Linking Real Time and Location in Scheduling Demand-Responsive Transit

Final Report
September 1996

We acknowledge the following for their help with this study.

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

Editor:
Kim Shetter

Midwest Transportation Center
Iowa State University
2521 Elwood Drive, Suite 125
Ames, Iowa 50010-8263
Telephone: 515-294-8103
Fax: 515-294-0467

Linking Real Time and Location in Scheduling Demand-Responsive Transit

Final Report
September 1996

Principal Investigators
Mary Kihl
Professor, Community and Regional Planning
Iowa State University

Michael Crum
Associate Professor, Transportation Logistics
Iowa State University

Duane Shinn
Professor, Community and Regional Planning
Iowa State University

Research Assistants
Eric Akunda, Patrick Pittenger, Himagiri Mukkamala, Anuradha Ramanathan, Madhu Midhe, Madhulika Singh, Lori Thomsen

Funded by
Iowa Department of Transportation
and
Midwest Transportation Center

Contents

INTRODUCTION

The role of rural demand-responsive transit is changing, and with that change is coming an increasing need for technology. As long as rural transit was limited to a type of social service transportation for a specific set of clients who primarily traveled in groups to common meal sites, work centers for the disabled, or clinics in larger communities, a preset calendar augmented by notes on a yellow legal pad was sufficient to develop schedules. Any individual trips were arranged at least 24 to 48 hours ahead of time and were carefully scheduled the night before in half-hour or twenty-minute windows by a dispatcher who knew every lane in the service area. Since it took hours to build the schedule, any last-minute changes could wreak havoc with the plans and raise the stress level in the dispatch office. Nevertheless, given these parameters, a manual scheduling system worked for a small demand-responsive operation.

Increased Demand for Service Brings
Demands for Service Efficiencies

Rural transit is now charged with serving a larger public. The Americans with Disabilities Act (ADA) raised expectations of a service that was complementary to a fixed route, accommodating the full range of impromptu trips. Enterprising entrepreneurs are expanding operations in rural areas. In Iowa, for example, the number of manufacturing jobs in metropolitan counties dropped 18 percent since 1970, while the number in rural, nonadjacent counties increased 27 percent (US Census, 1990). Since incomes at these jobs in rural America are very often lower than in urban areas and typically, two or three household members commute in different directions, demand for rural transit is increasing. A recent focus group of Iowa regional and urban transit managers noted that "an acute future need will be in providing public transit from rural areas to work sites" (Borich and Riggs, 1995).

Enterprising rural transit properties have already 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 Brazoz 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 five years, while adult ridership tripled in the same period

(Interviews with respective operators, May, 1996: cited in Kihl, 1996). For almost all of these groups, the 24-hour preplanned schedule is not viable. They need a system that is ready when they are. Workers especially need a system that is completely reliable, i.e. an expected 8:10 pick-up arrives at exactly 8:10 A.M.

Increased ridership and increased demand for service “on the fly” brings increased demands on fairly small fleets and over-worked staffs. These challenges often blunt the enthusiasm for opportunities for increased service even with a possible resulting expansion in revenue sources. Dedicated dispatchers 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.

The Appeal of Technologies

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 Systems (ITS) offer a menu of enticing options. Enthusiasm, however, is tempered by limited funds, limited time for staff training, and no time to assess the relative advantages of the various technologies for individual operations.

The tendency sometimes is 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 systems, maintaining that the new technology cannot possibly be cost effective.

Choosing the Appropriate Technology

Two types of advanced technological responses have been proposed as a means of increasing service through increased efficiency of operation:

- automatic vehicle location (AVL)
- dynamic scheduling.

The two technologies are not direct alternatives. In fact, they are complementary. AVL is based on real-time location and approximates schedule times, while automatic scheduling is based in real time and approximates vehicle location. AVL involves a vehicle tracking system and, usually, a graphic display that can pinpoint the location of all deployed vehicles. Dynamic scheduling involves real-time scheduling, permitting trip insertions and the constant adjustment of schedules. An associated trip networking feature selects the most efficient trip pattern for each vehicle and produces updates to accommodate inserted trips. With AVL it is possible to approximate travel time using network analysis, while dynamic scheduling approximates distance by associating travel time with familiar trips between points. Logically, responsive vehicle dispatch is dependent upon both vehicle location information and on real-time scheduling. A combined system (AVL with dynamic scheduling) would automatically schedule trips for vehicles with full knowledge of their actual location.

The issue for small demand-responsive transit operations is, however, the costs involved in selecting either or both technologies and the relative benefits associated with those choices. Do the benefits in increased effectiveness justify the investment in technology? This study addresses this important question in the context of the limited experience which community transit operations have had with either AVL or dynamic scheduling.

Investment in technology involves risktaking. That is not easy for properties that are operating at the margin, with limited prospects for increased or even steady-state funding. It is even more challenging for small operations whose staff members are already over-extended with the current operation and who have limited time to consider options or alternatives. Those who are intrigued are waiting for someone else to test a system first, shake out all the bugs, and provide a tight, verifiable evaluation that estimates probabilities for success. Given limitations in funding for demonstration grants that would provide incentives for experimentation, hard data is difficult, if not impossible, to find at the current time. Consequently, the current study has compiled what information is available, conducted its own tests, developed simulation modes, derived preliminary cost models, and offers a framework that can guide small operations in their decision making. A manual prepared in conjunction with the project is available to assist in that decision-making process.

Project Scope

In the two years since this project began in 1994, an increasing number of small transit properties have begun to look toward technology as a means of addressing the needs for both efficiency and effectiveness in operation.

Of the two technologies examined in this study, dynamic scheduling has clearly attracted more attention among small demand-responsive agencies. A number of agencies had been using computers to assist the dispatchers with the scheduling process even though the actual schedules were built manually. Computers held the databank of names of regular riders, their personal attributes, and the log of funding sources associated with each of them. Using a computer program to assist the dispatcher in building schedules was a logical next step.

The 1992 Paratransit computer guidebook reported on a wide variety of agencies that were using computers to assist with schedule building. Some programs even proposed routes that would help to retrieve passengers more efficiently. The next step was in part precipitated by the requirements of the ADA, which urges bus operators with fixed route systems to provide their paratransit service passengers the same opportunity to travel without advance reservations. The goal of scheduling in real time seems remote to many small rural operations that have no fixed route service, few if any service competitors, and announced 24-hour trip reservations. Nevertheless, an increasing number of small rural demand-responsive properties are now moving toward dynamic scheduling, which will allow dispatchers to insert trips as they are requested and increase both efficiency of operation and service effectiveness. This rise in interest also parallels the changes in scheduling programs themselves. They have become increasingly user friendly.

The leap to AVL has been less inviting to small rural operations. Rural operations are not accustomed to tracking their fleets with other than two-way radios. Even the step toward using digital radios is considerable. Although the display maps associated with most AVL systems make the process involved in using global positioning system (GPS) technology to track vehicles transparent to end users, and geographic information system (GIS) mapping programs are increasingly user friendly, there are still few demonstrations that can serve as models of the applicability of AVL to rural services. The scattered service areas and limited fleet size make it unlikely that increased efficiencies can be created in rerouting or selecting an alternate vehicle to pick up an inserted trip. The possibility of using AVL to track stranded vehicles in a snow storm seems more real. Some smaller urban transit operations, like that in Des Moines, have installed global positioning AVL on their paratransit fleet but the potential benefits of such a system for a rural operation have not yet been assessed.

The potential for real-world tests of the benefits of linking scheduling programs with AVL have yet to be realized. A few paratransit systems, like SMART outside Detroit and the paratransit operation in Santa Clara, California, have just begun to install GPS and plan to link it with dynamic scheduling. It is much too early for any assessment of these, let alone a consideration of the applicability of such a combined system to a smaller rural demand-responsive system.

For small rural demand-responsive operations the primary question remains whether the benefits to be gained from either or both of these technologies can justify the investment. With limited budgets any expenditure must be carefully weighed. Yet a decision based solely on minimizing costs might result in a false economy. The current study is intended to put that decision-making process into perspective.

Project Focus and Objective

The current study builds on the experience of the study team with assessing the viability of the application of GPS to paratransit and fixed-route buses in a mid-sized city, Des Moines. That project provided the basis for the actual investment of Des Moines Metro in a GPS for its paratransit fleet.

In this study the focus shifts to rural and small-town demand-responsive properties. The assumption is that these systems are not smaller versions of the urban system, but distinctive forms of transit with very different needs and operating parameters. The question is whether smart technologies that relate to systems operation are viable in this setting. In this context, viability is determined not so much in terms of technical feasibility but in terms of overall costs and benefits.

While the study began with a focus on AVL, dynamic scheduling was selected as a possible alternative technology. This allowed the study to follow up on the claims of some small operators that dynamic scheduling offers similar increases efficiency and improved service quality, at lower initial costs than AVL.

The study also explores the potential for a possible combination of AVL and dynamic scheduling in the rural context. The possibilities of securing the benefits of the technologies at reduced costs through coordination among several small operations is also considered. The specific objectives are as follows:

- Assess the benefits to a small rural demand-responsive transit operation of investing in smart technologies
- Assess the relative benefits of investments in AVL or dynamic scheduling in the context of a rural system
- Assess the potential increases in benefits to a small rural transit operation of a system that combines real-time vehicle tracking with dynamic scheduling
- Assess the level of benefits resulting from coordinating acquisition of technology across a consortium of small transit systems.

Approach

In completing this study the research team undertook the following tasks:

First, the study assembled information on current experience with dynamic scheduling from interviews with vendors and with transit operators who were either identified by the vendors or were listed in the Advanced Public Transportation Systems, Update '96. Since the study spanned two years, interviews were conducted both in 1994 and in 1996. This time-lapse approach enabled the team to telescope changes in scheduling programs and consider the extent of benefits observed by users. Several vendors contributed demonstration dynamic scheduling software disks which the team evaluated and also shared with members of the advisory group.

Second, team members conducted surveys and interviews with demand-responsive system operators in Iowa at several points in time. The approach offered a perspective on the level of technology deployed and on interests and needs that could potentially be addressed by the two technologies under consideration.

