Reduction in bus-miles and hours = 10% (assume 5% first three years and 10% last three years since benefits take time to achieve).  
 Savings for each of Years 1-3:

Total miles x percent reduction in mi. x operating cost per mi.  
 $250,000 \times .05 \times \$0.30 = \$3,750$

Total hours x percent reduction in hr. x driver cost per hr.  
 $16,000 \times .05 \times \$6.50 = \$5,200$

Subtotal = \$8,950

Total savings for each of Years 1-3 = \$24,950

Savings for each of Years 4-6:  
 $250,000 \times .10 \times \$0.30 = \$7,500$   
 $16,000 \times .10 \times \$6.50 = \$10,400$   
 Subtotal = \$17,900

Total savings for each of Years 4-6 = \$33,900

NPV of benefits per year:

Year 1:  $\$24,950/1.1 = \$22,682$

Year 2:  $\$24,950/1.21 = \$20,620$

Year 3:  $\$24,950/1.33 = \$18,759$

Year 4:  $\$33,900/1.46 = \$23,219$

Year 5:  $\$33,900/1.61 = \$21,056$

Year 6:  $\$33,900/1.77 = \$19,153$

Total NPV of benefits = \$125,489

NPV of Costs = \$ 72,300

NPV of Benefits = \$125,489

*On basis of financial analysis of operating efficiencies alone, the benefits greatly exceed the cost. However, this analysis has not included possible revenue impacts for the agency nor has it included cost savings to passengers due to improved service performance.*

**Based on financial operating efficiencies alone, benefits exceed costs**

### Part B

We assume here a passenger and revenue growth of 5 percent over base year for each of first three years after technology investment and 10 percent over base year for each of Years 4-6. As the revenues of increased ridership are offset somewhat by increased cost of serving more riders, this has to be reflected in the analysis. To be conservative in our benefits estimate, we will assume that the number of bus-miles and hours will increase by 5 percent and 10 percent, respectively, over these time periods.

Years 1-3:

Passengers per yr. x Growth rate = No. of new riders

$$91,000 \times .05 = 4,550 \text{ increase in riders}$$

Increase in riders x Average revenue per rider = Increase in revenue

$$4,550 \times \$4.20 = \$19,110 \text{ increase in revenue}$$

Years 4-6:

$$91,000 \times .10 = 9,100 \text{ increase in riders}$$

$$9,100 \times \$4.20 = \$38,220 \text{ increase in revenue}$$

Years 1-3:

Total bus-miles in base year (after 5% reduction) x Growth rate x Operating cost per bus-mile = Additional cost per year for increase in bus-miles

$$250,000 \times .95 \times .05 \times \$3.0 = \$3,563$$

Total hours in base year (after 5% reduction) x Growth rate x Driver cost per hour = Additional yearly cost for increase in hours

$$16,000 \times .95 \times .05 \times \$6.50 = \$4,940$$

$$\text{Total additional cost} = \$8,503$$

Years 4-6:

$$250,000 \times .90 \times .10 \times \$0.30 = \$6,750$$

$$16,000 \times .90 \times .10 \times \$6.50 = \$9,360$$

$$\text{Total additional cost} = \$16,110$$

Additional revenue per year - additional cost per year

$$\text{Years 1-3: } \$19,110 - \$8,503 = \$10,607$$

$$\text{Years 4-6: } \$38,220 - \$16,110 = \$22,110$$

$$\text{Year 1: } \$10,607/1.1 = \$9,643$$

$$\text{Year 2: } \$10,607/1.21 = \$8,766$$

$$\text{Year 3: } \$10,607/1.33 = \$7,975$$

$$\text{Year 4: } \$22,110/1.46 = \$15,144$$

$$\text{Year 5: } \$22,110/1.61 = \$13,733$$

$$\text{Year 6: } \$22,110/1.77 = \$12,492$$

$$\text{Total} = \$67,753$$

**Benefits of dynamic scheduling greatly exceed the cost of technology (i.e., almost triple the cost).**

Total Net Present Value of Benefits from Operating Efficiency Gains (from Example 1) and Increase in Ridership:

$$\$125,489 \text{ operating efficiency gains}$$

$$\$67,753 \text{ increased net revenues}$$

$$\$193,242 \text{ total NPV of benefits}$$

Summary: NPV of benefits = \$193,242  
 NPV of costs = \$72,300

*Benefits of technology greatly exceed the cost of technology (i.e., almost triple the cost).*

**Benefits from AVL Implementation**

**Example 3**

We assume here that the implementation of an AVL system provides the agency with more bus-hours to serve its passenger base, and that there is unmet demand or sufficient potential demand to utilize the freed-up bus time. The cost of the AVL system is \$80,000.

As discussed earlier, our simulation of a rural paratransit system indicated that 10 minutes per hour per vehicle could be added to the fleet capacity. Conservatively, we assume that one additional passenger could be added for every two bus-hours of operation, or in our example transit system 8,000 more passengers (i.e., 16,000 bus-hours divided by two) could be served per year. Consistent with our other examples, we will assume this increase is phased in over the six years with one-half of the increase attained during the first three years and the full increase in effect for the last three years.

The approach to determining the net revenue gain from this ridership increase is similar to that in Examples 1 and 2. First, the revenue increase is calculated by multiplying average revenue per passenger by the increase in number of

passengers. Second, the additional cost of serving these new passengers is calculated by taking the expected increase in number of bus-miles times the operating cost per bus-mile. The difference between the revenue increase and the cost increase is the net revenue gain.

A 4,000 passenger increase represents a 4.40 percent growth in passenger demand (i.e., 4,000/91,000), and an 8,000 passenger increase represents an 8.79% growth in passenger demand (i.e., 8,000/91,000). We will assume a 4.40% and an 8.79 percent increase in bus-miles to serve the new passengers for the two time periods.