Third, the study focused on the Boone County Transportation system as a “real world” laboratory. The intention was, however, not to provide recommendations that would be uniquely suited to the Boone system, but rather to reflect upon it as a prototype of a system with an expanding ridership and a limited fleet. The Boone system is particularly valuable as a prototype of the rural transportation system of the future since it serves a wide range of client groups and the general public. The fleet size, staff, and budget have not kept up with this increase in demand. Although the general manager has expressed a keen interest in various types of technology, all scheduling is currently done manually by a dispatcher. The existing computer serves as a databank for information regarding clients and for invoice information.

Fourth, given limited experience with application of AVL to rural settings, the study team engaged Larson Systems, Inc., to conduct an experimental test of the applicability of a GPS system on a Boone County bus. Data generated from observing that test were used in developing the benefit streams used in building the economic analysis of the two technologies.

Fifth, as indicated above, several vendors supplied demonstration disks for dynamic scheduling programs. However, they were not open to application to the test site in Boone County. Hence the study team developed its own simulated model for a dynamic scheduling program that incorporated data supplied by the GPS experiment and developed alternative routes for retrieving riders. These computer-generated routes were compared with the actual routes taken by the buses in the Boone system to observe any differences in efficiency. Data from this simulation was also included in the economic analysis generated by the study.

Sixth, team members generated a series of cost/benefit analyses to examine the relative effectiveness of dynamic scheduling and AVL (GPS) for small rural demand-responsive systems. The analysis used data derived from the experiments in Boone as well as a considerable amount of information supplied in the interviews conducted in step one. As indicated above, the size and type of operation represented by the Boone County system provided the prototype used in this analysis. However, the models developed in the economic analysis are intended to be broadly applicable to small demand-responsive operations.

Seventh, the analysis then moved to a consideration of a possible combined system that would include both AVL and dynamic scheduling. A cost/benefit model was developed. In addition, the study looked at potential savings to be realized by coordinating across two or more rural transit agencies.

Eighth, the study team developed a manual intended to serve as a guide to busy paratransit operators as they try to decide whether to select a smart technology (AVL or dynamic scheduling) that is designed to increase efficiency. The manual was pretested with Western Area Regional Transit (WART), a group of regional public transit systems operators representing the counties of the western half of Iowa. The manual was revised in response to their suggestions and a modified version was produced.

Product

The primary product of this study is a manual that is intended to assist rural and small town demand-responsive transit operators in deciding whether to invest in a technological solution as a means of addressing increased demand, calls for last-minute trips, and improved on-time performance.

The manual was developed from information gained from pilot tests using AVL, interviews with vendors and small-town and rural transit operators who deployed dynamic scheduling programs, and reviews of the evolving literature regarding AVL. Since many of the questions that small-town and rural operators raise relate to cost and payback time, a primary emphasis for the study was in building a set of cost/benefit models that can help to inform decision makers.

Report Outline

This report presents the findings associated with the study. In addition to an introduction and conclusion, it includes three sections:

I. The needs of small demand-responsive systems and the potential response offered by advanced transit technologies

II. Applications of technologies to rural demand-responsive systems

III. Assessment of the benefits and costs of these technologies to a small demand-responsive system

Each of the sections are further divided into two or more chapters that reflect the range of issues associated with each dimension of this study.

Conclusions and invitations for further research follow.

SECTION I

The Needs of Small Demand-Responsive Systems and the Potential Response of Technologies

Chapter 1
The Needs of Rural Transit Systems

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 multicounty 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. (US DOT, 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 Expressed 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 nonsubscription 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)

Responding to these Needs with Technologies

In the initial phases of the study (1994), the research team conducted a series of telephone interviews with a sample of fifteen rural transportation providers in Iowa. In order to account for potential regional differences and to focus on properties that might be able to benefit from economies of scale, the sample included properties in twelve different regions, but only transit properties with more than a ten-vehicle fleet. The interviews identified one agency (Great River Bend) that was beginning to install a dynamic scheduling program. Given the steep learning curve involved and the very limited experience in operation, that agency had little to contribute toward an assessment of possible benefits of the technology. One other agency, Linn County Lifts, was part of a larger consortium that was planning to install AVL on vehicles in the Cedar Rapids area. Very few agencies were even mildly interested in pursuing technological solutions to their need for greater efficiency.

A subsequent series of telephone interviews conducted with eleven agencies in fall, 1995 indicated increased interest in exploring dynamic scheduling. Nevertheless, all but two of those contacted were still using manual approaches to scheduling or a computer spreadsheet. Two of the ten agencies were using a computer to store databases and to assist the dispatcher in preparing the schedules. Only two (Great River Bend and MET Transit of Black Hawk County) were currently using automated scheduling and dispatch packages. Three others, however, planned to add automated scheduling shortly and two indicated that they hoped to add it in the longer range future in order to improve service to the customers and use their fleets more efficiently.

As one respondent noted, they are now using a paper-based system for scheduling, but this makes for a great deal of work in scheduling as many as 400 rides a week. They are most anxious to gain efficiencies and reduce stress. They also hoped that dynamic computer scheduling software would help them coordinate with fixed-route services in the urban center of the county. They underscored the hope that some type of technology would improve customer service while increasing staff efficiencies.

MET Transit in Black Hawk County already noted benefits from using automated scheduling. In the three years since they installed the program they have increased their ridership by 25 percent and they have increased passenger rides per hour from 2.3 to 3.3. They have also reduced operating miles and revenue hours. As a spokesperson noted, “This has basically paid for itself in savings.” The Great River Bend services had been using computerized dispatching for nine months but had not yet finished the training package. Hence it was still too early to note benefits.

One respondent (Linn County Lifts) indicated plans to install an initial phase of automated vehicle scheduling in spring, 1996. Lifts hopes to link the AVL system with dynamic scheduling. Two other systems are interested in considering AVL if funding is available. Table 1 reports the findings of the 1995 interviews.

Table 1: Report of telephone survey with Iowa Rural Systems, fall, 1995

Question	*Yes*	*No*	*Comments*
Does your system use computer scheduling for daily transit activities?	2	9	2 others use computer data banks (Excel)
If not, are you planning to add computer scheduling in the near future?	3	8	2 others will add dynamic scheduling in longer future
Do you use automated vehicle location?	1 experimental	10	2 others hope to add AVL in the future

The Importance of Self Assessment

Before making any decisions on the need for advanced technology, it is important that a rural carrier conduct a self assessment. What might be an ideal solution for one system might not be appropriate for 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 include:

- 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 include:

- 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.

Primary Considerations in Choosing Scheduling Software

- 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. Multicounty 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 refining 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 further.

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 shortcut 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. Chapter 3 of this report addresses some of these questions about data needs from a business perspective.

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." Telephone interviews with an array of transit operators across the country identified several who were not happy with their investment in dynamic scheduling software. One agency reported that they never took their scheduling program out of its box because no one knew how to use it and there was no training program associated with this low-cost software. Several other agencies noted that the particular software that they had purchased because it was inexpensive is proving to be cumbersome and unresponsive to changes inserted by the dispatcher. Two agencies have actually scrapped one software package and are now using another. One other agency is satisfied with the performance of the software, but found that the learning curve in the office was too steep to use the "add on features" that they bought initially.

Chapter 2
Dynamic Scheduling and Automated Vehicle Location and their Applicability to Small Demand-Responsive Operations

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.

Post Operation Monitoring

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

AVL systems can address the majority of concerns of small-town and rural operators as follows::

- Accurately pinpoint the location of vehicles in real time
- Monitor vehicle schedule adherence
- Report real-time precise locations for emergency distress calls and vehicle breakdowns
- Assist with on-time transfer
- With add-on 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, can announce key stops as required by ADA.

Global Positioning Systems (GPS)

Most cities that are considering AVL systems for their transit systems are focusing on 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, four or five of which 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 pin-pointed within three to five feet. An increasing number of GPS processors now have a differential correction feature built in.

Paratransit Requirements for Real-Time Locational Data

Paratransit dispatchers typically have a high demand for real-time data. Fixed-route dispatchers use real-time data primarily to monitor the progress of a vehicle and determine whether corrective action is needed to compensate for a vehicle's being too early or too late. For paratransit dispatchers, however, knowing the actual location of a vehicle greatly enhances the opportunity to schedule "on the fly" by inserting new trips. Schedules can be rebuilt at the base station and conveyed to the appropriate paratransit bus driver. In the rural setting, dispatchers typically rely on radio contact with the drivers both for gaining information on updated locations and to convey requests for inserted trips. Sometimes rural systems use an "all points alert to all drivers" urging that someone retrieve the new rider. That uses considerable radio frequency and may not yield the most efficient results.

Knowing the real-time location of all the vehicles in the fleet can not only help update a schedule and monitor the progress of the vehicles, but it can also indicate proximity to a transfer 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.

The level of accuracy of this real-time data in a rural setting is, however, far less stringent than for an urban fixed-route transit operation. While urban systems must have accuracy of fifteen meters or less, for a rural system with a small fleet of ten or fifteen vehicles, accuracy of 100 meters is quite sufficient. This flexible requirement can translate into lower costs.

The frequency of reporting back to the base station is another issue that distinguishes urban from rural systems. Because of the increased pressure on radio frequencies and the sheer volume of data produced by AVL systems, most urban systems are now moving toward exception reporting, whereby a vehicle only reports into base when it is outside the pre-established on-time performance parameters. The vehicles still collect data on their location every 15 seconds, or other agreed interval.

For rural systems constant reports of progress can prove to be unnecessary. Times of individual pick-up could be pre-established and those points could then serve as the time points for exception reporting. It is, however, essential that the rural system can also poll its vehicles at key internals to find out where they are and when a trip insertion is needed. To minimize the use of radio frequencies, polling could be on an "as needed" basis rather than on a routine interval. It is more important that the dispatcher knows where the vehicles are when a call comes in than to watch their regular progress across the rural landscape.

Geographic Information Systems (GIS)

The location 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 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.

Current GIS networking programs generally build optimum networks for paratransit vehicles using the “airport limousine” approach of retrieving a set of people and delivering them to a common destination. They also work with taxi cabs, which retrieve people in order and deposit them in the same order. Paratransit operations, however, feature the shared ride concept and in rural areas that is most important. Current networking programs, however, deal with efficiencies in time and space rather than on the preferences of individuals. Networking involves optimization. Minimum distance is converted to travel time by an impedance equation. Landmarks may be used for frequent pickups or drop-offs. It is possible that such networking programs can result in scheduling a drop-off before that person is retrieved.

Hence the software associated with GPS generally serves to enhance a dispatcher’s effort. The dispatcher can refer to the network suggestion and correct any problems regarding timing of origins and destinations. 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 with a message pad.

Map Data Sources

For a small rural operator to generate his or her own maps would be prohibitive. Instead rural operators can access pre-established maps. For small rural areas the choices usually include TIGER. TIGER is the U.S. Bureau of the Census product that can be purchased at a nominal fee and displayed readily as a background map. Errors in digitizing exist, but they are minor concerns for vehicle tracking in rural areas. The errors in street addresses are, however, large and make a market for value-added companies who enhance the quality of the product for a fee, usually about ten times the original price. TIGER classification of streets, roads and highways makes the files difficult, if not impossible, to use for network modeling.

ETAK, Inc. products are proprietary and built from scratch. The quality of the product is adequate for network modeling and use with routing of vehicles, but is not typically available in high-quality data sets for small communities. Generic data sets that serve the intercity routing needs of trucking companies are available for the entire United States. These, are, however, not sufficiently detailed, even for county-based systems.

In Iowa, Iowa Department of Transportation (IDOT) maps are available for all parts of the state at a small cost. The maps are of the same quality in linework as the TIGER. Both come from United States Geological Survey (USGS) 1:100,000 scale maps. Features such as street center lines are layered a consistent manner, which lend them to ready use for routing. Some GIS mapping software, such as InfoCAD, makes it possible to take a DXF file from these IDOT maps for any metropolitan area and be ready to begin routing on a one-to-many basis within one day. Given these advantages, this is the form of map data used by the study team.

It is, however, essential to associate the chosen map with available GPS monuments or control points so as to insure an accurate record of GPS vehicle tracking on the display. The benefits of accurate vehicle tracking are quickly lost if the map used in the display is some type of overlay map rather than one using a GPS-verifiable data base.

Map Projections

Maps have to be placed into a known projection for even the simplest tracking to be successful. It is possible to translate from one known projection to another successfully in many GIS software packages. The translators are the key to obtaining a satisfactory display. In this case, Universe Transverse Mercator is the standard used by the GPS. The IDOT maps use Lambert Conformal Conic. Translating is a mathematical function embedded with an algorithm in the software.

GIS Software

There are an increasing number of GIS software packages with transportation applications. The chart in Table 2 provides an overview of several such packages. The issue of level and type of operating system required could be significant in terms of overall cost.

Table 2: Capabilities of various GIS software systems

Software/ Function	*ArcCAD/ ArcView 2.0*	*AtlasGIS*	*InfoCAD Desktop*	*Map-Graphix*	*MicroGDS*
Map Conversion	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
Computer-Aided Design (CAD)	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
Data Base (DB)	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
Standard Query Language (SQL)	Full Boolean capability	Full Boolean capability in a query builder	Full Boolean capability in a query builder	Outside in the RDBMS	Full Boolean capability
Thematic Mapping	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

Operating System (OS)	DOS	DOS	Windows NT	MacOS	Windows NT
Software cost ($) for city for each computer	$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.

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 address 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)
- It geocodes the location of the pick-up point to assist with scheduling accuracy
- With add-on in-vehicle MDT's, immediately updates drivers on revised schedules and routes
- It networks pick-ups and drop-offs automatically using the shortest path determined by preset parameters
- It automatically updates transfer times, which can then be reported to drivers by voice radio, cellular phone, or MDT's
- It assists in monitoring schedule adherence and identifying slack time through downloaded reports

Computer data banks 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 taxicab 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 this report.

The Functions of Dynamic Scheduling

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 that 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 used for record keeping, billing or to review driver performance.

Post Operation Monitoring

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. The reports contain sufficient information to schedule preventative maintenance, increase fuel economy, and assess driver performance relative to others with similar routes and similar vehicles.

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 are gathered by on-board sensors and downloaded to a computer at the base station. More elaborate systems allow drivers to interact with this data storage device, but the least expensive approach is to have each vehicle couple with a data-reading device at the base station. The data are then analyzed by off-the-shelf software programs and the results are presented in easy-to-read graphics and charts. 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 GPS systems to convey information on vehicle performance in real time. Most commercial carriers now combine fleet monitoring with GPS.

One vendor, Rockwell, did share information with the study team regarding its product, Data Port, which can operate independently in post-operation mode with only one data logger computer located at the base station to download the data from the vehicle. Each vehicle would connect with the base station data logger through a simple ten-pin connector. When the cost of such a post-operation fleet management system is distributed over a fleet of fifteen vehicles, the cost would be about $2,000 per vehicle.

It should be noted, however, that while answering concerns about vehicle performance, this technology cannot track vehicles in real time or perform trip scheduling. A more advanced product, Info Trax, with greatly increased memory (512K instead of 156K) has Open Data Base Connectivity. This open architecture feature will associate vehicle performance with GPS. Vehicles can be displayed on a GIS map in post operation mode. The cost of this system would be about $2,700 per vehicle. To date fleet management does not operate in real time.

Combination Systems

Integrating dynamic scheduling with AVL maximizes the advantages achieved with both of those technologies. Real-time vehicle locational information gained from AVL directly informs trip scheduling, offering the transit property 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.

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 as yet no turnkey product available. This has clear implications for cost.

Properties Experimenting with Linked Systems

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-tm.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 MDTs 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.

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 the chart in Table 3 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 3: Relative benefits of technologies in meeting needs identified by rural transit operators

Needs of paratransit	*Need met by scheduling*	*Need met by AVL*
maximize opportunity to hire part-time workers	call takers can be employed instead of multiple dispatchers	limited impact
limit worker stress	greatly reduces time spent in scheduling	full knowledge of fleet relaxes anxiety
increase vehicle performance	minimal impact	tracking provides opportunity to improve performance
regularize maintenance schedules	no impact	add-ons track vehicle operation
anticipate problems requiring down time	no impact	add-ons track vehicle operation
respond to needs of “will call” patrons	a major benefit of system	assists dispatcher

increase number of nonsubscription riders	impromptu trips can be accommodated	assists dispatcher
permit real-time trip insertions	automatically	assists dispatcher
reduce time to schedule trips	major reduction	decrease in scheduling time, particularly same-day scheduling
reduce response time	some improvement	major improvement
assure driver schedule adherence	with help of driver call in	a major benefit
respond to ADA	can track eligibility and special needs	add-on enunciator can announce major intersections
permit interline transfers	limited help	major assistance in this area
enable schedule adjustments	automatic updates possible	adjustments possible after analyzing data. Fleet management systems regularize maintenance, increase vehicle performance, and improve schedule adherence through post operation analysis.

Chapter 3
Information Needs

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 are moving from a total manual system to computerization. In either case, it is important for the transit property to consider information needs in general. In interviews with rural transit operators the study team noted considerable interest in finding ways of simplifying data collection while at the same time shortcutting the time needed to assemble data needed to report to reporting requirements. 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.

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 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 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 include:

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:

- 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)

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
- charts of accounts
- trial balance sheet
- income and expense analysis reports.
- year-end financial statements

Operations Information Systems

The type of operating data that is needed is determined by the productivity or efficiency measurements and standards used 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 that 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

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 over-stretched 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 monitoring products can also supply needed information on vehicle operation. In fact, that is their major function.

It is essential to find out 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.

SECTION II

Application of the Advanced Technologies to Rural Demand Responsive Systems

Chapter 4
Designing AVL and Dynamic Scheduling for Rural Systems

Advanced technologies require customization. There is no off-the-shelf product that can respond to the needs of 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 set of parameters that individual properties can consider in light of their own unique attributes.

AVL

The 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 its 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 demonstrate 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 have 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 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.

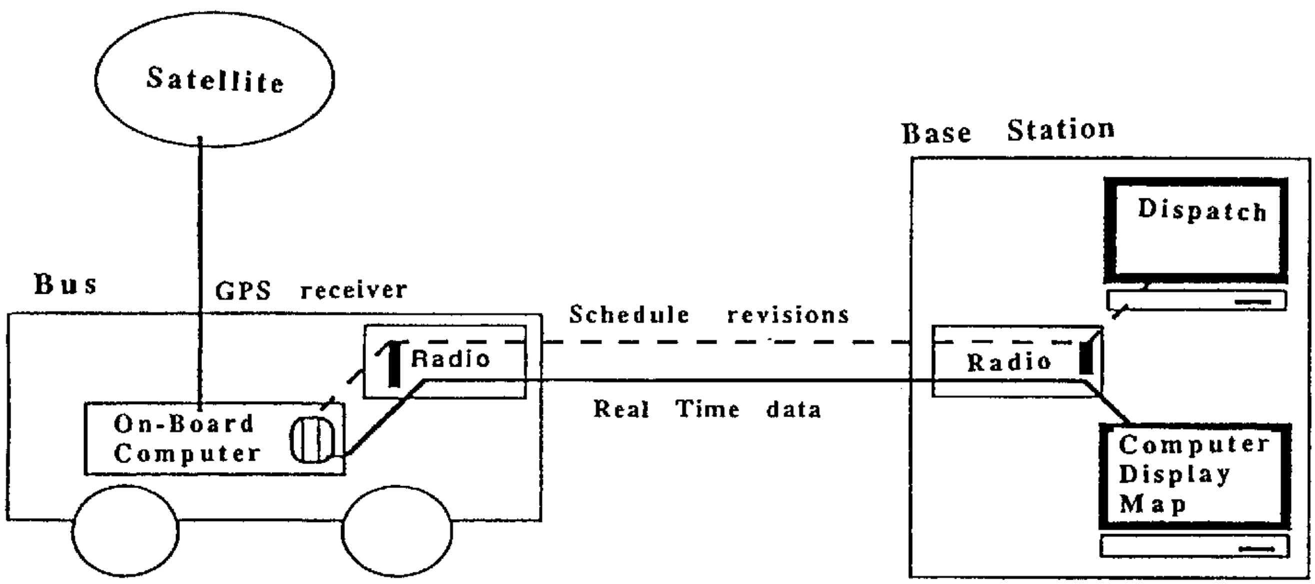

Fig. 1: GPS - Tracking Model

Base station

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

- a computer work station at the level of a Pentium. The two colored monitors will enable an overview map of the entire system while the other can zoom in on particular trouble points. This set up will work well with MapInfo and some other mapping software. Other more powerful GIS mapping programs, like InfoCAD, require a separate 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. 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 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-cost 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 Defense Department, which owns the GPS satellites.
- An uninterrupted power supply maintains the tracking even if there is a power failure.
- GIS is optional, but it provides the display map that transit operators expect will show vehicle tracking. The figure of $1,500 is now adequate for a site license for most GIS software.
- Installation is a key element. The integrator must install the system and provide training in how to use it.