### **Revenue Growth**

Years 1-3:

Increase in passengers per year x average revenue per passenger = 4,000 x \$4.20 = \$17,800 increase in revenue per year

Years 4-6:

Increase in passengers per year x average revenue per passenger = 8,000 x \$4.20 = \$33,600 increase in revenue per year

### **Additional Costs**

Increase in bus-miles per year x operating cost per bus-mile = Additional cost per year

Years 1-3:

Increase in bus-miles per year = 250,000 current bus-miles x .0440 increase in passengers = 11,000 more bus-miles per year

Additional cost per year = 11,000 x \$0.30 operating cost per bus-mile = \$3,300

Years 4-6:

Increase in bus-miles per year = 250,000 current bus-miles x .0879 increase in passengers = 21,975 more bus-miles per year

Additional cost per year = 21,975 x \$0.30 operating cost per bus-mile = \$6,593

### **Net Benefit Per Year**

Years 1-3:

\$17,800 additional revenue - \$3,300 additional cost = \$14,500 net revenue per year

Years 4-6:

\$33,600 additional revenue - \$6,593 additional cost = \$27,007 net revenue per year

**Net Present Value of Benefits**

Year 1: \$14,500/1.1	=	\$13,182
Year 2: \$14,500/1.21	=	\$11,983
Year 3: \$14,500/1.33	=	\$10,902
Year 4: \$27,007/1.46	=	\$18,498
Year 5: \$27,007/1.61	=	\$16,775
Year 6: \$27,007/1.77	=	\$15,258
Total	=	\$86,598

**Summary**

NPV of benefits	=	\$86,598
NPV of costs	=	\$80,000

*Benefits of technology exceed the cost of technology.*

**Benefits of  
adding AVL  
exceed the  
cost of  
technology**

## Payback Period

Another useful financial measure for public agencies is the payback period, the number of years it takes to recover the initial capital outlay. Stated another way, the payback period tells us how long it takes to generate the level of benefits that pays for the new technology.

We can use the preceding BCA examples to illustrate the payback period calculation. Tables 4 and 5 below summarize the net present value of operating efficiency benefits and increased ridership benefits from Examples 1 and 2. Table 6 summarizes the increased ridership benefits from Example 3 (adding AVL).

**Table 4: Example 1 NPV of adding dynamic scheduling**

(In this example, payback is in Year 4)

	Operating Efficiency Benefits (Part A)	Increased Ridership Benefits (Part B)	Total Yearly	Cumulative Net Benefits	Net Benefits
Year 1	\$17,800	\$5,639	\$23,439	\$ 23,439	
Year 2	\$16,182	\$5,126	\$21,308	\$ 44,747	
Year 3	\$14,722	\$4,664	\$19,386	\$ 64,133	
Year 4	\$17,089	\$7,265	\$24,354	\$ 88,487	
Year 5	\$15,497	\$6,588	\$22,085	\$110,572	
Year 6	\$14,096	\$5,993	\$20,089	\$130,661	
Total	\$95,386	\$35,275			\$130,661

The payback period is determined by the year in which the cumulative net benefits equal or exceed the cost of the new technology, or \$72,300 in our example. This occurs during Year 4.

**Table 5: Example 2 NPV of adding dynamic scheduling**

(In this example, payback is in Year 3)

	Operating Efficiency Benefits (Part A)	Increased Ridership Benefits (Part B)	Total Yearly	Cumulative Net Benefits	Net Benefits
Year 1	\$22,682	\$ 9,643	\$32,325	\$ 32,325	
Year 2	\$20,620	\$ 8,766	\$29,386	\$ 61,711	
Year 3	\$18,759	\$ 7,975	\$26,734	\$ 88,445	
Year 4	\$23,219	\$15,144	\$38,363	\$126,808	
Year 5	\$21,056	\$13,733	\$34,789	\$161,597	
Year 6	\$19,153	\$12,492	\$31,645	\$193,242	
Total	\$125,489	\$67,753			\$193,242

The payback period is three years in Example 2 since the cumulative net benefits exceed the \$72,300 cost of the technology during year 3.

**Table 6: Example 3 NPV of implementing AVL**

(In this example, the payback period is in Year 6)

	Increased Ridership Benefits per Year	Cumulative Benefits
Year 1	\$13,182	\$13,182
Year 2	\$11,983	\$25,165
Year 3	\$10,902	\$36,067
Year 4:	\$18,498	\$54,565
Year 5:	\$16,775	\$71,340
Year 6:	\$15,258	\$86,598

The payback period is six years in Example 3 since the cumulative net benefits exceed the \$80,000 cost of the technology during Year 6.

**Benefit-Cost Analysis Under Leasing Arrangement**

A transit agency could consider leasing equipment as an alternative to outright purchasing. The key advantage is that the agency does not need the upfront capital to acquire the equipment. The key disadvantage is that the cost of leasing is greater than the cost of purchasing.

preceding dynamic scheduling example will be used in conjunction with leasing terms recently offered by an AVL equipment lessor. Recall that the total cost of the dynamic scheduling equipment, software, installation, training, etc. was \$72,300.

To determine the cost of leasing one needs to apply the net present value method demonstrated in the BCA illustration. To illustrate, the

The lessor offered the following leasing options (at the end of each leasing period the equipment would be owned by the agency):

**Table 7: Leasing Rates**

Lease period	Lease rate	Monthly payment	Total payment per year
60 months	2.138%	\$1545.77	\$18,549.24
48 months	2.563%	\$1853.05	\$22,236.60
36 months	3.275%	\$2367.83	\$28,413.96
24 months	4.706%	\$3402.44	\$40,829.28

**Table 8: Cost of Leasing** (The NPV of leasing cost is still below the NPV of benefits)

The NPV of leasing cost for the five year (60 months) and three year (36 months) options are calculated as follows:

	5-year lease	3-year lease
Year 1	$\$18,549.24/1 = \$18,549.24$	$\$28,413.96/1 = \$28,413.96$
Year 2	$\$18,549.24/1.1 = \$16,862.95$	$\$28,413.96/1.1 = \$25,830.87$
Year 3	$\$18,549.24/1.21 = \$15,329.95$	$\$28,413.96/1.21 = \$23,482.61$
Year 4	$\$18,549.24/1.33 = \$13,946.80$	
Year 5	$\$18,549.24/1.46 = \$12,704.96$	
Total	\$77,393.90	\$77,727.44

*In this illustration the NPV of leasing cost is still considerably below the NPV of benefits (which range from \$130,661 to \$193,242: see pp. 41–43) in both of the BCA examples.*

---

## **Other Components of the Proposal**

Because many of the potential service benefits of dynamic scheduling systems are difficult (or impossible) to quantify, a funding proposal should contain a list and brief discussion of these benefits. For example, the following items were included in an example in a recent USDOT report:

### *Passenger Benefits*

- Substantial improvement in reliability, headway, schedule adherence
- More even passenger loading
- Better security because AVL facilitates faster emergency response

### *Community Benefits*

- Drivers of AVL-equipped vehicles with good communications systems can function as an important complement to police, fire, and emergency personnel.
- Improved transit service may be important component of community economic development efforts (for example, more reliable service provides means for employees to travel to and from work).

Finally, a number of other agency benefits that do not appear in the financial analysis (i.e., BCA) might be discussed. For example, the dynamic scheduling/AVL system creates a better work environment for employees leading to improved employee morale, less stress, etc. The new technology reduces the agency's dependence upon particular individuals (e.g., the one person with primary responsibility for scheduling and dispatching). The agency's image is improved because it is employing state-of-the-art technology.

The key to putting together a good proposal is to provide a financial analysis using realistic numbers and to identify and discuss those benefits and costs for which it is difficult to assess a dollar value.

# Are there other ways of accessing the technology without having each property purchase it individually?

---

Answering this question involves a consideration of possibilities of coordination of services or some type of lease option.

Coordination of services through regional rural transit areas is well established in Iowa. Multi-county regional transit districts were established about 20 years ago in order to facilitate service coordination, travel across county lines, and to manage distribution of funding and reporting mechanisms. The potential for saving costs by coordinating access to advanced technology is worth considering. Coordination can include a common tracking system, linked individual systems, or joint purchase of equipment. These various options are explored in terms of service benefits and cost reduction.

---

## **A common AVL system**

This concept involves a central base station which would receive and transmit GPS data on the location of buses managed by a group of cooperating sub-systems. Much like the land tracking systems in major metropolitan areas, the individual county systems would “buy-into” a common base station that would maintain a base station and relay information on the location of the buses associated with each of the cooperating partners

on request. The intervals for regularly reporting the real time locations of each fleet would be mutually agreed. If needed, the locations of 15 buses in each of four systems could be relayed every two minutes. Figure 2 presents this concept.

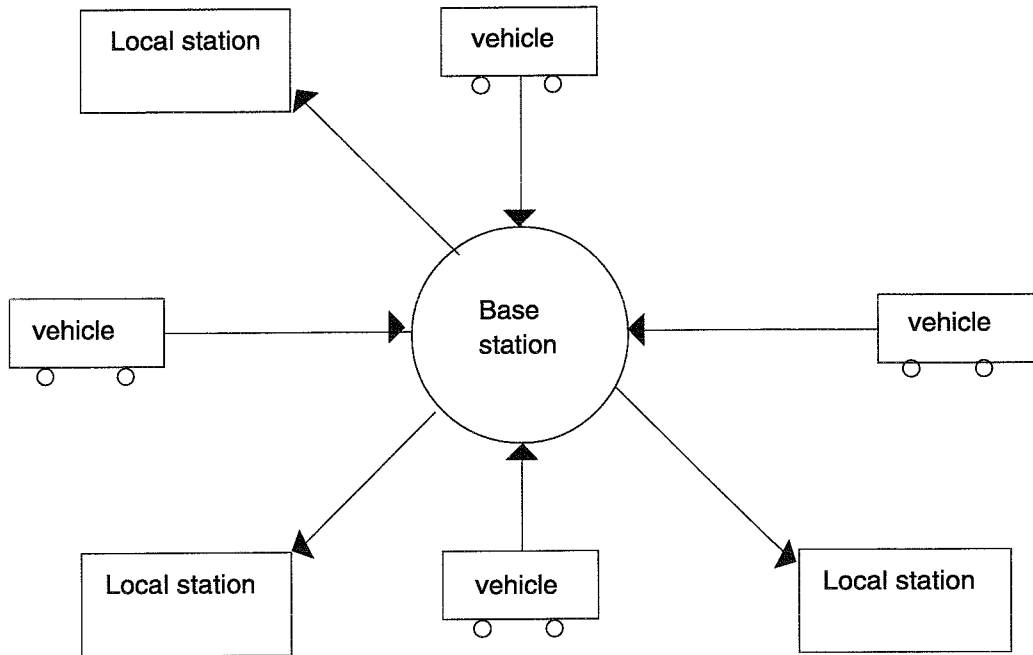
*The issues arising in the design of such a system would be:*

- The nature of communication between the base station and local stations
- The type of equipment to be used at both the base and local stations
- The frequency at which GPS data should be received at the base station
- The frequency at which GPS data should be received by the local station
- Software to be used at the base station and the local station
- Communication between the vehicles and the local stations

## **Communication between the base station and the local stations:**

*Communication between the base station and the local stations could be implemented using:*

- an Internet connection
- telephone lines
- a similar GPS receiver at the site of the local station



**Figure 2:  
Common AVL  
System**

Each of these approaches has advantages and disadvantages. Using an Internet connection would at first require costly connection charges. In the future this responsive fast communication will become less expensive and could become an ideal solution. Using existing telephone lines will make the process of communication less costly since it uses existing telephone connections and the charge for use of the lines is relatively low. The problem is that telephone communication is slow compared to Internet. Using a GPS receiver at the site of the local station will defeat the purpose of having a base station and will turn out to be expensive because radio repeater stations would be needed to relay data from the base station.

#### **Equipment**

Depending on the type of communication involved at both stations, this hardware and software can vary. For example, if existing telephone lines are to be used, then the local station will need a telephone modem. GIS software at the local station can trace the route. Software at the base station should include serial port communication software and so on. Hence this does depend on the kind of communication to be used at both stations.

#### **Frequency for receiving data at base station**

This implementation question would depend on the user. For some agencies downloading data at the end of

the day is sufficient, while for others it is important to collect data while the vehicle is traveling. This is an important decision since regular transmission of data from the vehicle to the base station requires a higher capacity duplex radio.

**Frequency at which GPS data is received by local station**

This is in part dependent upon the speed at which data is received by the base station and in part on the accuracy with which the vehicle is to be tracked. The cost and availability of the communication link is also an issue.

**Software to be used at the base station and the local station**

This again varies with the communication link. Both local stations and the central base station need the same GIS software. The base station needs serial communication software. The base station would need high-level GPS and communication software in order to route GPS data to individual local stations.

**Communication between the vehicle and the local stations**

Questions arise as to whether two-way communication is needed directly between vehicle and local station or whether the communication should be through the base station. Additional communication links will add to the cost because of the nature of the on-board equipment needed.