In-Vehicle Equipment

The on-board 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 enables the base station to send messages to the vehicle. The cost and quality of MDTs vary considerably. Some have a one-line display with room for codes relating to frequent messages, others have two-line displays and some even can display maps indicating optimum routes for pick-ups. Any MDT's will require two-way communication, necessitating a more powerful radio.
- Again, installation is important.

Costs

Table 4 gives general cost figures for the various system components. 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

Table 4: Cost estimates for AVL System Components

	AVL system components	*Range of Costs* *Low*	*High*
Base Station	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
	Total Base Station	$20,470	$54,020

In-Vehicle	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
	TOTAL per VEHICLE	$3,250	per vehicle
	Total for 15 Vehicles	$ 48,750	82,200

Other	Training	$3,000	10,000
	Communications RADIO NETWORK charges @$55-100 a month x 12	$660	per year

Total		$72,880	$147,420

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. Some sort of repeater system is necessary. However, the purchase and installation of multiple repeaters adds considerably to the cost involved. Each repeater needs 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 paying 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. This could be an added on to those 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 considering 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 MDTs 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 than figures available about a 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 lower-cost tracking systems that do not include an accurate GIS map. The maps they include are more of a background piece upon which bus locations are indicated, rather than an accurate indication of location.

For a rural system with limited technical expertise a primary consideration will need to 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. A number of smaller systems have gone with MapInfo. That certainly has a user-friendly display. However, it is more difficult to integrate the data stored in other programs with it since it does not have a relational database.

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 *Advanced State of the Art Update '94* listed only 41 paratransit properties with computer scheduling programs. A primary impetus for this increased interest in dynamic scheduling has come from the Americans with Disabilities Act, since scheduling programs make it easier to verify client eligibility.

There is a wide variety of software packages on the market. Although a number of these are directed toward paratransit operations, their features differ considerably.

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.

In 1992 Real Estate Information Service of Harriman, New York, conducted an extensive search of over 600 software programs and selected only those programs which had: PC-based operating systems, networking capacities, a database exportable to ASCII, an open system, multi-user licensing, and a fully automated scheduling module. With those guidelines they eliminated 99 percent of all the software packages. The characteristics of a selected set of remaining software packages which are still on the market are included as Table 5.

Table 5: Paratransit Software Features*

Feature	*PtMS*	*Scooter*	*GIRO*	*PASS*	*QuoVadis*	*EMTRACK*
client registration	Y	Y	Y	Y	Y	Y
demand-responsive scheduling	Y	Y	Y	Y	Y	Y
GIS interface	Y	Y	N	Y	Y	Y
fleet maintenance	Y	Y	N	Y	N	Y
reporting/billing	Y	Y	Y	Y	Y	Y
integrate with MDT	Y	Y	Y	N	N	Y
smart card	N	N	Y	N	N	Y
AVL link	N	N	N	N	N	N

* from table enclosed in letter from David Washburn , REIS Inc. to William Chase of the County of Rockland, Ponona, N.Y. Sept, 13, 1993

Assessment of Available Software

The study team conducted an independent assessment of 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 only available 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™ - QV.

Two of the vendors, Automated Business Solutions and On-Line Data Products, provided demonstration disks that provided a glimpse into the versatility of their programs. There are no doubt updates to both programs available since the demonstration disks were prepared in 1994. Efforts to obtain more updated disks did not succeed. Firms no longer take the time to prepare demo disks since the software is constantly being updated and the product for each system must be customized. Nevertheless, the team member who assessed the demonstration disks was able to provide an overall assessment of the contents of dynamic scheduling programs and to underscore preferred features.

Key factors were:

The On-Line Product (PASS) can handle real-time scheduling. It can also offer advanced reservations, and build in subscriptions. It should be noted that there is an extra program that can be purchased to augment PtMs. That will add the automatic scheduling dimension that is not included in the basic program.

Both PtMs and PASS provided a user-friendly menu-driven system that would appeal to busy dispatchers.

PtMs included a zoom feature with ten zoom levels to note origins and destinations. It was capable of handling multi-tasking operations and skipping from one screen to the next. Data stored included:client records, service requests, vehicle manifests and billing and reporting. The versatile main menu includes: client records, scheduling and dispatching, vehicle service summaries , accounts receivable and management reports.

It includes maps that provide detail of streets at the location of the cursor and a trip can be assuaged to a bus ID. After inputting all the pick-up points the command “navigate” will optimize a route to pick up the callers. The software will also offer the driver specific directions if he/she cannot find the pick-up point. The program accommodates single- or multi-user systems and can run on a DOS or Novell network.

PASS offers a more automated call-taking procedure. If the caller makes a mistake while entering the client ID, the system will offer all possible combinations of similar names. It is also possible for the scheduler to click a screen and get the past travel history of the caller as well as a second screen with billing information. PASS also includes reference to the ADA status of clients. Unlike PtMs, this version of PASS does not offer automatic routing or offer information on the optimized route. PASS is PC-compatible and can be used on a multi-user system using a Novell network.

In addition to On-Line and Automated Business Systems, Comsis, Rides Unlimited and Trapeze provided brochures and lists of clients, whom the study team subsequently interviewed.

Among the companies interviewed, only Trapeze™ - QV is actively working on an interface between its scheduling program and an AVL tracking program. Trapeze™ - QV 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 was been merged with Trapeze, but PASS is still marketed independently to smaller transit agencies. In a few locations, transit properties are also linking Midas with GPS.

Software Costs

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. In general,

- Full dynamic scheduling programs are more expensive that programs that provide information to assist dispatchers in building schedules.
- Customized installations that tailor the software to a particular setting are more expensive than off-the-shelf packages. However, the least expensive packages will require considerable staff time in set up.
- Not all software packages come with training programs. In fact, some charge extra for such training.
- Maintenance and updating vary considerably among products. In some cases, this is a major "hidden cost."
- Scheduling programs also differ on the potential to interface with other technologies. Very few are set up to link with AVL or smart card technology. It is important not to inadvertently purchase software that will not allow add-on technologies.

The following offers an idea of the range of costs and features for a fifteen-vehicle fleet.

- Rides Unlimited (not automatic), $5,500 plus installation and technical support
- PtMS, basic package including 1 county geocoding and 3 days of training, about $10,000 (plus $2,500 for the Fully Automated Scheduler)
- Comsis (not fully automatic), about $15,000 plus installation and training
- PASS, about $40,000 including installation, training, maintenance extra
- Trapeze™ - QV, about $40,000 with an additional $20,000 to cover installation, training and maintenance.

User satisfaction

Overall satisfaction with scheduling programs is, however, not only dependent on the software system, but the particular combination of local needs and requirements, experience of staff with computers, basic efficiency of transit operation, training, interface with local computers. The study team conducted an extensive set of interviews with current users of dynamic scheduling in January 1996. A report of these interviews is included as Appendix I.

Chapter 5
Application to Target Site

AVL test application

Given limited available data based on experience of application of AVL to small rural demand-responsive systems, the study team arranged for a low-cost experimental application of GPS to two of the vehicles in the fleet of Boone County Transportation. The test was successful in tracking the vehicles, indicating that the technology is readily available. However, given the experimental design and the limited application to only two of the eleven vehicles in the fleet, it was not possible for the transit company to realize any operational benefits in terms of increased efficiency from the use of GPS.

Nevertheless, the experiment proved to be very helpful to the study team in developing the parameters used in the benefit cost model. The team used the GPS installation to gauge the differences between actual travel times of the vehicles and the expected travel times anticipated by the dispatcher who uses manual scheduling techniques

Even on heavily scheduled vehicles, which were carrying largely subscription customers, the study team observed slack time between pickups. If additional vehicles in the fleet were being monitored, it is quite possible that sufficient slack time could be captured to permit additional pick-ups. “Will call” pick-ups could also be more efficiently routed to the closest vehicle.

GPS Experiment Design

The GPS experimental design was installed by Larson Systems, Inc., of Ames. Larson has installed similar systems on farm equipment throughout Iowa and other locations in the Midwest. The concept involved use of a simple GPS receiver and processor on board the test vehicles. Data transmitted through a data radio was picked up at the base station in Boone City Hall at the offices of Boone County Transportation. There a parallel data radio received the data that was processed and was displayed on a display using a simple TIGER map with a proprietary software program. Fairchild Communications of Boone handled radio communications through its radio network. Given the experimental nature of the project, Fairchild allocated a 400 bandwidth radio to the application and there was no attempt to secure use of a repeater. Consequently it was only possible to track the transit vehicles within the city of Boone. Although the system does serve Ogden and Madrid and other locations in the county, it was not possible to track the vehicles into the county with the limited experimental design.

In addition to demonstrating that a GPS system could track vehicles on a rural demand-responsive system, the demonstration also contributed an array of useful information for planning more permanent installations for such a transit property.Findings are as follows:

1. It is possible to install a low-cost system that can track vehicles.

Cost of GPS receiver $300
Cost of on-board processor $700
Data radio $1000

Base station includes data radio($2000)
a GPS receiver and processor $1000
IBM 486 computer ($1500)
large 17-inch monitor $850

Radio frequency charge $54 a month

This simple system would cost about $36,000 for fifteen vehicles in terms of hardware.

Ideally the base station would have two computers—one which would receive data and the other for display. The display computer (a Pentium) itself would ideally have two monitors (including one 21-inch monitor), One monitor would be used to overview the entire system and the other would be used to focus in on a single vehicle. Nevertheless, even with those improvements, the base station hardware would still cost less than 10,000.