*The advantages of using a central base station include:*

- Single purchase of GPS tracking equipment
- Shared technical expertise at base station, and less technical people at the local stations
- Shared resources among transit agencies

- Simplification of technical work to be done at local stations
- Potential for coordinating route involving two or more transit properties

*The disadvantages of using a central base station include*

- A common point of failure (hence some fault tolerance needs to be provided)
- Possible lack of security when all properties access the same data bank.
- Higher communication costs because extra radio repeaters will be needed if the radio option is selected

**Equipment needed . . . . . at  
Local station**

<i>Communication system</i>	<i>Software</i>	<i>Hardware</i>
Network	Winsock software GIS software	486 (8 MB RAM) ethernet card
Telephone lines	GIS software, Windows programming software	486 (8 MB RAM) Modem

**Equipment needed . . . . . at  
Base station**

If there is only one-way communication between the base station and individual vehicles, the base station will need a powerful PC, probably a Pentium with large amounts of RAM (64) and large amounts of hard disk space. In addition, the base station will need a GPS receiver and software to store received values from all the vehicle. Additional software is needed to insure that each property only receives information corresponding to its own vehicles.

If there is to be two-way communication between the base station and the local station and the vehicle, another PC with lower RAM will be needed along with the earlier equipment. This new PC will be dedicated to communication between the base station and the vehicles and to polling vehicles. The equipment on board the vehicles will also need to be changed to take care of two-way communication.

**Economic Advantage of a Common AVL System**

Since the base station cost is a fixed cost, there is a real economic advantage to those transit agencies that form a partnership for implementing an AVL system. First, as more fleets

are included, the fixed cost of the base station is spread out over more owners so that each pays only a share of the capital acquisition cost. Second, as more fleets are added, the net present value of benefits will increase, thus making the investment in AVL more attractive. These concepts can be illustrated using Example 3 from our earlier section on benefit-cost analysis.

In Example 3 we analyzed an investment in AVL from the perspective of one small (15 van) agency. For simplicity sake, let us now assume that this agency has formed a partnership with a second agency with exactly identical operating and demand characteristics. The expected future benefits of the AVL technology will be twice as great since the second agency will experience the same reduction in bus-hours and potential for adding passengers. However, the initial investment for adding the second agency to the system will not double.

The \$80,000 capital cost in Example 3 is comprised of the following costs (for description of the AVL system components that comprise these costs please see p. 25):

* Base station cost	\$28,250
* In-vehicle cost (\$3,250 per vehicle)	\$48,750
* Training	\$ 3,000

The only costs from above that will be incurred when adding the second agency to the system are the in-vehicle cost and training cost (or \$51,750). However, there are two other sources of costs that will be incurred: the software and hardware needed at the local station and the communications systems to link the second agency to the base station.

Estimates for the local station's software and hardware costs may be found on page 25. Using the low-range cost figures, let us assume \$7,000 for the local station software and hardware costs. This pushes the total cost for adding the second agency up to \$58,750.

**Communication costs**

We obtained estimates of current costs for subscribing to the radio network of a commercial communications system and for programming the vans' radios to be compatible with the system. The subscription cost is \$6-7 per vehicle per month. The cost to reprogram the existing radios is approximately \$26 per vehicle. Thus, let's assume about \$100 per month subscription fee for the agency (or \$1200 per year) and a one-time expenditure of about \$400 to reprogram its radios.

The NPV of costs associated with adding the second agency are then \$59,150 (i.e., \$58,750 + \$400) plus the NPV of the monthly subscription fees.

The NPV of the \$1200 annual subscription fee is determined below:

**Table 9: Communication Costs (the benefits of adding a second agency exceed the costs)**

Year 1:	\$1200/1.1 = \$1091
Year 2:	\$1200/1.21 = 992
Year 3:	\$1200/1.33 = 902
Year 4:	\$1200/1.46 = 822
Year 5:	\$1200/1.61 = 745
Year 6:	\$1200/1.77 = 678
Total	= \$5230 NPV for the subscription fee

The total NPV of **costs** for adding the second agency is

$$\begin{aligned} & \$59,150 \\ & + \$5,230 \text{ (subscription fee)} = \$64,380 \end{aligned}$$

Plus capital costs for initial system in example 3 described above) ..... + \$80,000

$$\text{Total ..... } \$144,380$$

The NPV of the **benefits** of adding a second agency as developed above is equal to \$86,598 x 2, or .....

$$\$173,196$$

Less NPV costs ..... (\$144,380)

Total **benefits** over **costs** ..... \$28,816

In this example, the NPV of benefits of adding a second agency exceeds the NPV of the costs by \$28,816.

### **Other Benefits of a Coordinated System**

In addition to increasing the ratio of benefits to costs, each agency will realize a savings by sharing the cost of the base station. The fair share of the common base station costs for each agency must be determined by the partner agencies. One approach might be to apportion the cost on the basis of relative benefits achieved. For example, if one agency accounts for 35 percent of the total benefits gained, it would pay 35 percent of the common cost.

One final point is worthy of note. As more agencies are added to the partnership, additional investments in the base station may be necessary. For example, expanded computing power and memory may be required for significantly larger fleet sizes.

This example assumes that the two agencies which would share the AVL are in the same community or in very close proximity. In fact, this is the approach that is being taken in a number of cities where public service agencies like police and fire are joining with the bus company in establishing a common base station. Cedar Rapids, Iowa, is for example, incorporating its fire, police, city bus and county wide paratransit agency into a common AVL system.

### **Sharing communication links across several counties**

An added complexity is involved if two demand responsive properties in adjoining counties agree to cooperate. The range of radio reception typically does not extend beyond a 20-mile in radius without the help of a repeater station (which is a type of rebroadcast operation). To add a repeater station will require a set of equipment much like that in the initial base station. One way to potentially avoid this cost

would be have the agencies each take out a subscription with a local radio network which would provide access for a regular monthly charge. This approach would also bypass the complexities in applying for additional radio frequencies and licenses. With increased demand for radio bands the frequency application process can take many months. The cost for a subscription can run as low as \$50-100 a month.

One final point is worthy of note. As more agencies are added to the partnership, additional investments in the base station may be necessary. For example, expanded computing power and memory may be required for significantly larger fleet sizes. Typically, one pentium will be sufficient to track about 40 vehicles.

### **Assessment**

Given the greatly reduced cost of computers, this option may not be as appealing as it was about two years ago.

It is possible for a small system to purchase its own Pentium computer work station for less than the cost of setting up radio communication licenses and necessary repeater stations. A common technical specialist is a valuable consideration, but that is still possible if the local systems decide to go with individual computer stations with a joint purchase.

### **Joint Purchase**

Since rural demand-responsive systems are small, they do not individually have the attraction of a large purchase and hence they are not offered the level of discounts possible with larger purchases. A common RFP for a region would offer increased volume and might attract deeper discounts. New Haven,

Connecticut, and two other similar systems were each able to get a \$15,000 reduction in the cost of a scheduling program when they set up a common RFP. Since not all properties have the same level of technical expertise, relying on someone within the region with greater technical knowledge would also sharpen the RFP. An umbrella insurance policy that involves several rural transit regions in Iowa is another example of the benefits of joint purchase.

With several or all of the systems in the region selecting the same software and hardware, they can also share information on set up and operation. A common training program could also involve all operations in the regions at a lower cost per person than would a separate training program for each property. Again there is the benefit of sharing information within the region. Pooling resources and hiring one computer technician to serve the region would also be a wise decision.

#### **Leasing as an Option to Purchase**

Much as with the joint purchase approach, the leasing option works best when several small transit operations coordinate their efforts. A volume purchase of several AVL systems or combined AVL and scheduling programs would attract a leasing agent who could, with a relatively low interest rate of about 2 or 3 percent, agree to purchase the necessary equipment from an integrator. Each of the properties would pay monthly payments over a period of three to five years. As with an automobile lease, at the end of the leasing period, the properties would have the option of purchasing the equipment or replacing the equipment and software with updated models.

#### **A Common Scheduling Program**

This is not a viable option since each dynamic scheduling program is unique to an individual system. Requests for rides come into a specific dispatcher who can then immediately log in the request automatically dispatch a trip.

# How Do We Select a Vendor or Integrator?

---

The large investment and long-term nature of technology acquisition makes it one of the most important decisions a transit operator will make. Not surprisingly, there is an extensive literature on making purchasing decisions. A summary of key points from this literature should prove useful to the transit agency that is searching for the right technology for its operations.

Useful insights are also available from current users of smart technologies. Interviews with these transit operators revealed some problems or dissatisfaction with various vendors and products. These revelations provide a good starting point for discussing important factors and considerations in choosing a technology supplier. Appendix I in this manual summarizes a series of telephone interviews conducted with current users within the last six months.

Similar guidelines can be applied in selecting an integrator who will serve as a type of general contractor in installing complex smart systems, like AVL. In this case the actual vendor selection becomes the responsibility of the integrator. Hence the transit agency must be convinced that the package of products and software

proposed by the integrator meets the on-going needs of the agency as well as fits the current funding level.

## **Summary of Interviews with Current Users**

The more common prepurchase considerations made by current users of automated or dynamic scheduling systems include:

- ability to perform scheduling, billing, and routing
- data accuracy
- cost
- system flexibility

These same users experienced some common problems after purchase and implementation of their systems:

- hardware problems
- software inadequacies
- long training periods
- inconvenient position of screens mounted on vehicles
- inconsistent time estimations
- difficulty in achieving real-time performance
- incorrect manifest printouts
- poor maintenance and overall service

With this anecdotal evidence of encountered problems as background, a framework and process for selecting a vendor and product will now be presented. The process involves

identifying key factors in a purchase decision and researching the vendors and products.

### Key Factors in a Purchase Decision

Cost is, of course, a major consideration in selecting a product and vendor. However, there are several important noncost factors to be considered as well.

- service offerings (e.g., installation, implementation, customization, technical support such as formal training programs, available in-house expertise, and internal mechanisms to correct manufacturing defects)
- vendor knowledge and technical know-how (so as to be able to provide products and services that meet the purchaser's specifications)
- technical assistance pre- and post-sale (product/service provision in your area, a hotline, and the capability of the person answering to offer immediate solutions)
- evidence of future product developments (systems expansion capability)
- evidence of expeditious repair and availability of spare parts warranty programs
- overall performance record (through customer references and evaluations about on-time delivery, quick and fair settlement of disputes, informing buyers of any price changes, exceptional technical assistance and post-sale service)
- reputation (the number of years in business is one indicator; customer evaluations are another)
- reliability and cooperation
- sound financial position (will vendor be around in future for product and service add-ons and enhancements?)

*Satisfactory answers to the following questions may be indicative of a good service provider.*

- does the vendor have an effective value analysis program for its products?
- to what extent does it have a service-shop available?
- are repair parts and repair personnel locally available? on short notice?
- to what extent will the vendor help us cut acquisition, repair, and maintenance costs (e.g., by visits, telephone calls, etc.)?

### Key Factors in Choosing an Integrator

In selecting an integrator who can oversee the installation of an AVL system several additional criteria are critical.

- Is the integrator competent and experienced and interested in installing a basic AVL system for a small transit company?
- Is the integrator capable of overseeing initial maintenance and debugging of the system?
- Is the integrator dedicated to low-cost-with-quality as an objective and interested in long-term financing?
- Is the integrator dedicated to a installing an open system that will allow a small transit company to expand the system incrementally as more funds become available?

This last point is particularly important, since small agencies will want to be reassured that they are not buying low-cost "white elephants" that will work today but lock the agency out of system expansions and upgrades in the future. (see *Improving Interbus Transfer with Automatic Vehicle Location*, 1995, by Kihl and Shinn for a more complete discussion of these issues.)

### **Researching Vendors**

There are a number of possible sources for finding potential vendors and obtaining information about them. The following list is not exhaustive.

- acquaintances (especially other transit operators) who may possess beneficial information through experience and/or contacts
- vendor catalogs & trade publications
- trade registers and directories which contain addresses and other information on leading manufacturers
- trade journals which have advertisements of products, an important initial source of product knowledge
- trade exhibits which offer an opportunity to view new and old modified products, and the comparison of competing products on various aspects
- company personnel based on knowledge from their own contacts
- sales personnel who are usually well informed on the capabilities and features of their own and competing products.

### **Additional Observations and Advice**

Finally, some general observations and good advice were offered by interviewed current users. In no particular order, they are as follows.