The addition of an MDT on board, at a cost of an additional $850 per vehicle, would be helpful. The hardware for each vehicle would still be less than $3000.

Adding in a GIS software license, software development and installation would still allow a fleet of fifteen vehicles to have a viable GPS system with training and (one year of recurring) radio network charges for less than $73,000.

2. For a map display to be used extensively by the rural bus operator, the map display must be easy to read and have software that is responsive to the needs of the dispatcher. The experimental design did not include that.

3. Stronger radio signals and use of a repeater system is necessary for radio coverage into the county.

4. For GPS to be used by the dispatcher the display must be located on the dispatcher's desk and integral to the dispatching process. An adequate hands-on training program is essential.

5. The full fleet must be equipped in order maximize opportunities for inserted placing pick-ups and readjusting schedules.

6. Linking a scheduling program with the GPS tracking would permit the dispatcher to make better use of the GPS system.

7. The addition of an MDT on board the vehicle, while adding an extra cost, would really increase the value of the GPS system. Messages could be sent in digital form to individual drivers, helping them update their schedules and making better use of any available slack time. For the system to be used effectively, the various components do need to work together automatically. Otherwise the display is little more than a reference tool consulted periodically by the dispatcher, but not affecting the scheduling process.

Dynamic Scheduling

Since no existing dynamic scheduling program was available for experimental application to the target site, a member of the study team developed his own program and used it as a simulation, testing the potential for adding in additional pick-ups and will-call return trips. The simulation used a post operation trip schedule and allowed the scheduling program to "automatically schedule" and route the trips. The computer-generated trip routing did save several minutes over the course of an hour. With several vehicles that extra time could allow additional pickups. Such a program would also reduce the pressure on the dispatcher who is constantly glued to her desk and to the telephone.

The computer simulation involved a program written in C++ by one of the members of the study team. The program which fed into the GIS software, InfoCAD, was modeled after demonstration scheduling software. It included the networking function included in InfoCAD and the ability to insert trips interactively. The display included a GPS verified map of Boone, made available by the Iowa Department of Transportation Travel times between key points in Boone were determined by following a Boone County Bus through the city and actually timing out traffic signals. An average wait time was inserted into the program to account for the railroad crossing.

The Boone County Transit dispatcher supplied schedules for the specific buses which were equipped with GPS. These pick-ups were then fed into the scheduling program and the times involved in the simulation networking program were compared to the actual time involved in each pick-up. An example of the comparison of the times involved in actual pick-ups as observed from the GPS display map and the scheduled pick-ups as presented in the simulation is included in Appendix II. Dwell time is indicated.

These time differences became the basis for time savings included in the subsequent benefit cost analysis. Unfortunately, the Boone dispatcher did not have the opportunity to actually try scheduling using the experimental scheduling program.

Findings generated by these experimental tests were reviewed in light of the actual experience of a number of small transit companies as determined through a number of telephone interviews conducted in spring1996.

Telephone Interviews Directed toward Identifying Quantifiable Benefits

A series of telephone interviews conducted in spring 1996, were specifically directed at identifying quantifiable benefits associated with application of technologies. The target sample for this set of interviews was the list of contacts and users included in the FTA report, State of the Art Update, 1996. Since many more small operators were using dynamic scheduling than AVL, the sample reflects that bias.

Most respondents were pleased with their investment in dynamic scheduling, although a few felt that they had not benefited as much as anticipated. A number of the respondents noted that they experienced changes in their operations at the same time as the introduction of dynamic scheduling. Hence they were unable to distinguish the benefits specifically linked to the introduction of the scheduling program.

Overall the benefits were considerable. With dynamic scheduling the amount of time spent in scheduling was reduced dramatically--one agency reported a drop in scheduling time from 8 hours to 8 minutes. Other benefits were noted. However, the greatest benefit overall was the reduction in stress in the office. While that is somewhat difficult to quantify, it is nonetheless a major benefit.

A sample of the interviews follows. The rest are included in the appendices as Appendix III.

Dynamic Scheduling

Madison County, Illinois

This property, with twenty-five vehicles, was the first US installation of Trapeze QuoVadis 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. and there are plans to add AVL in October. They are already using MDTs and find them most helpful in communicating with drivers. When the GPS base station is functional in October, these MDTs will offer real-time data communication with the base station and on-board 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 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.

Golden Empire Transit in Bakersfield

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 serves 250 passengers a day at 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

This system 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 the level before introduction of the system. They note that they were able in increase inserted trips by 2 percent. 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 they have already experienced.

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 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 than 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 savings 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.

SECTION III

Assessment of the Benefits and Costs of These Technologies as Applied to Small Demand-Responsive Systems

Chapter 6
Benefit Cost Analysis in the Context of Rural Transit

Overview

To determine the economic viability of the dynamic scheduling and AVL technologies, the study team conducted a benefit-cost analysis (BCA). In addition, since transit operators are also concerned with the financial implications of technology decisions, the payback period for such an investment was also determined. Actual operating and financial data were used from Boone County Transportation System, a small rural paratransit agency that is considering the acquisition of these technologies. The costs associated with purchasing and implementing the technologies (including training) were presented earlier in the report. The primary difficulty in this sort of analysis, however, is determining the magnitude of the 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 uses 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 U.S. Department of Transportation (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."

As the goal of this study is to present an objective and conservative (i.e., not overly optimistic) economic and financial assessment of dynamic scheduling and AVL, only the more predictable and quantifiable monetary benefits are estimated. The key quantifiable potential benefits of dynamic scheduling and AVL systems are reduced dispatching and scheduling cost, decreased vehicle operating costs resulting from more efficient scheduling, and increased revenues arising from increased ridership due to better service quality. A brief discussion of these benefits and how they are to be calculated will be provided before the benefit-cost methodology is presented.

Estimates of the increase in vehicle utilization and ridership due to dynamic scheduling were based on telephone interviews with current transit users of the technology. To date, relatively few small or rural transit systems have implemented either the dynamic scheduling or AVL technologies, and usually they have adopted only 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 still reported some substantial operating improvements.

Given the scarcity of transit users of AVL, simulation analysis was performed to estimate the potential reduction in bus-hours that might accrue from better information about bus location. Given the magnitude of the task, simulation analysis was performed on only one vehicle in the fleet. The results, thus, underestimate the benefits of the technology since network effects were not reflected. The benefits may be further underestimated because of the vehicle selected for the simulation. The selected vehicle ran a more regular route than many of the other vehicles in the fleet because a higher proportion of its passengers were subscribers who used the system on a daily basis. (This vehicle was dedicated to these passengers but also picked up will-calls.) AVL would be expected to provide greater benefits when a more random demand is involved. The choice of vehicle was consistent with the generally conservative approach of this study.

Finally, the recommendations of a recent USDOT report (Morlok, 1993) on smart technologies for transit systems were followed in selecting the discount rate (for present value calculations) and time horizon for the benefit-cost analysis. A discount rate of 10 percent was suggested as appropriate for public agencies. A six-year period was deemed appropriate given the rate of technology development.

A brief discussion of the benefits of dynamic scheduling and AVL is provided prior to the results of the benefit-cost analysis.

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 and Scheduling 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 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.

Decreased Vehicle Operating Cost

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).

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 be eligible for 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.

Two levels of ridership increases, 5 and 10 percent, were used in the benefit-cost analysis to reflect the gain reported by a number of interviewed users and a higher gain reported by some of the users who had more success. Both of these increases were phased in over the six-year time frame in the analysis.

Though these are only rough estimates of likely passenger gains for the Boone County system, it is important to note that they appear reasonably attainable given the population and ridership characteristics of the area. Currently, the system provides approximately 350 rides per day. Senior citizens comprise about 60 percent of the system's riders, or about 210 rides per day. The population of the county is a little less than 25,000 and 50 percent of the population, or about 12,500 citizens, is 55 years old or older. Therefore, the market penetration of the over-55 sector is about 1.6 percent, i.e., 210/12,500.

The total number of daily rides represents only 1.4 percent of the total population. Thus, a 5 percent increase in ridership would result in a market penetration rate of 1.76 percent for the over-55 sector (i.e., 220.5/12,500) and 1.47 percent overall (i.e., 367.5/25,000). The market penetration rates would be only 1.8 percent and 1.5 percent, respectively, if ridership increased by 10 percent.

Clearly there is opportunity to expand ridership if the deployment of technologies can increase efficiencies without adding to the costs of operation or the need for more vehicles.

The 1994-1998 Transit Development Plan for Transit Region 11, which includes Boone County, noted that Boone County had the highest level of need for transit based on a need index which considered:

- the percent of household with 0 or 1 vehicle
- the percent of the population below poverty level
- the percent of the population over age 60
- the percent of the workforce employed out of the county
- the percent of the workforce whose travel time to work exceeds 45 minutes
- the percent of the workforce that travels to work by car pool
- the percent of the workforce that currently uses public transportation.

Yet, at the time that the report was prepared (1993), ridership for Boone County was lower than for other counties with lower scores on the need index. This does help to underscore a potential latent demand for transit in the county.

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. For example, 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.

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 (Morlok, 1993) 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.

Finally, the USDOT report (Morlok, 1993) cites a non-transportation 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.

Chapter 7
Application of Benefit Cost Analysis to Transit Technologies

Benefit-Cost Analysis (BCA)

A general model for BCA and its application to three cases are presented in the following sections. The first two cases represent the purchase of dynamic scheduling capability: Case 1 assumes a 5 percent increase in vehicle utilization and ridership and Case 2 assumes a 10 percent gain. Case 3 involves a BCA for the acquisition of an AVL system. Additionally, a BCA will be conducted for an alternative acquisition scenario—leasing the technology.

General Model for Benefit Cost

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 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 (NPV) of net benefits is then compared to the initial cost of the new technology to determine if the expenditure is economically justified. Thus, the basic approach to conducting a BCA consists of the following steps:

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 <u>net</u> 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($)/(1+rate of return on capital)^{1} , or net savings($)/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($)/(1.1)^{3}, or net savings($)/1.33, 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.

The three BCA cases are presented next.

Benefit-Cost Analysis Cases

As noted earlier, Cases 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.

Case 1 uses more conservative estimates of benefits representative of many of the interviewed current users of dynamic scheduling.

Case 2 assumes more significant benefits such as those achieved by the more successful interviewed current users. Each BCA 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.

Case 3 applies BCA to 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. The simulation discussed earlier provided a very conservative estimate of how much slack time might be generated if AVL was implemented. It indicated that precise vehicle location information would free up ten minutes per hour for the vehicle. For the calculation of benefits in Case 3 it was conservatively estimated that one passenger could be picked up for every two hours of bus service. This would represent an annual growth rate of about 8.8 percent as will be shown later.

The transit system data and technology cost data utilized in the BCA cases are presented below.

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	=	$.09
	maint.	=	.15
	insur.	=	.06
	total	=	$ .30

Driver wage per hour = $6.50

Dispatcher salary = $16,000 per year

Technology Cost Data

Dynamic Scheduling (software, training, implementation) + MDT's for each bus

Software, training, and implementation 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 same USDOT report)

Case 1

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 determines the operating efficiency gains from dynamic scheduling, and Part B provides an analysis of increased ridership benefits.

The benefit estimates in Case 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.

NPV of cost = Investment in Dynamic Scheduling = ... **$72,300**
(from p. 65)

(maintenance and operating cost of systems can be ignored 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:

Year 1: annual savings/$(1.1)^1$ = annual savings/1.1

Year 2: annual savings/$(1.1)^2$ = annual savings/1.21

Year 3: annual savings/$(1.1)^3$ = annual savings/1.33

Year 4: annual savings/$(1/1)^4$ = annual savings/1.46

Year 5: annual savings/$(1.1)^5$ = annual savings/1.61

Year 6: annual savings/$(1.1)^6$ = annual savings/1/77

Case 1: Part A

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 fifteen minutes. This frees up dispatcher to do other work. Thus, the agency is essentially adding a new employee for no additional cost.

Savings, 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 x .02 x $.30 = $1,500

Total hours x percent reduction in hr. x driver cost per hr: 16,000 x .02 x $6.50 = $2,080

Sub-total = ... $3,580

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

Savings for each of Years 4-6:

250,000 x .05 x $.30 = $3,750

16,000 x .05 x $6.50 = 5,200

Sub-total = ...$ 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		**=**	**$95,386**

Summary

NPV of Costs (from p. 65)**= $ 72,300**

NPV of Benefits (see above)**=** .... **$ 95,386**

On the basis of economic 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.

Case 1: Part B

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.

<u>Revenue Growth</u>

Years 1-3:
Passengers per yr. x growth
rate = No. of new riders .... 91,000 x .03 = 2,730
Increase in riders x average
revenue per rider = Increase in revenue........... 2,730 x $4.20 = . $11,466

Years 4-6:
91,000 x .05 = 4,550

4,550 x $4.20 = .$19,110

<u>Additional Costs</u>:

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 x .98 x .03 x $.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 x .98 x .03 x $6.50 = ...<u>$3,058</u>

Total additional cost = ...$5,263

Years 4-6:

250,000 x .95 x .05 x $.30 = ... $3,563
16,000 x .95 x .05 x $6.50 = ...$4,940

Total additional cost = ...$8,503

Net benefit per year:

Revenue growth less additional costs	Years 1-3: $11,466 - $5,263 =	$6,203
	Years 4-6: $19,110 - $8,503 =	$10,607

NPV of Benefits:

Year 1:	$6,203/1.1	=	$5,639
Year 2:	$6,203/1.21	=	$5,126
Year 3:	$6,203/1.33	=	$4,664
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**

Case 1 Summary

Total NPV of Benefits from Operating Efficiency Gains
(from Case 1 Part A) and Increase in Ridership (from Case 1 Part B):

Operating efficiency gains... $95,386
Increased net revenues $35,275

Total NPV of benefits..**$130,661**

Summary

NPV of costs (from p. 65) = **$ 72,300**
NPV of benefits (see above)= **$130,661**

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

Case 2

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.

Case 2: Part A

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

(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 x .05 x $.30 = $3,750

Total hours x percent reduction in
hr. x driver cost per hr: 16,000 x .05 x $6.50 = $5,200
Sub-total = ... $8,950
Total savings for each of Years 1-3 = ... $24,950

Savings for each of Years 4-6:
250,000 x .10 x $.30 = $7,500
16,000 x .10 x $6.50 = $10,400
Sub-total = ... $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		=	**$125,489**

Summary
NPV of Costs (from p. 65)=.. **$ 72,300**
NPV of Benefits (see above)= **$125,489**

On the basis of a 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.

Case 2: 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.

Revenue Growth:

Years 1-3:

Passengers per yr. x growth
rate = No. of new riders .... 91,000 x .05 = 4,550
Increase in riders x average
revenue per rider = Increase in revenue .... 4,550 x $4.20 = ... $19,110

Years 4-6:

.... 91,000 x .10 = 9,100
.... 9,100 x $4.20 = ...$38,220

Additional Costs:

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 x .95 x .05 x $.30 = ... $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 x .95 x .05 x $6.50 = ... $4,940

Total additional cost = ... $8,503

Years 4-6:

250,000 x .90 x .10 x $.30 = ... $6,750
16,000 x .90 x .10 x $6.50 = ... $9,360

Total additional cost = ... $16,110

Net benefit per year:

Revenue growth less additional costs	Years 1-3:	$19,110 - $8,503 = $10,607
	Years 4-6:	$38,220 - $16,110 =$22,110

NPV of benefits per year:

Year 1:	$10,607/1.1	=	$ 9,643
Year 2:	$10,607/1.21	=	$ 8,766
Year 3:	$10,607/1/33	=	$ 7,975
Year 4:	$22,110/1.46	=	$15,144
Year 5:	$22,110/1.61	=	$13,733
Year 6:	$22,110/1.77	=	$12,492
Total		=	**$67,753**

Case 2 Summary

Total NPV of Benefits from Operating Efficiency Gains (from Case 2 Part A) and Increase in Ridership (from Case 2 Part A):

Operating efficiency gains.. $125,489
Increased net revenues .... $ 67,753

Total NPV of benefits... $193,242

Summary

NPV of Costs (form p. 65)= .... **$ 72,300**
NPV of Benefits (see above)= .... $**193,242**

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

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

<u>Revenue Growth</u>

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

<u>Additional Costs</u>
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

<u>Net Benefit Per Year</u>

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

<u>NPV of Benefits</u>

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

Case 3 Summary

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

Benefits of technology exceed the cost of technology.

Payback Period

An important 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 results to determine the payback period for each case. Tables 6 and 7 below summarize the net present value of operating efficiency benefits and increased ridership benefits from Cases 1 and 2. Table 6 summarizes the increased ridership benefits from Case 3.

Table 6: Payback period for Case 1

	Operating Efficiency Benefits (Part A)	*Increased Ridership Benefits (Part B)*	*Total Yearly Net Benefits*	*Cumulative 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
	$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.
This occurs during Year 4.

Table 7: Payback period for Case 2

	Operating Efficiency Benefits (Part A)	*Increased Ridership Benefits (Part B)*	*Total Yearly Net Benefits*	*Cumulative 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

	$125,489	$67,753	$193,242	

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

Table 8: Payback period for Case 3

	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 Case 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 should consider leasing equipment as an alternative to outright purchasing. The key advantage is that the agency does not need the up-front capital to acquire the equipment. The key disadvantage is that the cost of leasing is greater than the cost of purchasing.

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

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

Table 9: Various leasing options

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

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

Table 10: NPV of leasing cost

	5-year	*3-year*
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 in both Cases 1 and 2.

Chapter 8
The Potential Benefits From a Coordinated System

Coordination of services through regional rural transit areas is well established in Iowa. Multicounty regional transit districts were established about twenty 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.

This concept involves a central base station that 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 fifteen 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.

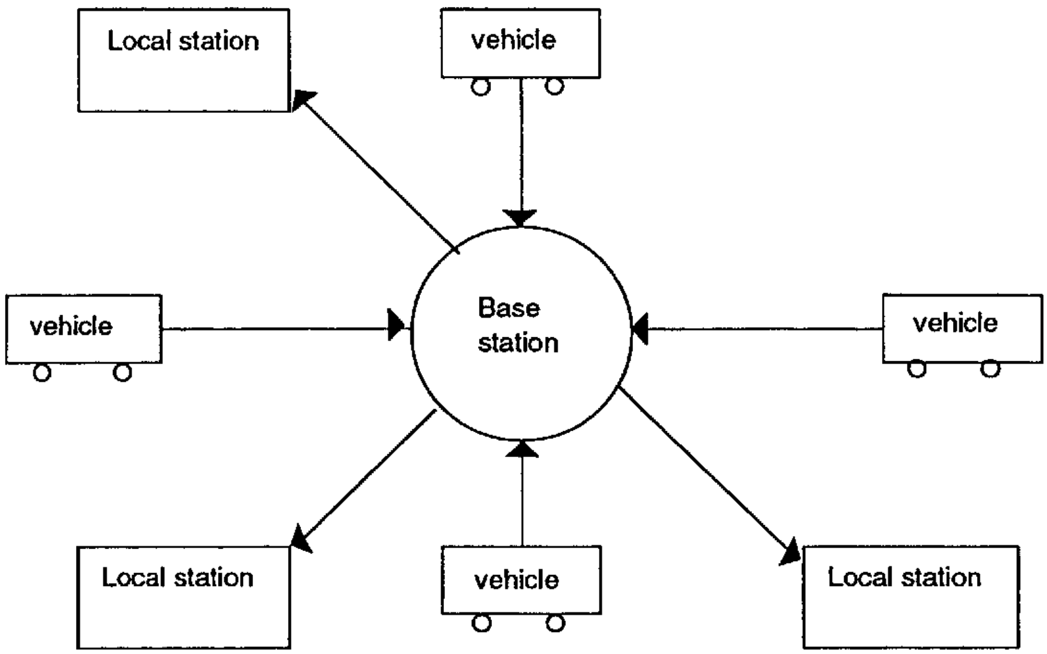

Fig. 2: Common AVL System

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.

Table 11: Equipment needed at local station

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

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.

Assessment

Given the greatly reduced cost of computers, this option may no longer be as appealing as it was about two years ago. Cost savings in having a single computer would be quickly lost in additional communication costs. 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. The 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.