- If not fairly technology literate or knowledgeable, the transit operator should endeavor to become so prior to initiating the purchasing process—in particular, the buyer should attempt to gain some technical understanding of the required product in terms of use, limitations, and substitutes.
- The buyer should request (demand) to observe prospective systems in operation at least a few customer sites. If possible, the buyer should visit these sites without the vendor representatives in order to obtain a candid assessment by the customer and to see a realistic demonstration of both the

capabilities and limitations of the system.

- The software should be purchased first and then the appropriate hardware can be acquired. Often the software vendor recommends hardware specifications, and will assist the customer in hardware selection (this is another vendor service the transit operator should inquire about).
- Be sure to visit with past major customers of the vendor to evaluate the vendor's general reputation, product and service quality, reliability, post-sales service, etc.

### **Developing Requests for Proposals and Contracts**

Some transit agencies may choose to buy software by an RFP (Request for Proposal) process. Basically, this approach entails putting all of the agency's specifications and requirements (of the software and vendor) in writing and presenting them to selected vendors for competitive bids. A recently completed report by Systan, Inc. identifies the following tasks for the procurement of demand responsive transit software:

1. Identify your needs and develop specifications
2. Identify the list of vendors
3. Identify available software capabilities
4. Identify potential vendor's strength 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

The Systan report provides an excellent and detailed discussion of the whole process, with an especially good section on the RFP preparation. It contains numerous examples of software specifications and a few sample RFP's. The interested reader should refer to this study.

## What are possible sources of funds?

---

*The Community Transportation Reporter's Resource Guide*, January, 1996, vol. 14, No. 1, is an excellent guide not only to federal sources of funds, but also lists state, federal, and regional contacts and even Internet resources. Another fine source is *Building Mobility Partnerships: Opportunities for Federal Funding* developed by the US Department of Health and Human Services and the Community Transportation Assistance Project in May, 1996. This useful booklet references funding sources related to transportation in eleven federal departments.

As with any funding request, the focus should be on what is anticipated as a result of the effort rather than simply on the acquisition of technology. Funding agencies are far more impressed with the anticipated result than in the means to that end. Technology must certainly be regarded as a means to an end rather than an end in itself.

In considering funding sources it is always important to ask the "why" questions. For example, the property wants to increase efficiency. Yes, but why? "To serve a broader segment of the general public without increasing the fleet size." That is a valuable objective, but why is that significant

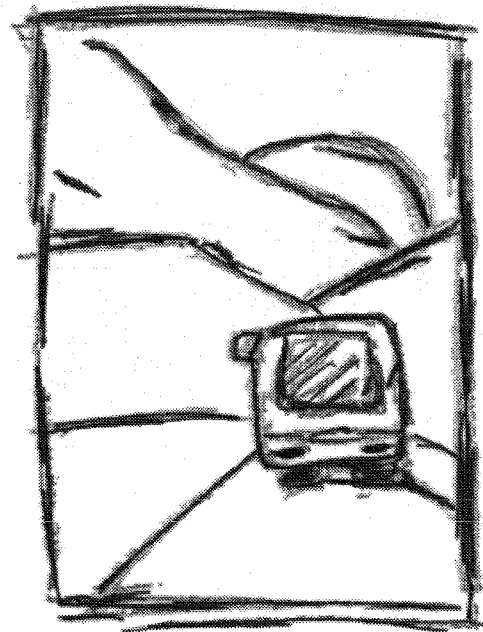
in this place at this time? The economic development council has repeatedly cited limited transportation to employment sites as a reason for the slow growth in the service sector in this area. More efficient reliable transit could help address that goal. Now we have an objective that may correspond with that of several local and state funding sources. This might even be applicable for a federal Rural Economic Development Grant from the Department of Agriculture. Matching grants from the State Transit Assistance Program might be possible

As another example, a major area hospital is planning to open a new rural health clinic in a small community that has been campaigning for better health care. The question is, how are outpatients without cars going to get to this location? The rural transit system is already overtaxed providing services to seniors and to a developmentally disabled workshop in a larger town nearby. Increased efficiency and help with scheduling could go a long way in helping to meet this increased demand for transportation. Advanced scheduling programs could be very effective here. Again the goal is broader, more appealing, and has the potential for partnering. A federal Social Services Block Grant

(Title 20) might be applicable with a matching state transit assistance grant.

Funds for demonstration projects through the Department of Transportation are more limited, especially for retesting technology that has already been proven successful such as dynamic scheduling. On the other hand, there is potential for funding a coordinated rural transit project focused on expanded service to the general public to assist with economic development. The Rural Advanced Public Transit division of ITS America would probably be interested in helping to identify funding sources for such a venture if it involved a combined AVL and dynamic scheduling program.

Flexible Funding through the Intermodal Surface Transportation Efficiency Act of 1991 is a possible source. Reauthorization will determine future availability of this funding source.



**List of Acronyms**

ADA	Americans with Disabilities Act
AVL	Automatic Vehicle Location
BCA	Benefit-Cost Analysis
CTA	Community Transportation Association
FTE	Full-time Equivalency
GIS	Geographic Information System
GPS	Global Positioning System
ITS	Intelligent Transportation Systems
MB	Megabytes
MDT	Mobile Data Terminals
NPV	Net Present Value
PC	Personal Computer
RAM	Random-Access Memory
RFP	Request for Proposals
SMART	Suburban Mobility Authority for Regional Transportation
USDOT	United States Department of Transportation