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 and automatically dispatch a trip.

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.

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 (fifteen-van) agency. For simplicity's 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 a description of the AVL system components that comprise these costs please see p. 43):

- Base station cost
- In-vehicle cost ($3,250 per vehicle)
- Training

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 17. 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 re-program 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:

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

$59,150 + $5,230 = $64,380 (including subscription fee)
$64,380 + $80,000 (in capital costs for initial system in example 3 described above) = $144,380

The NPV of costs of adding a second agency is $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.

NPV benefits ($173,196) - NPV costs ($144,380) = $28,816

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

Hence, in this case, the benefits of adding a second agency clearly exceed the costs.

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 that 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 twenty-mile 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 forty vehicles.

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.

Chapter 9
Moving Beyond Technology Assessment to Purchase

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.)

Manual Focus

As a primary product of this project, the study team developed a manual which is intended to guide small paratransit operators in deciding whether to invest in mart technology as a means of increasing their efficiency and effectiveness. In addition an abridged version of the technical material presented in this report, the manual goes on to summarize advice offered from current users to future users, provide hits on offering an RFP and provide a brief review of possible funding sources.

CONCLUSIONS

As the foregoing analysis indicates, the benefits of investment in technology far exceed the costs even for small rural transit properties. An investment in dynamic scheduling can pay back in only three years even using the conservative analysis presented in this report. Investments in AVL have a somewhat longer payback period, but still the benefits exceed the costs.

In general, small transit operations can feel optimistic about the scope and extent of benefits that they will experience from either technology, despite initial concerns about up front costs. Current riders will benefit from a more efficient system and from the opportunity to take a ride without a required 24-hour advance reservation. A more efficient operation will also open the door to providing additional service for their members of the community. Real-time scheduling will allow the system to respond to the needs of workers who could benefit from reliable transportation to remote work sites. A rural system that can guarantee on-time arrival and service that is "ready when you are" can genuinely offer service to the general public. The ability to locate a stranded vehicle precisely even on a back country road provides considerable assurance to both drivers and passengers.

At the same time both AVL or dynamic scheduling will generally reduce stress among the staff in the transit agency and permit staff with limited experience with the transit system to begin scheduling rides. With an automated scheduling program, transit agencies can delegate scheduling to lower skilled employees—call takers. This allows agencies to use experienced dispatchers to a focus on the broader operation and to forego hiring additional dispatchers. The direct result of such an effort is a reduction in agency personnel costs.

The report and the study began, however, with a focus on the specific needs of individual transit providers. Each property is distinct in terms not only its fleet size, service area and budget, but also in terms of the expertise of the staff. To realize even the level of benefits identified in this study a transit property needs an enthusiastic staff with an interest in innovation and a level of comfort in working with computers. The extent of training programs, especially training programs on site, should be a critical part of the bid selection process, but the success of those training programs is dependent upon the interest and determination of the staff. Almost all operators who were interviewed in connection with this study noted a learning curve after installing either dynamic scheduling or AVL. Reducing that learning curve and moving quickly to full deployment the technology is critical to realizing the anticipated benefits.

The study, as initially envisioned, was to explore the potential for linking real time and location in scheduling demand responsive transit. That is a logical step. Unfortunately, for purposes of this study, vendors have only begun to recognize the importance of this link. Both dynamic scheduling and automatic vehicle location (GPS) are now mature technologies. Within the last few years the application of GPS to fixed-route urban transit and even paratransit has moved from experimental to fully operational, while computer-assisted dispatching has been transformed into automated dynamic scheduling for demand responsive operations. With this maturity has come reduced costs and user-friendly interfaces. It is now possible for a small rural operation to consider applying one of these technologies. For them to be able to acquire both will still take more experimentation and the development of a transparent interface with user-friendly display menus. Even though the benefits still exceed the costs of a combined system, the benefits added with the addition of GPS to dynamic scheduling do not appear to be substantial for a small rural operation.

In a rural area with a small fleet operating is scattered areas, it is often not easy to reduce slack time by rescheduling vehicles on the fly to pick up additional passengers. It is, however, usually clear even without GPS, which vehicle is in the appropriate part of the county. Drivers usually call in via voice radio to indicate a pick-up. This information can help to geocode the dynamic scheduling program, but it can be seen as making GPS monitoring unnecessary.

The disadvantages of replying on dynamic scheduling without some sort of regular updating is that the schedules being created may not be grounded in reality. Additional pick-ups can be inserted based on anticipated pick-up and arrival times and those could easily differ from reality, given street closings, road repair, natural disasters, or even lengthy waits at railroad crossings. The result can be false expectations on the part of the new passenger, and frustration on the part of the driver involved. GPS would immediately verify actual location of a vehicle before scheduling the additional pick-up. Actual drive times rather than anticipated drive times would constantly update the run time of individual pick-up routes. Hence conceptually a combined system would be useful for all paratransit, and for rural systems especially.

The concern is that currently only a limited number of vendors are actively working on that interface between dynamic scheduling and GPS. Creating that linking software is technically not difficult if the interface is considered at the time that either of the pieces of software are deployed. To add it on after the fact will run into typical compatibility issues. It is, therefore, not surprising that Trapeze™ - QV, which is a custom-built scheduling program, is among those moving ahead with GPS interface.

How to link these two technologies remains an issue. It is possible to start with a scheduling program and add in GPS during the geocoding process. However, a more viable concept would be to start by installing GPS on the vehicles. Then a dynamic scheduling program could overlay that infrastructure. The actual vehicle location could be fed into the scheduling system for updating rather than a pre-established set of travel times. Such a combined system could start with reserved trips and any travel between points could be captured for additional pick-ups along the way.

To accomplish this interface would require a compatible scheduling program that could be linked into the GPS infrastructure. Ideally, the GIS map associated with the GPS system would be used for the display and the updated schedule routing could overlay the display.

Unfortunately, vendors with both types of technology are building in redundancies and creating proprietary closed systems. Even if AVL follows the national requirements of open architecture for Intelligent Transportation Systems, the GIS software packages that are associated with display are often self-contained. For example, InfoCAD, the GIS program which the study team worked with on this project, does its own networking (routing) between points. Other GIS programs also attempt networking. Dynamic scheduling programs like PASS builds in its own geocoding of locations to inform real-time scheduling. Both proprietary software are self-contained and do not readily interface with other technologies. This is particularly true of the scheduling programs that are moving closer to “off the shelf” purchase. The result is that GPS software vendors are beginning to develop their own scheduling programs that are admittedly crude compared to the user-friendly products described in this report.

Small rural transit companies will be inclined to invest in products that require minimum up-front cost and meet their immediate needs. With the immediate need being more efficient scheduling and ease in report generation, it is not surprising that they will move more readily into lower-cost packages involving dynamic scheduling. As the benefit cost analysis in this study indicates, that is a wise present investment with a limited payback time. At the same time, however, they will be generally precluding the option of adding on linkage with GPS down the road.

The costs for the combined system in this study incorporated a customized dynamic scheduling package and reflects a fairly low-cost GPS system. That approach puts all the requirements for user-friendly interface on the scheduling software, which is what the dispatcher would be relating to directly. GIS display maps would be incorporated directly into the scheduling program reducing the requirement for a user friendly GIS map display specifically to monitor the locations of vehicles.

The linkage between the two technologies would be transparent to the dispatcher, who would only look at one set of monitors. One monitor would display the data bank associated with regular riders along with a code that would be used to would locate them on a display map. Other callers from the general public could be easily inserted into this list, possibly with a different code. This is what dynamic scheduling programs currently do independently. A second computer would receive GPS data and have an associated monitor with a basic display showing the location of all vehicles in the fleet. Given a small fleet and a wide service area, this map would not need precise details. A zoom feature would be helpful, but not essential. A third computer tied to both the GPS computer and the scheduling data would overlay the scheduling data on the GPS location data. This computer, at the level of a Pentium, would house the user-friendly dynamic scheduling program and would offer automatic scheduling for individual vehicles. That computer should have a large twenty-inch monitor connected to the others through a local Novell network. The dispatcher would be primarily concerned with that third monitor, which would display routes built not just in real time but grounded in real space.

The investment costs of such a system may now appear to be considerable and the payback time may seem long-term to small operators. In fact, the out-of-pocket cost to a small agency exceeds the quantifiable benefits at this time. That is why the concept of joint purchase involving a consortium of small operators developing a common purchasing unit with a single RFP, a single training program, and a common computer technician to help with the maintenance of such systems is very appealing.

Further study of current linkage systems being installed in the counties surrounding Detroit and in Santa Clara, California, will help to inform further analysis of the application of linked GPS-dynamic scheduling programs to small rural systems. Hopefully the success of such demonstrations will encourage vendors of dynamic scheduling programs to build the potential of linkage into their software. The rapid evolution of scheduling software from computer-assisted to fully automated in real time over a period of four years offers confidence that these vendors will soon incorporate the spatial dimension provided by GPS into their programs as well. This will make it possible for increasing numbers of rural demand-responsive systems to reap the benefits of increased efficiency and service offered by a scheduling system that operates in both real time and real space.

Bibliography

"A Growing Gaggle of Windows DBMS Software." *Datamation* (February 1, 1993): 84-5.

Allen, Arletha Vickers. "Software You Can Count On." *Black Enterprise* 25 (March 1995): 44-45.

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.

Borich, Timothy and Norman Riggs. *Iowa Regional and Urban Transit Managers Focus Groups: A Summary Report.* November 20, 1995.

Community Transportation Assistance Project, US Department of Health and Human Services, and the Community Tranportation Association of America. *Building Mobility Partnerships: Opportunities for Federal Funding,* 1996. Available through the National Resource Center Hotline 800-527-8279.

Connolly, James. "Consistency Helps Microsoft's Access Take Charge." *Computer World* 129 (August 14, 1995): 82-83.

Dobler, Donald W. and David N. Burt. *Purchasing and Supply Management (Text and Cases).* 6th ed. McGraw-Hill, 1996.

England, Wilbur B. *Procurement Principles and Cases.* 5th ed. Richard D. Irwin, Homewood, Ill., 1967, p. 405.

Heart of Iowa Transit Agency. *Region II Transit Development Plan, FY 1994–98,* submitted 1993.

Hunton, James E. and M. K. Raja. "When is a Database not a Database? (When It's a Spreadsheet)." *Journal of Accountancy* 179 (June 1995): 89-93.

J. K. Lasser Tax Institute. *How to Run a Small Business.* 6th ed. McGraw-Hill, 1989.

Kihl, Mary. "Rural Passenger Transportation: Nostalgia or Innovation?" *CIS Seventh Annual Transporation Research Conference Proceedings* , University of Minnesota, May 14-15, 1996.

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 (August 1993): 39-42.

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 Burn, and Kimberly Battle Blackmon. *Advanced Vehicle Monitoring and Communication Systems for Bus Transit: Benefits and Economic Feasibility.* Prepared for the US Department of Transportation, 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 ed. Vol. 1. Prentice-Hall, 1994.

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

RTAP National Transit Resource Center. *Innovative Funding Strategies,* Technical Assistance Brief, No. 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 (September 1995): 132.

Stone, John and Peter Gray-Mullen, North Carolina 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 Administration, Office of Technical Assistance and Safety, US Department of Transportation.

Systan, Inc. *A Guide for Acquiring Demand Responsive Transit Software.* Preliminary draft prepared for Transportation Cooperative Research Program, Transportation Research Board, March 1996. (Not yet released for general distribution).

Washburn, David, *Real Estate Information Service*. Consulting report submitted to County of Rockland (N.Y.), Department of Public Transportation, September, 1993.

APPENDICES

Appendix I: Interviews Reflecting User Satisfaction*

User	*Vendor*	*Time used*	*Vehicles*	*Reason(s) selected*	*Training*	*Comments*
Pinole, CA Charlie Anderson 510-724-3331	On-Line	1 year				• serves more passengers per hour • increase in same day schedules • long learning curve • time estimates not always right
Modesto, CA Dean Galloway 209-527-4900	On-Line	13 months	8 buses	• comprehensive - scheduling, database, routing	several months full staff	• on-time performance up • stock reporting system inadequate • customized reporting better
Vine (Napa, CA) Jerica Estevez 707-257-9517	3M	demon-stration I year	20 buses	• vendor approached them	considerable including use of Windows	• user friendly • good for on-time performance • needs to have scheduling added
Riverside, CA Helen Wariner 909-351-6138	Model-ing Systems, Inc./ Airtouch, Inc.	used Scooter since 1986, MDT/ AVL for 2 years	19 vehicles	• Few available 1986 • Police use Airtouch	a week for MDTs	• sunscreen hard to read on dash • guaranteed rides • stable, reliable
Santa Clara, CA Katie Heatley 408-436-2865	Trapeze/ Trimble naviga-tion	18 months	40 mini-vans out of 80	• wanted customized system • demonstration with Cal Trans		• portion of shared rides up from 38-55 percent • System provides exact mileage for fares • Extent of GPS coverage now limited by geography

*Report of telephone interviews conducted in 1995 with properties using dynamic scheduling and AVL recommended by vendors and supplemented by some identified in government documents.

Wheat Ridge, CO Hank Braaksma 303-235-6970	Multi Systems Dispatch-a- Ride	6-7 years	13 vehicles	• few available at time • low cost • (now moved to network operation and needs UNIX computer)		• good security of files and reliability • helps with demo • graphic information and trip counts. • not doing real time yet
Black-hawk County, IA Sharon Krieger-Maltas 319-234-5714	On-Line	3 years	11 to 13 buses 300-350 rides a day	• does scheduling, dispatching, custom reports	user friendly good support	• 1.7 rides per hr per vehicle up to 3.2 rides per hr • can do reporting related to tracking of billing • doesn't do automated rerouting or will call
Iowa City, IA Bernel Chattick 319-339-6128	On-Line	just started	13 vans 400 riders a day	• level of experience • low bid		• only purchased scheduling so far • hope to add GPS
Musca-tine, IA Kathy Meier 319-263-8152	Dispatch Manager		fixed route, para-transit operation			• bought it not yet using it
Sioux City, IA Dan Jensen 712-279-6405	Not yet selected		Fixed route and para-transit.	• expect to estimate route times rather than driving routes • plan to work with city GPS • want to move away from one-person dispatch function		

Hender-son, KY Pam Stone 502-831-1249	Dispatch Manager	1 year	2 vehicles 50-60 trips a day	• only cost $300		• time to create manifests down 1 hour to 3 minutes • user-friendly manual • no real-time functions
Brockton, MA Lisa Marog-nano 508-584-5330	Trapeze	almost ready	33 vehicles 800 trips a day	• billing, routing, scheduling • reputation of vendor	4 weeks	
Troy, MI Philip Shaw 810-362 3436	Trapeze	1 year	100 buses	• plan to tie in with AVL • hope to unify SE Michigan		• only 1 county up so far, good support
Anoka, MN Tim Kirchoff 612-422-7088	On-Line	since 1992		MINN DOT recommended On-Line does address issues and deals with real time		• had 25 percent drop in no-shows • 2.5 passengers per hour before, now 3.1 per hour per vehicle
Dakota Co., MN Sara Lenz 612-296-3441	Trapeze	schedul-ing since 1995, AVL will be added	25 vehicles, 500 trips/ day, 50 percent pre-sche-duled	FHWA operational test Trapeze is best in mix of urban and rural area		• system running well so far
Eden Prairie, MN Tom Juhnke 612-949-8303	On-Line	2 years		• only company with 5 customers with 1 year experience	poor training experience	• not working up to expectations • problems with MDTs • fewer riders per hour than before
Alamance Co, NC Forrest Paullet 910-222-0565	Multi Systems Dispatch-a-Ride	7 years	22 vehicles, 500 rides a day			• good statistical reporting • they lend out software to others • only using part of program

Mountain Empire, VA Mike Hensen 540-343-1721	PtMS	4 years	35 vehicles	• state DOT gave it to them	extra charge for training, training is off site	• good accounting program • performs automatic scheduling • good upgrades, but maintenance costs $1500 a year
Prince William CO, VA 703-490-4811	Trapeze and Gandoff	Trapeze 1 year AVL not up yet	12 buses, 5 routes	• these relate to route deviation • wanted to link GPS with scheduling	1 week good program	• 1-hour scheduling down to 5-7 minutes • programs use considerable RAM • need extra UNIX computer for MDTs
Everett, WA George Baxter 206-259-8803	On-Line	2 months	15 vehicles	• cost and plans to use MDTs	1 week for supervisors, 3 days for schedulers.	• staff still adjusting • vendor responsive to problems
Winston Salem, NC Susan Telechea 910-727-2648	On-Line	1 year		• it can do routing, MDT, AVL and smart card	2 weeks	• good combination of capabilities, reporting software inadequate, hardware poor maintenance
Sidney, OH Jerry Alexander 513-498-8117	Dispatch Manager		6 vehicles	• low cost ($300)		• not using it
Scranton, PA Kurt Kempter 717-343-1720	Auto Track, Inc. (now part of TMI) AVL system	1994	32 vehicles	• few companies in the field		• complaints down from 10 to 6 per week • enunciators helpful, very effective with checking on-time performance, fuel efficiencies

Houston, TX Jim Lauhlin 713-739-4986	On-Line	1 year	150 vehicles	• most efficient of available systems • allows wide range of operational styles		• 10 percent increase in scheduled passengers • 3 to 8 months before MDTs • increase in productivity and telephone staff
Blacks-burg, VA Kevin Danker 540-961-1185	Comsis	1 month	5 vehicles	• other responses too expensive • could integrate with existing programs best	2 weeks on site	• hoping for benefits with real-time scheduling

Appendix II: Route simulation

This is a simulation of the route using networking techniques of Infocad. The first column indicates the starting point and the second column indicates the ending point of that part of the route. The third column gives the time taken for this part of the route obtained by using the simulation. The fourth column gives the actual values recorded at the site using the GPS data.
The fifth column indicates whether this part of this trip had dead mileage.

FROM	TO	TIME(min) Simulation	TIME(min) Driving	Indication
P/V	709 CAROLL	2.31	3	
709 CAROLL	SH	3.15	4	D
SH	423 TAMA	3.71	5	
423 TAMA	22'nd & GREEN	5.85	8	D
22'nd & GREEN	CITY HALL	5.83	6	D
CITY HALL	SH	2.04	2	D
SH	SCHOOL	2.51	3	
SCHOOL	HYVEE	2.94	3	D
HYVEE	1727 LYNN	1.72	2	
1727 LYNN	1604 CAROLL	2.71	3.5	
1604 CAROLL	CAROLL & 6'th	2.55	3	D
CAROLL & 6'th	E*	3.51	4	
E*	LEDGES	4.32	NO TIME	
LEDGES	RR	1.89	NO TIME	
RR	PAGE	3.01	NO TIME	D
This part of the trip corresponds to the school kids				
PAGE	725 S. DIVISION	3.55	4	
725 S. DIVISION	403 MARION	2.42	2.5	
403 MARION	LINCOLN	2.01	2	
LINCOLN	116 W 9'th	2.96	3	

116 W 9'th	320 12'th	**1.42**	**1.5**	
320 12'th	FRANKLIN	**1.85**	**2**	
FRANKLIN	1403 BENTON	**4.19**	**5**	
1403 BENTON	7'th & CAROLL	**2.97**	**3**	
7'th & CAROLL	420 MONONA	**2.29**	**3**	
420 MONONA	1901 1ST LOT	**4.51**	**5**	
1901 IST LOT	CITY HALL	**4.11**	**4**	**D**

Appendix III: Interviews with end users to determine quantifiable benefits (conducted Spring 1996)

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 medicais, 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 increase 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

1(995-6), 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 Trapeze™-QV

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.

Prince William County, VA
12 buses, deviated fixed route
703-490-4811 Scheduling, Trapeze™-QV, Gandolf AVL/MDT

New system. Trapeze™-QV 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.

Santa Clara, CA
40 minivans
Katie Heatley, David Brandauer 408-436-2865 scheduling, Trapeze™-QV, Trimble Navigation, GPS

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

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™-QV System almost ready to use. Selected because will be helpful with billing, scheduling, routing.

Anoka, MN
Tim Kircholl 612-422-7088 Scheduling

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.

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 Recorders, 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 passengers. 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.