## Bibliography

- "A growing gaggle of Windows DBMS Software," *Datamation* pp. 84-85, February 1, 1993.
- Allen, Arletha Vickers. "Software You Can Count On" *Black Enterprise* 25: 44-45. March 1995
- Behnke, Robert. *Cost Estimates for selected California Smart Traveler Operational Tests*, March, 1993, Prepared for the Office of Technical Assistance and Safety, Federal Transit Administration, US Department of Transportation.
- Berle, Gustav. *The Small Business Information Handbook*. John Wiley and Sons 1990.
- Community Transportation Assistance Project, U.S. Department of Health and Human Services, and the Community Transportation Association of America. *Building Mobility Partnerships: Opportunities for Federal Funding*, 1996 available through National Resource Center Hotline 800-527-8279.
- Connolly, James. "Consistency helps \Microsoft's' Access Yake Charge," *Computer World* 129: 82-83, August 14, 1995.
- Dobler, Donald W. and David N. Burt. *Purchasing and Supply Management (Text and Cases)*, 6th ed., The McGraw-Hill Companies, Inc., 1996.
- England, Wilbur B. *Procurement Principles and Cases*, 5th ed., Richard D. Irwin, Homewood, Ill., 1967, p. 405.
- Hunton, James E. and M. K. Raja. "When is a data base not a database (when it's a Spreadsheet). *Journal of Accountancy* 179: 89-93 June 1995.
- J. K. Lasser Tax Institute. *How to run a small business*. McGraw Hill, 6th Edition 1989.
- Kihl, Mary and Duane Shinn. *Improving Interbus Transfer with Automatic Vehicle Location*, June, 1995, prepared for the Midwest Transportation Center, funded by the Iowa Department of Transportation and the US Department of Transportation, available through the Center for Transportation Research and Education, Iowa State University.
- Knaster, Barry. "Payroll Software: The tools for a payroll niche" *The Practical Accountant* 26:39-42. August 1993.
- LaBell, Larry and Carol Schweiger. *APTS, State of the Art Update 1996*, Prepared by the Volpe Center, Federal Transit Administration, US. Department of Transportation., January, 1996.

Morlok, Edward, Eric Burrn, and Kimerly Battle Blackmon. *Advanced Vehicle Monitoring and Communication Systems for Bus Transit: Benefits and Economic Feasibility*, prepared for the US DOT, Mass Transportation Administration (1991,1993),available through US Department of Commerce, National Technical Information System, Springfield, Va.22161.

O'Brien, James A. *Computers in Business Management- An Introduction*. Richard Irwin Inc. 1979.

Plank, Tom M. and Lois R. Plank. *Encyclopedia of Accounting Systems* 2nd edition Vol. 1. Prentice Hall 1994.

Rhagunathan, Bhaun and Suzzane L. Wobser. "Accounting Software Selection by small Business organizations" *National Public Accountant* 40: 20-23. September 1995.

RTAP National Transit Resouce Center. *Innovative Funding Strategies*, Technical Assistance Brief, number 10, 1996.

Rucker, George,Community Transportation Association of America. *Status Report on Pubic Transportation in Rural America*, 1994, prepared for the Federal Transit Agency of the US Department of Transportation.

Silver, Gerald A. *Database Management Software*. Graphic Arts Monthly 67:132, September, 1995.

Stone, John and Peter Gray-Mullen, NorthCarolina State University. " Winston Salem Mobility Management, An evaluation of Computer-Aided Dispatch and Scheduling," preprint of paper presented at Transportation Research Board, annual Meeting, January 1-11,1996.

Stone, John Gorman Gilbert, and Anna Nalevanko. *Assessment of Computer Dispatch Technology in the Paratransit Industry*, March, 1992, prepared for Federal Transit Administrtion, Office of Technical Assistance and Safety, US Department of Transportation.

Systan, Inc. *A Guide for Acquiring Demand Responsive Transit Software, a Preliminary Draft*, prepared for Transportaton Cooperative Research Program, Transportation Research Board, March 1996. (Not Yet Released for General Distribution).

**Appendix:**  
**Agency  
Technology  
Observations**

**Western Contra Costa/Pinole, CA**  
*(10 vehicles dial-a-ride)*

Ron Bell 510-724-3331 Scheduling (PASS)

Adding MDTs higher productivity, improved information, better record keeping, some ridership increase. Takes time to learn system, takes a while to get maps right, rides per hour stayed at about 5.

**Space Coast Area Transit/Cocoa, FL**  
*27 demand resp. / 13 fixed route*

Jim Liesenfelt 407-635-7815 Scheduling (PASS)

Testing 1 bus AVL adds flexibility, more passengers per revenue mile, easier scheduling of medicaid, shorter wait time for ride, ridership up 10 percent on demand responsive, dispatcher took 3 weeks to learn, total training period 3-4 months. New Pentiums adding to increased speed in scheduling.

**Community Transit/Snohomis, Evert, WA**

*15 demand responsive, 30 fixed. mixed urban / rural*

Deborah Hashman 369-786-8585 Scheduling (PASS)

Countywide system. Schedules 15 vehicles now, only 8 manually, passengers per hr. dropped from 2.75 per vehicle hr, back to 2.3 now. No change in vehicle miles. Best feature is data tracking, rides now booked same day, ridership up, clients up from 558 to 2244, employees up from 3 to 13 to handle more riders. Learning curve dependent on particular trainer.

**Aberdeen, WA**

*18 vehicles, urban / rural, fixed routing and dial-a-ride*

Dianne Knowels 360-532-2770 Scheduling(RIDES UNLIMITED)

No AVL, limited radio coverage. Some problems with system, had a

major crash, system only tracks clients not vehicles. Benefits: helps with transfers, handles cancellations/rescheduling, shorter waits, ridership up 20 percent, scheduling took 45-60 minutes before, 10 minutes now.

**URTA, Columbia, MD**

*Paratransit, 25 percent demand responsive, 75 percent fixed route, 23 vehicles*

Janet McGynn 410-997-7588 Scheduling (PtMS)

5 years experience, has Fully Automated Schedule Package (\$2,000 extra) good reporting capabilities, service provided to 10 different agencies, reports available for all, less time spent at SCHEDULING. Increases in on-time pickups, now 70 percent within 10 minutes, ridership up 87,000 (1993), 104,000 (1995). Dispatcher works 4-5 hrs scheduling also on phone. Training is big problem, map poor geocoding, quirky system, important to have Pentiums.

**Jefferson Parish, Metairie, LA**

*16 vehicles paratransit*

Karleen Smith 504-836-6166 and Bob Chadborn 504-889-7152 Scheduling (PASS)

Plans to add MDTs, better record-keeping now, 70 percent trips in 15-minute window on time, reduced wait time, increased ridership from increased service demand. Increase in average monthly ridership up 17 percent (1993-4) up 22 percent (1994-5) up 13 percent (1995-6), increase due to efficiency. No new vehicles. Great decrease in time spent in scheduling. Doesn't use maintenance portion of system. Cost of system \$24,000 including training with \$32,000 for a network server, 5 workstations, a laser and matrix printers. Excellent technical support 24 hours a day. Program very user friendly: learning curve is 2 weeks.

**SCUCS, NJ**

*35 vehicles, mod fixed route*

Dale Keith, 609-456-1121 scheduling, PtMS

Ridership up 15 percent with same fleet and driving staff, no change in mileage, more efficient computer, 20 percent reduction in scheduling time. System takes 3 months to learn, but scheduling, full reporting, billing, client database, trip reservations, good technical support.

**Burlington Transit Handitrans,  
Burlington, Ontario, Canada**

*fixed route and paratransit, urban and rural*

Vince Mauceri, 905-335-7763/7869 scheduling Quo Vadis

10-20 percent increase in riders per hour. Efficiency maximized without increase in budget/equipment. Scheduler can override computer and does 25 percent of the time. 8 hours in scheduling now done in 2 minutes. More time to fine tune, deal with clients and drivers. Learning curve 1 week. Training and technical support excellent.

**Mountain Empire, VA**

*35 vehicles demand response and deviated fixed route*

Mike Hensen 540-343-1721

Scheduling and management package, PtMS. Strong accounting package. Can do costing per mile, hour, trip. Automatic scheduling. Runs in DOS with C program. Maintenance is \$1,500/yr. for network, \$800 for single user. Purchase \$5,000 for single user and \$15,000 for network.

**Prince William County, VA**

*12 buses, deviated fixed route*

703-490-4811 Scheduling, Trapeze Quo Vadis, Gandolf AVL/MDT

New system. Trapeze designed a system to work with GPS. One hour

to schedule reduced to 5 to 7 minutes. Help with adjusting to no-shows. One week training on QV in DOS, but now moving to Windows NT to tie to AVL. Moving from basic radio to MDT with a separate UNIX computer.

**Everett, WA**

*15 vehicles*

George Baxter, 206-259-8803, Scheduling On Line

New, MDTs just added staff, still adjusting. Training 1 week for supervisors, 3 days extra on MDTs.

**Santa Clara, CA**

*40 minivans*

Katie Heatley, David Brandauer 408-436-2865 scheduling, Trapeze, Trimble Navigation, GPS

Motorola radios scheduling program greatly reduced time spent in scheduling, from 8 hours to 8 minutes. AVL portion just being added.

**Wheat Ridge, CO**

*13 vehicles, demand responsive*

Hank Braaksma 303-235-6970 scheduling

Multisystems, Dispatch a Ride. Had system for 6-7 years. Experienced decrease in staffing, increased data accuracy. Reliable, data entry straight forward. Just moved to network operation. cost \$6,500. Not being used in real time.

**Blackhawk Co., IA**

*13 buses*

Sharon Krieger-Maltas 319-234-5714 scheduling

On-Line. Had system 3 years. Does scheduling, dispatching and custom reports. Does not do automatic scheduling or routing. Greatest benefit is detailed manifest to the minute for each driver. User-friendly software. Maintenance \$300 a year.

**Iowa City, IA***13 vans*

Bernel Chattick 319-339-6128

Scheduling

On-Line. Just started with scheduling. Selected system because lower cost. Anticipate adding AVL in the future.

**Henderson, KY***2 vehicles*

Pam Stone 502-831-1249 Scheduling

Dispatch Manager selected because low cost (\$300). Time in developing manifests down from 1 hour to 3 minutes. User friendly, helpful manual. Not automatic or dynamic.

**Brockton, MA***33 vehicles*

Lisa Marognono 508-584-5330

Scheduling

Trapeze Quo Vadis System almost ready to use. Selected because will be helpful with billing, scheduling, routing

**Troy, MI***100 buses*

Philip Shaw 810-362-3436 Scheduling

Trapeze Quo Vadis selected because is capable of interface with AVL. Plans are to link all of SW Michigan. Support is very good. Still modifying software.

**Anoka, MN**

Tim Kircholl 612-422-7088 Scheduling

ing

On-Line (since 1992) Wanted real-time environment. Had 25 percent drop in no-shows. Had 2.5 passengers per hour, now 3.1 per hour. Had MDTs since 1995

**Dakota County, MN***25 vehicles*

Sara Lenz 612-296-3441 Scheduling,

Trapeze

MDTs . Adding AVL summer, 1996. 50 percent trips prescheduled. System

already working well so noticed little change with scheduling. They are now scheduling based on where bus is supposed to be. With AVL, scheduling with where vehicle really is. This will end problem of drivers changing schedules and altering records.

**Eden Prairie, MN**

Tom Juhnke 612-949-8303 Scheduling

On-Line, MDTs. MDTs still not functioning well. With MDT problem ridership is down from 4.5 per hour to 3 per hour. Long training time needed. got bad hardware with system.

**Alamance, CO***22 vehicles*

Forrest Paullet 910-222-0565

Multisystems. Dispatch a ride Statistical base is very good with good reporting. This agency even leases out the reporting software for other agencies to use. Does not address other issues such as improving on-time arrival.

**Winston Salem, NC**

Susan Telechea 910-727-2648

Scheduling

On-Line system can do routing and can link with MDTs, AVL and smart cards. Excellent capacity. They have noted more on-demand service and reduced staff stress levels. 2-week training period provided. Needed customized programs for billing; off-the-shelf version not adequate. Recommended hardware not well maintained.

**Scranton, PA (COLTS)***32 vehicles, fixed route*

Kurt Kempter 717-343-1720 AVL Auto Track, Inc., (now part of TMI).

Dispatcher watches buses on 5 monitors, notes early and late and contacts drivers via MDTs. In past had 6-10 complaints a week, now none. Annunciators for Digital Re-

cordors, Inc. Cost of whole system  
\$358. Excellent on-time performance  
and checking fuel efficiencies.

**Houston, TX**

*150 vehicles, paratransit*

Jim Laughlin 713-739-4986

**Scheduling**

On-Line very efficient system, will  
allow wide range of options. 10  
percent increase in scheduled passen-  
gers. Will have MDTs added to help  
with same-day scheduling. Gives info  
to driver without dispatcher interface.  
Used to overbook on standby, now not.  
Works well with 90 MHZ. Needs more  
operators to run increased service.

**Blacksburg, VA**

*5 vehicles*

Kevin Danker 540-961-1185

Comsis. Gradually move from  
manual to computer assisted. Took 9  
months to select software. 2 weeks on-  
site training. Same-day scheduling.

**Sidney, OH**

*6 vehicles*

Jerry Alexander 513-498-8117

dispatch manager

Cost of system low, only \$300. Their  
staff is all part-time and ridership is  
increasing, so they have no time to  
train on system and are not using it.